Article XVII. — AMERICAN EOCENE PRIMATES, AND THE SUPPOSED RODENT FAMILY MIXODECTIDÆ.

By Henry Fairfield Osborn.

The only American Primates at present known are those in the Eocene. The supposed Oligocene Primates, *Laopithecus* Marsh and *Menotherium* Cope, have proved to be identical with *Leptochœrus* Leidy, an Artiodactyl.

Invariably associated with the discovery and literature of the Primates is the family Mixodectidæ, including *Mixodectes* and possibly *Indrodon*, *Cynodontomys*, and *Microsyops*, now supposed to be very primitive Rodents. In the writings of Cope, Marsh, and Leidy, the bibliographical relations of these two groups are so intimate that it is convenient to revise them together.

Altogether fifty-one species have been named, many of them based upon defective types; the synonymy is truly appalling, as shown in the chronological table.

Many years ago I devoted several months to systematic revision as the basis of the present paper, examining and comparing the types in the collections made by Leidy, Marsh, and Cope, now in the Philadelphia Academy (Ph.), American Museum (A. M.) and Yale University (Y.). Unfortunately all the types described by Cope for the Wheeler Survey, and figured in his 'Extinct Vertebrata of New Mexico' of 1874 have disappeared. A beginning is made here by pointing out the synonymous genera but the species require prolonged and microscopic examination and comparison. This, however, is intended to supersede and replace all previous revisions by the author and his staff in the Museum.

Dr. W. D. Matthew has rendered invaluable aid and advice both in the morphological and descriptive part. In putting together these notes and tables I have also been greatly assisted by Mr. W. K. Gregory. The drawings are chiefly the work of Mr. Weber, Mr. Horsfall, and Mr. Anderson.

PART I. PRIMATES.

I. SUPPOSED BASAL EOCENE (MONTIEN AND THANÉTIEN) PRIMATES.

None of the Basal Eocene (Puerco and Torrejon) types appear to be positively ancestral to the Lower Eocene or Wasatch Primates; the Primates of the latter stage (Sparnacien) thus far *appear to represent a new primate fauna* like the new ungulate fauna of horses, tapirs, etc.

The Puerco and Torrejon species include a great number and variety of small animals whose relationships are still largely a matter of individual opinion, because the material, except in the case of one skeleton (No. 823, see below), affords no absolutely distinctive characters. They have been referred by different authors, chiefly Cope, Schlosser, Earle, and Osborn, to such diverse orders as the Creodonta, Rodentia, Condylarthra, Insectivora, and Primates. I have always inclined to refer many of the smaller types to the Primates, but without being able to give conclusive grounds for the opinion, the main reason being the general adaptive resemblance which they bear to the existing Lemurs.

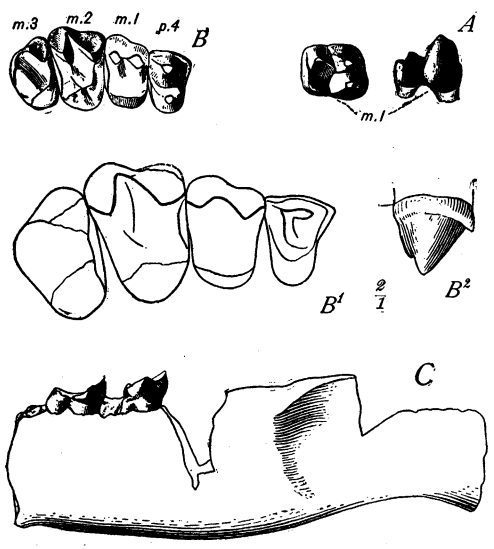

Fig. 1. *A*, *Mioclænus acolytus*. Amer. Mus. No. 829*a*. Lower molar. *B*, supposed Primate. Am. Mus. No. 823. *B*, superior molars, enlarged 2 diam., B^1, contour of same still more enlarged. *C*, lower jaw of same specimen, 2 diam. Compare Fig. 2. Twice natural size.

Indrodon malaris (Torrejon stage) was placed by Cope in the Anaptomorphidæ; this is an error. The structure of the superior

molar teeth relates it rather to *Mixodectes*, a supposed primitive Rodent.

The skeleton (Amer. Mus. No. 823) originally associated with *Indrodon* by error (Osborn and Earle, 1895, pp. 16–20) deserves most careful examination, for if it belongs to a Primate it is by far the most primitive known. The astragalus is not like that of a Rodent. The figures (Figs. 1, 2) give the proportions of the limbs.

Mioclænus acolytus and *M. lemuroides* Matthew are two other small Torrejon species in which the lower molar teeth suggest those of *Hyopsodus*, especially in the reduction of the paraconid (Fig. 1*A*).

Oxyacodon apiculatus (Puerco) and *O. agapetillus* (Puerco), also *Carcinodon filholianus* (Puerco), deserve examination in this connection.

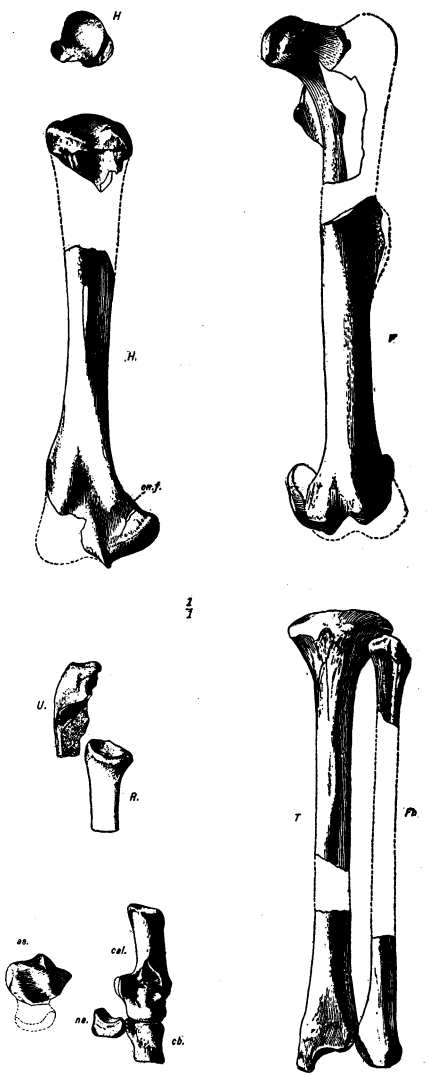

Fig. 2. Supposed Primate. Am. Mus. No. 823. Fore and hind limb bones and tarsals. All natural size. Compare Fig. 1.

CHRONOLOGICAL TABLE OF SPECIES REFERRED TO EOCENE PRIMATES

OMITTING CERTAIN PUERCO AND TORREJON STAGES.

Species Number and Reference Page in this Article.	*Original Reference.*	*Figure.*	*Type.*	*Present Location.*	*Horizon.*
(1) *Omomys carteri* Leidy, p. 190.	Proc. Acad. Sci. Phila., Apr., 1869, p. 63.	Ext. Fauna Dak. and Nebr., 1869, p. 408, pl. xxix, figs. 13 and 14.	Rt. ramus; fragment of cranium.	Ph.	Bridger.
(2) *Hyopsodus paulus* Leidy, p 185.	*Ibid.*, Oct. 4, 1870, p. 110.	Contr. Ext. Fauna West. Terr., 1873, pl. vi, figs. 1–9, 18–22.	Rt. ramus with p_4–m_3.	Ph.	Bridger.
(3) *Microsus cuspidatus* Leidy p. 180. = *Hyopsodus paulus.*	*Ibid.*, p. 113.	*Ibid.*, pl. vi, figs. 10, 11.	Part low. jaw cont. m_2, m_3.	U. S.	Bridger.
(4) *Notharctus tenebrosus* Leidy, p. 196.	*Ibid.*, pp. 113–114.	*Ibid.*, p. 86, pl. vi, figs. 36, 37.	Rt. ramus cont. c–m_3.	U. S.	Bridger.
(5) *Hyopsodus gracilis* Marsh, p. 198. =? *Sarcolemur gracilis.* Or may antedate (7)	Amer. Jour. Sci., II, 1871, p. 42; sep. "June 5, 1871," p. 10.		Part low. jaw cont. p_3, p_4, m_1.	Y.	Bridger.
(6) *Limnotherium tyrannus* Marsh, p. 197. =? *Notharctus tyrannus.*	*Ibid.*, p. 43; sep. "June 5, 1871," p. 16.		Low. jaw with several teeth.	Y.	Bridger.
(7) *Limnotherium elegans* Marsh, p. 198. =? *Notharctus elegans.*	*Ibid.*, pp. 43–44; sep. "June 5, 1871," p. 12.		Portions of rami cont. p_4 and m_1, m_3.	Y.	Bridger.
(8) *Microsyops gracilis* Leidy, p. 210.	Proc. Acad. Sci. Phila., 1872, Feb. 6, p. 20. (Publ. Apr. 16.)	*Ibid.*, pl. vi, fig. 14.	Left ramus.		Bridger. (Grizzly Buttes).
(9) *Palæacodon verus* Leidy, p. 210. =*Microsyops verus.*	*Ibid.*, p. 21.	*Ibid.*, p. 122, pl. vi, fig. 46.	Part up. jaw cont. one m.	Ph.	Bridger.
(10) *Hipposyus formosus* Leidy, p. 198. =? *Notharctus formosus.*	*Ibid.*, Apr. 2, p. 37. (Publ. June 25.)	*Ibid.*, p. 90, pl. vi, fig. 41.	Part of up. jaw cont. m^1, m^2. Cotype inf. ms.	Ph.	Bridger.
(11) *Lophiotherium* (*Hyopsodus, Sarcolemur*) *pygmæus* Cope, p. 189. =*Sarcolemur pygmæus.*	Proc. Amer. Phil. Soc., 1872, p. 461; sep. "July 29, 1872."		Part of rt. ramus cont. m_1, m_2, and p_4–m_3 emerging.	A. M. (No. 5006.)	Bridger.
(12) *Notharctus* (*Hipposyus*) *robustior* Leidy, p. 198. = *Notharctus robustior.*	Hayden's Rep. Geol. Surv. Mont., 1871 (1872), p. 364.	*Ibid.*, p. 93, pl. vi, fig. 40.	Part lower jaw with one tooth (m_2).	Ph.	Bridger.
(13) *Thinolestes anceps* Marsh, p. 197. =? *Notharctus anceps.*	Amer. Jour. Sci., IV, Sept., 1872, p. 205; sep. "Aug. 7, 1872," pp. 13–14.		Up. and low jaws, teeth, humerus, astrag., caud. vert.	Y.	Bridger.
(14) *Telmatolestes crassus* Marsh, p. 198. =? *Notharctus crassus.*	*Ibid.*, p. 206; sep. "Aug. 7, 1872," p. 14.		Sup. ms., lower jaw with teeth.	Y.	Bridger. (Henry's Fork.)
(15) *Limnotherium affine* Marsh, p. 197. =? *Notharctus affinis.*	*Ibid.*, p. 207; sep. "Aug. 7, 1872," p. 14.		Skull, teeth, lower jaw, portions of skel.	Y.	Bridger. (Grizzly Buttes.)

