FOSSIL VERTEBRATES

IN THE

American Museum of Natural History.

DEPARTMENT OF VERTEBRATE PALÆONTOLOGY.

Volume II.

ARTICLES COLLECTED FROM THE AMERICAN
MUSEUM BULLETINS OF THE YEARS

1898–1903.

BY

HENRY FAIRFIELD OSBORN,	J. W. GIDLEY,
J. L. WORTMAN,	F. W. LOOMIS,
W. D. MATTHEW,	BARNUM BROWN,
O. P. HAY,	R. S LULL,
WALTER GRANGER,	W. K. GREGORY.

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EXPLORATIONS AND RESEARCHES

OF THE

Department of Vertebrate Palæontology.

PREFACE TO VOLUME II.

BY HENRY FAIRFIELD OSBORN, CURATOR.

In the preface of Volume I a brief outline was given of the foundation of the Department in May, 1891, together with the successive appointments of the curator and different members of the staff, of the purposes of the Department, of the twenty-one expeditions sent out between 1891 and 1897, and of the acquisition of the Cope collection of fossil mammals; also a summary of the collections, embracing in 1897 the remains of 3,000 animals; and of the palæontological, geological and stratigraphical work accomplished; and a resumé of the chief scientific results contained in the twenty-one Bulletins.

It appears appropriate to introduce Volume II with a similar summary of the work accomplished in the six years between 1897 and 1903.

Staff.—The preface of this second volume must first refer with regret to the resignation of Dr. J. L. Wortman in March, 1899, to take charge of vertebrate palæontology in the newly established Carnegie Museum. Dr. Wortman's services to this Department both in the field and in scientific writing were of the highest order. Under his able and energetic direction in the field seventeen of the twenty-one expeditions were conducted, laying the foundations especially for the remarkably representative Eocene and Oliogocene collections of mammals and the Jurassic collection of fossils. Dr. W. D. Matthew, now Associate Curator, was appointed in Dr. Wortman's place. In January, 1900, Dr. O. P. Hay, now Associate Curator of Chelonia, joined the staff in connection with the cataloguing and arrangement of the Cope Collection of fossil reptiles, amphibians and fishes. Mr. Walter Granger continued in charge especially of the Jurassic field work until the season of 1903, when he reëntered the mammalian fossil field in the Bridger basin. Mr. J. W. Gidley joined the staff in 1899, with reterence to strengthening our collection of Miocene, Pliocene and Pleistocene mammals, and in 1900 he took charge of the exploration for fossil horses under the Whitney Fund. Mr. Barnum Brown joined the staff in 1896 in connection with the Jurassic explorations, and in 1900 was put in charge of the exploration of the Cretaceous.

We are indebted to Mr. F. B. Loomis, of Amherst College, for coöperation in the expeditions of 1900, 1901 and 1902; and to Professor R. S. Lull, of the Amherst Massachusetts Agricultural College, for coöperation in the Cretaceous and Jurassic expeditions of 1899 and 1902. In 1903 Mr. Peter Kaison, who formerly served as field and Museum assistant, took charge of the continued excavation of the Bone Cabin quarry.

Mr. Adam Hermann has continued as head prepartor, and has been constantly perfecting his methods of mounting. Mr. W. K. Gregory joined the staff in 1900 as an assistant to the curator and in charge of the Department Library. Mr. A. E. Anderson has continued in charge of the photographic and art department. Among the artists who have illustrated our publications should be mentioned especially: Messrs. Weber, Christman, Yoshiwara; Mrs. Stirling and Miss Cox.

Total Summary of Collections. — The collections made by our field expeditions during the fourteen years embrace the remains of over 5,000 fossil animals.

Our collections have also been strengthened by friendly exchange with American and foreign museums, and by purchases, the most important being that of the second portion of the famous collection brought together by Professor Edward D. Cope, known as the *Cope Collection of Fossil Fishes, Amphibians, Reptiles and Birds.* This was generously presented to the Museum by President Morris K. Jesup in 1902. At the same time the *Pampean Collection of Ameghino, Larroque and Brachet,* originally exhibited at the Paris Exposition in 1881, and there purchased by Professor Cope, was secured for this Museum by the gift of Messrs. H. O. Havemeyer, D. Willis James, Adrian Iselyn, Henry F. Osborn and the late James M. Constable and William E. Dodge, Trustees of the Museum. Among the other purchases are those from Charles H. Sternberg from his explorations in the Kansas chalk. Altogether the purchases have added 1,800 specimens.

The chief *exchanges* have been with the museums of London, Paris, Munich, St. Petersburg, Berlin, Stuttgart, Lyons and Buenos Aires.

The collections as a whole now include fourteen thousand four hundred specimens, representing:

Fossil mammals	9,873
Fossil reptiles	2,694
Fossil birds	57
Fossil amphibians	593
Fossil fishes	1,202
Total	14,420

Beginning in 1891, the horizons have been explored in the following order:

Permian, Texas, 1902.
Triassic, North Carolina, 1894, 1895.
Upper Jurassic (Como Beds), Wyoming, 1897–1903; Montana, 1903.
Upper Cretaceous (Niobrara), Kansas, 1897.
Upper Cretaceous (Fort Pierre), South Dakota, 1903.
Upper Cretaceous (Laramie), Wyoming, 1892, 1900; Montana, 1902.
Basal Eocene (Puerco), New Mexico, 1892.
Basal Eocene (Torrejon), New Mexico, 1892, 1896.
Lower Eocene (Wasatch), Wyoming, 1891, 1896; New Mexico, 1896.
Middle Eocene (Wind River), Wyoming, 1891, 1896; Colorado, 1897.
Middle Eocene (Bridger), Wyoming, 1893, 1895, 1903; Colorado, 1897.
Upper Eocene (Uinta), Utah, 1894, 1895.
Oligocene (White River), South Dakota, 1892, 1894, 1901, 1902.
Oligocene (White River), Colorado, 1898, 1901; Montana, 1902.
Middle Miocene, Colorado, 1898, 1901, 1902.
Upper Miocene (Loup Fork), South Dakota, 1894, 1902, 1903.
Upper Miocene, Texas, 1899, 1900, 1901; Montana, 1902.
Pliocene (Blanco), Texas, 1900, 1901.
Pleistocene (Sheridan), Nebraska, 1893, 1897; Texas, 1899, 1900, 1901.
Pleistocene Arkansas, 1903.

General Exploration.—Two series of expeditions, for mammals and for reptiles, conducted by from two to four parties, have been sent out each year since 1897 in the systematic search for fossil reptiles and mammals in different formations.

These expeditions during the past five years, namely between 1898 and 1903, have had a considerable measure of success. They have added some 2,500 specimens to the collections, including some thirty more or less complete skeletons, eight of which have already been mounted and placed on exhibition, as follows :

Equus scotti.
Ornitholestes hermanni.
Hypohippus equinus.
Neohipparion whitneyi.
Merycodus osborni.
Glyptotherium texanum.
Dinictis squalidens.
Cynodictis gregarius.

RECENT EXPLORATIONS.

Exploration for Dinosaurs. — A large part of the field work of the Department since 1897 has been directed to securing the remains of Dinosaurs, especially from the Upper Jurassic (Como Beds) of Wyoming and Colorado, and from the Cretaceous. A rich and extensive deposit, the "Bone Cabin Quarry," was opened up in Wyoming in 1898, and has been worked with good results for six years.

Evolution of the Horse. — The generosity of one of the Trustees of the Museum, Mr. William C. Whitney, enabled the Curator to send out in 1899 and subsequent years a series of expeditions into various Tertiary formations of which the chief object was to obtain materials to illustrate the evolution of the horse.

GEOLOGICAL RESULTS.

The field parties beginning in 1900 have with one or two exceptions made very exact stratigraphical field records. The result is the accumulation of important data concerning the distribution of faunas and especially concerning the subdivision of horizons which were formerly considered single or incorrectly identified. We may summarize these results since 1900 as follows :

1. *Uinta* (Upper Eocene) subdivided by Peterson into Telmatotherium and Diplacodon Horizons.

2. *Puerco* (Basal Eocene) subdivided by Wortman and Matthew into Puerco and Torrejon.

3. Two other *Eocene* horizons determined and correlated in the Huerfano Basin of Colorado by Osborn and Matthew.

4. *White River* (Oligocene) subdivided by Wortman and Matthew by the addition of two upper divisions, *Protoceras* beds and *Leptauchenia* beds.

5. The three divisions of the White River, first made by Hayden and Leidy, further defined and correctly correlated with the stratigraphy, and the existence shown of two contemporary faunal phases in each division (Wortman and Matthew).

6. The various *Miocene* formations which have been grouped under the general names of Loup Fork and Deep River, distinguished and correctly correlated with their respective Miocene horizons, and the so-called Palo Duro horizon eliminated (Matthew and Gidley).

7. **The Æolian Theory.** — Our field researches have resulted in replacing the lake basin theory by the fluviatile and æolian theory, especially under the observations of Dr. W. D. Matthew, the arguments derived from which are fully summarized in his memoir.

This demonstration has been nearly simultaneous with that of Messrs. Hatcher, Davis, and Gidley, who have reached and published similar results.

8. **Stratigraphical Succession of Horizons.** — The most complete paper on stratigraphical succession is that by Matthew, No. 28, entitled "A Provisional Classification of the fresh water Tertiaries of the West," summarizing results obtained by our field parties by

comparison with those obtained previously by Leidy, Cope, Marsh, and others. Of the same nature are the exact researches by Mr. F. B. Loomis, on the Jurassic stratigraphy of Wyoming (Nos. 37, 48.)

PALÆONTOLOGICAL RESULTS.

Dinosaurs and other Reptiles. Bulletins. — The first paper, No. 27, is an erroneous identification by Osborn of *Camarasaurus* Cope with *Brontosaurus* Marsh, it having since been found that *Camarasaurus* is more nearly allied to *Morosaurus*. In this paper the vertebral structure of Sauropoda is discussed. The fore and hind limbs of carnivorous and herbivorous Dinosaurs are discussed by Osborn in later papers. The latest contributions are an account of the skull of *Creosaurus* by Osborn, No. 61, and of the skull of *Triceratops* by Lull, No. 60.

Attention should be called here to a series of important memoirs on fossil reptiles, namely: *A complete Mosasaur Skeleton*, by Osborn; *A Skeleton of Diplodocus*, by Osborn; *On the Reptilian Subclasses Diapsida and Synapsida and the early history of the Diaptosauria*, by Osborn.

Evolutionary Series. — One of the principal objects of our expeditions has been the completion of the evolutionary or phyletic series so far as possible, with a view to working out the development of different orders and families from their first appearance to their extinction.

To this subject the following papers have been especially devoted: No. 7, *Ancestors of the Tapir*, by Wortman and Earle; No. 19, on the *Ganodonta and Edentata*, by Wortman; No. 24, on the *Camelidæ*, by

Wortman; No. 26, on the *Amblypoda*, by Osborn; No. 29, on the *Canidæ, Viverridæ and Procyonidæ*, by Wortman and Matthew; No. 33, on the *Rhinoceroses of Europe*, by Osborn; No. 35, on the *Creodonta*, by Matthew; No. 40, on the *Titanotheres*, by Osborn; No. 43, on the *Eocene Primates*, by Osborn.

Systematic Revisions. — We have also taken up one group after another, and have succeeded in giving a more or less complete and final revision of certain of the groups, incidentally determining questions as to priority, synonymy and the location of type specimens. Among the papers of this character have been the following: No. 2, *Species of Coryphodon*, Earle; No. 8, *Upper Cretaceous Mammals*, Osborn; No. 12, *Puerco Mammals*, Osborn and Earle; No. 10, *Species of Hyracotherium*, Wortman; No. 21, *Puerco Mammals*, Matthew; No. 26, *Pantolambda and Coryphodon*, Osborn; No. 35, *Creodonta*, Matthew; No. 36, *American Species of Equus*, Gidley; No. 43, *Eocene Primates*, Osborn; No. 46, the *Hypertragulidæ*, Matthew; 49, *Cretaceous Actinopterous Fishes* Hay; No. 53, *Mt. Lebanon Fishes*, Hay.

Morphological Series. — The chief morphological or anatomical papers are the following: No. 3, *Protoceras*, Osborn and Wortman; No. 5, *Aceratherium tridactylum*, Osborn; No. 9, *Patriofelis*, Wortman; No. 14, *Agriochœrus*, Wortman; No. 18, *Psittacotherium*, Wortman; No. 22, *Teleoceras*, Osborn; No. 23, *Coryphodon*, Osborn; No. 25, *Phenacodus*, Osborn; No. 30, *Oxyæna*, Wortman; No. 32, *Equus scotti*, Gidley: No. 34, *Oxyæna* and *Patriofelis*, Osborn; No. 41, *Dinocyon*, Matthew; No. 42, *Bunælurus*, Matthew; No. 45, *Ceratogaulus*, Matthew; No. 46, *Hypi-*

sodus, Matthew; No. 54, *Ornitholestes*, Osborn; No. 55, *Neohipparion*, Gidley; No. 57, *Glyptotherium*, Osborn; No. 58, *Paramylodon*, Brown; No. 60, *Triceratops*, Lull; No. 61, *Creosaurus*, Osborn.

Papers especially relating to *philosophical anatomy* are those on the teeth and feet by Osborn and Wortman and Gidley and especially No. 39, *Dolichocephaly* and *Brachycephaly*, by Osborn and No. 52, *The Elephants' Skull*, by Gregory.

Faunal Lists of Different Horizons.—We have also attempted to give complete faunal lists of different horizons. The most comprehensive paper of this character is No. 28, by Matthew, including faunal lists of the entire *Freshwater Tertiaries* of the West. Other papers are No. 12, *Puerco Mammals*, Osborn and Earle; No. 21, *Puerco Mammals*, by Matthew; No. 47, *Pleistocene Fauna from Hay Springs*, by Matthew; No. 50, *Lower Oligocene Fauna of the Pipestone Springs*, by Matthew; No. 59, *Miocene Fauna of Northwestern Texas*, by Gidley.

Memoirs on Fossil Mammals.—These include *The Extinct Rhinoceroses*, Part I, by Osborn, and *Fossil Mammals of the Tertiary of Northeastern Colorado*, by Matthew. The memoir on the Rhinoceroses will be continued and the memoir on the *Evolution of the Horse* is in preparation by Osborn with the coöperation of Mr. J. W. Gidley.

PHOTOGRAPHY.

Field Photographs.—In connection with the various expeditions enumerated on page iii a series of 580 field photographs have been taken, the negatives of which are filed in the department for use in connection with our publications as well as for lecture and illustrative purposes.

Museum Photographs. — These include photographs of mounted skeletons of skulls, of feet and other portions of fossil mammals and reptiles numbering altogether 590 negatives, also photographs of the restorations of fossil mammals and reptiles by Charles R. Knight.

RESTORATIONS AND MODELS.

The work of the department would be incomplete without reference to the very interesting series of restorations of fossil mammals and reptiles executed by the artist Mr. Charles R. Knight, chiefly under the direction of Professor Osborn, a complete list of which is given at the close of this volume and in a new catalogue which will be issued in 1904.

December, 1903.

PUBLICATIONS FROM THE DEPARTMENT OF VERTEBRATE PALÆONTOLOGY.[1]

MEMOIRS.

1. *The Extinct Rhinoceroses.* Part I. By Henry Fairfield Osborn. Vol. I, Part III, pp. 75–164, pll. xiia-xx, and 49 text figures. April 22, 1898. Price, $4.20.
2. *A Complete Mosasaur Skeleton.* By Henry Fairfield Osborn. Vol. I, Part IV, pp. 165–188, pll. xxi-xxiii, and 15 text figures. October 25, 1899.
3. *A Skeleton of Diplodocus.* By Henry Fairfield Osborn. Vol. I, Part V, pp. 189–214, pll. xxiv-xxviii, and 15 text figures. October 25, 1899. Price of Parts IV and V, issued under one cover, $2,00.
4. *Fossil Mammals of the Tertiary of Northeastern Colorado.* By W. D. Matthew. Vol. I, Part VII, pp. 353–446, pll. xxxvii-xxxix, and 34 text figures. November, 1901. Price, $2.00.
5. *The Reptilian Subclasses Diapsida and Synapsida and the Early History of the Diaptosauria.* By Henry Fairfield Osborn. Vol. I, Part VIII, pp. 449–507, pl. xl, and 28 text figures. November, 1903. Price, $2.00.

BULLETINS.

Contents of Volume I.

1892

1. *Fossil Mammals of the Wahsatch and Wind River Beds.* Collection of 1891. By Henry Fairfield Osborn and J. L. Wortman. Vol. IV, No. 1, Article xi, pp. 81–147, pl. IV, and 19 text figures. October 20, 1892. Price, 80 cents.
2. *Revision of the Species of Coryphodon.* By Charles Earle. Vol. IV, No. 1, Article xii, pp. 149–166, 2 text figures. October 18, 1892. Price, 15 cents.
3. *Characters of Protoceras (Marsh), the New Artiodactyl from the Lower Miocene.* By Henry Fairfield Osborn and J. L. Wortman. Vol. IV, No. 1, Article xviii, pp. 351–371, 6 text figures. December 30, 1892. Price, 25 cents.

1893

4. *Artionyx, a New Genus of Ancylopoda.* By Henry Fairfield Osborn and Jacob L. Wortman. Vol. V, Article i, pp. 1–18, 5 text figures. February, 1893. Price, 20 cents.

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[1] Separates of most of these papers can be obtained of the Librarian of the Museum at the prices indicated, or in exchange.

5. *Aceratherium tridactylum from the Lower Miocene of Dakota.* By Henry Fairfield Osborn. Vol. V, Article vii, pp. 85–86. April 29, 1893. Price, 15 cents.
6. *On the Divisions of the White River or Lower Miocene of Dakota.* By J. L. Wortman, M.D. Vol. V, Article ix, pp, 95–105. June 27, 1893. Price, 15 cents.
7. *Ancestors of the Tapir from the Lower Miocene of Dakota.* By J. L. Wortman and Charles Earle. Vol. V, Article xi, pp. 159–180, 7 text figures. August 18, 1893. Price, 25 cents.
8. *Fossil Mammals of the Upper Cretaceous Beds.* By Henry Fairfield Osborn. Vol. V, Article xvii, pp. 311–330, pll. VII and VIII, and 4 text figures. December 15, 1893. Price, 40 cents.

1894

9. *Osteology of Patriofelis, a Middle Eocene Creodont.* By J. L. Wortman, M.D. Vol. VI, Article, v. pp. 129–164, pl. I and 5 text figures. May 24, 1894. Price, 40 cents.
10. *Fossil Mammals of the Lower Miocene White River Beds.* Collection of 1892. By Henry Fairfield Osborn and J. L. Wortman. Vol. VI, Article vi, pp. 199–228, pll. II and III, and 8 text figures. July 28, 1894. Price, 50 cents.
11. *On the Affinities of Leptarctus primus of Leidy.* By J. L. Wortman. Vol. VI, Article viii, pp. 229–231. July 30, 1894. Price, 15 cents.

1895

12. *Fossil Mammals of the Puerco Beds.* Collection of 1892. By Henry Fairfield Osborn and Charles Earle. Vol. VII, Article i, pp. 1–70, 21 text figures. March 8, 1895. Price, 80 cents.
13. *Fossil Mammals of the Uinta Basin.* Expedition of 1894. By Henry Fairfield Osborn. Vol. VII, Article ii, pp. 71–105, 17 text figures. May 18, 1895. Price, 50 cents.
14. *On the Osteology of Agriochœrus.* By J. L. Wortman. Vol. VII, Article iv, pp. 145–178, pl. I, and 24 text figures. June 17, 1895. Price, 60 cents.
15. *Perissodactyls of the Lower Miocene White River Beds.* By Henry Fairfield Osborn and J. L. Wortman. Vol. VII, Article xii, pp. 343–375, pll. VIII to XI, and 12 text figures. December 23, 1895. Price, 80 cents.

1896

16. *Species of Hyracotherium and Allied Perissodactyls from the Wahsatch and Wind River Beds of North America.* By J. L. Wortman. Vol. VIII, Article vi, pp. 81–110, pl. II, and 18 text figures. May 12, 1896. Price, 50 cents.

17. *The Cranial Evolution of Titanotherium.* By Henry Fairfield Osborn. Vol. VIII, Article ix, pp. 157–197, pll. III and IV, and 13 text figures. July 31, 1896. Price, 75 cents.
18. *Psittacotherium, a Member of a New and Primitive Suborder of the Edentata.* By Dr. J. L. Wortman. Vol. VIII, Article xvi, pp. 259-262. November 30, 1896. Price, 15 cents.

1897

19. *The Ganodonta and their Relationship to the Edentata.* By J. L. Wortman. Vol. IX, Article vi, pp. 59–110, and 36 text figures. March 22, 1897. Price, 85 cents.
20. *The Huerfano Lake Basin, Southern Colorado, and its Wind River and Bridger Fauna.* By Henry Fairfield Osborn. Vol. IX, Article xxi, pp. 247–258. October 20, 1897. Price, 15 cents.
21. *A Revision of the Puerco Fauna.* By W. D. Matthew. Vol. IX, Article xxii, pp. 259–323, and 20 text figures. November 16, 1897. Price, 75 cents.

List of Casts, Models, Photographs of Skeletons and of Restorations, issued March 15, 1898. Price, 40 cents.

BULLETINS.

Contents of Volume II.

1898

22. *A Complete Skeleton of Teleoceras fossiger.* Notes upon the Growth and Sexual Characters of this Species. By Henry Fairfield Osborn. Vol. X, Article iv, pp. 51–59, pll. IV, IV*a*. March 18, 1898. Price, 25 cents.
23. *A Complete Skeleton of Coryphodon radians.* Notes upon the Locomotion of this Animal. By Henry Fairfield Osborn. Vol. X, Article vi, pp. 81–91, pl. X, and 2 text figures. April 4, 1898. Price, 20 cents.
24. *The Extinct Camelidæ of North America and some Associated Forms.* By J. L. Wortman, M.D. Vol. X, Article vii, pp. 93–142, pl. XI, and 23 text figures. April 9, 1898. Price, 70 cents.
25. *Remounted Skeleton of Phenacodus primævus.* Comparison with *Euprotogonia.* By Henry Fairfield Osborn. Vol. X, Article ix, pp. 159–164, pl. XII, and 4 text figures. May 6, 1898. Price, 20 cents.
26. *Evolution of the Amblypoda.* Part I. Taligrada and Pantodonta. By Henry Fairfield Osborn. Vol. X, Article xi, pp. 169–218, and 29 text figures. June 3, 1898. Price, 80 cents.

27. *Additional Characters of the Great Herbivorous Dinosaur Camarasaurus.* By Henry Fairfield Osborn. Vol. X, Article xii, pp. 219–233, 13 text figures. June 4, 1898. Price, 35 cents.

1899

28. *A Provisional Classification of the Fresh Water Tertiary of the West.* By W. D. Matthew. Vol. XII, Article iii, pp. 19–77. March 31, 1899. Price, 50 cents.
29. *The Ancestry of Certain Members of the Canidæ, the Viverridæ and Procyonidæ.* By J. L. Wortman and W. D. Matthew. Vol. XII, Article vi, pp. 109–139, pl. VI, and 10 text figures. June 21, 1899. Price, 40 cents.
30. *Restoration of Oxyæna lupina Cope, with Descriptions of Certain New Species of Eocene Creodonts.* By J. L. Wortman. Vol. XII, Article vii, pp. 139–148, pl. VII, and 3 text figures. June 21, 1899. Price, 20 cents.
31. *Fore and Hind Limbs of Carnivorous and Herbivorous Dinosaurs from the Jurassic of Wyoming.* Dinosaur Contributions, No. 3. By Henry Fairfield Osborn. Vol. XII, Article xi, pp. 161–172, 8 text figures. October 30, 1899. Price, 25 cents.

1900

32. *A New Species of Pleistocene Horse from the Staked Plains of Texas.* By J. W. Gidley. Vol. XIII, Article xiii, pp. 111–116, and 5 text figures. August 18, 1900. Price, 15 cents.
33. *Phylogeny of the Rhinoceroses of Europe.* Rhinoceros Contributions No. 5. By Henry Fairfield Osborn. Vol. XIII, Article xix, pp. 229–267, and 16 text figures. December 11, 1900. Price, 50 cents.
34. *Oxyæna and Patriofelis Re-studied as Terrestrial Creodonts.* By Henry Fairfield Osborn. Vol. XIII, Article xx, pp. 269–281, pll. XVIII and XIX, and 4 text figures. December 21, 1900. Price, 35 cents.

1901

35. *Additional Observations on the Creodonta.* By W. D. Matthew. Vol. XIV, Article i, pp. 1–38, and 17 text figures. January 31, 1901. Price, 50 cents.
36. *Tooth Characters and Revision of the North American Species of the Genus Equus.* By J. W. Gidley. Vol. XIV, Article ix, pp. 91–142, pll. XVIII–XXI, and 27 text figures. May 31, 1901 Price, $1.20.

37. *On Jurassic Stratigraphy in Southeastern Wyoming.* By F. B. Loomis. Vol. XIV, Article xii, pp. 189–197, pll. XXVI and XXVII. June 17, 1901. Price, 25 cents.

38. *Fore and Hind Limbs of Sauropoda from the Bone Cabin Quarry.* By Henry F. Osborn and Walter Granger. Vol. XIV, Article xiii, pp. 199–209, and 6 text figures. July 9, 1901. Price, 20 cents.

1902

39. *Dolichocephaly and Brachycephaly in the Lower Mammals.* By Henry Fairfield Osborn. Vol. XVI, Article vii, pp. 77–89, and 5 text figures. February 3, 1902. Price, 20 cents.

40. *The Four Phyla of Oligocene Titanotheres.* By Henry Fairfield Osborn. Vol. XVI, Article viii, pp. 91–109, and 13 text figures. February 18, 1902. Price, 20 cents.

41. *A Skull of Dinocyon from the Miocene of Texas.* By W. D. Matthew. Vol. XVI, Article xi, pp. 129–136, and 4 text figures. April 7, 1902. Price, 20 cents.

42. *On the Skull of Bunælurus, a Musteline from the White River Oligocene.* By W. D. Matthew. Vol. XVI, Article xii, pp. 137–140, and 3 text figures. April 7, 1902. Price, 20 cents.

43. *American Eocene Primates, and the Supposed Rodent Family Mixodectidæ.* By Henry Fairfield Osborn. Vol. XVI, Article xvii, pp. 169–214, and 40 text figures. June 28, 1902. Price, 75 cents.

44. *New Canidæ from the Miocene of Colorado.* By W. D. Matthew. Vol. XVI, Article xxi, pp. 281–290, and 4 text figures. September 18, 1902. Price, 15 cents.

45. *A Horned Rodent from the Colorado Miocene.* With a Revision of the Mylogauli, Beavers, and Hares of the American Tertiary. By W. D. Matthew. Vol. XVI, Article xxii, pp. 291–310, and 17 text figures. September 25, 1902. Price, 35 cents.

46. *The Skull of Hypisodus, the Smallest of the Artiodactyla, with a Revision of the Hypertragulidæ.* By W. D. Matthew. Vol. XVI, Article xxiii, pp. 311–316, and 4 text figures. September 25, 1902. Price, 10 cents.

47. *List of the Pleistocene Fauna from Hay Springs, Nebraska.* By W. D. Matthew. Vol. XVI, Article xxiv, pp. 317–322. September 25, 1902. Price, 10 cents.

48. *On Jurassic Stratigraphy on the West Side of the Black Hills.* Second Paper on American Jurassic Stratigraphy. By F. B. Loomis. Vol. XVI, Article xxxi, pp. 401–407, pll. LIV–LV. November 3, 1902. Price, 25 cents.

1903

49. *On Certain Genera and Species of North American Cretaceous Actinopterous Fishes.* By O. P. Hay. Vol. XIX, Article i, pp. 1–95, pll. I–V, and 72 text figures. March 4, 1903. Price, $1.95.

50. *The Fauna of the Titanotherium Beds at Pipestone Springs, Montana.* By W. D. Matthew. Vol. XIX, Article vi, pp. 197–226, and 19 text figures. May 9, 1903. Price, 40 cents.

51. *A Fossil Hedgehog from the American Oligocene.* By W. D. Matthew. Vol. XIX, Article vii, pp. 227–229, and 1 text figure. May 9, 1903. Price, 10 cents.

52. *Adaptive Significance of the Shortening of the Elephant's Skull.* By W. K. Gregory. Vol. XIX, Article ix, pp. 387–394, pl. XXIII and 4 text figures. July 8, 1903. Price, 10 cents.

53. *On a Collection of Upper Cretaceous Fishes from Mount Lebanon, Syria, with Descriptions of Four New Genera and Nineteen New Species.* By O. P. Hay. Vol. XIX, Article x, pp. 395–452, pll, XXIV–XXXVII. July 8, 1903. Price, 95 cents.

54. *Ornitholestes hermanni, A New Compsognathoid Dinosaur from the Upper Jurassic.* By Henry Fairfield Osborn. Vol. XIX, Article xii, pp. 459–464, and 3 text figures. July 23, 1903. Price, 10 cents.

55. *A New Three-Toed Horse.* By J. W. Gidley. Vol. XIX, Article xiii, pp. 465–476. July 24, 1903. Price, 10 cents.

56. *On Two Species of Platygonus from the Pliocene of Texas.* By J. W. Gidley. Vol. XIX, Article xiv, pp. 477–481, and 5 text figures. July 24, 1903. Price, 10 cents.

57. *Glyptotherium texanum, A New Glyptodont, from the Lower Pleistocene of Texas.* By Henry Fairfield Osborn. Vol. XIX. Article xvii, pp. 491–494, pl. XLIII. August 17, 1903. Price, 15 cents.

58. *A New Genus of Ground Sloth from the Pleistocene of Nebraska.* By Barnum Brown. Vol. XIX, Article xxii, pp. 569–583, pll. L and LI. October 28, 1903. Price, 35 cents.

59. *The Fresh-Water Tertiary of Northwestern Texas.* American Museum Expeditions of 1899–1901. By J. W. Gidley. Vol. XIX, Article xxvi, pp. 617–635, pll. LII–LVIII. November 21, 1903. Price, 85 cents.

60. *Skull of Triceratops serratus.* By Richard Swan Lull. Vol. XIX, Article xxx, pp. 685–695, pl. LIX, and 1 text figure. December 24, 1903. Price, 20 cents.

61. *The Skull of Creosaurus.* By Henry Fairfield Osborn. Vol. XIX, Article xxxi, pp. 697–701, and 2 text figures. December 24, 1903. Price, 10 cents.

1903

53*a*. *A New Species of Fossil Edentata from the Santa Cruz Formation of Patagonia.* By Barnum Brown. Vol. XIX, Article xi, pp. 453-457, 2 text figures. July 8, 1903. Price, 10 cents.

a. *Provisional Guide to the Hall of Fossil Vertebrates.* By W. D. Matthew. Edition of 1900–1901, 4 pp. Price, 5 cents. Superseded by Guide Leaflet No. 3.

b. Guide Leaflet No. 3. *The Hall of Fossil Vertebrates.* By W. D. Matthew. Supplement to American Museum Journal. Vol. II, No. 1. January, 1902. 1 pl. and 10 text figures. Superseded by Guide Leaflet No. 12.

c. Guide Leaflet No. 9. *The Evolution of the Horse.* By W. D. Matthew. Supplement to American Museum Journal. Vol. III, No. 1. January, 1903. 7 pll. and 4 text figures. Price, 10 cents.

d. Guide Leaflet No. 12. *The Collection of Fossil Vertebrates.* By W. D. Matthew. Supplement to American Museum Journal. Vol. III, No. 5. October, 1903. 1 pl. and 15 text figures. Price, 10 cents.

Revised List of Casts, Models, Photographs of Skeletons and of Restorations, issued March, 1904. Price, 50 cents.

A Complete Skeleton of Teleoceras fossiger. Notes upon the Growth and Sexual Characters of this Species.

BY HENRY FAIRFIELD OSBORN.

PLATES IV AND IVA.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
VOL. X, ARTICLE IV, pp. 51–59.
New York, March 18, 1898.

Article IV.—A COMPLETE SKELETON OF TELEOCERAS FOSSIGER. NOTES UPON THE GROWTH AND SEXUAL CHARACTERS OF THIS SPECIES.

By Henry Fairfield Osborn.

Plates IV and IVa.

The remarkable series of Rhinoceros skulls in the Cope and American Museum Collections from the Upper Miocene or Loup Fork Beds of Kansas and Nebraska, has finally been prepared for exhibition and research purposes. Associated with them, and of very great value, is a complete skeleton representing an aged female of very large size, mounted from materials belonging to several individuals secured by our excavations in Phillips Co., Kansas, under the direction of Dr. Wortman in the months of September, October and November, 1894.

By the comparison of the 16 skulls and 13 jaws, representing both sexes and all stages of growth, we are enabled for the first time to positively define the animal long known as *Aphelops fossiger*, to distinguish it both from *Rhinoceros* and *Aceratherium*, and point out its important sexual and individual variations. The writer's attention was first drawn to the largely disregarded sexual and age characters of fossil Ungulates in studying the group of Titanotheres;[1] the extinct Rhinoceroses conform to the laws which were observed in that group, and which are familiar enough among living types, namely: males, of larger size with more robust and rugose skulls; horns, if present, more prominent; canines largely developed; incisors and anterior premolars disappearing in adults.

We owe to Hatcher[2] the valuable demonstration that *Aphelops fossiger* bore a terminal horn upon the nasals, although he assigned this character to a type which he supposed represented a new species, namely, *Teleoceras major*. Hatcher's type of *T.*

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[1] 'The Cranial Evolution of Titanotherium,' Bull. Am. Mus. Nat. Hist., July 1, 1896, pp. 157–197.

[2] American Geologist, March, 1894, pp. 149–150.

major proves to be a middle-aged male of *A. fossiger*, and his distinction of *Teleoceras* as a genus supersedes *Aphelops* Cope,[1] because Cope[2] originally applied the term *Aphelops* to *A. megalodus*, defining it as an Acerathere with only three premolar teeth in the lower jaw. This is true of the type species (*A. megalodus*), but this species should, so far as we know at present, be referred to the genus *Aceratherium*, in which the lower premolars vary from four to three in number according to age and individual variation, as in the living Rhinoceros.

Technically, however, Hatcher's definition did not clearly distinguish *Teleoceras* from *Rhinoceros*, as he himself stated (*op. cit.*, page 245). Our abundant material proves not only that *Teleoceras* is a Rhinoceros with a median horn on the tips of the nasals, but that it is fully distinguished from the genus *Rhinoceros* as follows:

	Horns.	Lower Premolars.	Digits.
Genus *Rhinoceros*	Upon anterior portion of nasals	4 in young, 3 in aged individuals	3–3
Genus *Teleoceras*	Upon tips of nasals	3 in young, 2 in aged individuals	3–3

The reduction of the lower grinders to 5 in *T. fossiger* (as compared with 6 in *Rhinoceros*) is a very important and distinctive character, as it absolutely excludes *Teleoceras fossiger* from the ancestry of any of the modern Rhinoceroses, and shows it to have represented a distinct side phylum, as Scott and Osborn had already determined from its skeletal characters.

EXCAVATION OF THE SKELETON.

The Phillips County Quarry,[3] near Long Island, Kansas, was discovered in 1883 by Mr. Charles Sternberg, who collected for the University of Kansas and for the Harvard University Museum. From the latter collection Scott and Osborn procured materials

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[1] American Naturalist, March, 1894, pp. 241–246.

[2] 'On Some New Extinct Mammalia from the Tertiary of the Plains.' Palæon, Bull. No. 14, Proc. Am. Phil. Society, July 25, 1873.

[3] See Williston, 'Restoration of *Aceratherium fossiger* Cope,' Kansas University Quarterly, Vol. II, No. 4, April, 1894, pp. 289–290.

for the restoration which they published in 1890.[1] Subsequent collections were made by Sternberg and Hatcher for the United States Geological Survey, between 1884 and 1886. Later Professor Cragin collected here, and in 1891 Mr. E. P. West of the University of Kansas, aided by Mr. T. R. Overton, began the extensive collections which led to the preparation of the skeleton for the University under the direction of Professor Williston.[2] This skeleton, as mounted in the Kansas Museum and described by Williston, gives a much more accurate idea of this animal than the previous restoration by Scott and Osborn, in which the chest is represented far too shallow.

Its principal dimensions are as follows: Length, not including tail, 9 ft.; height, 4 ft.; greatest girth, 9 ft., 4 in.

The measurements of the American Museum skeleton as mounted are: Length, 10 ft. 2 in. to bend of tail; height at withers, 4 ft. 1 in.; greatest girth, 9 ft. 2 in.

From the above accounts, and especially from our own observations, it is seen that this quarry represents an old bone-bed, probably the deposit of some stream or small river along which the rhinoceroses herded in great numbers. The materials collected by the American Museum party are extremely numerous, especially in the skeletal parts, the figures running somewhat as follows: Skulls, 4; scapulæ, 7; vertebræ, 159; humeri, 13; radii, 20; ulnæ, 10; carpals, 90; metacarpals, 38; pelves, 5; femora, 8; tibiæ, 20; astragali, 22; calcanea, 18.

In this typical bone-bed are mingled individuals of both sexes and of all sizes, and the proximity of one specimen to another is not a certain guide. There are certain spots, however, where considerable portions of individual skeletons have drifted together. We associate the skull and pelvis in our mounted specimen, for they are of similar age and were found within about six feet of each other, the skull being that of a fully adult female, and the pelvis indicating a corresponding age, because the ilia are united above the sacrum; with the pelvis moreover was found a part of the jaw belonging to the skull; also with this pelvis

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[1] 'Preliminary Account of the Fossil Mammals from the White River Formation contained in the Museum of Comparative Zoölogy.' Bull. Mus. Comp. Zoöl., Vol. XIII, No. 5, p. 92, 1890.

[2] *Op. cit.*

belong a femur, tibia and fibula, astragalus, calcaneum and cuboid of one side, several metacarpals and metatarsals and two cervical vertebræ. The selection of the other limb and foot-bones was made from these as a guide.

Similarly about 300 feet distant were found the principal ribs which have been selected for this mount, characterized by the very rugose appearance and oblique lines for the insertion of the abdominal muscles (*sacro-lumbalis*, *longissimus dorsi*). Near these ribs were large jaw and limb-bones corresponding in size with those placed in the mounted skeleton. Apart from these probable associations, the main principle of selection adopted throughout has been that of the age and size standard, after a careful comparison of all the elements. In each region the largest and oldest bones were chosen. Upon this principle the ribs are shown to be of very great length ; the chest girth exceeds that indicated in the Scott-Osborn restoration, and equals that in the mount in the Kansas Museum, which has heretofore appeared extreme. In additional support of this correlation of material belonging to different individuals, this bone-bed gives evidence of the existence of only one species of Rhinoceros, namely, *T. fossiger*. All the differences observed are due to growth, individual and sexual variations, as set forth below.

The following description is supplementary to the very full statements of the skeletal characters of *T. fossiger* made by Osborn in 1890.

DESCRIPTION OF MOUNTED SKELETON.

(Museum Catalogue Number, 2604.)

Mounting.—The composite skeleton shown in the accompanying plate (Plate IV) has been mounted with remarkable skill by Mr. Adam Hermann, preparator. All the bones are traversed by small steel rods, rendering them firm and solid and the limbs self-supporting. As shown in the photograph, the only visible parts of the metal framework are the two uprights for the shoulder and skull, and pelvis. The bones are in a beautiful state of preservation, and except in the case of the artificial elongation of a few of the ribs and completion of the upper border of the scapulæ (from complete scapulæ of smaller size) no plaster was necessary.

Skull.—Nasals smooth, expanding into a laterally-compressed beak anteriorly, probably characteristic of adult females, with sharp sides and a lateral notch. Temporal ridges forming a sessile sagittal crest; premaxillaries with triple infraorbital foramina; lachrymals with well-defined, knoblike projection; zygomata very deep, with extensive attachment for masseter muscle inserted on a well-defined ridge on angle of jaw. Occiput broad and low. Jaw with a single mental foramen below the second or third premolar, and a marked median depression between the canines upon front surface of the chin.

Dentition. — Formula: $I\frac{2}{1}$, $C\frac{0}{1}$, $P\frac{3}{2}$, $M\frac{3}{3}$. Lower and median upper incisors vestigial; lower canines worn, enamel measuring 40 mm. (1½ inches). Adult condition indicated by very slight wear of crown of third superior molar. Upon outer surfaces of upper grinders parastyle nearly obsolete. First upper molar with enamel crown of same length as that of premolars. Second upper molar with sudden elongation or hypsodontism, with enamel crown measuring 70 mm. Thus $m\frac{2}{2}$ and $m\frac{3}{3}$ elongate or hypsodont, and of great service as reserve teeth for old age. Molars with secondary folds characteristic of the species.

Vertebræ.—Atlas much narrower than in *R. indicus*, with vertebraterial canal directly traversing the transverse process; axis with a very low spine; cervicals 1–3, with transverse process restored; characters of inferior lamellæ somewhat conjectural.

Supposed Vertebral Formula: C.7, D.19, L.3, S.5.

The above formula is purely conjectural. It is made to conform to that of the living *R. unicornis* and *R. sumatrensis.*[1] Seventeen of the ribs are provided with both capitular and tubercular facets. The ribs are extremely long and powerful, not very widely arched; lower line of chest nearly reaching the ground, as in

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[1] The definitely ascertained formula of the Oligocene *A. tridactylum* is D, 19; L, 5; S, 3. This animal gives us no clue to *A. fossiger*, because it belongs to the Diceratherе series.

the Hippopotamus ; girth (9′ 2″) exceeding that of *R. unicornis* (8′ 9″) ; chest section deep and heavy, rather than rounded as in *R. unicornis.*

Scapula very characteristic, triangular in contour, with pointed upper border ; narrow supraspinatus and very broad, triangular infraspinatus fossa ; acromion placed midway on spine, reflected backwards, so that attachment of deltoid and trapezius muscles is elevated. Coracoid process forming a prominent rugosity for short head of biceps ; bicipital tendons passing through a double osseous groove upon front of humerus (as in *R. unicornis*, *R. bicornis* and *R. simus*)[1, 2] and inserted distally in a prominent rugosity upon front of radius. Humerus exhibiting prominent rugosity for subscapularis muscle interior to inner tendon of biceps ; greater tuberosity consisting of a large incurved hook for supraspinatus muscle, and a separate and distinct knob for infraspinatus muscle ; powerful deltoid ridge, everted but not hooked ; distally a large external condyle for extensor muscles, which exhibit rugose insertion areas in the proximal ends of metapodials.

Pelvis with ilia arching over and coalescing above the five sacral vertebral spines, affording a stout area of origin for *latissimus dorsi*, *erector spinæ* and *gluteus maximus* muscles, correlated with support and propulsion of the enormous abdomen ; a foramen piercing the posterior superior border of the ilium. Femur with rugose but not very prominent greater trochanter; lesser trochanter for insertion of *gluteus maximus* muscle, much less prominent than in *R. unicornis*, and not hooked ; third trochanter not prominent. Pubis and ischium more slender than in *R. unicornis.* Tibia with a characteristic fissure in the cnemial crest dividing it into two distinct tuberosities for patellar tendons (unlike single crest of *R. unicornis* and *A. malacorhinus*). Fibula fused with tibia in aged individuals.

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[1] Busk 'On the Ancient or Quaternary Fauna of Gibraltar,' Trans. Zoöl. Soc., 1877, p. 97.
[2] De Blainville, 'Ostéographie,' Atlas 3, Gen. Rhinoceros, Pl. iv.

COMPARATIVE MEASUREMENTS.

	Teleoceras fossiger.		*Rhinocerus indicus.*	
	Feet.	Meters.	Feet.	Meters.
Total length to bend of tail	10. 2	3.10	10.8	3.05
Height, skull	4. 1	1.23		
" withers	3.11½	1.21	5.6½	1.69
Breadth, across pelvis	2.10	0.87	2.8	0.82
" " ribs	2.11	0.89		
Skull, length condyles to pmx	1.11¼	0.59	2.1½	0.65
" width across arches, dental series	1. 3	0.38		
Vert. column, total excluding caudals*	7. 9	2.36	8.2	2.48
Cervicals, including intervert. spaces	1. 6½	0.47		
Dorsals, " " "	4. 6½	1.39		
Lumbars, " " "		0.24		
Sacrals		0.21		
Rib (? 5th)—length (around the curve)		0.80		
(? 10th) "	3. 3½	1.01		
Girth of chest at 11th rib (estimated)	9. 2	2.80	2.9	2.66
Fore limb, total flexed (ball of hum. vert. to ground)	2. 4½	0.72	3.5	1.04
Scapula		0.38		
Humerus		0.31	1.4	0.40
Radius		0.24	1.3	0.38
Ulna		0.34		
Mc. iii		0.105	.8	0.20
Hind limb, total flexed (ball of femur vent. to ground)	2. 7½	0.80	3.8½	1.13
Femur		0.41	1.8	0.52
Tibia		0.23	1.2½	0.36
Mt. iii		0.100	7. ½	0.19
Lower jaw, total length, condyle to tip of canine		0.51		
Dentition, to tip of canine		0.35		
Grinding series		0.26		
*Length caudals (along curve)		0.81		

From the above measurements it appears that from head to tail *T. fossiger* is only six inches shorter than *R. unicornis*, while the back is eighteen inches (.580 mm.) nearer the ground. This remarkable lowering of the trunk is chiefly caused by the great reduction of the fore arm, fore leg and metapodials. The humerus and femur are respectively only 90 and 110 mm. shorter than in *R. unicornis*, while the radius and tibia (typically shorter elements) are respectively 140 and 130 mm. shorter, and the metacarpals and metatarsals are respectively 90 and 950 mm. shorter. This limb reduction is very striking. At the same time the abdominal girth exceeds that of *R. unicornis*, justifying Cope's conclusion that this animal had rather the proportions of the Hippopotamus than of the Rhinoceros. It will be recalled[1] that *R. unicornis* has a lower abdominal line than *R. sondaicus* or *R. sumatrensis*, or than either of the African Rhinoceroses. *T. fossiger*, therefore, had a totally different external appearance from any existing form.

JUVENILE, SENILE AND SEXUAL CHARACTERS.

There are conspicuous differences in the dentition of different specimens, all of which may be explained as due to influences of growth or sex.

In the young calf jaw (No. 2608) the milk cutting teeth are as follows : $\mathrm{di}_{\overline{2}}$, $\mathrm{dc}_{\overline{1}}$, $\mathrm{dp}_{\overline{3}}$. In the young *R. sondaicus* (*R. javanicus*), according to de Blainville, we similarly observe two milk incisors. A somewhat older calf of *T. fossiger* shows $\mathrm{di}_{\overline{1}}$, $\mathrm{dc}_{\overline{1}}$, $\mathrm{dp}_{\overline{3}}$.

Even in older jaws there is evidence in one case (No. 8391) of two lower incisors upon one side, the formula being : $\mathrm{i}_{\overline{2}-\overline{1}}$, $\mathrm{c}_{\overline{1}}$, $\mathrm{p}_{\overline{3}}$, $\mathrm{m}_{\overline{3}}$, as indicated by the incisor alveoli. The outer incisors ($\mathrm{i}_{\overline{3}}$) in the lower jaw tend to drop out at an early age, leaving only the alveoli ; but the vestigial upper incisors ($\mathrm{i}^{\underline{2}}$) are remarkably tenacious, although entirely useless.

The *canines* vary strikingly in the sexes. In the females (Nos. 2604–6, 2610-11, 2623), as shown in the photographs, they are of moderate size. In certain males (Phillips Co., Kansas, No. 2612 ; Republican River, Nebraska, Nos. 8391–2) they exceed in size any that have been recorded in other Rhinoceroses living or extinct, as shown in Pl. IVA.

No jaw shows any vestige of $\mathrm{p}_{\overline{1}}$. $\mathrm{P}_{\overline{2}}$ is present in young jaws, and invariably absent in very aged jaws. Its dehiscence is correlated with the coming into use of $\mathrm{m}\frac{3}{3}$. The upper molars, especially the second and third, are extremely hypsodont, the unworn enamel of the crown measuring, respectively : m2,=m3=. They are reserved for middle and old age.

The size of the skull differs considerably in the two sexes, the female skulls (Phillips Co., Kansas, Nos. 2604, 2607, 2622–3 ; Decatur Co., Kansas, No. 8388 ; Republican River, Nebraska, No.

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[1] See Sclater 'On the Rhinoceroses now or lately living in the Society's Menagerie,' Trans. Zoöl. Soc., 1875, pp. 645–651.

8393) being smaller and less rugose, with less prominent sagittal crests, and decidedly smaller nasals, as shown in Pl. IVA. In old females the nasals acquire a slightly rugose surface, and probably bore a small horn. In the males (Decatur Co., Kansas, Nos. 8385, 8396; Republican River, Nebraska, No. 8420) the nasals become greatly thickened at the extremities (Pl. IVA), forming a vertically compressed plate, which undoubtedly bore a considerable horn. Differences in size are observed in skulls from various localities, those from Decatur Co., Kansas, and from Nebraska, being larger than those from the Phillips Co. quarry, which are probably due to differences of geological level, the species running into a larger and more robust type before its extermination.

Growth-changes in the limbs are especially observed in the close fusion of the fibula with the tibia, and of the remarkable arching over of the sacrum by the superior borders of the ilium; this whole area above the sacrum forming a solid plate.

CONCLUSIONS.

T. fossiger may be briefly characterized as a brachycephalic, extremely short-limbed Rhinoceros, partly aquatic in its habits, with a very large brain and no diploë of the skull.[1] It parallels the African Rhinoceroses *R. simus* and *R. bicornis*, in the form of the humerus, femur and atlas, and in the terminal position of the nasal horn. The occiput, however, is widely different from that of the African Rhinoceroses, as well as of *R. sumatrensis*, resembling rather that of *R. unicornis*, although less pitched forward. The limbs are much shorter than in any living type, and, as pointed out by Pavlow,[2] at once recall those of *R. brachypus* and *R. aurelianensis*. A further comparison of *T. fossiger* strengthens the resemblance to the latter form. The proportions of the skull, limbs and metapodials are very similar. In both the cnemial crest of the tibia is double; the secondary folds of the superior molars are similar, as well as the general form of the skull. Further details will be given in the writer's forthcoming Memoir on the Extinct Rhinoceroses.

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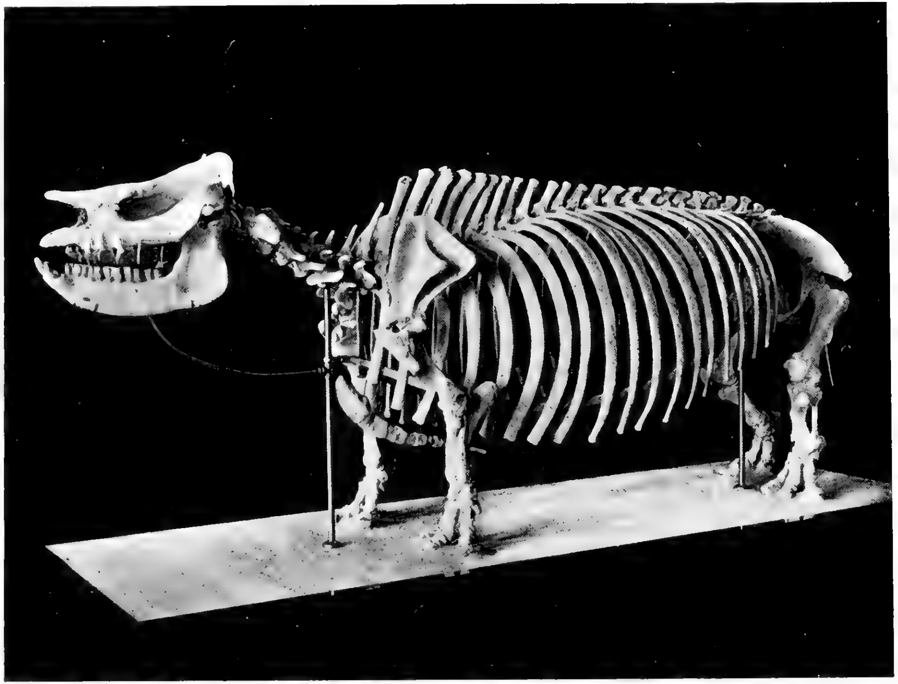
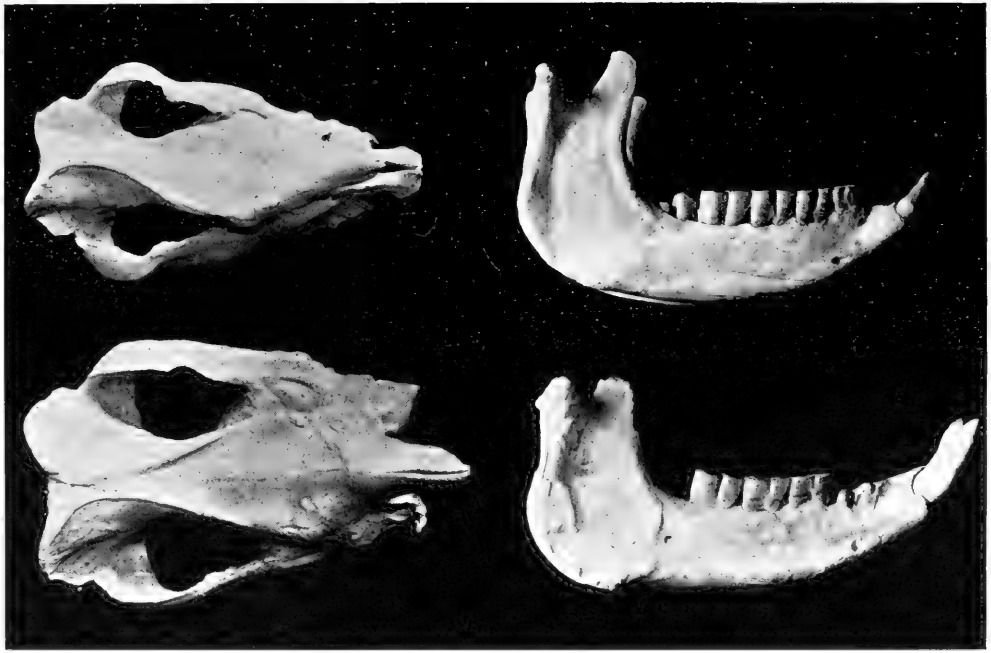
[1] See Scott and Osborn, *op. cit.*, 1890, p. 93.

[2] 'Les Rhinoceridæ de la Russie et le développement des Rhinoceridæ en général,' Bull. d. la Soc. d. Nat. d. Moscou, 1892.



MOUNTED SKELETON OF *Teleoceras fossiger.*

One-twentieth natural size.



Teleoceras fossiger.

FEMALE SKULL (No. 8393) AND JAW (No. 2606).

MALE SKULL (No. 8396) AND JAW (No. 2612).

A Complete Skeleton of Coryphodon radians. Notes upon the Locomotion of this Animal.

By HENRY FAIRFIELD OSBORN.

PLATE X.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
VOL. X, ARTICLE VI, pp. 81–91.

New York, April 4, 1898.

Article VI.—A COMPLETE SKELETON OF CORYPHODON RADIANS. NOTES UPON THE LOCOMOTION OF THIS ANIMAL.

By Henry Fairfield Osborn.

Plate X.

The chief object of the writer in planning the American Museum Expedition of 1896 was to complete materials for the investigation of the evolution of the Amblypoda, and extend our knowledge of *Coryphodon*. The observations of Cope, Marsh, Osborn, Wortman and Earle have been principally upon scattered and imperfect material, and it seemed of the utmost importance to secure materials sufficient to determine the relations of this animal to its ancestral form, *Pantolambda*, and to its successive form, *Uintatherium;* also the proportions of the body, the positions of its limbs and the number of its vertebræ. Accordingly our party, led by Dr. Wortman, aided by Mr. Granger of the Museum, and Messrs. Brown and Riggs of the University of Kansas, spent the months of April and May in northwestern New Mexico, revisiting the locality where Cope's most complete *Coryphodon*, *C. elephantopus*, had been found. The search here in the 'Coryphodon' or 'Wasatch Beds' was entirely unsuccessful, but fortunately the underlying 'Torrejon Beds' yielded a remarkably complete series of *Pantolambda*. The party moved to the north in June, and devoted July and August to a most energetic exploration of the Big Horn Basin, especially of the exposures on the south side of the Gray Bull River from Brown's Ranch towards the Big Horn River below Otto.

The party soon discovered two skulls, both in the sandstone. The first (No. 2867), upon level A, with four vertebræ and some fragments of limb bones associated with it, the teeth being badly weathered, has been mounted in our skeleton. The second (No. 2963) was found upon level B, 40 feet higher; it exhibits the form of the top and back of the skull, together with the complete teeth and palate. Shortly afterwards, upon the same level A as No. 2867, the skeleton (No. 2865) was discovered with fifteen ribs and vertebræ, the humerus, ulna, radius and two or three of the sternal bones. This was followed by the discovery on level A of the hind limb (No. 2869), several pairs of jaws, and finally, upon level B, the part of a crushed skeleton (No. 2829), including the skull, jaws, all the ribs and vertebræ in position. This, as Dr. Wortman wrote, made the party absolutely certain of a mount. The four skulls; Nos. 2827, 2867, 2963, 2865, with the associated skeletons, were thus found substantially upon the same geological level, they are in the same stage of evolution, and are found to belong to the classic species *C.* (*Bathmodon*) *radians* Cope, the first known in America.

The party then moved to the overlying Wind River Beds, and discovered a unique skull (No. 2977) of a distinct species, which reverses the natural order of evolution, since the sagittal crest is a little broader than one's finger. This exhibits the desired transition between *Pantolambda* and *Coryphodon*, and represents, in all probability, a persistent primitive type.

Altogether parts of 18 individuals were found in the Wasatch Beds (supplementing the 30 individuals found by Dr. Wortman in 1891), and 7 individuals in the Wind River Beds. The selection of nine individuals for mounting was done with great care as follows: The mounted skull, No. 2867, agrees exactly in size, and is specifically identical with the skull and jaws of No. 5829. The latter (No. 2829), while laterally crushed, had associated with it the right scapula and complete forelimb, left scapula and parts of left limb which were used in mounting; also all the vertebræ as far back as the pelvis; these vertebræ, while too much crushed to mount, enabled us to determine the formula and select, from series Nos. 2865 and 2863, vertebræ which exhibit the same characters. The latter individual (No. 2863) included the pelvis and hind limb, thus determining *positively the correct proportions of the entire animal.* The mounting was done with great skill and care by Mr. Hermann.

DESCRIPTION OF SKELETON.

Composite of nine individuals, all from the Big Horn Beds, as follows: No. 2867; skull, left humerus, left mtc. I and ectocuneiform; caudals 1–3, 10–11. No. 2867, lower jaw. No. 2829; right scapula and fore-limb complete; left scapula, magnum, trapezium, trapezoid, metacarpals I–V and phalanges. No. 2865; all cervical vertebræ, dorsals and ribs 1–9 complete, 3 phalanges of right pes. No. 2963; dorsals 10–15 and ribs complete, lumbars 1–5 complete, pelvis, left pes (excepting mts. I, III–V, and ectocuneiform). No. 2869; right hind limb complete (excepting mts. IV–V and 3 phalanges. No. 4329, left ulna, femur and tibia. No. 258; caudals 4, 5, 8. Sternals complete from No. 2825. *Restored:* left radius, left fibula, right mts. IV–V, left mts. III–V, caudals, 6, 7, 9, and 12–22.

In general one is struck by the very large size of the head, formidable front teeth, the shortness of the ribs, the heavy character of the girdles, the heavy limbs, and the semiplantigrade or subdigitigrade condition of the feet. It is probable, as already shown by the writer, that in the hind foot the calcaneum nearly touched the ground in the forward step.

The *skull* presents a very peculiar appearance with its powerful and spreading upper and lower canines, and widely spaced incisors, slender zygomatic arch and broad, flattened cranium. The following characters distinguish this specific type: Premaxillaries short, not reaching nasals; free portion of nasals short; nasals projecting between maxillaries, and then spreading upon inner side of frontal tuberosities; naso-frontal suture disappearing posteriorly; maxillaries occupying a broad area and bulging out opposite the canine alveoli and concave behind; lachrymals not clearly defined; frontals above the orbits supporting two prominent knobs or convexities, confluent with parietals posteriorly; parietals expanding above middle portion of temporal fossa, and lateral parietal crest thickening, as indicative of a rudimentary parietal horn; mid-parietal region depressed and extremely rugose for muscular attachment (*occipito-frontalis*); malars extending to the front of orbit, exhibiting a downward masseteric process slightly behind the orbit, expanding widely but slender in section; postglenoid processes for squamosal rather slender; external auditory meatus widely open, and paroccipital and posttympanic region compressed into a narrow ridge; occiput low and broad; lower jaws with condyle facing upwards and backwards; prominent depression posteriorly; a mental foramen below first premolar, a second mental foramen below lower canine.

Dentition.—The superior teeth, wanting in this specimen, are perfectly preserved in No. 2829, and agree with the fragmentary type specimen of *Coryphodon* (*B.*) *radians* Cope.

Vertebral formula: C.7, D.15, L.5, S.4.

This remarkably low vertebral formula is ascertained from No. 2829, in which all the dorsals and lumbars are retained in a single block and can be counted with considerable certainty. The formula is very low, but not more so than in *Titanotherium*, in which D. L.=20. The chief characteristic of the vertebral column is the series of low, undifferentiated neural spines, which are ill correlated with the heavy skull.

Cervicals.—Atlas moderately broad with a slightly expanded transverse process, perforated slightly above the base by the vertebrarterial canal. The spine of the axis extends equally forwards and backwards. The remaining cervicals exhibit a gradual development of the inferior lamella, which is well marked in C.6, but lacks the strength exhibited in the larger Perissodactyla. The cervical centra are very short, and the vertebral centra gradually increase in length and depth toward the lumbar region.

The most striking feature of the *dorsal* vertebræ, which is shared by *Phenacodus*, is the great prominence of the transverse process supporting the tubercle of the ribs. This projects widely out from the side of the vertebra in D.1, and gradually recedes to D.11, which is apparently the last vertebra in which the rib tubercle articulates. In all the dorsals the head is placed directly between the adjacent vertebræ from D.1 to D.15. The low spines characteristic of the cervical region extend back as a feature of the dorsals, the vertebræ exhibiting terminal tuberosities for the fascia of the ligamentum nuchæ. The dorsal vertebral spines gradually thicken in antero-posterior diameter; as they pass backwards they decrease in height. In the lumbar region they are cleft on the dorsal line. The lumbars terminate inferiorly in compressed keels.

MEASUREMENTS OF SKELETON.

	FEET AND INCHES.	METERS.	
Length incisors to perpendicular of tail	7′ 9½″	2.38	
Height at withers	3 4½″	1.03	
Fore Limb:			
Scapula	1′ 5″	.43	
Humerus.	1′ 3½″	.39	2′ 8½″ or .82
Radius.	10″	.25	
Manus, total.	7″	.17	
Hind Limb:		.71	
Pelvis, transverse	2′ 4″		
Femur	1′ 6½″	.47	2′ 11½″ or .90
Tibia	11″	.28	
Pes, total	6″	.15	

These measurements show that the tibia is only an inch longer than the radius, while the femur is three inches longer than the humerus.

The anterior pair of *ribs* is extremely short, the succeeding ribs increase in length and decrease in diameter, passing from a flattened into a trihedral form in D.6 and 7, and finally into an oval form in D.10–15. A characteristic feature of the ribs of D. 6-11 is a pit upon the upper surface just external to the tubercle.

The zygapophyses have horizontal faces as far back as D.15. In D.14 and 15 they turn obliquely upwards, the faces being vertically flattened. In L.1 to L.5 the zygapophyses are sharply concave and nearly vertical in position. The characters of the *caudals* are not certainly known, the few centra being restored from a number of different specimens. We have not ventured to give the tail the remarkably flattened character already described in a specimen found in 1892.

Fore Limb.—The scapula is vertically elongate, terminating in a point superiorly, and distinguished from that of *Uintatherium* by nearly subequal supraspinatus and infraspinatus fossæ. It is partly restored in the mount, but perfectly preserved in No. 2873. The spine rises near the superior border, is slightly thickened and reflected, and passes down into the acromion process, which turns sharply forwards and overhangs the great tuberosity of the humerus. The humerus is distinguished by the prominent greater tuberosity, which enters inferiorly the prominent and recurved deltoid ridge, extending far down upon the anterior surface, two-thirds the length of the shaft. The characters of this bone are best seen in No. 2780, an animal of the same size.

The entepicondyle is a rugose tuberosity, the ectepicondyle is more elevated on the shaft, and is marked by an anteverted ridge. The forearm is perfectly preserved upon the right side. The radius covers the front face of the humerus, and the distal faces of the ulna and radius are placed obliquely to the transverse axis of the body, facing upwards and throwing the fore feet and toes outwards rather than forwards. In this specimen the cuneiform does not articulate with the fifth metapodial, as observed in certain other specimens. The manus, as above described, is subdigitigrade, the lower surfaces of the proximal ends of the metapodials being slightly raised above the ground. The position of the metapodials in the forward step is, however, much more oblique than in the manus of the Elephant, the lower surfaces being nearer the ground.

The *pelvis* is partly restored in this mount. Its characters are better shown in No. 258. The ilia expand widely, but the antero-inferior border is not extended very far down. The ischia and pubes are strongly developed, and enclose a wide obturator notch.

A very characteristic feature of the skeleton is the long and rather slender form of the femur and the disproportion between the femur and the tibia, which is much greater than that which exists between the humerus and the radius. The great trochanter does not rise to the level of the head. The third trochanter is a long rather low crest, much less strongly marked than in *Pantolambda*, placed on the upper third of the inner side of the shaft. The lesser trochanter is very prominent, and lies slightly below the middle of the shaft. The patella is a very characteristic bone, but there is some doubt as to its position; it appears probable that the slender pointed spine of the patella faces upwards, as the long patella facet is thus made to correspond with the long facet on the inner side of the front face of the trochlea of the femur. The tibia is a very stout bone with a rather low cnemial crest, and rests by a slightly concave distal face upon the broad flat astragalus. The position of the pes is probably fairly represented in the left right foot, and although it is possible for the astragalus to be brought still nearer to the ground in the long forward step, it appears that in this type plantigradism is not so marked as has been stated by Osborn; probably the different species varied in this respect. As in the fore feet, the median digit faces outward. The astragalus has a well-marked astragalar foramen.

GENERAL APPEARANCE OF CORYPHODON.

The most accurate forecast of the appearance of the animal was that made by Cope[1] in 1874:

> "The general appearance of the Coryphodons, as determined by the skeleton, probably resembled the Bears more than any living animals, with the important exceptions that in their feet they were much like the Elephant. To the general proportions of the Bears must be added a tail of medium length. Whether they were covered with hair or not is, of course, uncertain; of their nearest living allies, the Elephants, some were hairy and others naked. The top of the head was doubtless naked posteriorly, and in old animals may have been only covered by a thin epidermis, as in the Crocodiles, thus presenting a rough, impenetrable front to antagonists.
>
> "The movements of the Coryphodons, doubtless, resembled those of the Elephant in its shuffling and ambling gait, and may have been even more awkward, from the inflexibility of the ankle. But, in compensation for the probable lack of speed, these animals were most formidably armed with tusks. These weapons, particularly those of the upper jaw, are more robust than those of the Carnivora, and generally more elongate, and attrition preserved rather than diminished their acuteness. The size of the species varied from that of a Tapir to that of an Ox."

Osborn[2] in 1892 wrote as follows:

> "The fact is, the position of the fore and hind feet of Coryphodon is absolutely different. The *fore foot was digitigrade*, like that of the Elephant, the *hind foot was plantigrade*, like that of the Bear. In other words, the carpus was entirely raised from the ground and the manus rested upon the distal ends of the metacarpals and upon the spreading phalanges, while the calcaneum

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[1] Vertebrate Palæontology, Vol. IV, Wheeler Survey, p. 203.

[2] Fossil Mammals, of the Wasatch and Wind River Beds, Collection of 1891, Osborn & Wortman, Bull. Am. Mus. Nat. Hist., Sept., 1892, p. 121

and tarsus rested directly on the ground together with the entire plantar surface of the foot. This substantial difference between the advanced state of evolution of the fore foot and retarded evolution of the hind foot, is of great interest. It is clearly shown in the accompanying figures."

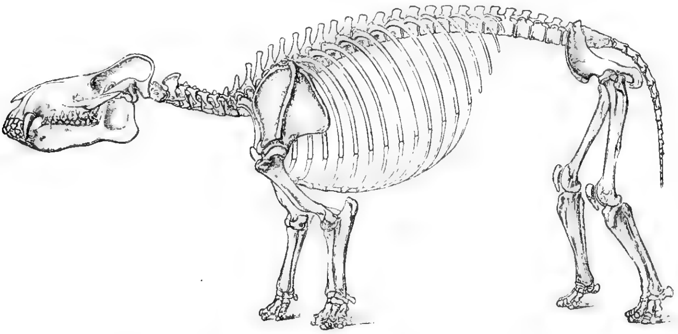

Fig. 1. *Coryphodon hamatus*, as restored by Marsh, 1893. One-twentieth natural size.

In 1893, Marsh,[1] in his description and restoration, presented quite a different conception of the animal as *unguligrade.* In regard to these matters he makes the following statement :

"This restoration is given one-twelfth natural size. The position shown was chosen after careful consideration, and is believed to represent fairly one naturally assumed by the animal in life when standing at rest. The figure represents a fully adult individual, and one of the largest species of the genus which, when alive, was nearly six feet in length and about three feet in height. The basis of this restoration is the type specimen of *Coryphodon hamatus.* This was supplemented by other remains, which appeared to be superficially identical. A large number of such specimens were available, some of them in excellent preservation. For parts of the skeleton where such remains were wanting specimens from nearly allied forms were used, but no serious error can thus result.... The fore feet presented in the present restoration are constructed mainly from the same specimen (that first figured and described by the writer), and the position given in the original figure has been essentially retained.... The position first given to the figure is retained in the restoration after a careful investigation of the whole posterior limbs in a number of well-preserved specimens. In *Dinoceras* the terminal

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[1] 'Restoration of Coryphodon,' Amer. Journ. Science, Oct., 1893, p. 324.

phalanges are much larger than in the Elephant, so that they thus bore a greater weight, the digit being undoubtedly free, although a pad may have helped to support the feet. In *Coryphodon* the digits were still more elongate and the terminal phalanges proportionately larger and broader, indicating that they

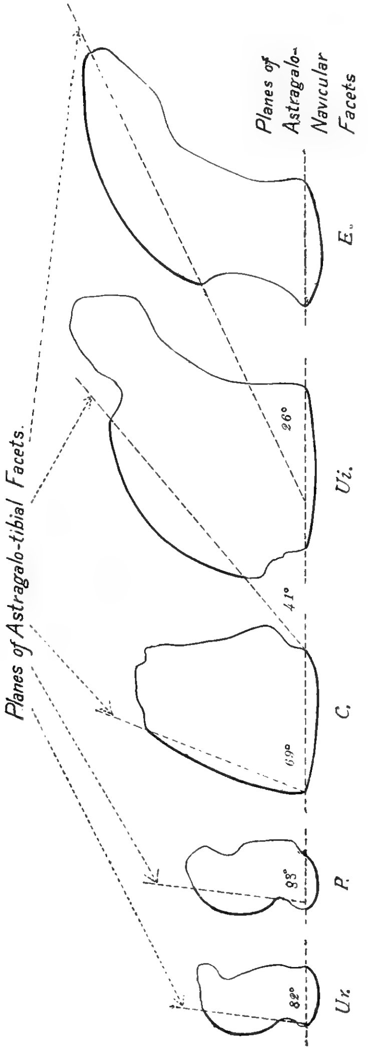

Fig. 2. Diagrams showing the *Angles* between the *Astragalo-tibial* and *Astragalo-navicular* facets, obtained by vertical sections of the Astragalus. *Ur.*, Ursus, plantigrade; angle, 82°. *P.*, Pantolambda, plantigrade; angle, 83°. *C.*, Coryphodon, transitional; angle, 69°. *Ui.*, Uintatherium, subdigitigrade; angle, 41°. *E.*, Elephas, digitigrade; angle, 26°.

were covered with hoofs that supported the feet. This would agree with the position given them in the restoration, which coincides with the anatomical structure of the entire hind limb."

This clear statement of Professor Marsh's as to the position of these limbs is consistent with his restoration, in which not only the metapodials but the phalanges are raised from the ground, and the animal is represented as walking upon the tips of its toes, or terminal phalanges, the latter being supported by hoofs. The morphological importance of this restoration is very great. If correct it places *Coryphodon* among the Unguligrada, widely removed from the unquestionably plantigrade *Pantolambda*. Contrary evidence that *Coryphodon*, so far from being unguligrade, was transitional between complete *plantigradism* and *digitigradism*, is given below. Many other important morphological characters are involved in Marsh's restoration, and are now found to be incorrect. The scapula is given a trihedral form, with a very broad angular infraspinatus fossa; the pelvis is extraordinarily reduced; the limbs are elongate and, together with the above-mentioned unguligrade action of the digits, elevated the body very much from the ground. In proportion to the scapula, the humerus, the ulna and the radius are of very great length, and similarly the tibia is only slightly shorter than the femur. The most important character, however, is that assigned to the vertebral column, there being 19 dorsals and, as far as can be determined from the drawing, 6 lumbars, or D. L.=25, a formula exceeding that of the Rhinoceros. The net result of these observations is to give the animal the general appearance and characters of a modern Perissodactyl,[1] with the single important exception of the five digits preserved in the fore and hind feet.

It appears from our more complete material that the difference between the feet was exaggerated by Osborn, as already observed by Marsh. There is no doubt, however, that as seen in the mounted specimen, in the forward step the calcaneum rested very near the ground, being separated merely by a thick plantar pad. The digits of the fore and hind feet have nearly the same relations to the ground. *Both feet are in a somewhat similar stage of transition between plantigradism and digitigradism.* *Pantolambda* has a long tuber-calcis and pes like that of the Bear. *Uintatherium* has a very short tuber-calcis and bore the pes slightly more plantigrade than the Elephant. *Coryphodon* has a tuber-calcis intermediate in length; in the astragalus the upper facet for the tibia and lower facet for the navicular presents an oblique angle, the astragalus thinning out to a sharp edge in front (whereas in *Uintatherium* these facets are more nearly parallel, and the astragalus is truncate in front). The angles between the tibial and navicular facets of the astragalus, as shown in sections in Fig. 2, afford the most decisive evidence that the pes of *Coryphodon* was intermediate between the nearly plantigrade *Pantolambda* and the sub-digitigrade *Uintatherium.*

Coryphodon had a very short back and short, spreading limbs, with a very clumsy, shuffling gait.

The rudimentary horn observed for the first time in the parietals is prophetic of the great parietal horn of *Uintatherium.* Many other characters of the skull and skeleton are also prophetic, but there is little tendency displayed to reduce the upper incisors or lower canines into the Uintathere type.

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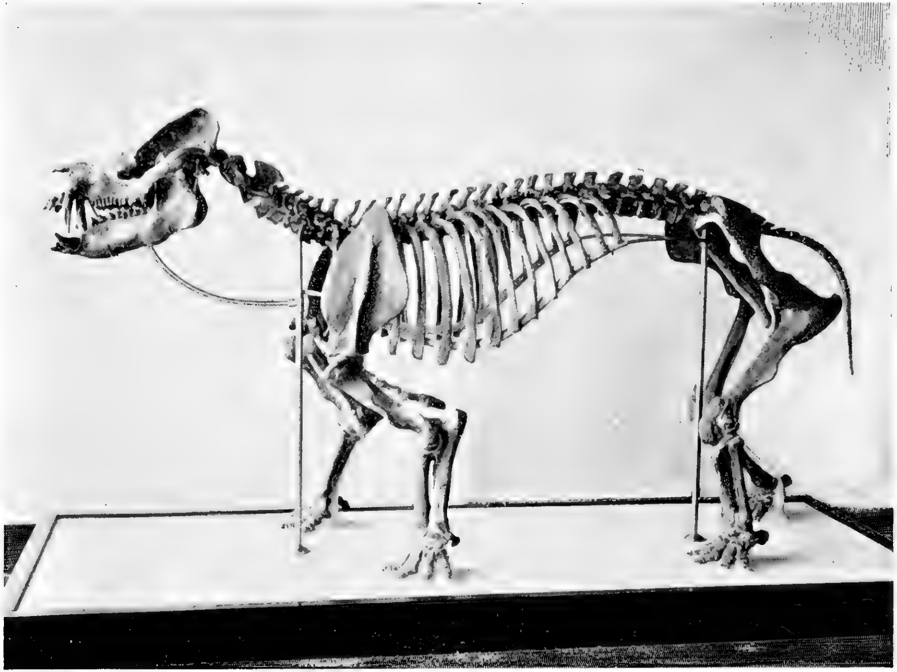
[1] The Perissodactyl affinities of the animal were dwelt upon in Professor Marsh's earlier papers (Am. Jour. Sc., 1876, page 428; *op. cit.*, 1877, page 84), but were abandoned subsequently ('Dinocerata,' 1884, page 177), in which *Coryphodon* was correctly associated with *Uintatherium* in the Amblydactyla (Amblypoda).



MOUNTED SKELETON OF *Coryphodon radians*.
Slightly exceeding one-fifteenth natural size.

The Extinct Camelidæ of North America and some Associated Forms.

By J. L. WORTMAN, M.D.

PLATE XI, AND TWENTY-THREE TEXT CUTS.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
VOL. X, ARTICLE VII, pp. 93–142.
New York, April 9, 1898.

Article VII.—THE EXTINCT CAMELIDÆ OF NORTH AMERICA AND SOME ASSOCIATED FORMS.

By J. L. Wortman, M.D.

Plate XI, and Twenty-three Text Cuts.

Among the living selenodont Artiodactyla the Camels and Llamas of the Old and New World represent a very aberrant group. Even if one were not familiar with the wonderful record of their past history as revealed in the Tertiary deposits of this country he would be quite justified, from the number of anatomical peculiarities which they exhibit, in placing their origin far back in the Tertiary, at a time when the primitive divergence of the various lines of the Selenodonts was taking place.

The evidence is not yet sufficiently complete to trace the phylum with absolute certainty below the upper Eocone or Uinta stage, but from this point on to the present time there is very little to be desired, in the way of intermediate species, to form a compact and closely connected series, reaching to the modern types.

More or less elaborate studies of this group have been made by Cope[1] and Scott,[2] to whom we are especially indebted for much knowledge concerning the extinct forms, and while it would be difficult to add anything to their statements from the specimens known to them, yet the acquisition of a large amount of new material bearing upon this subject by the various Museum expeditions within the past few years has rendered it especially desirable to review the whole subject, with a view to defining, if possible, the exact limits of the various genera and species of the extinct North American representatives. The object of the present paper, therefore, is: (1) A review of the genera and species of the North American Tylopoda, with descriptions of

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[1] 'Phylogeny of the Camelidæ,' Amer. Nat., 1886, p. 611.

[2] 'On the Osteology of Poëbrotherium,' Journ. of Morph., 1891. 'The Mammalia of the Uinta Formation,' Trans. Amer. Phil. Soc., Aug. 20, 1889.

additional materials of known types, as well as of new allied forms; (2) a careful consideration of the various steps in their evolution; and (3) a study of certain osteological characters of the higher selenodont Artiodactyla in its direct bearing upon the transmission of acquired characters.

The oldest members of Tylopoda which we can determine with certainty are found in the Upper Eocene deposits of the Uinta Basin, which strata, it may be noted, contain the first remains of true selenodont Artiodactyla in this country, a fact originally pointed out by Marsh, who was the first to explore this region for fossil remains. In the preceding deposits of the Bridger Basin the remains of Artiodactyla are found, but are very rare, no truly selenodont types being known. It is true that in several genera, such as *Homacodon* and *Helohyus* of Marsh, we have a distinct foreshadowing of the selenodont molar, yet it is not until the Uinta is reached that the true Selenodonts appear.

Mr. O. A. Peterson, to whom we are largely indebted for the beautiful collection now in the Museum from this horizon, divides these beds into three stages,[1] which he designates as the lower, middle, and upper Uinta Beds, or, to use his own field designation, Horizons *A*, *B*, and *C*. A large part, if not the entire lot, of these remains were obtained from the lower part of Horizon *C*, or the upper part of Horizon *B*, so that their stratigraphical position would be correctly stated to be at least 300 to 400 feet below the top, and at least 800 feet from the bottom of the Uinta formation. No fossils are known from the upper levels of Horizon C, nor do we know any Artiodactyla from the Brown Sandstones, 800 feet in thickness, constituting Horizon A. If, therefore, close connections between these Uinta forms and the preceding Bridger species, on the one hand, and the succeeding White River, Oligocene species, upon the other, are not shown to exist, the fact is, in all probability, due to our lack of knowledge of the species which lived during the time of deposit of these intermediate strata.

The identification of these Uinta Cameloids is attended with more or less difficulty, owing in part to the fragmentary condition

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[1] See Osborn's 'Fossil Mammalia of the Uinta Basin,' Bull. Am. Mus. Nat. Hist., Vol. VII, p. 74.

of some of the material, and in part to other lines which resemble them in certain points of skull and limb structure. These resemblances are, no doubt, due to the close proximity to the point at which the respective phyla began to diverge.

For the purpose of bringing into stronger relief the characters of the Cameloids of this horizon, it is necessary to compare them accurately with the cotemporary Selenodonts, and, since several of them apparently represent new genera, they are herewith described.

Leptoreodon marshi,[1] gen. et sp. nov.

This genus and species is represented in the collection by an almost perfect skull in good state of preservation, a number of vertebræ, and a few fragments of the limbs (No. 2064), which I use as the type. There are several other specimens of a more fragmentary character which are probably to be referred to the same genus and species, but they contribute little additional information to the knowledge of the skeleton. The genus differs from all the Oreodonts hitherto described in the possession of a short diastema in front of, and a longer diastema behind, the first superior premolar, together with a considerable diastema between the first and second premolar in the lower jaw. The incisors are

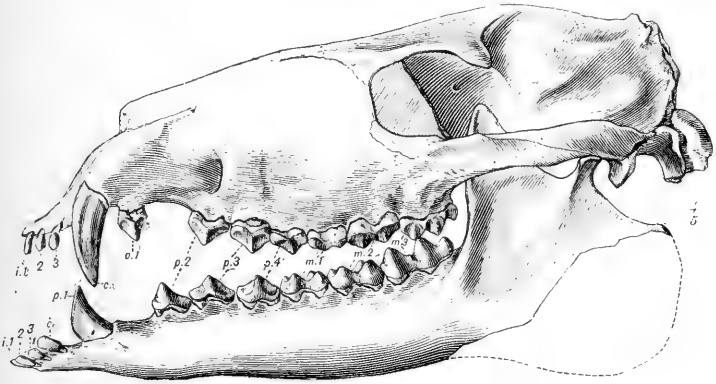

Fig. 1. Side view of skull of *Leptorcodon marshi.*

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[1] This species is dedicated to Prof. O. C. Marsh, in recognition of his numerous contributions to American palæontology.

present in full in both jaws; the inferior canine is small and incisiform; the superior canine is large, with the characteristic D–pattern of the Oreodonts on cross section, and the first inferior premolar is enlarged and caniniform as in the Oreodonts. The first superior premolar is two-rooted with a high, compressed cutting crown, the second is similar but somewhat larger, the third has a principal broad, lunate external cusp and a faint internal cingular ledge. The fourth premolar crown is composed of a single external and internal cusp, much as in the Oreodonts.

The superior molars closely resemble those of *Protoreodon* (*Eomeryx*) in the composition of the crown, so far as can be determined in their advanced stage of wear in the type specimen. It is impossible to say whether or not there were anterior intermediate cusps present, but judging from certain appearances in this region of the crown, I am inclined to think that less worn teeth would show them. The mesostyle consists of a vertical pillar as in the Oreodonts generally, and not of a wide open loup as in *Agriochœrus*.

In the lower jaw the incisors and canines are of the typical oreodont pattern, but they are unusually procumbent in position. The first premolar is enlarged and caniniform, the second simple, the third with a small internal cusp and posterior heel, and the fourth similar in pattern, except that the internal cusp is smaller and the heel more pronounced. The lower molars are almost identical in structure with those of the early Oreodonts.

The whole skull differs from that of the Oreodonts in its more slender proportions. This is particularly noticeable in the lower jaws, which are relatively long and shallow, especially in the region of the symphysis, in marked contrast with the deep and abrupt chin of the Oreodonts in general. There does not appear to have been a preorbital pit present, and the orbit was not enclosed by bone posteriorly. The present genus may be distinguished from its contemporaries in the following dental characters, viz.: from *Protoreodon* (*Eomeryx*) in the possession of diastema in both jaws and the full number of incisors in the upper jaw.[1]

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[1] In all of our material I have not yet seen a specimen among the Oreodonts other than *Leptoreodon* that has a full set of incisors in the upper jaw. Marsh figures the type of *Eomeryx pumilis* with but two superior incisors, and if *Protoreodon* has the full complement, as believed by Scott, then the two genera are certainly distinct. In two specimens in the Musuem collection which correspond closely with *Protoreodon parvus*, as described by Scott, there is but a single incisor on each side above, and the premaxillæ are widely separated from each other in the median line.

From *Hyomeryx* it is readily distinguished by the full number of superior incisors and by the diastema, although it resembles this latter genus, which is described by Marsh[1] as having more slender jaws than *Protoreodon* (*Eomeryx*). From the cameloid, *Leptotragulus*, it is easily separated by the numerous oreodont characters which the skull exhibits, although the symphyseal region is strikingly similar in the two genera.

Of the hind foot, the cuboid, navicular and the head of the third metatarsal are sufficiently preserved to afford characters for identification. These bones indicate an animal with far more slender limbs and feet than any of the Oreodonts with which I am familiar. The navicular has an inconspicuous posterior hook unlike that of the Oreodonts, and, judging from the much reduced facet on the cuboid, the fifth digit was considerably diminished in size if not entirely rudimental. The limb-bones are not well enough preserved to confirm or negative this conclusion of the slender and delicate proportions of the animal, but, upon the whole, I think it may be safely concluded, from the evidence at hand, that *Leptoreodon* held the same position with reference to the American Oreodontidæ that *Xiphodon* did to the European Anoplotheriidæ.

The second genus to be described in this connection contains species somewhat smaller in size and less perfectly selenodont.

Bunomeryx montanus, gen. et sp. nov.

There are two specimens in the collection which I classify under this head, viz. : an anterior portion of a cranium somewhat crushed, containing the maxillary dentition complete upon one side, together with the greater part of the left mandibular ramus of the left side having all the true molars and the last premolar in good preservation (No. 2071). The second specimen consists of a portion of a lower jaw with a few teeth, the posterior part of the cranium, a nearly complete fore foot, portions of the hind limbs and other parts of the skeleton (No. 2070). The first of these specimens may be taken as the type, but there can be very

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[1] 'Descriptions of Tertiary Artiodactyles,' Amer. Jour. Sci., Vol. XLVIII, Sept., 1894, p. 268.

little doubt that the second specimen is identical with the first and can be regarded as a collateral type.

This genus most nearly resembles *Homacodon* Marsh, from the Bridger Beds, although it presents some dental characters similar to *Dichobune* of the European Eocene. The more important generic characters may be stated as follows :

Dentition, $I\frac{?}{3}$, $C\frac{1}{1}$, $Pm\frac{4}{3}$, $M\frac{3}{3}$. Superior molars, having well-defined crescentic outer cusps and a distinct mesostyle and parastyle ; first molar provided with two conic internal cusps (protocone and hypocone), with anterior and posterior subcrescentic intermediates; second molar having anterior subcrescentic intermediate, subconic protocone, a posterior subcrescentic intermediate and no hypocone ; third molar similar to second. The superior premolars are present in full number ; the two anterior have simple cutting crowns, while the crowns of the third and fourth are made up of single external and internal conic cusps well developed. In the lower jaw the structure of the molars is intermediate between the bunodont and selenodont pattern ; there are only three premolars, the anterior two of which have simple compressed crowns, while the last or fourth of which is provided, in addition to the principal cusp, with anterior and internal cusps, together with a well-defined heel.

As compared with *Homacodon*, *Bunomeryx* is readily distinguished (1) by the possession of three premolars in the lower jaw ; (2) by the crescentic character of the external cusps of the superior molars ; (3) by the presence of a well-developed parastyle and mesostyle ; (4) by the absence of the hypocone on the second superior molar, and (5) by the subcrescentic character of the intermediates. (6) The internal cusp of the third superior premolar is, moreover, better developed in *Bunomeryx* than in *Homacodon*, and (7) the fourth inferior premolar is much more advanced in structure. The structure of the inferior molars is much more selenodont in *Bunomeryx* than in *Homacodon*.

From *Dichobune* the present genus is readily distinguished by the absence of all traces of the anterior cusp of the trigon in the lower molars as well as the more crescentic character of the outer cusps of the superior molars, and the possession of well-defined mesostyle and parastyle. The complete adult dentition of *Dichobune* is apparently not known, but there can be but little doubt that it had the full number, forty-four teeth, in which case *Bunomeryx* would be sharply distinguished by the inferior premolar formula. I cannot at present say in what manner *Bunomeryx* differs from the European *Deilotherium*, *Spaniotherium*, *Metriotherium*, *Mouillacitherium* and *Oxacron* of Filhol, which are placed by Zittel in the subfamily Dichobuninæ. On account of the very imperfect knowledge we have of these forms, no comparisons are at present possible.

In specimen No. 2071, the upper and posterior portion of the cranium is sufficiently preserved to indicate a relatively high overhanging occipital and a strong sagittal crest, the latter dividing into two well-marked lateral postorbital branches. In advance of the point of division of these two branches a strong ridge is continued forward upon the frontals in the median line as in many of the lower forms of the Selenodonts. The postorbital process is well developed, but it does not join the molar, so that the orbit is not enclosed by bone posteriorly. There is no evidence of the presence of any long horn-cores.

Of the fore limb, the distal ends of the ulna and radius are preserved, but they are considerably crushed. There is apparently little or no tendency to coössification of the bones, although the shafts are closely applied to each other in the lower third of their extent. The articular end of the radius shows distinct facets for scaphoid and lunar, but does not touch the cuneiform. The distal end of the ulna articulates solely with the cuneiform.

The carpus is of the typical artiodactyl pattern, and especially resembles that of the earlier Selenodonts. In the proximal row the cuneiform rests exclusively upon the unciform, the lunar about equally upon magnum and unciform, while the scaphoid is supported below by magnum, trapezoid and trapezium. In the distal row the unciform articulates distally with Mt. III, and to a slight extent with Mt. II. In the modern Suillines, the Cameloids and the later Oreodonts, the second metacarpal has lost all connection with the magnum, but in the early Oreodonts Mt. II still retains a contact between these two bones. In *Protoceras* of the Oligocene a very minute contact is observable.

The trapezoid is free, and shows no tendency to unite with the magnum as in *Leptomeryx*, the later Tragulines and Pecora. The trapezium is not preserved in the specimen, but judging from the well-marked facets upon the scaphoid, trapezoid and Mt. II, it is quite certain that it was not only present and of good size, but that it supported a very considerable vestige of the first digit. It would not indeed be a matter of surprise to find this digit complete in more perfect specimens very much as in *Oreodon.*

There are four metacarpals preserved of which the median ones, Mt. III and IV, are the largest and subequal in size. Mt. II is slightly larger and longer than Mt. V, and in all of them the distal keels are confined to the palmar surfaces, as in all primitive Ungulates. The phalanges of the fore feet are not known.

Of the hind limb the materials are not so complete as of the fore limb, but enough is preserved to make out its more important characters. The fibula was much reduced, and probably incomplete in the middle part of the shaft. The distal end of the tibia displays no usual form of the more generalized Selenodonts, as do the tarsal bones. The cuboid and navicular were not coössified, and there is evidence of four complete metapodials, the lateral ones, however, being unusually slender and delicate. The first two phalanges resemble those of the early Cameloids, *Protoceros* and *Leptomeryx* in their form, as do likewise the unguals in being relatively high-pointed and flattened upon their opposed surfaces.

Bunomeryx elegans, sp. nov.

A second species of this genus is indicated in the collection by a portion of a cranium containing the last three premolars and the molars, in excellent preservation, together with both mandibular rami bearing all of the teeth with the exception of the incisors and canines.

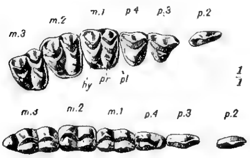

Fig. 2. Crown view of upper and lower teeth of *Bunomeryx elegans*. *hy.*, hypocone; *pr.*, protocone; *pl.*, protoconule.

The most important difference between the two species is seen in the presence of a short diastema between premolars two and three of the lower jaw in *B. elegans.* In *B. montanus* this diastema is absent, and the teeth of the lower jaw were apparently in a continuous series or closed row. *B. elegans* is smaller and more delicate than *B. montanus*, a fact that is not only indicated by all the teeth but particularly emphasized by the fourth inferior premolar, which is considerably narrower and has a less development of the internal cusp. Another important distinction between the two species is found in the greater development of the vestigial hypocone of the second superior molar of *B. elegans.* In *B. montanus* this cusp has almost entirely disappeared, the only evidence of its presence being indicated by a cingulum in this portion of the crown.

One fact of great interest in connection with this genus is the probable light which it throws upon the homologies of certain cusps of the molar crown in the higher selenodont Artiodactyla. It is here that we witness the actual passage from the bunodont to the selenodont type of molar in this important group. If we can trust the evidence before us, *Bunomeryx* is a direct lineal descendant of the Bridger *Homacodon*, and it is a matter of the utmost moment to note that in the latter genus there are six fully-developed cusps upon the crowns of the first and second superior true molars ; in the third there are only five cusps present. In *Bunomeryx*, as already indicated, the full six cusps are found on the first superior molar only, while in the second molar there is but a vestige of the postero-internal cusp or hypocone. The evidence appears to be conclusive, therefore, that the true homological hypocone is in process of retrogressive disappearance, and in proportion as this cusp is reduced, the posterior intermediate is pushed out to take its place. As a further evidence of the truth of this proposition it may be stated that the true hypocone of both the first and second molars of *Homacodon*, as well as the first molar of *Bunomeryx*, exhibits no tendency whatever to develop a selenodont structure, while the posterior intermediates especially in *Bunomeryx*, exhibit very decided advances in this direction. The very position of this cusp, moreover, precludes any possibility of its entering into the formation of the single posterior internal crescent of the more perfectly developed selenodont molar of the higher types.

I believe therefore that the history of the formation of the four crescents of the superior molar crowns of the Selenodonts has been as follows, tracing it from the five-cusped *Pantolestes*[1] of the

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[1] From this genus I exclude the type of *Pantolestes etsagicus* Cope as belonging to a distinct genus ancestral to and leading directly up to the bunodont Artiodactyla. It is very probably synonymous with *Eohyus distans* of Marsh, who properly placed it among the Bunodonts.

Wasatch. The primitive condition of this oldest type of the Artiodactyla was two buniform external cusps, two buniform intermediates, together with one large more or less lunate internal cusp, flanked by a rudimental postero-internal cusp which is clearly shown to be an outgrowth from the cingulum. There is no evidence that this postero-internal cusp was ever developed on the last molar, because in all the forms from *Pantolestes* to *Bunomeryx* it is persistently absent. The next step consisted in the reduction of the large lunate internal cusp and the full development of a well-marked postero-internal cusp, or hypocone, on the first and second molars. This condition is seen in, and is characteristic of, *Homacodon.* The third step consisted in the disappearance of the true hypocone and the gradual usurpation of its place and function by the posterior intermediate in the crown of the second true molar, a condition seen in *Bunomeryx.* As a fourth step in this development one can readily imagine this process extended to the first true molar, when it would be complete.

This hypothesis may be objected to on the ground that *Bunomeryx* cannot stand as the direct ancestor of any of the Selenodonts at present known, on account of its reduced premolar dentition in the lower jaw, but if we are to regard the type of superior molar exhibited by either *Homacodon*, *Dichobune* or *Helohyus* as the one which preceded, and from which was derived the tetraselenodont or four-crescented crown, then this hypothesis must be accepted as true.

The only case so far known wherein the true hypocone has been preserved and has become crescentic, is in *Cænotherium* and *Plesiomeryx,* and here we have three well-developed crescents upon the posterior moiety of the crown, of which the inner one represents the hypocone and the middle one the posterior intermediate. It is possible that the cusps of the two anterior superior molars of *Xiphodon* are to be interpreted in the same way, and that the posterior inner crescent is composed solely of the posterior intermediate, the true hypocone having come to occupy a more anterior and median position. In this case the anterior internal crescent would be made up of protocone and the anterior intermediate. Future discovery will no doubt reveal considerable variety in the formation of the internal crescents in the various phyla of the Selenodonts, but it appears to me certain that the hypothesis herein advanced is the correct one for the formation of the tetraselenodont superior molars of the Cameloids, Pecora, Tragulines, and probably the Oreodonts and Anthracotheres.

Parameryx (Leptotragulus) proavus *S. & O.*

This genus was first described by Marsh[1] and later by Scott and Osborn,[2] who considered that it to belongs to the Traguline division of the order. Later Scott gave a fuller account of it[3] and placed it in the Tylopoda[4] immediately ancestral to *Poëbrotherium* of the White River Oligocene. The materials in the Museum Collection do not add very materially to the knowledge of this form ; however, there are some important points to be made out from it. There are four specimens which I refer to this species, the most important of which are a fragmentary skeleton containing a fairly good hind foot, together with the posterior part of the last lower molar (No. 2509). The other specimens pertain exclusively to the lower jaw (Nos. 1803, 1805 and 1808).

In the lower jaw there is one diagnostic character by means of which the last lower molar can be recognized, and that is the presence of an extra cusp upon the inner border of the heel near its point of junction with the postero-internal cusp. It is by means of this character alone that I associate the fragmentary skeleton with this species. The lower molars are of the typical selenodont pattern, and the cusps more elongated than in any of the cotemporary Selenodonts.

The inferior premolars are three in number, the fourth being provided with a well-developed internal cusp and heel. The second and third are simple and without accessory tubercles. In advance of the second premolar there is a considerable diastema, in front of which is the large procumbent alveolus for the canine. The incisors are not preserved, and this region of the jaw is so much broken as not to reveal their alveoli.

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[1] 'Introduction and Succession of Vertebrate Life in America,' 1877.

[2] 'Preliminary Report on the Vertebrate Fossils of the Uinta Formation,' Proc. Am. Philos. Soc., 1877, pp. 255, 264.

[3] 'Mammalia of the Uinta Formation,' Trans. Am. Philos. Soc., N. S., Vol. XVI, Part iii, Aug. 20, 1896, pp. 479–486.

[4] Marsh had, however, clearly recognized the affinities of this genus with the Tylopoda ten years previously, since we find in the address above quoted the following statement : "A most interesting line, that leading to the Camels and Llamas, separates from the primitive selenodont branch in the Eocene, probably through the genus *Parameryx.*

Of the bones of the hind foot, the entire tarsus is preserved with the exception of the cuneiform. These parts of the skeleton present a most striking resemblance to those of *Poëbrotherium* in all the details of their structure, the only difference discoverable being that of size. The third metatarsal is present but unfortunately a small part of the shaft is missing so as not to exhibit its full length; there is enough, however, to indicate that it was unusually long and slender, much flattened upon the surface which it offered to the second metatarsal, and that the form of the shaft, moreover, had that peculiar squarish outline upon cross section, a feature so highly characteristic of the Oligocene Cameloids. Another distinctive cameloid feature is seen in the increased size of the medullary cavity. The lateral or fifth metapodial was reduced to a mere splint, as is indicated by the much-reduced facet upon the cuboid; this facet is relatively as small as it is in the cuboid of *Poëbrotherium.* The phalanges have about the same proportions and shape as the corresponding bones of the White River species.

That *Parameryx* (*Leptotragulus*) was a member of the Tylopoda, as has already been pointed out by Marsh and Scott, there can be very little doubt, but at the same time the evidence is equally conclusive that it does not stand in direct ancestral line with the succeeding Poëbrotheres. The evidence against such a conclusion is to be found in the fact that *Parameryx* (*Leptotragalus*) has only three premolars in the lower jaw, an enlarged caniniform canine and relatively short, thick inferior premolars, the last of which, or fourth, has a considerable development of the internal cusp. It may therefore be looked upon as a precociously specialized side branch which died out at the close of the Eocene and left no modified descendants.

Protylopus petersoni,[1] gen. et spec. nov.

This genus and species is primarily founded upon the anterior portion of a skull from which the left ramus is missing. The specimen is broken obliquely in such a manner as to show upon the right side all of the facial portion, including the orbit and the

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[1] This species is named in honor of Mr. O. A. Peterson, whose explorations of the Uinta Beds have been attended with such marked success.

anterior root of the zygomatic arch, while upon the left side the greater part of the orbit is missing. Fortunately the skull contains the dentition nearly complete. In association with it were found the greater part of an ulna and radius of the same individual. A second specimen which I refer to this genus and species includes a large part of both hind legs, together with a large number of vertebræ, ribs and other parts of the skeleton. A third specimen contains hind limbs and vertebræ, while a fourth includes the greater part of a hind foot.

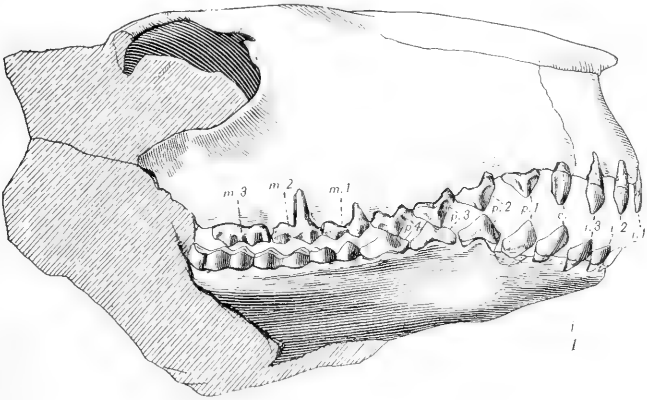

Fig. 3. Side view of skull of *Protylopus petersoni.*

The more important generic characters may be stated as follows :

Molars tetraselenodont without intermediate cusps. Teeth of the typical number, forty-four, arranged in a continuous series. Canines of both upper and lower jaws small and incisiform, the first inferior premolar not caniniform. The first three superior premolars elongated from before backwards, secant and without accessory cusps, the fourth with single external and internal crescentic cusps. The inferior premolars elongated and cutting, the fourth without internal cusps. Hind feet provided with but two functional digits, the outer ones, second and fifth, reduced to mere vestiges. Lumbar vertebral formula 7. Ulna and radius, at least in old individuals, coössified in the middle part of their shafts but free at their proximal ends.

The skull is crushed laterally so as not to reveal the exact form of the face, but it can be safely stated that the muzzle had moderate length, with slightly overhanging nasals, much as in *Poëbrotherium wilsoni.* The premaxillæ are relatively broad and extend upwards and backwards to articulate with the nasals. The orbit is not enclosed by bone posteriorly, but exhibits a marked tendency towards that peculiar roofing so highly characteristic of *Poëbrotherium* and the later Tylopoda. In advance of this bony shelf is seen a faint though distinct indication of the supraorbital notch, so constant a feature of the cameloid skull. The lower jaws may be described as long and slender, with a considerably elongated symphysis.

The superior incisors are relatively small, of a more or less conical form, and directed downwards. The premaxillæ were apparently not in contact in the median line. The superior canine is but little larger than the outer incisor, of a more or less hook-shaped appearance, and provided with a distinct sulcus upon the outer portion of the crown as in *Poëbrotherium wilsoni.* The first premolar follows after a very short interval and, like the second, is a simple two-rooted cutting tooth. The third premolar has a faint internal cingular ledge, while the fourth, as already mentioned, is provided with single external and internal crescents. The molars are much worn, and do not show clearly whether or not intermediate tubercles were present, but I think it may be safely assumed, from the general appearance of the crown, that they were absent. In the second and third molars, between the internal crescents, is to be seen a small styliform cingular cusp which is entirely absent, so far as I can determine, in *Poëbrotherium.*

In the lower jaw the incisors are of a more spatulate form and more procumbent in position. As in the upper jaw, the canine is slightly larger than the outer incisor, but of a very marked incisiform pattern. After a very short interval or diastema, is placed the first premolar, a two-rooted tooth whose crown closely resembles that of the canine, the two teeth being about equal in size. The second and third premolars have elongated secant crowns like the Tragulines.

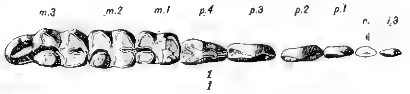

Fig. 4. Crown view of lower teeth of *Protylopus petersoni.*

The fourth has a well-marked heel and anterior basal cusp, but there is apparently no internal cusp present. The molars are so much worn that their structure is not very apparent. There can be very little doubt however that they had the usual structure. In the heel of the last molar a prominent accessory cusp is seen upon the border of the inner side near the point where it joins the lower posterior internal cusp. In *Poëbrotherium* this cusp is clearly present, but it has fused with the postero-internal, producing a prominent angle at this portion of the crown. In perfectly unworn teeth of *Poëbrotherium wilsoni*, it can be readily demonstrated to be an independent cuspule.

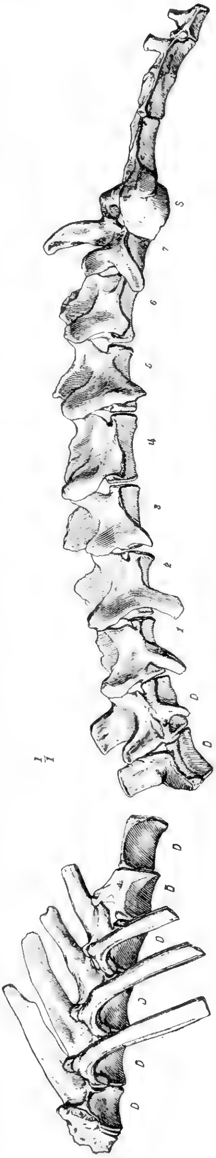

Fig. 5. Vertebræ of *Protylopus petersoni* (?)

Of the vertebræ, unfortunately, no cervicals are known, consequently it is impossible to say whether they exhibit the peculiar features of the more typical Camelidæ or not. The dorsals are well represented in specimen No. 2564, the whole series being present, with the exception of the first three or four, together with all the lumbars locked in position. The vertebræ resemble those of the modern Llamas closely in their general proportions. The bodies of the anterior dorsals are but moderately keeled, and towards the posterior end of the series strongly keeled; they increase gradually in size from before backward. The neural spine of the fifth is long and recurved, those of the succeeding dorsals decreasing in length posteriorly. The neural spines of the last two are considerably shorter and broader, having an almost vertical direction. The rib facets in the anterior region have their usual relations and positions, the ribs articulating with the vertebræ by two distinct facets, but in the last two the capitular and tubercular facets appear to be fused together as in these dorsals of the Llama. The lumbars are seven in number, the constant formula for the Tylopoda; they resemble closely the corresponding bones of *Poëbrotherium* and the later Cameloids. The sacrum is composed of only four vertebræ, but it is highly probable that another one or two was added from the caudal region as age advanced, just as in *Poëbrotherium* and the modern Llamas. The three anterior vertebræ of the sacrum have very reduced neural spines, while in the fourth the spine is well developed. The ribs do not display any characters of especial importance.

The pelvis is in a very fragmentary condition, but it may be stated that the ilium is well expanded, and, so far as one can judge, the whole bone would correspond closely with that of *Poëbrotherium.* The femur is present in its entire length with both ends in a good state of preservation, although the shaft is somewhat crushed. The proximal end has practically the same relations and arrangement of the different parts as that of *Poëbrotherium* and other members of the group. The distal end thus early gives slight though conclusive evidence of the peculiar and characteristic appearances which this part of the bone assumes in the later Camelidæ. This is especially seen in the great extension of the condyles backwards behind the median line of the shaft as well as the forward projection of the borders of the rotular groove, which serve to increase the antero-posterior diameter of this part of the bone. Although not clearly indicated on account of crushing, yet there seem to be distinct traces of the beginning of that peculiar depression at the proximal end of the rotular groove so highly characteristic of the later Tylopoda. In a like manner the patella has begun to assume the distinctively cameloid form by the great elongation of its lower border into a long, pointed process.

The tibia, which about equals the femur in length, shows a great resemblance to that of *Poëbrotherium.* The cnemial crest is unusually well developed, and extends quite one-third of the way down the shaft. The fibula is much reduced, and although the specimen does not show whether or not the shaft was complete, the probabilities are that it consisted of a distal portion only. That part of the shaft which is preserved is very slender and closely applied to the shaft of the tibia. In the hind foot the tarsal bones have nearly the same relations as in *Poëbrotherium.* The tuber of the calcaneum is somewhat shorter proportionately than in the White River genus, but otherwise both the calcaneum and astragalus are strikingly alike in the two genera. The cuboid of *Protylopus* is slightly narrower in proportion to its height than the corresponding bone in *Poëbrotherium,* and the navicular is provided with a much better developed posterior hook. As in *Poëbrotherium,* there are two cuneiforms present, the inner of which is a vestigial nodule of bone only.

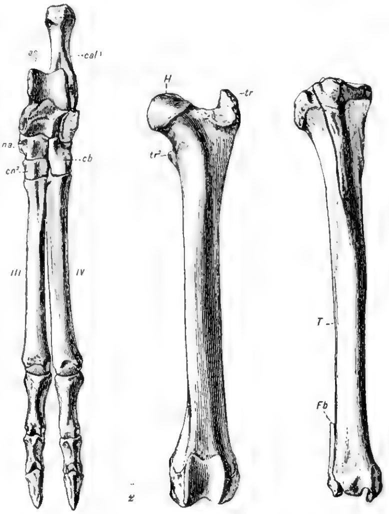

Fig. 6. Left hind foot, femur, tibia and fibula of *Protolypus petersoni* (?). *cal.*, calcaneum ; *as.*, astragalus ; *cb.*, cuboid ; *na.*, navicular ; *cu*³., external cuneiform ; *h.*, head of femur ; *tr.*, greater trochanter ; *tr*²., lesser trochanter ; *t.*, tibia ; *fb.*, fibula.

There are but two functional metapodials, the third and fourth, the second and fifth being reduced to mere vestiges. Upon one side the vestige of the second metapodial is preserved in place, and it is seen to articulate by a peculiar ledge-like facet upon the principal cuneiform. Upon its posterior surface is a distinct facet by which it articulates with the small cuneiform. The remnant of the fifth is not preserved, but the facet by which it articulates with the cuboid is very small, and there can be no doubt that it was as much reduced as the second.

The functional metapodials are relatively much shorter than in *Poëbrotherium,* and of a considerably more primitive form. They are well flattened upon their opposed surfaces in the upper half of the extent of their shafts. Below this the inner surfaces of the two bones are well rounded. Unlike the metapodials of *Poëbrotherium,* they lack that characteristic four-sided appearance of the later Camels, but on the contrary, are more or less triangular upon cross section, especially in the proximal half of their shafts. The metapodials as well as the long bones show their cameloid affinities in the unusually large size of the medullary cavities. The phalanges exhibit comparatively few differences from those of *Poëbrotherium*, the unguals being flattened upon their opposed surfaces. The fore foot is entirely unknown, but it is highly probable that it will be found to possess four complete functional toes.

It may transpire that the association of this skeleton with the above-described skull is incorrect, and that these bones belong to separate and distinct species; however, they agree so well in the matter of proportionate sizes of the different parts, and both are so distinctly cameloid, that I am persuaded to believe that they refer to one and the same species. It may be noted here, however, that in one of the specimens referred to above (No. 2067), there is evidence that at least one of the lateral metapodials of the hind foot was complete though very slender, and should probably be referred to another species on this account. The bones are, moreover, somewhat more slender and delicate than the one here described. At all events, whatever form of skull belongs with these skeletal parts it is nevertheless certain that the skull of *Protylopus*, above described, is just such a type as is required to satisfy all the necessary conditions in order to occupy a position in direct ancestral relation with *Poëbrotherium.* The true Tylopod phylum is therefore traceable directly to it. Beyond this, there is at present no satisfactory evidence to establish, with any degree of certainty, the identity of the true Camel pedigree.

Poëbrotherium *Leidy.*

With a consideration of this genus we pass from the Eocene to the Oligocene representatives of the group. It was established by Leidy as early as 1847 upon an imperfect skull presented to the Philadelphia Academy by Mr. Alexander Culbertson of Chambersburg, Pa., who was at the time engaged in the western fur trade. It was among the first of the mammalian fossils from the remarkable Bad Lands of the Cheyenne River region, whose treasures were destined in later years to play such an important part in the development of American palæontology. Leidy at first[1] regarded the skull as pertaining to a genus nearly allied to the Musk Deer, but later[2] pointed out its true position among the Camelidæ.

The generic differences between *Poëbrotherium* and *Protylopus* are not great, and indeed it would appear at first sight that they are insignificant. It is more than probable, however, as stated above, that *Protylopus* will be found to have four complete and functional digits in the fore limb. So far as our knowledge extends at the present, the chief distinctions are as follows: In *Poëbrotherium* the molars are much more selenoid and the crowns more lengthened than in *Protylopus*; the third superior incisor is larger than the superior canine; the ulna and radius are firmly coössified, even before the epiphyses of the bones are joined to the shaft and the shaft of the fibula has completely disappeared.

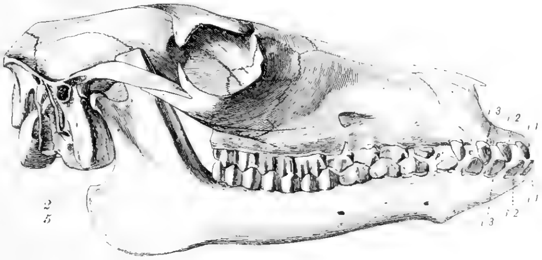

Fig. 7. Side view of skull of *Poëbrotherium wilsoni*.

Poëbrotherium wilsoni *Leidy.*

This species, although very abundant in the White River Beds of the Cheyenne River region, has not been very fully described. All of the specimens in the Museum collection have been found in the Lower Oreodon level, and it is doubtful if the vertical range of the species extends much above this point. It differs very markedly from its successor, *P. labiatum*, in the practical

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[1] 'Ancient Fauna of Nebraska,' Dec., 1852, p. 19.

[2] 'Extinct Mammalian Fauna of Dakota and Nebraska,' 1869, p. 141.

absence of diastemata in the lower jaw. The canines of this series are, moreover, broad and incisiform, being separated from the first premolars by very short diastemata. In the same manner the second premolars follow after a very short interval. In *P. labiatum*, on the other hand, the lower canines and outer incisors are almost in contact, the canines are subcaniniform in shape, and there is a short diastema in front of, and a long diastema behind, the first inferior premolar. The bones of the limbs and other parts of the skeleton are, as far as can be determined, very much alike in the two species. As in *P. labiatum*, there is a considerable range in size in the various specimens referred to this species.

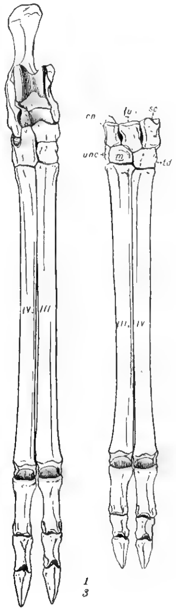

Fig. 8.

Fig. 9.

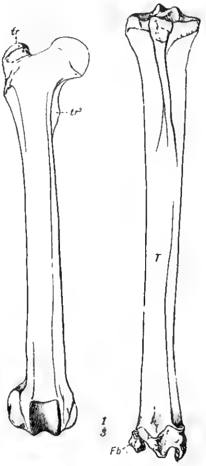

Fig. 10.

Fig. 8. Fore and hind foot of *Poëbrotherium wilsoni.*
Fig. 9. Ulna and radius and humerus of *Poëbrotherium wilsoni.*
Fig. 10. Femur and tibia of *Poëbrotherium wilsoni.*

Poëbrotherium labiatum *Cope.*

The type of this species consists of the larger part of a skeleton of a single individual from the White River Beds of northeastern Colorado (No. 6520). Associated with this specimen are two almost complete lower jaws from the same locality (Nos. 6517, 6518) showing the characteristic diastemata of *P. labiatum*, but considerably smaller. These specimens were erroneously referred by Cope to *P. wilsoni*. I have not been able to correlate with certainty the level from which these specimens were taken, with that in which similar remains in the Cheyenne River region occur, but judging from Cope's unpublished sketch of the section of the bed, there can be little doubt that it corresponds closely with the upper part of the Oreodon horizon. This surmise is strengthened by the fact that there is one specimen in the collection (No. 638), from the extreme upper part of the Oreodon Bed, which agrees in every way with the type of *P. labiatum*, except that it is a little larger. Another specimen from the Cheyenne River Bad Lands includes a lower jaw and a good part of the skeleton. The lower jaw exhibits the characteristic diastemata of *P. labiatum*, but is much smaller than the type, and of the same size as the two jaws mentioned above. Unfortunately the exact level of this specimen is not known, but it has every appearance of having come from the upper part of the Oreodon stratum.

Whether or not these smaller specimens are to be referred to a species distinct from *P. labiatum* is a matter which requires a greater amount of material than we at present possess in order to decide correctly. So far as one can determine at present, the only distinction between the two is one of size, and this is not great. I have thought best to regard them as belonging to the same species until other differences are shown to exist. Taken as a whole, *P. labiatum*, as exemplified by the larger individuals, was considerably larger than *P. wilsoni*, and in the possession of diastemata in the lower jaw, as well as the more caniniform shape of the lower canines, makes a distinctive approach to the species from the John Day Beds. In this connection it is proper to observe that no remains of Camels are known from the Protoceras level of the White River Beds. When such are found they will probably establish a complete transition between *P. labiatum* and the John Day species.

Gomphotherium *Cope.*

It is especially to Cope that we are indebted for the discovery of Camels in the John Day Beds. The first remains secured by him from this horizon were referred to *Poëbrotherium*, but later he established the genus *Gomphotherium*[1] for their reception, which he distinguished from *Poëbrotherium* by the more simplified character of the crown, and the one-rooted condition of the first superior premolar. As this distinction was founded largely upon error, I am now able to give the more important and true characters which serve to separate the two genera in a satisfactory manner.

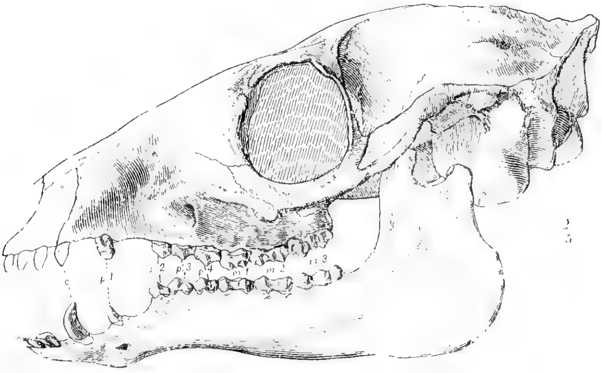

Fig. 11. Side view of skull of *Gomphotherium sternbergi.*

In *Poëbrotherium* the inferior canine is either in contact with the outer incisor, or is separated from it by a very short diastema, and the form of the canine is either like that of an incisor or very imperfectly caniniform. In *Gomphotherium*, on the other hand, the inferior canine is either separated from the outer incisor by a very distinct diastema or the diastema is absent, and the shape of the canine is strongly pointed and recurved, as

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[1] 'The Phylogeny of the Camelidæ,' Amer. Nat., 1886, p. 618.

in many of the later Camelidæ. In *Poëbrotherium* again, the orbit is not inclosed by bone posteriorly, whereas in *Gomphotherium* the posterior boundary of the orbit is complete. Another important distinction is seen in the character of the articular facets of the third and fourth metapodials of the fore foot. In *Poëbrotherium* these bones give evidence of having been more widely separated in the living animal, and capable of considerable independent movement, the facets being relatively large and the opposed surfaces comparatively smooth. In *Gomphotherium* these facets are much reduced, the metapodials closely applied to each other and their contiguous surfaces much roughened, clearly foreshadowing the coössification of these elements into a cannon bone.

Gomphotherium sternbergi *Cope.*

The type of this species consists of the greater part of the skeleton of a single individual in good preservation from the lower beds of the John Day Valley, Oregon. Other specimens from the same horizon include more or less perfect foot-bones, fragments of jaws, and other parts of the skeleton. The form of the skull presents a striking resemblance to that of the modern Camels in its general make up. The nasal bones are, however, proportionately longer, the bony roof of the orbits not so broad, and the muzzle apparently more laterally constricted in front of the infraorbital foramen. As compared with *Poëbrotherium* and the Llama the face is less bent down on the basicranial axis, in this respect resembling more the skull of the Camel. The vertical depth of the face immediately in front of the orbit is relatively greater than in *Poëbrotherium*, and the opening of the posterior nares has a more forward position.

A very interesting transition from the relatively low, much-swollen otic bullæ of *Poëbrotherium*, to the high, little-swollen condition of these parts in the living species, is observable. The otic bullæ of all the Camels are highly characteristic ; they consist of an inner, longitudinally-directed swollen part, together with an outer vertical buttress, which joins the inner part at an angle, and at the upper limit of which is placed the external auditory meatus. Immediately behind the point of junction of these two parts is seen the deep recess where the hyoid arch is articulated to the skull. In *Poëbrotherium* the inner portion of the bulla is much the larger, and the recess for the tympanohyal is inconsiderable. In *Gomphotherium* the two parts are about equal in size, and the tympanohyal recess much more pronounced. In the living genera, *Camelus* and *Auchenia*, the inner part of the bulla is much reduced and the tympanohyal recess is converted into a deep circular pit surrounded by bone.

Fig. 12. Humerus, ulna and radiaus of *Gomphotherium sternbergi.*

In the skeleton of the limbs the lower end of the femur is peculiar in the unusual size and development of the areas of attachment of the outer and inner heads of the gastrocnemius. This same peculiarity is seen in the femora of old individuals of both *Poëbrotherium labiatum* and *Procamelus occidentalis*, although to a somewhat less extent, and is doubtless a result of age. The head of the humerus shows the first distinctive change leading to the development of the double bicipital groove, a feature so characteristic of the later Camelidæ. In no individual in the collection is there evidence, even in those of the most advanced age, of any traces of bony union of the metapodials. In size *G. sternbergi* exceeded *P. labiatum* by at least one-third.

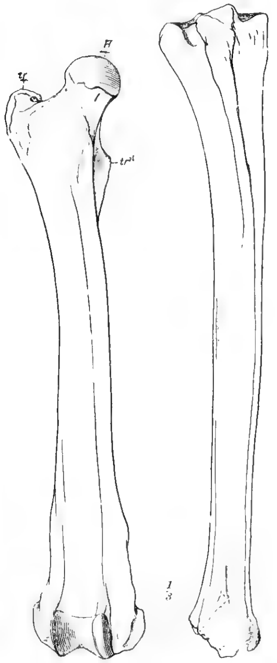

Fig. 13.

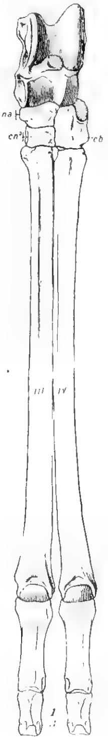

Fig. 14.

Fig. 13. Femur, tibia and fibula of *Gomphotherium sternbergi.*
Fig. 14. Hind foot of *Gomphotherium sternbergi.*

Gompotherium cameloides, sp. nov.

This species is represented in the collection by an almost complete mandibular ramus from the uppermost levels of the John Day deposits (No. 8179). To this same species I also refer an upper dentition (No. 7915), an almost complete fore limb (No. 7912), as well as several other fragments. The chief distinctions

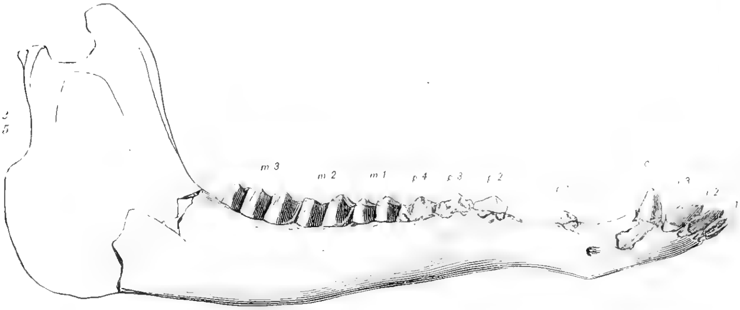

Fig. 15. Lower jaw of *Gomphotherium cameloides.*

between this species and the older *G. sternbergi* are seen in the increased size and the absence of a diastema between the lower canine and the outer incisor in *G. cameloides.* The comparative measurements display these differences at a glance; they are as follows:

	G. sternbergi. MM.	*G. cameloides.* MM.
Length of sup. ms. and three posterior pms...	60	83
" " inf. ms. and three posterior pms...	65	97
" " entire inferior dentition.	110	170
" " anterior metapodials..............	180	228

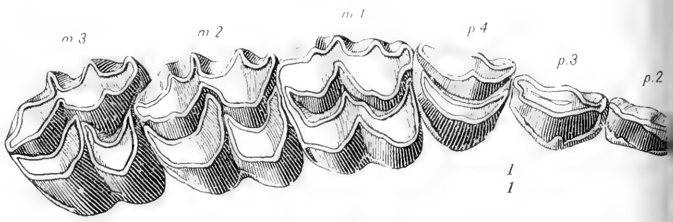

Fig. 16. Upper teeth of *Gomphotherium cameloides.*

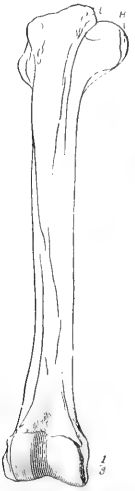

Fig. 17. Humerus of *Gomphotherium cameloides.*

It will therefore be seen that *G. cameloides* shows the same increase in size over *G. sternbergi* as *G. sternbergi* does over *Poëbrotherium labiatum.* Of the bones of the anterior limb, no differences are observable between them and the corresponding parts of *G. sternbergi*, except in the matter of size already noted above.

The exact stratigraphical position of this species is several hundred feet above that of *G. sternbergi*, and there can be no doubt whatever that *G. cameloides* is not only the direct lineal descendant of the older species, but is, at the same time, the progenitor of the succeeding Loup Fork species. This conclusion is somewhat at variance with the view expressed by Scott,[1] in which he says: "The Camels of the John Day formation do not present any important modifications of the dentition; in some of them the first upper premolar has but a single fang, and others are decidedly reduced in size; the former Cope has erected into a separate genus, *Gomphotherium*. It seems probable that these forms are not in the direct line of the cameline descent." A careful examination of Cope's type of *Gomphotherium sternbergi*, the only species, by the way, with the exception of the one above named, which has so far been described from these beds, reveals the fact that the first superior premolar, instead of being a single-rooted tooth, is *strongly two-rooted;* and that the succeeding premolars exhibit a most interesting and instructive transitional stage between *Poëbrotherium* and *Protolabis*, not only as regards their form but their degree of reduction as well. I have been unable, after the most exhaustive study, to find any evidence whatever tending to show that

Fig. 18. Ulna and radius of *Gomphotherium cameloides.*

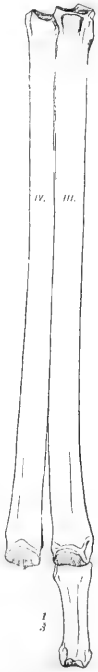

Fig. 19. Fore foot of *Gomphotherium cameloides.*

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[1] 'The Osteology of Poëbrotherium,' 1891, p. 49.

these John Day species are not in the direct line of the tylopodean ancestry.[1]

Protolabis *Cope.*

The next step in the line of cameline ancestry is furnished by the genus *Protolabis*, originally established upon the greater portion of both premaxillæ and maxillæ, together with the front of the lower jaw upon one side. This specimen was found near Pawnee Buttes, Colorado, and is from the typical Loup Fork horizon.[2] Another specimen was found by the writer in the so-called Loup Fork Beds of the upper John Day Valley of central Oregon, which was described by Cope as a new species of the same genus. It consists of the anterior portion of the cranium bearing the complete upper dentition in good preservation.

As regards the type specimen upon which the genus was originally founded, it is necessary to remark that the only distinction between it and *Procamelus robustus* is to be found in the possession of alveoli for the first and second incisors above, which would indicate a complete superior incisor dentition. In *Procamelus*, of the adult stage at least, these incisors are wanting. A careful examination of the specimen shows that the part of the premaxilla in front of the third incisor, upon the right side, is much shorter than that upon the left side, and instead of two alveoli there are in reality three, which would make altogether four incisors in the premaxilla upon this side. The corresponding part of the premaxilla upon the opposite side is much longer, and contains the two alveoli for the first and second incisors. In every other detail the specimen agrees perfectly with *Procamelus robustus*. Indeed, Cope has pointed out that these first and second incisors of this series, in all the species of *Procamelus*, were

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[1] In this connection it is proper to call attention to the fact that there are important faunal differences between the upper and lower beds of the John Day deposits. These distinctions are so marked as to entitle them to be regarded as separate and distinct divisions of the North American Miocene Besides the species of cameloids above described, this upper division contains two species of *Merycochœrus* among the Oreodonts. *Mesohippus præstans* among the Horses, and *Elotherium humerosum* of the Elotheres, which have not been found thus far in the lower division of the beds. There can be little doubt that other important faunal distinctions will be discovered when careful collections are made with this particular object in view. For the lower series the name Diceratherium Beds may be retained, but for the upper series I herewith propose the name Merycochœrus Beds.