Species Number and Reference Page in this Article.	*Original Reference.*	*Figure.*	*Type.*	*Present Location.*	*Horizon.*
(16) *Stenacodon rarus* Marsh, p. 190. = *Hyopsodus rarus.*	*Ibid.*, p. 210; sep. "Aug. 13, 1872," p. 18.		m_3.	Y.	Bridger. (Henry's Fork.)
(17) *Antiacodon venustus* Marsh, p. 189. cf. *Homacodon* (? Artiodactyla).	*Ibid.*, p. 210; sep. "Aug. 13, 1872," p. 19.		Part low. jaw cont. m_3.	Y.	Bridger. (Henry's Fork.)
(18) *Bathrodon typus* Marsh, p. 212. = ? *Microsyops typus.*	*Ibid.*, p. 211; sep. "Aug. 13, 1872," p. 19.		Part low. jaw cont. m_1–m_3.	Y.	Bridger. (Grizzly Buttes.)
(19) *Bathrodon annectens* Marsh, p. 213. = *Microsyops annectens.*	*Ibid.*, p. 211; sep. "Aug. 13, 1872," p. 20.		Part low. jaw cont. m_3.	Y.	Bridger. (Henry's Fork.)
(20) *Mesacodon speciosus* Marsh, p. 212. = *Microsyops speciosus.*	*Ibid.*, p. 212; sep. "Aug. 13, 1872," p. 21.		Low. jaw.	Y.	Bridger. (Grizzly Buttes.)
(21) *Hemiacodon gracilis* Marsh, p. 200. =*Omomys gracilis.*	*Ibid.*, p. 212; sep. "Aug. 13, 1872," p. 21.		Part several low. jaws.	Y.	Bridger. (Henry's Fork.)
(22) *Hemiacodon nanus* Marsh, p. 200. = *Omomys nanus.*	*Ibid.*, p. 213; sep. "Aug. 13, 1872," p. 21.		Rt. ramus cont. p_4–m_3.	Y.	Bridger. (Henry's Fork.)
(23) *Hemiacodon pucillus* Marsh, p. 200. = *Omomys pucillus.*	*Ibid.*, p. 213; sep. "Aug. 13, 1872," p. 22.		Lower jaw cont. m_2.	Y.	Bridger.
(24) *Entomodon comptus* Marsh, p. 189. = ? *Sarcolemur comptus.*	*Ibid.*, p. 214; sep. "Aug. 13, 1872," p. 23.		Several isolated teeth, incl. p_4 (rt. side).	Y.	Bridger.
(25) *Pantolestes longicaudus* Cope, *Incertæ sedis.*	Proc. Amer. Phil. Soc., Aug. 15, 1872, p. 467.	Tert. Vert., 1884, p. 725, pl. xxiv, figs. 13–17.	Left ramus low. jaw, p_4–m_3 and caudals.	A. M. (No. 5142.)	Bridger.
(26) *Palæacodon vagus* Marsh, p. 200. = ? *Omomys, (Microsyops) vagus.*	Amer. Jour. Sci., IV, Sept., 1872, p. 224; sep. "Aug. 17, 1872," p. 34.		Upper jaw cont. m^1, m^2; m^3.	Y.	Bridger. (Grizzly Buttes.)
(27) *Tomitherium rostratum* Cope, p. 197. = ? *Notharctus rostratus.*	Proc. Amer. Phil. Soc., Sept. 19, 1872, p. 470; sep. Pal. Bull. No. 3, p. 3, "Aug. 7, 1872."	Tert. Vert., 1884, p. 221, pl. xxv, figs. 1–9.	Complete low. jaw with teeth. Skeleton (humerus, ulna, radius, femur, ilium).	A. M. (No. 5009.)	Bridger. (Black's Fork.)
(28) *Anaptomorphus æmulus* Cope, p. 202.	Proc. Amer. Phil. Soc., Oct. 18, 1872, p. 554; sep. Pal. Bull., No. 8, p. 1, "Oct. 12, 1872."	Tert. Vert., 1884, p. 248, pl. xxv, fig. 10.	Left ramus, p_4–m_2 and alveoli of front teeth.	A. M. (No. 5010.)	Bridger. (Green River.)
(29) *Hyopsodus minusculus* Leidy, p. 186.	Contr. Ext. Fauna West. Terr., 1873, p. 81.	Contr., etc., pl. xxvii, fig. 5.	Part up. jaw cont. several ms.	Ph.	Bridger. (Dry Creek.)
(30) *Washakius insignis* Leidy, p. 200. *Incertæ sedis* (? Rodentia).	*Ibid.*, p. 123.	Contr., etc., pl. xxvii, figs. 3, 4.	Part low. jaw cont. m_2, m_3.	Ph.	Bridger.
(31) *Antiacodon furcatus* Cope, p. 189. = *Sarcolemur furcatus.*	Ann. Rep. Geol. Surv. Terr. (Hayden), 1872 (1873), p. 608.	Tert. Vert., 1884, p. 233, pl. xxiv, figs. 18, 19.	Part rt. ramus cont. p_4–m_3.	A. M. (No. 5008.)	Bridger. (Bluffs of Upper Green River.)
(32) *Microsyops* (*Hyopsodus*) *vicarius* Cope, p. 187. = *Hyopsodus vicarius.*	*Ibid.*, p. 609.	Tert. Vert., 1884, p. 237, pl. xxiv, figs. 20, 21; pl. xxva, fig. 7.	Two fragments of jaws.	A. M. (No. 5003.) (Cotype No. 5004.)	Bridger. (Cottonwood Creek.)

Species Number and Reference Page in this Article.	*Original Reference.*	*Figure.*	*Type.*	*Present Location.*	*Horizon.*
(33) *Menotherium lemurinum* Cope, p. 169. = *Leptochærus lemurinus* (? Artiodactyla).	Bull. U. S. Geol. Surv., Series 1, Vol. 1, No. 1, Jan., 1874, p. 22. Proc. Acad. Sci. Phila., Feb. 17, 1874, p. 419. (Read Dec. 23, 1873.)		Low. jaws, pms. and ms.	A. M. (No. 5349.)	White River. (Colorado.)
(34) *Esthonyx* (*Hyopsodus*) *miticulus* Cope, p. 183. = *Hyopsodus miticulus.*	Rept. Vert. Foss. disc. in New Mexico, Extr. Appendix FF., Ann. Rept. Chief of Engineers, Survey West of 100 Merid., Wheeler, 1874, "Nov. 28, 1874," p. 8. Syst. Cat. Vert. Eoc., New Mex., Surv. West of 100 Merid., Wheeler, "Apr. 17, 1875," p. 18.	*Ibid.*, p. 150, pl. xlv, figs. 10–12.	Rami and teeth.	U. S.	Wasatch. (New Mex.)
(35) *Prototomus* (*Pelycodus*) *jarrovii* Cope, p. 193. = *Pelycodus jarrovii.*	Rept. Vert. Foss. disc. in New Mexico, Extr. Appendix FF., Ann. Rept. Chief of Engineers, Survey West of 100 Merid., Wheeler, 1874, "Nov. 28, 1874," p. 14. Syst. Cat. Vert. Eoc. New Mex., Surv. of 100 Merid., Wheeler, "Apr. 17, 1875," p. 14.	Final Rept. Surv. West of 100 Merid., Vol. IV, 1877, pl. xxxix, figs. 17, 18; pl. xlv, figs. 1–15.	Rt. ramus cont. pms. and ms., portions of skel.	U. S.	Wasatch. (New Mex.)
(36) *Lemuravus distans* Marsh, p. 187. = *Hyopsodus distans.*	Amer. Jour. Sci., IX, March, 1875, p. 239.		Teeth, jaw, parts skull and skel., brain cast.	Y.	Bridger.
(37) *Laopithecus robustus* Marsh, p. 169. = *Leptochærus robustus* (Artiodactyla).	Amer. Jour. Sc., IX, March, 1875, p. 240.	Amer. Jour. Sci., XLVI, 1893, pp. 407–412, pl. x, fig. 5.	Ramus cont. m_1–m_3.	Y.	White River.
(38) *Pelycodus* (*Tomitherium*) *frugivorus* Cope, p. 193.	Syst. Cat. Vert. Eoc. New Mex., Surv. West of 100 Merid., Wheeler, "Apr. 17, 1875," p. 14.	Final Rept. Surv. West of 100 Merid., Vol. IV, 1877, p. 144, pl. xxxix, fig. 16.	Ramus cont. m_2–m_3.	U. S.	Wasatch. (New Mex.)
(39) *Pelycodus angulatus* Cope, p. 202. *Indeterminate.*	*Ibid.*, p. 14.	*Ibid.*, p. 144, pl. xxxix, fig. 15.	Part rt. ramus cont. one m., an isolated m.	U. S.	Wasatch. (New Mex.)
(40) *Antiacodon* (*Sarcolemur*) *mentalis* Cope, p. 191. cf. *Pelycodus. mentalis.*	*Ibid.*, p. 17.	*Ibid.*, p. 149, pl. xlv, fig. 15.	Ramus cont. m_1, m_2.	U. S.	Wasatch. (New Mex.)
(41) *Antiacodon* (*Sarcolemur*) *crassus* Cope, p. 189. = *Sarcolemur crassus.*	*Ibid.*, p. 17.	*Ibid.*, p. 149, pl. xlv, fig. 16.	Part rt. ramus cont. m_1, m_2.	U. S.	Wasatch. (New Mex.)
(42) *Sarcolemur* (*Antiacodon*) *furcatus* Cope, p. 189.	Proc. Acad. Sci. Phila., May 11, 1875, p. 256.	Tert. Vert., 1884, pl. xxiv, figs. 18–19.	See species (31).	A. M. (No. 5008.)	Bridger. (Green River.)
(43) *Tomitherium* (*Pelycodus*) *tutus* Cope, p. 194. = *Pelycodus tutus.*	Final Rept. Surv. West of 100 Merid., 1877, IV, p. 141.	Final Rept. Surv. West of 100 Merid., 1877, pl. xxxix, fig. 19; xl, figs. 16–25.	Part lower jaw with two pms. and one m.; fragments skel.	U. S.	Wasatch. (New Mex.)

Species Number and Reference Page in this Article.	*Original Reference.*	*Figure.*	*Type.*	*Present Location.*	*Horizon.*
(44) *Microsyops speirianus* Cope, p. 210. = ? *Anaptomorphus speirianus.*	Amer. Nat., XIV, Dec., 1880, p. 908. Tert. Vert., 1884, p. 216.	Tert. Vert., pl. xxva, fig. 8.	Part rt. ramus with m_1–m_3.	A. M. (No. 4190.)	Wind River.
(45) *Pelycodus nunienus* Cope, p. 195.	Bull. U. S. Geol. Surv. Terr., Hayden, Vol. VI, Feb. 11, 1881, p. 187.		Right ramus, p_3–m_3.	A. M. (No. 4734.)	Wind River.
(46) *Mucrosyops scottianus* Cope, p. 209.	Bull. U. S. Geol. Surv. Terr., Hayden, Vol. VI, Feb. 11, 1881, p. 188. Tert. Vert., 1884, p. 217.	*Ibid.*, pl. xxiva, fig. 26.	Left ramus, p_4 and broken m_2.	A. M. (No. 4748.)	Wind River.
(47) *Anaptomorphus homunculus* Cope, p. 200.	Amer. Nat., Jan., 1882, p. 73. Proc. Amer. Philos. Soc., Vol. XX, 1881 (March 11, 1882), p. 152.	*Ibid.*, 1884, p. 249, pl. xxive, fig. 1.	Cranium (nearly entire).	A. M. (No. 4194.)	Wasatch. (Big Horn.)
(48) *Hyopsodus lemoinianus* Cope, p. 183.	Proc. Amer. Philos. Soc., Vol. XX, 1881 (Mar. 11, 1882), p. 148. Pal. Bull. No. 34, p. 148, "Publ. Febr. 20, 1882."	*Ibid.*, p. 236, pl. xxive, figs. 8, 9.	9 rami of low. jaws (fragmentary) of which Cope selected as type No. 4139.	A. M. (No. 4139.)	Wasatch. (Big Horn.)
(49) *Cynodontomys latidens* Cope, p. 208. = ? *Microsyops latidens.*	Proc. Amer. Philos. Soc., Vol. XX, 1881 (Mar. 11, 1882), p. 151. Sep. Pal. Bull., No. 34, "Feb. 20, 1882," p. 151.	*Ibid.*, 1884, p. 244, pl. xxive, fig. 22.	Rami, m_1, m_2r, p_4l.	A. M. (No. 4195.)	Wasatch. (Big Horn.)
(50) *Diacodexis* (*Phenacodus*) *laticuneus* Cope, p. 184. (? Artiodactyla, cf. *H. powellianus*).	Proc. Amer. Philos. Soc., Vol. XX, 1881 (Mar. 11, 1882), p. 181. Sep. Pal. Bull, No. 34, Feb. 20, 1882, p. 181. Amer. Nat., Dec., 1882, p. 1029.	*Ibid.*, 1884, p. 492, pl. xxve, figs. 17–18.	Three superior molars and last inferior molar in a fragment of lower jaw.	A. M. (No. 4202.)	
(51) *Mixodectes pungens* Cope, p. 206.	Proc. Amer. Philos. Soc., 1882–3, p. 559.	Tert. Vert., p. 241, pl. xxivf, fig. 1.	Right ramus.	A. M. (No. 3081.)	Torrejon.
(52) *Mixodectes erassiusculus* Cope, p. 207.	*Ibid.*, p. 559.	*Ibid.*, pl. xxivf, fig. 2.		A. M. (No. 3087.)	Torrejon.
(53) *Hyopsodus powellianus* Cope, p. 184. = ? *D. laticuneus.*	Tert. Vert., 1884, p. 235.	*Ibid.*, pl. xxiiid, figs. 3, 4.	11 rami, of which Cope selected as type at time of cataloguing in 1896 one with m_1–m_3, r.	A. M. (No. 4147.)	Wasatch. (Big Horn.)
(54) *Microsyops uintensis* Osborn, p. 202.	Bull. Amer. Mus. Nat. Hist., VII, 1895, p. 77.	Bull. Amer. Mus., etc., VII, fig. 1, p. 77.	Part left ramus.	A. M. (No. 1899.)	Uinta.
(55) *Hyopsodus wortmani* Osborn, p. 185.	*This Bull.*, p. 185.	*This Bull.*, fig. 11.	Mx. and pmx., i^2, c–m^3.	A. M. (No. 4716.)	Wind River
(56) *Hyopsodus marshi* Osborn, p. 187.	*Ibid.*, p. 187.	*Ibid.*, fig. 13.	Maxillæ containing p^2, m^3.	A. M. (No. 1706a.)	Bridger.
(57) *Hyopsodus uintensis* Osborn, p. 187.	*Ibid.*, p. 187.	*Ibid.*, fig. 14.	R. max., p^4–m^3.	A. M. (No. 2079.)	Uinta.
(58) *Notharctus venticolus*, p. 195.	*Ibid.*, p. 195.	Tert. Vert., pl. xxva, figs. 1, 2.	Upper and lower molars.	A. M. (No. 4715b.)	Wind River.
(59) *Olbodotes copei* Osborn, p. 205.	*Ibid.*, p. 205.	*Ibid.*, fig. —.	Fragm. ramus, c_1–m_3.	A. M. (No. 2385.)	