[2] Proc. Philad. Acad., 1876, p. 145.

retained in the jaw for a longer or shorter period, and in some instances until the animal was almost if not quite adult. In view of these facts I am disposed to interpret this specimen as a case of abnormal retention of the incisors of the rather abundant species *P. robustus*. If this conclusion is correct, then the species *Protolabis heterodontus* becomes a synonym of *Procamelus robustus*. The second species regarded as belonging to this genus from the Nebraska Loup Fork, *Protolabis prehensilis* Cope, was founded upon the anterior portion of a lower jaw without teeth, and as there is no indication whatever what the upper dentition was like, the reference at most is mere guesswork. In fact, I doubt very much if it even is specifically distinct from *Procamelus robustus*.

With the elimination of these forms from the Nebraska Loup Fork, we have left the single species *Protolabis transmontanus*, represented by the Oregon specimen above referred to. In this specimen we have a genuine case of normal retention of the superior incisors, a fact which separates it at once from *Procamelus*, but the distinctions between it and its predecessor, *Gomphotherium*, are less clear. Cope assumed that it differed from this latter genus, in the coössification of the metapodials into a cannon bone, but of this there are no specimens at present known to demonstrate the truth or falsity of such an assumption. It is true that Camel remains have been found in the Deep River Beds of Smith's Valley, Montana, which deposits have been generally looked upon as older than the Loup Fork of both Oregon and Nebraska. These fossils have been uniformly referred to the genus *Protolabis* by Cope and Scott, but it does not appear, from any materials with which I am acquainted, whether these remains have been correctly determined or not. Neither skulls, jaws, nor even teeth, are known from this horizon which would enable one to say definitely whether the dentition was that of *Protolabis* or *Procamelus*. The metapodials of both fore and hind feet are united into a cannon bone, and the size almost, if not quite, equals that of *Procamelus robustus*, a circumstance which would seem to indicate that if they belong to the genus *Protolabis* they must represent a different and later species, since *Protolabis transmontanus* is much smaller, scarcely exceeding *Gomphotherium* *cameloides* in size. The only valid distinction between *P. transmontanus* and *G. cameloides* is seen in the marked reduction of the second superior premolar in the former, and as this is in the direct line of modification leading to the Loup Fork *Procamelus*, I have thought best to regard it as of generic rank, especially until the question of the coössification of the metapodials is definitely settled.

Protolabis transmontanus *Cope.*

This species was somewhat smaller than the modern Llama, and so far as one can judge from the imperfect remains, exhibits very similar proportions in its general form. The crowns of the molars are notably shorter and have a more quadrate outline than those of either the modern genus or *Procamelus*. This, however, may be due in a measure to wear. The superior canine is smaller than the third incisor; the first premolar is two-rooted, and the second is much reduced in size, as in *Procamelus*. The first and second incisors are of goodly size, implanted by strong roots and with obliquely-directed, more or less spatula-shaped crowns. The nasals are relatively longer than in the Llama, and the muzzle is moderately compressed laterally.

Procamelus *Leidy.*

In the widespread Loup Fork deposits of the plains region remains of Camels are very numerous; next to the Horses, they are perhaps the most abundant fossils to be found in these beds. A number of genera and species of these Camels have been described, but, as has too frequently happened in the history of the science in this country, unfortunately, misplaced zeal in the finding and describing of new forms has been allowed to run riot, and much of this work is apparently characterized by an utter lack of the most ordinary display of judgment and discrimination. No less than four or five genera have been proposed, of which not more than two are entitled to recognition. Of these *Procamelus* is the more abundant, and is represented by three well-marked and easily-distinguished species. The most distinctive features of the genus are the possession of a full complement of premolars in both jaws, the loss of the first and second pairs of incisors in the upper jaw in the adult stage, and the at least partial coössification of the metapodials of both fore and hind feet into cannon bones.

Procamelus robustus *Leidy.*

I place as synonyms of the above those proposed by Cope, *Protolabis heterodontus* and *Protolabis prehensilis*. The type specimen, as figured by Leidy, consists of a lower jaw bearing all the premolars and molars with the exception of the second, together with the second and third molars of the upper jaw. The jaw is broken just in advance of the first premolar so as not to show the characters of the incisors, canine and chin. In Cope's type of *P. heterodontus* the lower jaw is preserved as far back as the root of the last premolar, and this is associated with the almost complete superior dentition. The type of *P. prehensilis* is represented by the front of both rami of the lower jaw, associated with a last lower molar. A careful comparison of these specimens reveals a remarkable agreement in all details, and I do not think there can be any question of their belonging to one and the same species. The only difference worthy of note is seen in the jaw fragment which constitutes the type of *P. prehensilis ;* in this specimen the chin is not so abrupt nor deep, and the lower border of the symphysis is more nearly in line with the long axis of the jaw. The size is practically the same in all. I distinguish the species by the following characters : Size, large ; lower molars with much greater transverse diameter than in other species ; symphysis not coössified ; chin abrupt and deep. In one specimen only is the upper incisor dentition known, and in this the first and second incisors are retained. It may transpire that this is not an abnormal case as expressed above, but that it is a further character of the species. No other parts of the skeleton are known with certainty.

Procamelus occidentalis *Leidy.*

This species is by far the most abundant of the Camels in the Loup Fork Beds. I regard the name proposed by Leidy, *Homo-*

camelus caninus, as synonymous with the above, together with *Procamelus angustidens* given by Cope to various remains. It is somewhat smaller than *P. robustus*, and is altogether intermediate in size between this latter species and *P. gracilis.* It can be readily distinguished from *P. robustus* by the coössification of the two rami of the lower jaw at the mandibular symphysis, and especially by the narrow lower molars. The first and second incisors disappear early in life and no traces of their alveoli are seen in the adult skull. A large part of the skeleton is known, and this is surprisingly like the modern genera. The two main metapodials are firmly united into a cannon bone, and the vestigial representatives of the two lateral metapodials are coössified with them. No ungual phalanges, however, are known, and it is a matter of uncertainty whether they were relatively high and compressed like the early Camels, or whether they were broad and depressed like those of the living *camelus.* It is probable that when found they will show the intermediate conditions between these two extremes. Most of the skeleton has been described and figured by Cope,[1] and need not be repeated here.

Procamelus gracilis *Leidy.*

The species, described by Cope under the name of *P. fissidens*, agrees in every particular, so far as the measurements are concerned, with the above, and I therefore regard them as synonymous. *P. gracilis* is the smallest species of the genus, and its remains are not uncommon in the Loup Fork Beds of Colorado and Nebraska. It about equals the modern Llama in size, and is considerably smaller than *P. occidentalis.* Of the materials in the collection referable to this species, there are three lower jaws. One of these has the posterior part of the symphysis preserved, and this agrees with *P. robustus* and differs from *P. occidentalis* in the lack of coössification of the rami, although the well-worn teeth indicate an old animal. The lower molars are of the narrow type, in this respect agreeing with *P. occidentalis* rather than *P. robustus.* In two of the specimens the second premolar is well developed and two-rooted, but in the third specimen this tooth is much reduced and single-rooted, thus indicating a ten-

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[1] Surv. W. 100th M., p. 329.

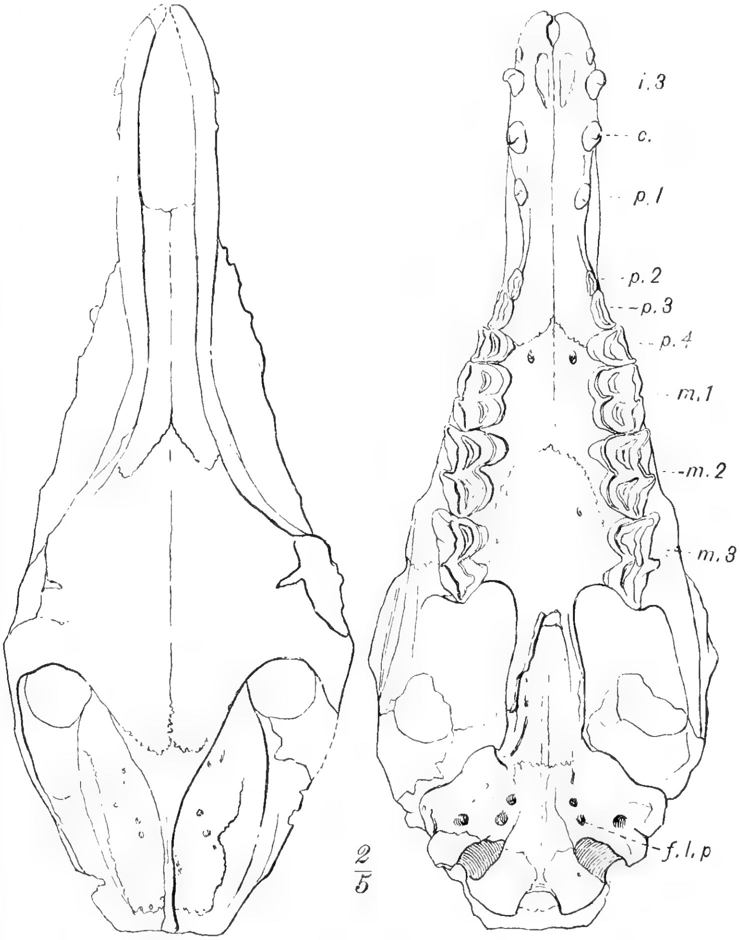

Fig 20. Top and under view of skull of *Procamelus gracilis*, after Cope.

dency to disappear. This, it may be said, constitutes a decided advance in the direction of the next genus, *Pliauchenia*, in which this tooth is permanently absent. I give herewith some comparative measurements of the three known species in order that the differences in size may be more readily understood :

	P. robustus.	*P. occidentalis.*	*P. gracilis.*
	MM.	MM.	MM.
Length of last three pms. and ms.....	152	126	111
		133	
		126	
		135	
Length of last three pms. and first two ms.................	106	90	77
		85	76
		88	76
		92	

Two incomplete metapodials in the collection, which are of suitable size for those of this species, show lack of bony union, notwithstanding the fact that the epiphyses are completely joined to the shaft. It is not certain, but there is evidence, that these metapodials belong to the fore foot, in which event it will not be surprising to find in more complete and perfect specimens that these bones are not coössified in this species, except in old individuals. In the hind foot the metapodials are completely united, as is shown by several specimens. In one specimen, which corresponds in size with *P. occidentalis*, the proximal part of the cannon bone shows lack of bony union for a distance of nearly two inches down the shaft.

Pliauchenia *Cope.*

The only character so far known in which this genus differs from *Procamelus* is found in the absence of the second lower premolar, and as this constitutes an important step in the dental evolution of the Camels, the species displaying it are entitled to rank as a separate and distinct genus. The exact stratigraphic position of the group is not known, owing to the imperfect collecting that has been done in the Loup Fork Beds. It is generally stated that *Pliauchenia* was contemporaneous with *Procamelus* in the Loup Fork, and comes from the same horizon, but of this one cannot be certain. It must be remembered that this deposit is several hundred feet in thickness in places, and it would not be a matter for surprise if it is found, upon more careful investigation, that *Procamelus* comes from the lower levels and *Pliauchenia* from the upper strata of the same bed.

Three species have been described by Cope, of which two are from the Loup Fork of New Mexico and one from the later

Blanco Beds of Texas. One of these species, *P. vulcanorum*, was founded upon a superior maxillary bone with most of the teeth in place, but as the diagnosis of the genus rests exclusively upon the number of premolars in the lower jaw, I do not see how this species can be admitted until the lower dentition is determined. It is therefore discarded.

Pliauchenia humphresiana *Cope.*

The type of this species consists of the anterior portion of two lower jaws from the Loup Fork of New Mexico. A second specimen which I refer to this species is from the Loup Fork Beds of Long Island, Phillips County, Kansas, collected by the Museum party during their explorations there. The specimen consists of the greater part of a lower jaw broken just in advance of the first premolar and bearing all the molars and premolars with the exception of the first and third. In size the specimen about equals the smaller individuals of *Procamelus occidentalis*, which it otherwise closely resembles in the structure of the teeth. The molars are of the narrow and elongated type, and the premolars have the same structure as that seen in the various species of *Procamelus*.

Pliauchenia minima, sp. nov.

The smallest species of Cameloid yet known from the Loup Fork deposits is represented in the collection by the greater part of a lower jaw, from Decatur County, Kansas, which I provisionally refer to the above genus. The specimen is broken posterior to the symphysis and does not display the incisors, canine nor first premolar, if indeed this latter tooth were present. The diastema in front of the third premolar is unusually long and the ramus in this region remarkably slender; more so, in fact, than in any known species of the Camelidæ. The third and fourth premolars are present but considerably reduced in size. The molars are of the usual pattern. Some fragmentary remains of a hind foot from this same region are probably to be referred to this species. The phalanges and distal ends of the metapodials are extremely cameloid, but unusually slender and delicate. The metapodials are firmly coössified. The size of the species is about equal to that of *Poëbrotherium labiatum* of the White River. The reference of this species to *Pliauchenia* is of course only provisional, and until the entire dentition is known the reference is uncertain. If it should transpire that the first premolar is absent it could not be placed in *Pliauchenia*, but would occupy a position between this genus and *Auchenia*.

Pliauchenia spatula *Cope.*

This species is founded upon an unusually complete lower jaw from the Blanco beds of Texas. According to Cope it is one of the largest Camels yet found, and considerably exceeds the modern Dromedary in size. A comparison of the measurements of the three known species will exhibit the striking difference in size; they are as follows:

	P. spatula. MM.	*P. humphresiana.* MM.	*P. minima.* MM.
Length of last two pms. and ms....	188	110	70

Camelops *Leidy.*[1]

Camel remains in the Pleistocene, Equus Beds, are very numerous; they have been found in nearly every State and Territory west of the Mississippi River, and are, in places, exceedingly abundant. Unfortunately, however, in most instances the fossils are so fragmentary that it is impossible to determine the genus or species to which any given specimen is to be referred. This fact has been taken advantage of, it appears to me, to inordinately multiply the genera and species, upon no better ground, frequently, than mere guesswork. These remains have been grouped at different times in no less than five distinct genera and ten species. The first of these genera, *Camelops*, was proposed by Leidy (Proc. Acad. Nat. Sci. Phila., 1854, p. 172), upon the fragment of an upper jaw of a large Camel from the gravel drifts of Kansas. The second genus, *Megalomeryx*, was also proposed by Leidy (Proc. Acad. Nat. Sci. Phila., 1858, p. 24), for the reception of some large teeth supposed to belong to an extinct Camel, from the Pleistocene of Nebraska. In 1872

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[1] Proc. Acad. Nat. Sci. Phila., 1854. p. 172.

Dr. Leidy again described some large Camel remains from California, which he referred to the living genus *Auchenia*.[1] Following this Cope[2] described two new genera, *Holomeniscus* and *Eschatius*, which he based upon fragmentary materials from Oregon, Mexico and elsewhere. He distinguished these genera from *Pliauchenia*, *Auchenia* and *Camelus* by the possession of a single superior premolar, the fourth, and separated *Eschatius* from *Holomeniscus* by the extreme reduction of this tooth to a simple cone. The evidence upon which a knowledge of the superior premolar dentition of these forms rests is furnished, so far at least as I have been able to learn, by (1) a fragment of an upper jaw of *H. vitikerianus*, containing the first and second molars, together with the roots and alveoli of the premolar or premolars immediately in advance, as well as a portion of the free border of the jaw ; (2) a much damaged fragment of a superior maxilla of *H. hesternus*, in which no knowledge of the premolar dentition is possible, since neither the teeth nor their alveoli are preserved ; and (3) a portion of a superior maxilla of *Eschatius conidens* without teeth but having nearly all the alveoli preserved.

It appears from a careful examination of this material that the number of superior premolars in all these Pleistocene cameloids, with the exception of *Eschatius conidens*, is uncertain. In the only specimen in which it can be possibly made out, there are undoubted traces of an alveolus for a third premolar. If there were two premolars above, then the dental formula is the same as in the living genus *Auchenia*, and is indistinguishable from it, so far, at least, as the number of teeth is concerned. The third superior premolar is very small in *Auchenia*, and it will not be surprising to find, when a larger number of suitable specimens of these North American Pleistocene species are known, that in some cases a vestige of this tooth remained in the jaw for a longer or shorter time during the life of the animal ; at least this seems to be the rule in many cases wherein a tooth is about to disappear from the series.

I therefore reject the definition given by Cope, but retain the genus as distinct from *Auchenia*, upon an entirely different

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[1] Report U. S. Geolog. Surv. Territories, 1873, p. 225.
[2] Proc. Amer. Philos. Soc., 1884, p. 16.

ground. In the lower molars of *Auchenia* there is a very prominent buttress, amounting almost to a lamina, developed at the outer extremity of the antero-external crescent, especially in the second and third molars. This structure is not present in the lower molars of any of the North American species which I have seen, although there are faint traces of it to be found in some of them.

As regards the generic name to be applied to these North American species, I revive the one originally given by Leidy, *Camelops*, notwithstanding the fact that no attempt was made by him to give a generic definition. The extreme reduction of the fourth premolar, together with the small size of the inferior canine, satisfactorily distinguishes *Eschatius*, which is undoubtedly a distinct genus and is here regarded as such.

In the description of the numerous remaining species which have been proposed, apparently very little latitude has been allowed for individual and sexual variations, and because of the very fragmentary condition of the material so far known any accurate understanding of their limits is quite impossible. On this account it is very difficult to determine what species are valid and entitled to recognition. Until a larger number of specimens in a less fragmentary state are obtained, I cannot distinguish more than two, or at the utmost three species, and these determinations rest solely upon size.

Camelops kansanus *Leidy.*

This species is by far the most abundant of all the North American Pleistocene Cameloids, and of the widest geographical distribution. I regard as synonymous of the above the following specific names: *Megalomeryx niobrarensis* Leidy,[1] *Auchenia hesterna* Leidy,[2] *Holomeniscus hesternus*[3] Cope, *Auchenia huerfanensis* Craigin,[4] and *Holomeniscus sulcatus* Cope.[5] Leidy's type of *Camelops kansanus* consists of a fragment of the anterior portion only of the upper jaw, bearing the root of the incisor and a portion of the alveolus of the canine, and does not reveal the

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[1] Proc. Acad. Nat. Sci. Phila., 1858, p. 24.
[2] Rep. U. S. Geolog. Surv. Territories, 1873, p. 225.
[3] Proc. Amer. Philos. Soc., 1884, p. 16.
[4] Amer. Geologist, 1892, p. 257.
[5] Rep. Geol. Surv. Texas, 1893, p. 84.

number of premolars nor the character of the lower molars. It agrees so well in size and character, however, with the corresponding parts of other specimens from different localities in which the dentition can be accurately determined, that there can be very little doubt that they belong to one and the same species. The type of *Megalomeryx niobrarensis* consists of lower molars from the sand hill region of Nebraska; and since they do not present any characters which will serve to distinguish them from the corresponding teeth of *C. kansanus* they may be safely regarded as belonging to the same species. In the same way the teeth described by Leidy from California under the name of *Auchenia hesterna* present no differences, either in size or structure, that would lead one to consider them as belonging to a distinct species. *Auchenia huerfanensis* of Craigin comes apparently in the same category and does not differ, so far as can be made out from the description, from *C. kansanus.* Neither can one detect any characters in the type of *Holomeniscus sulcatus* of Cope from the Pleistocene of Texas that separate it from the above species. Cope described a sulcus upon the inner face of the lower molars, which he thought distinguishes this species. Upon careful comparison I find this sulcus is quite as well developed in many other specimens, the reference of which to *C. kansanus* there can be no reasonable doubt. I find it to be a character which not only varies with the state of wear of the tooth but is subject to a considerable degree of individual variation.

The dentition of the species thus considered is as follows: $\mathrm{I}\frac{1}{3}$, $\mathrm{C}\frac{1}{1}$, $\mathrm{Pm}\frac{?\,2}{1}$, $\mathrm{M}\frac{3}{3}$. In size the majority of the specimens about equal the corresponding parts of the Dromedary, although some are notably more robust, while others are decidedly more slender. In fact, there appears to be a very great range, as far as size is concerned, in certain bones, especially those of the feet. The length does not seem to vary so much as the degree of robustness, and this probably is due to differences in sex and age. I give herewith the measurements of some of the principal limb bones of this species from the Pleistocene sand beds near Hay Springs, Nebraska, collected by the Museum expedition during last summer. These bones, it is proper to remark, pertain to many individuals, and were found hopelessly mixed together. I also give measurements of the corresponding bones of the Dromedary for comparison :

	C. kansanus. MM.	*Dromedary.* MM.
Length of posterior cannon bone	345 360 365	325
Length of anterior cannon bone	330 370	325
Length of ulna and radius	555	580
Length of humerus	375	420
Length of scapula	415	460
Length of phalanges, proximal row	98 to 124	102

A specimen from an anterior cannon bone from the Silver Lake locality in Oregon is considerably more robust than either the Dromedary or those of *C. kansanus* from Hay Springs ; it measures 385 mm. There is yet another specimen in the collection consisting of a complete posterior cannon bone from the Pleistocene of Hitchcock County, Nebraska, which greatly exceeds in length that of any known Camel. It is notably more slender than the cannon bone of the Dromedary, has less distal spread of the metapodials, but is nearly double the length ; its exact measurement is 555 mm. It is highly probable that this represents a distinct species, but I refrain from creating another specific name until we know more of the skeleton.

Camelops vitikerianus *Cope.*

A fragment of an upper jaw containing the first and second molars, together with the roots and alveoli of the two superior premolars, is the only specimen of this species so far known with certainty. A complete lower jaw was described by Cope from the Pleistocene of Texas under the name of *Holomeniscus macrocephalus*,[1] which I strongly suspect belongs to this species. It agrees, so far as one can judge, in size, but no exact comparison is possible, since the inferior condition of *C. vitikerianus* is unknown. Cope remarks in his description: "I observe here that it is not certain that the species now described is not an *Auchenia*, as the superior dentition is not known." The lower molars, as figured, are

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[1] Rep. Geolog. Surv. Texas, 1893, p. 85.

certainly not those of any *Auchenia* with which I am familiar, since they entirely lack the antero-external buttress of this genus and agree with those of *Camelops*. I cannot see any reason whatever to regard this jaw as belonging to a species different from that represented by the upper molars above noticed. The size of the species is near that of the living *Auchenia*, and is hence much smaller than *C. kansanus*, the only character to my knowledge by which it can be distinguished.

Camelus americanus, sp. nov.

From the Pleistocene Beds of the Hay Springs locality were obtained by the Museum expedition last year several specimens of a Cameloid apparently different from anything hitherto described from this country. One specimen consists of the greater part of both rami of the mandibles of a fully adult individual, in excellent state of preservation, but broken in such a manner as to display but little of the jaw posterior to the last molar. The second specimen consists also of a mandibular ramus, but the individual was young, in which the milk molars had not yet been shed.

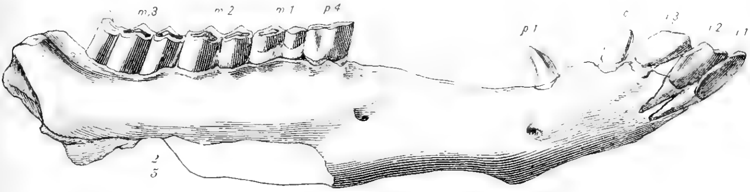


Fig. 21. Lower jaw of *Camelus americanus*, side view.

The inferior dental formula of the adult specimen is as follows: $I_{\bar{3}}$; $C_{\bar{1}}$, $Pm_{\bar{2}}$, $M_{\bar{3}}$. This it will be noticed is the dentition of the genus *Camelus*, from which I cannot distinguish it generically at present. If this is a true Camelus, as I suspect, it is the first time that it has been found in the western hemisphere.

The incisors display the usual spatulate cameloid pattern, and are very procumbent in position. Almost immediately behind the third incisor follows a rather weak incisiform canine. At the posterior termination of a comparatively short diastema is placed the first premolar, a moderately well developed tooth, with a compressed, internally grooved, pointed, recurved crown, very similar to the lower canine of *Auchenia*. After a relatively long interval follows the fourth premolar, which with the molars makes a continuous series. The fourth premolar is relatively more robust than that of the Llama or Dromedary, and gives evidence by this fact of a less reduced condition. Its form is the same as in these two genera. The molars display the same structure as those of the later Cameloids in general, except the second and especially the third show the first indication of the external buttress so characteristic of *Auchenia*. The two rami are firmly coössified at the symphysis. I distinguish the species from *Camelus dromedarius* by the relatively small incisiform canine, as well as by the less reduced fourth premolar and much smaller size. A comparison of the measurements of this species with *C. dromedarius* and *A. lama* are herewith given :

	A. lama. MM.	*C. americanus.* MM.	*C. dromedarius.* MM.
Length from incisive border to end of last molar....................	165	205	265
Length of molars and fourth premolar...........................	80	92	132
Length from incisive border to fourth premolar.....................	85	114	233

Eschatius conidens *Cope.*

The last of the American Cameloids to be considered is this species which, so far as we are now aware, was the most specialized of the Camelidæ. As already noted, the characters which distinguish this group from all others is found in the extreme reduction of the fourth superior premolar to a simple cone, as originally pointed out by Cope ; this is associated with a marked reduction in size of the lower canine. The specimens from which

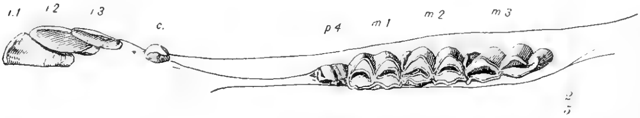


Fig. 22. Crown view of lower teeth of *Auchenia lama*.

the genus and species is known are, unfortunately, very fragmentary, so that it is impossible to say much concerning it. It was first found at the Silver Lake locality in southeastern Oregon, but subsequently Cope identified remains referable to it from certain localities in Mexico, showing that it was most widely distributed. Two species have been described by Cope, *E. conidens* and *E. longirostris*, but it is very doubtful indeed whether the material at present known warrants the recognition of more than a single species. There are some trifling differences in the length of the diastema of the lower jaw, it is true, but this is probably due to individual variation. The size of the species about equals that of the Dromedary.

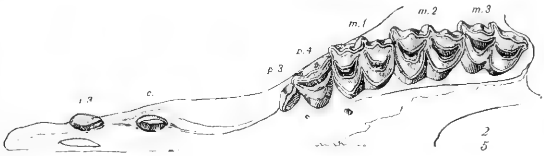


Fig. 23. Crown view of upper teeth of *Auchenia lama*.

THE EVOLUTION OF THE CAMELIDÆ.

We come next to consider the evolution of the Camelidæ, and although the principal facts of their development have been quite fully set forth in the foregoing pages, yet it seems proper to summarize them here. The earliest forms in which one can detect true tylopodean peculiarities, as already pointed out, are found in the upper Eocene or Uinta stage ; at the same time it is quite certain that the phylum was detached from the main stem of the Artiodactyla at a much earlier date. Both Cope and Scott have expressed the opinion that the ancestry of the group is traceable directly to the Wasatch genus *Pantolestes*, and Scott believes that the connection is established by the Bridger genus *Homacodon*. Whether or not these opinions will bear the test of future discovery time alone will reveal. At present I am of the opinion that the osteology of these genera is too imperfectly known to speak with any degree of confidence as to its correctness.

The principal changes of structure in the evolution of the group relate largely to the limbs and skull, although, as is well known, the cervical vertebræ are highly characteristic in the whole family. Unfortunately the cervicals are entirely unknown in the earliest representative, *Protylopus*, but in the succeeding genus, *Poëbrotherium*, they had already assumed the typical cameloid peculiarities. If one is permitted to judge by analogy, it is more than likely that *Protylopus* possessed the peculiar cameloid cervicals, and it seems highly probable that one of the crucial tests of tylopodean affinity, in any genus older than this, will be found in the incipient changes leading to this modification.

The changes in the limbs consisted mainly in (1) their gradual elongation, (2) coössification of certain bones, (3) modification of the patella and loss of the greater part of the tibia, and (4) the subtraction of digits, the change in the character of the feet and modification of the phalanges, together with the coössification of the podial elements into a cannon bone. In this connection should also be mentioned the development of a double bicipital groove upon the humerus and the modification of the carpal and tarsal elements.

The question of the elongation of the limbs is closely associated with the general increase in size, in which there is as complete a gradation, from the little *Protylopus*, scarcely larger than a good-sized Jack Rabbit, to the more modern species, larger than the Dromedary, as the most hypercritical opponent of the Evolution Theory could possibly demand. In the matter of the coössification of certain bones, the ulna and radius were the first to be affected by this process. As we have already seen, it had taken place in *Protylopus* in *a very old individual*, and then only in the middle of the shaft, leaving the proximal ends entirely ununited. In *Poëbrotherium* the complete coössification of these elements was accomplished in young individuals before the milk dentition had been completely shed, and before the epiphyses had united to the shafts of the long bones, as is demonstrated by many specimens in the Museum collection. In all the later types these bones are firmly united.

The patella of the later Camels is peculiar in that it is narrow and of great vertical depth. The first evidence of this modification is seen in the development of a long pointed process upon the inferior border of the bone in *Protylopus*; this is continued in *Poëbrotherium* and *Gomphotherium*, until in *Procamelus* the modern condition is reached. The shaft of the fibula in all the modern types has completely disappeared, and the bone is represented by a distal nodular element which lies under the end of the tibia. In *Protylopus* a considerable part of the shaft of the bone was present, but it was probably not complete. In *Poëbrotherium* the shaft is reduced to a very short bony spicule, and the distal part is partially pushed under the end of the tibia; in *Gomphotherium* the shaft has completely disappeared, and in *Procamelus* the modern arrangement is attained.

In the matter of the loss of digits I cannot speak with any very great degree of confidence, especially as regards the older types. Our materials fail to reveal the number of toes in the fore feet of *Protylopus*, but there is very little doubt that there were four. In one specimen which I have referred to this genus, the lateral toes of the hind feet are reduced to mere nodular splints, while in another specimen in the collection there is evidence that the lateral toes of the hind feet were complete but very slender. In *Poëbrotherium* the lateral toes are reduced to vestiges in both fore and hind feet, while in the later forms even these vestiges disappear.

The modifications in the character of the feet refer to what may be properly termed a retrograde change, if we regard the subject from the standpoint of the podial evolution of the Ungulates generally. *Protylopus*, as well as *Poëbrotherium* and *Gomphotherium*, had apparently a fully developed unguligrade gait. The ungual phalanges are relatively high, keeled upon their dorsal surfaces, and more or less flattened upon their opposed sides. The distal ends of the proximal phalanges do not have their articular surfaces extended upon the dorsal side, while the distal phalanges of the second row have this surface well extended upon the dorsal portion of the bone. This arrangement is highly characteristic of all the higher Artiodactyla, and is the strongest possible evidence that can be adduced from the skeleton of the unguligrade gait.

In *Procamelus*, on the other hand, the distal ends of the proximal phalanges, as well as those of the second row, have the articular surfaces reaching well back upon the dorsal aspect, just as in the modern Camel and Llama, and this we know to be accompanied by the digitigrade gait and the peculiar cushioned foot. There is likewise a marked change in the character of the ungual phalanges, which are much reduced and flattened vertically especially in *Camelus*.

The conclusion is obvious, therefore, that this peculiar tylopod character is secondary, and was developed from the unguligrade condition. Just what led to it is impossible to say. Zittell's explanation that it resulted as a consequence of the coössification of the metapodials can hardly be the correct one, since the same thing occurred in all of the Pecora in which the unguligrade gait was retained.

The coössification of the metapodials and the consequent formation of a cannon bone took place comparatively late in the history of the phylum, much later in fact than the union of the ulna and radius. In *Protylopus* and *Poëbrotherium* the metapodials were not only free but capable of considerable independent movement, as indicated by the facets. The opposed surfaces of these bones, moreover, are relatively smooth and less flattened than in the succeeding *Gomphotherium.* In this latter genus the bones are more closely applied to each other, the surfaces roughened, and the articular facets, by which they join one another, much reduced. The feet of *Protolabis* are wholly unknown. In one species of *Procamelus* (*P. gracilis*), there is evidence that the metapodials of the fore feet were not united until late in life, if at all, while those of the hind foot were fully coössified into a cannon bone. *Procamelus occidentalis* had the posterior metapodials fully united and those of the fore foot only partially coössified, being free at their proximal ends for some distance.

In the Pleistocene species the metapodials were fully united into a cannon bone early in life, and in the modern Camelidæ bony union of these elements takes place before birth, almost as soon in fact as bony tissue is thrown down in the shafts.

It will thus be seen that the coössification of the metapodials, as well as that of the ulna and radius, was a gradual process, and is always found first in the old individuals ; its further advance has consisted in reducing the time of its appearance to such an extent that it is now altogether intra uterine. I leave for a future paper the discussion of these important facts in their relation to the question of the transmission of acquired characters. I may state here, however, that they furnish very strong presumptive, if not conclusive, evidence of the transmission of a pathological change.

The modifications of the skull include some minor changes in the position of the orbit, its inclosure by a complete bony rim, a broadening of the frontal region and a shortening of the nasal bones. There have also occurred some modifications of the tympanic bullæ and a change in the position of the posterior nares. The most important of all the modifications connected with the skull, however, are found in the dentition, and here the changes are quite as profound as have occurred in any other group of mammals within the same length of time. In *Protylopus* the structure of the molars is, to a large extent, intermediate between the bunodont and selenodont pattern. This is especially seen in the lower molars, the internal cusps of which are rather more conical than crescentic ; the outer cusps are not perfectly crescentic, and the crowns of all the molars are very short. The lower canines are small and incisiform, the inferior incisors are sub-erect, and there is evidence of the fact that these teeth had a more or less effective bite against the upper ones.

In *Poëbrotherium* the crowns of the molars are much more elongated and the crescents fully developed. The lower canine is yet incisiform in the older species, *P. wilsoni*, but has begun to assume the caniniform shape in the later *P. labiatum*. The lower incisors have a very procumbent position, but while yet opposing the superior incisors, the effectiveness of the bite is considerably diminished on this account. The only important change in the teeth of the John Day species is seen in the reduction in size of the first upper premolar and the assumption of the caniniform shape of the lower canine. The inferior dentition of *Protolabis* is not known, but an important change has taken place in the second superior premolar, in that it is much reduced in size.

If the specimen which I have referred to *Procamelus robustus* is normal, it offers the first evidence of the diminution in size, leading to the final loss of the first and second pair of superior incisors. In *Procamelus occidentalis* these teeth have completely disappeared in the adult, but vestiges of them have been found in the young, a fact which was demonstrated by Cope.

Pliauchenia furnishes us with the next step in which the second premolar has disappeared from the lower jaw, leaving the first, third and fourth of this series. The superior premolar dentition of this genus has not yet been found, but it is highly probable that some of the species will show a loss of the corresponding tooth in the upper jaw. It is highly probable that at this stage, or the one preceding, three diverging lines took origin, of which one continued into *Auchenia*, another into *Camelus*, and a third into *Camelops* and *Eschatius*.

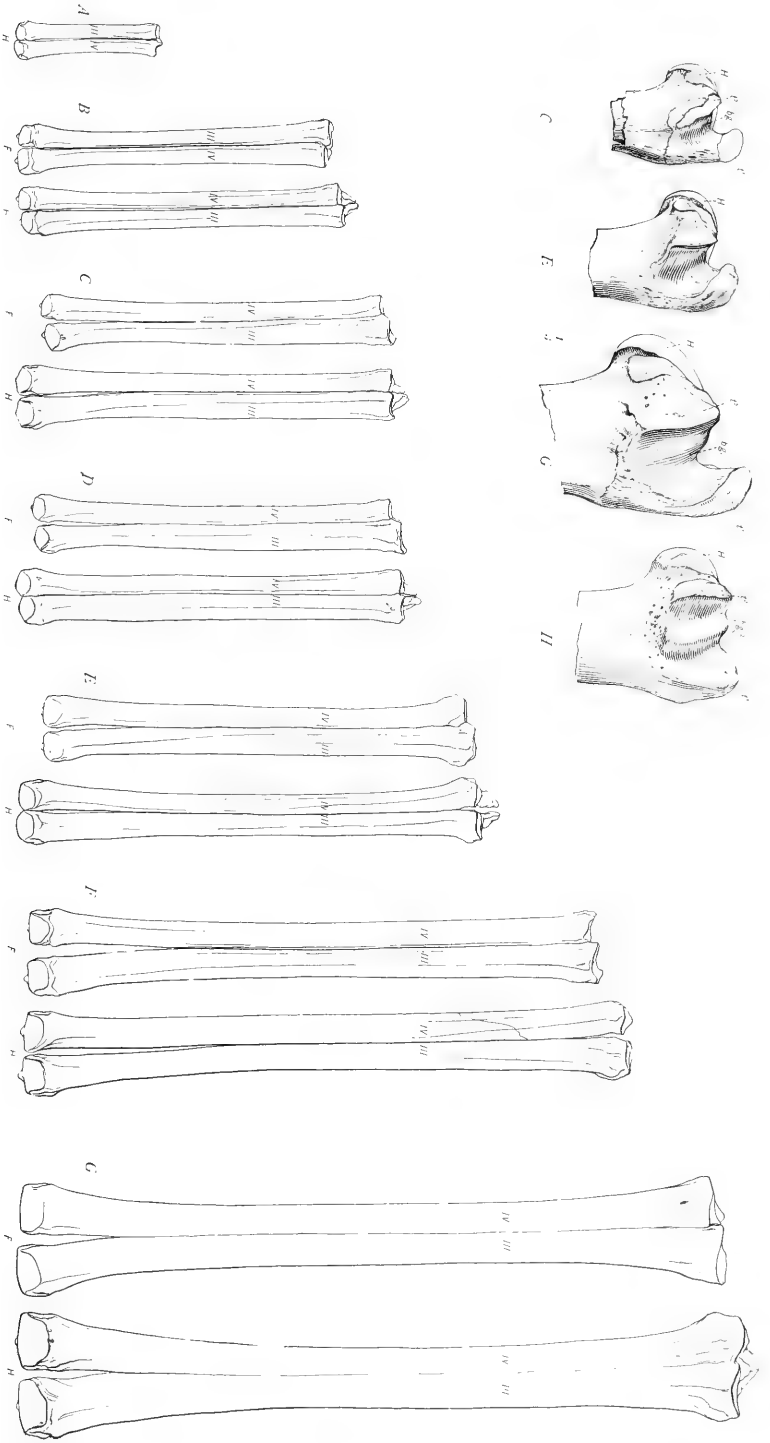
From *Pliauchenia* the transition is easy to *Camelus*, in which there are three premolars in the upper and two in the lower jaw. In *Auchenia* the premolars are still further reduced, there being two above and only one below. The first evidence of the peculiar buttress found in the lower molars of this genus is seen in *Procamelus gracilis*, and on this account I am of the opinion that this species is the ancestor of the Llamas. It is highly probable that the species migrated to South America at the close of the Miocene, and that the intermediate links between it and the living genus will be found in that country. *Camelops* could have easily been derived from *Pliauchenia spatula*, requiring the loss of only two premolars in the lower jaw and probably one above; in a like manner *Eschatius* follows *Camelops* and carries dental reduction to the extreme limit reached in the Camel group.

In this attempt to indicate the more exact specific evolution of the group one is necessarily handicapped by want of knowledge of the osteology of many species which are at present represented by fragmentary remains only. I doubt not that it will be materially altered when we come to have a more perfect understanding of these forms. I give herewith a table of distribution in time, of the Cameloids treated of in the foregoing pages.

PERIODS.	FORMATIONS.	THICKNESS.	FAUNAL DIVISIONS.	EVOLUTION OF SPECIES.
Recent.	Recent.			*Camelus.* *Auchenia.*
Pleistocene.	Equus.	150	Equus.	*Eschatius* *Camelus americanus.* *Camelops kansanus.* *Camelops vitikerianus.*
Pliocene.	Blanco.	100	Pliauchenia.	*Pliauchenia spatula.*
			Hippidium.	
Miocene.	Loup Fork.	400	Procamelus.	*Pliauchenia humphresiana.* *P. minima.* *Procamelis occidentalis.* *Procamelus robustus.* *P. gracilis.*
	Deep River.	200	Cyclopidius.	*Protolabis.*
		INTERVAL	OF MIGRATION.	
	John Day.	1000	Merycochœrus.	*Gomphotherium cameloides.*
			Diceratherium.	*Gomphotherium sternbergi.*
Oligocene.	White River.	800	Protoceras.	
			Oreodon.	*Poëbrotherium labiatum.*
			Titanotherium.	*Poebrotherium wilsoni.*
Eocene.	Uinta.	800	Diplacodon.	*Protylopus.* *Parameryx.*
			Telmatotherium.	
	Bridger.	2000	Uintatherium.	*? Homacodon.*
	Wind River.	800	Bathyopsis.	
	Wasatch.	2000	Coryphodon.	*? Pantolestes.*
	Torrejon.	300	Pantolambda.	
	Puerco.	500	Polymastodon.	

EXPLANATION OF PLATE XI.

A, hind metapodials of *Protylopus petersoni*; *B*, fore and hind metapodials of *Poëbrotherium wilsoni*; *C*, fore and hind metapodials and head of humerus of *Poëbrotherium labiatum*; *D*, same species from higher level; *E*, fore and hind metapodials and head of humerus of *Gomphotherium sternbergi*; *F*, fore and hind metapodials of *Gomphotherium cameloides*; *G*, fore and hind metapodials and head of humerus of *Procamelus occidentalis*; *H*, head of humerus of *Auchenia lama*.



METAPODIALS OF EXTINCT CAMELOIDS.

Remounted Skeleton of Phenacodus primævus. Comparison with Euprotogonia.

By Henry Fairfield Osborn.

Plate XII and Four Text Figures.

AUTHOR'S EDITION,** extracted from* ***BULLETIN

OF THE

American Museum of Natural History,

Vol. X, Article IX, pp. 159–164.

New York, May 6, 1898.

Article IX.—REMOUNTED SKELETON OF PHENACODUS PRIMÆVUS. COMPARISON WITH EUPROTOGONIA.

By Henry Fairfield Osborn.

Plate XII and Four Text Figures.

This unique skeleton was transferred to the American Museum with the remainder of the Cope Collection in 1893. It had been mounted[1] as found (Fig. 1), laterally crushed, a large portion of the vertebræ and ribs concealed so that their number could not be definitely ascertained, and in such position as to convey a false impression both of the proportions and mode of location of this remarkably primitive Ungulate.

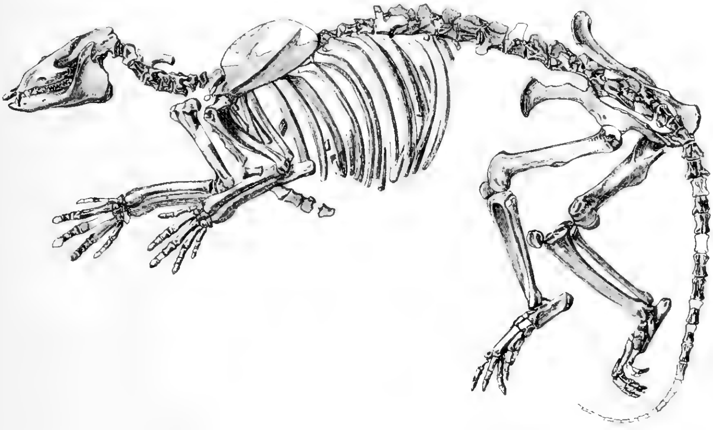


Fig. 1. Skeleton of *Phenacodus primævus* as originally mounted and cast under the direction of Professor Cope.

After very careful deliberation we decided to remove the skeleton entirely from the matrix, and remount it as nearly as possible in the natural position. This removal cost many months of labor

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[1] See Cope, 'Tertiary Vertebrata,' Plate LVII E.

and two months more were occupied by Mr. Hermann, Preparator, in mounting the animal as represented in Plate XII. This mount is now a model of its kind, since it not only displays the real characters of the animal, but every bone upon one side of the body or the other can be removed for purposes of detailed study. Moreover, in course of removal of the stone and plaster matrix, the two missing cervical vertebræ were found inserted in the tail, and the number of ribs was definitely ascertained to be fifteen on each side, thus positively determining the dorsal vertebral formula, a matter of very great importance. These results alone justify the labor involved.

As photographed in Plate XII, *Phenacodus primævus* strikes us as a rather slenderly built, straight-limbed animal, digitigrade like the Tapir, five-toed, but almost exclusively supported on three toes both upon the fore and hind feet, with the median toe considerably enlarged, well hoofed, and extended beyond the others; therefore functionally of the tridactyl type. Flower's restoration, in his volume upon the Horse, is very nearly correct. The upwardly-arched back, powerful lumbar vertebræ, the long hind-quarters (measuring 635 mm.), the long powerful tail, when contrasted with the much shorter fore-quarters (measuring 460 mm.), the rather low withers and small head, are reminiscent of Creodont ancestry.

Phenacodus was, in fact, a swift-footed, cursorial, small-brained, microcephalic type (in distinction from *Coryphodon*). It was largely propelled by its powerful hind limbs. The skeleton is, however, straight limbed at the elbow in contrast with the early Amblypods, such as *Pantolambda* and *Coryphodon.*[1] In this respect it approaches that of the Perissodactyla. The terminal phalanges of the three median toes are broad and spreading, while the lateral phalanges have rather the narrow compressed type seen in *Euprotogonia.*

The most striking features of the skull are the small size and separation of the basicranial foramina, the simple primitive structure of the whole region around the ear at the base of the skull (the auditory meatus being bounded posteriorly by the mastoid),

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[1] See Osborn, 'A Complete Skeleton of Coryphodon,' Bull. Am. Mus. Nat. Hist., Vol. X, April 5, 1898, pp. 81-91.

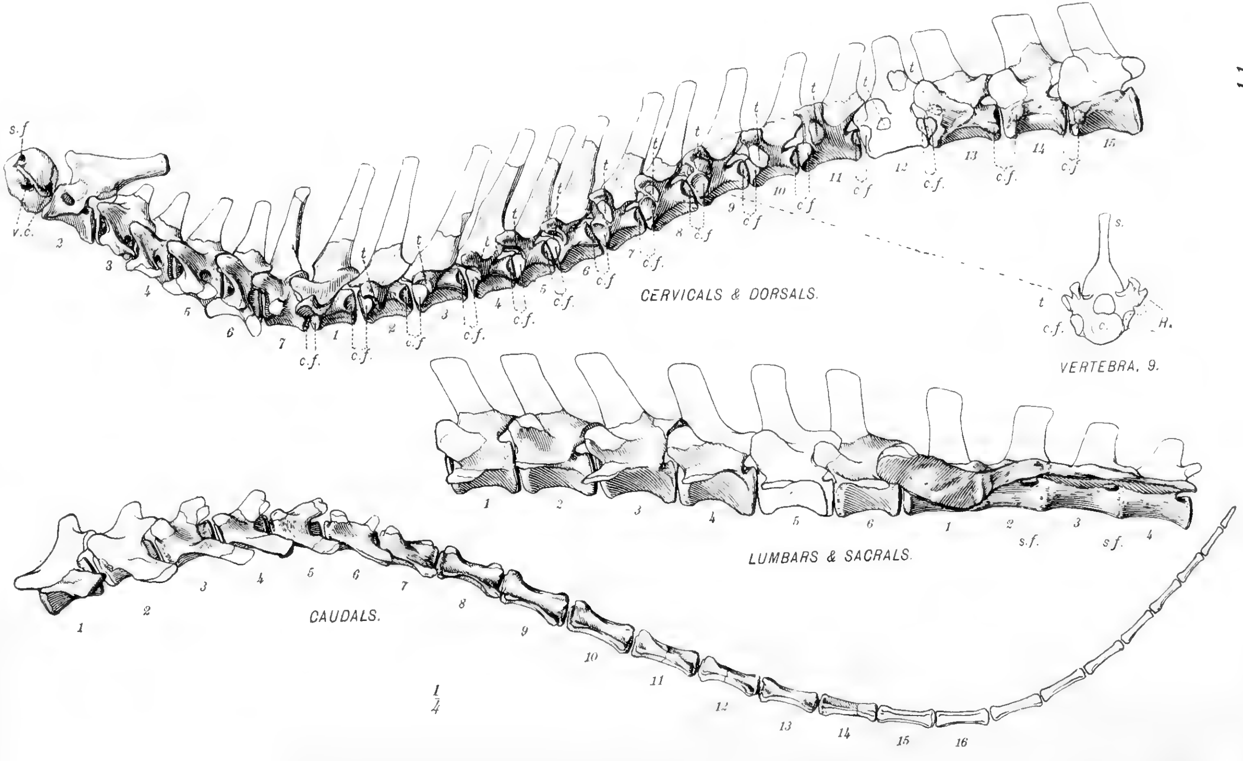

Fig. 2. Vertebral Column of *Phenacodus primævus*. *s. f.*, spinous foramen; *v. c*, vertebrarterial canal; *c. f.*, capitular facets; *t*, tubercular facets. Spines, fifth lumbar vertebra and posterior caudal vertebræ restored. One-fourth natural size.

and the longitudinal grooves upon the superior intranareal surfaces of the maxillaries (also observed in *Coryphodon*). The proportions and characters of the skull (exclusive of the teeth) are identical with those in the ancient Amblypoda, such as *Periptychus* and *Pantolambda*.

The distinctive feature of the vertebral column is the small number of dorsal vertebræ, namely 15, exactly as in *Coryphodon* and *Titanotherium*, giving a dorso-lumbar formula of 20-21. In the writer's opinion this number is characteristic of the primitive Condylarthra or Protungulata. Marsh,[1] on the other hand, has assigned to the Holodactyla (Condylarthra) 23 dorso-lumbars, and to the Protungulata 30 dorso-lumbars or more. The second distinctive feature is found in the splitting of the transverse processes on the posterior dorsals for articulation with the tubercles of the ribs and for the support of the zygapophyses respectively, as shown in Fig. 2, these processes being sharply separate.

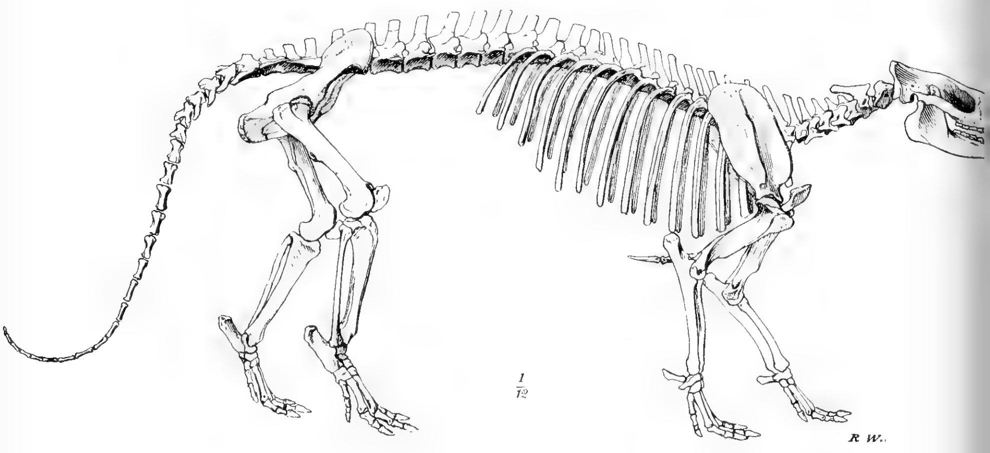

Fig. 3. Skeleton of *Phenacodus primævus* placed in the standing position to show elevation of the withers. One-twelfth natural size.

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[1] 'Dinocerata,' pp. 171, 172.

TABLE OF MEASUREMENTS.

	Phenacodus. Feet.	In.	Metres.	*Euprotogonia.* Metres.
Length, chin to perpendicular line of tail....	4	4¾	1.340	
Length, chin to ischiac symphysis			1.220	.590
Length skull, condyles to symphysis of premaxillæ			.235	
Height, dorsal spines at withers...........			.550	.270
Height, dorsal spines at hips..............			.585	.280
Limbs, total length of hind limb, outside measurement....	2	1	.635	.310
Limbs, total length of fore limb, outside measurement........................	1	6	.460	

Euprotogonia puercensis thus appears to be about one-half the size of *Phenacodus primævus* in all its measurements. As shown in Fig. 4, the lateral digits are considerably longer, reaching the ground.

Fig. 4. Skeleton of *Euprotogonia puercensis* as now mounted, with missing parts restored in outline from *Phenacodus*. One-twelfth natural size. Same scale as *P. primævus*.

COMPARISON WITH EUPROTOGONIA.

Euprotogonia. [TORREJON.]	*Phenacodus.* [WASATCH.]
(1) Caudals 18 preserved, neural arches complete in C 1-8. D. L. formula unknown.	Caudal formula indeterminate. Neural arches complete anteriorly. D. L. = 20-21.
(2) Fore-limb. Posterior face of ulna convex. (*C.*)	The same, concave.
(3) Ectepicondylar ridge prominent. (*C.*)	The same.
(4) Magnum very small. (*C.*)	Magnum somewhat enlarged.
(5) ? Os centrale. (*C.*)	The same wanting.
(6) Trapezoid very short. (*C.*)	The same somewhat enlarged.
(7) Terminal phalanges laterally compressed, intermediate between hoofs and claws.	Hoofs fully formed in *P. primævus.* More compressed in *P.* (*Trispondylus*) *wortmani.*
(8) Hind-limb. Femur with sharp and prominent patellar trochlea.	The same.

Comparison with Euprotogonia.—*Continued.*

Euprotogonia. [Torrejon].	*Phenacodus.* Wasatch.
(9) Tibial spines sharp and prominent; cnemial crest very prominent and elongate. (*C.*)	The same. Cnemial crest less prominent, and shorter.
(10) No fibulo-calcaneal facet.	The same.
(11) Astragalo-cuboidal facet depressed.	The same.
(12) An astragalar foramen; tibial trochlea in front of foramen, *i.e.*, subdigitigrade. (*C.*)	No astragalar foramen. Tibial trochlea extended further back, *i.e.*, fully digitigrade.
(13) Meso-cuneiform very short. (*C.*)	The same.
(14) Lateral digital reduction advanced: ratio of Mts.V : Mts.III : 23 mm. 37 mm., or as 2 : 3.	Lateral digital reduction still more advanced: ratio of Mts.V : Mts. III : 35 mm. : 73 mm., or as 1 : 2,
(15) Metatarsals and phalanges slightly curved. (*C.*)	The same nearly straight.

This strengthens the observation of Matthew,[1] in his recent comparison of these types, that the features in which *Phenacodus* differs from *Euprotogonia* are progressions from the Creodont type, as indicated in the above column by the letter *C.*

A far larger proportion of Creodont characters are, however, found in the Amblypod contemporary of *Euprotogonia*, namely, *Pantolambda*, which will be fully described by the writer in a forthcoming paper.

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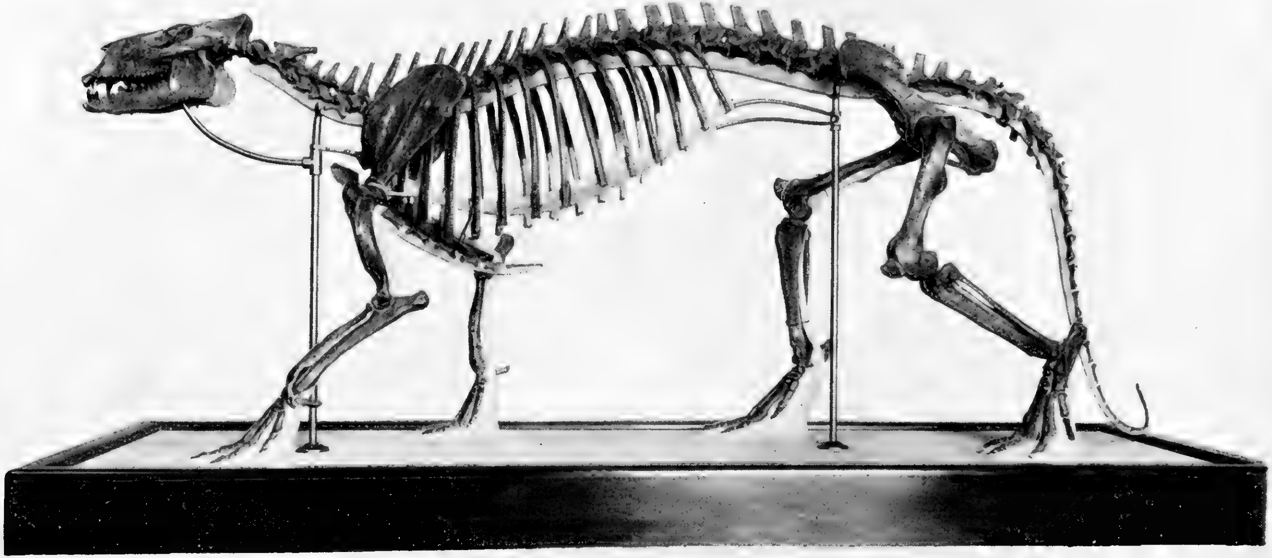
[1] 'Revision of the Puerco Fauna,' Bull. Am. Mus Nat. Hist., Vol. IX, 1897, pp. 305–308.



MOUNTED SKELETON OF *Phenacodus primævus.*

One-twelfth natural size.

Evolution of the Amblypoda. Part I.
Taligrada and Pantodonta.

By Henry Fairfield Osborn.

Twenty-nine Text Figures.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. X, Article XI, pp. 169–218.
New York, June 3, 1898.

Article XI. — EVOLUTION OF THE AMBLYPODA. PART I. TALIGRADA AND PANTODONTA.

By Henry Fairfield Osborn.

Twenty-nine Text Figures.

The Amblypoda constitute a sharply distinguished order of Ungulates which probably sprang from the Creodonta during the Cretaceous period and extended through the Eocene period in three great stages of evolution known as the suborders Taligrada, Pantodonta and Dinocerata, the latter entirely confined to North America.

They are arrested or persistently archaic in structure throughout, but especially in the brain, the triangular teeth, and the pentadactyl feet. The morphological problems involved in the skeleton and teeth, and the phylogenetic problems involved in the succession and extinction of the main and collateral lines, form the main subjects of this essay.

The American Museum has sent out a series of expeditions after remains of the Amblypoda: First, into the Wasatch of Wyoming, 1891; second, into the Bridger and Washakie Basins, 1893 and 1895; third, into the Torrejon, 1892 and 1896; fourth, into the Wasatch of New Mexico, and Big Horn Mountains of Wyoming, 1896. We have thus succeeded in bringing together invaluable material for the history of this remarkable group from the time it issued in the Creodont-like *Pantolambda*, of the Torrejon Beds until it became extinct in the largest Uintatheres of the Upper Washakie and Middle Uinta Beds.

Several very important results are obtained:

First.—The evidence can be clearly stated as to the succession of the known types of Pantolambdidæ, Coryphodontidæ and Uintatheridæ. Many prophetic or ordinal characters are now observed in the earliest types; certain species of *Coryphodon* are found to show the rudimentary parietal horns and the incisiform lower canines of the Uintatheres, but no known species leads directly into *Uintatherium.*

Second.—It is now demonstrable that the Periptychidæ belong in this group as a *bunodont division*, which probably arose and diverged in the Cretaceous period.

Third.—The nearly complete skeleton of *Pantolambda bathmodon*, the most archaic type of Ungulate known, places almost upon the firm basis of fact Cope's hypothesis, that the Ungulates sprang from the Creodont division of the Unguiculates.

Fourth.—A fairly complete systematic revision of the entire group is rendered possible.

The writer desires to express at the outset his indebtedness to Dr. J. L. Wortman for his energetic and intelligent supervision in the field of these various expeditions, assisted by Mr. Walter Granger, Mr. Barnum Brown and others ; to Dr. W. D. Matthew for the skill and care with which the very fragmentary skeletons of *Pantolambda* have been put together, and for critical assistance in the diagnosis of specific types. Also to the various preparators and draughtsmen of the department.

I.—ORIGIN OF THE AMBLYPODA.

A. THE CRETACEOUS TRITUBERCULATE MOLAR.

Hypothetical Upper Cretaceous Ancestors.—In describing the Laramie mammals in 1893 the writer[1] directed attention to the resemblance which certain isolated upper and lower molars bore to the teeth of the Periptychidæ, especially to *Ectoconus* and *Haploconus.* The figures of these teeth are here reproduced.

In *C* (*Synconodon*), the crowns are laterally compressed, thus bringing the primary proto–, para– and metacones, both of the trigon and trigonid, very close together. This compression of the primary cones is also true of *F* (*Ectoconodon*), in which type the outer wall is reinforced as in *Ectoconus* by accessory tubercles.

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[1] Osborn, 'Upper Cretaceous Mammals,' Bull. Am. Mus. Nat. Hist., Vol. V, pp. 325–329.

This compression is an essential character of the Periptychidæ. The upper and lower molars of *Protolambda*, *Hl*, *A* and *Al*, on the other hand, resemble those of the Pantolambdidæ.

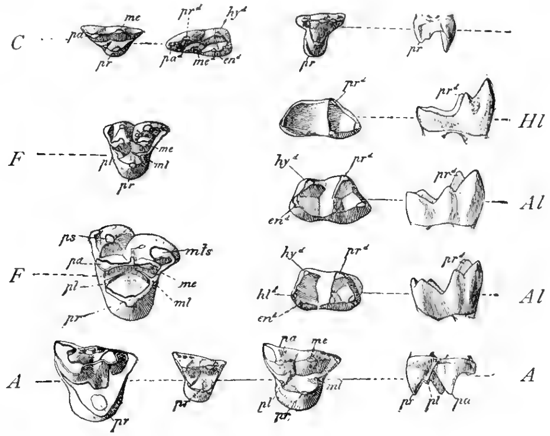

Fig. 1. LARAMIE TRITUBERCULATES.

C. Synconodon sexicuspis. Upper and lower molar types. Nos. 2218, 2220. Am. Mus. Coll.
F. Ectoconodon petersoni. Upper molar types. Nos. 2224, 2223. Am. Mus. Coll.
A. Protolambda hatcheri. Upper molar types. Nos. 2201-3. Am. Mus. Coll.
Lower molars *Hl*, *Al* (possibly correlated), Nos. 2241, 2230, 2231. Am. Mus. Coll.

These types may now be defined as follows :

Synconodon, gen. nov.

Type.—Isolated upper and lower molars. Am. Mus. Coll., Nos. 2218, 2220.

Definition.— Molars long and narrow. Trigons laterally compressed, *primary cones approximated.* Talonid well developed.

S. sexicuspis, sp. nov.

Definition.—Talonid of lower molars with three cusps, hypoconid, hypoconulid, entoconid. Type as above. Fig. 1, *C.*

Ectoconodon, gen. nov.

Type.—Isolated superior molars Loc., Laramie. Am. Mus. Coll., Nos. 2223, 2224.

Definition.—Superior molars very broad. Trigon laterally compressed. Two *external prominent cones* (parastyle and metastyle), reinforcing the outer wall of the crown.

E. petersoni, sp. nov.

Superior molars with conules and a rudimentary mesostyle. Type as above. Fig. 1, *F.*

Protolambda,[1] gen. nov.

Type.—Four isolated upper molars. Loc., Laramie. Am. Mus. Coll., Nos. 2201–3.

Definition.—Superior molars with open trigon and elongate outer wall. Paracone and metacone laterally compressed. Conules subcrescentic. Parastyle prominent.

P. hatcheri,[2] sp. nov.

With rudimentary spur, metastyle on posterior external border.

Type, as above. Fig. 1, *A*.

The lower molars *Hl* and *Al*, in Fig. 1, probably are associated with this type.

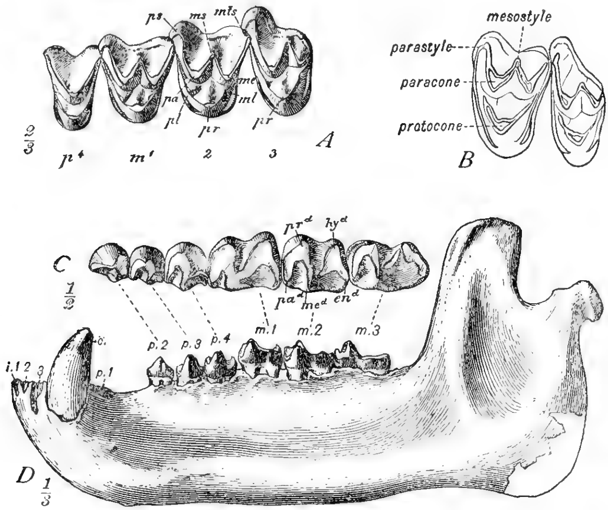

Fig. 2. *Pantolambda cavirictus.* *A*, superior molars, No. 963; *B*, diagram of same; *C*, inferior molars, crown view, No. 3961; *D*, lower jaw, type of *P. cavirictus.* Am. Mus. Coll.