II. LOWER, MIDDLE, AND UPPER EOCENE PRIMATES.

(SPARNACIEN, YPRÉSIEN, LUTÉTIEN, BARTONIEN, LIGURIEN.)

Originating in the lower Eocene or Wasatch (Sparnacien, Yprésien) of North America are found three phyla of Primates, quite distinct from those in Europe.

1. The HYOPSODONTIDÆ are analogous in certain respects of molar tooth structure to the Microchœridæ of Europe, but are distinct in the simple cutting teeth.

2. The NOTHARCTIDÆ resemble in size and general form the contemporaneous Adapidæ of Europe, but the much more complex structure of the upper molars constitutes good grounds for not placing them in the same family.

3. The very specialized ANAPTOMORPHIDÆ so far as known (skull, teeth and jaws only) remotely resemble the living

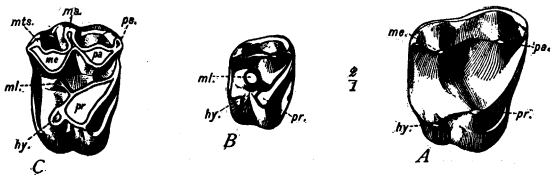

Fig. 3. Superior molars. *A*, *Adapis magnus*; *B*, *Hyopsodus uintensis*, type; *C*, *Notharctus* sp.

Tarsiidæ of the Oriental region, but it seems to be a premature conclusion to place them in the same family because they are so widely separated geologically and geographically.

The European Eocene Primates, also placed in three families, Adapidæ, Microchœridæ, and Plesiadapidæ, are now generally (Trouessart, '97) referred to the Lemuroidea. The force of Schlosser's remark ('87, p. 19) uniting them in the distinct suborder Pseudolemuroidea ("This suborder includes only extinct forms, which certainly mark a transition between the true Monkeys and Lemurs, but stand in direct genetic relations neither with one nor the other") has been vigorously disputed by Leche ('96), who, on the ground of resemblances in milk succession, places certain of these families (Microchœridæ) in the Lemuroidea.

It may be possible with the material now in hand to

positively determine the relationships of some of these forms to the existing Anthropoidea or Lemuroidea; but it will require detailed investigation, which I am not able to undertake at present.[1]

Three suppositions are possible: First, that these Primates represent an ancient and generalized group (Mesodonta, Cope) ancestral to both Lemuroidea and Anthropoidea; second, that they include representatives of both Lemuroidea and Anthropoidea, contemporaneous and intermingled; third, that they belong exclusively to one or the other order. There are certain advantages in the revival of the term Mesodonta Cope, a suborder (anticipating the terms Pseudolemuroidea and Tarsii) which would bear somewhat the same relationship to the modern specialized Monkeys and Lemurs that the Condylarthra bear to the Ungulata and the Creodonta to the Carnivora. The serious difficulty with this view is the very considerable separation of these families.

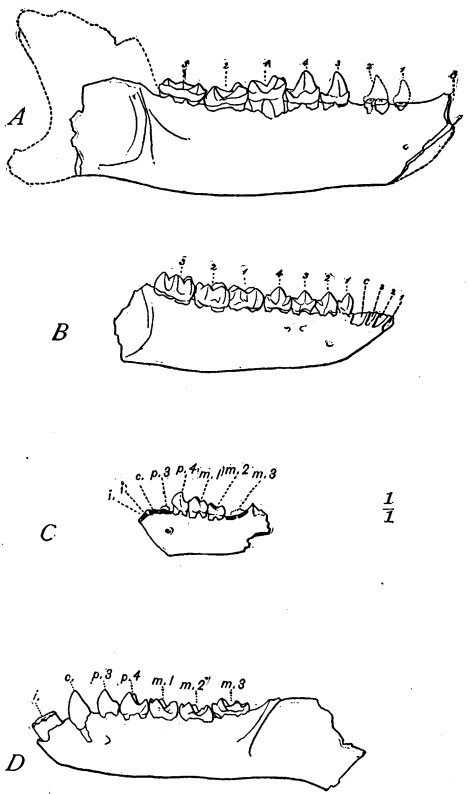

Fig. 4. Jaw outlines. All natural size. *A*, *Pelycodus tutus*; *B*, *Hyopsodus paulus*; *C*, *Anaptomorphus æmulus*; *D*, *Microsyops*.

[1] Dr. J. L. Wortman is now taking up these problems with the rich materials afforded by the Yale Museum Collections. I therefore omit phylogenetic questions here.

The extensive material in the American Museum is at the disposal of any thoroughly competent investigator who desires to exhaustively study this group. The present revision, while not final, will certainly be of service.

GEOLOGICAL DISTRIBUTION.

Partial List of Species.	Puerco.	Torrejon.	Wasatch.	Wind River.	Bridger.	Uinta.
HYOPSODONTIDÆ.						
Hyopsodus miticulus	....	....	×			
" *lemoinianus*	....	....	×			
" *powellianus*	....	....	×			
" *wortmani*	....	....	....	×		
" *paulus*	....	....	....	....	×	
" *minusculus*	....	....	....	....	×	
" *distans*	....	....	....	....	×	
" *uintensis*	....	....	....	....	....	×
Sarcolemur pygmæus	....	....	....	....	×	
" *furcatus*	....	....	....	....	×	
NOTHARCTIDÆ.						
Pelycodus jarrovii	....	....	×			
" *frugivorus*	....	....	×			
" *tutus*	....	....	×			
Notharctus nunienus	....	....	....	×		
" *tenebrosus*	....	....	....	....	×	
" *tyrannus*	....	....	....	....	×	
" *anceps*	....	....	....	....	×	
" *affinis*	....	....	....	....	×	
" *crassus*	....	....	....	....	×	
ANAPTOMORPHIDÆ.						
Anaptomorphus homunculus	....	....	×			
" *æmulus*	....	....	....	....	×	
" *? uintensis*	....	....	....	....	....	×

ORDER MESODONTA COPE.

Pachylemuriens Filhol, in part; *Pseudolemuroidea* Schlosser, in part; *Tarsii* Gill, in part.

Characters: Primitive Primates. Incisors typical or reduced to $\frac{2}{2}$; canines typical or enlarged, premolars $\frac{4}{4}$ to $\frac{2}{2}$; molars $\frac{3}{3}$; upper molars ranging from trituberculy to sexituberculy; lower molars ranging from quinquetuberculy (tuberculo-sectorial) to quadrituberculy. Lachrymal

foramen external or internal to orbit. Orbits opening into temporal fossæ, with or without postorbital bar. Humerus with entepicondylar foramen.

The American forms divide into three contemporaneous phyla as follows:

1. *Hyopsodontidæ* Schlosser.

i. $\frac{3}{3}$, c. $\frac{1}{1}$, p. $\frac{4}{4}$, m. $\frac{3}{3}$=44.

Mesaticephalic. Lachrymal canal marginal or internal to orbit. Dental series not crowded. Premolars slowly reduced. Superior molars becoming sexitubercular, quadrate. Talonid elevated, with pointed cusps. No postorbital bar.

2. *Notharctidæ* Osborn.

i.? $\frac{3-2}{3-2}$, c. $\frac{1}{1}$, p. $\frac{4}{4}$, m. $\frac{3}{3}$= 40;

Dolichocephalic. Premolars persistent. Superior molars triangular to quadrate, tritubercular, progressively sexitubercular. Inferior molars with depressed, crenulate talonid.

3. *Anaptomorphidæ* Cope.

i. $\frac{2}{3}$, c. $\frac{1}{1}$, p. $\frac{2}{3-2}$, m. $\frac{3}{3}$= 36—32.

Brachycephalic. Lachrymal canal external to orbit. Dental series reduced and compressed. Premolars rapidly reduced. Superior molars tritubercular, transversely extended. Short deep jaw. A postorbital process.

Family **HYOPSODONTIDÆ** Schlosser.

Lemuravidæ [1] Marsh.

Definition.—Dentition with slight or no reduction, incisors and canines normal; canines slightly enlarged in males; superior molars progressive from tri- to sexituberculy, with progressive external cingulum, but without mesostyle; inferior molars evolved from quinque- to quadrituberculy by reduction of paraconid; inferior molars with hypoconulid; external cusps progressively opposite; pointed cusps both on talonid and trigonid. Lachrymal foramen marginal or within orbit. Skull without postorbital bar.

Analogous to the Microchœridæ and *Necrolemur* in sexitubercular superior molars; differing in typical incisor and canine teeth. Analogous to the Adapidæ in typical incisors and canines; differing in sexitubercular evolution of molars.

Chronological List.

Species of Hyopsodus.

(2) *Hyopsodus paulus* Leidy.....Bridger.
(3) " (*Microsus*) *cuspidatus* Leidy..... "
(16) ? " (*Stenacodon*) *rarus* Marsh..... "

[1] The genus *Lemuravus* is a synonym of *Hyopsodus*.

(29)		*Hyopsodus minusculus* Leidy		Bridger.
(32)		"	(*Microsyops*) *vicarius* Cope	"
(34)		"	(*Esthonyx*) *miticulus* Cope	Wasatch.
(36)		"	(*Lemuravus*) *distans* Marsh	Bridger.
(48)		"	*lemoinianus* Cope	Wasatch.
(50)	?	"	(*Phenacodus, Diacodexis*) *laticuneus* Cope	"
(53)		"	*powellianus* Cope	"
(55)		"	*wortmani* Osborn	Wind River.
(56)		"	*marshi* Osborn	Bridger.
(57)		"	*uintensis* Osborn	Uinta.

Species of Sarcolemur.

(11)		*Sarcolemur* (*Hyopsodus*) *pygmæus* Cope		Bridger.
(31)		"	(*Antiacodon*) *furcatus* Cope	"
(41)		"	(*Antiacodon*) *crassus* Cope	"
(5)	?	"	(*Hyopsodus*) *gracilis*, Marsh	"
(24)	?	"	(*Entomodon*) *comptus* Marsh	"

This family embraces a great variety of middle-sized Primates extending from the Wasatch (Suessonien) to the Uinta (Ligurien) divided into two readily distinguishable genera, *Hyopsodus* Leidy and *Sarcolemur* Cope.

Hyopsodus.	*Sarcolemur.*
Paraconid typically wanting.	Paraconid persistent, close to metaconid.

A single specimen (Am. Mus. No. 4192) of *Hyopsodus* exhibits a vestigial paraconid and bridges the gap between these genera.

Genus HYOPSODUS Leidy.

Microsus Leidy, *Lemuravus* Marsh, ? *Stenacodon* Marsh. Compare also *Diacodexis laticuneus* Cope.

Hyopsodus is one of the most abundant and persistent of the Mesodonta, extending from the Wasatch to the Bridger and even into the Uinta. It was first described by Leidy in 1870 from a lower jaw found near Fort Bridger; the types of *Microsus* Leidy and *Lemuravus* Marsh, also from the Bridger, appear to be generically identical with it. *Lemuravus* was mistakenly separated by the formula i $\frac{3}{3}$, a character which is common to all the known species of *Hyopsodus*. This is the only Primate with the complete eutherian dentition known, namely : $\frac{3}{3}$, $\frac{1}{1}$, $\frac{4}{4}$, $\frac{3}{3}$ = 44. The

narrow form and pointed cusps of the lower molars, both upon talonid and trigonid, readily distinguish the members of this family from the Notharctidæ. All the known species include animals of small size.

Hyopsodus does not show a progressive increase in size; for example, the largest Wasatch species, *H. powellianus*, (Fig. 9) is larger than the largest known Bridger species.

Premolar and molar transformation.—Bridger species of Ungulates, and in fact of all bunodont mammals, are generally more complex in dentition than Wind River species, and invariably far more complex than Wasatch species, so we cannot agree with Cope in identifying Wasatch specimens of *Hyopsodus* with typical Bridger species such as *H. paulus*. The species therefore require thorough rearrangement according to geological succession and the law of progressive complication of the molar and premolar teeth.

The grinding teeth gradually become more complex, homoplastic with those of Ungulates. The upper molars progress from a triangular, tritubercular condition with a rudimentary hypocone to a quadrate, sexitubercular condition with a prominent hypocone (Bridger and Uinta); the external cingulum increases in strength until it entirely extends across the outer surface of the crown (*H. marshi*); it does not develop a mesostyle. The upper premolars progress by the addition of internal cusps; the fourth upper premolar has an internal cusp (deuterocone) in the Wasatch specimens; the fourth, third, and second have internal cusps in the upper Bridger specimens. The third and fourth lower premolars are similarly transformed, but less rapidly.

If we should follow the same principle as that which obtains among the horses, the species of *Hyopsodus* in successive geological stages might well be separated as genera but it would not subserve clearness to do this.

1. Wasatch (Sparnacien, Yprésien) Stage.

Common characters of the Wasatch species.—Superior molars sub-triangular with hypocone depressed and rudimentary or

feebly developed; fourth superior premolar only with a well developed internal cusp or deuterocone, third superior premolar with a small deuterocone, no trace of paraconid on

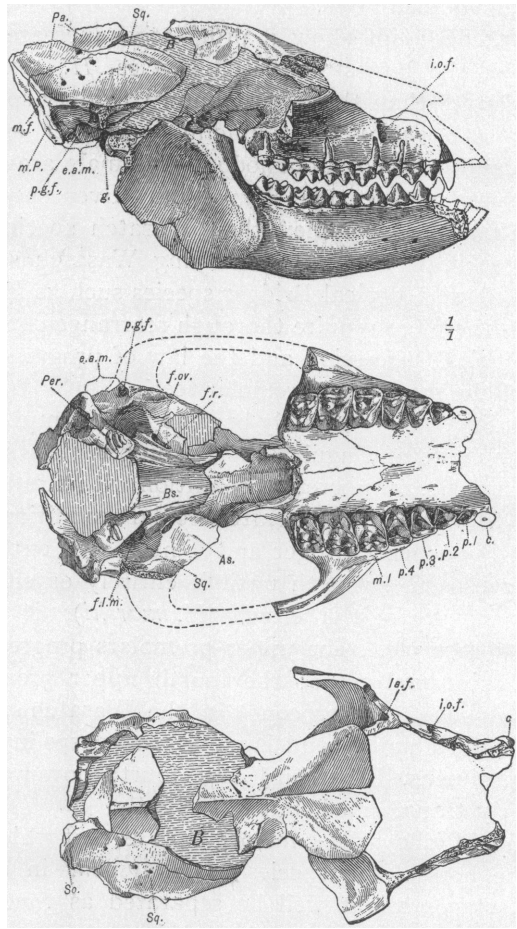

Fig. 5. *Hyopsodus paulus.* Am. Mus. No. 2301. Lateral, palatal, and superior views of skull. See page 186. Natural size.

lower molars except as an occasional vestige on m_1; this is a remarkably early specialization of these Primates towards a quadritubercular type and readily distinguishes them from the contemporary Notharctidæ, and Anaptomorphidæ. The

hypoconulid indicated on all the lower molars, is strongly developed as a posterior spur on m^3.

(Sp. 34) **Hyopsodus (Esthonyx) ? miticulus** *Cope.* Measurements in the type are: three inferior molars = 12 mm.; this species may include the small Wasatch specimens which Cope has referred to *H. vicarius* and *H. paulus* (both Bridger species) in which the molars vary from 10 mm. to 12 mm. The identification of these very small jaws and teeth with *H. miticulus* is provisional. The best preserved specimen (Am. Mus. No. 4128) shows an exceptionally reduced third superior molar (Fig. 6).

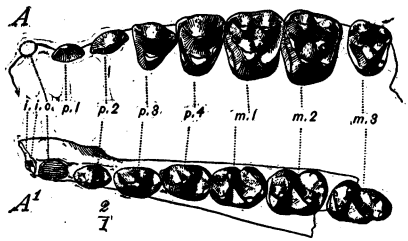

Fig. 6. *Hyopsodus ? miticulus.* Am. Mus. Cope, No. 4128. Twice natural size.

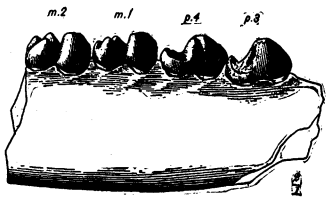

Fig. 7. *Hyopsodus lemoinianus.* Type: Am. Mus. Cope, No. 4139. Left ramus, internal view. Twice natural size.

(Sp. 48) **Hyopsodus lemoinianus** *Cope.* — Measurements of three inferior molars estimated at 15 mm. This species includes the middle-sized individuals collected in the Wasatch of Wyoming, namely, No. 4139, which is the first figured specimen or

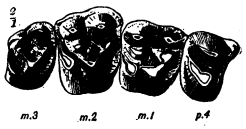

Fig. 8. *Hyopsodus lemoinianus.* Am. Mus. No. 4100. Twice natural size.

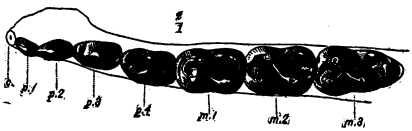

Fig. 7*a*. *Hyopsodus lemoinianus.* Am. Mus. No. 1. Twice natural size.

type, and Nos. 4140, 4138, as well as many of the specimens referred by Cope to *H. paulus* and *H. vicarius*. No satisfactory specific distinction can be given at present. This may include specimens ranging as follows: m_1–m_3 = 13 to 15 mm.

(Sp. 53) **Hyopsodus powellianus** *Cope.* — Measurements of three inferior molars in the type: 18 mm. This includes the robust jaws and teeth, namely, Am. Mus. Coll., the type No. 4147, and Nos. 4148, 4150, 4151, 4152. These are as large as, or larger than, the largest species known from the Bridger; the $m_1 - m_3 = 16$ to 18 mm.

(Sp. 50) **? Hyopsodus (Diacodexis) laticuneus** resembles

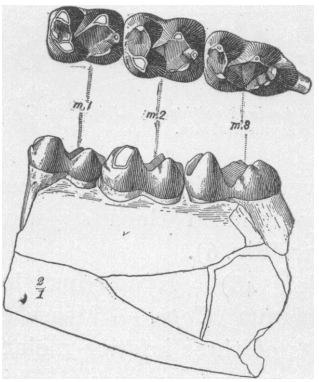

Fig. 9. *Hyopsodus powellianus.* Am. Mus. No. 4147. Slightly less than twice natural size.

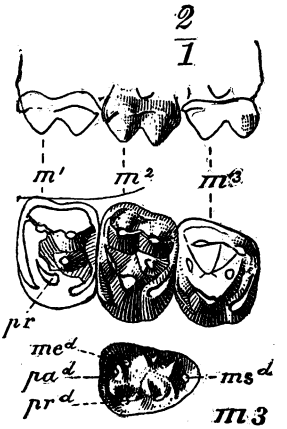

Fig. 10. *Diacodexis laticuneus.* Type. Am. Mus. No. 4202. Twice natural size.

this species in size but differs in the presence of a paraconid. This type is, however, of uncertain reference.

Dr. Matthew has observed that these species may be arranged in three groups, including larger and smaller jaws in each group, which may represent successive stages of development in a long geological age; these differences of size may however represent males and females respectively.

2. Wind River (Lutétien) Stage.

Common characters of the Wind River species.—Hyopsodus is represented by a large number of specimens from the Wind River beds which Cope mistakenly referred to the Bridger species *H. paulus* and *H. vicarius*. The superior molar teeth

are somewhat more primitive than those found in the Bridger in the more triangular shape and less prominent development of the hypocone. The hypocone is stronger than in the Wasatch specimens and both third and fourth premolars exhibit deuterocones. It is therefore probable that there are valid specific differences between these animals and the overlying Bridger species.

(Sp. 55) **Hyopsodus wortmani,** sp. nov.

Type No. 4716, Am. Mus. (figured by Cope as *H. vicarius*), Fig 11. is valuable because it shows a complete maxilla and premaxilla, the latter with three incisors of which the median pair is possibly slightly enlarged; the crown of the second incisor preserved is pointed. Third superior premolar narrow with a deuterocone. Superior ms = 10 mm. Inferior pms–ms = 21 mm.

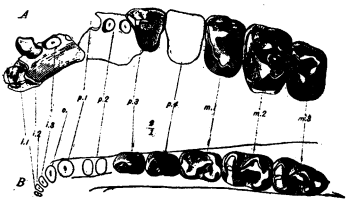

Fig. 11. *Hyopsodus wortmani.* Type. Am. Mus. Cope, No. 4716. Superior and inferior teeth. Twice natural size.

The best specimens in the American Museum collection are Nos. 4716, 4712. Inferior true molars measure 11 to 13 mm.

A slightly larger and somewhat different variety is represented by Nos. 4701, 4715, 4732.

3. Bridger (Bartonien) Stage.

As shown in the chronological list above, six species have been named from this formation and the synonomy can only be cleared up by exact comparison of the types. Deuterocones begin to appear on the second as well as the third and fourth upper premolars; hypocones are still more prominent. The Bridger specimens show a more or less decided external cingulum in the upper molars.

(Sp. 2) **Hyopsodus paulus.**— This includes the species of middle size, inferior molars = 14 mm. With this should be compared the type of (3) *H.* (*Microsus*) *cuspidatus* Leidy, also of (16) *Stenacodon rarus* Marsh; also of (32) *H.* (*Microsyops*) *vicarius* Cope.

Skull of Hyopsodus.—The most beautiful specimen in the collection consists of a skull and jaws of *Hyopsodus* (Fig. 5), collected during the American Museum expedition of 1895 by Dr. J. L. Wortman. Unfortunately the anterior region of the orbit is fractured, but on the left side the lachrymal foramen is seen to be marginal or internal as in the Anthropoidea and not external as in many of the Lemuroidea; the infraorbital foramen is placed above the interval between the third and fourth premolars; the temporal fossa is surmounted by a thin sagittal crest, which is broken away in this specimen. The external auditory meatus is widely open inferiorly, and there is no trace of a tympanic tube (the absence of a tympanic tube distinguishes the South American from the European monkeys); the bulla is also broken away, exposing a portion of the semicircular canals. Behind the auditory meatus is apparently a narrow exposure of the mastoid, perforated by the mastoid foramen; the posterior nares open just behind the last molar.

Dentition. — The last molar is a small tooth with a small hypocone, the first and second molars have the hypocone better developed. Unlike *H. marshi*, the third and fourth premolars only have internal cusps (deuterocones), the second premolar has an internal basal cingulum, the first is a simple conical tooth; close in front of this is the canine, a much larger tooth. The grinding series do not converge anteriorly, being nearly parallel; this is an important point. There is a faint external cingulum.

The lower jaw. — The inferior molars measure 14 mm; they cannot be distinguished from those of *H. paulus;* the animal was thus a small one. The fourth lower premolar presents a deuteroconid, the third premolar presents a rudiment of the same, the second and first are absolutely simple. The jaw has a well marked masseteric fossa, the condyle is raised somewhat above the level of the molar series, the chin is not very distinctly defined, the mandibular symphysis is coössified.

(Sp. 29) **Hyopsodus minusculus** *Leidy.*— This appears to be

the smallest representative of the genus in this geological stage.

(Sp. 32) **Hyopsodus vicarius** *Cope.*—The type of this species (Amer. Mus. 5003) is a single worn molar tooth, very uncharacteristic. We have provisionally associated with it a finely preserved jaw, Am. Mus. Coll., No. 1730, Fig. 12.

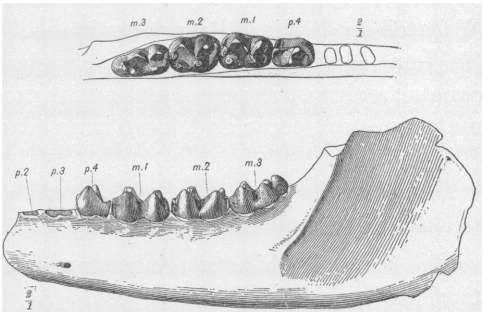

Fig. 12. *Hyopsodus? vicarius.* Am. Mus. No. 1730. Slightly less than twice natural size.

(Sp. 36) **Hyopsodus (Lemuravus) distans** *Marsh.*—A small animal; inferior true molars = 12.5 mm. In separating this genus Marsh mistakenly supposed that the true *Hyopsodus* had but two superior incisors. The coössification of the symphysis is possibly a valid specific distinction of *H. distans* from *H. paulus* in which the jaws are usually found with the symphyses imperfect; the symphysis is lacking in the *H. paulus* type but coössified in the skull described above, so that the present character of this species is entirely a matter of conjecture.

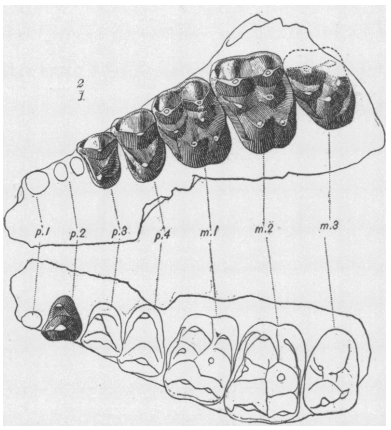

Fig. 13. *Hyopsodus marshi.* Am. Mus. No. 1706*a*. Slightly less than twice natural size. Dental series too convergent in figure.

(Sp. 56) **Hyopsodus marshi,** sp. nov.

Among the Bridger specimens in the American Museum is a pair of upper jaws (No. 1706 *a*) with a very perfectly

preserved molar series which may be taken as the type of a new species. It is probably from the upper Bridger (Fig. 13). The second, third, and fourth superior premolars show well developed internal cusps, thus differing widely from the Wasatch and Wind River specimens. The superior molars ($m^1 - m^3 = 13$ mm.) are quadrate with a well developed hypocone now almost as prominent as the protocone; the para- and metacones are conic and there is no trace of a mesostyle.

4. Uinta (Ligurien) Stage.

The genus in this stage is represented by three specimens: two parts of jaws, Nos. 2078, 2078a, also the molar series No. 2079, which unmistakably belongs to *Hyopsodus*, but indicates a new species.

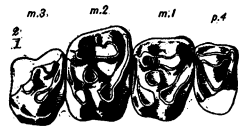

Fig. 14. *Hyopsodus uintensis.* Am. Mus. No. 2079. Twice natural size. Type.