These types are quite distinct from the trituberculates described by Marsh[3] from the Laramie, namely, *Didelphops*, *Cimolestes*, *Pedomys*, *Telacodon*, *Batodon*, so far as these are known.

These animals are defined and placed here *hypothetically* merely to show that *in the Upper Cretaceous are found types of upper and lower teeth capable of giving origin to the teeth of the Amblypoda.*

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[1] Having a type of tooth antecedent to that of *Pantolambda*.

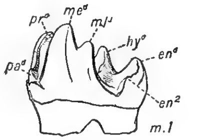
[2] Dedicated to Mr. J. B. Hatcher, the well-known writer and explorer.

[3] Discovery of Cretaceous Mammalia, Pts. I, II, III, Am. Jour. Sci., July, 1889, to Mch., 1892.

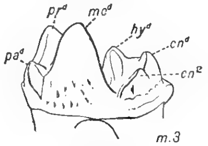
Evolution of the Molars in the Amblypoda.

The upper and lower molars of the Periptychidæ are purely bunodont, characterized by a compressed trigon, the development of accessory external cusps, and crescentic internal cusps upon the superior premolars. The latter recall the teeth of *Pantolambda*. *Ectoconus* is the only type in which the lower premolars tend to become molariform.

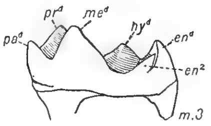
The *Pantolambda* superior molar (Fig. 2 *A*) shows a crescentic disposition of the three primary cones, which are, however, closely approximated as in the Periptychidæ, the outer wall of the crown extending widely into the parastyle. The lower molar shows a lofty trigon distinguished by the marked elevation of the metaconid, and a talonid best shown in Fig. 2 *D*. No true hypoconulid is developed. From the entoconid a spur extends forwards and inwards, to which the designation 'entoconid 2' may be given, as seen in Fig. 3. This little cusp becomes a very important feature of the crown in *Bathyopsis* and *Uintatherium*.



Bathyopsis.



Coryphodon.



Pantolambda.

Fig. 3. Lower molars, Amblypoda. Diagrams showing evolution of crown. Not to scale.

pr^d protoconid ; pa^d paraconid ; *me* metaconid ; ml^d metastylid ; hy^d hypoconid ; en^d entoconid ; *en.2* entoconid 2.

The *Coryphodon* superior molar (Fig. 4), as homologized by Cope, Earle and the writer, exhibits a protoloph and an ectoloph consisting of a greatly reduced paracone, a vestigial mesostyle and strongly crescentic metacone. In the last superior molar these ectoloph elements are transformed into a single oblique lophoid crest. The inferior *Coryphodon* molar (Fig. 3) shows a greatly elevated protoconid, an enlarged metaconid and depressed paraconid. The talonid consists of a hypoconid, entoconid and a low spur, the entoconid 2, prophesied in *Pantolambda*.

From this, the *Bathyopsis* and *Uintatherium* lower molar is readily derived, as shown in Fig. 3, simply by the fission of the metaconid into the metastylid, *mld*, and further reduction of the paraconid and entoconid 2. This fission is an additional analogy with the Horse molar to those which the writer has already pointed out.

The superior molar of *Bathyopsis* is unknown. That of *Uintatherium* probably represents, as Cope supposed, the ectoloph swung around so as to form with the protoloph a V opening outwards. Just internal to the apex of the V the hypocone is often developed.

We thus observe a set of profound changes resulting finally in the unique lophodont crown of *Uintatherium.*

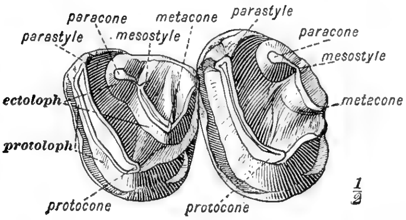


Fig. 4. Upper molars of *Coryphodon testis*, showing primary and secondary elements. Am. Mus. Coll., No. 274.

B. EVOLUTION OF THE UNGULATE FOOT FROM THE CREODONT TYPE.

Cope's famous generalization as to the serial character of the primitive ungulate foot, supported and extended by Osborn, has been recently disputed by Matthew (1897, p. 320) upon the very strong ground that most of the earliest, *i. e.*, basal Eocene, feet are non-serial or displaced; so far as known, both the Creodont carpus and tarsus are certainly non-serial. Cope's generalization

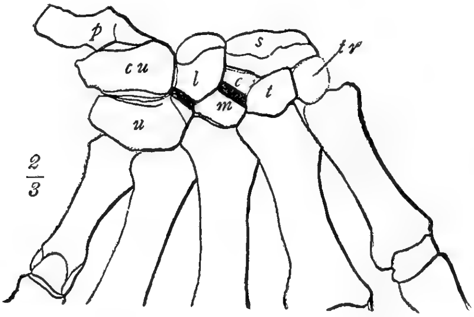


Fig. 5. Creodont carpus (*Dissacus carnifex*), heavy lines showing hypothetical protungulate displacement.

therefore appears to be non-consistent with his own theory that the Ungulates sprang from Creodonts.

The evidence *as to the earliest types* stands thus :

	Creodonta.	*Amblypoda.*	*Condylarthra.*	*Meniscotherium.*
Carpus	Non-serial.	Non-serial.	Non-serial.	Non-serial.
Tarsus.........	Non-serial.	Non-serial.	Serial.	Serial.

Carpus.—Matthew's conclusion is important as concentrating our attention upon the *interlocking* or *alternating* (lunar on unciform, scapho-centrale on magnum) carpus of such a Creodont type as *Dissacus* (Fig. 5), from which the *carpus* of the *Amblypoda* and *Condylarthra*, and probably of all Ungulata, may be derived. The manner in which this was probably effected is :

Amblypoda.	*Condylarthra.*
Absorption or coalescence of centrale. Lunar remaining on unciform. Magnum somewhat enlarged.	Absorption or coalescence of centrale. Magnum greatly enlarged and spreading beneath lunar, which is thus separated from unciform.

The *enlargement of the magnum*, as observed in both Amblypoda and Condylarthra, would tend to *readjust* the primitive Creodont interlocking or displaced arrangement, and, especially where the weight is concentrated on the median toes, give us the *secondarily serial Phenacodus* type.

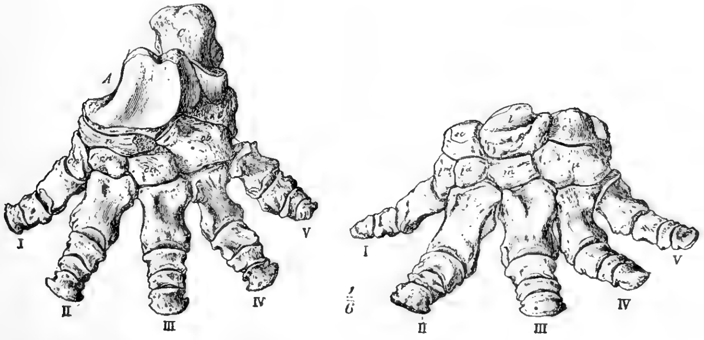


Fig. 6. Pes and Manus of *Coryphodon testis*, viewed from above, showing enlarged magnum. Am. Mus. Coll., No. 258.

Tarsus.—In the tarsus the case is different; while the non-serial Amblypod (*Pantolambda*) tarsus can be directly derived from the Creodont, the serial Condylarth tarsus probably arose from an unknown serial Creodont. Hence a double or parallel derivation of the two-hoofed orders, as follows:

Protungulate Creodonta.	Persistent atypical displacement in carpus and tarsus.	Carpus secondarily serial. Tarsus persistently serial.	Carpus and tarsus typically displaced.
Tarsus interlocking, Carpus interlocking.	....*Amblypoda.*		
Tarsus serial.	....	...........*Condylarthra.*....	*Diplarthra.*

Other characters of the primitive foot are given in the following synopsis, also upon pages 184, 187, 188, 216 of this Bulletin:

2.—SYNOPSIS OF THE EVOLUTION OF THE AMBLYPODA.

The subjoined table brings out the three important laws of phylogeny as applied to taxonomy:

First.—The *persistent primitive* characters (*P.p.*) are also the *ordinal characters*, which serve to separate this phylum from the Condylarthra, Proboscidia, Hyracoidea, Diplarthra and other ungulate orders.

Second.—The *primitive* (*Pr.*) *progressive*, (*Pg.*) and *retrogressive characters* (*Re.*) constitute the *subordinal characters.*

Third.—Among the above characters are innumerable characters both in skull, limb and foot structure in which the Amblypoda *parallel* certain Perissodactyla, Artiodactyla and Proboscidia. The latter are mainly approached in the adaptations to great body weight, which first misled Cope to place this group with the Proboscideans.

Primitive [*Pr.*], Persistent primitive [*P.p.*], Progressive [*Pg.*] and Retrogressive [*Re.*] Characters.

	Taligrada.	*Pantodonta.*	*Dinocerata.*
SKULL.	*P.p.* Brain small, olfactory lobes large, hemispheres smooth, cerebellum exposed.	The same.	The same.
	Pr. No air cavities. Sagittal crest. Frontoparietal sutures open.	*Pg.* Extensive air cavities. Cranium flattened. Frontoparietal sutures closed.	The same. The same.
	P.p. Anterior nares terminal.	The same.	The same.
	Pr. Premaxillæ separate, reaching nasals.	Premaxillæ grooved above, separate, not reaching nasals.	*Re.* Premaxillæ divergent, edentulous, reaching nasals.
	Pr. Maxillaries smooth.	The same.	*Pg.* Maxillaries with horns.
	Frontals smooth.	*Pg.* Frontals with supraorbital knobs.	The same.
	Pr. Parietals smooth.	*Pg.* Rudimentary parietal horns.	Large parietal horns.
	Pr. Nasals smooth, extending between orbits.	The same, shortened, extending between orbits.	*Pr.* Nasals with rudimentary horns ; reduced in length.
	P.p. Mastoid (periotic) widely exposed, perforate, bordering auditory meatus.	The same, much compressed.	The same, widely exposed and perforate, bordering auditory meatus.
	Pr. No alisphenoid canal.	The same.	*Pg.* An alisphenoid canal.
	P.p. Zygomatic arches slender.	The same.	The same.
	Pr. Mandibular condyle elevated, facing upwards.	Condyle elevated, facing obliquely.	*Pg.* Condyle depressed, facing backwards.
DENTITION.	*Pg.* Molars triangular (tritubercular), selenodont.	Molars triangular, selenolophodont.	Molars triangular, lophodont.
	Pr. Paracone complete.	*Pg.* Paracone reduced.	*Re.* Paracone wanting.
	Superior premolars composed of two crescents, unlike molars.	The same.	Superior premolars submolariform.
	Pr. Superior incisors present.	The same present.	*Re.* The same absent, or vestigial.
	Pr. Canines round, normal.	*Pg.* Canines round, trihedral, or compressed, enlarged.	*Pg.* Superior canines lance-shaped. Inferior, incisiform.
VERTEBRÆ.	*Pr.* Cervicals short, dorsals and lumbars with short spines.	The same.	The same.

	Taligrada. *Continued.*	*Pantodonta.* *Continued.*	*Dinocerata.* *Continued.*
VERTEBRÆ.	*P.p.* D. L. — ?. Sacrals unknown.	*Pr.* D.=15, L.=5. Sacrals unknown.	D. L.=? Sacrals = 4.
RIBS.	*Pr.* Very short.	The same.	The same.
ARCHES.	*Pr.* Scapula acuminate, fossæ subequal.	*Pg.* The same, infraspinatus fossæ somewhat enlarged.	*Pg.* Scapula triangular; infraspinatus fossæ greatly enlarged.
	Pr. Ilium acuminate.	*Pg.* Ilium, border expanded.	The same.
FORE-LIMB.	*Pr.* Bent outwards at elbow : manus everted.	The same.	*Pg.* Straight, or vertical at elbow.
HUMERUS.	*Pr.* An entepicondylar foramen.	*Pg.* No entepicondylar foramen.	The same.
	Pr. Prominent deltoid and ectepicondylar (supinator) crests.	*Pg.* Entepicondyle somewhat reduced.	The same.
RADIUS AND ULNA.	*Pr.* Subequal.	The same.	The same.
	Pr. Ulna, posterior border convex.	*Pg.* The same, concave.	The same, concave.
CARPUS.	*Pr.* Lunar resting upon cuneiform.	The same.	The same.
	Pr. An os centrale.	*Pg.* Os centrale united.	The same.
	Pr. Magnum small.	*Pg.* Magnum larger.	The same.
	Pr. Plantigrade.	*Pg.* Sub-digitigrade.	Digitigrade.
FEMUR.	*Pr.* Prominent third trochanter.	*Re.* Reduced third trochanter.	No third trochanter.
TIBIA.	*P.p.* Rudimentary spine and cnemial crest.	The same.	The same.
	Femoral facets, approximate.	The same, approximate.	The same, confluent.
FIBULA.	*Pr.* Articulating with calcaneum.	The same.	*Pg.* Not articulating with calcaneum.
TARSUS.	*Pr.* A tibiale.	*Pg.* A tibiale, variable.	A tibiale, variable.
	Pr. Mesocuneiform small.	*Pg.* The same, enlarged.	The same, enlarged.
	Pr. Astragalus with neck.	*Pg.* Astragalus without neck.	The same.

	Taligrada. *Continued.*	*Pantodonta.* *Continued.*	*Dinocerata.* *Continued.*
TARSUS.	*P.p.* Astragalar foramen.	The same, variable.	The same, variable.
	Pr. An astragalo-cuboidal facet.	The same.	The same.
	Pr. Astragalo-tibial facet very limited and facing obliquely outwards.	*Pg.* The same, extended, horizontal, approaching astragalo-navicular facet anteriorly.	*Pg.* The same, extended, horizontal, separated from astragalo-navicular facet anteriorly.
	Pr. A calcaneo-fibular facet.	The same.	*Pg.* No calcaneo-fibular facet.
	Pr. Mts. V. curved with prominent 'peroneus brevis' process.	*Pg.* The same straight, process reduced.	The same, straight; process vestigial.
	Pr. Plantigrade.	*Pg.* Subdigitigrade.	*Pg.* Digitigrade.
FEET.	*Pr.* Pentadactyle and isodactyle.	The same.	The same.

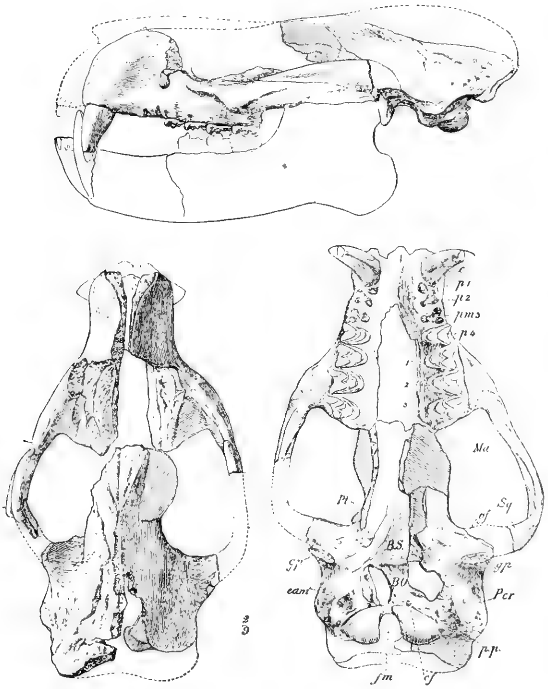


Fig. 7. *Pantolambda cavirictus.* Cotype. Lateral, inferior and superior views of cranium. Am. Mus. Coll., No. 963.

3.—SYSTEMATIC REVISION.

Order AMBLYPODA *Cope.*

Most primitive order of Ungulates known. *Brain* very small, with smooth cerebral hemispheres, large olfactory lobes and exposed cerebellum. *Dentition* brachydont: Superior molars triangular (tritubercular, bunodont, selenodont, lophodont), rarely with functional hypocone. *Feet* pentadactyl, isodactyl; plantigrade (as in Bear) to subdigitigrade (as in Elephant). *Displacement* in carpus (unlike Diplarthra); lunar resting on unciform only; in tarsus (like Diplarthra), astragalus resting on cuboid. A tibiale tarsi. Astragalus perforated or grooved.

The three suborders are very widely separated.

SUBORDINAL CHARACTERS.

Taligrada Cope.	*Pantodonta* Cope.	*Dinocerata* Marsh.
Dentition.		
Typical Eutherian formula.	The same.	No superior incisors.
Molars tritubercular selenodont.	Lopho-selenodont.	Lophodont.
Premolars simple, with two crescents.	Premolars simple, two crescents.	Premolars submolariform.
Skull.		
Nasals, frontals and parietals smooth. A sagittal crest. No alisphenoid canal; no air cavities.	Rudimentary parietal horns. Cranium flattened. No alisphenoid canal. Air cavities.	Nasal, maxillary and parietal horns. Cranium flattened. An alisphenoid canal. Air cavities.
Limbs.		
Plantigrade. An entepicondylar foramen. A 3d trochanter. An os-centrale. Fibula articulating with calcaneum. Astragalus with neck.	Semi-plantigrade. No entepicondylar foramen. A 3d trochanter. No os-centrale. Fibula articulating with calcaneum. Astragalus without neck.	Sub-digitigrade. Entepicondylar foramen. A 3d trochanter. Os-centrale wanting. Fibula not articulating with calcaneum. Astragalus without neck.

Suborder TALIGRADA *Cope.*

Family Periptychidæ *Cope.*	Family Pantolambdidæ[1] *Cope.*
Molars bunodont, primitive triangle compressed in superior molars; secondary internal cusps developed (protostyle and hypocone). Lower molars with hypoconulid. Third and fourth upper and lower premolars enlarged.	Molars selenodont, primitive triangle less compressed. Lower molars without hypoconulid. No secondary internal cusps.

Family PERIPTYCHIDÆ *Cope.*

In 1892 (op. cit., p. 47) Osborn pointed out that *Periptychus* is distinguished from the order Condylarthra (in which it had been placed by Cope) first, because the *tarsus is not serial*, there being a displacement of the astragalus upon the cuboid; second, because it has the *strictly trigonal molar* of the Amblypoda. In 1897[2] Cope adopted this view and removed the Periptychidæ to the Amblypoda. The close comparison of *Pantolambda* and *Periptychus* given below fully confirms this step. The condition of the upper premolars as composed of two crescents and (unlike

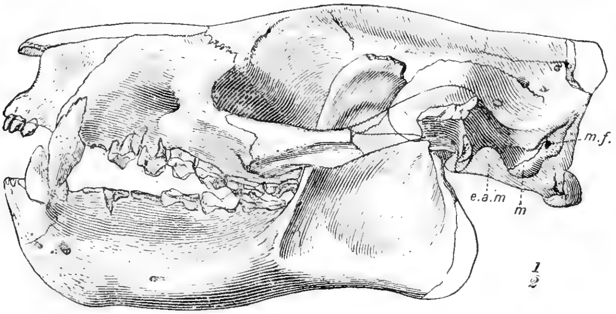


Fig 8. *Pantolambda bathmodon.* Lateral view of skull, showing wide exposure of mastoid. Composition of Nos. 2550 and 2549, Am. Mus. Coll.

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[1] See Osborn and Earle, 1892, p, 49.
[2] Am. Nat., 1897, p. 335. Matthew has, however, retained the Periptychidæ in the Condylarthra.

the Condylarthra) with little or no tendency to acquire the molar pattern, is essentially similar in the two families.

Subfamily ANISONCHINÆ *O.&E.*	Subfamily PERIPTYCHINÆ *O.&E.*
Smaller forms. ? Arboreal.	Larger forms. ? Terrestrial.
Superior molars with conules suppressed or wanting. Paraconid reduced or wanting. Astragalus short and wide,[1] with deeper trochlea.	Superior molars well developed. Paraconid strong. Astragalus with shallower trochlea.[2]

The genera and species of Periptychidæ, as recently revised by Matthew,[2] are given in the following geological table.

	Cretaceous.	Basal Eocene.		Lower Eocene.			Middle Eocene.			
				Wasatch.				Bridger.		
	Laramie.	Puerco.	Torrejon.	Lower.	Middle	Upper.	Wind River.	Bridger.	Washakie.	Uinta. A and B.
UINTATHERIIDÆ	....	...	...	...	..	...	...	×	×	×
BATHYOPSIDÆ	....	...	...	...	...	...	×			
CORYPHODONTIDÆ	....	...	...	×	×	×	×			
PANTOLAMBDIDÆ.										
Pantolambda cavirictus	.....	...	×							
" bathmodon	.....	...	×							
PERIPTYCHIDÆ.										
Ectoconus ditrigonus	.....	×								
Periptychus rhabdodon	.....	...	×							
" carinidens	.....	...	×							
" coarctatus	.....	×								
Conacodon entoconus	.....	×								
" cophater	.....	×								
Haploconus lineatus	.....	...	×							
" corniculatus	.....	...	×							
Anisonchus sectorius	.....	...	×							
" gillianus	.....	×								
Hemithlæus kowalevskianus	.....	×								
INCERTÆ SEDIS.										
Ectoconodon	..×									
Synconodon	..×									
Protolambda	..×									

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[1] Matthew, Bull. Am. Mus. Nat. Hist., 1897, p. 297.

[2] Op. cit., p. 265.

Family PANTOLAMBDIDÆ *Cope.*

Genus **Pantolambda** Cope.

Dentition typical. First upper premolar one-rooted. Second, third and fourth three-rooted, with internal cones. Canines rounded.

P. bathmodon.	*P. cavirictus.*
Type: Mandibular ramus, No. 3956. Smaller size. Both dental series continuous.	*Type:* Jaw, No. 3961. Larger size. First lower premolar close to canine and separated from second by a wide diastema. Premolars reduced in size.

P. cavirictus[1] *Cope.*

The type lower jaw, described and figured by Cope (Am. Nat., Vol. XVIII, p. 1111) is peculiar in the close apposition of the first lower premolar to the canine, and the wide diastema behind it. This is the largest type known and the diastema is probably prophetic of the diastema invariably observed in *Coryphodon*, (Fig. 2).

The skull (Fig. 7) was mistakenly described by Osborn and Earle in 1895 (1895,[2] p. 43) as *P. bathmodon.* It differs in its much greater size from *P. bathmodon*, and in the absence of diastemata from the *P. cavirictus* jaw. Unlike *Coryphodon* the upper canines are mainly worn upon the inner posterior surface.

Fig. 9. Skeleton of *Pantolambda bathmodon.* Scapula wholly, pelvis partly restored. Composition from several individuals. One-eighth natural size.

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[1] Am. Nat., Vol. XVII, 1883, p. 968.
[2] Am. Nat., Vol. XVI, 1882, p, 418.

P. bathmodon[1] *Cope.*

The composition skeleton of *P. bathmodon* measures 2 feet 9 inches (830 mm.) from the premaxillaries to the back of the ischiac symphysis, and 1 foot 1¾ inches at the withers. It is thus about the size and proportions of a large Wolverene (*Gulo luscus*).

Excepting in the selenodont teeth, it typifies the *hypothetical Protungulate*, being more primitive than either *Euprotogonia* or *Phenacodus*. The step is that of the Bear, the feet very broad and spreading, the wrist and ankle being slightly raised off the ground, and the phalanges terminating in hoofs.

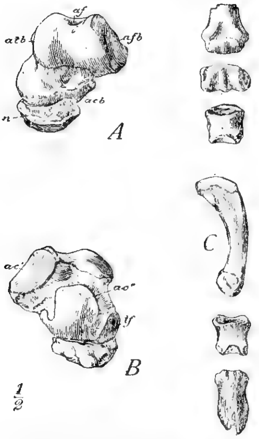

Fig. 10. *Pantolambda bathmodon.* Astragalus, metacarpal III and phalanges. Am. Mus., Cope Coll., No. 3957.

The vertebræ preserved (Nos. 2549, 2551) indicate a short neck (C. 6 = 10 mm.) as in *Periptychus*, and *a back increasing in strength and power as we pass towards the lumbar region.* Thus the dorsals are short anteriorly (D. 5 = 15 mm., No. 2549) and indicate less separation of the zygapophysial and rib-tubercle facets than in *Phenacodus.* The lumbars (L. 4 = 25 mm., No. 2549) are longer; unlike most Creodonts they present horizontal rather than vertical zygapophysial facets. The tail is long and powerful.

Primitive or Protungulate Characters.—Among the *persistent primitive* or Creodont characters of Pantolambda are the following:

Brain small, olfactory lobes large, hemispheres smooth. Skull with a sagittal crest; terminal anterior nares; nasals very long and expanding posteriorly; mastoid (periotic) widely exposed and forming lower posterior border of external auditory meatus; tympanic bones rudimentary; zygomatic arches slender; no alisphenoid canal; basi-cranial foramina separate.

Dentition typical; no diastemata; molars tritubercular, incisors small, cylindrical; canines rounded. Girdles: scapula unknown; ilium acuminate as in *Phenacodus.*

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[1] See Cope, Am. Nat., Vol. XVII, p. 406.

Fore-limb strongly bent outwards at elbow (as in Creodonta and Carnivora), manus everted. Humerus with powerful deltoid, pronator (entepicondylar) and supinator (ectepicondylar) crests; ulna with a convex posterior border; carpus with an os centrale, an extremely small magnum and short trapezoid, causing the metacarpal IV to be inserted proximally between the trapezoid and magnum (Fig. 12).

Hind-limb straight, with three trochanters upon the femur (Fig. 11). Tibia with a rudimentary spine, a very long cnemial crest (Fig. 11) and femoral facets approximate. Tibia (Fig. 11) articulating with calcaneum. Probably an *os-tibiale* (Fig. 12). Mesocuneiform short (analogous to trapezoid in the carpus), so that metatarsal IV articulates between ento– and ectocuneiforms (analogous to metacarpal IV). Articulation between tibia and astragalus slanting obliquely inwards, very limited in extent, bounded posteriorly

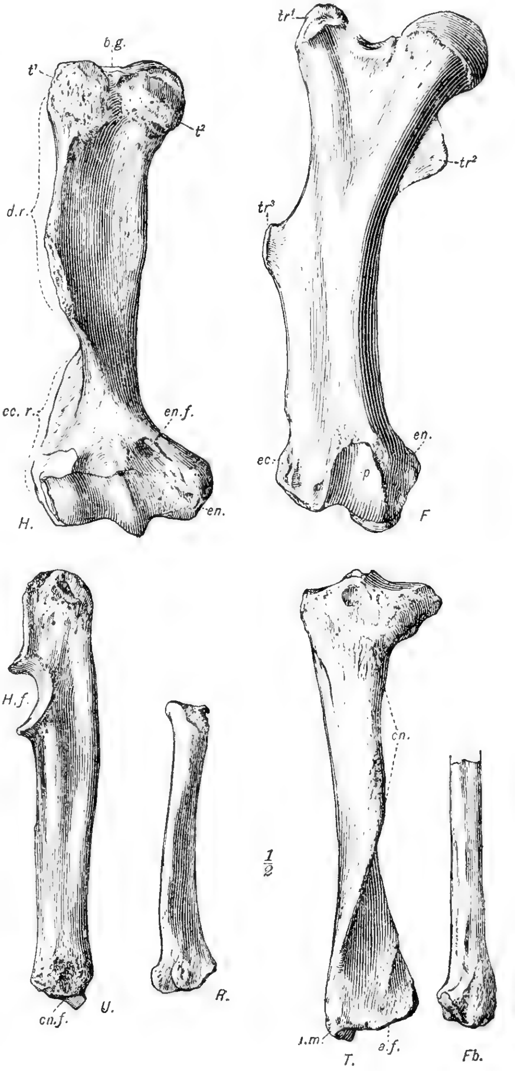


Fig. 11. *Pantolambda bathmodon.* Anterior view of fore and hind limbs, showing powerful development of crests and trochanters as in the Creodonta. Humerus, No 2549. Femur, No. 2523 (2551, 2549). Tibia, No. 2551. Ulna, Nos. 2550, 2547. Radius, No. 2547 (2546). Am. Mus. Coll.

by astragalar foramen which issues posteriorly between the ectal and sustentacular facets (Fig. 12) (as in Creodonta). Astragalo-navicular head broad convex; two astragalo-calcaneal facets only. Fifth metatarsal curved with a prominent external tuberosity for the *peroneus brevis* muscle, as in the Bear.

All these osteological characters are shared by Periptychus, so far as the skeleton of the latter genus is known; (the carpus of *Periptychus* is unknown). The skull, vertebræ and proportions of the limb bones in the two types are remarkably similar.

ORDINAL OR AMBLYPOD CHARACTERS.—*Primitive ordinal characters.* It will be observed in the definition of the Amblypoda, p. 180, that many of these above-described primitive characters persist throughout the evolution of the order, and therefore rank as *ordinal.*

MEASUREMENTS: SKULL, TEETH, SKELETON.

	P. BATHMODON.		P. CAVIRICTUS.	
	Mus. Nos.	Mm.	Mus. Nos.	Mm.
Skull, condyles to premaxillaries . . est.	2548	157	963	est. 272
Molar-premolar series, superior.......	....	055	"	088
inferior........	2550	060	3961	118
Lower jaw, symphysis to angle	2550	126	"	est. 251
Fore-limb: Humerus, total length...	2549	124		
" Radius, " ...	2547	083		
" Manus, " ...	"	081		
Hind-limb: Femur, " ...	2551	148		
" Tibia, " ...	"	119		
" Pes, " ...	"	109	3963	184
Ilium, total length, as restored........	"	111		
" width....................	....	031		
RESTORED SKELETON.				
Skull to perpendicular of ischiac symphysis....................	....	830		
Height at shoulder blade....	....	350		
" ilium....................	....	332		

SPECIALIZED ORDINAL CHARACTERS.—There are, however, many structures in *Pantolambda* which amply affirm Cope's view, that *Pantolambda* is the ancestral type of the great lower and middle Eocene forms. These are: the separation of the premaxillæ in the median line (as in *Coryphodon* and *Uintatherium*), the widely exposed mastoid (as in *Uintatherium*); the nasals extending far back between orbits (as in *Coryphodon*); the molars triangular and selenodont leading to the *Coryphodon* type. The scapula is unknown, probably acuminate as in *Periptychus*. The most striking likenesses to *Coryphodon* in the fore-limb are in the muscular crests of the humerus, the outward flexure of the elbow, the displacement of the lunar upon the unciform.

STRUCTURE OF THE FEET IN PANTOLAMBDA.

Both manus and pes are of exceptional interest. The terminal phalanges are hoof-bearing.

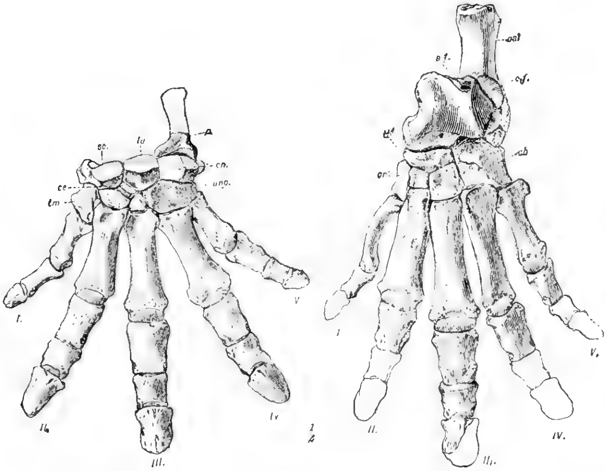


Fig. 12. *Pantolambda bathmodon.* Superior view of carpus No. 2546, partly restored, and tarsus (composition No. 2551), showing essential Creodont structures. Coll. Am. Mus. Nat. Hist.

Fore-foot.—As carefully put together by Dr. Matthew (see Fig. 12), the manus certainly possessed a separate *centrale.* Other exceptional features are the curvature of Mtc.I and the proportions of the distal carpals.

Pantolambda bathmodon.	Magnum smallest. 4 mm.	Trapezoid intermediate. 9 mm.	Trapezium large. 16 mm.
Coryphodon testis.	Magnum large. 37 mm.	Trapezoid smallest. 30 mm.	Trapezium largest. 40 mm.

These proportions show that the evolution of the carpus in the Amblypoda marks an *enlargement of the magnum* and *trapezium* and absorption or coalescence of the *centrale.*

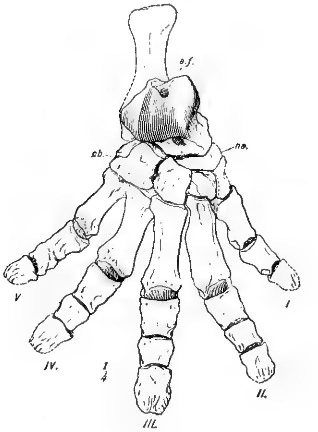


Fig. 13. *Pantolambda cavirictus.* Right pes, directly from above. No. 3963, Am. Mus. Coll.

Hind-foot.—The very large pes, probably belonging to *P. cavirictus* (No. 3963), and small pes of *P. bathmodon* (No. 2550) agree in the many primitive characters enumerated in the Table, p. 178. Analogous to the manus we find a curved first metapodial (Mts. I). As in *Periptychus* and in *Ursus* the fifth metapodial bears a prominent process for the *peroneus brevis* abductors. As in most Creodonts the cuboid is wedge-shaped proximally for the calcaneum and astragalus, and the astragalo-tibial facet faces obliquely inwards (instead of upwards as in *Coryphodon*); this facet is very narrow, bounded by the astragalar foramen posteriorly and a deep pit anteriorly. A very important feature in this species is the thinning out of the inner side of the navicular, bringing the ectocuneiform almost into contact with the astragalus.

Comparative Measurements.

	P. bathmodon. MM.	*P. cavirictus.* MM.
Astragalus, greatest diameter................	20	44
Tarsals, transverse measurement.............	33	68
Metatarsal I..............................	23	35
" II..............................	34	Est. 60
" III..............................	40	61
" IV..............................	36	60
" V..............................	28	50

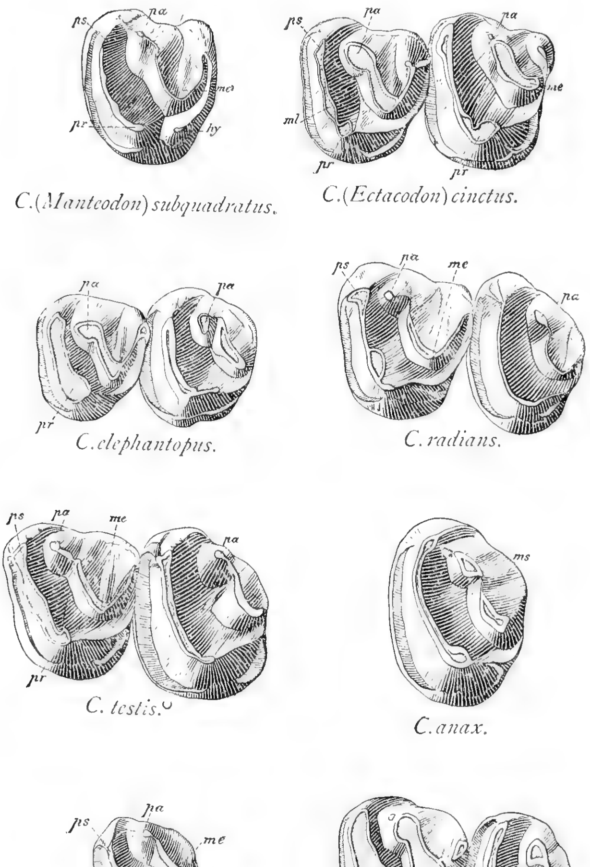
Suborder PANTODONTA *Cope.*

The Pantodonta or Coryphodontia are distinguished by a very great increase in size, the large development of the upper and lower canines, the lopho-selenodont molar teeth, and the broad-topped skulls. These and other advances upon the *Pantolambda* type were effected in the interval between the deposition of the Torrejon or Upper Puerco and the Wasatch Beds.

Fig. 14. Skull of *Coryphodon testis*. Male specimen, No. 2867, as mounted in skeleton. Lower jaw, No. 2872. Am. Mus. Coll. The back part of the skull is elevated by distortion.

REVISION AND CRITERIA OF SPECIES.

Twenty-one species were named by Cope, with as little regard for the laws of individual variation as for the association of skeletons with teeth or of jaws with skulls. It is *a priori* improbable that such numerous species should have coexisted, considering that all the collections come from a few levels and a single geographical region. Our knowledge of large living quadrupeds, such as the African Rhinoceros, shows that rarely more than two species of one genus coexist, and these have different local feeding habits. The writer has found the same to be true of the Eocene Titanotheres of Wyoming. Earle's revision of the species (1892), therefore, marked a valuable advance but left much to be done, owing to his lack of comparative material at the time.


C. (Manteodon) subquadratus. *C. (Ectacodon) cinctus.*

C. elephantopus. *C. radians.*

C. testis. ♂ *C. anax.*

C. armatus *C. testis.* ♀

Fig. 15. Typical upper molars. *C. subquadratus*, type; *C. cinctus*, type; *C. elephantopus*, cotype; *C. radians*, type; *C. testis*, male, No. 274; *C. anax*, type; *C. armatus*; *C. testis*, type, female. All in the Am. Mus. Coll.

Altogether there are about thirteen distinct species known at present, which are distributed as in the following Table.

	WASATCH.						WIND RIVER.
	N. M.	WYOMING.					WYOMING.
	New Mexico.	Evanston.	Black Buttes.	Gray Bull, Big Horn Mts.	Clark's Fork.	Buffalo Basin, Big Horn Mts.	Wind River Mts.
SERIES I.							
C. wortmani							×
SERIES II.							
C. testis				×			
" repandus				×			
" marginatus				×			
" cinctus				×			
" semicinctus		×					
" *lobatus*	×			×			
" anax				×		×	
" pachypus						×	
" *elephantopus*	×					×	
" cuspidatus	×						
" obliquus	×			×			
" latipes		×					
" *latidens*	×						
" *ventanus*							×
SERIES III.							
C. armatus			×			×	
" *simus*	×						
" molestus	×						
" lomas	×						
INCERTÆ SEDIS.							
C. radians		×		×			
" *hamatus*		×					
" *subquadratus*				×			
" *curvicristis*				×			
" *singularis*							×

MOLAR TYPES.—It is essential, first, to clearly conceive the correlated changes taking place in the upper and lower molar teeth, as shown in the accompanying figures and diagrams.

In the *upper molars:*

1. *Pantolambda* (Fig. 2) exhibits the triangular upper molar ancestral to *Coryphodon*, ectoloph (with crescentic cones and mesostyle) at *right angles* to protoloph

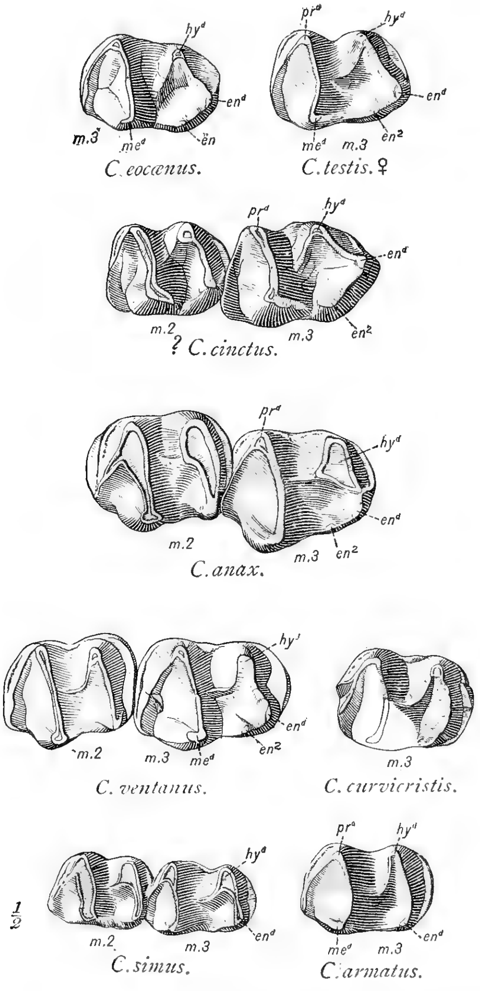


Fig. 16. Typical lower molars. *C. eocœnus*, cast of Owen's type. *C. testis*. *C. cinctus*, variety, with triangular heel, No. 4329. *C. lobatus*, typical lower molar, No. 4305. *C. ventanus*, type, No. 2970. *C. curvicristis*, type, No. 4326. *C. simus*, No. 2563. *C. armatus*, type, No. 4316. All in the Am. Mus. Coll.

2. *C. radians* presents an intermediate stage, ectoloph (with crescents and mesostyle disappearing) *oblique* to protoloph (Fig. 15).

3. *C. armatus* presents a final stage, oval crown, ectoloph (a slightly concave crest) *parallel* to protoloph (Fig. 15).

The second upper molar slowly goes through the same phases as the third, and both approach the *Uintatherium* pattern.

In the *third lower molar* various species of *Coryphodon* exhibit (Fig. 16):

1. *Primitive stage*, a trilobed heel (hypoconid, entoconid, entoconid 2); crests *oblique*, heel with three main cusps, *C. eocœnus*.

2. *Intermediate stage*, a heel with two main cusps (hypoconid, entoconid), third cusp (entoconid 2) degenerate; crests *less oblique*, *C. testis*.

3. *Final stage*, a bilobed heel (hypoconid, entoconid), entoconid 2 absent, crests *transverse*, *C. simus*. A tooth exactly of the Tapir or Lophiodon type.

Thus the crests of the upper and lower molars slowly become transverse, and simultaneously also preserve their mutual interlocking shear; the stages, 1, 2 and 3, in each being probably correlated.

It is, however, extremely difficult to determine the species by these principles alone, because the hypolophid, or posterior crest, of the third lower molar seems to be highly variable, not in its *obliquity of angle*, but in the greater or less development of the *entoconid 2*, as frequently seen upon opposite sides of the same jaws (*e. g.*, Nos. 2868 and 4321).

CUTTING TEETH.—The *canines* aid us: the primitive form is *round* (persisting in *C. wortmani*) as in *Pantolambda;* the intermediate form is *triangular* and antero-posteriorly compressed (*C. testis, C. ventanus*); the final form is flattened and laterally compressed (*C. armatus*), paralleling the *Uintatherium* type, because the long axis of the blade is longitudinal.

SKULL.—When fully known, the top of the skull will prove highly distinctive. At present we know only the comparatively primitive crested type (Fig. 18 *B*), and the flattened type (Fig. 18 *C*), which approaches *Uintatherium.*

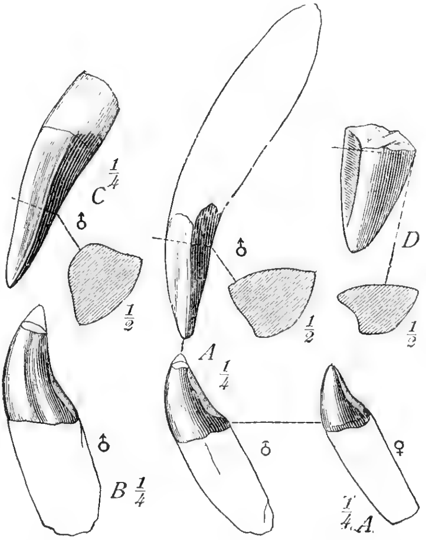


Fig. 17. Upper and lower canines, lateral views and sections. *A*, *Coryphodon testis*, ♂, male upper and lower canines, No. 274. ♀, female lower canine. *B*, *C. anax*, male lower canine, No. 4328. *C*, *C. ventanus*, male upper canine, No. 2970. *D*, *C. armatus*, upper canine and section, No. 4315. This very small canine is upon double the scale of the other teeth.

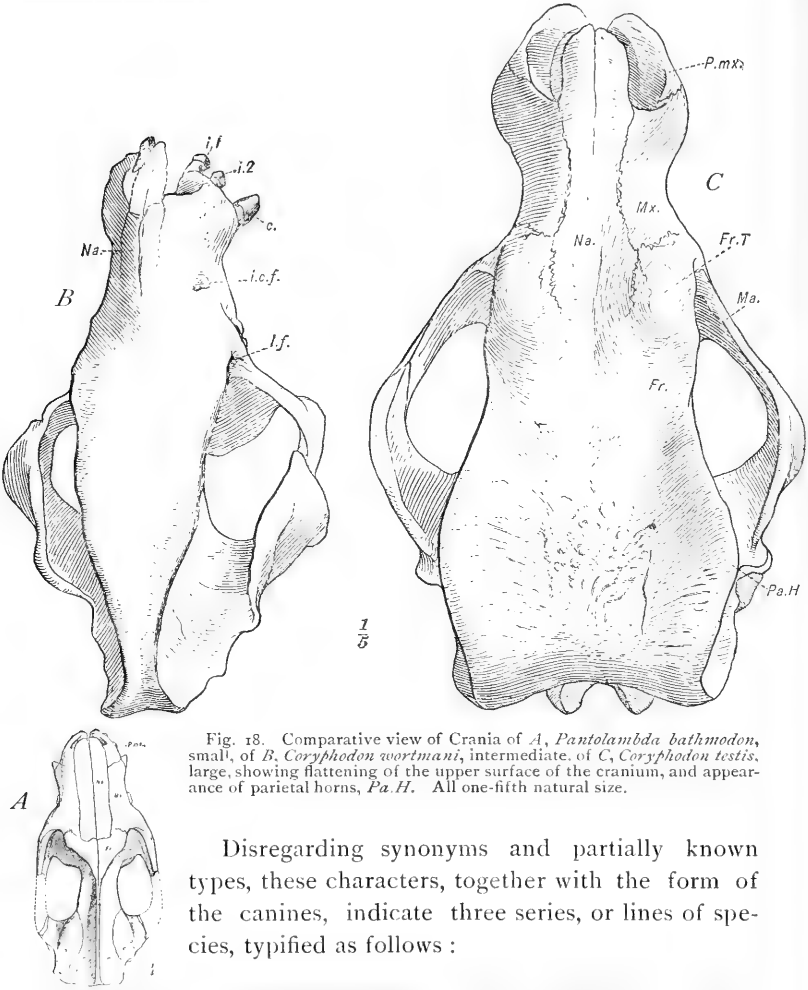


Fig. 18. Comparative view of Crania of *A*, *Pantolambda bathmodon*, small, of *B*, *Coryphodon wortmani*, intermediate, of *C*, *Coryphodon testis*, large, showing flattening of the upper surface of the cranium, and appearance of parietal horns, *Pa.H.* All one-fifth natural size.

Disregarding synonyms and partially known types, these characters, together with the form of the canines, indicate three series, or lines of species, typified as follows :

Levels.	*Series I.*	*Series II.*	*Series III.*
	Primitive. Narrow crested skull. Canines rounded.	Specialized. Broad crested skulls. Canines triangular. Second lower incisors enlarged; third ditto reduced. Lower molar crests oblique to transverse. $M_{\overline{3}}$ trilobate to bilobate.	Specialized. Medium crested skulls. Canines laterally compressed, grooved. Molar crests nearly or quite transverse. $M_{\overline{3}}$ bilobate.
Wind River	*C. wortmani.*		
Wasatch. . .	. . . .	*C. elephantopus*.	*C. armatus.*

The presence of the narrow crested *C. wortmani* in the Wind River Beds, the highest level in which the genus appears, shows that the *two series* evolved simultaneously, just as we observe among the flattened and crested Eocene Titanotheres. In each the evolution of the molar crests from *oblique* to *transverse* angles, with degeneration of the entoconid, loss of crescents, etc., was apparently parallel.

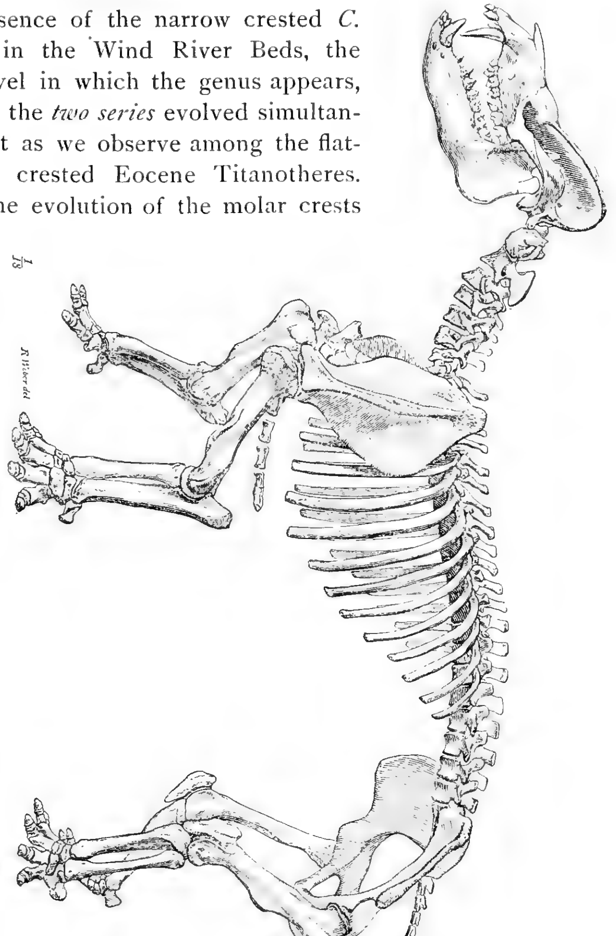


Fig. 18*a*. *Coryphodon testis*. Mounted skeleton in the American Museum of Natural History.

The *sex* characters, as clearly shown in numerous specimens of *C. testis*, are: Males larger, with powerful upper and lower canines; females smaller, with smaller upper and lower canines. (See Fig. 17.)

Among the specific or variable characters in the skeleton are the presence or absence (compare Earle) of the tibiale facet, of the astragalar foramen, and of the articulation of the cuneiform with Mtc. V, which variation is similarly observed in *Uintatherium*, as shown by Marsh. ('Dinocerata,' p. 107.)

None of the generic characters assigned by Cope to *Bathmodon*, *Ectacodon*, *Metalophodon* and *Manteodon* appear to the writer to be valid, as they rest either upon errors in field collection or upon individual variations.

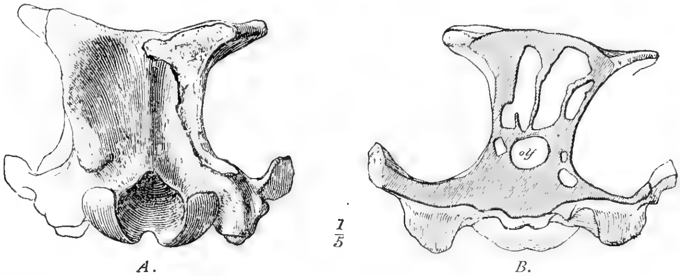


Fig. 19. *Coryphodon elephantopus*, showing flat-topped skull. *A*, view of occiput; *B*, transverse section of cranium through region of olfactory lobes, showing air cells. Coll. U. S. Nat. Mus., No. 111.

Series II.—LARGE CORYPHODONS WITH BROAD, FLAT-TOPPED SKULLS, RUDIMENTARY PARIETAL HORNS, TRIANGULAR CANINES.

12. C. elephantopus *Cope.*

Type, U. S. Nat. Mus. Coll. Superior molar 3; inferior molar 3. Loc., New Mexico. This type has been temporarily displaced.

Cotype, No. 111, U. S. Nat. Mus. Coll. Skull with upper dentition complete; inferior dentition and fragmentary jaw.

Definition.—Superior molars=158 ♂. Skull characters as in *C. testis*, excepting $m^{\underline{3}}$ more quadrate (cotype) with slightly convex mesostyle; m^3 (type) with hypolophid and entoconid 2; incisors equal sized.

Synonyms.

C. obliquus Cope. Type, U. S. Nat. Mus. Coll. A single fragmentary inferior molar. Hypolophid oblique. Entoconid 2 reduced.

This is a smaller animal than *C. testis*, but is found upon a higher level.

Cope's association of type and cotype is open to some question. The type has been temporarily lost, and unfortunately the

TABLE SHOWING THE PROPOSED SPECIES WITH ORIGINAL NAMES, NATURE OF TYPE, ETC.

Spec's No.	NAME.	DATE.	TYPE.	FIGURE.
1	Coryphodon eocænus *Owen*.......	Hist. Brit. Foss. Mamm., 1846, p. 299....	Inf. m. 2 and m. 3...	Figs. 103, 104.
2	" anthracoideus *Blainville*..			
3	" oweni *Hébert*..........	Ann. d. Sc. Nat., VI, 1856, p. 87........	Skull and teeth.	
4	Bathmodon radians *Cope*	Proc. Am. Phil. Soc., Feb. 16, 1872, p. 418,	Sup. m. 2 and 3 with skeleton	Tert. Ver., pls. 45-57.
5	" semicinctus *Cope*......	" " " " p. 420,	Teeth.	
6	Metalophodon armatus *Cope*.......	" " 1872, p. 542.......	Superior molars.....	Tert. Ver., pl. 49.
7	Bathmodon latipes *Cope*	" " 1873, p. 70.........	Skeleton	" " 48.
8	" brevipes[1]....	Proc. Acad. Nat. Sci. Phila., 1873, p. 103,		
9	" simus *Cope*..........	Rep. Vert. Fos. N. M. Wheeler, 1874, p. 120,	Inferior molars......	Pal. of N. M., pl. 55.
10	" molestus *Cope*.........	" " " " " p. 121*a*,	Sup. and inf. molars,	" " pls. 56-57.
11	" lomas *Cope*..........	" " " " " p. 121*b*,	Inferior molars, 3....,	" " pl. 54.
12	" elephantopus *Cope*.....	" " " " " p. 121*c*,	Last sup. and inf. m. 3,	" " pls. 50-54.
13	" latidens *Cope*.........	Syst. Cat. Vert. N. M., 1875, p. 29......	Jaw with teeth......	" " " 48-50.
14	" cuspidatus *Cope*.......	" " " " p. 30.....	Inferior molars 3....	" " pl. 46.
15	Coryphodon hamatus *Marsh*......	Am. Jour. Sci. and Arts, 1876, p. 426....	Sup. and inf. molars,	Mon. of Dinocerata, p. 52.
16	" obliquus *Cope*.........	Pal. of New Mexico, Wheeler, 1877, p. 207,	" " "	Vert. Pal. N. M., pl. 47.
17	" lobatus *Cope*.	" " " " p. 209,	" " "	" " " 46.
18	Manteodon subquadratus *Cope*.....	Proc. Amer. Phil. Soc., Dec. 16, 1881, p. 166,	Last sup. m. with incisors	Tert. Vert., pl. 44a.
19	Ectacodon cinctus *Cope*...........	" " " " p. 167,	Superior molars.....	" " "
20	Coryphodon anax *Cope*	" " 1881, p. 168.......	Sup. and inf. molars,	" pls. 44a-e.
21	" repandus *Cope*... .. .	" " " p. 171.......	Inferior m. 2 and 3	" pl. 44c.
22	" curvicristis *Cope*......	" " " p. 172.....	Sup. m. 2 and mand. with teeth.......	" " 44c.
23	" marginatus *Cope*	" " " p. 174.......	Superior molars 3 ...	" " 44e.
24	Metalophodon testis *Cope*	" " " p. 175.......	" "	" " 44a.
25	Bathmodon pachypus *Cope*........	Proc. Acad. Nat. Sci. Phila., 1882, p. 294,	Skeleton	" pls. 44d-g.
26	Coryphodon ventanus *Osborn*......	Bull. Amer. Mus. Nat. Hist., X, 1898, p. 210,	Jaw and teeth.......	Op. cit., fig. 16.
27	" wortmani *Osborn*	" " " p. 212,	Skull.	" " " 27.
28	" singularis *Osborn*	" " " p. 214,	Tarsus.	" " " 28.

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[1] Name only.

TABLE OF COMPARATIVE MEASUREMENTS.

Species Number.		Sex.	Museum Number.	Pm. and M. Sup.	Inf.	M³, long.	trans.	$M_{\overline{3}}$, long.	trans.	Skull, inc. to cond.	Scap. vert.	Hum.	Rad.	Mtc. III.	Pelvis, trans.	long.	Fem.	Tib.	Mts. III.	Ast. Tr.
4	*C. (Bathmodon) radians*...Type.	♀	4300	....	....	32	43	....	...	....	....	...	...	..	....	....	432			
19	C. (Ectacodon) cinctus....Type.	?	4341	e182	....	33	42													
21	Coryphodon repandus....Type.	♂	4309	....	....	33	46	40	28											
	" testis.......Skull.	♂	2829	181	192	34	..	42	....	514	e425	366	248	75						
	" " ....Skull.	♂	2867	....	....		....	....	....	523										
	" " ....Skull.	♀	2963	169	e177	27	39	....	....	494	....	...	....	71	e705	e555				
	" "	?	2869	....	...	..	....	....	..	. .	....	...	....	..	....	....	465	283	56	
	" "	♂	2827	181	...	33	e52													
	" "	♂	4329	....	....	....	....	43	27	...	....	377	....	..	....	....	456			
	" " ....Jaw.		4322	...	172	..	...	42	26											
	" " ....Jaw.	♀	2868	....	182	....	....	39	26											
	" " ....Skel.		258	....	....	....	..	....	....	....	...	...	247	78	....	610	463	...	63	94
23	Coryphodon marginatus. Type.	?	....	....	....	28	38													
17	*Coryphodon lobatus*...... Type.	?	....	....	....	38	...	46	30											
22	*Coryphodon anax*.........Type.	♂	....	..	..	39	55													
	" "	?	267a	....	....	40	55													
	" " ....Skull.	♂	2866	193	....	37	48													
	" " ....Jaw.	♂	4333	....	196	....	. .	45	31											
25	" pachypus ....Type.	?	4335	....	....	....	....	....	....	....	....	...	....	80	....	572	507	...	..	93
	" anax............	?	4336	....	....	....	....	....	....	....	....	405	263							
	" "	?	4356	....	...	....	....	....	....	....	....	...	....	..	....	....	....	...	70	
24	C. (Metalophodon) testis..Type.	♀	4317	175	....	29	41													
12	*Coryphodon elephantopus*. Cotype.	♂	....	158	...	31	40	....	....	450										

TABLE OF COMPARATIVE MEASUREMENTS—*Continued.*

Species Number.		Sex.	Museum Number.	Pm. and M. Sup.	Pm. and M. Inf.	M. 3. long.	M. 3. trans.	M. 3, long.	M. 3, trans.	Skull. inc to cond.	Scap vert.	Hum.	Rad.	Mtc. III.	Pelvis, trans. long.	Fem.	Tib.	Mts. III.	Ast. Tr.
	Coryphodon elephantopus.. Skull.	♂	275	158	...	30	39	...	...	e440									
	" " .. Type.	?																	
14	Coryphodon cuspidatus... Type.	?	Nat. Mus																
	" "	?	4324	...	...	...	...	e36	23										
16	" obliquus..... Type.	?	Nat. Mus.	...	...	...	...	32	23										
	" " ...... Jaw.	♀	276	e134	155	24	37	36	25										
	" " ...... Jaw.	♂	4321	...	174	...	...	39	26										
	....		4351	...	...	...	...	...	...	...	...	309	e190	60					
	" latipes .... Skel.		4311	...	...	...	...	...	...	...	...	...	234	...	...	365			
	" " ...... Skel.		4312	...	...	...	...	...	...	...	...	320	...	...	...	375			
7	" " ..... Type.		4313	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	71
9	" simus....... Type.	♂	....	e140	154	26	36	34	21										
	" "	♀	2563	...	e125	...	...	30	19										
13	" latidens ..... Type.	♂		...	156	...	...	33	26										
	Coryphodon wortmani..... Skull.		2977	154	...	27	39	...	...	407	...	...	...		...	340			
	" " ...... Jaw.		2970	...	e185	...	...	42	31										
6	C. (*Metalophodon*) *armatus*, Type.	♂	4316	...	...	28	38												
10	C. (armatus) molestus .... Type.	♀	Nat. Mus.	148	...	30	37	37	23	...	...	...	...	76					
11	C. (Bathmodon) lomas.... Type.	?	..	...	...	...		41	27										
22	Coryphodon curvicristis... Type.	?	4326	...	...	...	...	36	27										
15	" hamatus[1] .... Type.	♂	Yale Mus	164	186														
28	*Coryphodon singularis* .... Type.		2980	...	...	...	...	...	...	...	...	...	...	...	...	365	218	48	61

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[1] Measurements taken from teeth as figured by Marsh.

e=Measurements estimated, especially where pm. $\frac{1}{1}$ is wanting.

characteristic last lower molar, $m^{\underline{3}}$ in the cotype, is wanting. The species must therefore rest upon the characters of the cotype. No lower teeth were found with the fine palate (No. 275, Am. Mus.) rightly associated with the cotype by Earle. The cranial and dental characters of the cotype (Fig. 20) are those of *C. testis* and *C. lobatus* upon a smaller scale; $m^{\underline{3}}$ has a well-marked postero-external elbow (Fig. 15), and the paracone is sharply dis-

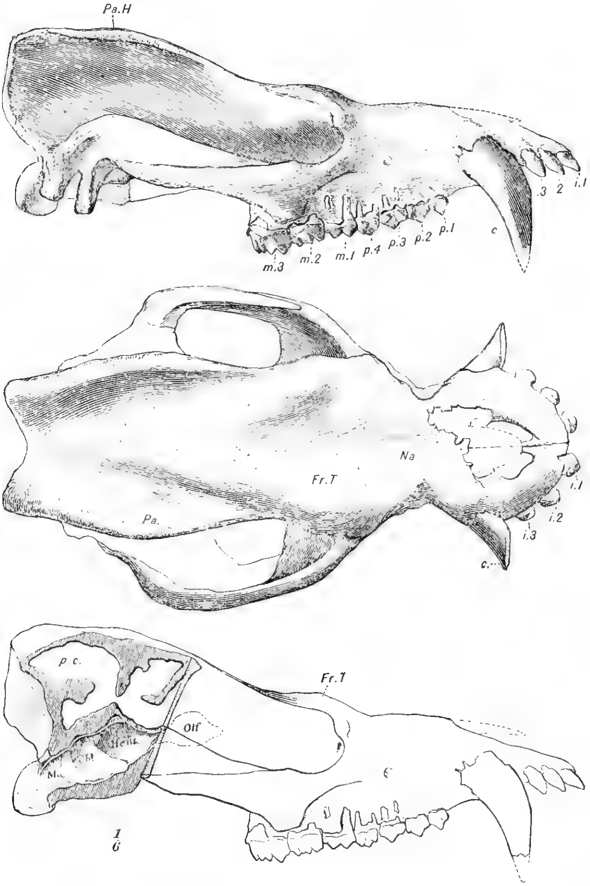

Fig. 20. *Coryphodon elephantopus*, Cotype. Lateral, superior and sectional views of cranium. No. 111, U. S. Nat. Mus. Coll.

tinct from the metacone; the ectoloph thus does not form a continuous crest as in the supposed type. The parietal protuberances or rudimentary horns *Pa.H*, are less pronounced but equally rugose; the premaxillary symphysial borders are extensive although without contact; the incisors are equal in size, i 1 and i 3 being fully as large as i 2 in both jaws. This is therefore a smaller and perhaps more primitive type than either *C. lobatus* or *C. testis*, although skull No. 275 is definitely recorded by Wortman from the Buffalo Basin, the highest true Wasatch level.

Unfortunately the characteristic last lower molar is missing in the cotype; the series pm 1–m 2 measure 122 mm. The lower jaws of *C. elephantopus* are also represented either by Cope's *C. obliquus* or by his *C. latidens* (see below). The former is more probably the case for the following reason. According to the ratio of upper and lower teeth established in the *C. testis* jaws (see Table, p. 199, No. 3829), the lower grinders in *C. elephantopus* should measure 167 mm. The type lower molar of *C. obliquus* approximately agrees with this size (see Table, p. 199) and character. The last lower molar of *C. obliquus* agrees closely with that of the supposed type of *C. elephantopus*. We may therefore consider the greater or less development of the entoconid 2, which these molars present, as variations similar to those which we have observed in the other species of this series, namely, *C. testis* and *C. lobatus*.