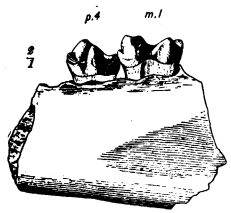

Fig. 15. *Hyopsodus uintensis.* Am. Mus. No. 2078*a*. Twice natural size.

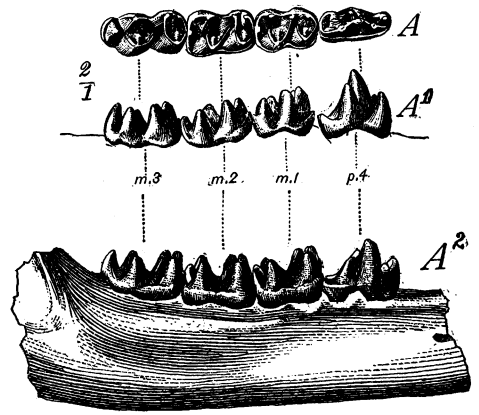

Fig. 16. *Sarcolemur furcatus.* Type. Am. Mus. Cope, No. 5008. *A*, superior, A^1, internal, A^2, external views of teeth and jaw. Twice natural size.

(Sp. 57) **Hyopsodus uintensis,** sp. nov.

Type No. 2079, Am. Mus. A right maxilla containing p^4–m^3. Superior molars with broad, well defined external cingulum, but no mesostyle; m^1–$m^3 = 12.5$ mm. Hypocone feeble or wanting on m^3. The level is Horizon C or the upper true Uinta beds of Utah.

Genus SARCOLEMUR Cope.

Entomodon Marsh, *Antiacodon* Cope.

1. Bridger (Bartonien) Stage.

The type of the genus is the jaw of the species *S.* (*Antiacodon*) *furcatus* Cope, belonging to an animal about the same size as *Hyopsodus paulus* but well distinguished by the presence of a prominent paraconid which is closely connate with the metaconid, also by the more crescentic form of the external cusps (protoconid and hypoconid), and by the more elongate form of the fourth premolar (Fig. 16). Three inferior molars = 15 mm.

S. pygmæus Cope.	*S. furcatus* Cope.
P_4 simple, lacking internal cusp.	P_4 complex, elongate, with prominent internal cusp.

(Sp. 11) **Sarcolemur pygmæus** *Cope.*—This species, from the Bridger basin of Wyoming, was originally referred by Cope to *Hyopsodus*. It bears a superficial resemblance to *Microsyops* but the simple structure of p_4 and the more elevated and connate para- and metaconids readily distinguish it; the hypoconulid on m_1 and m_2 is quite distinct as in *Hyopsodus*, enabling us to readily distinguish this type of molar from that of *Anaptomorphus*.

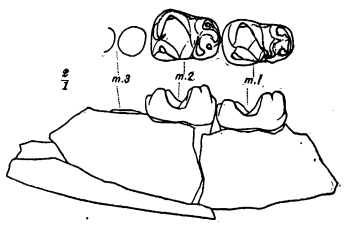

Fig. 17. *Sarcolemur pygmæus.* Co-type. Am. Mus. No. 5007. Left ramus, internal and superior views. Twice natural size.

(Sp. 31) **Sarcolemur furcatus** *Cope.*— Represented by the type lower jaw in the American Museum (No. 5008) containing the fourth premolar and three molars. With this should be compared the prior type of (Sp. 24) *Entomodon comptus* Marsh, a fourth lower premolar closely resembling that of *Sarcolemur;* if identical *Entomodon* has priority.

FAMILY **NOTHARCTIDÆ** OSBORN.

Limnotheridæ Marsh.

The type genus, *Limnotherium*, is apparently preoccupied by *Notharctus* Leidy; if not, *Limnotheridæ* takes precedence.

Definition.—Upper incisors early reduced to $\frac{2}{2}$. Premolars persistent, but with reduced fangs. Molars relatively low crowned and low cusped; lower molars especially like those of many true Monkeys in the broad depressed and early crenulate or tuberculate talonid. Paraconid gradually reduced. External cusps of upper molars more crescentic than in *Hyopsodus* or *Adapis*, consequently developing a meso-style; also showing external cingulum.

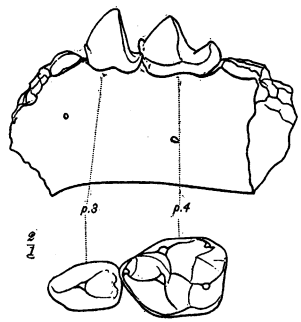

Fig. 18. *Sinopa* (*Prosinopa*) *eximia*. Type. Phila. Acad. Twice natural size.

Unlike the Hyopsodontidæ these animals show a progressive increase in size in ascending levels. This phylum certainly includes the numerous Wasatch and Wind River species referred to *Pelycodus* by Cope, the Bridger species referred to *Notharctus* and *Hipposyus* by Leidy; to *Hyopsodus* (in part), *Limnotherium*, *Thinolestes*, and *Telmatolestes* by Marsh; to *Prototomus* and *Tomitherium* by Cope. The species *Sinopa* (*Prosinopa*) *eximia* Leidy was based upon a jaw containing p_3, p_4, which should be compared with *Notharctus*.

To be compared with this family are the small animals, *Omomys carteri*, Leidy (?i. $\frac{2}{2}$, c. $\frac{1}{1}$, p. $\frac{3}{3}$); and *Hemiacodon gracilis* Marsh ($\frac{2}{2}$, $\frac{1}{1}$, $\frac{3}{3}$, $\frac{3}{3}$.), true molars = 11 mm., molars and premolars = 17.2 mm. Also *H. nanus* Marsh, *H. pucillus* Marsh; the two species last named, however, should also be compared with *Anaptomorphus*.

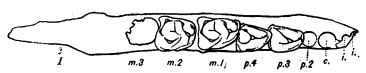

Fig. 19. *Omomys carteri*. Type. Superior view of right ramus, traced from a photograph. Twice natural size.

CHRONOLOGICAL LIST.

Species of Pelycodus.

(35)	*Pelycodus* (*Prototomus*) *jarrovii* Cope	Wasatch
(38)	" (*Tomitherium*) *frugivorus* Cope	"
(43)	" *tutus* Cope	"
(45)	" *nunienus* Cope	Wind River

Species of Notharctus and Allied Types.

(4)	*Notharctus tenebrosus* Leidy	Bridger
(6)	" (*Limnotherium*) *tyrannus* Marsh	"
(7)	" " *elegans* Marsh	"
(10)	" (*Hipposyus*) *formosus* Leidy	"
(12)	" " *robustior* Leidy	"
(13)	" (*Thinolestes*) *anceps* Marsh	"
(14)	" (*Telmatolestes*) *crassus* Marsh	"
(15)	" (*Limnotherium*) *affinis* Marsh	"
(27)	" (*Tomitherium*) *rostratus* Cope	"

PELYCODUS.

Jaw elongate. Mandibular symphysis uncoössified. Superior molars triangular with rudimentary hypocone; no mesostyle.

NOTHARCTUS.

Jaw stout. Symphysis typically coössified. Superior molars quadrate, with pronounced hypocone; a mesostyle.

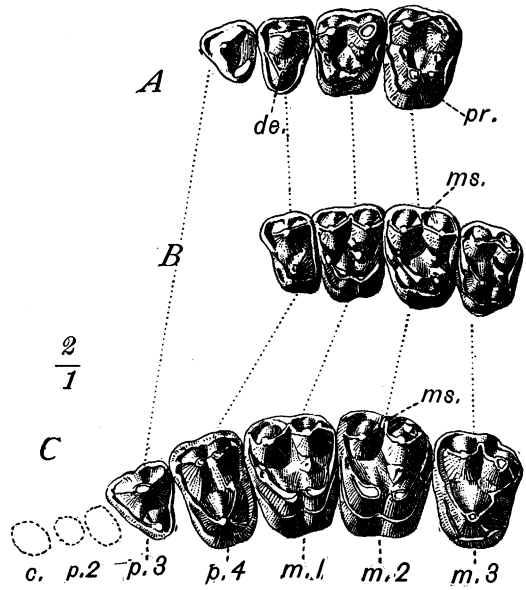

Fig. 20. Evolution of molars in Notharctidæ. *A*, *Pelycodus frugivorus*, Wasatch; *B*, *Notharctus nunienus*, Wasatch; *C*, *Notharctus* sp. indet. Bridger.

Genus PELYCODUS Cope.

Pelycodus is distinguished generically from the later members of the family by the more tritubercular upper molars, which exhibit the hypocone in all stages of development (Fig. 20) and the quinquetubercular lower molars which correspondingly show the paraconid in various stages of degeneration (Fig. 22). *P. frugivorus* is more tritubercular; *P. tutus* is more sexitubercular; a constant distinction from the contemporary *Hyopsodus* in the upper molars is the presence of an internal cingulum in *Pelycodus* which is wanting in *Hyopsodus*. In the Wind River specimens we also note the rise of the external intermediate column or mesostyle in a manner precisely analogous (homoplastic) to its development in the equine Perissodactyla. In other words the Lower Eocene *Pelycodus* is in a lower stage of evolution from the tritubercular (tuberculo-sectorial) type than its successors in the Middle Eocene (or Bridger) stage (Fig. 20).

Dentition.—In examining the rich Cope collection, now in the American Museum, the incisors are apparently $\frac{2}{2}$; the upper pairs are conical and not spaced; the canines are slightly enlarged and erect; the dental series is somewhat spaced, that is, the first and second premolars are not crowded (Fig. 21). The *lower molars* show traces of a hypoconulid; the first premolar is usually single fanged, and exceptionally bifanged; the crowns of pms 1–2 are simple. The third and fourth upper premolars show a single external cusp (protocone) and an internal cusp (deuterocone) while the fourth lower premolar is also slowly transforming into the molar pattern by the addition of a tritoconid. The *upper molars* may be clearly distinguished from those of the *Microsyops* line by the stronger development of the intermediate tubercles or conules (Fig. 20), which are exceptionally progressive, also by the more rounded or quadrate contour.

In the following descriptions dependence is placed largely upon the specific determinations made by Cope himself. The species undoubtedly require careful reëxamination.

Skeleton.—In the Wasatch species the jaw (*P. tutus*) is

stout but not very deep with a well rounded border and an uncoössified symphysis; the jaw increases in depth in the Wind River species (*P. nunienus*, Fig. 22). Many portions of the skeleton have been described by Cope, including metacarpals and digits, also a clawed terminal phalanx (as in the second digit of the lemuroid pes); unfortunately we must consider this association as somewhat doubtful. The femur (*P. tutus*) has a pit for the ligamentum teres and a long crest below the great trochanter. The radius has an oval head. The scapula has a prominent coracoid process. The head of the astragalus (*P. jarrovii*, Coll. U. S. Nat. Mus.) is convex and prolonged beyond the calcaneum. The caudals are long and slender.

1. Wasatch (Sparnacien, Yprésien) Stage.

Common Characters.—Superior molars more or less triangular, with rudimentary hypocone, without mesostyle.

(Sp. 35) **Pelycodus jarrovii** *Cope.*— This, the first species described, is represented by a rather imperfect type in the National Museum.

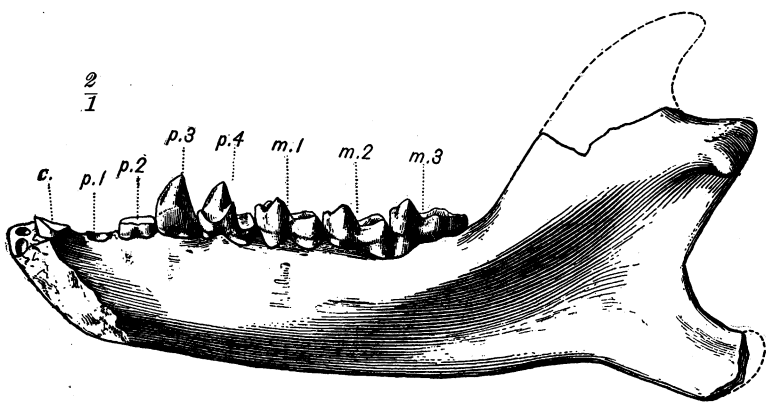

Fig. 21. *Pelycodus frugivorus.* Am. Mus. No. 65. Slightly less than 2 diam.

(Sp. 38) **Pelycodus frugivorus** *Cope.*— Includes the smaller and more primitive Wasatch specimens in which there is a variable rudiment of the hypocone in the upper molars (see

especially Nos. 55, 65, 4174, 4182, Amer. Mus.); the upper molars are strictly tritubercular, with little or no indication of a mesostyle. This is certainly a very primitive species and it probably comes from the lower levels of the Wasatch beds. Inf. ms = 15.5.

(Sp. 43) **Pelycodus tutus** *Cope.*— This, on the contrary, is the largest (inf. m. series=17.5 mm.), most progressive, and most abundant species. The superior molars are triangular in form but show a well developed hypocone forming a double internal lobe, but no mesostyle (see No. 4162, Am. Mus.). The paraconid, which is always the first primitive element to disappear among the Primates, shows every stage of position and development; it sometimes appears on $m_1 - m_3$, but is always distinct on m_1.

Fig. 22. *Pelycodus nunienus.* Type. Am. Mus. Cope, No. 4734.

Genus NOTHARCTUS Leidy.

2. Wind River (Lutétien) Stage.

As we might expect, in the Wind River specimens the first lower premolar is always single fanged, while in the superior molars the hypocone is decidedly more prominent so that in some cases they might be described as quadrate and sexicuspidate; a very conspicuous difference is the presence of the mesostyle (Fig. 20). The Wind River species are also generally distinguished by the more advanced transformation of the posterior premolars. As observed by Matthew, the Wind River species show closer affinities to those of the Bridger. In fact the Wind River specimens may well be referred to the Bridger genus *Notharctus* as characterized below. Cope was entirely mistaken in identifying the progressive Wind River species with the older Wasatch species (*P. jarrovii* and *P. tutus*).

(Sp. 45) **Notharctus nunienus** *Cope.*— Includes the smaller Wind River forms (m_1–m_3 = 15 mm.). We find a strong deuterocone (internal cusp) on pm_4.

(Sp. 58) **Notharctus venticolus,** Sp. nov.

A much larger monkey (No. 4715*b*, Am. Mus.) was referred by Cope to *P. tutus* but is clearly distinguished from this older Wasatch species by the presence of a mesostyle in the upper molars, and by the more progressive character of the grinding teeth throughout m — m_3 = 17. The type (No. 4715 *b*) was figured by Cope, 'Tertiary Vertebrata,' Pl. xxv, figs. 1, 2. Other specimens are No. 4726 (*op. cit.* fig. 3), Nos. 4728, 4738.

3. Bridger (Bartonien) Stage.

The gradual steps toward sexituberculy in the upper molars and quadrituberculy in the lower, begun in *Pelycodus*, lead directly into a number of Middle Eocene (Bridger) forms, mostly of larger size and on a higher plane of general development, baptized by Leidy, Cope, and Marsh with an unusual number and variety of names, as shown in the chronological table of species above. The identification of all these genera, however, needs confirmation by further comparison of types.

Unfortunately we have an incomplete record of the levels at which the types of these species and genera were found, but it is important to remember that the Bridger was a very long period, with time for the marked progression in dental structure observed in various specimens which may provisionally be referred to the single genus *Notharctus*. While there was considerable range of progression from the lower to the higher forms we cannot at present specify any single generic character which will enable us to clearly subdivide the Bridger species into different genera, because the progression although on a higher scale, is precisely analogous to that observed in the transition from *Pelycodus frugivorus* to *P. tutus*.

Notharctus has the same dental formula as *Pelycodus* but is readily distinguished by the coössified mandibular symphysis, the chisel-shaped incisors, the usually single fang of the first and sometimes of the second lower premolar, the comparatively well developed hypocone and the subquadrate shape of the upper molars; the usually marked reduction or absence of the paraconid in the lower molars.

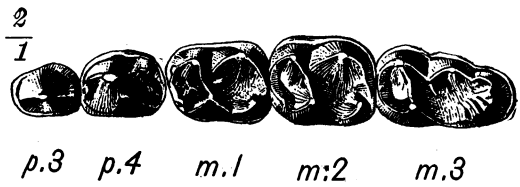

Fig. 23. *Notharctus* sp. indet. Princeton Mus. No. 10,020.

Thanks to the excellent type selected by Leidy, *N. tenebrosus*, to the beautiful specimen of *T. rostratum* (Am. Mus. No. 5009), and to the very complete series belonging to the Yale Museum, this genus is by far the best represented of all the American Primates, or in fact of any sub-Pliocene form excepting possibly *Adapis*. It is most interesting to observe the exact homoplasy between the variations in the cheek teeth with those seen in the early Ungulates.

(Sp. 4) **N. tenebrosus** *Leidy.*— The type (Phila. Acad.) is a relatively primitive species in which the second premolar is still bifanged, and there are traces of the paraconid on all the true molars; the third lower molar has a well developed heel or hypoconulid, the fourth premolar is sub-molariform. On the other hand its progressive specialization is marked by the low uniform wearing surface of the molars, the primitive trigonid being almost as depressed as the talonid; also by the large erect canine (probably indicating a male individual), by the well defined chin, by the unbroken dental series, and by the elevated condyle.

First Stage? Lower Bridger.

A stage beyond *N. tenebrosus* is the species or variety

(Sp. 13) **N. (Thinolestes) anceps** *Marsh*, in the type of which the second lower premolar is bifanged but the paraconid has disappeared upon the second and third molars, which are now truly quadritubercular. The mandibular dentition is otherwise closely similar to that of *N. tenebrosus;* the lower jaws are coössified, with the suture visible externally. In the upper molars of this important specimen we find the crown subtriangular, the primitive triangle with distinct intermediate tubercles, but the hypocone is prominent and well separated; there is also an external intermediate cusp or mesostyle; the first upper premolar is small or rudimentary. The third upper premolar has a broad internal cingulum, the fourth is submolariform.

Second Stage.

(Sp. 6) **N. (Limnotherium) tyrannus** *Marsh.*— (Type, Yale Mus.). The second specimen named in 1871 was also founded upon a lower jaw. Marsh described this as a "pachyderm" and distinguished the genus *Limnotherium* from *Notharctus* by the single fangs of the first and second lower premolars, by the quadritubercular lower molars "with a rudimentary double tubercle on the anterior margin" (paraconid). This type was probably found upon a somewhat higher level than *N. tenebrosus*. It marks perhaps the next higher stage of evolution in which the first and second premolars have single fangs; the paraconid is a vestigial tubercle seen on all three lower molars; the third upper molar is tritubercular. Close to this stage is the type of

(Sp. 27) **N. (Tomitherium) rostratum** *Cope*, with small, spaced, first and second lower premolars; in the latter the fang is still grooved.

Related to these are the more slender jaws forming the type of

(Sp. 15) **Limnotherium affine** *Marsh.* In this beautiful specimen, belonging to a young individual, we note a slight progression in the cheek teeth, the fourth upper premolar differs from the first molar only in the absence of the

hypocone, and sexituberculy is slightly more marked in the true molars than in *N. anceps;* the first and second lower premolars are single fanged, and, correlated with the development of the hypocone above, the paraconid has degenerated and disappeared upon the first and second molars below.

(Sp. 7) **N. (Limnotherium) elegans,** according to Marsh, is a much smaller but related species.

(Sp. 5) **N. (Hyopsodus) gracilis** *Marsh* exhibits a paraconid on the lower molars and thus either antedates *Notharctus (Limnotherium) elegans* or is possibly referable to *Sarcolemur.*

Third Stage.

It is evident from the study of the foregoing series that this line would inevitably terminate in sexituberculy above and quadrituberculy below. This condition is fulfilled in the type of

(Sp. 14) **N. (Telmatolestes) crassus** *Marsh*, a large species in which the first and second upper molars are nearly quadrate in form and bear six tubercles, the hypocone being almost as large as the protocone on m^1 and m^2; the hypocone however is wanting on m^3. The lower molars still retain a faintly developed paraconid. Near this stage is

(Sp. 10) **Hipposyus formosus** *Leidy*, founded upon a single upper molar (Leidy, '73, plate vi, fig. 41).

General Characteristics of the Teeth.— *Notharctus* was very abundant in the Bridger period and as seen in the above analysis presented progressive variations which are certainly due to the passage from lower to higher geological levels. The two pairs of incisors are compactly placed, with chisel-edges as contrasted with the rounded incisors of *Pelycodus;* the opposite pairs are spaced, that is there is a slight interval between them. The unworn *lower molars* are elongate (Fig. 23); they exhibit a transverse anterior crest (metalophid) between the protoconid and metaconid, in front of which is an oval valley bounded internally by the paraconid in all stages of degeneration; behind this ridge is the

posterior basin or talonid in which the enamel is waving or crenulate; the hypoconulid has disappeared excepting on the broad heel of m_3; the lower molars are thus very similar to those of monkeys and it is a complete surprise to find the *upper molars* with greatest diameter transverse and almost indistinguishable in pattern from those of the contemporary horses such as *Orohippus*. The protocone forms a low transverse crest with the protoconules (this is a rudimentary protoloph mechanically correlated with the metalophid below), while the hypocone and metaconule are isolated; the external cusps (paracone and metacone) are compressed with apical ridges running into an external intermediate mesostyle; the anterior cingule, or parastyle, is also developed. The fourth upper premolar is submolariform, with three large cusps (protocone, tritocone, deuterocone); it also exhibits traces of the conules (Fig. 20). The fourth lower premolar has an elevated protoconid connected by a low crest with a tritoconid and a deuteroconid.

This genus is finely represented in the American Museum by the skeleton and teeth, No. 1727; the upper molars are in a very progressive (*Telmatolestes*, *Hipposyus*) stage.

Family **ANAPTOMORPHIDÆ** Cope.

Definition.—Skull brachycephalic. Post-orbital process. Facial portion of lachrymal greater than orbital; fossa lacrymalis in front of crista. Premolars reduced, $\frac{2}{3-2}$. Grinding teeth arched, molars compressed antero-posteriorly, extended transversely, tritubercular, rudimentary hypocone. Short, deep, lower jaw. Lower molars with elevated trigonid region, reduced paraconid, no hypoconulid.

This family is represented by the type jaw of *A. æmulus* from the Bridger, the famous skull of *A. homunculus* from the Wasatch, together with portions of four isolated jaws; also possibly by a larger Upper Eocene species *Microsyops uintensis*.

Prior to Cope's description of the Bridger jaw are a number of specimens named by Marsh, as shown in the following chronological list, which possibly are related to this family or to the genus *Omomys*.

CHRONOLOGICAL LIST OF SPECIES.

Sp. (21) ? *Hemiacodon gracilis* Marsh.....Bridger.
(22) ? " *nanus* " ..... "
(23) ? " *pucillus* " ..... "
(26) ? " (*Palæacodon*) *vagus* Marsh..... "
(28) ? *Anaptomorphus æmulus* Cope..... "
(39) ? *Pelycodus angulatus* Cope.....Wasatch (Indeterminate).
(47) *Anaptomorphus homunculus* Cope.....Wasatch.
(54) " (*Microsyops*) *uintensis* Osborn.....Uinta.

Fig. 23*a*. *Washakius insignis*. Type. Phila. Acad. External, superior, and internal views.

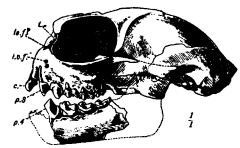

Fig. 24. *Anaptomorphus homunculus*. Type. Am. Mus. Cope. Skull, No. 4104; partly reconstructed from the two sides. Jaw from another specimen, Am. Mus. No. 43. Natural size.

Other animals to be considered in this connection are Leidy's *Washakius insignis*, Fig. 23*a*, '*Microsyops*' *speirianus* Cope, Fig. 37, and *Palæacodon vagus* Marsh.

It appears that Osborn was mistaken (Osborn and Wortman 1892, p. 102) in referring to this family the genus and species *Omomys carteri* Leidy.

GENUS ANAPTOMORPHUS COPE.

Paraconid reduced, hypoconulid absent except on m_3, canines of medium size.

1. WASATCH (SPARNACIEN, YPRÉSIEN) STAGE.

(Sp. 47) **Anaptomorphus homunculus** *Cope.—Type skull*, Amer. Mus. Cope Coll. No. 4194.

Definition.—i.$\frac{1}{1}$, c.$\frac{1}{1}$, p.$\frac{2}{3}$, m.$\frac{3}{3}$. M_1–m_3 with reduced paraconid, p_4 with very slight rudiment of deuterocone.

The species is represented by the famous type skull, also by specimens Nos. 41, 44. Paraconid on m_1 somewhat larger than in the Bridger *A. æmulus;* the deuteroconid is barely visible on p_4; there is a very small alveolus for the root of the second lower premolar.

The skull has been refigured with care (Fig. 24) to exhibit

its principal characters. In reference to Forsyth-Major's (1901) very precise examination of the lachrymal in the Lemuroidea and Anthropoidea it is important to note that this bone in *Anaptomorphus* resembles that in the Lemurs, especially such a form as *Opolemur* (*op. cit.*, p. 139, text fig. 37), much more closely than it does the lachrymal of *Adapis* or of any of the Anthropoidea, in the following respects: (1) the *pars facialis* is broader than the *pars orbitalis;* (2) the lachrymal fossa is extra-orbital, being bounded posteriorly by the *crista posterior lacrymalis* which forms the anterior rim of the orbit. In the words of Forsyth-Major: "In Lemurs, *as a rule* the *crista lacrymalis posterior* rides on the lower orbital margin, of which therefore it forms a portion . . . the anterior part of the lachrymal thus becoming the *pars facialis*, the posterior part the *pars orbitalis* . . . As a result, we have the lachrymal fossa outside the orbit. . . ." (*op. cit.* p. 134). *Anaptomorphus* resembles *Chrysothrix* in the reduplication of the infra-orbital foramen.

This sustains Cope's statement (1884, p. 250) and definitely proves that in the structure of its lachrymal *Anaptomorphus* is lemuroid; it does not, however, prove positively that it is a Lemur.