No complete jaw is nearer this size than No. 4321 (Am. Mus., Cope Coll.), in which the lower grinders measure 172 mm.; this specimen is also significant because the last inferior molar on the right side agrees in form with *C. cuspidatus* (*i.e.*, entoconid 2, distinct), while the same tooth on the left side agrees with *C. obliquus* (*i.e.*, entoconid 2, obsolete). Another proof of the variability of these cusps. This jaw, however, may belong to a small female of *C. testis*.

INCERTÆ SEDIS.

21. Coryphodon repandus *Cope.*

Type, No. 4309, Am. Mus., Cope Coll. Superior and inferior molars m^1, m^3, $m_{\overline{2}}$, $m_{\overline{3}}$. Symphysis of lower jaws. Size=*C. testis*, male. Loc., Big Horn, Wyoming.

This is an indeterminate type. It is distinguished by angulation of ectoloph in m^3 (as in *C. elephantopus*, cotype); perhaps also by the more transverse direction of hypolophid in m_3; second incisors only slightly larger than first and third (as in *C. elephantopus*, cotype). The nearest resemblance is therefore to *C. elephantopus*, from which it is distinguished by larger size. Superior molars No. 4366, from New Mexico, furnish a transition in the angular form of the ectoloph of m^3 to the *C. testis* type. Altogether *C. repandus* is of very doubtful validity.

19. C. cinctus *Cope.*

C. (*Ectacodon*) *cinctus.* Type: No. 4341, Am. Mus., Cope Coll. Superior molars complete. A strong cusp appearing at postero-external angle of m^2. Loc., Big Horn, Wyoming.

The distinctive feature of this type, viz., the quadrate form and postero-external basal cusp of m^3 (Fig. 15), and to a less extent on m^2, are either individual variations or valid specific characters. They are certainly not generic.

Lower teeth which may possibly be correlated (Nos. 4329, 4334, 266) have a triangular heel upon the last lower molar (Fig. 16), with entoconid very distinct and extremely short and oblique hypolophid.

24. C. testis *Cope.*

24. *C.* (*Metalophodon*) *testis* Cope. Type: No. 4317, Am. Mus., Cope Coll. Superior molar series. Originally distinguished by reduction of posterior crescent spur in m^2.

Definition.—Sup. molars=169 ♀ to 182 ♂. Inf. molars=172 ♀ to 192 ♂. Third superior molar typically oval, with oblique posterior crest with primitive paracone, mesostyle and meta-crescent more or less distinct. Third inferior molar with oblique hypolophid, entoconid 2 reduced or vestigial. Second incisor the largest.

This includes the most completely known Coryphodon. It has been heretofore described by Earle and the writer as *C. radians*, but is now found to be distinct. The identification with Cope's type of *C. testis* is made by means of a careful comparison with the superior molars in the female skull No. 2963. The form and measurements are identical. As this skull undoubtedly belongs to the same species as the male skull (Fig. 21) and skeleton, all the characters of this fine type are now available.

This is the largest Coryphodon but one, and is very abundant in the Middle Wasatch levels, being represented by a magnificent series of skulls and skeletons in our collection. From these the sexual characters are clearly made out. The large male skull is used in the complete mounted skeleton, Fig. 18 *A*. The smaller female type of this species is represented in the skull No. 2963, and jaws (Nos. 2868, 259) in contrast with the powerful male skulls (Nos. 2829, 2867) and jaws (4322).

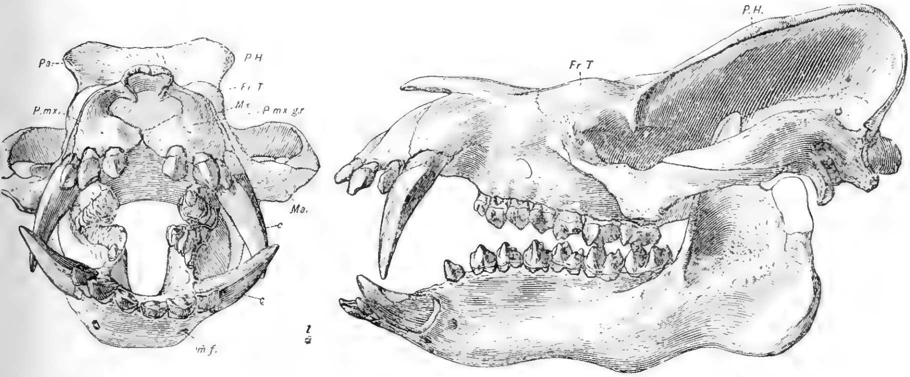

Fig. 21. *Coryphodon testis.* Large male, showing rudimentatary parietal horns. Upper canines partly restored. Skull No. 2867, lower jaw, No. 2872. Am. Mus. Coll.

Variations in the last lower molar are considerable, from an oblique to a bilobed (No. 259) or less oblique condition of the posterior crest, with all the stages in reduction of the entoconid 2. Exactly similar variations are found in the lower molars of the larger and smaller members of Series II. The development of entoconid 2 also varies in the posterior molars upon opposite sides of the same jaws of several specimens of *C. lobatus*.

The osteological characters have been fully described and figured by the writer (this Bulletin, 1898, pp. 81–91). Full characters of the vertebral column are shown in Fig. 23.

Certain specimens (skull, No. 2866) of the still larger *C. lobatus* have been found below it, and the much smaller *C. elephantopus* occurs in the higher levels of Buffalo Basin, Wyoming. Our scanty evidence therefore appears to indicate a retrogression in size in this series, but this is an inference by no means certainly established.

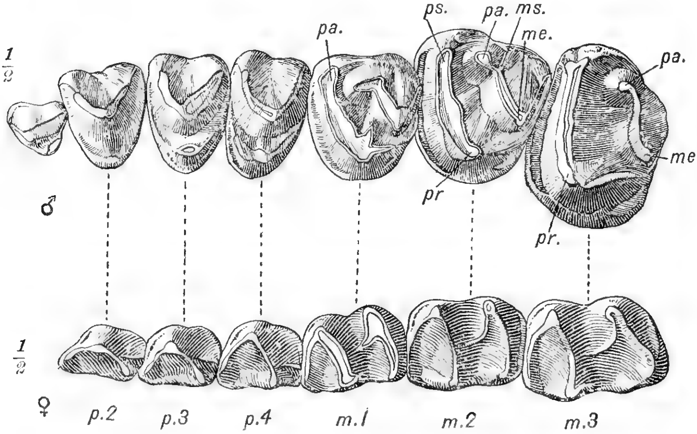

Fig. 22. *Coryphodon testis.* Superior molar series, male (Am. Mus Coll. No 274); inferior molar series, female (Am. Mus. Coll. No. 2868).

17. C. lobatus *Cope.*

Type, Nat. Mus. Coll. Sup. molar 3; inf. molar 3; part of sup. and inf. canine, indeterminate.

Definition.—Sup. molars=193 ♂. Inf. molars=196 ♂. Dental characters as in *C. testis*, excepting elongation of protoloph and degeneration of posterior metacone crescent in m^2. Astragalus usually lacking astragalar foramen. Cranium massive, with widened parietal horn rudiments.

Synonyms.

20. *Coryphodon anax.* Type: No. 4327, Am. Mus., Cope Coll. Superior molar 3; inferior molars, premolars and incisors. Loc., Big Horn, Wyoming.

25. *C.* (*Bathmodon*) *pachypus* Cope. Type: No. 4335, Am. Mus., Cope Coll. Astragalus, calcaneum, pelvis, femur, &c. Indeterminate type. Loc., Big Horn, Wyoming.

This is the largest Coryphodon known; it surpasses *C. testis* in size, the ratio being 50 : 45, as indicated by the femora.

Unfortunately the name *C. lobatus* is prior to the more appropriate *C. anax*, and must supersede it. The lower molars defined

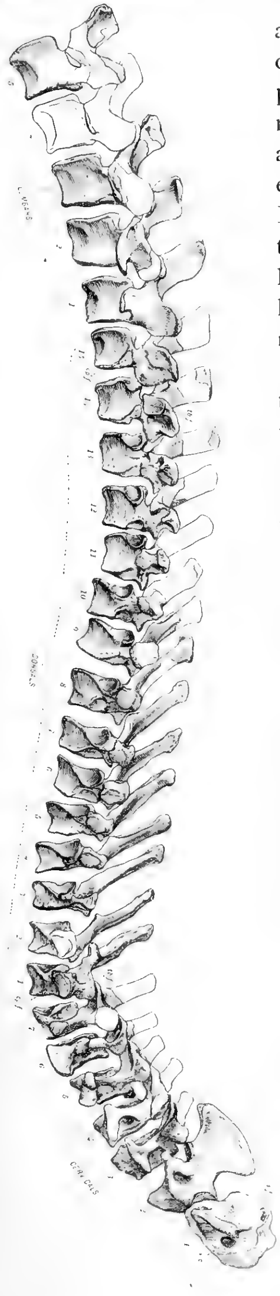

Fig. 23. *Coryphodon testis.* Vertebral column of mounted skeleton. *Ve*, vertebrarterial canal; *s.f*, spinous foramen; *cp.f*, capitular facets; *tb.f*, tubercular facets for ribs. Composition of several individuals; numbers determined from a single individual. One-eighth natural size.

as *C. lobatus* Cope, which may be considered as indeterminate types, present exactly the *C. anax* measurements (see Table, p. 198), and exhibit an oblique hypolophid and depressed entoconid 2 upon $m_{\overline{3}}$, as shown in Fig. 16. This may be considered the typical *C. lobatus* or *C. anax* third lower molar. It is well shown in the large jaw, No. 4333, and in the fragment, No. 4305.

A *variation*, No. 266, in molars of the *C. lobatus* size is paralleled by a variation, No. 4239, in molars of the *C. cinctus* size, as represented in Fig. 16, in which the three cusps form a posterior triangle, as also in *C. cuspidatus* (No. 4324). If these are not variations they represent three distinct species, which is possible but not probable.

Synonym.—The skeleton defined as *C. pachypus* by Cope (No. 4335) undoubtedly belongs here. The astragalus of *C. pachypus* and of another specimen (No. 2870) exhibit no astragalar foramina, and show a wider interval on the front face of the astragalus between the tibial and navicular facets than we find in *C. testis.*

The massive male skull in our collection (No. 2866) is most interesting in its progressive development of the parietal horn thickenings, parallel with those of *Uintatherium.* Its geological level, however, according to Wortman, is below that of *C. testis*, an observation very difficult to reconcile with the more advanced evolution of its skull and molar teeth.

14. C. cuspidatus *Cope.*

Type, Nat. Mus. Coll. Fragmentary inferior molars 2 and 3, and a portion of the jaw. Originally distinguished by prominent entoconid 2.

Cotype, No. 276, Am. Mus. Coll. Complete lower dentition; upper pm^2–m^3. This specimen was referred to *C. obliquus* by Earle (1892, p. 162).

Definition.—Inferior m.pm. = 154. Superior m.pm. = 150. Last superior molar oval, antero-posteriorly compressed. Last inferior molar with oblique hypolophid and more or less prominent entoconid 2. Metaconid with rudimentary metastylid. Inferior incisors unequal in size.

This is a diminutive Coryphodon, of the size and very similar in molar type both to *C. eocænus* Owen, from the London Clay, and to *C. owenii* Hébert, from the Suessonian of France. The characters of Cope's type are very indefinite; the complete upper and lower series of teeth, No. 276, therefore serve as a cotype to define this species, the most diminutive of the series. The last lower molar of the right side agrees in form and measurement with Cope's type, although the entoconid 2 is less prominent and isolated; on the left side the entoconid 2 is nearly obsolete, again demonstrating the variability of this cusp. The very small lower canines indicate that the animal is a female. The enlarged second incisors and general form of m3 confirm its reference to Series II. A unique feature is the reduplication of the metaconid in m2 and m3 into a rudimentary metastylid, parallel with the large metastylid of *Uintatherium.* Another example of this species is No. 4324.

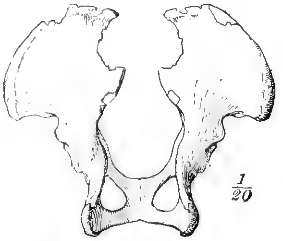

Fig. 24. Back view of pelvis of *Coryphodon lobatus.* Am. Mus., Cope Coll., No. 4335.

13. C. latidens *Cope.*

Type, Nat. Mus. Coll, ♂. Lower jaws and teeth, left premaxillary and incisors, superior canine. Loc., New Mexico.

Definition.—Inferior m. and pm. = 156. Inferior molars short and broad with crests nearly or directly transverse (angle = *e* 85°); entoconid 2 vestigial or wanting. Inferior incisors equal sized. Superior canines nearly straight, antero-posteriorly compressed, subtriangular, with an external ridge.

This imperfectly-known animal appears to represent a rather small and specialized form in Series II.

It is distinguished from the type of *C. elephantopus* by the straighter and more compressed superior canine observed in the type, by the transverse position of the crests of the inferior molars, and by the absence of entoconid 2. As shown in the Table, p. 199, the measurements of Cope's *C. latidens* type are identically the same as those of *C. simus*, although Cope speaks of the latter as being much smaller than the former.

Cope has suggested the possible association of *C. latidens* with the cotype skull of *C. elephantopus*. It appears to be distinguished, however, by the form and compressed section of the superior canine. It is, however, certainly related to Series II by the subtriangular form of the canine and the characteristic swelling of the jaw below m3. Unfortunately the types have been temporarily misplaced, and no determination of this question by direct comparison can be made at present. If these jaws should prove to belong to *C. elephantopus*, the species *C. obliquus* will have to be revived.

It will be noted that both types come from New Mexico. In New Mexico, also true Wasatch, we found in 1897 a lower jaw (No. 2563, Fig. 16) of extremely small size, associated with *Meniscotherium*, *Ambloctonus* and *Didymictis*, which may represent a female of this species. Unfortunately the canines are not preserved. The total lower grinding series does not exceed 125 mm., so that this is the smallest Coryphodon jaw known; the last lower molar measures only 30 x 19 mm.; the posterior crest forms an angle of 85° with the long angle of the jaw; a minute vestige of the entoconid 2 can however be observed.

22. **Coryphodon curvicristis** *Cope.*

Type, No. 4326, Am. Mus., Cope Coll. Lower jaw fragments containing pm.4 to m3; canine.

Definition.—Molar crests transverse. Posterior crest of m_3 directly transverse, crenulate, depressed. Superior incisors with sharply angulate anterior faces. Canines as in *C. testis*.

The systematic position of this species (Fig. 16) is indeterminate. It resembles *C. latidens* in the transverse crest angulation and in the rather broad proportions of the molars, but exceeds this species in size. The complete superior canine determines the position of the animal in Series II. The canine is powerful, curved and antero-posteriorly compressed, partly as the result of pressure. The inferior premolars are exceptionally short.

A fourth member of this series, *C. ventanus*, is found in the Wind River Beds. It appears to resemble *C. latidens* in the form of the superior canines.

Series III.—SMALLER CORYPHODONS. SPECIALIZED. RELATIVELY NARROW, FLAT-TOPPED SKULLS, (?) WITHOUT PARIETAL HORN RUDIMENTS. CANINES COMPRESSED LATERALLY AND GROOVED ANTERIORLY. LOWER MOLARS ELONGATE, CRESTS NEARLY OR QUITE TRANSVERSE; M3 BILOBATE, NO ENTOCONID 2.

In 1872 Cope defined certain teeth as *Metalophodon armatus*, mistaking the posterior superior molars, m^3, of two individuals for m^2 and m^3 of one individual, as can be proved by a comparison with his type of *C. molestus*. The latter type moreover gives us the cranial characters and constitutes a valuable cotype.

6. C. (Metalophodon) armatus.

Type, No. 4315, Am. Mus., Cope Coll. Superior m^3, m^2, premolars, superior canine and incisors; two individuals, probably mingled, fully adult.

Cotype, No. 4316, Am. Mus., Cope Coll. Superior m^2 and m^3, m_3, premolars, etc., juvenile.

Definition.—Upper and lower canines greatly compressed, with a deep antero-internal groove upon the upper canine. M^2 with powerful anterior crest, m_3 without entoconid 2. Lower molars elongate, crests lunate, nearly transverse. (Angle with long axis of jaw, 81°.)

Synonyms.

9. *C. simus* Cope. Type, U. S. Nat. Mus. Coll. Inferior m and pm=154. Fragmentary skull, probably female. Superior canine. Mandibular rami and teeth. Loc., New Mexico.

10. *C. molestus* Cope. Type, U. S. Nat. Mus. Coll. Skull, dentition and parts of skeleton. Loc., New Mexico.

11. *C. lomas* Cope. Type, U. S. Nat. Mus. Coll. Posterior inferior molar. Loc., New Mexico.

The slender crests and the elongate form of the posterior lower molars in this species at once distinguish it as a type from members of the foregoing series, since they form an angle of 81°, or nearly a right angle, with the long axis of the jaw, and m3 is entirely devoid of the entoconid (Fig. 16).

Specimen No. 4315, Fig. 17, gives the most distinctive character, shown again in Cope's type of *C. molestus* (Cope, 1877, Pl. LVI, fig. 4), which agrees with *C. armatus*, namely, the flattened form of the canines. Cope himself referred *C. lomas* to *C. molestus* (1877, p. 237). The type of *C. simus* has lower teeth of the same character, rather long and narrow. The upper canines are, however, described by Cope as triangular and grooved ; this raises a doubt as to the reference of this type to *C. armatus*.

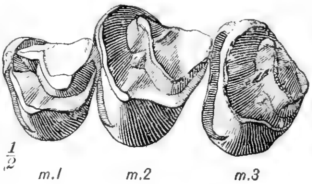

Fig. 25. *Coryphodon armatus* superior molars, left side (type of *C. molestus* Cope).

The juvenile type specimen of *C. molestus* demonstrates the flat-topped character of the skull (Coll. U. S. Nat. Mus. No. 1119, Cope, *op. cit.*, Pl. LVI) ; the skull is far less expanded laterally, when seen from above, than any of the skulls in Series II ; but this may be in part due to its juvenile and undeveloped condition.

"The inferior canine," observes Cope, "has a flat interior and convex exterior face, which are separated by anteriorly and posteriorly directed cutting edges." The most distinctive feature of the canines therefore is that the antero-posterior diameter greatly exceeds the transverse, as in *Uintatherium*. An aberrant feature is the antero-external groove. The median incisors are as large or larger than the others.

ISERTÆ SEDIS.

23. C. marginatus *Cope.*

Type, No. 4374, Am. Mus., Cope Coll. Superior molar 3, canine and pm. Loc., Big Horn, Wyoming.

This indeterminate type resembles *C. armatus* in the form of m^3, but differs from it in the form of the canine, which is less compressed and may possibly represent a milk tooth. The canine corresponds with Cope's description of that of *C. simus.*

WIND RIVER TYPES.

Cope's Wind River material of *Coryphodon*, all of which is now in the American Museum (Nos. 4811, fragments of skull and teeth; 4812, lower molar, incisors and fragments; 4813, lower jaw and fragments; 4814–4817, fragmentary teeth; 4818), merely sufficed to determine the existence of this genus in these beds.

Our Wind River collection and the determination of manus No. 4351 (Am. Mus., Cope Coll.) as belonging to the Wind River Beds, is therefore of very great importance. It demonstrates that *Coryphodonts of considerable diversity and size persisted into the Wind River period.*

Owing to the general scarcity of fossil remains in these beds, the relative abundance of these animals cannot be estimated. Of intermediate size is the jaw of No. 2976, described below as *C. ventanus*; of smaller size there is a well-preserved skull (No. 2977), type of the new species *C. wortmani.* They represent respectively the persistence of at least two series, namely of Series I, and of Series III now discovered for the first time.

SUCCESSORS OF SERIES II.

26. Coryphodon ventanus, sp. nov.

Type, No. 2976, Am. Mus. Coll. Jaws and lower teeth. Superior incisors and canine. L. metacarpal IV.

Definition.—Size of *C. testis* ♂. Inferior m and pm series=*e* 172. Superior canines posteriorly compressed, with antero-internal depression and long sharp external ridge. Lower canines with short external ridge near apex. Second incisors enlarged; lateral incisors much reduced. Posterior inferior molars with crests more transverse than in *C. testis* (angle = 74°) a persistent entoconid 2. (? Cuneiform articulating with Mtc. V.)

This species is clearly distinguished from *C. testis* by the form of the canines, which in this animal are comparatively straight and lance-shaped (Fig. 17), the long axis transverse (unlike *Uintatherium*), with an antero-internal groove which is worn away by the lower canine. They resemble those of *C. latidens* Cope (except in the groove), but are much less compressed than those of *C. armatus* Cope, besides having the long axis in a different plane. The posterior crest of m_3 (Fig. 16) differs from those of *C. armatus* and *C. simus* in form and in the retention of an entoconid 2, and from that of *C. testis* in being slightly less oblique. Another character is the very rapid increase in size of the molar series as we pass backward: m1=28, m3=42.

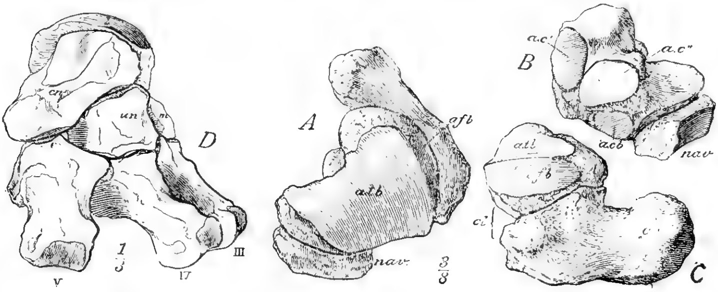

Fig. 26. Foot structure of *Coryphodon*. *D*, external view of manus of *C. ventanus* (No. 4351, Coll. Am. Mus.); *A*, superior view of astragalus and calcaneum found near *C. simus*, no tibial facet (Bathmodon type); *B*, lower surface of astragalus, showing calcaneal and cuboidal facets; *C*, external view of calcaneum and astragalus, showing reduction of tibio-calcaneal facet. (Coll U. S. Nat. Mus.)

To this species belong Nos. 2982, 4813, 4812, 277*B*, and 2978 of our collection. The latter contains the complete lower teeth which exhibit the marked disproportion between the second and the first and third incisors embodied in the definition of this species. The incisor proportions are indicated by the length of roots, i 1=36, i 2=59, i 3=28.

The metacarpal IV agrees in length (54 mm.), and lends some probability to an association with that of the complete carpus No. 4351 from the Wind River.[1] This associated complete carpus (Fig. 26) agrees with some specimens of *Uintatherium* in the very exceptional character *that the cuneiform articulates with Metacarpal V.*

Series I.—PRIMITIVE, NARROW-CRESTED SKULLS. CANINES ROUNDED. INCISORS SUBEQUAL IN SIZE.

The lower teeth are unknown, and the ancestral members of this series have not thus far been determined in the underlying Wasatch formation.

27. **Coryphodon wortmani,** sp. nov.

Type, No. 2977, Am. Mus. Coll. Loc., Wind River, Wyo.

Definition.—Superior m and pm=154. Superior canines rounded. Occiput very high and narrow. Supratemporal ridges converging posteriorly to form a comparatively narrow sagittal crest.

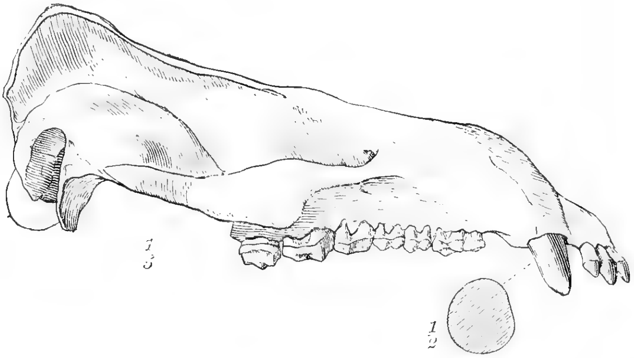

Fig. 27. *Coryphodon wortmani*, type. Lateral view of skull and section of superior canine.[2]

The discovery of this type (Figs. 18 and 27) in the high level of the Wind River Beds is most surprising. It is far more primitive both in its narrow cranium and rounded canines than any of the

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[1] This carpus was mistakenly described by Cope as coming from the Wasatch. Dr. Wortman identifies it as found by himself in the Wind River.

[2] Dedicated to my colleague Dr. J. L. Wortman.

C. testis series found in the Middle Wasatch. It appears like a direct successor of *Pantolambda cavirictus.*

The median incisors are equal to the others, the lateral incisors being slightly the smallest. The canines have a rounded crown somewhat flattened in front by wear. The superior grinding series present a rudimentary posterior crescent on m^2 and an oval m^3 with short oblique ectoloph. The most unique features are the form of the occiput and the cranium as defined above, which is intermediate between that of *Pantolambda* and *Coryphodon armatus.*

The metatarsal V is short and robust (= 42 mm.), with the characteristic peroneus tuberosity of the true *Coryphodon.* Both femora are finely preserved (length, = 340 mm.), being of the smallest size known.

INSERTÆ SEDIS.

The position of the following types with reference to the Series I–III, which we have been considering, is uncertain.

4. **Coryphodon radians** *Cope.*

Type, No. 4300, Am. Mus., Cope Coll. Superior molars 1, 2 and 3. Probably associated lower jaw, No. ? 4300. Portions of skeleton. Loc., Evanston, Wyoming.

Definition.—Third superior molar with a spur (metacrescent) upon the posterior crescent of the ectoloph. Third inferior molar without entoconid 2, hypolophid nearly transverse. Lower canines somewhat incisiform.

This classic species, which rests upon somewhat uncertainly associated upper and lower teeth, jaws and skeleton, was the first described in America. The structure of the last upper molar is shown in Fig. 15. The last lower molar has crests nearly as transverse and simple as in *C. latidens.* The most distinctive structure is the lower canine which, although badly broken, exhibits a distinct flare at the base of the inner face, as in the incisors, and is apparently becoming incisiform, an interesting approach to *Uintatherium.*

15. Coryphodon hamatus *Marsh.*

Type, Yale Museum No. 1330. Skull and dentition much worn.

Cotype, Yale Museum No. 1334. Female skull with perfect superior and inferior dentition. Loc., Evanston, Wyoming.

Synonym.

18. *Coryphodon* (*Manteodon*) *subquadratus* Cope. Type, No. 4340, Am. Mus., Cope Coll. Superior molar 2, incisors and fragmentary premolar. Loc., Big Horn, Wyoming.

Definition.—Size large. Superior molars with quadrate crowns and well developed hypocones upon m 1 and m 2. Inferior molars with nearly transverse crests; $m_{\bar{3}}$ without entoconid 2.

This species was mistakenly associated with *C. elephantopus* by Earle. In size it equals *C. testis*, but it is well distinguished by the quadrate form of the superior molar teeth in which, according to the figures of Marsh (Dinocerata, Fig. 55, p. 52), a representative of the hypocone is present. This is developed from the ridge extending backwards from the protocone. In the inferior molar teeth the crests are nearly transverse, and there is no trace of the entoconid 2.

The unique quadrate tooth with a prominent hypocone, type of *Manteodon subquadratus* (Fig. 15), was without reason considered by Cope as a third superior molar. It proves, upon comparison with Marsh's cotype made by Dr. Matthew, to resemble a second superior molar of *C. hamatus*. It differs, however, from *C. hamatus* in the more distinct development of the posterior spur of the metacone crescent, a character which may subsequently prove to give it distinct specific rank.

The type skull of *C. hamatus* is somewhat fractured. The top of the skull of the cotype, a female, is considerably narrower than that of *C. testis*, female, presenting a condition intermediate between that of *C. testis* and *C. armatus*. The canines in this animal, as in other females, are small.

28. Coryphodon singularis, sp. nov.

Type, A hind limb, tibia, fibula and pes No. 2980. Loc., Wind River, Wyo.

A small and unique hind foot and limb from the Wind River Beds, found upon the level of *C. wortmani*, is of exceptional interest (Fig. 28). Associated lower tooth fragments, put together by Dr. Matthew, resemble those of a small *Coryphodon*, and clearly separate this animal from *Bathyopsis*. The differences from the pes of *Coryphodon* are very significant, as follows :

1. Navicular laterally reduced, excluded from cuboid by ectocuneiform, a unique condition.

2. Ectocuneiform enlarged, articulating with astragalus (unique).

3. Second or middle phalanges greatly abbreviated upon all digits, I–V, as in *Uintatherium* manus.

4. Front surface of astragalus widened, separating tibial and navicular facets as in *Uintatherium*.

5. Tibia long and slender, unlike *Coryphodon*.

The measurements of the metatarsals are as follows:

Mts. I=22. Mts. II=42. Mts. III=48. Mts. IV=42. Mts. V=34. Other measurements in Table on page 199.

Fig. 28. *Coryphodon singularis*. Superior and lateral views of pes. Am. Mus. Coll. No. 2980.

This animal thus shows one progressive character (4), two entirely unique and distinctive characters (1, 2) ; the latter, together with (5), sharply separate it from *Coryphodon ;* two characters, 3, 4, parallel or approach *Uintatherium*. The other Wind River species, *C. wortmani* and *C. ventanus*, are distinguished from this by their typical metapodials, one of which is known in each type.

The associated femur (No. 2970) is proportioned like the tibia, long and slender.

Prophetic of this type, perhaps, is the pes of *Pantolambda cavirictus* (Fig. 12), in which the navicular is reduced upon the outer side and the ectocuneiform is elongated so as to nearly come in contact with the astragalus.

FOOT STRUCTURE.

Cope (1884, 1, p. 1120) proposed the theoretical groups, *Platyarthra* (with flat astragalus) and *Amblypoda hyodonta* (astragalus without a neck) from which to derive the Amblypoda. Both groups are superfluous now that it is clear that the ancestral Amblypoda can be derived directly from the Creodonta, all of which possess an astragalar neck.

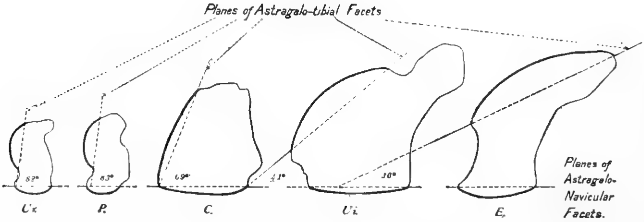

Fig. 29. Angles formed by tibio-astragalar astragalo-navicular facets, to exhibit widening of front face of astragalus. *Ur*, *Ursus ; P. Pantolambda ; C*, *Coryphodon testis ; Ui*, *Uintatherium ; E*, *Elephas.*

The transition is simple. By *shortening of the neck of the astragalus* (Fig. 29 *P.* and *C.* and *Ui.*) the tibio-astragalar facet is gradually brought almost into confluence anteriorly with the astragalo-navicular facet, as in *C. radians.* In *C. lobatus* and *C. singularis* this space widens as in *Uintatherium.*

1. The variables in these feet are the *astragalar foramen* and the *tibiale facet.* From our present knowledge both these structures (inherited in *Coryphodon* from *Pantolambda*) are *useless or vestigial, inconstantly developed and therefore not constant specific characters.*

In Fig. 26 (identical with Coryphodon III, Cope, 1877, Pl. 60), a small astragalus and calcaneum is shown which lacks both astragalar foramen and tibiale facet. In *C. lobatus* (No. 4335, type of *C. pachypus*) there is a large tibiale facet, while the astragalar foramen is not even grooved. In No. 2870 the tibiale facet is irregular, and a groove represents the astragalar foramen. In *C. testis*, No. 258, the ibiale facet is irregular, the astragalar foramen is wanting; in No. 2869 it is completely bridged over; in No. 4300 (Cope's cotype) it is partly bridged over.

2. In the relative constancy of the tibiale facet and of the astragalar foramen or groove, the pes of *Uintatherium mirabile* is therefore more primitive than that of *Coryphodon.*

CONCLUSION OF PART I.

The phylogenetic conclusions drawn from this analysis of the Taligrada and Pantodonta will be more fully discussed at the close of Part II of this paper, which will treat of the Dinocerata.

The two main results thus far brought out are these: First, the demonstration of a number of separate phyletic lines of Coryphodons; these lines probably represent the local differentiations of the Coryphodon type in adaptation to different feeding ranges, that is, swamp, plain, and upland. The second result is, that certain Coryphodons approach the Dinocerata in some structures as closely as they depart widely from them in others; for example, *C. armatus* resembles *Uintatherium* in canine type, but differs from it in skull type; *C. testis* approaches *Uintatherium* in the upper posterior portion of the skull, but differs from it widely in the anterior portion of the skull, and in the structure of the canine teeth; *C. radians* shows the assumption of the incisiform shape by the lower canines, so distinctive of *Uintatherium.* But no Coryphodon is fully known which fills all the conditions of an ancestor of *Uintatherium.* Until the skull of *Bathyopsis* is known the transition between the above types will remain obscure.

BIBLIOGRAPHY—PRINCIPAL REFERENCES.

COPE, E. D. 1877.—Report upon the Extinct Vertebrata obtained in New Mexico by parties of the Expedition of 1874. U. S. Geol. Surv. west of 100th Mer. Palæontology, Vol. IV, Part ii.

" 1884.—The Vertebrata of the Tertiary Formations of the West. U. S. Geol. Surv., Vol. III, Part i, 1884.

" 1884 (1).—The Amblypoda. American Naturalist, Nov. & Dec., 1884, pp. 1110–1121 and pp. 1192–1202. Jan., 1885, pp. 40–55.

EARLE, CHAS. 1892.—Revision of the Species of Coryphodon. Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, pp. 149–166.

MARSH, O. C. 1876.—On some of the Characters of the genus Coryphodon, Owen. Am. Jour. Sci. (3), Vol. XI, pp. 425–428, 1 pl.

" 1877 (1).—Brain of Coryphodon. American Naturalist, Vol. XI, p. 375.

" (2).—Principal Characters of the Coryphodontidæ. Amer. Jour. Sci. (3), Vol. XIV, pp. 81–85, pl. iv.

" (6).—Introduction and Succession of Vertebrate Life in America. (Vice-President's Address before the American Association for the Advancement of Science, Nashville (Tenn.) meeting, Aug. 30, 1877.) Proc. Assoc., Vol. XXVI, pp. 211–258, 1 pl. 1878.

" 1884 (9).—Dinocerata: A Monograph of an Extinct Order of Gigantic Mammals. With 56 plates and 200 woodcuts. Washington, 4to, XVIII, pp. 237. Author's edition.

" 1893 (7).—Restoration of Coryphodon. Amer. Jour. Sci. (3), Vol. XLVI, pp. 321–326, plates v and vi. New Haven, Oct., 1893.

OSBORN, H. F. 1893 (4).—Rise of the Mammalia in North America. (Vice-Pres. Add. Amer. Assoc. Adv. Sci., Sec. Zool., Aug. 16, 1893.) Amer. Jour. Sci., Nov. and Dec., 1893.

" (5).—Fossil Mammals of the Upper Cretaceous. Bull. Am. Mus. Nat. Hist., Vol. V, p, 15, Dec. 20, 1893.

" 1895 (1).—Fossil Mammals of the Puerco Beds. Collection of 1892. Bull. Am. Mus. Nat. Hist., Vol. VII, Art. 1, pp. 1–70, Mch. 8, 1895. (With Charles Earle.)

" 1898.—A complete Skeleton of *Coryphodon radians.* Notes upon the locomotion of the animal. Bull. Am. Mus. Nat. Hist., Vol. X, April 4, 1898. pp. 81–91.

Additional Characters of the Great Herbivorous Dinosaur Camarasaurus.

By Henry Fairfield Osborn.

With Thirteen Figures in Text.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. X, Article XII, pp. 219–233.
New York, June 4, 1898.

Article XII.—ADDITIONAL CHARACTERS OF THE GREAT HERBIVOROUS DINOSAUR CAMARASAURUS.

By Henry Fairfield Osborn.

With Thirteen Figures in Text.

This gigantic reptile was found in the famous Como Bluffs of Wyoming by Dr. J. L. Wortman, of the Museum party of 1897, and Prof. Wilbur C. Knight, of the University of Wyoming. The Museum number is R. 222. The bones include the left ilium, the ischia and pubes of both sides, the right and left femora, the left tibia and astragalus, the right scapula and coracoid, two shattered cervicals, two complete dorsal vertebræ, two incomplete dorsals, three or four incomplete ribs, coalesced spines of three sacral vertebræ and one sacral centrum, twenty caudals and twelve chevron bones. With the exceptions stated, the bones are in a remarkable state of preservation, having been worked out with exceptional skill by Mr. Granger and others, under the direction of Mr. Hermann.

This is a large individual. The identification is provisional. The measurements, in comparison with those taken from the type of *B. excelsus* Marsh, are as follows:

	Brontosaurus excelsus.	American Museum No. 222.
Length of femur	5 ft. 9 in.	5 ft. 10 in.
" " tibia	3 ft. 6 in.	3 ft. 8 in.
" " pubis	3 ft. 10 in.	3 ft. 10 in.
" " ischium	3 ft. 8 in.	3 ft. 9½ in.
" " scapula	5 ft. 3 in.	5 ft. 7 in.
" " coracoid	2 ft. 2½ in.	2 ft. 5 in.

The new points of greatest importance are:

First.—The discovery of the hitherto unknown characters of the anterior caudal vertebræ.

Second.—The apparent resemblances of *Camarasaurus* Cope to *Amphicœlias*[1] Cope, to *Brontosaurus* Marsh, *Atlantosaurus* Marsh, and *Apatosaurus* Marsh.

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[1] This has been anticipated by Marsh (Am. Jour. Sci., Aug., 1881) in his first classification of the Dinosauria, in which *Amphicœlias* is bracketed after *Camarasaurus*, and placed in the *Atlantosauridæ*. In the final classification of the Dinosauria, however ('The Dinosaurs of North America,' p. 241), *Camarasaurus* and *Amphicœlias* are removed to the Morosauridæ.

Third.—The observation of structural analogy to certain struthious birds in the anterior dorsals and posterior cervicals.

1. HABITS AND SIZE OF THE ANIMAL IN RELATION TO ITS STRUCTURE.

The estimate given by Marsh of the total length of this animal is nearly or quite 60 feet; the tail is figured at about 24 feet. Since the vertebra believed by Marsh to be the third caudal is probably the 10th or 11th, the tail should be increased to over 30 feet in length, by the addition of at least seven large anterior caudals. The total number of caudals is estimated at 40 as against 37 in *Diplodocus.* Marsh has attributed to *Brontosaurus* 27 precaudal vertebræ, or 13 cervicals and 14 dorso-lumbars. From reasons given below it is probable that there was a larger number of dorso-lumbars, which would still further increase the length of the animal to considerably over 60 feet.

We can only conceive of the Camarasaur as a great wading and swimming quadruped, enjoying a habitat similar to that of the Upper St. John River, Florida, at the present time, namely, a relatively firm bottom gently graded to all depths, supporting a richly luxuriant aquatic vegetation, the river banks bordered by sloping shallows of sand (Colorado, Cañon City Beds) or clays (Wyoming, Como Beds). As imagined by Cope in his picture of *Amphicœlias* ('Century Magazine,' November, 1887), the animal could walk along the bottom, raising the anterior portion of its body. We believe also that it could swim rapidly, propelled by its light but long and powerful tail, which would be useless upon land. The abundance of cartilage around all the limb joints and the non-osseous nature of many of the carpals and tarsals afford positive evidence that the limbs were not continuously subjected to the hard impact of the enormous weight of the body by motion on land. Feeding was done in the water and along the shores. Excursions upon shore were therefore like those of the Alligator, mainly for breeding and egg-laying purposes, and they exposed the animal to attack by the Megalosaurs. By means of powerful mid- and posterior-dorsal spines and opisthocœlous vertebræ, the entire anterior part of the body, *while in the water*, could be raised or lowered with the great acetabulum acting as a fulcrum, thus presenting an analogy to the Hadrosaurs, which exerted a similar movement *upon land.* The long neck, similar in structure and almost as flexible as that of an Emeu (*Dromæus*), could thus pass through a prodigious arc in the search for food either under or above water. The neck motion apparently involved the anterior non-spine-bearing dorsals as in *Dromæus*, behind which the comparatively inflexible large spine-bearing dorsals rose to maximum height in the sacrum for the insertion of the ligamentum nuchæ and elevator muscles.

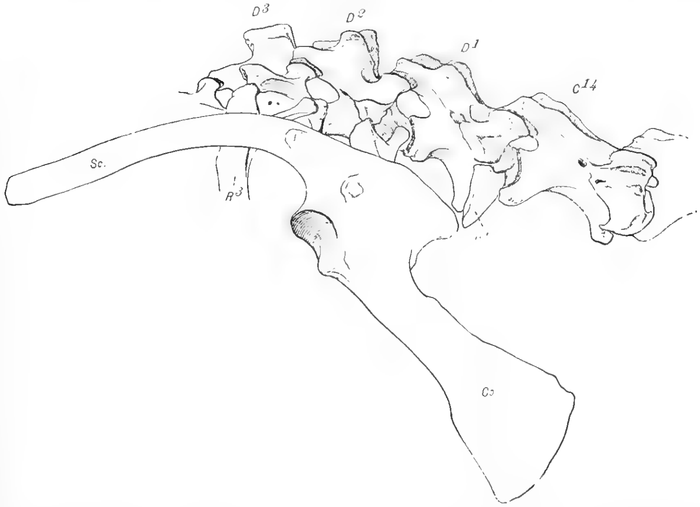

Fig. 1. *Dromæus.* Cervicals 13 and 14; dorsals 1 and 2, showing absence of median spines. Dorsal 3, showing large blunt median spine, resembling that of the *Camarasaurus* dorsal, Fig. 11 of this Bulletin, Am. Mus. Coll., No. 607.

The importance of such an hypothesis of function will appear in the following description and discussion, and it applies to all the Cetiosauria, namely, to the *Morosaurus* and *Diplodocus* types as well, which so far as known *are uniform with the Camarasaur type in the peculiar bird-like structure of the posterior cervicals and anterior dorsals* and in the possession of a very powerful swimming tail.

Ten of the caudals in our specimen afford an interesting illustration of the cause of the distribution of these large skeletons over a considerable surface. The dorsal spines, and in some cases the sides of the centra are found to be deeply gashed with the sharp teeth of a carnivorous Dinosaur. The upper portion of several spines, in fact, is entirely bitten away, the upper surface containing jagged transverse grooves, which prove that the carnivore was of great power, and applied its pointed teeth with strong effect to the gristle and muscles upon the sides of this prodigious tail.

TABLE I.—MEASUREMENTS OF VERTEBRÆ.

	Centrum, Longitudinal.	Centrum, Transverse.	Centrum, Vertical.	Centrum to top of Spine.	Capitular Processes Transverse.	Tubercular Processes Transverse.	Transverse Processes.	Estimate of Missing Vertebræ.
Anterior dorsal.	?	e310	310	1050	470	e864		
Posterior dorsal.	?	368	340	1280	......	e715		
First caudal....	162	383	335	1075	......	......	957	
e 2d caudal.......	164	......	e350	......	......	......	......	<3 & 4
e 5th caudal.... .	168	360	324	892	......	......	e695	<6 & 7
e 8th caudal......	177	340	300	830	......	......	615	
e 9th caudal......	167	333	300	798	.....	.....	622	<10&11
e 12th caudal[1]....	179	305	274	712	.....	......	587	
e 13th caudal.	170	283	260	633	......	......	537	
e 14th caudal.	173	282	258	598	......	......	505	<15
e 16th caudal.....	180	272	248	548	......	......	e444	
e 17th caudal... .	180	256	228	520	......	......	e395	<18&19
e 20th caudal[2] ...	185	220	205	?	......	......	e265	
e 21st caudal[2]....	192	210	194	?	......	......	172	
e 22d caudal[2].....	200	202	186	?	......	......	137	
e 23d caudal[2].....	198	194	176	?	......	......		
e 24th caudal[2]....	205	184	175	?	......	......	......	
e 27th caudal[2]. ..	203	171	162	......	......	......	......	<25&26
e 28th caudal[2]....	197	170	155	......	......	......	......	
e 30th caudal[2]....	200	152	146	......	......	......	......	<29
e 31st caudal[2]...	203	148	136	......	......	......	......	
e 36th caudal[2]....	185	127	115	......	......	......	......	<32&35
e 40 total	......	......	......	......	......	......	......	<37

NOTE.—Many interesting facts are brought out by the exact measurements of the caudals given in this Table. The centra decrease steadily in their transverse and vertical diameters, but they increase steadily in the longitudinal diameter as far back as the 26th caudal, then begins a decrease. Thus the estimated 31st caudal measures 203 mm.; the 36th caudal, measuring 185 mm., probably marks the natural decrease towards the tip of the tail. A constant ratio of decrease, however, characterized the dorsal spines.

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[1] Measurements agree approximately with supposed 4th caudal, Marsh.

[2] Summits of spines bitten off and grooved by large cutting teeth.

2. DESCRIPTION OF SKELETON.

The mid-dorsal (Fig. 2) corresponds closely with the supposed 'posterior-dorsal,' described by Marsh as belonging to *Brontosaurus excelsus* (Fig. 12). With the exception of the anterior portion of the centrum and the extremities of the tubercular processes, this vertebra is in a remarkable state of preservation, the neural spine being complete upon the anterior face, and lacking only the upper and lateral portions. It displays the characteristic hyposphen, the complex laminated and excavated condition of the spine, and a pair of small cavities upon the sides of the centra.

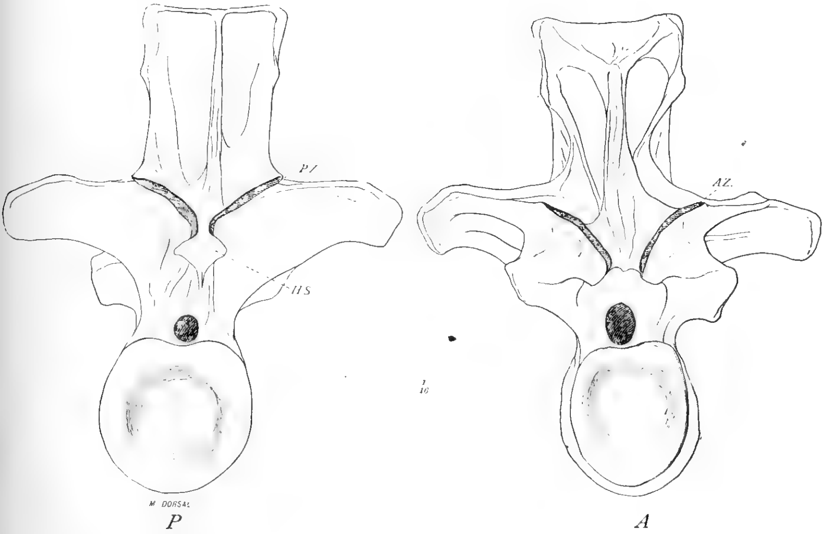

Fig 2. *Camarasaurus.* Mid-dorsal. *A*, anterior view. *P*, posterior view. Am. Mus. Coll. R. 222. Approximately $\frac{1}{16}$ natural size.

The true posterior dorsal (Fig. 3) is a superb vertebra, in nearly perfect preservation, lacking only the anterior portion of the tip of the spine, parts of the extremities of the tubercular processes, and the anterior face of the centrum. It corresponds closely with Cope's type of *Amphicœlias altus* (Fig. 13) both in form and measurement, and in the lateral cavities of the centra.

It is possible, however, that Cope's type represents a *Diplodocus*.

The mid- and posterior-dorsal vertebræ are so different that Cope supposed that they represented different genera, viz., *Camarasaurus* and *Amphicœlias*.

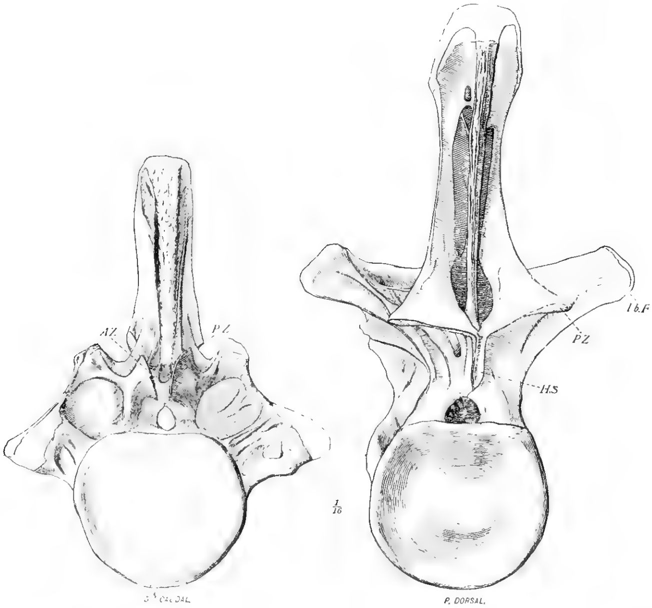

Fig. 3. *Camarasaurus*. Estimated 5th caudal. Posterior dorsal vertebra. Am. Mus. Coll. R. 222. Approximately $\frac{1}{16}$ natural size.

The sacrum is represented in this specimen by *a single large free sacral vertebra*, and by the coalesced spines of *three sacrals*. The significance of these facts will be pointed out later.

The tail of *Camarasaurus* includes a far more powerful and complex series of vertebræ than has been indicated in the figures and descriptions of Marsh.

Immediately behind the sacrum, the first caudal of *Camarasaurus* (Fig. 4) is an entirely unique vertebra, extending laterally into two great transverse plates, which may have come in contact at their extremities with the posterior portions of the ilia. These plates are concave anteriorly. The pre- and post-zygapophyses are small and obliquely inclined inwards ; the anterior face of the spine has a prominent rugose crest, similar to the crest upon the posterior face of the spine, but the latter (posterior crest) sinks between two prominent laminæ, which extend downward to support the post-zygapophyses, *pz*.

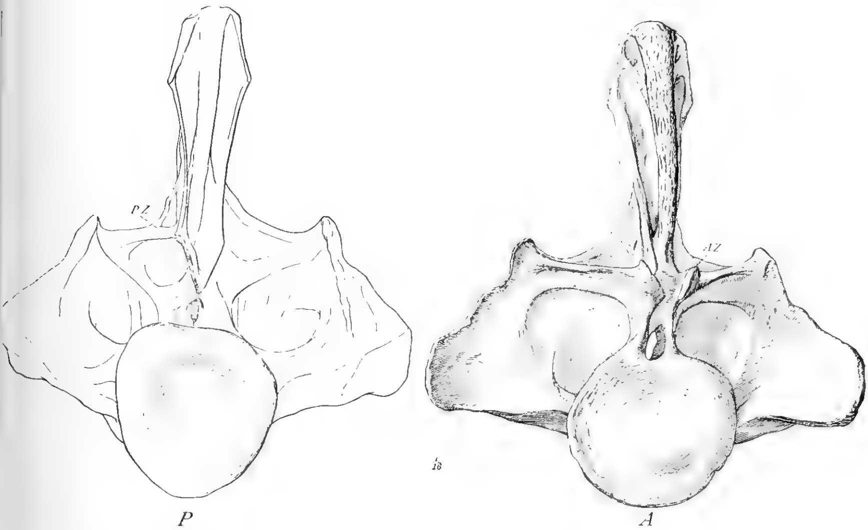

Fig. 4. *Camarasaurus.* First caudal. *A*, anterior view. *P*, posterior view. Am. Mus. Coll. R. 222. Approximately $\frac{1}{16}$ natural size.

Behind this highly specialized vertebra, three vertebræ were probably intercalated, only one of which is preserved in our collection, giving us the transition to the vertebra estimated as the 5th caudal (Fig. 3).

This supposed 5th caudal (Figs. 3, 5) exhibits a marked reduction of the spine as well as of the transverse lamina ; the posterior surface of this lamina being excavated by two deep depressions. This vertebra was followed probably by two, which are missing, so that the fourth preserved in our collection is estimated as the 8th caudal (Fig. 5); in this the transverse lamina is still more reduced, and the lateral pockets upon the posterior face are wanting. Behind this is the supposed 9th caudal, which approaches in its structure that which Marsh has figured as the 4th, but is somewhat more complex. Here follows another interval (Fig. 5), in which would lie the vertebræ described by Marsh as the 4th. (Fig. 6.)

The estimated 12th, 13th and 14th succeed each other with a regular diminution in size, and a steady reduction of the transverse processes, which gradually transforms into a horizontal plate. The next vertebra preserved is the estimated 16th, which exhibits a very marked reduction in the transverse process, and this disappears entirely in the supposed 20th and 21st, in front of which at least two vertebræ are missing. (See also Note 1, p. 233.)

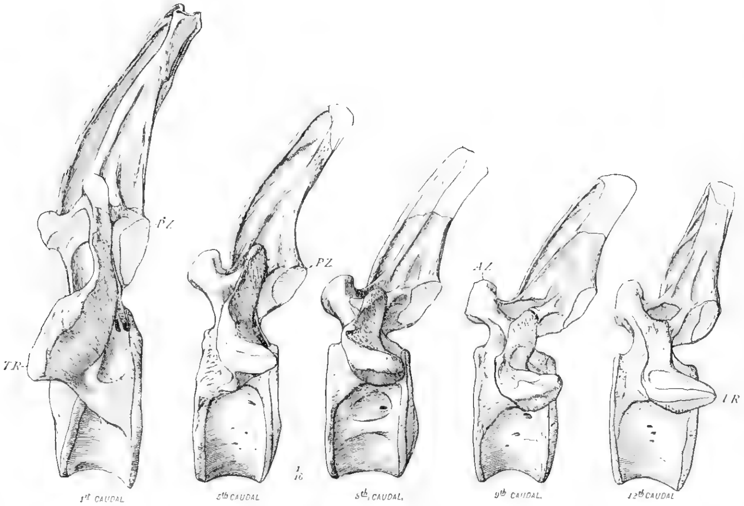

Fig. 5. *Camarasaurus.* Anterior caudals. First caudal and 5th, 8th, 9th, 12th caudals as estimated. Am. Mus. Coll. R. 222. Approximately 1/16 natural size.

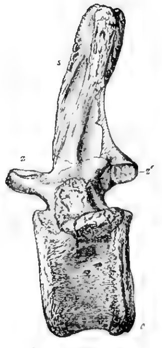

Fig. 6. *Brontosaurus excelsus.* Supposed 4th caudal vertebra. After Marsh, 1897, Plate xxiv. Approximately 1/16 natural size.

The missing 16th and 17th vertebræ were probably detached in the manner described above, and the 16 or 20 vertebræ at the end of the tail were also drawn away. In front of the 15th no tooth marks are observed.

3. HISTORICAL NOTES.

Large Cetiosauria have been named from these and similar beds[1] in Colorado, as follows:

No. 1. *Titanosaurus montanus* Marsh.—Am. Jour. Sc., July, 1877, p. 87.—Golden, Colorado.

No. 2. *Camarasaurus supremus* Cope.—Pal. Bull. 25, Aug. 23, 1877, Proc. Am. Phil. Soc.—Cañon City, Col.

No. 3. *Caulodon diversidens*[2] Cope.—Pal. Bull. 26, p. 193.—Cañon City, Col.

No. 4. *Tichosteus lucasanus*[2] Cope.—Pal. Bull. 23, p. 194, Nov. 21, 1877. Proc. Am. Phil. Soc.—Cañon City, Col.

No. 5. *Atlantosaurus* (*Titanosaurus*) *montanus* Marsh.—Am. Jour. Sc., Dec., 1877, p. 514.—Colorado.

No. 6. *Apatosaurus ajax* Marsh.—Am. Jour. Sc., Dec., 1877.—Colorado.

No. 7. *Apatosaurus grandis* Marsh.—Am. Jour. Sc., Dec., 1877, p. 515.—Colorado.

No. 8. *Amphicœlias altus* Cope.—Pal. Bull. 26, Dec. 10, 1877. Proc. Am. Phil. Soc.—Cañon City, Col.

No. 9. *Amphicœlias latus* Cope.—Pal. Bull. 26, Dec. 10, 1877. Proc. Am. Phil. Soc.—Cañon City, Col.

No. 10. *Symphyrophus musculosus*[2] Cope.—Pal. Bull. 26, p. 246, Jan. 12, 1898.—Cañon City, Col.

No. 11. *Atlantosaurus immanis* Marsh.—Am. Jour. Sc., March, 1878, p. 241.—Colorado.

No. 12. *Brontosaurus excelsus* Marsh.—Am. Jour. Sc., Dec., 1879.—Como, Wyoming.

The rapid and profound transformations in the characters of the vertebræ in different parts of the back bone give these animals an entirely unique position among reptiles, and largely explain the diversities of view as well as the numerous generic references, held by different authors, as indicated in the following brief résumé:

(1) The first notice of these animals in American literature was by Marsh,[3] under the name of *Titanosaurus montanus*. This generic name had been shortly before employed by Lydekker.[4] (2) The second notice was by Cope,[5] in which the name Camarasaurus was proposed. The species *Camarasaurus supremus* was based upon a number of dorsal vertebræ from the supposed Dakota Beds of Colorado, near Cañon City. In 1878[6] these remains were

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[1] These beds are equivalent to the Wealden of England, from which many large Dinosaurs have been described, of the same order (Cetiosauria) and possibly representing the same genera.

[2] Never fully characterized or figured.

[3] Notice of a new and Gigantic Dinosaur, Am. Journ. Sc., July, 1877, p. 88.

[4] Rec. Geol. Surv. Ind., Vol. IV, p. 38, 1877.

[5] On a Gigantic Saurian from the Dakota Epoch of Colorado. Pal. Bull., XXVI, Published Aug. 23, 1877.

[6] On the Saurians recently discovered in the Dakota Beds, etc.—Am. Nat., Feb., 1878, p. 71.

figured. It now appears that the anterior dorsal vertebra (Fig. 2, p. 73, of Cope's article), characterized like the cervicals, by the absence of the median spine, was correctly determined by Cope. In this vertebra the hyposphen is less accented than in the vertebra figured upon the following page (Fig. 5, p. 75), in which the hyposphen is sharply defined, and there is also a median dorsal spine. (5) The fifth notice was by Marsh,[1] in which the name *Atlantosaurus* was proposed to replace *Titanosaurus*. (6) In the same paper the new genus *Apatosaurus ajax*, was distinguished by the opisthocœlous cervicals with hollow centra; anterior dorsals with similar characters; posterior lumbars with flat articular faces; sacral vertebræ more solid; anterior caudals biconcave; chevrons not united above. (7) In the same paper the species *A. grandis* is described with the following measurements:

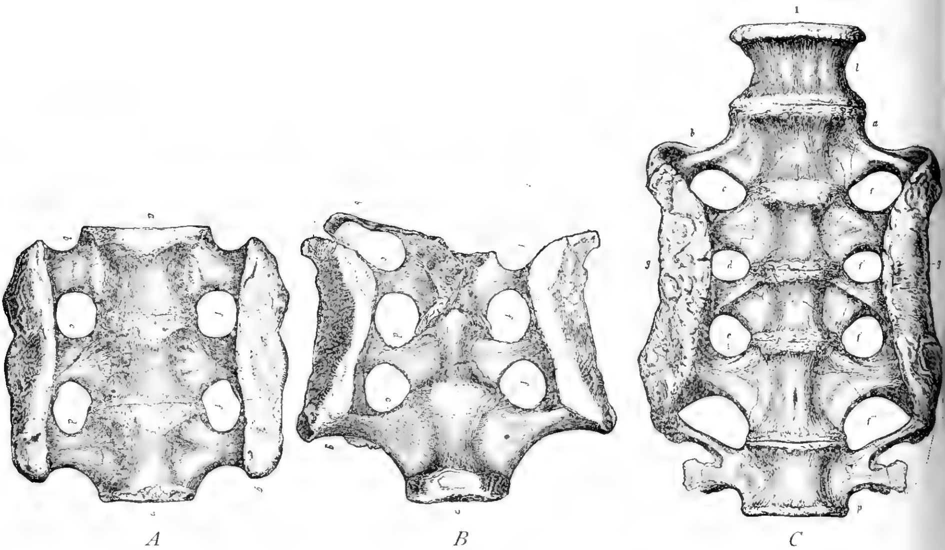

Fig. 7. Sacra of Cetiosauria.

A, *Apatosaurus ajax*. Three coalesced sacrals. After Marsh, 1897, Plate xvii.

B, *Atlantosaurus montanus*. Three coalesced sacrals and portion of a fourth. After Marsh, 1897, Plate xvii.

C, *Brontosaurus excelsus*. Five coalesced sacrals. After Marsh, 1897, Plate xxiii. All figures approximately $\frac{1}{20}$ natural size.

Length of femur..........	1050 mm.
Transverse diameter of proximal end.....................	340 mm.

(8) The eighth notice by Cope was based upon characters of the posterior dorsal vertebræ. The vertebra (Fig. 13, p. 80) with a very prominent dorsal spine, re-

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[1] Notice of new Dinosaurian Reptiles from the Jurassic Formation. Am. Jour. Sc., Dec., 1877, p. 514.

ferred to *Amphicœlias altus*, agrees closely with that here shown to belong to *Camarasaurus*. (12) In the twelfth notice (Marsh, 1879) a new type, *Brontosaurus excelsus*, was defined. Characters: Sacrum composed of five thoroughly coössified vertebræ; in other respects resembling *Morosaurus* from the Como Beds of Wyoming. The succeeding notices of these animals are fully embraced in Marsh's Memoir, "The Dinosaurs of North America," published in 1897. Here (pp. 166-241) the order Sauropoda and family Atlantosauridæ are described, the latter, however, not including the genus *Camarasaurus*, which is placed in the Morosauridæ (page 241).

COMPARATIVE MEASUREMENTS OF LIMBS, ARCHES, VERTEBRÆ.

	Camarasaurus supremus.[1]	*Camarasaurus* No. 222, Am. Mus.	*Amphicœlias altus.*[1]	*Apatosaurus grandis.*	*Brontosaurus excelsus.*[2]
Total length of scapula	1517	1597	..	..	1600
Greatest diameter of coracoid	690	736	..	..	672
Antero-posterior, ilium	..	1373	..	..	..
Total length of ischium	..	1150	..	..	1118
" " pubis	..	1168	1060	..	1168
" " femur	1820	1776	1930[3]	1050	1750
Height of ant-dorsal spine	830	1050	..	..	948
" post-dorsal spine	..	1280	1100	..	..
Length, centrum ant-dorsal	275	..	..	..	276
Median caudal	..	..	..	..	..

It is *a priori* improbable that so many different genera of gigantic Saurians of similar size co-existed. It is against the principles of evolution that closely similar types of equal size should occupy the same territory at the

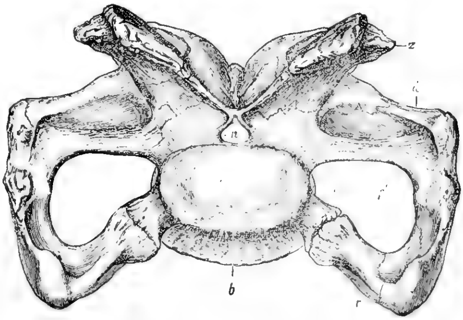

Fig. 8. *Brontosaurus excelsus*. Posterior cervical vertebra. After Marsh, 1897, Plate xxi. Approximately $\frac{1}{16}$ natural size.

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[1] These measurements are given in Cope's second paper upon *Camarasaurus*. (Am. Phil. Soc., Dec., 1877, pp. 242–245.)

[2] These measurements are approximate, as no exact measures have been published.

[3] Cope gave the length of this femur as 6 feet 4 inches (=1930), and described it as longer than that of *Camarasaurus*, but in his metric table it is by misprint assigned 1524 mm.

same time. It appears moreover to the writer that the evidence which has been brought forward to demonstrate such an exceptional condition is inadequate and is capable of different interpretation, as follows :

Amphicœlias having been shown to be in all probability related to *Camarasaurus*, the only absolute basis of separation of the remaining types is the number of sacral vertebræ, as in the definitions of Marsh and Cope :

Apatosaurus.	*Camarasaurus.*	*Atlantosaurus.*	*Brontosaurus.*
3 sacrals.	4 sacrals.	4 sacrals.	5 sacrals.

This definition does not separate *Atlantosaurus* from *Camarasaurus ;* the type sacrum of *Atlantosaurus* (Fig. 7*B*) is, however, fractured anteriorly, and this animal may therefore have possessed 5 sacrals, like *Brontosaurus* (Fig. 7*C*).

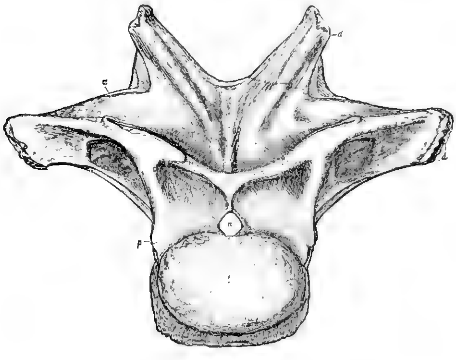

Fig. 9. *Apatosaurus ajax.* Dorsal vertebra. After Marsh, 1897, Plate xviii. Approximately $\frac{1}{16}$ natural size.

The three coalesced sacral spines and the single free sacral centrum in our specimen suggest the following hypothesis, namely, that *Camarasaurus had five sacral vertebræ ; three of these constantly coalesced both by centra and neural spines, two others coalesced less constantly and possessed free spines.*

Such difference in the growth and degree of coalescence is shown to be probable (1) by *Diplodocus*, in which at least three vertebræ coalesce by centra but only two coalesce by spines ; (2) by our specimen, No. 222, in which (closely resembling *Brontosaurus* in every other respect) one centrum is free and three spines are coalesced ; (3) by the type of *B. excelsus*, in which three spines are coalesced, as figured. (See also Note 2, p. 233.)

The removal to a distance of one or both of the freer sacral vertebræ is quite explained by the fact that these skeletons are in the great majority of cases very much disturbed and confused before embedding. An instance in point is the loss of all the anterior caudals in Marsh's otherwise excellent *B. excelsus* specimen.

Let us suppose that the three early united vertebræ (of the more primitive Cetiosaur sacrum) were found alone, the others having been detached and lost, we would then have the genus *Apatosaurus;* if *one* of the freer vertebræ had united we would have the genus *Atlantosaurus* or *Camarasaurus;* if *both* of the freer vertebræ had united we would have *Brontosaurus.*

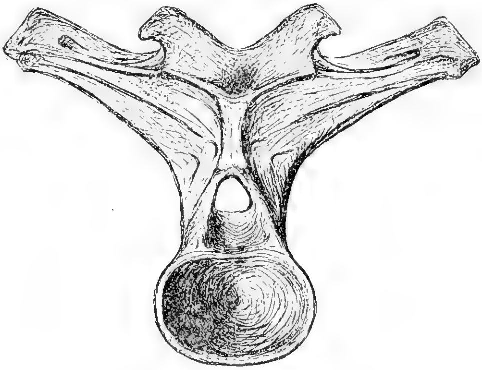

Fig. 10. *Camarasaurus supremus* type. Anterior dorsal vertebra. After Cope. Approximately $\frac{1}{16}$ natural size. Compare *Morosaurus*, Marsh, 1897, fig. 31, p. 181.

4. ANTERIOR DORSAL VERTEBRÆ OF THE CETIOSAURS ARE OF AVIAN TYPE.

Anterior dorsals without median spines have been described by Cope in *Camarasaurus* (Fig. 10) and by Marsh in *Apatosaurus* (Fig. 9), *Morosaurus* and *Diplodocus.* This condition seems so general as to constitute almost an ordinal character of the Cetiosaurs.

These vertebræ are, moreover, remarkable in resembling those of certain Struthious birds such as *Dromæus* (Fig. 1), in the absence of median spines, in the elevation of lateral spinous processes above the zygapophyses, and in the abrupt development of a median spine upon the third or fourth dorsal.

It is also not improbable that the abrupt transition from vertebræ without median spines to a vertebra with a strong median spine (*Dromæus*, D.3) is paralleled in the blunt spine of the *Camarasaurus* dorsal (Fig. 11), which may well represent D 3 or

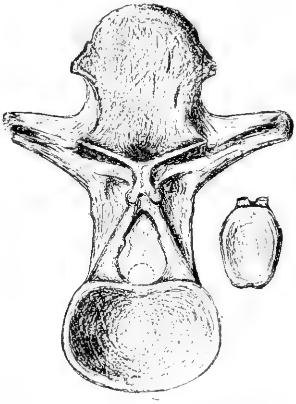

Fig. 11. *Camarasaurus supremus.* Anterior dorsal. Supposed to be the first possessing a median spine. After Cope. Approximately $\frac{1}{16}$ natural size.

D 4. Behind this would appear the transversely expanded mid-dorsal spines of the *Brontosaurus*[1] (Fig. 12) type, and of our specimen, No. 222 (Fig. 2). Behind this again would appear the posterior dorsal of the Amphicœlias type (Fig. 13) or the still more posterior dorsal of our specimen, No. 222 (Fig. 3).

The difference between these three types of vertebræ (Figs. 9, 12 and 3) is so profound that it seems hardly possible that they could be compressed within the limits of 14 dorso-lumbars—the number which Marsh has figured

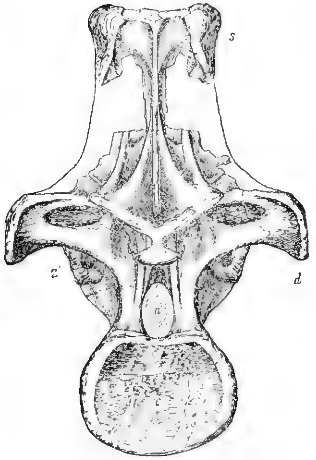

Fig. 12.

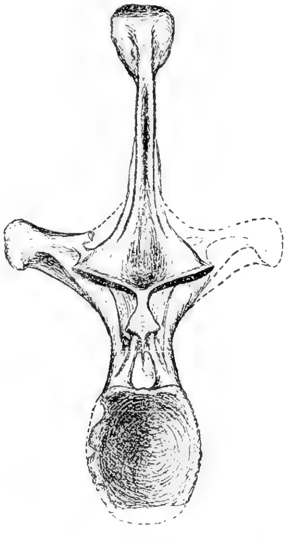

Fig. 13.

Fig. 12. *Brontosaurus excelsus.* Dorsal vertebra. After Marsh, 1897, Plate xxi. Approximately $\frac{1}{16}$ natural size.

Fig. 13. Posterior dorsal of *Amphicœlias altus*, type. After Cope. Approximately $\frac{1}{16}$ natural size.

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[1] This is mistakenly determined by Marsh ('Dinosaurs of North America,' p. 169) as a "posterior dorsal."

in *Brontosaurus.* There were, therefore, in all probability, more dorso-lumbars than 14. Cope has assigned 20 dorso-lumbars to *Camarasaurus.*

So far as habit and function are involved, the transition from the lateral spined to the median spined dorsals, as in *Dromæus,* probably indicates that *Camarasaurus* had a comparatively free anterior dorsal region, consisting of two or more vertebræ, which bore short ribs and moved in all directions with the neck.

The differences in proportion, in length of limb and in other parts subject to age, sex and individual variation noted in these different specimens are undoubtedly superseded by genuine specific differences which mark the Camarasaurs of different geological levels, also by generic differences, which, however, are still to be positively determined by more careful and thorough exploration, and by comparison of the type specimens. The generic name *Camarasaurus* is therefore provisionally employed here.

NOTE 1.—CENTRA OF CAUDALS.

There is also great diversity in the caudal centra.

The first caudal centrum is *biconvex.*

The second to the estimated seventeenth caudal centra are *procœlous.*

The estimated twentieth caudal centrum and all behind it are *amphicœlous.*

NOTE 2.—SIZE SACRUM.

The four sacrals of *Camarasaurus* exhibit exactly the same measurement as the four anterior sacrals of *Brontosaurus.*

A Provisional Classification of the Fresh-Water Tertiary of the West.

By W. D. Matthew.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XII, Article III, pp. 19–75.
New York, March 31, 1899.

Article III.—A PROVISIONAL CLASSIFICATION OF THE FRESH-WATER TERTIARY OF THE WEST.

By W. D. Matthew.

The table of formations immediately following was drawn up by the writer under the guidance of Prof. Osborn and Dr. Wortman, for the arrangement of the collections in the American Museum of Natural History, and submitted to the late Prof. Cope and to Prof. W. B. Scott for approval or amendment. The faunal lists appended are made up chiefly from the study of these collections, covering all the formations of the Western Lakes except the Pliocene horizons. A partial essay is made at a critical revision of the species; characteristic and well marked species are in special type, and those considered invalid are in roman. It is quite impossible to make this revision with any approach to completeness, from the fragmentary character of many types and the meagreness of descriptions. The object of the lists is to assist in the correlation and classification of the various basins by showing the characteristic fauna. The exact horizon and locality are therefore given as fully as possible; and to facilitate future comparison of species, the location of each type specimen is given, as far as known to the writer. No bibliography or complete synonymy of the species is included; it would be undesirable in this connection, as well as rendered superfluous by the excellent bibliography of mammals recently published by Prof. Trouessart.

In this preliminary attempt, errors will doubtless be numerous. The writer will be glad to have his attention called to any, that they may be corrected in a subsequent edition. The synonymy of genera and species is necessarily to a considerable extent provisional, and will require revision, especially in the Creodonta and Primates. Some of the results of Dr. Wortman's recent studies on the former group are embodied here.

New genera defined in this list: *Palæictops*, p. 35; *Phlaocyon*, p. 54; *Miolabi* Hay, p. 74.

New species defined: *Palæolagus intermedius*, p. 53; *Phlaocyon leucosteus*, p. 54; *Ictops bullatus*, p. 55; *Aceratherium profectum*, p. 71.

The following names not heretofore used will be defined in forthcoming articles by Dr. Wortman and the writer: *Palæosinopa veterrima*, n. g. and sp., p. 31; *Procynodictis vulpiceps*, n. g. and sp., p. 49; *Oxyænodon dysodus*, n. g. and sp., p. 49; *Prodaphænus*, n. g., p. 49; *Paradaphænus* and *Nothocyon*, p. 62; *Pachyæna intermedia*, n. sp., p. 31.

DIVISIONS OF THE TERTIARY LAKE-BASINS.

PERIODS.		FORMATIONS.	THICKNESS.	FAUNAL DIVISIONS.	LAKE BASINS.
Pleistocene.		Sheridan.	100	Equus.	*Silver Lake* and other localities in Oregon, Nevada, and elsewhere.
Pliocene.		Blanco.	150	Pliauchenia. Hippidium.	*Great Plains* (Niobrara Basin).
Miocene.	Upper.	Loup Fork.	400	Procamelus.	
		Deep River.	150	Cyclopidius.	*Deep River*, Montana.
	Middle.				
	Lower.	John Day.	1000	Diceratherium.	*John Day*, Oregon.
Oligocene.		White River.	800	Protoceras. Oreodon. Titanotherium.	*Great Plains* (Sioux Lake).
Eocene.	Upper.	Uinta.	800	Diplacodon. Telmatotherium.	*Uinta*, Utah.
	Middle.	Bridger.	2000	Uintatherium.	*Upper Green River*, Wyoming. *Huerfano*, Colorado.
	Lower.	Wind River.	800	Bathyopsis.	*Wind River*, Wyoming.
		Wasatch.	2000	Coryphodon.	*Big Horn*, Wyoming.
	Basal.	Torrejon.	300	Pantolambda.	*San Juan*, New Mexico.
		Puerco.	500	Polymastodon.	

NOTES ON THE LAKE BASINS.

San Juan Basin.—In northwestern New Mexico, on the divide between the Rio Grande and San Juan Rivers. The beds conformably overlie the marine and brackish water Cretaceous (Laramie), and contain fossils confined in the Basal Eocene to three strata, two at the bottom of the Puerco beds, one in the Torrejon. The Wasatch is sparingly fossiliferous throughout.[1]

Big Horn Basin.—In northern Wyoming. No weighty faunal distinctions have been shown to exist in this great mass of sediment, which is sparingly fossiliferous throughout. Buffalo Basin is a subordinate basin, apparently somewhat later than the main basin.[2]

Wind River Basin.—In central Wyoming. Fossils are rather scarce in this basin. All the sediments are later than the Wasatch and earlier than the Bridger.[3]

Huerfano Basin.—In southern Colorado. Osborn has recently shown that the Wind River is represented here as well as the Bridger. There are also overlying sediments of ? Pleistocene age.[4]

Upper Green River Basin.—In southern Wyoming. This includes the Bridger and Washakie, with Middle Eocene fossil mammals, and much larger areas where Green River (= Wind River) and Vermillion Creek (= Wasatch) sediments are the only beds not washed away by the extensive erosion which has taken place. The Vermillion Creek sediments contain fossil mammals in a few localities (Evanston, Black Buttes, etc.), while the Green River shales contain fossil fish in abundance.[5]

Uinta Basin.—In northeastern Utah. The Middle and Upper Eocene beds are underlain by a considerable thickness of sediments, probably of Lower Eocene age, in which no fossils have been found. The three fossiliferous horizons are: *C*, the Upper or True Uinta, explored for fossils by Marsh in 1870 and the Princeton party of 1886; *B*, the Lower Uinta or Telmatotherium Beds; and *A*, probably equivalent to the upper part of the Bridger. The last two horizons were discovered by the American Museum Expedition of 1894.[6]

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[1] Authority, Wortman. See Bull. Amer. Mus. Nat. Hist., 1892, 135; 1897, 259.

[2] Authority, Wortman, Bull. Amer. Mus. Nat. Hist., 1892, 135.

[3] Authority, Wortman, *l. c.*

[4] Bull. Amer. Mus. Nat. Hist., 1897, 247.

[5] Authority, Hayden Survey Reports, etc. Also Wortman (communicated).

[6] Authority, Peterson, Bull. Amer. Mus. Nat. Hist., 1895, 72; Marsh, Amer. Jour. Sci., March, 1871.

Basin of the Great Plains.—The precise relations of the fossiliferous horizons in different parts of this wide area stand in need of further study. The deposits are coëxtensive with the Neocene and Quaternary, but in no place has a continuous section been observed, and the series of fossiliferous horizons is still more incomplete.

The following table is an attempt at correlation of a number of typical sections with the section published by Hayden and Leidy thirty years ago. The proper identification of these divisions has been prevented by a confusion as to the fauna properly belonging to Horizon *D*. The descriptions given by Hayden of the character of the rocks in the several divisions of his section agree accurately with the corresponding divisions observed by the writer in Colorado. But the fauna which Hayden and Leidy ascribe to Horizon *D* was found by the writer in Horizon *C*, while *D* belonged stratigraphically and faunally to the Upper Miocene. The fauna which Leidy ascribes to *C* is a mixture of Oreodon and Protoceras Beds species.

The Middle Miocene does not appear to be represented in any of the sections. The faunal break is least serious in Colorado and Oregon, where a number of genera pass through without more than specific change. Such are, in Colorado, *Anchippus*, *Aceratherium* (sensu stricto), *Merycochœrus*, *? Canis*. In Oregon, *Mesohippus* and probably others.

Another break occurs in the Pliocene, partly if not completely bridged in Texas, but tolerably well marked elsewhere.

It is probable that the Protoceras Beds overlap to some extent on the Lower Miocene John Day. Further study of both and determination of the exact horizons of different species will be necessary to find the extent of the overlap. At present it seems that some lines of descent are more advanced in one basin, some in the other. The Rhinoceroses seem to have run into *Diceratherium* in the John Day, while continuing the line towards *Aphelops* in the Plains. The Camels are more advanced in the western basin, but the Horses are persistently primitive, while *Anchippus* had already appeared in the Leptauchenia Beds. Side branches of Canidæ appear in both basins, while the more direct line shows little difference in age between the two. *Merycochœrus* and *Eporeodon* appear in both, but the relations of

	Neb. & S. Dak. Hayden & Leidy, 1869.		S. Dakota. Wortman, 1895.	N. E. Colorado. Matthew, 1899.	N. W. Kansas & S. W. Nebraska. Matthew, 1899.	N. W. Nebraska. Wortman, 1897.	Deep R., Mont. Scott, 1894.	John Day R., Oregon. Wortman, 1880.	Llano Estacado, Texas. Cope & Cummins, 1892.
	Stratigraphy.	Faunal List.							
					Prairie Marls.				
Pleistocene.					Sand-hills.	Equus Beds.			Equus Beds.
Pliocene.									Blanco.
								Loose gravels.	Palo Duro.
	F	F	Loup Fork.		Loup Fork.	Loup Fork.			Loup Fork.
	E			E			Upper Beds. (*Ticholeptus*)	Cottonwood beds. (*Protolabis*)	
				D					
Miocene.	? D								
		? E	Leptauchenia (*sub-zone*)		(Cretaceous, unconformable under the Loup Fork.)			Up'r John Day. (*Merycochærus*)	
	C	D	Protoceras.	C			Lower Beds.	L'r John Day. (*Diceratherium*)	
		C	Up'r Oreodon						
Oligocene.	B	B	L'r Oreodon.	B		(Barren white clays, probably White River.)			
	A	A	Up. Titanoth'm Mid. " Low. "	A					

the species to each other are not yet known. *Leptauchenia* is unknown in the John Day basin, and is very close to the Upper Miocene *Cyclopidius*, but if these genera were aquatic they may have had a peculiar and limited habitat, and their absence would not have much weight.

The so-called Loup Fork Beds are not all strictly of the same age. The more easterly and southerly deposits in Nebraska, Kansas, and Texas are uppermost Miocene or Pliocene. The species described by Leidy and Marsh came chiefly from these beds. The Colorado Loup Fork is a distinctly older horizon, Upper or perhaps in part Middle Miocene. Prof. Cope explored this region in 1873 and 1879 and described its fauna. He seems to have been less familiar with the eastern Loup Fork; and this may partly explain the discrepant views held as to the age of the Loup Fork Tertiary. Williston and some other recent writers entirely refuse to assign a definite age to the Kansas Loup Fork; and the present writer desires to avoid including with the beds to which a definite age is assigned, any but those in which a sufficient fauna has been found. The Colorado Loup Fork is here placed as equivalent to the Deep River of Montana, the Ticholeptus Beds of Cope—an unfortunate name, as *Ticholeptus* is a synonym of *Merychyus*, and *Merychyus* is equally characteristic of the typical Loup Fork or Procamelus Beds. Cope placed with the Deep River the Upper Miocene Beds of the John Day valley, and of Laramie Peak, Wyoming. Other beds on the western and northern margin of the Great Plains basin may be equivalent. Scott considers the Deep River as older than any of the beds above mentioned, laying especial stress on the occurrence of *Cyclopidius* in that basin only. *Cyclopidius*, however, occurs in the extreme west of Nebraska (Cheyenne Co.), and its absence elsewhere may be explained, as above noted, by its aquatic habitat. *Miolabis*[1] characterizes the Colorado Loup Fork and the Oregon beds, and stands well in opposition to *Procamelus* of the upper horizon. The lower beds have been called Cyclopidius Beds.[2] They show the following characteristic faunal differences:

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[1] (= *Protolabis* Wortman, 1898, not Cope.)

[2] On account of its evident inconstancy a name derived from the fauna to designate a particular horizon is less suitable than a geographic term. Pawnee Creek Beds would be a better name for the lower horizon in Colorado, Deep River being used correlatively with Loup Fork for the general designation of the lower beds.

Procamelus Beds.	*Cyclopidius Beds.*
Pliohippus.	Pliohippus.
Protohippus.	Protohippus.
Hipparion.	Hipparion.
? Mesohippus.[1]	Desmatippus.
	Anchippus.
	Anchitherium.
Pliauchenia.	Mesohippus.
Procamelus.	Procamelus.
	Protolabis.
	Miolabis.
	Cyclopidius.
Teleoceras.	Aceratherium.
Cosoryx.	Blastomeryx.

That is to say, Horses with short-crowned teeth and Camels with split metapodials persisted into the lower horizon, as did also the aquatic Oreodonts and more primitive Aceratheres. *Blastomeryx* characterized the lower, as *Cosoryx* did the upper horizon. The large *Teleoceras* (*Aphelops*) *fossiger*, unknown in the older horizon, is the most abundant fossil of the later one.

King[2] applied the names 'Sioux Lake' and 'Cheyenne Lake' to the supposed lakes of the Oligocene and Upper Miocene of the Plains (Miocene and Pliocene of older writers); and Marsh[3] has called the latter the Niobrara basin. The deposits cover to a great extent the same area, and a single geographical name may conveniently be used, as is done in the other Tertiary basins.

The White River sediments are usually considered as lacustrine, A similar origin has been assigned to all the later sediments, but recent studies of Gilbert in Arkansas, Williston and others in Kansas, and Darton in South Dakota, tend toward the view that the Loup Fork is chiefly flood-plain sediment while the Pleistocene is flood-plain and æolian deposit.[4] With this view the observations made by the writer in Colorado in 1898 entirely coincide.

John Day Basin.—In central Oregon. Two or three more or less separate basins in the valley of the John Day River. The Cottonwood basin, containing a higher fauna, equivalent to the

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[1] Two lower molars referred to *Mesohippus* are described by Scott and Osborn as coming from the true Loup Fork of Nebraska. This is the only occurrence in the Procamelus Beds, as far as I am aware.

[2] 40th Parallel Survey Rep.

[3] Am. Ass. Adv. Sci., Ann. Address, 1872.

[4] Gilbert, 17th Ann. Rep. U. S. Geol. Survey, 1895-6, part II, 575. Williston, Kansas Univ. Geol. Survey, Rep. 1896.

Deep River (Cope and Wortman) or Loup Fork (Scott), is separated from the lower beds by a basaltic flow. Dr. Wortman has recently found sufficient differences in the true John Day to warrant its division into two horizons ; the upper, containing a great abundance of *Merycochœrus*, being exposed at Bridge Creek and elsewhere ; the lower, typical at the locality known as 'The Cove.'[1]

Deep River Basin.—In central Montana. It would seem to be an outlier of the Great Plains basin. The upper beds, containing the typical Deep River fauna, rest unconformably on beds containing a scanty fauna which Scott considers equivalent to the Upper John Day. The facies of the fauna does not seem, however, to forbid placing it as equivalent to the Leptauchenia fauna of the Great Plains.[2]

New Mexico Loup Fork Basins.—A number of small scattered areas, of which the *Santa Fé Basin* in the northern part of the state, and the *San Francisco Basin* in the southwest corner, are the most important. Some of these deposits may be Pliocene.

The Pleistocene fossil beds are scattered over all parts of the West, and cannot be grouped into any definite areas. The Equus Beds, largely river sediments, contain abundant remains of *Equus*. The prairie loess, so far as the writer is acquainted with it, represents a later deposit, æolian, and still in progress. The wind cuts out all exposed places at a very considerable rate, as may be seen by the rapid hollowing out of roads and ploughed fields. The dust is caught by the sodded prairie and spread uniformly over it. The effects of this mode of deposition are characteristic and curious features of the plains. The deposits are over two hundred feet thick in places, and contain remains of *Equus* in the lower layers, but in the upper chiefly *Bison* bones in various stages of fossilization. In the Cordilleras are many dried-up lake basins of small size, in the deposits of which the Equus fauna has been found. Silver Lake in Eastern Oregon is the most noted of these.

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[1] Authority, Wortman (communicated).

[2] Scott, "Mammalia of the Deep River Beds."

CHARACTERISTIC FOSSIL MAMMALS.

The more important or abundant species are in heavy type; invalid species in roman. Present location of the type specimen is stated (under the formation in which it was found) as follows:

A. M.	American Museum of Natural History, New York.
U. S.	National Museum, Washington.
Ph.	Philadelphia Academy of Sciences.
Y	Yale University, New Haven, Conn.
K.	Kansas University, Lawrence, Kan.
H.	Harvard University, Cambridge, Mass.
P.	Princeton University, N. J.
T.	Texas Geological Survey.
C. G. S.	Canadian Geological Survey.

I. *PUERCO.*

All the types and described specimens are preserved in the American Museum of Natural History. The localities of all are in northwestern New Mexico, west of the divide between the Rio Grande and San Juan Rivers.

MULTITUBERCULATA.[1]

PLAGIAULACIDÆ.

- *Catopsalis foliatus* Cope.
- **Polymastodon taöensis** Cope.
  - Polymastodon latimolis *Cope.*
- *Polymastodon attenuatus* Cope.
- “ *selenodus* Osborn & Earle.
- **Neoplagiaulax americanus** Cope.
  - Neoplagiaulax sp.

CREODONTA.

OXYCLÆNIDÆ.

- *Oxyclænus cuspidatus* (Cope.)
- “ *simplex* (Cope.)
- **Protochriacus priscus** (Cope.)
- *Protochriacus hyattianus* Cope.
  - Loxolophus adapinus *Cope.*
- *Protochriacus attenuatus* O. & E.

TRIISODONTIDÆ.

- **Triisodon quivirensis** Cope.
- “ **heilprinianus** Cope.
  - Triisodon rusticus *Cope.*
  - Triisodon biculminatus *Cope.*
  - Conoryctes crassicuspis *Cope.*
  - Sarcothraustes coryphæus *Cope.*
  - Mioclænus bathygnathus *Cope.*
- *Triisodon gaudrianus* (Cope).

INCERT. SED.

- **Oxyacodon apiculatus** O. & E.
- *Oxyacodon agapetillus* (Cope).
- *Carcinodon filholianus* (Cope).

CONDYLARTHRA.

PERIPTYCHIDÆ.

- **Periptychus**[1] **coarctatus** Cope.
  - Periptychus brabensis *O. & E.*
- **Ectoconus ditrigonus** (Cope).
- **Hemithlæus kowalevskianus** Cope.
- **Conacodon entoconus** (Cope).
  - Anisonchus coniferus *Cope.*
- *Conacodon cophater* (Cope).
- **Anisonchus gillianus** Cope.
  - Hemithlæus apiculatus *Cope.*
  - ? Zetodon gracilis *Cope.* (Indeterminate.)

PHENACODONTIDÆ.

- **Protogonodon pentacus** (Cope).
- *Protogonodon stenognathus* Matthew.

MIOCLÆNIDÆ.

- *Mioclænus turgidunculus* Cope.

EDENTATA.

STYLINODONTIDÆ.

- **Hemiganus otariidens** Cope.

CONORYCTIDÆ.

- **Onychodectes tissonensis** Cope.
- *Onychodectes rarus* O. & E.

INDETERMINATE SPECIES.

- Mioclænus interruptus *Cope.*
- “ rütimeyeranus *Cope.*

II. *TORREJON.*

All the types and described specimens are preserved in the American Museum of Natural History. The localities are in northwestern New Mexico, on either side of the divide between the Rio Grande and San Juan Rivers.

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[1] The name *Periptychus* is perhaps preoccupied by *Periptyches.* If this be the case, the name *Catathlæus*, proposed for the permanent dentition of the same species, takes its place, *C. rhabdodon* being the type.

MULTITUBERCULATA.

PLAGIAULACIDÆ.

Neoplagiaulax molestus Cope.
Ptilodus mediævus Cope.
Ptilodus trovessartianus Cope.

BOLODONTIDÆ.

Chirox plicatus Cope.

PRIMATES.

TARSIIDÆ.

Indrodon malaris Cope.

RODENTIA.

MIXODECTIDÆ.

Mixodectes pungens Cope.
Mixodectes crassiusculus Cope.

CREODONTA.

OXYCLÆNIDÆ.

Tricentes subtrigonus (Cope).
Mioclænus bucculentus *Cope.*
Phenacodus zuniensis *Cope.*
Tricentes crassicollidens Cope.
Chriacus pelvidens (Cope).
Chriacus stenops *Cope.*
Chriacus baldwini (Cope).
Chriacus truncatus Cope.
Chriacus schlosserianus Cope.
Deltatherium fundaminis Cope.

TRIISODONTIDÆ.

Goniacodon levisanus (Cope).
Sarcothraustes antiquus Cope.
Triisodon conidens *Cope.*

MESONYCHIDÆ.

Dissacus navajovius Cope.
Dissacus carnifex *Cope.*
Dissacus saurognathus Wortman.

VIVERRIDÆ.

Viverravus haydenianus (Cope.)
Didymictis primus *Cope.*

ARCTOCYONIDÆ.

Clænodon ferox (Cope).
Clænodon corrugatus Cope.
Clænodon protogonioides Cope.

CONDYLARTHRA.

PERIPTYCHIDÆ.

Periptychus[1] **rhabdodon** Cope.
Periptychus carinidens Cope.
Anisonchus sectorius Cope.
Anisonchus mandibularis (*Cope*).
Haploconus lineatus Cope.
Haploconus xiphodon *Cope.*
" angustus *Cope.*
Haploconus corniculatus Cope.

PHENACODONTIDÆ.

Euprotogonia[2] **puercensis** (Cope).
Phenacodus calceolatus *Cope.*
Protogonia subquadrata *Cope.*
" plicifera *Cope.*
Mioclænus floverianus *Cope.*
Euprotogonia minor Matthew.

MIOCLÆNIDÆ.

Mioclænus turgidus Cope.
Mioclænus zittelianus *Cope.*
Mioclænus lydekkerianus Cope.
Mioclænus lemuroides Matthew.
" **acolytus** (Cope).
Mioclænus inæquidens (Cope).
Mioclænus minimus *Cope.*
Protoselene opisthacus (Cope).
Hemithlæus baldwini *Cope.*

AMBLYPODA.

PANTOLAMBDIDÆ.

Pantolambda bathmodon Cope.
" **cavirictus** Cope.

EDENTATA.

STYLINODONTIDÆ.

Psittacotherium multifragum Cope.
Psittacotherium aspasiæ *Cope.*
" megalodus *Cope.*
Hemiganus vultuosus *Cope.*

CONORYCTIDÆ.

Conoryctes comma Cope.

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[1] See note on p. 28.

[2] Dr. T. S. Palmer has kindly called my attention to the fact that the generic name *Euprotogonia* is antedated by *Tetraclænodon*, a genus of Creodonts founded by Prof. Scott on *Mioclænus floverianus* of Cope, a wrongly interpreted specimen of *Euprotogonia puercensis.* The generic description of *Tetraclænodon* is doubtfully valid, very misleading, and founded on error; the name is inappropriate in the extreme; and I have therefore retained *Euprotogonia* as a well known and appropriate name substituted for the original preoccupied name *Protogonia.*

III. *WASATCH.*

	Big Horn.	Buffalo Basin.	New Mexico.	Location of Type.
PRIMATES.				
Omomys (*Anaptomorphus*) *homunculus* (Cope)........	×	×		
Hyopsodus paulus Leidy..........................	×	×		
" **vicarius** Cope..........................	×	×		
" **powellianus** Cope....................	?			A. M.
Hyopsodus lemoinianus Cope......................	×	×		"
" *miticulus* Cope..........................			×	U. S.
" *laticuneus* [1] (Cope).......................	?			A. M.
Pelycodus frugivorus Cope.......................	×		×	
Pelycodus nunienus *Cope*..........................	×			
Pelycodus tutus Cope..........................	×		×	
Pelycodus jarrovii Cope..........................	×		×	
" *angulatus* Cope	×			A. M.
Microsyops ? gracilis Leidy..........................	×			
" *speirianus* Cope..........................	×			A. M.
Cynodontomys latidens Cope..........................	×			"
RODENTIA.				
ISCHYROMYIDÆ.				
Paramys buccatus Cope..........................	×		×	
" **delicatior** Leidy..........................		×		
" **delicatissimus** Leidy..................	×	×		
CREODONTA.				
VIVERRIDÆ.				
Viverravus [2] **protenus** (Cope)	×	×	×	U. S.
" **leptomylus** [3] (Cope)..................	×	×		
Viverravus curtidens (Cope)	×			A. M.
" *massetericus* (Cope).....................	×			"
" *gracilis* Marsh........................	×			
Uintacyon (Miacis [4]) **canavus** (Cope)	×			A. M.
Uintacyon (Miacis) *brevirostris* (Cope)...............	×	×		"
" " *sp*		×		"

---

[1] The premolars associated with the type and only specimen of *Diacodexis laticuneus* Cope, are those of *Hyracotherium index*; the upper and lower molars belong to *Hyopsodus*, closely allied to *H. powellianus*. See Wortman, Bull. Am. Mus. Nat. Hist., 1896.

[2] *Viverravus* as defined by Marsh in 1872 covers *Didymictis* Cope, 1874. See note on p. 35.

[3] The type of *Didymictis leptomylus* of Cope may be the same as Marsh's *Limnocyon riparius* of the Bridger. This Wasatch species was referred by Cope to *leptomylus* but is probably distinct from the type.

[4] These species are considerably different in type from the Bridger species to which the name was originally given.

III. WASATCH.—*Continued.*

	Big Horn.	Buffalo Basin.	New Mexico.	Location of Type.
PROVIVERRIDÆ.				
Palæosinopa veterrima Wortman [1]	×			A. M.
Sinopa (Stypolophus) **hians** (Cope)	×		×	U. S.
" " **strenua** (Cope)	×		×	"
" " **whitiæ** (Cope)	×	×		
" " **viverrina** (Cope)	×		×	U. S.
Sinopa (Stypolophus) *multicuspis* (Cope)			×	"
" " *secundaria* (Cope)			×	"
" " *aculeata* (Cope)[2]				P.
OXYÆNIDÆ.				
Oxyæna lupina Cope	×	×	×	U. S.
" **forcipata** Cope	×		×	"
Oxyæna morsitans Cope			×	"
PALÆONICTIDÆ.				
Palæonictis occidentalis Osborn and Wortman	×			A. M.
Amblyctonus sinosus Cope			×	U. S.
MESONYCHIDÆ.				
Pachyæna[3] **ossifraga** (Cope)	×		×	U. S.
Pachyæna intermedia Wortman [1]	×			A. M.
Pachyæna gigantea Osborn and Wortman	×			"
Dissacus leptognathus O. & W.	×	×		"
ARCTOCYONIDÆ.				
Anacodon ursidens Cope		×		A. M.
INCERTÆ SEDIS.				
Didelphodus absarokæ Cope	×			A. M.
Didelphys comstocki (Cope) [4]	×			"
Diacodon celatus Cope			×	U. S.
" *alticuspis* Cope			×	"
INSECTIVORA.				
LEPTICTIDÆ.				
Palæictops [5] *? bicuspis* (Cope)	×			
TILLODONTIA.				
ESTHONYCHIDÆ.				
Esthonyx [6] **burmeisteri** Cope	×	×	×	U. S.
Esthonyx acer Cope			×	"
" *bisulcatus* Cope			×	"
" *spatularius* Cope			×	"

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[1] Unpublished.

[2] The original type from the Bridger was indeterminate. The species properly dates from Cope's description in 1884 (Tert. Vert.) of a specimen in the Princeton Museum referred to *S. aculeata*.

[3] Unworn molars of *Pachyæna* show that it possessed a vestigial metaconid, though less distinct than that of *Dissacus*; the original ground for the separation of the two therefore fails. I retain them separate however, believing that a careful comparison will show distinctions of generic importance between them.

[4] Generic position very doubtful.

[5] See note on p. 35.

[6] The species of *Esthonyx* need revision.

III. WASATCH.—*Continued.*

	Big Horn.	Buffalo Basin.	New Mexico.	Location of Type.
EDENTATA.				
STYLINODONTIDÆ.				
Calamodon simplex Cope	×		×	U. S.
Calamodon arcamœnus *Cope*			×	"
Calamodon novomehicanus *Cope*			×	"
Dryptodon crassus *Marsh*			×	"
CONDYLARTHRA.				
PHENACODONTIDÆ.				
Phenacodus primævus Cope [1]	×		×	A. M.
Phenacodus omnivorus *Cope*			×	U. S.
Phenacodus nunienus Cope [2]	×			A. M.
Phenacodus wortmani Cope [3]	×		×	
Phenacodus apternus *Cope*	×			A. M.
Phenacodus hemiconus Cope. [4]	×			"
Phenacodus brachypternus Cope	×	×		"
Phenacodus macropternus Cope	×			"
" *sulcatus* Cope			×	U. S.
" (Ectocion) *osbornianus* Cope	×			A. M.
Eohyus [5] distans *Marsh*			×	Y.
" robustus *Marsh*			×	"
MENISCOTHERIIDÆ.				
Meniscotherium chamense Cope.			×	U. S.
" **terræ-rubræ** Cope.			×	A. M.
Meniscotherium tapiacitis Cope			×	"
Hyracops socialis Marsh [6]			×	Y.

---

[1] Type from Evanston, Wyoming.

[2] Perhaps a small variety of *P. primævus*.

[3] See note on this species on p. 36.

[4] Doubtfully distinguishable from *P. nunienus*.

[5] *Eohyus* Marsh (nom. nud., 1877) is perhaps a synonym of *Phenacodus; E. distans* (figured, 1894) might be taken for the very uncharacteristic m^3 of that genus, and the description of *E. robustus* (1894) corresponds as far as it goes to the lower jaw of *P. primævus*. Wortman (Bull. Am. Mus. Nat. Hist., 1898, p. 101, foot-note) believes that *E. distans* is founded on the last upper molar of *Trigonolestes etsagicus;* but the tooth as figured by Marsh is too large for that species, even on the supposition that m^3 is unreduced, which, judging from the reduction of the heel of m_3, is not the case.

[6] *Hyracops*, which has been identified by Osborn with *Meniscotherium*, differs considerably in its foot structure if Marsh's figures are accurate. The large magnum, the entirely serial carpus, and the epicuneiform seen in Marsh's figures of *Hyracops* are not present in *Meniscotherium*, which has a carpal and tarsal structure very like that of *Euprotogonia*, with small magnum, lunar supported partly on unciform, and other normal primitive features. The metapodials and phalanges are like those of *Hyracops*.

III. WASATCH.—*Continued.*

	Evanston, Wyo.	Big Horn.	Buffalo Basin.	New Mex.	Location of Type.
AMBLYPODA.					
CORYPHODONTIDÆ.					
Coryphodon (Bathmodon) *radians* Cope	×				A. M.[1]
Coryphodon (Metalophodon) **testis** (Cope)		×			"
Coryphodon repandus *Cope*		×			"
Coryphodon lobatus Cope		×	×	×	U. S.
Coryphodon anax *Cope*		×			A. M.
Bathmodon pachypus *Cope*		×			"
Coryphodon elephantopus Cope		×	×	×	U. S.
Coryphodon obliquus *Cope*				×	"
Coryphodon cuspidatus *Cope*		×		×	"
Coryphodon hamatus Marsh	×				Y.
Manteodon subquadratus *Cope*		×			A. M.
Coryphodon latidens Cope		×		×	U. S.
Coryphodon simus *Cope*				×	"
" molestus *Cope*				×	"
Coryphodon curvicristis Cope		×			A. M.
" (Metalophodon) *armatus* (Cope). Black Buttes, Wyo.					"
" (Ectacodon) *cinctus* (Cope)		×			"
Coryphodon latipes *Cope*.[2]	×				"
" marginatus *Cope*.[2]		×			"
PERISSODACTYLA.					
EQUIDÆ.					
Hyracotherium (Eohippus[3]) index Cope	×	×	×	×	A. M.
Hyracotherium angustidens *Cope*				×	U. S.
" cuspidatum *Cope*				×	"
Eohippus pernix *Marsh*	×				Y.
Hyracotherium (Eohippus) vasacciense Cope.	×	×			A. M.
Eohippus validus *Marsh*				×	Y.
Hyracotherium (Eohippus) tapirinum Cope		×		×	U. S.
Hyracotherium (*Eohippus*) *cristatum* Wortman		×			A. M.
" (*Pliolophus*) *cristonense* Cope			×	×	U. S.
" " *montanum* Wortman		×			A. M.
LOPHIODONTIDÆ.					
Heptodon posticus Cope		×			A. M.
" *singularis* Cope				×	U. S.

---

[1] Part of the same individual is in the Yale University Museum.

[2] Indeterminate types, synonymy doubtful.

[3] In *Hyracotherium* proper, p^2 has but one cusp ; in all the American species, a trittocone is also present. "It may yet be found that there are other important differences between these groups which will necessitate recognizing a separate genus for the American forms, in which event the name *Eohippus*, proposed by Marsh, would have to be adopted." Wortman, Bull. Am. Mus. Nat. Hist., 1896, 101.

III. WASATCH.—*Continued.*

	Evanston, Wyo.	Big Horn.	Buffalo Basin.	New Mex.	Location of Type.
TAPIRIDÆ.					
Systemodon protapirinus Wortman		×	×		A. M.
Systemodon primævus Wortman		×			"
" *semihians* Cope		×			"
ARTIODACTYLA.					
HOMACODONTIDÆ.					
Trigonolestes chacensis Cope.[1]		×		×	U. S.
Trigonolestes brachystomus Cope		×			A. M.
" *nuptus* Cope.		×			"
" *metsiacus* Cope		×			"
" *etsagicus* Cope		×			"
ACHÆNODONTIDÆ.					
Parahyus vagus Marsh	×				Y.
" *aberrans* Marsh	×				"

IV. *WIND RIVER.*

All the types and described specimens are in the American Museum of Natural History.

	Wind River, Wyoming.	Huerfano, Colorado.	Location of Type.
PRIMATES.			
Hyopsodus paulus Leidy	×		
" **vicarius** Cope	×		
Hyopsodus ? lemoinianus Cope	×		
" *? powellianus* Cope		×	
Pelycodus tutus Cope	×	×	
Pelycodus frugivorus Cope	×		
Pelycodus nunienus *Cope*	×		A. M.
Microsyops gracilis Leidy	×		
Microsyops scottianus Cope [2]	×		A. M.

---

[1] This is the common species of *Trigonolestes*. The others are founded on somewhat smaller or otherwise different individuals, but all very closely allied except *T. etsagicus*, which differs widely and may have to be separated generically, as Wortman has suggested (Extinct Camelidæ of North America, Bull. Am. Mus. Nat. Hist., 1898, p. 101, foot-note). I have seen no specimen of *Trigonolestes* proper (our collection contains 26) in which the paraconid is not present and twined with the metaconid in a peculiar way.

[2] Doubtfully distinguishable from *M. gracilis*.

IV. WIND RIVER.—*Continued.*

	Wind River, Wyoming.	Huerfano, Colorado.	Location of Type.
RODENTIA.			
ISCHYROMYIDÆ.			
Paramys delicatior Leidy	×	×	
" **delicatissimus** Leidy	×		
CREODONTA.			
VIVERRIDÆ.			
Viverravus[1] (Didymictis) **altidens** (Cope)	×		A. M.
Viverravus (Didymictis) *protenus* (Cope)	×	×	
" (Limnocyon) *riparius* (Marsh)			
? Didymictis leptomylus *Cope*, type only	×		A. M.
Viverravus gracilis Marsh	×	×	
Didymictis dawkinsianus *Cope*	×		A. M.
Uintacyon (Miacis) **canavus** (Cope)	×		"
" " **brevirostris** (Cope)	×		"
Uintacyon (Miacis) *cf. vorax* Leidy	×		
Uintacyon sp. minima		×	
PROVIVERRIDÆ.			
Sinopa (Stypolophus) **whitiæ** (Cope)			A. M.
Sinopa, cf. viverrina (Cope)[2]			"
OXYÆNIDÆ.			
Oxyæna huerfanensis Osborn		×	A. M.
Patriofelis tigrinus (Cope)	×		"
INSECTIVORA.			
LEPTICTIDÆ.			
Palæictops[3] *bicuspis* (Cope)	×		A. M.
" *didelphoides* (Cope)[4]	×		"
CHIROPTERA.			
Vesperugo anemophilus Cope	×		[5]
? Chiropter indet		×	A. M.

---

[1] *Viverravus* Marsh antedates *Didymictis* Cope, and refers to the same genus. The generic description appears to the writer to be a sufficient one, although Marsh in this as in other descriptions uses the term "tubercular" to describe a tuberculo-sectorial tooth.

[2] Apparently a different species from the Big Horn specimens referred to *S. viverrina*. I have not compared either with the type, from New Mexico.

[3] Referred by Cope to *Ictops*, an Oligocene genus closely allied to *Leptictis* Leidy. Though not distinguishable by the dentition from *Ictops*, there are important and very constant differences in the skull characters, among which I select for generic definition the backward extension and broadening of the posterior ends of the nasal bones, and the presence of a single median crest on the cranium instead of the two parallel crests of *Ictops* and *Leptictis*.

[4] Pertinence of this species to the genus very doubtful.

[5] Type lost.

IV. WIND RIVER.—*Continued.*

	Wind River, Wyoming.	Huerfano, Colorado.	Location of Type.
TILLODONTIA.			
ESTHONYCHIDÆ.			
Esthonyx acutidens Cope	×		A. M.
Esthonyx spatularius Cope	×		"
EDENTATA.			
STYLINODONTIDÆ.			
Stylinodon (*Calamodon*) *cylindrifer* (Cope)	×		
CONDYLARTHRA.			
PHENACODONTIDÆ.			
Phenacodus ? primævus Cope [1]	×		
Phenacodus wortmani Cope [2]	×		A. M.
Phenacodus (Ectocion) **osbornianus** Cope	×		
AMBLYPODA.			
CORYPHODONTIDÆ.			
Coryphodon ventanus Osborn	×	×	A. M.
Coryphodon wortmani Osborn	×		"
" *? singularis* Osborn	×		"
UINTATHERIIDÆ.			
Bathyopsis fissidens Cope	×		A. M.
PERISSODACTYLA.			
EQUIDÆ.			
Hyracotherium craspedotum Cope	×		A. M.
Protorohippus (Hyracotherium) venticolus (Cope)	×	×	"
Lambdotherium popöagicum Cope [3]	×	×	"
LOPHIODONTIDÆ.			
Heptodon calciculus Cope	×		"
Heptodon ventorum Cope	×		"
TITANOTHERIIDÆ.			
Telmatotherium (Palæosyops) boreale (Cope)	×		
Lambdotherium brownianum *Cope*	×		
ARTIODACTYLA.			
HOMACODONTIDÆ.			
Trigonolestes secans Cope [4]	×	×	A. M.

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[1] The single jaw fragment referred to this species differs in several particulars from the Wasatch specimens.

[2] Two or three species are apparently included under this name, but the material is too fragmentary for their separation. The Wind River specimens, including the type, are, I believe, distinct from those of Wasatch age, including the complete skeleton described by Cope in 'Tertiary Vertebrata.' Two points of difference are the internal instead of postero-internal position of *de* on p^3, and the more compressed p^4—both points approximating the Wind River species to *Ectocion*, the most advanced of the Phenacodonts.

[3] See Osborn, Am. Nat., 1897.

[4] Upper molars being unknown this species can be placed in *Trigonolestes* only provisionally.

V. *BRIDGER*

		Bridger Basin.										Washakie.				
	Huerfano Basin.	Lodge Pole Trail.	Fort Bridger.	Grizzly Buttes.	Henry's Fork.	Dry Creek.	Cottonwood Creek.	Black's Fork.	Ham's Fork.	Twin Buttes.	Unrecorded.	Haystack Mtn.	Mammoth Buttes.	La Clede.	Unrecorded.	Location of Type.
? PRIMATES.																
Hyopsodus paulus Leidy		×		×	×		×				×	×		×	×	U. S.
Lemuravus distans *Marsh*																Y.
Hyopsodus vicarius Cope							×									A. M.
Hyopsodus gracilis Marsh																
" *minusculus* Leidy						×										Ph.
Microsus cuspidatus Leidy								×								U. S.
Microsyops gracilis Leidy																
Microsyops (Limnotherium) **elegans** Marsh	×			×	×											Y.
Notharctus tenebrosus Leidy[1]								×								U. S.
Tomitherium rostratum *Cope*					×		×	×								A. M.
Notharctus (Limnotherium) *tyrannus* (Marsh)						×										Y.
" " *affinis* (Marsh)				×												"
Hipposyus formosus Leidy			×	×												Ph.
" *robustior* Leidy					×											U. S.
Thinolestes anceps Marsh											×					Y.
Telmatolestes crassus Marsh					×											"
Bathrodon typus Marsh				×												"
" *annectens* Marsh					×											"

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[1] *Notharctus*, *Limnotherium*, and *Tomitherium* are probably synonymous, *Notharctus* having priority. The specific synonymy has not been cleared up.

V. BRIDGER.—*Continued.*

		Bridger Basin.										Washakie.				
	Huerfano Basin.	Lodge Pole Trail.	Fort Bridger.	Grizzly Buttes.	Henry's Fork.	Dry Creek.	Cottonwood Creek.	Black's Fork.	Ham's Fork.	Twin Buttes.	Unrecorded.	Haystack Mtn.	Mammoth Buttes.	La Clede.	Unrecorded.	Location of Type.
Antiacodon venustus Marsh					×											Y.
Hemiacodon nanus Marsh[1]					×											"
" *gracilis* Marsh					×											"
" *pucillus* Marsh				×												"
Omomys carteri Leidy										×						Ph.
Anaptomorphus æmulus Cope									×							A. M.
Washakius insignis *Leidy*											×					Ph.
Palæacodon verus Leidy																"
" *vagus* Marsh					×											Y.
Mesacodon speciosus Marsh					×											"
Sarcolemur pygmæus Cope							×									A. M.
Sarcolemur furcatus *Cope*											×					"
Prosinopa[2] (*Sinopa*) *eximia* (Leidy)				×												Ph.
RODENTIA.																
ISCHYROMYIDÆ.																
Paramys[3] **delicatus** Leidy			×					×								Ph.
" **delicatior** Leidy			×				×									"

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[1] Marsh states that *Antiacodon nanus* (? = *Hemiacodon nanus*) is synonymous with *Anaptomorphus æmulus*; but the description and measurements of *H. nanus* do not bear out this statement. It is possibly a synonym of *Omomys carteri*, but the synonymy of these Bridger Primates is very uncertain, as the descriptions are inadequate, and the types have not been compared.

[2] Proposed by Trouessart, Cat. Mam.

[3] The number of species should probably be reduced.

V. BRIDGER.—*Continued.*

	Huerfano Basin.	Bridger Basin.										Washakie.				Location of Type.
		Lodge Pole Trail.	Fort Bridger.	Grizzly Buttes.	Henry's Fork.	Dry Creek.	Cottonwood Creek.	Black's Fork.	Ham's Fork.	Twin Buttes.	Unrecorded.	Haystack Mtn.	Mammoth Buttes.	La Clede.	Unrecorded.	
Paramys delicatissimus Leidy			×													Ph.
" **robustus** Marsh				×	×											Y.
Paramys buccatus (Cope)																A. M.
" *superbus* S. & O							×									P.
" *hians* (Cope)							×									A. M.
" *leptodus* Cope													?			"
Paramys (Sciuravus) **undans** (Marsh)				×				×								Y.
Paramys (Sciuravus) *nitidus* (Marsh)				×												"
" " *parvidens* (Marsh)				×	×											"
Tillomys senex Marsh					×											"
" *parvus* Marsh				×												"
Taxymys lucaris Marsh					×											"
Colonomys celer Marsh					×											"
Apatemys bellus Marsh											×					"
" *bellulus* Marsh											×					"
Mysops (*Syllophodus*) *minimus* Leidy				×												Ph.
" " *fraternus* Leidy											×					"
CREODONTA.																
VIVERRIDÆ.																
Vulpavus palustris Marsh			×													Y.
Miacis parvivorus Cope							×									A. M.

V. BRIDGER.—*Continued.*

	Huerfano Basin.	Bridger Basin.										Washakie.				Location of Type.
		Lodge Pole Trail.	Fort Bridger.	Grizzly Buttes.	Henry's Fork.	Dry Creek.	Cottonwood Creek.	Black's Fork.	Ham's Fork.	Twin Buttes.	Unrecorded.	Haystack Mtn.	Mammoth Buttes.	La Clede.	Unrecorded.	
Uintacyon edax Leidy											×					Ph.
" *vorax* Leidy					×											U. S.
" (Miacis) *bathygnathus* (Scott)																P.
Viverravus gracilis Marsh				×												Y.
Viverravus nitidus Marsh					×											"
Viverravus (Limnocyon) **riparius** (Marsh)				×												"
Ziphacodon rugatus Marsh					×											"
Harpalodon sylvestris Marsh					×											"
" *vulpinus* Marsh					×											"
" *Canis* "[1] *montanus* Marsh				×												"
PROVIVERRIDÆ.																
Sinopa rapax Leidy			×													Ph.
Sinopa (Limnocyon) **vera** (Marsh)				×												Y.
" " **agilis** (Marsh)				×												"
Stypolophus brevicalcaratus *Cope.*								×								A. M.
Sinopa (Stypolophus) **pungens** (Cope)							×									"
Stypolophus insectivorus *Cope.*[2]								×								"
Proviverra americana Scott											×					P.
Thinocyon velox Marsh											×					Y.

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[1] Probably *Viverravus* or *Miacis.*

[2] Indeterminate type.

V. BRIDGER.—*Continued.*

		BRIDGER BASIN.										WASHAKIE.				
	Huerfano Basin.	Lodge Pole Trail.	Fort Bridger.	Grizzly Buttes.	Henry's Fork.	Dry Creek.	Cottonwood Creek.	Black's Fork.	Ham's Fork.	Twin Buttes.	Unrecorded.	Haystack Mtn.	Mammoth Buttes.	La Clede.	Unrecorded.	Location of Type.
OXYÆNIDÆ.																
Patriofelis ulta Leidy	×		×													U. S.
" (Limnofelis) **ferox** (Marsh)				×												Y.
Patriofelis (Limnofelis, Oracodon) *latidens* Marsh				×												"
? PALÆONICTIDÆ.																
Ælurotherium (*Patriofelis*) *leidyanum*, O. & W																U. S.
MESONYCHIDÆ.																
Mesonyx obtusidens Cope			×							×						A. M.
" (Synoplotherium) *lanius* Cope													×			"
" (Dromocyon) *vorax* (Marsh)[1]																Y.
INDET.																
Triacodon[2] *fallax* Marsh				×												Y.
" *grandis* Marsh					×											"
" *nanus* Marsh				×												"
INSECTIVORA.																
Centetodon pulcher Marsh				×												Y.
" *altidens* Marsh				×												"

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[1] Scott identifies this species with *Mesonyx obtusidens*. It probably represents a distinct species, as the last lower molar is very much reduced, according to the measurements given.

[2] Probably Proviverridæ or Viverridæ.

V. BRIDGER.—*Continued.*

		Bridger Basin.													Washakie.						
	Huerfano Basin.	Fort Bridger.	Spanish John's.	Big Bone Buttes.	Sage Creek.	Cat-tail Spring.	Grizzly Buttes.	Dry Creek.	Henry's Fork.	Cottonwood Creek.	Camp Spring.	Tule Spring.	Twin Buttes.	Unrecorded.	Barrel Spring.	Dug Spring.	Mammoth Buttes.	Haystack Mtn.	La Clede.	Unrecorded.	Location of Type.
Passalacodon littoralis Marsh									×												Y.
Anisacodon elegans Marsh									×												"
Centracodon delicatus Marsh									×												"
Entomodon comptus Marsh									×												"
Entomacodon minutus Marsh									×												"
" *angustidens* Marsh								×													"
Euryacodon lepidus Marsh								×													"
Talpavus nitidus Marsh									×												"
CHIROPTERA.																					
Nyctitherium velox Marsh									×												"
" *priscum* Marsh									×												"
Nyctilestes serotinus Marsh								×													"
TILLODONTIA.																					
ESTHONYCHIDÆ.																					
Anchippodus riparius Leidy																					[1] Ph.
" *vetulus* Leidy		×																			
" *minor* (Marsh)														×							Y.
Trogosus castoridens *Leidy*		×																			
Tillotherium hyracoides Marsh														?							Y.

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[1] Type from Monmouth Co., N. J.

V. BRIDGER.—*Continued.*

		Bridger Basin.													Washakie.						
	Huerfano Basin.	Fort Bridger.	Spanish John's.	Big Bone Buttes.	Sage Creek.	Cat-tail Spring.	Grizzly Buttes.	Dry Creek.	Henry's Fork.	Cottonwood Creek.	Camp Spring.	Tule Spring.	Twin Buttes.	Unrecorded.	Barrel Spring.	Dug Spring.	Mammoth Buttes.	Haystack Mtn.	La Clede.	Unrecorded.	Location of Type.
Tillotherium fodiens Marsh	×													?							Y.
Tillotherium latidens Marsh														?							"
EDENTATA.																					
STYLINODONTIDÆ.																					
Stylinodon mirus Marsh														?							Y.
AMBLYPODA.																					
UINTATHERIIDÆ.																					
Uintatherium[1] **robustum** Leidy								×	×												Ph.
Uintamastix atrox *Leidy*																					"
Uintatherium (Dinoceras) mirabile (Marsh)				×	×		×		×		×	×		×		×		×		×	Y.
Uintatherium (*Dinoceras*) *agreste* (Marsh)			×																		"
" " *cuneum* (Marsh)				×																	"
" " *distans* (Marsh)														×				×			"
" " *laticeps* (Marsh)									×												"
" " *lucare* (Marsh)				×																	"
" " *reflexum* (Marsh)												×									"
" (*Tinoceras*) *anceps* (Marsh)					×																"
" " *affine* (Marsh)																×					"
" " *annectens* (Marsh)																		×			"
" " *crassifrons* (Marsh)						×															"

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[1] Pending a revision of the genera and species of this family, it is convenient to group them provisionally under the first described genus, *Uintatherium* Leidy.

V. BRIDGER.—*Continued.*

		Bridger Basin.													Washakie.						
	Huerfano Basin.	Fort Bridger.	Spanish John's.	Big Bone Buttes.	Sage Creek.	Cat-tail Spring.	Grizzly Buttes.	Dry Creek.	Henry's Fork.	Cottonwood Creek.	Camp Spring.	Tule Spring.	Twin Buttes.	Unrecorded.	Barrel Spring.	Dug Spring.	Mammoth Buttes.	Haystack Mtn.	La Clede.	Unrecorded.	Location of Type.
Uintatherium (Tinoceras) grande (Marsh)															×						Y.
Uintatherium (*Tinoceras*) *hians* (Marsh)						×															"
Uintatherium (Tinoceras) ingens (Marsh)														×				×		×	"
Uintatherium (*Tinoceras*) *jugum* (Marsh)																					"
" " *lacustre* (Marsh)			×														?				"
" " *latum* (Marsh)																					"
Uintatherium (Tinoceras) longiceps (Marsh)[1]																				×	"
Uintatherium (*Tinoceras*) *pugnax* (Marsh)																		×			"
" " *stenops* (Marsh)[2]																		×			"
" " *vagans* (Marsh)[1]																					"
Uintatherium (Loxolophodon) cornutum Cope																	×				A. M.
Uintatherium (*Loxolophodon*) *galeatum* Cope																	×				"
" " *speirianum* S. & O																					P.
" (*Eobasileus*) *furcatum* Cope																	×				A. M.
" " *pressicorne* Cope																	×				"
" (*Elachoceras*) *parvum* Scott																					P.
Uintatherium alticeps S. &. O.														×							"
Uintatherium princeps S. & O.									×												"
" *latifrons* Marsh				×																	Y.
" ***leidianum*** S. & O.								×													P.
" *segne* Marsh		×																			Y.

---

[1] From Red Dog Buttes.

[2] Cf. *U. ingens.*

V. BRIDGER.—*Continued.*

		Bridger Basin.										Washakie.				
	Huerfano Basin.	Lodge Pole Trail.	Fort Bridger.	Grizzly Buttes.	Henry's Fork.	Dry Creek.	Cottonwood Creek.	Black's Fork.	Ham's Fork.	Twin Buttes.	Unrecorded.	Haystack Mtn.	Mammoth Buttes.	La Clede.	Unrecorded.	Location of Type.
PERISSODACTYLA.																
EQUIDÆ.																
Hyracotherium osbornianum Cope								×								A. M.
" *procyoninum* Cope							×									"
Helohippus pumilus Marsh																Y.
Orohippus uintanus (Marsh)					×											"
" *major* Marsh											? ×					"
" *pumilus* Marsh				×			×									"
Orohippus agilis Marsh											? ×					"
Orohippus sylvaticus (Leidy)					×											U. S.
Anchitherium ballardi *Marsh*				×												Y.
Oligotomus cinctus Cope							×									A. M.
LOPHIODONTIDÆ.																
Helaletes böops Marsh,				×				×							[1]	Y.
" *guyoti* (Scott)																P.
" *minusculus* (Scott)																"
" *nanus* (Marsh) Leidy		×			×		×									
TAPIRIDÆ.																
Isectolophus latidens (S. & O.)					×											P.

---

[1] Dug Springs.

V. BRIDGER.—*Continued.*

	Huerfano Basin.	Bridger Basin.										Washakie.				Location of Type.
		Lodge Pole Trail.	Fort Bridger.	Grizzly Buttes.	Henry's Fork.	Dry Creek.	Cottonwood Creek.	Black's Fork.	Ham's Fork.	Twin Buttes.	Unrecorded.	Haystack Mtn.	Mammoth Buttes.	La Clede.	Unrecorded.	
HYRACODONTIDÆ.																
Hyrachyus agrarius Leidy	×	×	×	×	×	×	×	×		×	×					U. S.
Hyrachyus agrestis *Leidy*								×								"
Hyrachyus eximius Leidy					×	×	×									Ph.
Lophiodon bairdianus *Marsh*[1]																Y.
Hyrachyus princeps Marsh					×								×			"
" *modestus* Leidy			×													U. S.
" *imperialis* Scott, Speir & Osborn,					×		×									P.
" *paradoxus* " " "																"
" *implicatus* Cope													×			A. M.
Hyrachyus intermedius *S. & O.*							×									P.
" crassidens *S. & O.*					×											"
Triplopus cubitalis Cope															[2] ×	A. M.
" *amarorum* Cope															[2] ×	"
Colonoceras agrestis Marsh																Y.
AMYNODONTIDÆ.																
Amynodon antiquus (S. & O.)															×	P.
TITANOTHERIIDÆ.																
Palæosyops paludosus Leidy	×				×		×	×		×	× [3]					U. S.
Limnohyus robustus *Marsh*					×											Y.

---

[1] Recorded as from Bridger and Uinta beds. Size = *H. eximius.*

[2] South Bitter Creek.

[3] Type from Church Buttes.

V. BRIDGER.—*Continued.*

	Huerfano Basin.	Bridger Basin.										Washakie.				Location of Type.
		Lodge Pole Trail.	Fort Bridger.	Grizzly Buttes.	Henry's Fork.	Dry Creek.	Cottonwood Creek.	Black's Fork.	Ham's Fork.	Twin Buttes.	Unrecorded.	Haystack Mtn.	Mammoth Buttes.	La Clede.	Unrecorded.	
Limnohyus diaconus *Cope*					×											A. M.
Palæosyops major *Leidy*						×										
Palæosyops laticeps Marsh										×	1	×			×	Y.
Palæosyops lævidens *Cope*							×						×			A. M.
" minor *Earle*																
Palæosyops manteoceras Osborn MS.					×					×	×	×		×		A. M.
(Palæosyops vallidens *Osborn*,[2] not Cope)																
Telmatotherium validum Marsh[3]															×	Y.
Telmatotherium hyognathum *S. & O.*															×	P.
Telmatotherium vallidens (Cope)													×			A. M.
" *cultridens* S. & O					×					×						P.
Telmatotherium megarhinum Earle					×					×	×			×	×	"
? Palæosyops fontinalis *Cope*[4]											×					A. M.
? " longirostris *Earle*											×					P.
? *Palæosyops humilis* Leidy[5]																
? " *junius* Leidy[5]																Ph.
ARTIODACTYLA.																
? CAMELIDÆ.																
Ithygrammodon cameloides S. & O																P.

---

[1] Type from Marsh's Fork.
[2] Bull. Am. Mus. Nat. Hist., 1895, 87.
[3] *Telmatherium validus* in the original description.
[4] Indeterminate. Milk dentition, probably of *T. megarhinum*.
[5] Indeterminate. May be dwarfed or milk teeth of this or some other species.

V. BRIDGER.—*Continued.*

		BRIDGER BASIN.										WASHAKIE.				
	Huerfano Basin.	Lodge Pole Trail.	Fort Bridger.	Grizzly Buttes.	Henry's Fork.	Dry Creek.	Cottonwood Creek.	Black's Fork.	Ham's Fork.	Twin Buttes.	Unrecorded.	Haystack Mtn.	Mammoth Buttes.	La Clede.	Unrecorded.	Location of Type.
HOMACODONTIDÆ.																
Homacodon vagans Marsh[1]																Y.
Nanomeryx caudatus Marsh																"
Helohyus plicodon Marsh																"
" *validus* Marsh																"
" *lentus* Marsh																"
Stenacodon rarus Marsh					×											Y.
ACHÆNODONTIDÆ.																
Achænodon insolens Cope															[2] ×	A. M.
" *robustus* Osborn ... Lower Bridger.																P.
"*Platygonus*" *Ziegleri* Marsh																Y.
INDET.																
Pantolestes longicaudus Cope[3]								×								A. M.

---

[1] Aug. 3, 1872. If *Pantolestes* is an Artiodactyl, it may be a synonym of this genus.

[2] South Bitter Creek.