The transversely extended form of the upper molars and premolars is correlated with the brachycephaly of the skull; the molar pattern being best indicated in Fig. 25. Observe especially the depression and transversely oval form of the superior teeth, the relatively broad short crowns of the inferior teeth, the trigonid and talonid being of approximately the same width.

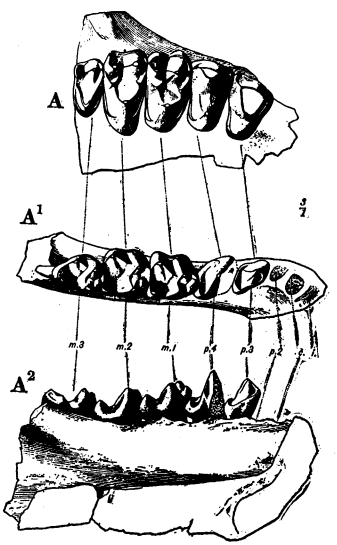

Fig. 25. *Anaptomorphus homunculus.* Am. Mus. No. 41. This specimen has unfortunately been misplaced.

The species *Pelycodus angulatus* Cope was based upon a type (Nat. Mus.), now unfortunately lost, containing a single lower molar which resembles that of *Anaptomorphus*, also that of *Cynodontomys*. In the absence of the type this species is indeterminate.

2. Bridger (Bartonien) Stage.

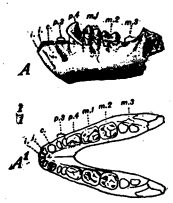

Fig. 26. *Anaptomorphus æmulus.* Type. Am. Mus. Cope, No. 5010. *A*, from side; A^1, reconstructed from above.

(Sp. 28) **Anaptomorphus æmulus** *Cope.*—*Type*, No. 5010, Amer. Mus. Cope Coll. This famous little jaw (Fig. 26) is the type of the genus. It exhibits progression on the Wasatch species in the loss of the second premolar, the formula being: I. $\frac{2}{2}$, C. $\frac{1}{1}$, P. $\frac{3}{3}$, M. $\frac{3}{3}$; paraconid especially on $m_{\frac{2}{2}}$ is also slightly more reduced, while the deuteroconid on $p_{\frac{4}{4}}$ is slightly more pronounced, but still not separate.

3. Uinta (Ligurien) Stage.

INCERTÆ SEDIS.

(Sp. 54) **? "Microsyops" uintensis** *Osborn.*—A reëxamination of the type of *Microsyops uintensis* (Amer. Mus. No. 1899) demonstrates that the reference of this type to *Microsyops* was an error, because the fourth lower premolar is totally unlike the molars. Its nearer reference is either to the Anaptomorphidæ or to some member of the Notharctidæ.

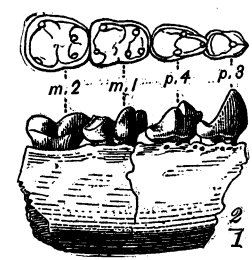

Fig. 27. "*Microsyops*" *uintensis.* Type. Am. Mus. No. 1899.

PART II. RODENTIA.

SUBORDER **PROGLIRES,** subordo nov.

A primitive suborder of Rodents distinguished by the presence of rooted incisors, and canine teeth, and by the absence of any considerable diastemata and of antero-posterior motion of the jaw. Types: *Mixodectes*, *Olbodotes*, *Microsyops*.

It is obvious that these animals are far too primitive to be classed with the Protrogomorpha of Zittel which was framed to include all those modernized fossil and living rodents which do not naturally enter either of the four great divisions of Brandt.

FAMILY **MIXODECTIDÆ** COPE.

Characters.—Median lower incisors close to symphysis, enlarged and elongating (unlike Tillodontia, in which second incisor is enlarged), lateral incisors early reduced; canines persistent (unlike Rodentia); no diastemata (unlike Rodentia), first and second premolars rapidly reduced; third premolar slowly reduced, fourth premolar progressively molariform (as in Tillodontia and Rodentia); lower molars with narrow, slightly elevated trigonid, but early reduced paraconid; talonid broad, hypoconulid small, except in third lower molar; superior molars tritubercular. A feature of the jaw is the sharp definition of a ridge descending from the coronoid and defining the masseteric insertion anteriorly (Fig. 3).

This phylum specialized very early.[1] The little animals which represent it are rare in the Torrejon and Wasatch, more abundant in the Wind River, and very common in the Bridger; not as yet reported in the Uinta. The specific forms range greatly in size but the essential progressive characters of the lower teeth are the same throughout this long geological period.

Ordinal position. — Cope placed *Mixodectes* among the Primates. Matthew ('97, p. 265) was the first to point out that the enlarged median tooth was probably an incisor and that the astragalus was exactly similar to that of a Rodent. He therefore took the important step of transferring this

[1] In 1892, Schlosser (Neues Jahrb. f. Min. Geol. u. Pal., Bd. II, s. 238) referred the contemporary Cernaysian Plesiadapidæ, *Plesiadapis* and *Protoadapis* Lemoine, to the Rodentia, removing them from the Insectivora.

genus to the Rodentia, leaving the position of the more recent members of the family undetermined.

Relationship to the Rodentia is now found to be indicated by: (1) progressive elongation of median incisor; (2) disappearance of lateral incisors; (3) reduction of canines; (4) disappearance of two anterior premolars and reduction of third premolar; (5) transformation of fourth premolar into molar form, thus foreshadowing a homodont molar-premolar series; (6) width and extension of talonid (as in Eocene *Paramys*); (7) rodent form of astragalus.

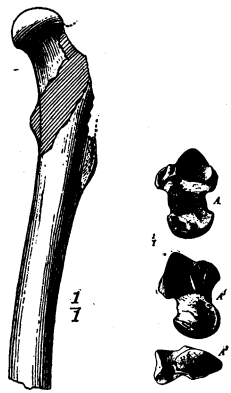

Fig. 28. *Mixodectes pungens.* Am. Mus. No. 2451. Left femur. Natural size. Astragalus, *A*, posterior; A^1, anterior; A^2, inferior or distal aspect. Natural size.

Against the Rodent relationship are: (1) Persistence of the canine; (2) absence of diastemata; (3) absence of any evidence (except the levelling of the premolars) of adaptation for antero-posterior or orthal motion of the jaw. Pending the final demonstration of this problem the Mixodectidæ may be placed in the new primitive suborder Proglires, defined above.

A careful reëxamination of all the material belonging to *Mixodectes*, *Cynodontomys*, and *Microsyops* has confirmed Matthew's observation that the enlarged median tooth is an incisor and has convinced us that these animals represent three successive stages in the same family.

A still more primitive stage is represented by a new genus to which the name *Olbodotes* (ολβοδότης) may be given, in reference to the happy solution it affords of the problem of the homology of the enlarged incisor teeth.

SYNOPSIS OF GENERA.

TORREJON.

Olbodotes.— $\frac{3}{3}, \frac{1}{1}, \frac{2}{2}, \frac{3}{3}$. One enlarged and two reduced incisors; two premolars, fourth premolar pointed; depressed paraconid on the molars.

Mixodectes.— $\frac{1}{1}$, $\frac{1}{1}$, $\frac{2-2}{2}$, $\frac{3}{3}$. One enlarged incisor tooth only; a canine, three to two premolars, fourth premolar pointed; depressed paraconid on the molars, a rudimentary hypoconulid.

WASATCH.

Cynodontomys.— $\frac{1}{1}$, $\frac{1}{1}$, $\frac{2}{2}$, $\frac{3}{3}$. One enlarged incisor only, two premolars, fourth premolar submolariform; a small paraconid and hypoconulid on the molars.

WIND RIVER AND BRIDGER.

Microsyops.— $\frac{1}{1}$, $\frac{1}{1}$, $\frac{2}{2}$, $\frac{3}{3}$. Greatly enlarged incisor; two premolars, third premolar further reduced, fourth premolar molariform; a small paraconid on the molars.

CHRONOLOGICAL LIST OF SPECIES. PARTLY INCERTÆ SEDIS.

Sp. (51) *Mixodectes pungens* Cope.....Torrejon.
(52) " *crassiusculus* Cope..... "
(8) *Microsyops gracilis* Leidy.....Bridger.
(9) " (*Palæacodon*) *verus* Leidy..... "
(18) " (*Bathrodon*) *typus* Marsh..... "
(19) " (*Bathrodon*) *annectens* Marsh..... "
(20) " (*Mesacodon*) *speciosus* Marsh..... "
(46) " *scottianus* Cope.....Wind River.
(49) " (*Cynodontomys*) *latidens* Cope,.....Wasatch.
(59) *Olbodotes copei* Osborn.....Torrejon.
Compare also *Indrodon malaris* Cope..... "
" " *Chriacus angulatus* Cope.....Wasatch.

1. TORREJON (THANÉTIEN) BASAL EOCENE.

(Sp. 59) **Olbodotes copei,** gen. et spec. nov.

Type, No. 2385, Amer. Mus., left lower jaw.

Dentition.— $\frac{3}{3}$, $\frac{1}{1}$, $\frac{2}{2}$, $\frac{3}{3}$. An enlarged median incisor, two smaller incisors on the alveolar border behind it; canine small; third premolar reduced; fourth premolar high, simple, pointed, as in *Mixodectes*.

This specimen had previously been referred to *Mixodectes* but it differs in the retention of three incisor teeth and the loss of the second premolar tooth, which is represented by an alveolus in the type of *Mixodectes pungens*. There is little question about the presence of three incisors, the median one of which, although not preserved, has been much enlarged

so far as we can judge by its alveolus. The second and third incisors are equal sized with laterally compressed fangs (Fig.

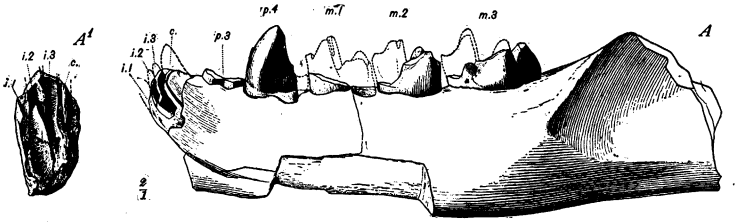

Fig. 29. *Olbodotes copei.* Type. Am. Mus. No. 2385. *A*, lateral view, A^1, anterior view, of left ramus.

29A¹). This further enables us to determine the single-fanged tooth at the edge of the jaw as a canine, an interpretation which is supported by the condition of this long single-fanged tooth, heretofore described as an anterior premolar, in *Cynodontomys* and *Microsyops*.

Fig. 29*a*. *Olbodotes copei*. Upper molar associated with type.

With the type of *Olbodotes* is associated an upper molar tooth (Fig. 29 a) resembling that of *Indrodon malaris* in the possession of a prominent mesostyle, and suggesting that *Indrodon* is probably a member of the Mixodectidæ. (See below.)

(Sp. 51) **Mixodectes pungens** *Cope*.— The well known type of this species (No. 3081 Amer. Mus.) shows no evidence

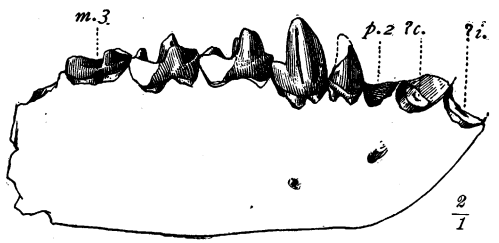

Fig. 30. *Mixodectes pungens*. Type. Am. Mus. Cope, No. 3081.

of the existence of the reduced lateral incisors seen in *Olbodotes* and is further distinguished by the variable presence of the second premolar.

Another specimen (No. 2557 *b*, Amer. Mus.) shows that the enlarged incisor is still a spatulate tooth with the enamel

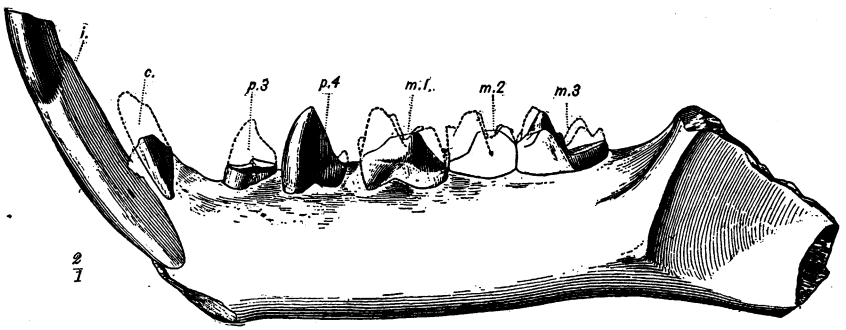

Fig. 31. *Mixodectes pungens.* Am. Mus. No. 2557*b*. Left lower jaw. Median incisor partly displaced.

completely surrounding the crown and a persistent fang (Fig. 31). Still another specimen (No. 3083 Amer. Mus.) gives a better view of the molar teeth.

(Sp. 52) **Mixodectes crassiusculus** *Cope.*— The type, No. 3087 Amer. Mus., consists of the posterior portion of the right and left rami of the lower jaws containing molar teeth. This specimen gives a perfect view of the structure of the molars, showing that they are even more specialized than those of *Cynodontomys* and *Microsyops* in the degeneration of the paraconid.