[3] Aug. 7, 1872. The supposed position of this species among the Artiodactyla rests entirely on the general resemblance of the teeth (much worn in the type specimen), and especially of p_4, to those of *Trigonolestes*. Characters of associated fragments do not favor the reference, tending rather to place it where Cope originally referred it, among the Primates,

VI. *UINTA.*

	Horizon A.	Horizon B.	Horizon C.	Location of Type.
PRIMATES.				
Hyopsodus gracilis Marsh			×	
Hyopsodus sp.			×	
Microsyops uintensis Osborn		×		A. M.
RODENTIA.				
Paramys sciuroides S. & O.			×	P.
Paramys uintensis Osborn		×		A. M.
Protoptychus hatcheri Scott				P.
CREODONTA.				
CANIDÆ.				
Miacis vulpinus Scott			×	P.[1]
Prodaphænus scotti[2]				
Prodaphænus (Miacis) **uintensis** (Osborn)		×	×	A. M.
Procynodictis vulpiceps[2]				"
OXYÆNIDÆ.				
Oxyænodon dysodus[3]		×	×	"
MESONYCHIDÆ.				
Mesonyx, cf. *obtusidens* Cope		×		
Mesonyx uintensis Scott		×	×	P.
AMBLYPODA.				
UINTATHERIIDÆ.				
Uintatherium sp.	×	×		
PERISSODACTYLA.				
EQUIDÆ.				
Epihippus uintensis Marsh			×	Y.
Epihippus gracilis (Marsh)			×	"
LOPHIODONTIDÆ.				
Helaletes guyotii Scott		×		P.
TAPIRIDÆ.				
Isectolophus annectens S. & O.			×	"

---

[1] Type mislaid or lost.

[2] Unpublished.

[3] Unpublished. See Osborn, Bull. Am. Mus. Nat. Hist., 1896, 78, fig. 3 (*Hyænodon*).

VI. UINTA.—*Continued.*

	Horizon A.	Horizon B.	Horizon C.	Location of Type.
HYRACODONTIDÆ.				
Triplopus obliquidens S. & O.			×	P.
Prothyracodon intermedium *S. & O.*				
Triplopus sp. (? = *Lophiodon bairdianus* Marsh, part).			×	
AMYNODONTIDÆ.				
Amynodon advenus Marsh			×	Y.
Amynodon intermedius S. & O.			×	P.
TITANOTHERIIDÆ.				
Telmatotherium cornutum Osborn		×		A. M.
Telmatotherium diploconum Osborn		×		"
Telmatotherium ? **diploconum**, var. **minus**[1]		×		"
Telmatotherium hyognathum S. & O.		×	×	P.
Palæosyops manteoceras Osborn[2]	×	×	×	A. M.
" **ultimus** Osborn[2]			×	"
Diplacodon elatus Marsh			×	Y.
Diplacodon emarginatus Hatcher			×	P.
Diplacodon sp. indesc.			×	A. M.
ARTIODACTYLA.				
HOMACODONTIDÆ.				
Bunomeryx montanus Wortman			×	A. M.
Bunomeryx elegans Wortman			×	"
CAMELIDÆ.				
Protylopus petersoni Wortman			×	A. M.
Leptotragulus proavus S. & O.		×	×	P.
Parameryx lævis Marsh			×	Y.
" *sulcatus* Marsh			×	"
Camelomeryx longiceps Scott			×	P.
OREODONTIDÆ.				
Leptoreodon marshi Wortman		×	×	A. M.
Merycodesmus gracilis *Scott.*			×	P.
Eomeryx (Protoreodon) **parvus** (S. & O.)			×	"
Eomeryx sp. major indesc.			×	
" *pumilus* Marsh			×	Y.
Agriotherium paradoxicum Scott			×	P.
Hyomeryx breviceps Marsh			×	Y.
Oromeryx plicatus Marsh			×	"
ACHÆNODONTIDÆ.				
Protelotherium uintense (Osborn)		×		A. M.
Achænodon sp. (*A. insolens*, fide Osborn)		×		
INCERTÆ SEDIS.				
Sphenocœlus uintensis Osborn		×		A. M.

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[1] Unpublished. Heretofore confounded with *T. megarhinum.*

[2] Unpublished.

VII. *WHITE RIVER.*

The localities tabulated below are :

1. *Colorado.* — Headwaters of Cedar, Lewis, Horsetail, and Pawnee Creeks in northeast Colorado. Fauna described by Cope in 1873 and later. The Lower, Middle, and Upper White River are represented. Cope's collections were from the lower and middle beds, Horizons *A* and *B* ; the fauna of Horizon *C* is determined from collections by the American Museum Expedition of 1898.

2. *Nebraska.* — Hat Creek Basin, adjoining the S. Dakota White River. Lower, Middle, and Upper White River are present.

3. *South Dakota.*—This is the largest and best known area. It lies between and about the White and Cheyenne Rivers, and furnishes the typical section. The Lower or Titanotherium Beds are divisible into three subzones, the Middle or Oreodon Beds into two subzones, and the Upper or Protoceras Beds probably into two subzones of which the uppermost one bears a generally scanty fauna.

4. *North Dakota.*—A small area near White Buttes contains a fauna apparently near to the Protoceras fauna in age.

5. *Montana.*—I have here included the lower beds of the Deep River valley, which Prof. Scott considers as Upper John Day. That they are later than the uppermost part of the White River (Horizon *C*, Leptauchenia Beds) is, I think, not proven, and they belong geographically to the White River.

6. *Canada.*—Swift Current Creek in the Cypress Hills, N. W. T. The area is limited and the rocks conglomeritic, so that the specimens were largely fragmentary. They are preserved in the Museum of the Geological Survey of Canada.

VII. WHITE RIVER.—*Continued.*

	Colo.			Neb.			S. Dakota.						
	Horizon A.	Horizon B.	Horizon C.	Titanoth'm.	Oreodon.	Protoceras.	Titanoth'm.	Oreodon.	Protoceras.	N. Dakota.	Montana.	Canada.	Type.
MARSUPIALIA.													
Didelphys pygmæa Scott		×											P.
? **Didelphys** (Peratherium) **fugax** (Cope)		×											A. M.
? " " **huntii** (Cope)		×											"
? *Didelphys* (Peratherium) *alternans* (Cope)		×											"
? " " *scalaris* (Cope)		×											"
? " " *marginalis* (Cope)		×											"
RODENTIA.													
ISCHYROMYIDÆ.													
Ischyromys typus Leidy		×			×			× ×					Ph.
SCIURIDÆ.													
Sciurus relictus Cope		×											A. M.
Sciurus cf. *wortmani* Cope		×											
CASTORIDÆ.													
Steneofiber nebrascensis Leidy						×			×	×			Ph.
Steneofiber montanus Scott											×		P.
GEOMYIDÆ.													
Gymnoptychus minutus Cope		×											A. M.
Gymnoptychus trilophus Cope		×											"
Heliscomys vetus Cope		×											"

VII. WHITE RIVER.—*Continuea*

	Colo.			Neb.			S. Dakota.			N. Dakota.	Montana.	Canada.	Type.
	Horizon A.	Horizon B.	Horizon C.	Titanoth'm.	Oreodon.	Protoceras.	Titanoth'm.	Oreodon.	Protoceras.				
CRICETIDÆ.													
Eumys elegans Leidy		×			×			× ×					Ph.
LEPORIDÆ.													
Palæolagus haydeni Leidy		×	×		×			× ×					"
" **intermedius** sp. nov.[1]		×	×										A. M.
" **turgidus** Cope		×										×	"
Palæolagus triplex Cope		×											"
CREODONTA.													
HYÆNODONTIDÆ.													
Hyænodon horridus Leidy								×					
" **cruentus** Leidy		×						×					
" **crucians** Leidy		×						× ?					
Hyænodon leptocephalus Scott													H.
" *paucidens* O. & W.								×					A. M.
Hemipsalodon grandis Cope												×	C. G. S.
CARNIVORA.													
CANIDÆ.													
Daphænus (Amphicyon) vetus (Leidy)		×						×					U. S.
Daphænus (Amphicyon) hartshornianus (Cope)		×						×					A. M.
" *felinus*, Scott					×								P.
" *dodgei* Scott				×									P.

---

[1] A species intermediate in size between *P. haydeni* and *P. turgidus*. The size in these species appears to be fairly constant, and there may be other characters to separate this form.

VII. WHITE RIVER.—*Continued.*

	Colo.			Neb.			S. Dakota.						
	Horizon A.	Horizon B.	Horizon C.	Titanoth'm.	Oreodon.	Protoceras.	Titanoth'm.	Oreodon.	Protoceras.	N. Dakota.	Montana.	Canada.	Type.
Cynodictis (*Canis*, *Galecynus*) **lippincottianus** Cope		×						× ×					A. M.
Amphicyon gracilis *Leidy* (nom. preoc.)								×					Ph.
" angustidens *Marsh*													Y.
Cynodictis (Galecynus) gregarius (Cope)		×						× ×		?			A. M.
? Cynodictis sp. maj			×						×				
Cynodesmus thöoides Scott													P.
PROCYONIDÆ.													
Phlaocyon leucosteus n. g. & sp.[1]			×										A. M.
MUSTELIDÆ.													
Bunælurus lagophagus Cope		×											"
Canis osorum *Cope*		×											"
FELIDÆ.													
Dinictis felina Leidy							?	× ×	?				"
Dinictis squalidens Cope		×						?					"
" *fortis* Adams							×	×					
Dinictis bombifrons *Adams*													
Dinictis paucidens Riggs													K.
Hoplophoneus (Drepanodon) primævus Leidy								×					U. S.
" " **occidentalis** Leidy								×					Ph.

---

[1] Generic characters: skull short and wide with thick, blunted low-cusped teeth; p^4 with postero-internal cusp, and strong, well separated antero-internal. Dentition $\frac{3.1.4.2}{3.1.4.3}$. Limbs and feet shorter than in *Cynodictis*, claws small and short. Apparently ancestral to the Procyonidæ. *P. leucosteus* is somewhat larger than *Cynodictis gregarius*. Length of skull 93.5 mm.; width 64.2; length of upper dentition 46.3; width across palate at posterior end of p^4, 34; length of tibia 84.5. The claws have a rudimentary basal sheath; the upper surfaces of the second phalanges are hollowed out as though the claws were slightly retractile.

VII. WHITE RIVER.—*Continued.*

	Colo.			Neb.			S. Dakota.			N. Dakota.	Montana.	Canada.	Type.
	Horizon A.	Horizon B.	Horizon C.	Titanoth'm.	Oreodon.	Protoceras.	Titanoth'm.	Oreodon.	Protoceras.				
Dinotomius atrox *Williston*													K.
Hoplophoneus (*Machærodus*) *oreodontis* (Cope)		×											A. M.
Hoplophoneus robustus Adams		?			×			×					
" *insolens* Adams								×	×				
" *crassidens* Cragin													
Eusmilus dakotensis Hatcher									×				P.
INSECTIVORA.													
LEPTICTIDÆ.													
Leptictis haydeni Leidy													Ph.
Ictops dakotensis Leidy								× ×					"
Ictops bullatus sp. nov.[1]								× ×					A. M.
Mesodectes caniculus Cope[2]		×											"
INCERTÆ SEDIS.													
Geolabis rhynchæus Cope		×											"
Domnina[3] *gradata* Cope		×											"
" *crassigenis* Cope		×											"
Protosorex crassus Scott													[4]
PERISSODACTYLA.													
EQUIDÆ.													
Mesohippus[5] (**Anchitherium**) **bairdi** Leidy		×			×		×	× ×					

---

[1] Distinguished from type species by presence of small auditory bulla, m^3 reduced without metacone, longer skull and somewhat larger size.

[2] Validity of this genus somewhat doubtful. The only character separating it from *Ictops* is absence of trittocone on p^3, which is partly due to wear. The only character separating *Ictops* from *Leptictis* is absence of deuterocone and trittocone from p^3; they would otherwise be identical.

[3] Doubtfully separable from *Geolabis*.

[4] Type in Mus. Chic. Univ.

[5] *Vide* Farr, Am. Phil. Soc. Proc., 1896, 147.

VII. WHITE RIVER.—*Continued.*

	Colo.			Neb.			S. Dakota.						
	Horizon A.	Horizon B.	Horizon C.	Titanoth'm.	Oreodon.	Protoceras.	Titanoth'm.	Oreodon.	Protoceras.	N. Dakota.	Montana.	Canada.	Type.
Anchitherium exoletum *Cope*		×											A. M.
" cuneatum *Cope*		×											"
Mesohippus intermedius O. & W.			?			×			×				"
" **copei** O. & W.								×	×				"
Mesohippus gracilis Marsh													Y.
" *celer* Marsh													"
" *westoni* (Cope)												×	C. G. S.
" (*Miohippus*) *? equiceps* (Cope.)[1]											×		
" " *? annectens* Marsh[1]											×		
Anchippus texanus Leidy[2]			?										? U. S.
Anchitherium agreste *Leidy*													"
LOPHIODONTIDÆ.													
Colodon (Lophiodon) occidentalis (Leidy)							×	×					Ph.
Colodon luxatus Marsh								×					Y.
" *dakotensis* O. & W.								×					A. M.
" *procuspidatus* O. & W.								×					"
? " (*Mesohippus*) *longipes* (O. &. W.)								×					"
TAPIRIDÆ.													
Protapirus simplex W. & E.								×					"
" **obliquidens** W. & E.									×				"
Protapirus validus Hatcher													P.

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[1] Determination provisional, by Prof. Scott.

[2] See note (¹) on p. 69.

VII. WHITE RIVER.—*Continued.*

	COLO.			NEB.			S. DAKOTA.						
	Horizon A.	Horizon B.	Horizon C.	Titanoth'm.	Oreodon.	Protoceras.	Titanoth'm.	Oreodon.	Protoceras.	N. Dakota.	Montana.	Canada.	Type.
HYRACODONTIDÆ.													
Hyracodon (Rhinocerus) nebrascensis Leidy		×	?	?	×	?	?	× ×	? ?				U. S.
Hyracodon arcidens Cope		×											A. M.
Hyracodon major S. & O.													H.
Hyracodon planiceps S. & O.													"
AMYNODONTIDÆ.													
Metamynodon planifrons S. & O.								×					H.
RHINOCEROTIDÆ.													
Leptaceratherium trigonodum O. & W.							×						A. M.
Aceratherium mite Cope		×						×					A. M.
Cænopus pumilus *Cope*												×	C. G. S.
Aceratherium copei O. & W.							×						A. M.
" **occidentale** (Leidy)		×			×			× ×				×	U. S.
" **tridactylum** Osborn									×	×			A. M.
Diceratherium proavitum *Hatcher*						×							
Aceratherium platycephalum O. & W.				×					×				"
Aceratherium simplicidens (Cope)					×								U. P.
" *quadriplicatum* (Cope)		×											A. M.
TITANOTHERIIDÆ.													
Titanotherium[1] **(Teleodus) avum** Marsh							×						Y.
Titanotherium (Megaceratops) coloradense Leidy.[2]							×					×	Ph.

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[1] For synonymy of species of *Titanotherium*, see Osborn, Bull. Am. Mus. Nat. Hist., 1896, pp. 174–196.

[2] Denver Basin.

VII. WHITE RIVER.—*Continued.*

	Colo.			Neb.			S. Dakota.						
	Horizon A.	Horizon B.	Horizon C.	Titanoth'm.	Oreodon.	Protoceras.	Titanoth'm.	Oreodon.	Protoceras.	N. Dakota.	Montana.	Canada.	Type.
Titanotherium (Symborodon) **trigonoceras** Cope	×						×						A. M
" (Brontotherium) **ingens** Marsh	×						×						Y.
Titanotherium (Symborodon) *heloceras* Cope	×												A. M.
" " *torvum* Cope	×						×						"
Titanotherium (Symborodon) **acre** Cope	×			×			×					×	"
Titanotherium (Diconodon) *montanum* Marsh							×						Y.
" (Haplacodon) *angustigenis* Cope												×	C. G. S.
" " *peltoceras* Cope							×						U. P.
Titanotherium (Brontops) **robustum** Marsh							×						Y.
Titanotherium (Menodus) *tichoceras* S. & O.							×						H.
" " *dolichoceras* S. & O.							×						"
Titanotherium (Titanops) **elatum** Marsh							×						Y.
Titanotherium (Titanops) *curtum* Marsh	×												"
Titanotherium (Menodus) **platyceras** S. & O.							×						H.
Titanotherium ramosum Osborn							×						A. M.
" (Menodus) *selwynianum* Cope												×	C. G. S.
ANCYLOPODA.													
CHALICOTHERIIDÆ.													
Chalicotherium bilobatum Cope												×	"
ARTIODACTYLA.													
ANTHRACOTHERIIDÆ.													
Anthracotherium (Heptacodon) *curtum* (Marsh)													Y.
Anthracotherium occidentale *O. & W.*							×	×					A. M.

VII. WHITE RIVER.—*Continued.*

	COLO.			NEB.			S. DAKOTA.							
	Horizon A.	Horizon B.	Horizon C.	Titanoth'm.	Oreodon.	Proteceras.	Titanoth'm.	Oreodon.		Protoceras.	N. Dakota.	Montana.	Canada.	Type.
Anthracotherium (Heptacodon) *gibbiceps* (Marsh)														Y.
" " *karense* O. & W.										×				A. M.
Octacodon valens *Marsh*														Y.
Elomeryx (Heptacodon) armatus *Marsh*														"
Anthracotherium (Elomeryx) *mite* (Marsh)														"
Hyopotamus americanus Leidy								×						
" **brachyrhynchus** O. & W.										×				A. M.
Hyopotamus deflectus Marsh ... S. Dakota.											?			Y.
ELOTHERIIDÆ.														
Elotherium mortoni Leidy	×				×		×	×						Ph.
" **crassum** Marsh	?	?						×	×	×				Y.
" **ingens** Leidy								×	×	×				
Elotherium robustum *Leidy*														? U. S.
Elotherium (Pelonax) *ramosum* Cope		×									×			A. M.
" *arctatum* Cope													×	C. G. S.
" (Ammodon) *bathrodon* Marsh														Y.
" " *potens* Marsh														"
" " *clavum* Marsh														"
INDET.														
Leptochœrus spectabilis Leidy.[1]									×	×				
Laopithecus robustus *Marsh*														Y.

---

[1] Marsh has described this genus as possessing artiodactyl feet. In the teeth it does not resemble any known Artiodactyl, and Marsh makes it the type of a new (undefined) family.

VII. WHITE RIVER.—*Continued.*

	Colo.			Neb.			S. Dakota.						
	Horizon A.	Horizon B.	Horizon C.	Titanoth'm.	Oreodon.	Protoceras.	Titanoth'm.	Oreodon.	Protoceras.	N. Dakota.	Montana.	Canada.	Type.
Leptochærus (Menotherium) *lemurinus* (Cope)		×											A. M.
" *gracilis* Marsh		?						?					Y.
SUIDÆ.													
Thinohyus robustus Marsh									×				
" *nanus* Marsh								×					
Perchærus probus Leidy								×					
" *antiquus* Marsh													
Nanohyus porcinus Leidy													
Bothrolabis (*Hyotherium*) *americanus* S. & O.													H.
" (*Palæochærus*) *platyops* Cope									?				A. M.
OREODONTIDÆ.													
Agriochœrus antiquus Leidy							×	×					
" **latifrons** Leidy							×	×					
" **major** Leidy									×				
Agriochærus (Agriomeryx) *migrans* Marsh									×				
Oreodon culbertsoni Leidy		×			×			×					
" **gracilis** Leidy		×			×	?		× ×					Ph.
" **bullatus** Leidy								×					"
Eporeodon major (Leidy)						×			×	×			
" **sp.**			×										
Mesoreodon chelonyx Scott			?								×		P.
Mesoreodon intermedius Scott											×		"
Merycochærus sp.			×						?				

VII. WHITE RIVER.—*Concluded.*

	Colo.			Neb.			S. Dakota.			N. Dakota.	Montana.	Canada.	Type.
	Horizon A.	Horizon B.	Horizon C.	Titanoth'm.	Oreodon.	Protoceras.	Titanoth'm.	Oreodon.	Protoceras.				
Leptauchenia major Leidy									×				
" **decora** Leidy			×						×				Ph.
Leptauchenia nitida Leidy									×				
CAMELIDÆ.													
Pöebrotherium wilsoni Leidy		?			×			×					Ph.
" **labiatum** Cope		×			×			×					A. M.
Pöebrotherium sp.	×												"
Protomeryx halli Leidy			×						×		?		
Stibarus obtusilobus Cope		×											A. M.
TRAGULIDÆ.													
Leptomeryx evansi Leidy		×	?		×			× ×	?	×		×	
Leptomeryx mammifer Cope		×										×	C. G. S.
" *semicinctus* Cope												×	"
" *esulcatus* Cope												×	"
Hypertragulus calcaratus Cope		×						×			×	×	A. M.
Hypertragulus tricostatus Cope		×											"
" *transversus* Cope												×	C. G. S.
Hypisodus minimus Cope		×											A. M.
PROTOCERATIDÆ.													
Protoceras celer Marsh									×				Y.
Protoceras comptus Marsh									×				"
" *nasutus* Marsh									×				"
Calops cristatus Marsh									×				"
" *consors* Marsh									×				"

VIII. *JOHN DAY.*

The level at which each species occurs is known only in a few cases, as noted.

RODENTIA.

SCIURIDÆ.

	Type.
Sciurus wortmani Cope	A. M.
Sciurus ballovianus Cope	"
Allomys nitens Marsh	Y.
" (Meniscomys) **hippodus** Cope	A. M.
Allomys (Meniscomys) *multiplicatus* Cope	"
" " *liolophus* Cope	"
" " *cavatus* Cope	"

CASTORIDÆ.

Steneofiber gradatus Cope	A. M.
" *peninsulatus* Cope	"

GEOMYIDÆ.

Pleurolicus sulcifrons Cope	A. M.
" *leptophrys* Cope	"
" *diplophysus* Cope	"
Entoptychus planifrons Cope	"
" **cavifrons** Cope	"
" **minor** Cope	"
Entoptychus lambdoideus Cope	"
" *crassiramis* Cope	"

MURIDÆ.

Hesperomys nematodon Cope	A. M.
Paciculus lockingtonianus Cope	"
Paciculus insolitus Cope	"

LEPORIDÆ.

Lepus ennisianus Cope[1]	A. M.

CARNIVORA.

CANIDÆ.

Paradaphænus[2] **(Amphicyon) cuspigerus** (Cope)	A. M.
Paradaphænus sp. indesc.	"
Amphicyon hartshornianus *Cope* (part)	"
Nothocyon[2] **(Galecynus) geismarianus** (Cope)	"
" " **lemur** (Cope)	"
" " **latidens** (Cope)	"
Temnocyon altigenis Cope	"
Temnocyon wallovianus Cope	"
" *ferox* Evermann	P.

---

[1] Includes all specimens from John Day referred by Cope to *Palæolagus*.

[2] Unpublished.

VIII. JOHN DAY.—*Continued.*

	Type.
Hypotemnodon (Temnocyon) coryphæus (Cope)	A. M.
Hypotemnodon (*Temnocyon*) *josephi* (Cope)	"
Hyænocyon basilatus Cope	"
" *sectorius* Cope	"
Oligobunis crassivultus Cope	"
Enhydrocyon stenocephalus Cope	"

MUSTELIDÆ.

Parictis primævus Scott	P.

FELIDÆ.

Dinictis cyclops Cope	A. M.
Archælurus debilis Cope	"
Nimravus gomphodus Cope	"
Nimravus confertus Cope	"
Pogonodon platycopis Cope	"
Pogonodon brachyops Cope	"
Hoplophoneus cerebralis Cope	"
Hoplophoneus strigidens *Cope* (sp. indeterm.)	"

PERISSODACTYLA.

EQUIDÆ.

Mesohippus (Anchitherium) præstans (Cope)[1]	A. M.
" " **equiceps** (Cope)	"
Mesohippus (*Anchitherium*) *brachylophus* (Cope)	"
" " *longicristis* (Cope)	"
" " *condoni* Leidy[2]	U. S.
" (*Miohippus*) *annectens* (Marsh)	Y.
" " *anceps* (Marsh)	"

LOPHIODONTIDÆ.

? *Colodon* (*Lophiodon*) *occidentalis* Leidy[2]	U. S.

RHINOCEROTIDÆ.

Aceratherium pacificum Leidy	U. S.
" ? *hesperium* Leidy	"
Aceratherium tubifer *Cope* (indet. sp.)	A. M.
Aceratherium truquianum Cope	"
" *annectens* Marsh	Y.
Diceratherium armatum Marsh	"
" **nanum** Marsh	"

INDETERMINATE.

Dæodon shoshonensis Cope	A. M.

? CHALICOTHERIIDÆ (aut EDENTATA).

Moropus distans Marsh	Y.
" *senex* Marsh	"

---

[1] Bridge Creek (Merycochœrus Beds).

[2] Bridge Creek.

VIII. John Day.—*Concluded.*

ARTIODACTYLA.

ELOTHERIIDÆ.

	Type.
Boöchœrus humerosus Cope[1]	A. M.
Elotherium imperator Leidy[2]	U. S.

SUIDÆ.

Bothrolabis (Dicotyles) pristinus Leidy[2]	U. S.
Bothrolabis trichænus Cope	A. M.
" *rostratus* Cope	"
" *subæquans* Cope	
Chænohyus decedens Cope	
Thinohyus lentus Marsh	Y.
" *socialis* Marsh	"

OREODONTIDÆ.

Agriochœrus trifrons Cope	A. M.
" **guyotianus** Cope	"
Agriochœrus ryderanus Cope	"
Agriochœrus (Coloreodon) *ferox* (Cope)	"
" " macrocephalus (Cope)	"
Eporeodon occidentalis Marsh	Y.
Eucrotaphus jacksoni *Leidy*, part	
" major *Leidy*, part	
Eporeodon occidentalis var. **leptacanthus** (Cope)[3]	A. M.
" " var. **pacificus** (Cope)[3]	"
Eporeodon trigonocephalus (Cope)	"
" *socialis* Marsh	Y.
" *major* var. *longifrons* (Cope)[3]	A. M.
Merycochœrus (Oreodon) superbus Leidy[4]	U. S.
" **chelydra** Cope[4]	A. M.
Merycochœrus leidyi Bettany[4]	
" *macrostegus* Cope[4]	A. M.

CAMELIDÆ.

Protomeryx (Gomphotherium) **sternbergi** Cope	A. M.
" " **cameloides** Wortman[4]	"
Hypertragulus calcaratus Cope	"

---

[1] Perhaps the same as *Elotherium imperator* Leidy.

[2] Bridge Creek.

[3] These may probably be distinct species.

[4] Bridge Creek Beds.

IX. *LOUP FORK.*

The localities tabulated below are as follows:

1. *Northeastern Colorado.* Headwaters of Cedar, Horsetail, and Pawnee Creeks, in Logan and Weld counties, north of the South Platte River. Sands and gravels overlying the White River clays, usually unconformably with heavy conglomerates at or near the base. Another unconformity of erosion occurs sometimes within the formation dividing it into horizons D and E (p. 23); but no important faunal distinctions appear. These unconformities of erosion in fluviatile beds are not of much importance. Collections made by Prof. Cope in 1873 and 1879, and Amer. Mus. Exped. of 1898.

2. *Laramie Peak, Wyoming.* A small collection chiefly of *Merychyus*, made for Prof. Cope in 1880.

3. *Deep River, Montana.* A limited area in the valley of Deep Creek or Smith River, near Great Falls. Collections made for Prof. Cope in 1877, and Princeton Expedition of 1892.

4. *Cottonwood, Oregon.* Cottonwood Creek in the valley of the John Day River. Collection made for Prof. Cope in 1879 by Dr. J. L. Wortman.

5. *Oregon Desert.* See foot-note, p. 70.

6. *Nebraska.* In the basins of the Loup River (Loup Fork) and Niobrara River, and elsewhere in the central and northern part of western Nebraska. The fauna, described mainly by Leidy and Marsh, is the typical and largest Loup Fork fauna.

7. *New Mexico.* This fauna was described by Cope in 1874 from the collections made by the Wheeler Survey, and now preserved in the National Museum. Most of the species came from the Santa Fé basin.

8. *Kansas–Nebraska.* Northwestern Kansas and southwestern Nebraska in the drainage basin of the Republican River. The latest of the Loup Fork faunas, some of it Pliocene according to Prof. Scott. The short-legged Rhinoceroses are the most abundant fossil.

9. *Texas.* In northern Texas, near the head of the Red River, along the northeastern border of the Llano Estacado.

IX. *LOUP FORK.*

	N. E. Colorado.	Laramie P'k, Wyo.	Deep River, Mont.	Cottonwood, Ore.	Oregon Desert.	Nebraska.	New Mexico.	Kansas-Nebraska.	Texas.	Type.
RODENTIA.										
SCIURIDÆ.										
Arctomys vetus Marsh						×				
Cynomys sp.								×		
MYLAGAULIDÆ.										
Mylagaulus sesquipedalis Cope								×		A. M.
Mylagaulus monodon Cope[1]	×							×		"
CASTORIDÆ.										
Steneofiber pansus Cope							×			U. S.
" sp.								×		
Eucastor tortus Leidy						×				
Sigmogomphius lecontei Merriam ... Pliocene, California.										
GEOMYIDÆ.										
Geomys bisulcatus Marsh[2]						×				Y.
Hesperomys loxodon Cope							×			U. S.
" sp.								×		

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[1] A skull and jaws of this species, collected in Colorado in 1898, show that Cope was justified in placing it in a separate family. It is partly intermediate between *Castoridæ* and *Sciuridæ*, but has many peculiar characters.

[2] Also from Blue Creek; identification uncertain; associated with *Cyclopidius*.

IX. Loup Fork.—*Continued.*

	N. E. Colorado.	Laramie P'k, Wyo.	Deep River, Mont.	Cottonwood, Ore.	Oregon Desert.	Nebraska.	New Mexico.	Kansas-Nebraska.	Texas.	Type.
LEPORIDÆ.										
Panolax sanctæfidei Cope							×			U. S.
Lepus sp.								×		
CARNIVORA.										
CANIDÆ.										
Ælurodon compressus Cope						×				A. M.
Ælurodon sævus Leidy						×	×	×		U. S.
" **haydeni** Leidy										"
" **wheelerianus** Cope						×	×			"
" **hyænoides** Cope								×		A. M.
Ælurodon taxoides Hatcher								×		P.
" *mæandrinus* Hatcher								×		"
" *ursinus* Cope						×	×			U. S.
? *Canis montanus* Marsh										Y.
" *vafer* Leidy						×				U. S.
" *temerarius* Leidy	×					×				"
" *brachypus* Cope		×								A. M.
" *anceps* Scott			×							P.
PROCYONIDÆ.										
Leptarctus primus Leidy						×				

IX. LOUP FORK.—*Continued.*

	N. E. Colorado.	Laramie P'k, Wyo.	Deep River, Mont.	Cottonwood, Ore.	Oregon Desert.	Nebraska.	New Mexico.	Kansas-Nebraska.	Texas.	Type.
MUSTELIDÆ.										
Mustela parviloba (Martes mustelinus *Cope*)	×					×				A. M.
" sp	×									"
Putorius nambianus Cope							×			U. S.
? *Stenogale robusta* Cope						×				A. M.
Brachypsalis pachygnathus Cope						×				"
Lutrictis lycopotamicus Cope				×						"
Tomarctus brevirostris Cope	×									"
FELIDÆ.										
Pseudælurus intrepidus Leidy	×					×				U. S.
Machærodus catocopis Cope								×		A. M.
? *Felis maxima* S. & O. (= *Machærodus*, fide Adams)								×		H.
? " *augustus* Leidy						×		×		U. S.
PROBOSCIDEA.										
ELEPHANTIDÆ.										
Tetrabelodon angustidens (Cuvier)							×	×		
" *brevidens* Cope	?		×							A. M.
" *serridens* Cope									×	
" *productus* Cope							×			U. S.
" *euhypodon* Cope								×		A. M.
" *campester* Cope								×		"

IX. LOUP FORK.—*Continued.*

	N. E. Colorado.	Laramie P'k, Wyo.	Deep River, Mont.	Cottonwood, Ore.	Oregon Desert.	Nebraska.	New Mexico.	Kansas-Nebraska.	Texas.	Type.
Dibelodon mirificus Leidy						×				
" *præcursor* Cope									×	
PERISSODACTYLA.										
EQUIDÆ.										
Mesohippus (*Miohippus*) sp.			×							
" (*Anchitherium*) *ultimus* Cope				×						A. M.
Anchitherium equinum Scott	?		×							P.
Anchippus texanus Leidy	×								[1] ×	
Anchitherium australe *Leidy*									[1] ×	
Anchippus (*Desmatippus*) *crenidens* (Scott)			×							P.
Anchippus brevidens Marsh				×						Y.
Protohippus[2] **perditus** Leidy	×	×				×		×	×	U. S.
Protohippus profectus *Cope*								×		
? " labrosus *Cope*	×									A. M.
Parahippus cognatus *Leidy*										
Protohippus placidus Leidy						×		×	×	
Hipparion gratus *Leidy*										
Protohippus (Equus) parvulus *Marsh*										
Protohippus medius Cope				×		×		×		
? Merychippus insignis *Leidy* (Indet. sp.)										
Protohippus sejunctus Cope	×		×			? ×	? ×			A. M.

---

[1] Type from Washington Co., "Miocene." May be White River.

[2] Strictly speaking, *Protohippus* is preoccupied by *Merychippus*, the type of which is generically though perhaps not specifically determinable. Cop (Tex. Geol. Sur., 1892) has stated the reasons for preferring the name *Protohippus*.

IX. LOUP FORK—*Continued.*

	N. E. Colorado.	Laramie P'k, Wyo.	Deep River, Mont.	Cottonwood, Ore.	Oregon Desert.	Nebraska.	New Mexico.	Kansas–Nebraska.	Texas.	Type.
Protohippus castilli Cope[1]										A. M.
" *avus* Marsh				?						Y.
Pliohippus pernix Marsh						×				"
" *robustus* Marsh						×				"
Pliohippus (Merychippus) mirabilis (Leidy)[2]	×					×			×	
Protohippus supremus *Leidy*										
Pliohippus (*Protohippus*) *pachyops* (Cope)								?	×	T.
" " *fossulatus* (Cope)								×		"
" (*Hippidium*) *spectans* (Cope)				×						A. M.
Hipparion (Hippotherium) isonesum (Cope)	×		×	×						"
" **speciosum** (Leidy)						×		×		
" **occidentale** (Leidy)				×[3]						
Hipparion sinclairii (Wortman)				×[3]						A. M.
" *montezumæ* (Leidy)[4]										
" *peninsulatum* (Cope)[5]										A. M.
" *paniense* (Cope)	×									"
" *calamarium* (Cope)	×						×			

---

[1] Type from Tehuichila, Vera Cruz, Mexico.

[2] It is probable that a more complete knowledge of the one-toed Horses of the Loup Fork would show them to be generically distinct from *Hippidion*. In this case Marsh's name *Pliohippus* can properly be used. They are much smaller, very much slenderer than *Hippidion*; the skulls are like *Protohippus* as far as known, and the nasals are probably as in that genus and very different from *Hippidion*. *Protohippus mirabilis* Leidy may, according to Cope, belong in this genus, a suggestion confirmed by a skeleton found recently in Colorado. *P. pachyops* and *P. fossulatus* are very similar. All are distinguished from *Protohippus* by large size, unusually large cement lakes, and very little complication of the enamel.

[3] From the loose gravels overlying the Cottonwood beds.

[4] Mexico.

[5] Tehuichila, Vera Cruz, Mexico.

IX. Loup Fork —*Continued.*

	N. E. Colorado.	Laramie P'k, Wyo.	Deep River, Mont.	Cottonwood, Ore.	Oregon Desert.	Nebraska.	New Mexico.	Kansas-Nebraska.	Texas.	Type.
Hipparion relictum Cope[1]					×					A. M.
H. seversum, H. sphenodus *Cope* (sp. indeterm.)	×									"
TAPIRIDÆ.										
Tapiravus rarus Marsh[2]										Y.
RHINOCEROTIDÆ.										
Aceratherium profectum n. sp.[3]	×									A. M.
" **(Aphelops) megalodum** (Cope)[4]	×		?							"
? Rhinoceros crassus *Leidy*										U. S.
Teleoceras fossiger (Cope)								×		A. M.
Teleoceras major *Hatcher*								×		P.
Aceratherium acutum *Marsh*								×		Y.
? **Teleoceras malacorhinus** (Cope)										A. M.
? Rhinoceros meridianus *Leidy*										
Teleoceras superciliosus (Cope)								×		A. M.
Aceratherium (*Aphelops*) *jemezanum* (Cope)							×			U. S.
" (*Rhinoceros*) *oregonensis* (Marsh)[5]				?						Y.

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[1] Teeth found in the Oregon Desert, along with bones of *Aphelops* (cf. *fossiger*), undetermined Proboscidea and a large Camel, in size equal to *Procamelus robustus* Leidy. Prof Cope referred these specimens to the Pliocene (= Blanco), but they do not seem separable from the Kansas Loup Fork fauna.

[2] "Lower Pliocene, east of the Rocky Mountains."

[3] Dentition and proportions of teeth as in *A. occidentale.* Jaw shorter, deeper, and more rounded than *A. occidentale*, angle as in *A. megalodus.*

[4] In the synonymy of the Loup Fork Rhinoceroses, I have followed Prof. Osborn's provisional use of Cope's specific names based on complete skulls, etc., rather than Leidy's earlier names based on fragmentary specimens.

[5] "Pliocene . . . . about two thirds the size of *R. crassus* Leidy."

IX. LOUP FORK.—*Continued.*

	N. E. Colorado.	Laramie P'k, Wyo.	Deep River, Mont.	Cottonwood, Ore.	Oregon Desert.	Nebraska.	New Mexico.	Kansas-Nebraska.	Texas.	Type.
? CHALICOTHERIIDÆ aut EDENTATA.										
Moropus elatus Marsh[1]	?					×				Y.
ARTIODACTYLA.										
SUIDÆ.										
Dicotyles serus Cope								×		A. M.
Platygonus striatus Marsh										
SUINÆ INDET.										
OREODONTIDÆ.										
Merycochœrus rusticus Leidy .... Wyoming.										U. S.
" *proprius* Leidy	?					×				"
" *cenopus* S. & O.						×				H.
" *montanus* Cope			×							A. M.
" *obliquidens* Cope				×						"
" sp.				×						
Merychyus elegans Leidy	?					×				U. S.
" **medius** Leidy	×					×	×			"
" **major** Leidy	×					×				"

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[1] Prof. Marsh (A. J. S., May, 1892, p. 448, foot-note) states that *Moropus* is distinct from *Chalicotherium*, with which it was identified by Scott and Osborn, but gives no reasons for the separation. The Colorado specimen indicated above has metatarsals and toes closely resembling *Ancylotherium*, and should be renamed if *Moropus* is edentate; the reference is only provisional. An undoubted chalicothere from Nebraska was referred by Scott and Osborn to Marsh's species.

IX. LOUP FORK.—*Continued.*

	N. E. Colorado.	Laramie P'k, Wyo.	Deep River, Mont.	Cottonwood, Ore.	Oregon Desert.	Nebraska.	New Mexico.	Kansas-Nebraska.	Texas.	Type.
Merychyus zygomaticus (Cope)			×							A. M.
" *pariogonus* (Cope)			×							"
" *arenarum* (Cope)		×								"
" *euryops* (Cope)		×								"
Cyclopidius emydinus Cope			×			[1]				"
" **simus** Cope			×							"
Pithecistes brevifacies *Cope*[2]			×							"
Cyclopidius incisivus Scott			×							P.
Cyclopidius (Pithecistes) **decedens** (Cope)			×			[1]				A. M.
? Pithecistes heterodon *Cope*			×							"
CAMELIDÆ.										
Procamelus robustus Leidy					?	×	×	×	×	U. S.
Protolabis prehensilis *Cope*								×		A. M.
Procamelus altus *Marsh*						×				Y.
Procamelus occidentalis Leidy						×	×	×	×	U. S.
Homocamelus caninus *Leidy*						×				"
Procamelus gracilis Leidy						×	×	×	×	"
Procamelus leptognathus Cope									×	T.

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[1] Blue Creek, Cheyenne Co., associated with *Merychyus* and ? *Merycochœrus*.

[2] *Pithecistes* was distinguished by Cope from *Cyclopidius* by: (1) lower incisors reduced to one on each side; (2) canine not incisiform; (3) p_1, absent. These characters are shown only in the single known specimen of the type species *P. brevifacies*, a very old individual. Careful comparison and more complete removal of the matrix show that: (1) the alveoli of two small incisors are present on each side; (2) the canine, mistaken by Cope for an incisor, is present and worn to a stump; (3), the first pre-molar, mistaken for canine by Cope, is present and caniniform; (4) there are no distinctions whatsoever from *Cyclopidius simus* except those due to age of the individual. *Pithecistes decedens* is the permanent and *P. heterodon* probably the milk dentition of a smaller species of *Cyclopidius*; both are founded on upper teeth.

IX. LOUP FORK.—*Concluded.*

	N. E. Colorado.	Laramie P'k, Wyo.	Deep River, Mont.	Cottonwood, Ore.	Oregon Desert.	Nebraska.	New Mexico.	Kansas-Nebraska.	Texas.	Type.
Protolabis heterodontus Cope[1]	×									A. M.
" (**Procamelus**) ? **angustidens** Cope	×		?							"
Miolabis (**Procamelus**) ? **fissidens** Cope	×									"
" (**Protolabis**) ? **transmontanus** Cope				×						"
" sp	×									"
Pliauchenia humphresiana Cope							×	×		U. S.
Pliauchenia vulcanorum *Cope*							×			"
Pliauchenia minima Wortman								×		A. M.
CERVIDÆ.										
Blastomeryx gemmifer Cope	×					×	×			A. M.
" **borealis** Cope	?		×	×						"
Blastomeryx antelopinus Scott			×							P.
Cosoryx furcatus Leidy						×	×	×		
Cosoryx ramosus *Cope*										
Cosoryx necatus Leidy						×		×		A. M.
Cervus warreni *Leidy*						×				U. S.
Cosoryx teres Cope								×		"
" *trilateralis* Cope								×		"
" *tehuanus* Cope								×		"
BOVIDÆ.										
Bison ferox Marsh[2]						×				Y.
" *alleni* Marsh[2]								×		"

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[1] Additional and more complete material from Colorado shows that the Camels of that region are not *Procamelus*, but belong to two distinct genera. For one of these *Protolabis* Cope can probably be used; the other, if distinct from *Protomeryx*, may be called *Miolabis*, a name suggested by Dr. O. P. Hay in a recent letter to Prof. Osborn. The genera will be more fully defined in a forthcoming article on the Colorado Miocene. At present the distinctions appear to be: *Procamelus*. Dentition $I\frac{1}{3}$, $C\frac{1}{1}$, $P\frac{4}{4}$, $M\frac{3}{3}$; metapodials united. *Protolabis*. Dentition $I\frac{3-1}{3}$, $C\frac{1}{1}$, $P\frac{4}{4}$, $M\frac{3}{3}$; metapodials united; neck and legs greatly elongated, as in the Giraffe. *Miolabis*. Dentition $I\frac{3}{3}$, $C\frac{1}{1}$, $P\frac{4}{4-3}$, $M\frac{3}{3}$; metapodials separate.

[2] "Lower Pliocene."

X. *PLIOCENE.*

A. Palo Duro.

(GOODNIGHT BEDS.)

This fauna, except for the presence of *Equus*, corresponds with the later Loup Fork fauna, which may also be Pliocene according to Prof. Scott. It is too scanty for certain correlation. The formation overlies the Texas Loup Fork unconformably.[1]

PERISSODACTYLA.

RHINOCEROTIDÆ.

Aphelops sp. ....

EQUIDÆ.

Protohippus lenticularis Cope .... T.
" *perditus* Leidy ....
" sp. ....
Pliohippus (*Hippidium*) *interpolatus* (Cope) .... T.
" " *spectans* (Cope) ....
Equus eurystylus Cope .... T.
" ? *simplicidens* Cope ....

B. Blanco.

CARNIVORA.

CANIDÆ.

Canimartes cumminsii Cope .... T.
Borophagus diversidens Cope .... "
Felis hillanus Cope .... "

EDENTATA.

Megalonyx leptostomus Cope .... T.

PROBOSCIDEA.

Dibelodon humboldtii (Cuvier) ....
" *tropicus* ....
" *præcursor* Cope .... T.
Tetrabelodon shepardii (Leidy)[2] ....

PERISSODACTYLA.

EQUIDÆ.

Equus simplicidens Cope .... T.
" *cumminsii* Cope .... "
" *minutus* Cope .... "

ARTIODACTYLA.

SUIDÆ.

Platygonus bicalcaratus Cope .... T.

CAMELIDÆ.

Pliauchenia spatula Cope .... T.

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[1] Texas Geol. Sur. Rep., 1892.

[2] One specimen in American Museum of Natural History.

The Ancestry of Certain Members of the Canidæ, the Viverridæ, and Procyonidæ.

By J. L. Wortman and W. D. Matthew.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
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New York, June 21, 1899.

Article VI.—THE ANCESTRY OF CERTAIN MEMBERS OF THE CANIDÆ, THE VIVERRIDÆ, AND PROCYONIDÆ.

By J. L. Wortman and W. D. Matthew.

Plate VI and Ten Text Figures.

The Eocene deposits of North America have yielded from time to time a large number of remains of primitive flesh-eating mammals whose nearest affinities appear to be with the modern Carnivora, although not a few of them, so far as their dentition is concerned, exhibit resemblances to certain of the Insectivora. This group has been held by some to represent a distinct order, and is considered by many authors under the name Creodonta, originally proposed for it by Cope. By others it has been placed as a suborder of the Carnivora, while still others have referred to it under the name Carnivora Primitiva.

Without entering into a discussion of the merits of this group to rank as a separate order or even a suborder, it is sufficient to observe in the present connection that it is not capable of very exact definition, and if it is desirable to retain a separate grouping of these forms it must be done with the understanding that it is purely as a matter of convenience.

That they stand in direct ancestral relationship to the later appearing families of the modern Carnivora, there can be no question whatever, but whether these families arose from one or several points among the Creodonta has never been demonstrated. In fact no actual contact between the two groups has ever been satisfactorily traced, and while many suggestions have been made in regard to these connections, they have, up to the present, been unsupported by any direct proof.

It is the object of the present paper, therefore, to trace the ancestry of two important modern families of the Carnivora directly backward into the Creodonta. We will also take occasion to point out the descent of several somewhat aberrant species of the existing Canidæ.

Another important discovery included in the present paper deals with the origin of the American family Procyonidæ, which is now shown to have existed as far back as the upper Oligocene.

I.—THE SHORT-JAWED DOGS OF THE EOCENE.

Uintacyon[1] *Leidy.*

This group of species has been found thus far in the Wasatch, Wind River, and Bridger beds, and is represented so far only by more or less complete specimens of the lower jaws. In one species, *Uintacyon vorax* from the Bridger, a few fragments of the skeleton are known, but beyond this the materials are very deficient. Most of the species which we place in this genus have been referred to *Miacis*, a genus originally established by Cope upon a jaw fragment from the Bridger.[2] It now appears, however, that this first described species, and therefore the genus *Miacis*, is synonymous with the genus *Vulpavus*, previously established by Marsh upon a first superior molar.[3] The name *Miacis* will therefore have to be abandoned and the name *Uintacyon*, given by Leidy, substituted. Leidy's type of *Uintacyon edax* is anomalous, in that it possesses five premolars instead of the normal number four, but this is not open to very serious objection, since the shape and position of the extra tooth will convince almost any one at a glance of its abnormal nature.

As the genus stands at present no very striking or trenchant characters can be assigned to it which will separate it sharply from its Bridger contemporary, *Vulpavus*. Although the upper dentition is completely unknown, there can be very little doubt that the most important distinctions between the two will be found to consist in the number of superior molars. In *Vulpavus* they are reduced to two, as in the modern genus *Canis*, while there can be very little doubt that the number was three in *Uintacyon*. The only positively known character by which the two genera can be separated at present, is seen in the thick, heavy lower jaw, together with the abruptly rounded chin. In *Vulpavus*, on the other hand, the jaw is relatively slender and without the abrupt chin, quite as in the modern Canidæ.

There are apparently several distinct lines of species in this genus reaching from the Wasatch into the Bridger. In one precocious series the jaw is remarkably deep and short, the lower

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[1] Proc. Acad. Nat. Sci. Philada. 1872, 277.

[2] Proceed. Amer. Philos. Soc. Aug. 1872, 740.

[3] Amer. Jour. Science, Aug. 1871.

canines laterally flattened, and the anterior premolars much reduced. In another line the jaw is somewhat more slender but still very short, the lower canines laterally compressed, but the premolars are not especially reduced in size. A third section includes a single very small species from the Bridger in which the jaw is very short and deep, the canines not flattened, and the premolars unreduced. In a fourth section the jaw is much more elongated and shallower, the canines not flattened, and the premolars are not reduced.

The dentition of the lower jaw is I. $\frac{}{3}$, C. $\frac{}{1}$, Pm. $\frac{}{4}$, M. $\frac{}{3}$. The second pair of incisors is much displaced, being pushed back out of the transverse line. The sectorial is made up of an elongated trigon and a basin-shaped heel; the second molar exhibits a crown of similar composition, but the trigon is much lower and the anterior cusp considerably reduced. In some species the last molar is very small and single-rooted, while in others it is larger and is implanted by two distinct roots. One peculiar feature of all the short-jawed species of the genus is the great length of the molar as compared with the premolar series. In many the molars occupy quite one half of the tooth-line of the jaw.

Uintacyon promicrodon, sp. nov.

This species is represented in the collection by a single specimen of an almost complete lower jaw (No. 83), in which the sectorial and fourth premolar are in good state of preservation; portions of the third premolar and second molar, as well as the roots and alveoli of all the remaining teeth, are present. The species belongs in the first section of the genus mentioned above, and is its oldest known representative, coming as it does from the Wasatch. The chief distinctions between it and *U. canavus* from the Wind River is seen in the size of the fourth lower premolar in comparison with that of the first molar. In the species under consideration it is of normal size and holds about the same relations to the succeeding tooth in this respect as is commonly observed in the modern Canidæ, whereas in *U. canavus* this tooth is much more reduced.

The remaining premolars were remarkably small and weak, if we can judge by the size of the roots; the first was implanted by a single root, while the second and third each had two. The crown of the fourth premolar has a prominent submedian cutting heel. The length of the lower dental series from the alveolus of the first premolar is 41 mm.

Uintacyon canavus[1] (*Cope*).

This species is represented by the jaws of four individuals in the collection, all from the Wind River beds [Nos. 4783 (type), 4784, 4786, 4798]. The type consists of a lower jaw bearing the first premolar, but displaying the roots of all the remaining teeth. In the other specimens the crowns of the other teeth are moderately well preserved, so that the lower dentition can be determined.

As compared with the preceding species, the jaw is not quite so deep and heavy, especially in the region of the symphysis, the anterior premolars are smaller and more spaced, and the fourth much more reduced than in the preceding species. Two of the specimens show the alveolus for the last molar, and indicate that this tooth was implanted by two distinct roots, whereas in the preceding species the alveolus is not divided.

In this connection it is proper to mention a specimen from the Wind River, consisting of the last two molars (No. 84), which does not agree with either of the Wind River species, *U. canavus* and *U. brevirostris*, in that the last molar is single-rooted, as it is in the Wasatch *U. promicrodon.* The premolars belonging to this type are entirely unknown, and it would not be at all surprising if another species is indicated by this specimen. If the anterior premolars are reduced, it undoubtedly represents the direct successor of *U. promicrodon* in the Wind River. Until better specimens are known, we refrain from proposing another specific name.

The entire length of the lower molar series of the present species as indicated by the type is 42 mm.

Uintacyon brevirostris[2] (*Cope*).

The type of this species consists of a lower jaw (No. 4785) from the Wind River beds ; it is the only specimen known from this horizon. The jaw is short and deep, as in the preceding species, and the canine is laterally compressed. The premolars,

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[1] Bull. U. S. Geolog. Surv. Terr. VI, Feb. 1881, 186.

[2] Bull. U. S. Geolog. Surv. Terr. VI, Feb. 1881, 190.

of which the crown of the fourth is preserved, show little or no reduction, differing in this respect from the preceding species in a marked degree. The second molar, whose crown is preserved in perfect condition, has a squarish outline with low tubercular cusps ; the trigon is very slightly raised above the heel, and the anterior cusp is much reduced. The last molar was distinctly two-rooted. The length of the molars and premolars is 38 mm.

There are five specimens of lower jaw fragments in the collection from the Big Horn Wasatch which agree very closely with the above type and which we provisionally refer to this species. The premolars were apparently unreduced, the jaw of the same depth and shortness, and the last molar strongly two-rooted. In one specimen (No. 4224), however, the anterior portion of the second molar is less elevated, and the anterior cusp of the trigon more reduced than in the type specimen from the Wind River.

Uintacyon vorax *Leidy.*[1]

This species is not represented in the Museum collection and the description here given is from the type of *U. bathygnathus* of Scott,[2] which name is undoubtedly synonymous with that of the above species.

The specimen, like that of the type, is from the Bridger, and consists of the greater part of both lower jaws, one of which contains the heel of the sectorial and the second molar in perfect condition. There are also present the proximal end of the femur, distal end of the tibia and fibula, part of the proximal end of the ulna, distal end of radius, a complete fifth metacarpal, a part of a metatarsal, and two phalanges. The original type of the species consists of a fragment of the lower jaw bearing the second molar, preserved in the collection of the Philadelphia Academy.

As in the preceding species the premolars are not especially reduced, and the jaw is relatively deep and short. The last molar is single-rooted, and the size is considerably greater than in *U. brevirostris;* the length of the lower molar and premolar series is 51 mm.

The fragments of limb bones are not certainly known to belong with the jaws, but they seem to agree so well in every respect

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[1] Proc. Acad. Nat. Sci. Phila. 1872, 277.
[2] Some Little Known Creodonts. Jour. Acad. Nat. Sci. Phila. Vol. IX, 172.

that there is comparatively little doubt that they do. They do not display any special characters which will serve to distinguish them from either the early Cats or Dogs. The more salient features may be stated to be a moderately well-developed third trochanter on the femur, a very slight grooving of the astragalus, as well as a well-flattened distal end of the radius, all of which belong to certain members of the early Canidæ and Felidæ.

Uintacyon pugnax, sp. nov.

This smallest known species of the genus is represented in the collection by a single nearly complete lower jaw (No. 1744), bearing the second and third molars in good preservation, together with the roots of the remaining teeth. The jaw is remarkably short and heavy, especially in the region of the symphysis, the canine is not laterally flattened, and the premolars apparently unreduced. The crowns of the second and third molars display the usual cusps, but the trigons are more elevated than in any of the preceding species. The length of the molar and premolar series is 27 mm.

Uintacyon edax *Leidy.*[1]

The type of this species and that of the genus is represented by a moderately complete lower jaw preserved in the collection of the Philadelphia Academy. The chief characters of this species are seen in the comparatively shallow, elongated jaw, as well as its smaller size. As already stated, the type displays an extra premolar, which is undoubtedly abnormal, since it is placed with its long axis transverse to the long axis of the jaw. Length of molar and premolar series, including the extra premolar, 33 mm.; canine not laterally flattened and premolars unreduced.

Several fragments of jaws from the Big Horn probably represent this species, but the specimens are so imperfect that the reference is uncertain.

Prodaphænus scotti,[2] gen. et sp. nov.

We propose this genus upon a series of upper molars (No. 11,238) of the Princeton collection, together with a lower jaw (No.

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[1] Proc. Acad. Nat. Sci. Phila. 1872, 277.

[2] This species is dedicated to Professor W. B. Scott, of Princeton, whose contributions to Palæontology are so well known.

2510) of the American Museum collection, both from the Uinta. The distinctions between it and *Daphænus* of the White River Oligocene are especially seen in the characters of the superior molars; in *Prodaphænus* the external cusps are flanked by a broad cingular ledge which anteriorly is developed into two distinct cusps. The unusual extension of this ledge serves to increase the transverse diameter of the tooth, especially upon its anterior border, and on this account it resembles the corresponding tooth of *Viverravus* more than that of the Dogs in general. Another important distinction is the small development of the postero-internal cusp, which in *Daphænus* is as large as it is in the modern Canidæ. In the specimen under consideration the tooth is broken in such a way as not to show this postero-internal ledge very distinctly, but there can be little doubt that it was present though small.

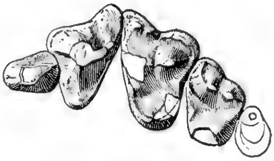
Fig. 1. *Prodaphænus scotti* W. & M. Upper teeth, crown view, natural size. Type specimen No. 11,238, Princeton Coll.

Its technical distinction from *Uintacyon* cannot at present be given on account of our lack of knowledge of the upper teeth of this later genus. That it is a direct descendant of *Uintacyon*, and the immediate forerunner of *Daphænus*, there can be little doubt. The most striking similarity to *Daphænus* is seen in the low rounded cusps of the molars, the absence or very small development of intermediates, the reduced size of the third superior premolar, as well as the molar formula above, which is 3.

Until it can be more clearly distinguished from *Uintacyon* the genus must be regarded as provisional only, but at the same time there is little probability that the genus *Uintacyon* continued into the Uinta without change.

II.—THE ANCESTRY OF THE DHOLES.

CYON, TEMNOCYON, DAPHÆNUS, PRODAPHÆNUS, UINTACYON.

1. *Cyon and Temnocyon.*

The Dhole or Red Dog of India (*Cyon*) can be confidently considered as the living representative of the John Day genus *Temnocyon*, and through this genus is probably descended from a line which we can trace back with tolerable accuracy into the lower Eocene.

This important connection has been entirely overlooked by previous writers, who have considered *Temnocyon* to be an abortive side-branch of the Canidæ.

The evidence is briefly as follows:

1. Heels of lower molars trenchant. This unusual character is shared by the recent *Icticyon* and the John Day genera *Oligobunis*, *Enhydrocyon* and *Hyænocyon*. All of these have dental formulæ excluding them from the ancestry of *Cyon*.

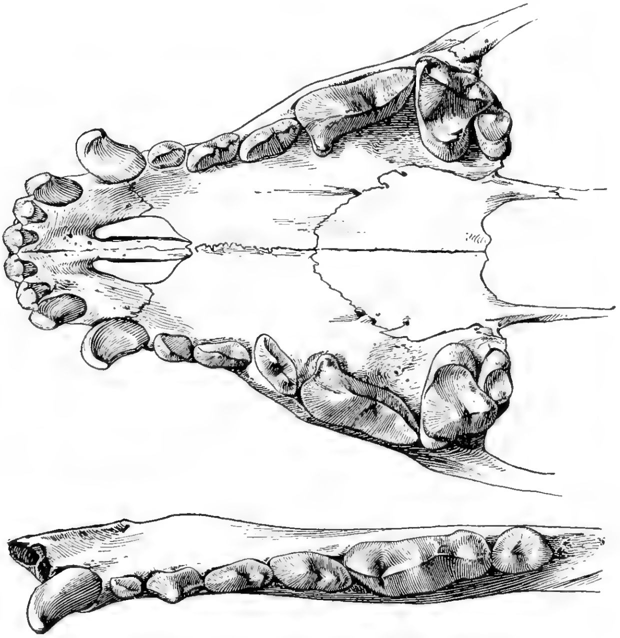

Fig. 2. *Cyon alpinus.* Upper and lower teeth, three fourths natural size. From a specimen in the American Museum collection.

2. Postero-internal cusp of superior molars reduced in *Temnocyon*, obsolete in *Cyon*, antero-internal cone reduced, separated from external cusps by an unusually deep valley, corresponding to the high trenchant heel of the lower molars.

3. Last lower molar reduced in *Temnocyon*, absent in *Cyon*. Last upper molar somewhat reduced in *Temnocyon*, considerably

so in *Cyon*. Premolars unusually large; m^2 unusually small, with internal cusp of the trigon reduced in *Temnocyon*, absent in *Cyon*. Jaw unusually deep under premolars.

The two are separated by the usual progressive characters seen in all modern Canidæ; the hallux is much reduced, mt. II falling from $\frac{1}{2}$ to $\frac{1}{5}$ the length of mt. III. The pollex suffers a similar reduction from $\frac{1}{2}$ to $\frac{1}{3}$ of mc. III. The foot is elongated and narrowed, the brain cavity increased, the skull shortened. Premolar 2 has acquired a posterior cusp in *Cyon*, lacking in *Temnocyon;* the internal cusp of the superior sectorial is more reduced in the modern species. In our skull of *Cyon alpinus* the incisors show a small basal lateral cusp. All these are acquired characters, most of them being developed in almost all species of dogs. We find no acquired characters in *Temnocyon* that *Cyon* has not, nor any primitive characters in the latter that the former has not.

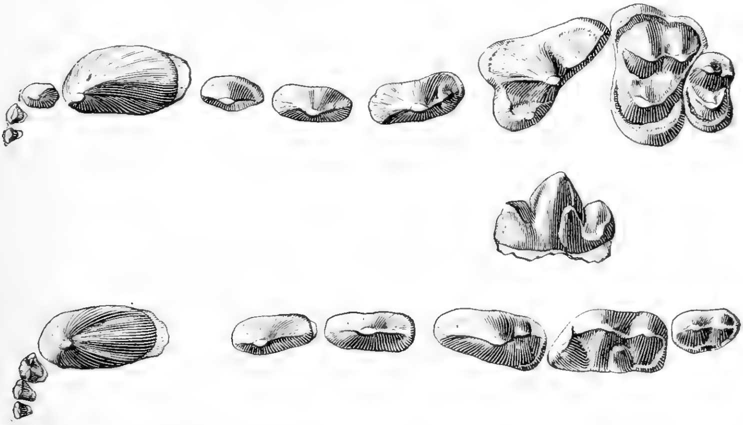

Fig. 3. *Temnocyon ferox* Eyerman. Upper and lower teeth, three fourths natural size. After Eyerman.

Cyon, with its congener *Icticyon*, retains more than any of the other dogs the primitive short legs and long body. The tail is much reduced in both genera.

2. *Related Genera.*

Related to the Dhole and *Temnocyon*, and distinguished like it by the trenchant heels to the molar cusps, are the modern *Icticyon*, and the John Day genera *Enhydrocyon*, *Hyænocyon* and *Oligobunis*, all with a more reduced dental formula. They form the most carnivorous division of the family, approximating the Viverridæ or Felidæ, while *Nothocyon* and *Megalotis* stand at the other extreme, approximating the Procyonidæ.

3. *Daphænus and Temnocyon.*

The relationship between these two genera has been pointed out by Prof. Scott[1] and Dr. Eyerman.[2] All our evidence tends to confirm the view that *Temnocyon* is a descendant of *Daphænus*, although the gap between them is in some respects considerable. Both have the same strong, round-edged, massive cusps, but in *Daphænus* the molars are large and low, while in *Temnocyon* they are small and high-cusped. *Daphænus* is just beginning to develop a trenchant heel on m $\frac{\ }{1-2}$; it has the same deep jaw, and does not show any intermediates on the upper molars.

Hypotemnodon has a somewhat problematic position intermediate between *Cynodictis* and *Daphænus* in most of the skull characters but with trenchant heel on m $\frac{\ }{1}$ only. Scott derives it from *Daphænus*; there is, however, a species of *Cynodictis* in the upper White River, which presents a closer approximation in character of teeth, and if our association of specimens is correct, has developed a low trenchant heel on m $\frac{\ }{1}$ only. For this reason it is placed provisionally in the *Cynodictis* line.

Prof. Scott derives *Cynodesmus* also from *Daphænus*, basing the derivation apparently on the presence of frontal sinuses in both. Whether the presence of these in the larger species of Canidæ is of much phylogenetic value seems uncertain ; on other grounds *Cynodesmus* might well be connected with *Cynodictis*.

4. *Prodaphænus and Daphænus.*

5. *Uintacyon and Prodaphænus.*

These have already been considered.

III.—THE EOCENE ANCESTORS OF CYNODICTIS.

Vulpavus palustris[3] *Marsh.*

With this species we come to consider the phylum which in all probability terminated in the modern genus *Canis*. Its oldest

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[1] Notes on the Canidæ of the White River Oligocene. Trans. Am. Phil. Soc. 1898.

[2] Amer. Geol. 1896.

[3] Amer. Jour. Sci. Aug. 1871, (p. 16 of separate).

known representative comes from the Wind River beds, and is known from only an imperfect fragment of a lower jaw in the Museum collection. In the Bridger the genus is represented by at least two species, one of which, *V. palustris*, was described by Marsh from a single superior molar and forms the basis of the genus; and the other, *V. parvivorus*, was described from a fragment of a lower jaw by Cope and made the type of his genus *Miacis.* In the Museum collection is a specimen which upon careful comparison with Marsh's type of *V. palustris* we identify with this species; it consists of two superior molars of the right side, two nearly complete mandibular rami, together with some fragments of the skeleton of the limbs (No. 2305). It was found by Mr. O. A. Peterson of the Museum party of 1895, and was obtained from the middle horizon near the extreme southern limits of the Washakie Basin.