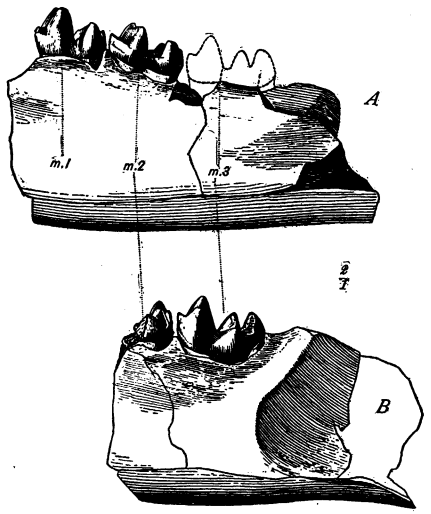

Fig. 32. *Mixodectes crassiusculus.* Am. Mus. Cope, No. 3087. Parts of right and left rami.

INCERTÆ SEDIS.

GENUS INDRODON COPE.

As stated above (p. 170) this does not belong near the Anaptomorphidæ, the molar structure being entirely different. In previous articles, owing to the incorrect association of another specimen (No. 823), there has also been much confusion, which Matthew has partly cleared up (1897, p. 265).

Indrodon malaris *Cope.*— The type skull (Amer. Mus. No. 3080) is carefully redrawn in Fig. 33. Its conspicuous characteristics are: slightly enlarged median incisors, three premolars well spaced, fourth premolar with deuterocone; molars with broad external cingulum, crescentic para- and metacones and prominent mesostyle, rudimentary hypocone. The molar teeth resemble those of *Olbodotes*.

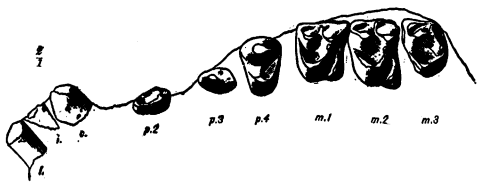

Fig. 33. *Indrodon malaris.* Type. Am. Mus. Cope, No. 3080. Left maxilla.

Specimen No. 833 also belongs to *Indrodon* but is more progressive than *I. malaris*, being distinguished by the breadth of the ectoloph and additional cusps on the fourth superior premolar.

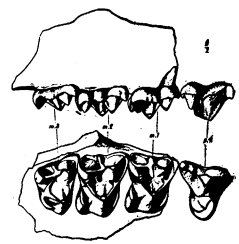

Fig. 34. *Indrodon* sp. Am. Mus. No. 833. Fourth premolar transposed from left side.

Specimen No. 823 (Figs. 1, 2) was associated by Osborn and Earle (1895, p. 17) and believed to give us the skeletal characters of this animal; this association appears very questionable (see page 171).

2. WASATCH (SPARNACIEN, YPRÉSIEN) STAGE.

The genus *Cynodontomys* is only by courtesy and for want of better knowledge separated from *Microsyops*.

(Sp. 49) **Cynodontomys latidens** *Cope.* ? Syn. *M.* (*Chriacus*) *angulatus* Cope.—*Type:* the two rami of a lower jaw (Amer. Mus.

No. 4195), with molar teeth (ms.=11.5 mm.) in nearly parallel series; anterior pair apparently well developed and procumbent; lower premolars spaced, p_3 with paired fangs; p_4 a sub-quadritubercular tooth, namely with protoconid, tritoconid, deuteroconid, and tetartoconid; molars with narrow trigonid, paraconid small but distinct and median in position, broad talonid with a small hypoconulid. The ramus is long and rather slender, and the angle is produced posteriorly.

Cynodontomys is barely distinguished from its successors in the Wind River and Bridger by the less complete transformation of the fourth premolar and by the smaller single incisor. It is represented also by the juvenile jaw (No. 65), by the specimen (No. 4184) referred to *Chriacus angulatus* by Cope.

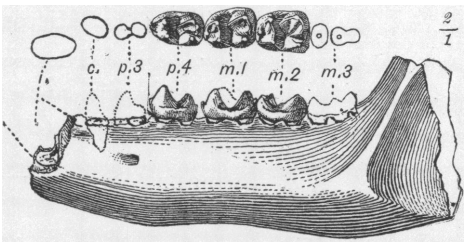

Fig. 35. *Cynodontomys latidens.* Type. Cope Coll. No. 4195 Wasatch. Big Horn Valley, Wyoming. Twice natural size.

Cope erroneously referred to this species a number of specimens from the Wasatch and Wind River horizons, with a short deep mandibular ramus, small heels upon the third lower molars, and general structure more similar to the Bridger series described below; ms. = 13.5 mm.

3. Wind River (Lutétien) Stage.

Genus MICROSYOPS Leidy.

Palæacodon Leidy, *Bathrodon* Marsh, *Mesacodon* Marsh.

(Sp. 46) **Microsyops scottianus** *Cope.—Type:* A long, shallow mandible (Amer. Mus. No. 4748), large semi-procumbent tooth with narrow diastema behind it; ms.=14 mm.; formula: $\frac{1}{1}, \frac{1}{1}, \frac{3}{3}, \frac{3}{3}$.

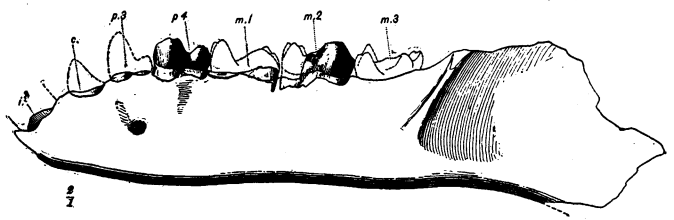

Fig. 36. *Microsyops scottianus.* Am. Mus. No. 4748. Slightly less than 2 diam.

The eight specimens from the Wind River formation (Amer. Mus. Nos. 4743–4748 inclusive), referred by Cope (Tertiary Vertebrata, p. 217) to *M. elegans* Marsh (or *M. gracilis* Leidy), represent a larger animal than *C. latidens* of the Wasatch; and agree closely with *M. scottianus* in size of the teeth, but certain of them differ in the greater depth of the mandible and coalescence of the fangs of p_3 (see No. 4743).

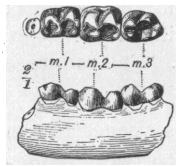

Fig. 37. "*Microsyops*" *speirianus*. Type. Am. Mus. Cope, No. 4190. Portion of right ramus.

(Sp. 44) **"Microsyops" speirianus** (Fig. 37). The type certainly does not belong to this genus. It resembles *Anaptomorphus* slightly.

4. Bridger (Bartonien) Stage.

(Sp. 8) **Microsyops gracilis.**— Leidy's type of the genus (*Microsyops gracilis* of the Bridger) was a small lower jaw in which he mistook the homologies and erroneously described six molars (ms. and pms.) and enlarged "canines," remarking that the number of incisors was indeterminate. Unlike those of the Anaptomorphidæ the lower molars are readily recognized by the narrow trigonid, now depressed to the level of the talonid, *i. e.*, more bunodont, depressed paraconid, behind which is the broad talonid bearing a hypoconulid; m_3 has a small cuspidate hypoconulid, unlike that in the Notharctidæ. So far as reported, upper molars have not been found associated, but it is probable that they are rightly identified in the broadly triangular (as distinguished from the more transversely oval form of the molars in the Anaptomorphidæ and the more quadrate form in the Hyopsodontidæ) tritubercular teeth, with a small cingule representing the hypocone, with intermediate spaces on the palatal side, as in all forms in which the trigonid is present; rudimentary conules and para-, meso-, and metastyles; the type of *Palæacodon verus* Leidy, described immediately after that of *Microsyops*, is such a tooth with small conules and a rudimentary hypocone (Leidy, '73, pl. vi, fig. 46).

It is probable that the types of *Palæacodon verus* Leidy, *Mesacodon speciosus* Marsh, *Bathrodon annectens* Marsh, also belong to this genus. The species *Palæacodon vagus* Marsh apparently belongs with the Anaptomorphidæ.

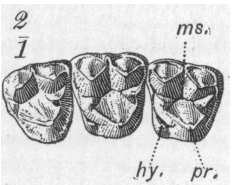

Fig. 38. *Microsyops.* Princ. Mus. Superior molars, isolated.

Leidy chose a rather uncharacteristic specimen [1] as the type and first adopted the specific name *M.* (*Hyopsodus*) *gracilis* Marsh; [2] but as the type of the latter species (*H. gracilis*) has four premolars it is probably related to *Notharctus* (*?Limnotherium*) *elegans*, as in fact suggested by Leidy himself (1873, p. 84). We are unable at present to straighten out the names of the Bridger formation species; they appear to be numerous.

Principal Characters of Microsyops.— $\frac{1}{1}$, $\frac{1}{1}$, $\frac{2}{2}$, $\frac{3}{3}$; median incisors very large, semi-procumbent, laterally compressed; p_4 submolariform; m_3 with small third lobe; symphysis not coössified.

The fourth premolar of *Microsyops* presents an advance upon that of *Cynodontomys* in the presence of a ridge uniting the two anterior cusps; the incisors were still larger and more procumbent, extending well back, below and inside of the fangs of the canines (Fig. 39). The external cingulum of the upper molars is not constant, sometimes faint; the valleys are smooth or slightly ridged. The upper molars (Fig. 38) are tritubercular, the primitive cusps (protocone, paracone, metacone), when unworn, being sharp and prominent; the conules faintly developed on m^1 and m^2; the hypocone is a

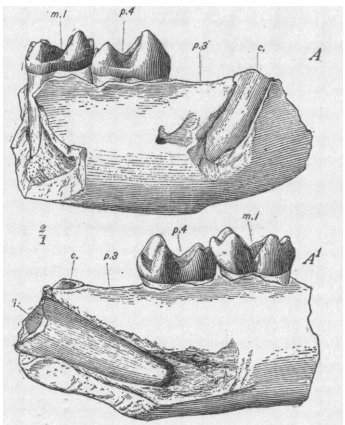

Fig. 39. *Microsyops.* Am. Mus. No. 1732. *A*, external, *A*¹, internal aspect of right ramus.

[1] Leidy '73 pl. vi, figs. 14, 17.

[2] Amer. Jour. Sci., July, 1871, p. 10.

mere cingule on the postero-internal slope of the protocone. The posterior heel (hypoconulid) of the lower molars is always very small, but sometimes forms a sharp narrow heel upon m_3; these teeth are further distinguished by the narrow primitive triangle; the paraconid is distinct on m_1, but decreases on m_2, m_3. The lower premolars are reduced.

(Sp. 20) **Microsyops (Mesacodon) speciosus** *Marsh.*—Type, a complete lower jaw (Yale Museum), lacking the incisive border and the articular portion. The measurements correspond with those of the other Bridger small species. The

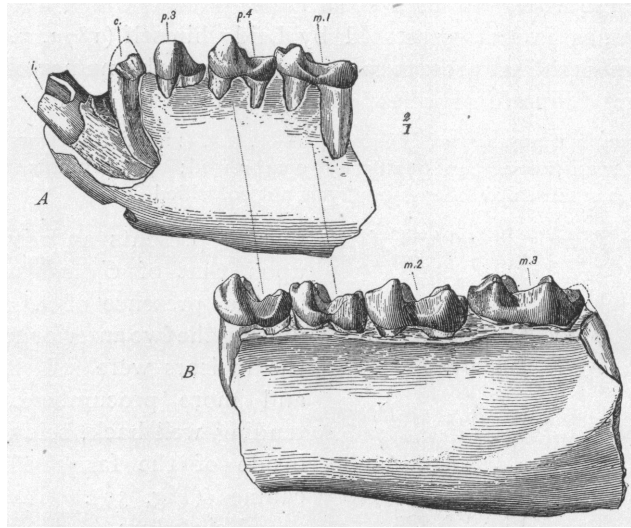

Fig. 40. *Microsyops? annectens.* Princ. Mus. Portions of rami of two individuals. Lower figure slightly exceeding 2 diam.

identification with *Microsyops* is due to the sub-molariform pattern of p_4. As observed by Marsh the anterior tooth is large, compressed, almost in contact with the symphysis; symphysis not coössified; lower border of jaw produced posteriorly angle slightly inflected; trigonid of lower molars very distinct.

(Sp. 18) **Microsyops (Bathrodon) typus** *Marsh.*— Type, a lower jaw (Yale Museum), containing the molar teeth (m_1–m_3=12 mm.) resembling that of *Microsyops* and *Mesacodon;*

coinciding in measurements and description, although the crucial tooth, p_4, is wanting.

(Sp. 19) **Microsyops (Bathrodon) annectens** *Marsh.*—Type, Yale Museum. This corresponds with the large specimens at the Princeton Museum (Fig. 40), but the paraconid is less elevated; the trigonid is narrow and the talonid broad, with three distinct cusps. The Princeton specimens have a deep jaw, with an unusually large procumbent incisor; the canine has a long single fang; p_2 is possibly represented by a rudimentary socket; the trigonid narrow and slightly elevated; the paraconid more or less distinct on m_1–m_3; hypoconulid faint on m_1, m_2, strong on m_3. The upper molars, which are provisionally associated with this species, bear a low, external, intermediate cusp or mesostyle, minute conules, and a low cingule representing a hypocone.

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