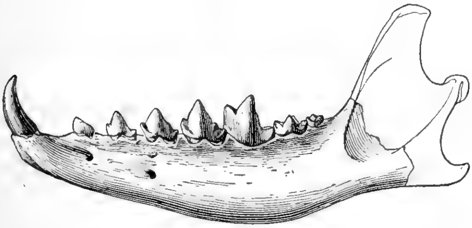

Fig. 4. *Vulpavus palustris* Marsh. Lower jaw, natural size. No. 2305.

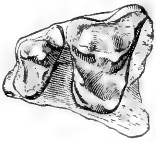

Fig. 5. *Vulpavus palustris* Marsh. Upper teeth, twice natural size. No. 2305.

The superior molars are two in number and display about the same proportions as those of many of the existing Canidæ. They present a number of features, however, very different from the modern Dogs. The first molar is remarkable for the great elongation of its anterior side in comparison with the posterior, and the drawing out of the antero-external angle, as well as the unusually broad ledge intervening between the base of the external cusps and the outer border of the crown. Another marked feature of this tooth is the great disparity in size between the anterior external and the posterior external cusps. The antero-internal cusp is large and lunate and there is a distinct anterior and posterior intermediate. The postero-internal cusp is represented by a strong cingulum in the usual position but it does not rise up into a distinct cusp as in the later Canidæ. The second molar is similar except that there is no representative of the postero-internal cusp. The general appearance of these teeth is more like that of many Creodonts than that of the modern Carnivora.

The lower jaw is very dog-like in its general proportions; the symphysial region is slender and the ramus is elongated. The teeth resemble those of the early Dogs, especially *Cynodictis;* the canine is long and pointed, being separated from the anterior premolar by a short diastema. The premolars have the usual form in the Canidæ, with compressed pointed crowns and basal cingula; the fourth has a distinct posterior accessory cusp. The sectorial closely resembles that of *Cynodictis.* The anterior and external cusps of the trigon form an effective shearing blade; the internal cusp is large and the heel basin-shaped. The second molar is similar in structure but its cusps are lower and there is no distinctive blade-like shear produced by a union of any of the cusps of the trigon. The last molar is much reduced, as in the later Canidæ.

Some fragments of the limb bones are preserved and they indicate, as do the teeth, a clear affinity with the early Dogs. The distal end of the radius is present, but the facet is cup-shaped and exhibits no distinct ridge separating scaphoid and lunar facets. This is not, however, conclusive proof that the scaphoid and lunar were not separate, since in *Viverravus*, *Oxyæna*, and other Creodonts in which these bones are distinct, the distal end of the radius gives little or no indication of the facet.

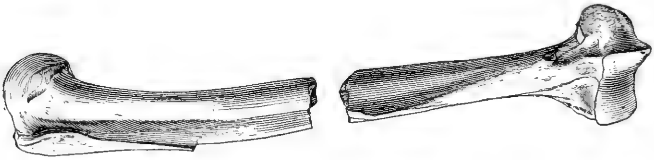

Fig 6. *Vulpavus palustris* Marsh. Humerus, natural size. No. 2305.

Vulpavus parvivorus[1] (*Cope*).

This second species is represented in the collection by a fragment of a lower jaw from the Bridger of Wyoming, and has been figured by Cope as the type of his genus *Miacis.* The fragment

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[1] Proc. Amer. Philos. Soc. Aug. 1872, 470.

carries the second molar in an excellent state of preservation, and exhibits the alveolus for the last molar and a portion of that of the first. The species can be readily distinguished from *V. palustris* by its smaller size and the less laterally compressed character of the second molar.

Procynodictis vulpiceps, gen. et. sp. nov.

This genus is proposed upon two specimens in the Museum collection, one of which (No. 2514) includes one upper and both lower jaws, together with the greater part of a hind foot, and the other (No. 2506) includes a part of the skull and the greater portion of the right fore foot. Besides these there are two fragments of jaws (Nos. 1895 and 1995) which we refer to the same species.

The dental formula is the same as in *Vulpavus* and *Cynodictis*, there being but two true molars above, and the systematic position of the genus is entirely intermediate between these two. In the structure of the superior molars it agrees with *Vulpavus* in that there is a great extension of the antero-external part of the tooth and a comparatively small development of the postero-internal cusp. In *Cynodictis* this cusp is as well developed relatively as in the modern Dogs, but the great antero-external extension is

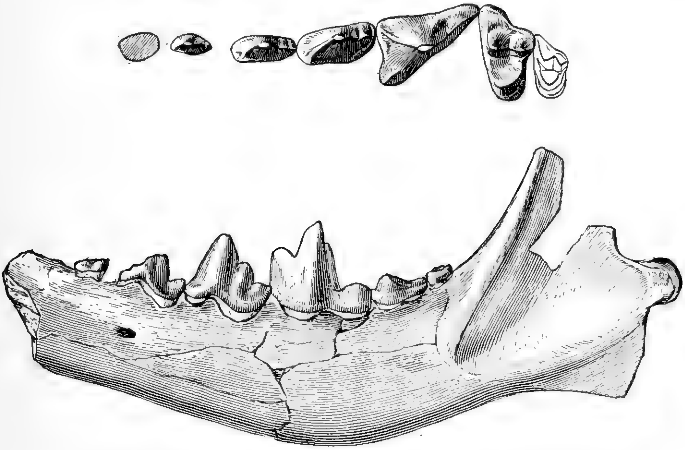

Fig. 7. *Procynodictis vulpiceps* W. & M. Upper and lower teeth, three halves natural size. Type specimen No. 2514.

lacking. The only important character in which it differs from *Vulpavus* is seen in the nearly equal size of the two external cusps of the first superior molar, whereas in *Vulpavus* the anterior greatly exceeds the posterior in size. This at first sight would seem to be of little significance, but the primitive condition was undoubtedly the one displayed by *Vulpavus*, and the more advanced one that of *Procynodictis* and *Cynodictis*. It therefore represents a distinct advance. The other teeth are very similar in their structure to those of *Vulpavus* and need no special mention.

The hind foot contains five toes; the metapodials are shorter and somewhat heavier than in *Cynodictis*, in which the hind foot had already begun to assume the elongated form so characteristic of the modern Canidæ. The tarsal bones are very like those of *Cynodictis*, as are also the remainder of the podial elements. The claws are much compressed laterally, with heavy subungual processes, and the middle phalanges are unsymmetrical, indicating some degree of retractility of the claw.

The fore foot also contains five toes, but, as in *Cynodictis*, it is much shorter than in any of the modern Canidæ. The scaphoid, lunar, and centrale are completely co-ossified as in the modern Dogs, without any trace of suture, into a scapholunar, which differs from that of *Cynodictis*, according to Scott's figure, in the greater vertical depth anteriorly, which is again a more primitive condition. The other carpals have practically the same proportions as in *Cynodictis*. The fore foot of *Vulpavus* is unknown, but it is more than probable that the scaphoid and lunar were separate in that genus, which if true will constitute an important difference between it and the present genus.

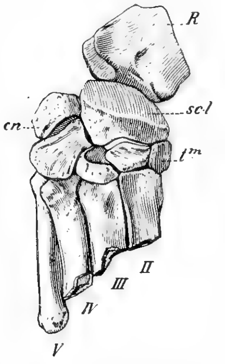

Fig. 8. *Procynodictis vulpiceps* W. & M. Fore foot, three halves natural size. No. 2506.

IV.—NOTES ON A SKELETON OF CYNODICTIS GREGARIUS.

In the American Museum Collection, Expedition of 1898, is a nearly complete and very well-preserved skeleton of *Cynodictis* *gregarius* (No. 8774). Prof. Scott has already fully described nearly all parts of this species, but we are able to fill out the description in one or two points for which his material was incomplete, and to give a series of measurements, which, being taken all from one individual, give the relative proportions with greater accuracy. Some of the individuals which Prof. Scott includes under *C. gregarius* may be referable to *C. lippincottianus*.

Hind Foot.—The *tarsus* has already been described in full by Prof. Scott. There are five *metatarsals*, the first slender, its length two thirds that of mt. III, diameter of the shaft half as great. Head rather small, shaft nearly straight, slender, rather compressed. Second, third, fourth, and fifth metatarsals symmetrical, the central pair a little longer and about one fourth greater in diameter of shaft. The distal articular ends are spheroidal, not at all of the square-cut style seen in all modern Dogs. The upper part of the shaft is somewhat compressed, the distal part not at all, and the distal ends are much more enlarged than in *Canis*, the diameter being one third more than that of the shaft, which in *Canis* increases in diameter at the distal end and is not over one tenth of the shaft diameter. The foot was therefore more spreading, as well as 15 per cent. shorter. The bones are as slender, however, as in a modern Dog. The phalanges are long and slender, quite as long as in modern Dogs. The second phalanx of each toe is asymmetrical and excavated, as in *Daphænus*, indicating, according to Scott, some retractility of the claws. No strong basal sheath appears to have been on the unguals, which are much as in *Canis*.

As the measurements indicate, the hind limb bones were much nearer to their present proportions, while the fore limbs were still quite short. The difference in the feet is yet more marked, for while the fore foot was scarcely more elongated than the Creodont ancestors, the hind foot was already long and slender, though not as narrow nor quite as long as in modern species. In both feet, however, the tetradactyl symmetry is already distinct, and both pollex and hallux are reduced.

The measurements of the skeleton, No. 8774, as far as at present obtainable, are given in comparison with those of the Fennec, the nearest living Canid in point of size.

Measurements of CYNODICTIS GREGARIUS (*Cope*), *in Comparison with* CANIS ZERDA.

	Cy. gregarius.	*Ca. zerda.*[1]
Skull, length, premaxillæ to condyles	est. 76 mm.	81 mm.
" length of palate (dentition)	" 42	45
" breadth "	" 27	24
" " brain case	29	35
Vertebræ, all pre-caudals		291
" cervicals		72
" dorsals		113
" lumbars	105	90
" sacrals	23	16
" caudals		350
Fore limb, total length	180	230
" humerus	71	80
" radius	56	79
" foot	53	71
" carpus	6	est. 12
" metacarpus	22	28
" phalanges	est. 25	est. 25
Hind limb, total length	241	272
" femur	80	81
" tibia	81	98
" foot (astragalus to ungues)	80	93
" tarsus	19	est. 22
" metatarsus	34	" 43
" phalanges	27	" 27

Taking the above measurements in order, we see that the skull of *Cynodictis* is shorter and with smaller brain-cavity. The neck and back vertebræ are nearly of the same size as in the Fennec, but cannot be measured at present. The lumbars and sacrum are considerably larger, and the tail was probably as long (no other living Dog has a tail of this length). The fore limb is one fourth shorter, while the hind limb is only one ninth shorter. The greater part of the elongation has been in the lower limb and foot bones. The phalanges have not lengthened at all, there being no tendency to become unguligrade.

V.—THE ANCESTRY OF CERTAIN SOUTH AMERICAN FOXES.

Nothocyon, gen. nov.

A genus or subgenus of Dogs distinguished by:

(1) Short muzzle; (2) upper carnassial very small, trigon of lower carnassial reduced, shear partly transverse; (3) molars

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[1] Measurements taken from Mivart's Monograph of the Canidæ.

large, not extended transversely, subquadrate ; (4) lower carnassial broad-heeled, and with an accessory cusp at the postero-external corner of the trigon ; (5) canines slender ; (6) otic bullæ large.

Canis urostictus Mivart, and *C. parvidens* Mivart, both from South America, belong to this genus, to which we also refer provisionally the three John Day species, *latidens* Cope, *lemur* Cope, and *geismarianus* Cope. These latter seem to be directly ancestral forms, and, like all the earlier Dogs, have shorter feet, longer lumbar region, and smaller brain-case than the modern species.

The distinctions above noted may seem hardly to be of generic value ; they are, however, tolerably constant, *Urocyon cinereoargenteus* being the only intermediate type. And if the group was first separated in the Oligocene, as seems probable, it gives it an ancestry that deserves full generic recognition. The alternative to uniting the John Day and modern species is to place the one as a subgenus of *Cynodictis*, the other of *Canis ;* the present method seems, however, to recognize more clearly the actual genetic affinities ; for if the living *Canis parvidens* and *urostictus* are lineally descended from the John Day *Cynodictis latidens lemur*, and *geismarianus*, the two modern species are more nearly related to the three Miocene species than to any living Canidæ. The best way to express this fact is to remove the Miocene species from *Cynodictis*, to the typical forms of which they are not more nearly related than the half-dozen or more distinct genera of the Phosphorites of France, and to unite them with two modern species, disregarding the considerable modernization of the latter, which retain, however, an unusual amount of the Tertiary facies.

Nothocyon urostictus (*Mivart*).

Canis urostictus MIVART, Proc. Zoöl. Soc. Lond. 1890, 112 ; Monograph of the Canidæ, 81.

The type and only specimen hitherto known is in the British Museum. No. 391, Dept. Osteol., Amer. Mus. Nat. Hist., we refer to this species and figure here. In size it is not very different from *Canis azaræ*, but the size and characters of the molars and carnassial easily distinguish it. The lyrate area on top of the skull is shared by many species of Dogs. Limbs and feet about as in modern species of *Canis ;* the lumbars appear to be larger in proportion. Locality, Chapada, Matto Grosso, Brazil.

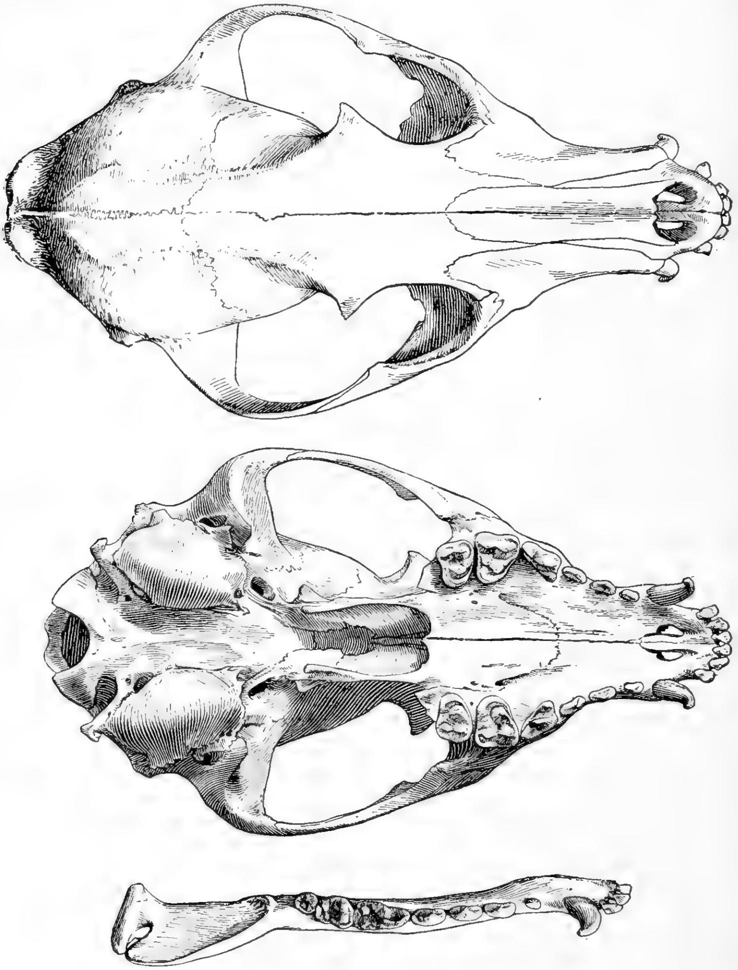

Fig. 9. *Nothocyon urostictus* (Mivart). Skull and jaw, five sevenths natural size. No. 391.

Nothocyon parvidens (*Mivart*).

Canis parvidens Mivart, loc. cit.

The only specimens hitherto known are three in the British Museum. We are enabled to add another skeleton, No. 349, Dept. Ost., Am. Mus. Nat. Hist., on the somewhat uncertain dental distinction separating it from *N. urostictus.* P^{4} is shorter, canines not so slender, m$_{3}$ more reduced, m^{1} and m^{2} seem to be variable in shape. No. 2091 also belongs to this or the preceding species. Locality, Chapada, Matto Grosso, Brazil.

As another division (Primævi) of the same genus, distinguished by relatively small brain, short feet, and long lumbar region, we place the three John Day species.

Nothocyon latidens (*Cope*).

Galecynus latidens Cope, Bull. U. S. Geol. Surv. VI, 1881, 181.
Cynodictis latidens Scott, Trans. Amer. Phil. Soc. 1898, 400.

Distinguished by exceptionally broad upper molars. Bullæ very large.

Nothocyon lemur (*Cope*)

Galecynus lemur Cope, Bull. U. S. Geol. Surv. VI, 1881, 181.
Cynodictis lemur Scott, Trans. Amer. Phil. Soc. 1898, 400.

Molars narrower, cusps marginal, double entoconid on m$_{1}$, postero-external accessory cusp on m$_{2}$ doubtful. Bullæ very large.

Nothocyon geismarianus (*Cope*).

Canis geismarianus Cope, Pal. Bull. No. 30, 1879, 9.
Cynodictis geismarianus Scott, loc. cit.

Larger species, deuterocone of p^{4} more reduced than in the others. Bullæ of more moderate size.

The skeleton of this species is fortunately known and has been described by Cope. It stands intermediate between that of *Cynodictis gregarius* and that of *Nothocyon urostictus.* The following comparisons show the advance in the especially progressive characters of (1) length of feet, (2) length of lumbar region, (3) size of brain.

Cynodictis gregarius, width of carpus, 15 mm.; length of mc. III, 22 mm.; proportion, 1 : 1.5.

Nothocyon geismarianus, width of carpus, 16.5 mm.; length of met. III, 33 mm.; proportion, 1 : 2.

Nothocyon urostictus, width of carpus, 18 mm.; length of mc. III, 48 mm.; proportion, 1 : 2.7.

In the same species we have :

Cynodictis gregarius, length of skull, 76 mm.; width of brain-case, 29, height, 22, length, 43 mm.; proportion of length of skull to width of brain-case, 1 : 0.37; length of seven lumbars, 104; proportion of length of skull to that of lumbar vertebræ, 1 : 1.37.

Nothocyon geismarianus, length of skull, 111 mm.; width of brain-case, 40, height, 33, length, 52 mm.; proportion of length of skull to width of brain-case, 1 : 0.37; length of seven lumbars, 155; proportion of length of skull to that of lumbar vertebræ, 1 : 1.39.

Nothocyon urostictus, length of skull, 112 mm.; width of brain-case, 45, height, 35, length, 52 mm.; proportion of length of skull to width of brain-case, 1 : 0.41; length of seven lumbars, 129; proportion of length of skull to that of lumbar vertebræ, 1 : 1.15.

From the above proportions it appears that the John Day species exhibits an important advance on the White River *Cynodictis* in the increase in length of feet and decrease in their width. The increase in the size and robustness of the species marks the advance in brain capacity, and the lumbar region has not suffered any proportionate reduction. In the modern species there is a further increase in length of feet, the brain increases in capacity, and the lumbar region is greatly reduced. The length of the femur and humerus does not increase in proportion; that of the tibia increases slightly and of the radius considerably.

	C. gregarius.	*N. geismarianus.*	*N. urostictus.*	Proportions, length of skull as unity.
Length humerus..	71	98	106	.93 : .90 : .94
“ radius....	55	?	105	.72 : ? : .94
“ femur....	79	110	116	1.03 : 1.00 : 1.04
“ tibia.....	80	116	120	1.04 : 1.04 : 1.07

The above measurements are from the complete skeletons of *C. gregarius* (No. 8774), *N. geismarianus* (No. 6886), *N. urostictus* (No. 391, Dept. Ost.).

The longer-legged specimens referred by Prof. Scott to *C. gregarius* may be referable to *C. lippincottianus.* These have the limbs, especially the tibia and fibula, much longer than in *C. gregarius* proper, but the feet apparently of the same size.

VI.—ANALYSIS OF THE MIOCENE GENERA OF CANIDÆ.

It is doubtful whether some of these genera should rank as such, the distinctions being probably of only subgeneric value. They certainly represent well-defined groups, and it would be difficult to invalidate one without invalidating nearly all. The mere *number* of the teeth cannot be considered as a more important character than their form, and unless certain characters are arbitrarily selected as generic, the representation of natural groups is the only valid foundation for generic distinctness. As a mere matter of convenience, the groups are here used as genera, with the proviso that they are not all of generic value. *Phlaocyon* stands widely apart from the rest, as does also *Oligobunis;* but whether two, three, or several genera are made out of the remaining species is a matter of arbitrary selection rather than natural grouping.

I. PROCYONIDÆ.

Skull short and wide, orbits well forward; carnassial teeth imperfectly or not sectorial; a hypocone on $p^{\underline{4}}$. Pentadactyl, plantigrade. Dentition typically $\frac{3-1-4-2}{3-1-4-2}$.

A. Third lower molar absent, second elongated. Modern genera *Bassariscus*, *Procyon*, *Bassaricyon*, *Nasua*, *Cercoleptes*.

B. Third lower molar present, second not elongated.

Phlaocyon. Dentition $\frac{3-1-4-2}{3-1-4-3}$.

II. CANIDÆ.

Becoming tetradactyl, digitigrade. Skull long, orbits not advanced, teeth sectorial and tubercular.

A. Short-footed, pentadactyl, with shear of sectorial partly transverse, small brain and other primitive characters.

1. Dental formula $\frac{3-1-4-3}{3-1-4-3}$.

a. Daphænus Leidy. Upper molars transversely unsymmetrical (paracone more external than metacone). $M^{\underline{3}}$ oval, aligned with inner cusps of anterior molars. Heels of lower molars low-ridged, with low entoconid crest, $m_{\overline{3}}$ a convex nub.

D. vetus Leidy. Amer. Mus., Nos. 1388, 1390.

D. hartshornianus (Cope). Amer. Mus., Nos. 6811, 1387.

D. felina Scott.

D. dodgei Scott.

The first three species are from the Oreodon beds, the last from the Titanotherium beds.

b. Paradaphænus, gen. nov. Upper molars much extended and symmetrical transversely; $m^{\underline{3}}$ aligned with outer cusps of anterior molars. Heels of lower molars wide and deep, basin-shaped; $m_{\overline{2}}$ and $m_{\overline{3}}$ with two anterior cusps and basin-heel.

P. cuspigerus (Cope). Nos. 6852 (type), and probably 6853 (type of *Amphicyon entoptychi* Cope).

P. transversus, n. sp.

Size one third larger (lineal). Upper premolars compressed.

Type No. 6851 (referred to *Amphicyon hartshornianus* by Cope).

Both species are from the John Day.

2. Dental formula $\frac{3-1-4-2}{3-1-4-3}$.

a. Temnocyon Cope. Heels of lower molars trenchant, without internal ridge. Trigon of $m_{\overline{2}}$ trenchant, without internal cusp.

T. altigenis Cope. Nos. 6855 (type), 6856.

T. wallovianus Cope. No. 6858 (type).

T. ferox Eyerman. No. 6857.

b. Hypotemnodon Eyerman. Heels of lower molars trenchant, internal ridge vestigial or wanting. Trigon of $m_{\overline{2}}$ with pr^{d} and me^{d} of equal size.

H. coryphæus (Cope). Nos. 6859 (type), 6860, 6862, 6922, and doubtfully Nos. 6861, 6920, 6909, etc.

H. josephi (Cope). Nos. 6878 (type), 6863, 6908, 6921.

All from the John Day.

c. Cynodictis Brav. and Pom. Heels of lower molars basin-shaped. Upper molars extended transversely. The American species are:

C. gregarius (Cope). Nos. 5297 (type), 5298, 5299 (fig. sp.), 1004, 1383, 1472, 8774, 5300. No. 6879 is probably a distinct species but does not present any well-marked specific characters.

C. lippincottianus (Cope). Nos. 5327 (type), 8757–63, 1384, 1389, etc. Teeth one fifth greater in lineal dimensions, somewhat more robust. Sectorial proportionately larger, shear less transverse.

? C. temnodon, n. sp. Size of *Hypotemnodon josephi*; lower premolars smaller than in that species and trigon wider; $p^{\underline{4}}$ (in associated upper jaws) with internal cusp almost obsolete, shear rather more longitudinal than in *Cynodictis lippincottianus*, $m^{\underline{1}}$ well extended transversely.

C. gregarius and *C. lippincottianus* come from the Oreodon beds (except the one skull No. 6879, of doubtful reference, which comes from the John Day). *C. temnodon* is from the Protoceras beds.

d. Nothocyon (section Primævi). Upper molars short transversely; $p^{\underline{4}}$ small; lower molars with wide basin heels, trigon of $m_{\overline{1}}$ reduced, and a small accessory cusp at its postero-external corner.

N. latidens (Cope). Nos. 6896 (type), 6897–99.

N. lemur (Cope). Nos. 6888 (type), 6889–94.

All from the John Day.

3. *Premolars* reduced.

a. Enhydrocyon Cope. Dentition $\underline{3-1-3-2}$.

E. stenocephalus Cope. Nos. 6901 (type), 6902.

John Day.

b. Hyænocyon Cope. Dentition $\frac{3-1-3-1}{3-1-3?-1}$.

H. basilatus (Cope). No. 6904 (type).

H. sectorius (Cope). No. 6905 (type).

John Day.

4. Molars reduced.

Oligobunis Cope. Dentition $\frac{3-1-4-1}{3-1-4-2}$.

O. crassivultus (Cope). No. 6903 (type).
John Day.

B. Modernized species. Long-footed, tetradactyl (functionally), with shear of sectorials nearly longitudinal, large brains and other advanced characters.

1. Dental formula $\frac{3-1-4-3}{3-1-4-4}$. *Otocyon.*
2. Dental formula $\frac{3-1-4-2}{3-1-4-3}$. *Canis*, *Nothocyon*, *Lycaon*, *Urocyon.*
3. Dental formula $\frac{3-1-4-2}{3-1-4-2}$. *Cyon.*
4. Dental formula $\frac{3-1-4-1}{3-1-4-2}$. *Icticyon.*

VII.—AN ANCESTRAL RACCOON.

Phlaocyon leucosteus *Matthew*[1]

Founded on an exceptionally perfect skull and jaws, with a nearly complete skeleton, discovered last summer by Mr. Handel T. Martin of the American Museum Expedition of 1898 in northeastern Colorado. The level is the uppermost beds of the White River formation, associated with *Merycochœrus*, *Anchippus*, *Leptauchenia*, *Hyracodon*, etc. The specimen was found in the rock mixed with skulls and skeletons of two adult and three young *Merycochœri*, all within a space of six feet square.

It represents a new and aberrant genus of Dogs, the characters pointing clearly in the direction of the Raccoons, so that if we adopt the genealogical conception of a family it must be placed in the Procyonidæ, although it is nearer to such primitive Dogs as *Cynodictis* than to the modern Raccoons.

Dentition.—(1) There is a small but clearly marked postero-internal cusp on the upper sectorial, which, however, (2) retains the triangular shape characteristic of the early Canidæ. (3) The dentition is that of *Cynodictis* and *Canis*, (4) but the cusps are low and rounded. (5) Premolars small, stout, and crowded ; (6) upper molars short transversely and subquadrate, as in *Cynodon*, (7) the lower molars broad and low. (8) Canines short, the upper ones not dagger-shaped, but curved as in the Dogs. (9) Incisors in an even, transverse row. *Jaw* (10) short and thick, deep in

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[1] Bull. Am. Mus. Nat. Hist. 1899, 54.

front, (11) condyles very wide, (12) coronoid process short and wide with deep fossa. *Skull* (13) short and wide, (14) orbits placed as far forward as in *Procyon*, (15) jugal process of squamosal not reaching as far forward as postorbital process of malar. (16) Shape and proportions of skull and jaws resemble those of *Procyon lotor*, except that (17) the brain-case is much smaller proportionately. (18) An alisphenoid canal as in *Cynodictis*. (19) A median and two lateral foramina in palate between canines. (20) Palate not extended posteriorly. (21) Base of skull much less broadened than in *Procyon*, (22) paroccipital process not developed.

Of the above Nos. 1, 4, 5, 9, 10, 11, 12, 13, 14, 15, 16, and 19 are progressive characters in the direction of the Raccoons. Nos. 2, 3, 6, 7, 8, 17, 18, 20, 21, 22, are primitive characters, shared by all early Canidæ.

Skeleton.—The hyoid bones were found perfectly preserved, but offer few characters for distinction.

The atlas is like that of *Cynodictis*; the posterior opening of the vertebral canal presents a little upward instead of directly upward as in recent Canidæ, or directly backward as in *Procyon*, where the opening is bounded by a strong ridge passing outward from the axial cotylus.

Concerning the other vertebræ no exact account can be given at present, as they are not yet removed from the matrix; they resemble in most respects those of *Cynodictis*. The ribs are somewhat larger; the dorso-lumbar formula is not yet known.

Fore Limb.—The *humerus* is of the same length as in *Procyon lotor*, but more slender throughout. The greater tuberosity is higher and the deltoid crest is more marked and extends farther down. The *radius and ulna* are 15 per cent. less in length and of about the same diameter in the shaft. Shafts of both trihedral or irregular in cross-section, instead of regularly oval as in modern Raccoons. *Carpus* with co-ossified scapholunar, thin cuneiform, large unciform, rather small magnum, rather large trapezoid, and small trapezium. Five metacarpals, of which mc. I is only half the length or diameter of III; mc. V is three fourths as long, but of considerably greater diameter than mc. III; mc. II and IV equal in diameter to, but a little shorter than, mc. III.

Hind Limb.—The *femur* is of nearly the same length as that of *P. lotor*, and one fifth slenderer. The shape resembles *Cynodic-*

tis; the greater trochanter is much less prominent than in *Procyon*, the lesser trochanter more prominent, the neck longer and more slender. The distal end of the femur is only three fourths as wide as in *Procyon;* condyles projecting more than in that animal, less than in *Canis* and *Cynodictis*.

The *tibia* is one sixth shorter than that of *P. lotor*, somewhat more slender in proportion, stouter than that of *C. gregarius* and of the same length. Its distal trochlea is narrower antero-posteriorly, deeper and more oblique than in *Procyon;* the fibular facet also is twisted around so as to face postero-externally instead of externally as in *Procyon*. The *fibula* is somewhat less reduced, its shaft being as stout as in the Raccoon, the ends somewhat smaller.

The hind foot, though uniformly smaller, is proportioned like that of the Raccoon, with the following differences worth noting. The *astragalar trochlea* is narrower, sharper, less entended backward. The internal hook of the *navicular* is smaller. The *cuboid* is wider and has a small facet for the astragalus. The *entocuneiform* is not nearly so high. The first *metatarsal* is only two thirds as long, though somewhat stouter in proportion; and the fifth is as long as the second, and nearly as large in the shaft; in the Raccoon it is intermediate between mt. I and mt. II in length. The hind feet of *Phlaocyon* have thus a tetradactyl symmetry, while in *Procyon* they are intermediate between tetra- and pentadactyl symmetry. The second row of *phalanges* shows a distinction of some importance, the superior external surface of the shaft being excavated, especially toward the distal end, a character which Scott has observed in *Daphænus* and considers a probable indication of slight retractility of the claws. It is also present in *Cynodictis* and in some Creodonts, and is probably a primitive character. In the Raccoon this excavation of the second phalanx has entirely disappeared.

The *ungual* phalanges are a little larger and less compressed than those of *Procyon lotor*.

AFFINITIES OF PHLAOCYON.

PLATE VI.

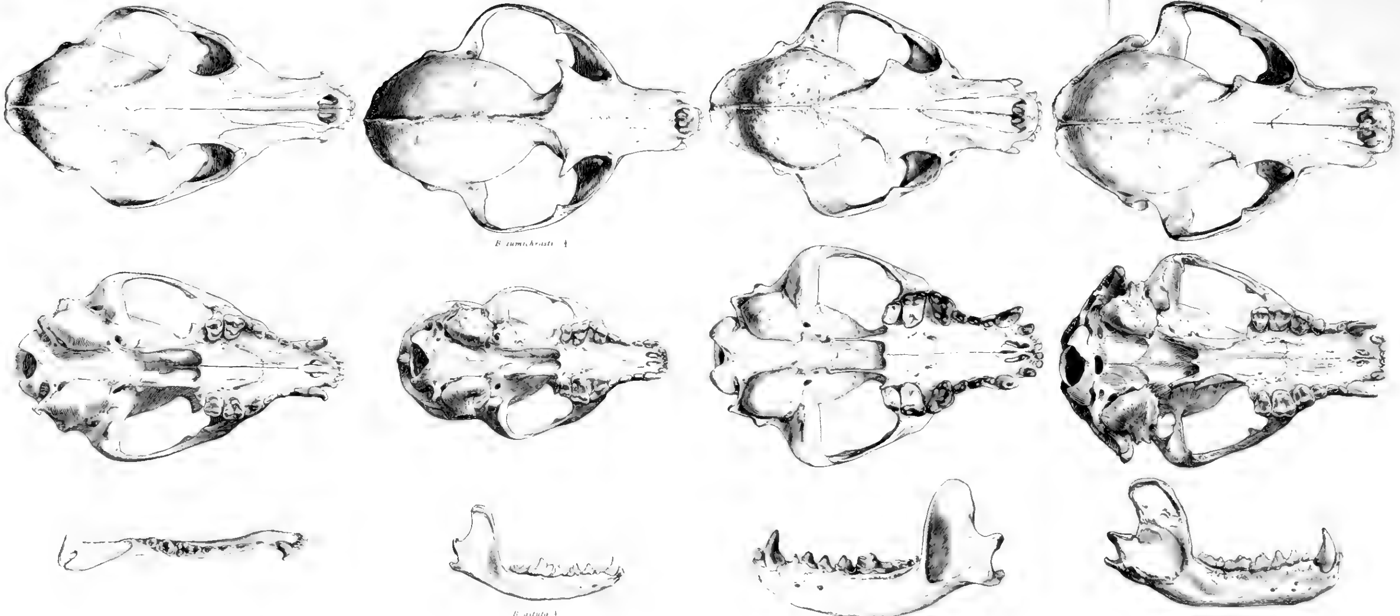
Phlaocyon, in both skull and skeleton characters, seems to point towards *Procyon*, standing intermediate between that genus and *Cynodictis* in almost every character. The entirely intermediate character of the skull and teeth is well shown in our drawings: especial attention should be drawn to the postero-internal cusp on p^4; short jaws with deep muzzle and round blunt premolars; broad low sectorials, with additional postero-external cusp on trigon of m_1; reduced m_3; lower incisors in a straight row. Eyes set far forward, skull short, arches wide. On the other hand the resemblance to *Cynodictis* is closer in the form and cusp-arrangement of the teeth; palate terminating opposite m^2, alisphenoid canal; occiput not so much expanded; retention of m_3; m_2 not lengthened out.

In the skeleton the same story appears. The limb bones are like those of *Cynodictis* with varying amounts of change to *Procyon*. Only in the hind foot is there any difficulty. Here the first toe is more reduced in *Phlaocyon* than in *Procyon*, which makes it seem probable that *P. leucosteus* is slightly off the line from *Procyon lotor*.

The resemblance to *Bassariscus* is even closer. But *Bassariscus* cannot be considered as the living representative of *Phlaocyon*. It shows less departure from *Cynodictis* in many characters, especially in the shape of the upper molars and lower sectorial and slender jaw; the postero-internal cusp of the upper sectorial is not developed in one species, and although it is present in the other, the tooth retains much more of its trenchant function. The loss of m_3 is an advance on *Phlaocyon;* on the other hand, the eyes are not set so far forward, nor is the muzzle so much shortened or the arches so wide. The brain is very much larger in proportion, as might be expected, but the feet are precise copies of those of *Cynodictis*.

With *Nasua* the comparison is not so close as with *Procyon*. The long skull, large dagger-shaped canines, comparatively narrow, square occiput, reduced and peculiarly shaped bullæ, carry it out of the probable line of evolution pursued by *Phlaocyon*. The limbs and feet are somewhat nearer to *Phlaocyon* in some characters; the feet have the internal toe unreduced.

Cercoleptes is much more aberrant in the skull and teeth and *Ælurus* has a different pattern of teeth. Altogether *Procyon* seems to come nearest to fulfilling the conditions required of a descendant of *Phlaocyon*.



B. zumichrasti ½

B. astuta ½

½
NOTHOCYON

BASSARISCUS

½
PHLAOCYON

½
PROCYON.

CONNECTING LINKS BETWEEN THE CANIDÆ AND PROCYONIDÆ.

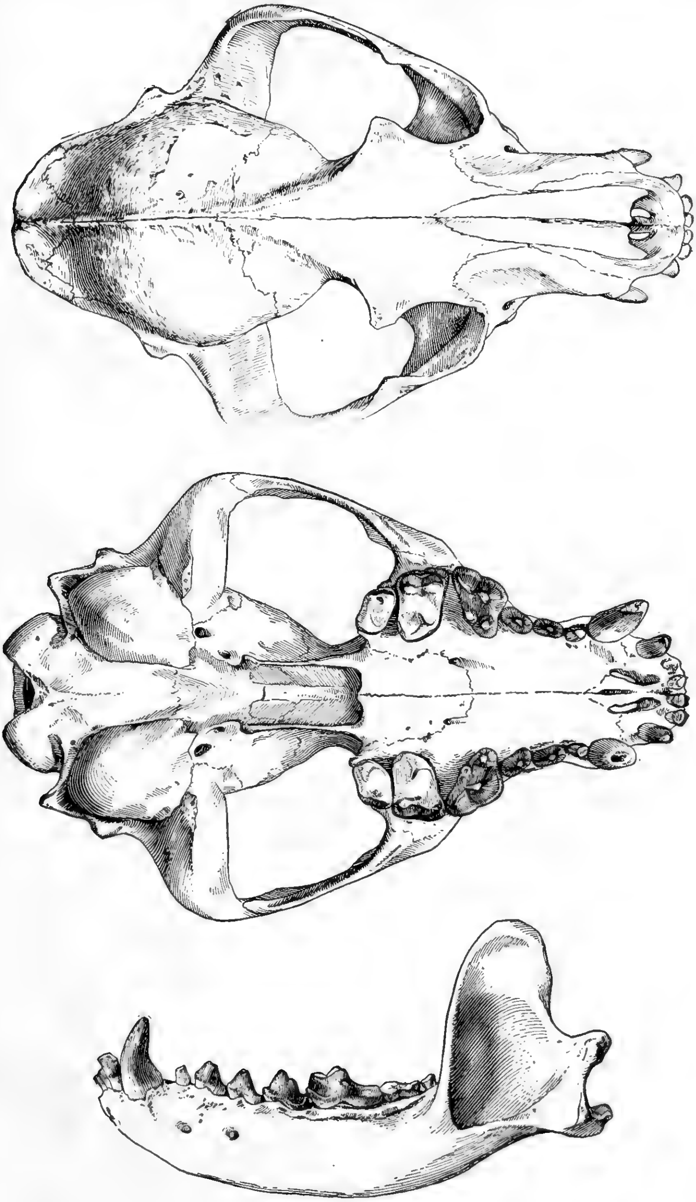


Fig. 10. *Phlaocyon leucosteus* Matthew. Skull and jaw, natural size. Type specimen No. 8768.

VIII.—VIVERRAVIDÆ, fam. nov.

This family is proposed to include the species which have been formerly arranged under the genus *Didymictis* of Cope. That this genus is synonymous with the one previously established by Marsh, there cannot be the slightest question whatever. A careful comparison of the type of *Viverravus gracilis* Marsh,[1] with the type of *Didymictis dawkinsianus*[2] Cope, reveals the fact that they are identical in every detail; the name *Didymictis* must therefore be abandoned and the name *Viverravus* substituted for the genus.

It has been customary to associate this group of species, together with that which has been referred to *Uintacyon* (*Miacis*), in the family *Miacidæ*. We have already shown that this latter is clearly related to, and no doubt ancestral to the *Daphænus*, the *Cyon* section of the Canidæ. It is also evident from much additional material now in the Museum collections that *Viverravus* belongs to an entirely distinct line and has no relationship with the Canidæ whatever, but in so far as the skeleton can be depended upon for evidence of affinity it finds its nearest relationship with the living Viverridæ. This opinion is not a new one, having been first expressed as long ago as 1886,[3] and later in 1891.[4]

The new evidence consists of the greater part of a skeleton of *Viverravus protenus* from the Wasatch Eocene of Wyoming, together with a considerable portion of a skeleton of *V. leptomylus* from the same horizon. The skull, of which there is a fairly well-preserved example, shows many striking resemblances to the more typical Viverrines, especially *Viverricula*; it is long and narrow, with prominent overhanging occiput and high sagittal crest. The muzzle is long, the basilar portion of the skull is narrow, and the mastoid not very prominent. The tympanic bulla is not preserved, but the general conformation of this part of the skull is very Civet-like. The lower jaw is long and relatively slender, with high coronoid and prominent angle. The dental formula, as is well known, is that of the Viverridæ, and the pattern of the teeth resembles most astonishingly that of the more typical members of

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[1] Amer. Jour. Sci. 1872 (p. 7 of separate).
[2] Bull. U. S. Geol. Surv. VI, 1881, 191.
[3] Wortman, Teeth of the Vertebrata, 457.
[4] Flower and Lydekker, Mammals Living and Extinct, 539.

this family. This is especially seen in the superior sectorial, in which there is a deep vertical notch separating the two halves of the blade, and a prominent anterior basal cusp, which is invariably present in the carnivorous Civets. The superior molars, moreover, have the same characteristic pattern, and the lower teeth, with the exception of some unimportant details, are very viverrine. The atlas has the same arrangements of the perforations for the vertebral artery as is found in the Civets, differing in this respect from the other known families of the Carnivora. The remaining vertebræ agree with those of the Viverridæ, and the lower end of the radius has the same characteristic triangular form in cross-section as in *Viverricula*. The feet and limbs are also very like those of the Viverrines, with the exception that the scaphoid and lunar bones of the carpus are free and not united as in the modern family.

Altogether we think it may be stated with considerable certainty that the group represents the forerunners of the Viverrine phylum whose members towards the close of the Eocene migrated to Asia. This view receives strong additional support from the fact that the typical genus *Viverra* runs backward without change into the Upper Eocene of Europe, showing a remarkable degree of persistence of structure, which also characterizes the genus *Viverravus*, passing as it does with only slight specific modifications from the Torrejon beds of New Mexico through to the Bridger.

The technical definition of the group rests upon the exclusive development of the fourth superior premolar and the first inferior molar into enlarged typical sectorials, thereby distinguishing it from all the other known Creodonts except the early members of the Canidæ. From this latter family it is distinguished by having only two molars in the lower jaw and an anterior basal cusp upon the superior sectorial. From the Viverridæ it is separated by the free condition of the scaphoid, lunar, and probably the centrale as well.

The species are numerous and range in time from the Torrejon to the Bridger.

SUMMARY.

The principal points brought out in the foregoing paper may be briefly summarized as follows :

(1) The tracing of the *Daphœnus* ancestry back into the Wasatch Eocene by way of *Prodaphœnus* and *Uintacyon*, which latter has always been considered a Creodont.

(2) The establishment of the relationship of *Daphœnus* to *Temnocyon*, and that of *Temnocyon* to the living genus *Cyon*.

(3) Tracing the ancestry of the *Canis-Cynodictis* line back into the Eocene through *Procynodictis* and *Vulpavus*.

(4) Some additional points in the structure of *Cynodictis*.

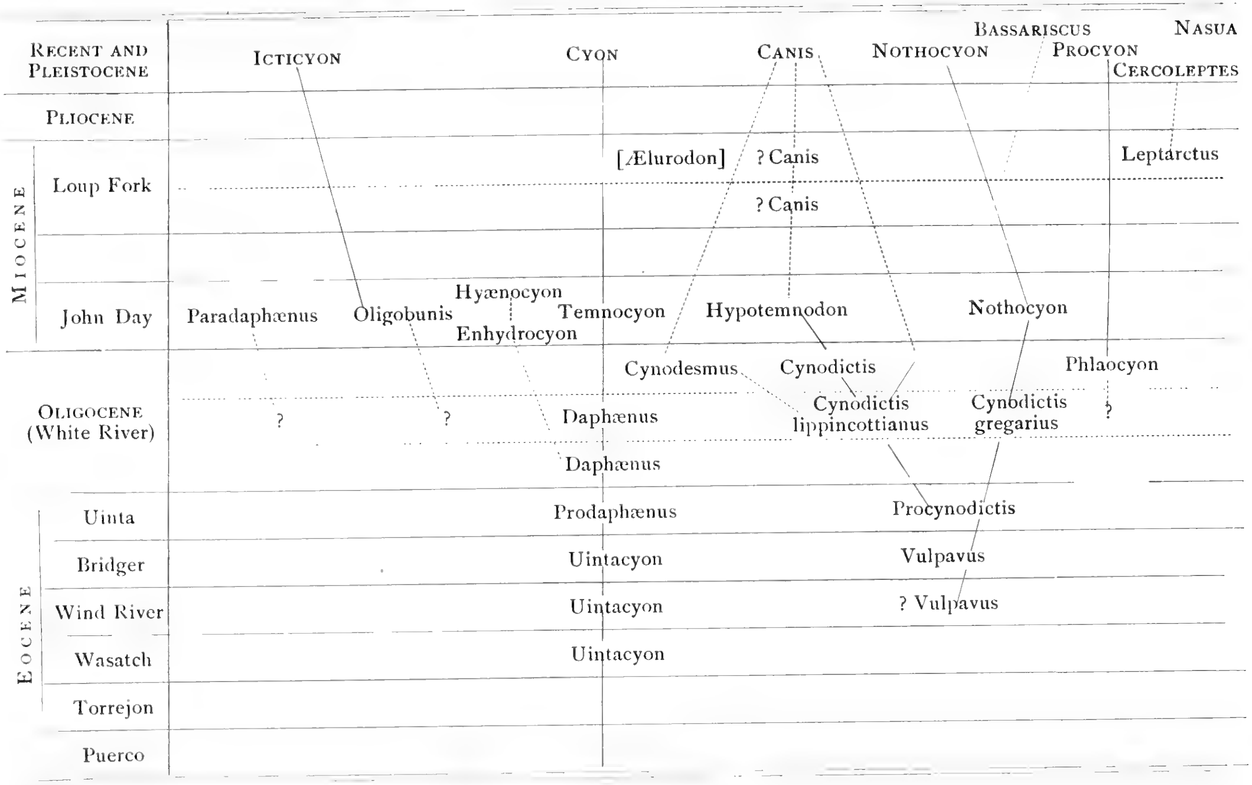
(5) The descent of certain South American Foxes from North American Miocene species, with the establishment of a new genus, *Nothocyon*, for their reception.

(6) Classification of the Miocene genera of the Canidæ.

(7) The discovery of the origin of the Procyonidæ from the Canidæ through the new genus *Phlaocyon*.

(8) The discovery of the genus *Viverravus* and the establishment of a new family.

PHYLOGENETIC TABLE OF THE AMERICAN TERTIARY CANIDÆ AND PROCYONIDÆ



Restoration of Oxyæna Lupina Cope, with Descriptions of Certain New Species of Eocene Creodonts.

By J. L. Wortman.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XII, Article VII, pp. 139–148.

New York, June 21, 1899.

Article VII.—RESTORATION OF OXYÆNA LUPINA COPE, WITH DESCRIPTIONS OF CERTAIN NEW SPECIES OF EOCENE CREODONTS.

By J. L. Wortman.

Plate VII and Three Text Figures.

Family OXYÆNIDÆ.

This family of the Creodonta was the most specialized in certain ways of any of the primitive flesh-eaters of Eocene times, and apparently occupied the same position with reference to the remainder of the fauna that the modern Felidæ do to the existing fauna. In the matter of dental equipment it is surprising to find that even as early as the Wasatch this family had developed a sectorial dentition almost if not quite as effective as that of the modern Cats. In other respects, however, they were far inferior; this is particularly seen in the small brain capacity, as well as the comparatively smaller, decidedly weaker limbs with shorter, more spreading feet, provided with flatter, fissured, non-retractile claws.

The origin of the family is completely unknown at the present. They begin with several species abruptly in the Wasatch deposits of both the San Juan and Big Horn beds without any known predecessors in the underlying Torrejon. For this reason there can be very little doubt that they represent migrants from another region, probably northern Asia, which came with the Coryphodonts, Artiodactyles, Perissodactyles, Primitive Dogs, as well as many other types whose existence begins so abruptly in the Wasatch beds of North America.

According to our present knowledge the family represents a perfectly natural grouping of the known species, and is easily distinguished from the other groups of typical Creodonts that had developed a more or less perfect sectorial dentition. A convenient distinction of these families may be made upon the enlargement of a special molar in the lower jaw; it is as follows:

1. Third lower molar enlarged,—HYÆNODONTIDÆ. Includes the genera *Palæosinopa*, *Sinopa*, *Proviverra*, *Cynohyænodon*, *Pterodon*, *Hyænodon*.

2. Second lower molar enlarged,—OXYÆNIDÆ. Includes the genera *Oxyæna*, *Patriofelis*, *Oxyænodon*.

3. First lower molar enlarged,—PALÆONICTIDÆ. Includes the genera *Palæonictis*, *Amblyctonus*, *Ælurotherium*.

Oxyæna lupina *Cope.*

By a fortunate circumstance I am now enabled to give a rather full account of the skeleton of this species, which has hitherto been only imperfectly known. At the time of my first trip into the Big Horn Basin in 1880 the country was a wild, uninhabited region, save for the occasional visits of roving bands of hostile Indians, and any explorations there by a small party were attended by no small amount of risk to one's personal safety. In fact, I was advised by the commander of Fort Washakie, at that time the base of our operations, that the trip was a hazardous one, and that he would not undertake to answer for our safe conduct. We went through, however, without serious inconvenience, but at the same time the collecting was not as thoroughly done as it probably would have been under less trying circumstances.

On this expedition, among other things, I secured a part of the skeleton of this species, which was erroneously referred to Cope's somewhat larger but closely allied species *O. forcipita*, in his volume 'Tertiary Vertebrata.' In 1891, I conducted another expedition into this same region for the American Museum, at which time, through a general settlement of the country, the former more hazardous conditions had been entirely removed and undertakings of this sort were not accompanied by the same risks of violence at the hands of savage Indians as formerly prevailed. Our knowledge of methods of collecting had, moreover, materially increased, and while the actual number of specimens secured was perhaps less, yet a somewhat greater success attended our efforts, especially in securing those parts which had already been washed out of the matrix in which they had been originally imbedded. In this category comes the present specimen, a portion of which had been collected by the expedition of 1880, and the remainder by the expedition of 1891.

During this latter expedition, a new method was employed for securing the missing parts which had been washed out and covered up again by the accumulating debris. Wherever possible the loose dirt containing the fragments was gathered up and transferred to the nearest stream where it was washed out after the manner of the placer miner. In this way, wherever conditions were favorable, all the fragments were recovered, but in the case of the present skeleton, after every possible exertion, a large number of pieces necessary to complete the skeleton remained missing. When the Cope collection was purchased by the Museum and the two collections were brought together it was accidentally discovered by Dr. Matthew that the specimen of the Cope collection furnished the missing parts of one and the same individual of the Museum specimen collected in 1891 ; in this way an unusually complete skeleton for an Eocene fossil results and furnishes all the more important characters.

Skull.—All the details of the form of the skull cannot be accurately made out owing to the great amount of crushing and fracture which the specimen had sustained during the process of fossilization ; but enough is preserved in an uninjured condition to indicate that the facial portion was very short and broad in proportion to the total length of the cranium. That part of the skull posterior to the orbits is proportionately much elongated and, owing to the small size of the brain-case, it appears to be unusually so. The sagittal crest is prominent and extended well forward ; the zygomatic arches are wide and heavy, and the glenoid cavity has a distinct pre- and post-glenoid process. The

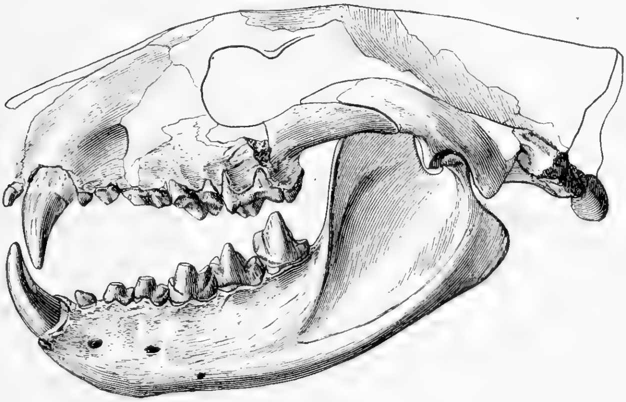


Fig. 1. *Oxyæna lupina* Cope. Skull and jaws, ⅜ natural size. No. 107.

mastoid is prominent, and the paroccipital process has a more or less backward direction. The foramina of the base of the skull cannot be determined, but it appears probable that there was a distinct post-glenoid present.

The dentition, the formula of which is I. $\frac{3}{3}$, C. $\frac{1}{1}$, Pm. $\frac{4}{4}$, M. $\frac{2}{2}$, has been quite fully described and requires but a brief mention. It appears from the very perfect lower jaws that there were *three* incisors present upon each side, although this is not entirely demonstrable. In the upper jaw, the outer incisors are much larger than the two inner pairs, which are subequal. The canines are long and pointed, being slightly compressed at the base. The first premolar is small, single-rooted, and has a simple crown. The second is two-rooted and has a prominent posterior heel. The third is three-rooted with two external and one internal cusp. The fourth premolar, while possessing all the elements of the superior sectorial of the typical Carnivora does not form a very perfect shear between the rudimental blade and that of the inferior first molar. The great shearing function was transferred to the first molar above and the second molar below; the first superior molar is curiously modified, in that the two original external cusps are placed very close together, and a large postero-external cusp added, which, in conjunction with the true postero-external cusp, form a very effective blade, the internal cusp being small. This is, at least, the interpretation which has

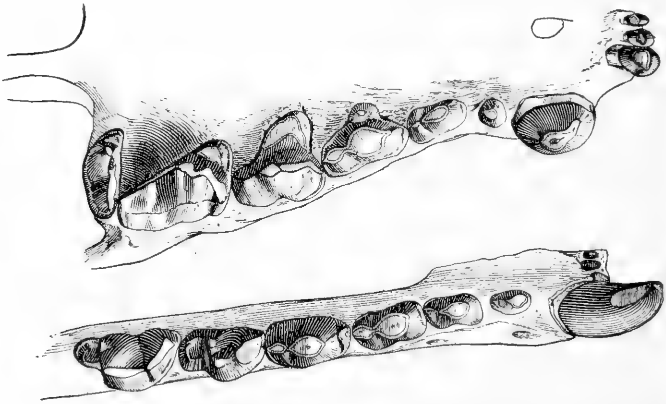


Fig. 2. *Oxyæna lupina* Cope. Upper and lower teeth, ¾ natural size. No. 107.

been placed upon the structure of this tooth, and the evidence in favor of such a view is found in the gradual assumption of a similar if not identical structure seen in *Hyænodon* from the more generalized pattern of the tooth exhibited by *Sinopa.* The last molar is transverse, and its crown consists of a single external cusp, with a great extension of the antero-external angle, together with a low, smaller internal cusp.

In the lower jaw the first premolar is small, the succeeding teeth gradually increasing in size to the last molar. Premolars two, three, and four have prominent heels, and the fourth has a small anterior basal cusp in addition. The molars have the typical sectorial pattern, with elevated trigon and a low, relatively small, basin-shaped heel. The internal cusp and heel are reduced in the last molar, foreshadowing its almost complete loss in *Patriofelis.*

Vertebræ.—The usual seven cervicals are present which, so far as the imperfect state of their preservation will permit one to judge, resemble closely those of *Patriofelis.* The atlas has rather wide, roomy cotyles for articulation with the occipital condyles and the transverse processes are perforated at the base quite as in *Patriofelis* and the modern Cats. The axis has a peg-like odontoid, a prominent inferior tubercle on the inferior posterior surface of the centrum, and distinct transverse processes, which are perforated at the base for the passage of the vertebral artery. The spine is not preserved. The remaining cervicals have rather flattened centra and resemble those of *Patriofelis.*

The dorso-lumbar formula is 20, of which 13 are dorsals and 7 are lumbars. They increase in size gradually from before backwards, the posterior lumbars being the largest. The lumbar articulations are not so complex as those of *Patriofelis*, the convex postzygapophyses fitting into concave prezygapophyses with no evidence of the double, concavo-convex arrangement of certain of the other Creodonts. There are distinct anapophyses, but no metapophyses appear to have been developed. The sacrum is not preserved. Of the caudals enough are preserved to indicate that there was a long and powerful tail. The vertebræ resemble those of *Patriofelis* in all their details of structure.

Fore Limb.—Very little of the scapula is preserved, only the proximal portion of both bones being present. The glenoid cavity has an oval form; the coracoid is prominent, and the relatively strong spine arises a short distance behind the glenoid border. There is evidence of a well developed acromion and metacromion, about as in *Patriofelis*. The humerus, like that of many of the Creodonts, has a powerful deltoid crest which occupies somewhat more than one half the entire length of the shaft. The head is pyriform, the tuberosities well developed, and the bicipital groove is deep. Distally the bone is broad, as in many of the modern Carnivores, especially the felines. There is a very prominent internal condyle; an entepicondylar foramen, and a somewhat reduced supinator ridge. The articular surface is very much as in the Cats. The ulna has a very prominent incurved olecranon, the shaft is straight, and the two distal articular facets are well separated as in the Cats. The head of the radius presents an oval outline with an unusually prominent tubercle. The lower end of the shaft is triangular in cross-section, and the scapholunar facet is concave. The fore foot has already been fully described,[1] and there is little of importance to add. The foot is relatively broad and spreading as in *Patriofelis;* the scaphoid, lunar, and centrale are free; the first phalanx of the thumb is relatively large, and all the claws are deeply fissured with the possible exception of the fifth. There is reason to believe that the habitual position of the foot was digitigrade, but there is no evidence of any retractility of the claws.

Hind Limb.—The pelvis is not very well preserved but enough is present to indicate that it was very similar to that of *Patriofelis*. The femur has a well-rounded head, a nearly straight shaft, and a small though distinct third trochanter. The tibia equals the humerus in length and has a slightly curved shaft; the cnemial crest is prominent, the internal malleolus is unusually thick and heavy, and the distal trochlea is directed obliquely inwards and is little excavated. The fibula is complete and comparatively little reduced. The hind foot is more slender than the fore foot. The tibial facet of the astragalus is but slightly grooved; the astragalar foramen is distinct, and the head of the bone is flattened from before backward, rounded and oblique; it articulates with both cuboid and navicular. The

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[1] 'Fossil Mammals of the Wasatch and Wind River Beds.' Bull. Amer. Mus. Nat. Hist., Vol. IV, 1892, p. 108.

three cuneiforms have about the same relationship and arrangement as in the modern Cats. Of the metapodials there is a distinct interlocking, although the degree is much less than in the Felidæ. The third is the longest but the second is slightly the heaviest of the series. As in the fore foot, the claws are fissured and non-retractile.

Oxyænodon dysodus, gen. et sp. nov.

This genus is founded upon an unusually perfect half of a skull from the Uinta Eocene, collected by the writer in 1896. It indicates an animal of the size of a Gray Fox and is, therefore, if properly referred to the Oxyænidæ, the smallest member known. The dental formula is the same as that of *Oxyæna*, viz. : I. $\frac{3}{3}$, C. $\frac{1}{1}$, Pm. $\frac{4}{4}$, M. $\frac{2}{2}$, and the last superior molar is, moreover, transverse. The chief distinctions between the two are seen in the form of the skull and the character of the premolars, as well as the great enlargement of the symphysis in the Uinta genus. In *Oxyænodon* all the lower premolars are simple and have only rudimental posterior heels, whereas in *Oxyæna* the heels of the second, third, and fourth are large, and form important elements of the crown. In *Oxyænodon* the third superior premolar has no internal cusp, while in *Oxyæna* a well developed inner cusp is present. The heel of the last lower, as well as the internal cusp of the trigon, are more reduced in the Uinta genus than in *Oxyæna*. In *Oxyænodon* the mandibular symphysis is enlarged and extends back under the third premolar, the lower jaw being relatively shallow and thick, while in *Oxyæna* the mandibular

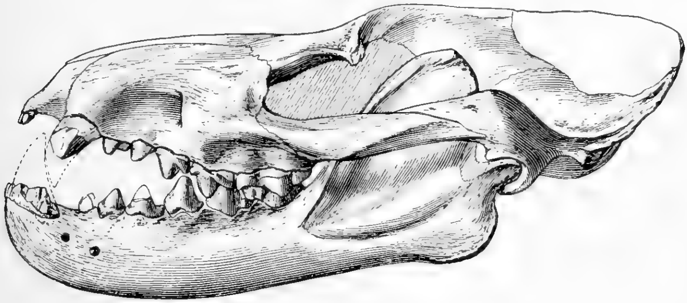

Fig. 3. *Oxyænodon dysodus.* Skull and jaw ¾th natural size. Type specimen, No. 2515.

symphysis is of much less extent and the jaw is deeper. The facial portion of the skull in *Oxyænodon* is longer.

I have suggested[1] that this family has some affinities with the Seals. The skull *Oxyænodon* strengthens this view in certain particulars. The most important resemblances to the Sea Lion are seen in (1) the great postorbital construction of the skull; (2) the pressure of a distinct lachrymal tubercle; (3) the exclusion of the frontal from any share in the anterior boundary of the orbit; (4) early union of lachrymal with maxillary; (5) forward extension of sagittal crest; (6) absence of anterior process of frontal between nasal and maxillary, and (7) an elongated mandibular symphysis. While the skull is not strikingly seal-like in its general appearance yet when we know the immediate ancestors of such a form as the Sea Lion it will not be surprising if it is found to connect with such a form as *Oxyænodon*.

FAMILY MESONYCHIDÆ.

The Mesonychidæ undoubtedly represent a distinct line of the primitive Carnivora whose later representatives came to be characterized by elongated and specialized limbs for a running habit, as well as by a peculiar reduction and simplification of certain cusps of the molar teeth. Somewhat contrary to the generally accepted arrangement of this group, I unite with them the so-called Triisodontidæ as a well marked subfamily. This latter series is the older and displays the same tendency towards the peculiar reduction and rounded, conical form of the cusps of the molars as is seen in the *Dissacus-Pachyæna-Mesonyx* line. The differences between the subfamilies are not great and, as observed by Matthew,[2] consist in the deep, heavy jaws with powerful symphysis, and the much wider, more distinctively tubercular character of the molars in the Triisodontidæ.

The single genus *Triisodon*, with three species, comes from the Puerco and is succeeded in the Torrejon by the two genera *Sarcothraustes* and *Goniacodon*. Matthew has pointed out that *Sarcothraustes antiquus* is without doubt the direct descendant of *Triisodon* and in this opinion I entirely agree. As noted by this

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[1] 'Osteology of *Patriofelis*,' Bull. Amer. Mus. Nat. Hist., Vol. IV, 1894, p. 157.
Bull. Am. Mus. Nat. Hist., Vol. IX, 1897, p. 278.

author, the same cusp reduction and simplification is observed in this succession as occurs in the *Dissacus-Pachyæna-Mesonyx* series.

The second subfamily, Mesonychinæ, so far as at present known, finds its oldest representatives in the Torrejon beds in the single genus *Dissacus*, with two well marked species. It is, indeed, very doubtful, if not impossible, that any of the known species of *Triisodon* can be placed ancestral to the present genus, although it is not at all improbable that some slender jawed type in the Puerco having the cusp pattern of *Triisodon* will be found to have commenced an early modification of the teeth terminating in *Dissacus*. The evidence for the view that the inferior molar pattern in this genus is a degenerative one, is found in the fact that in the succeeding Wasatch *Pachyæna* the postero-internal cusp of the trigon is still more reduced than it is in *Dissacus*, while in the Bridger *Mesonyx* it exists as the merest vestige, the cusps of all the molars at the same time assuming a very rounded and characteristic conical form.

Pachyæna intermedia, sp. nov.

It has been shown by Osborne and Earle[1] that neither of the known species of *Pachyæna* (*gigantea* and *ossifraga*) can stand directly in the line of descent leading to *Mesonyx* on account of the greater reduction of the last upper molar in the two species of *Dissacus* (*navajovius* and *saurognathus*) than in *Pachyæna*. Scott has shown[2] that *Mesonyx* has only two superior true molars, so that any species of *Pachyæna* which exhibits a less reduction of the last upper teeth than *Dissacus* cannot be placed ancestral to *Mesonyx*. Fortunately the collections of the Museum contain a specimen of a *Pachyæna* from the Big Horn, obtained by the expedition of 1896, which shows, proportionately, as great or a little greater reduction of the last upper molar than *Dissacus navajovius*. The specimen consists of the last two upper molars and bears the Museum number 2854. The teeth in question are somewhat smaller than the corresponding ones in *P. ossifraga* and exhibit a considerably greater reduction of the last molar in comparison with the tooth in advance than in this species. It

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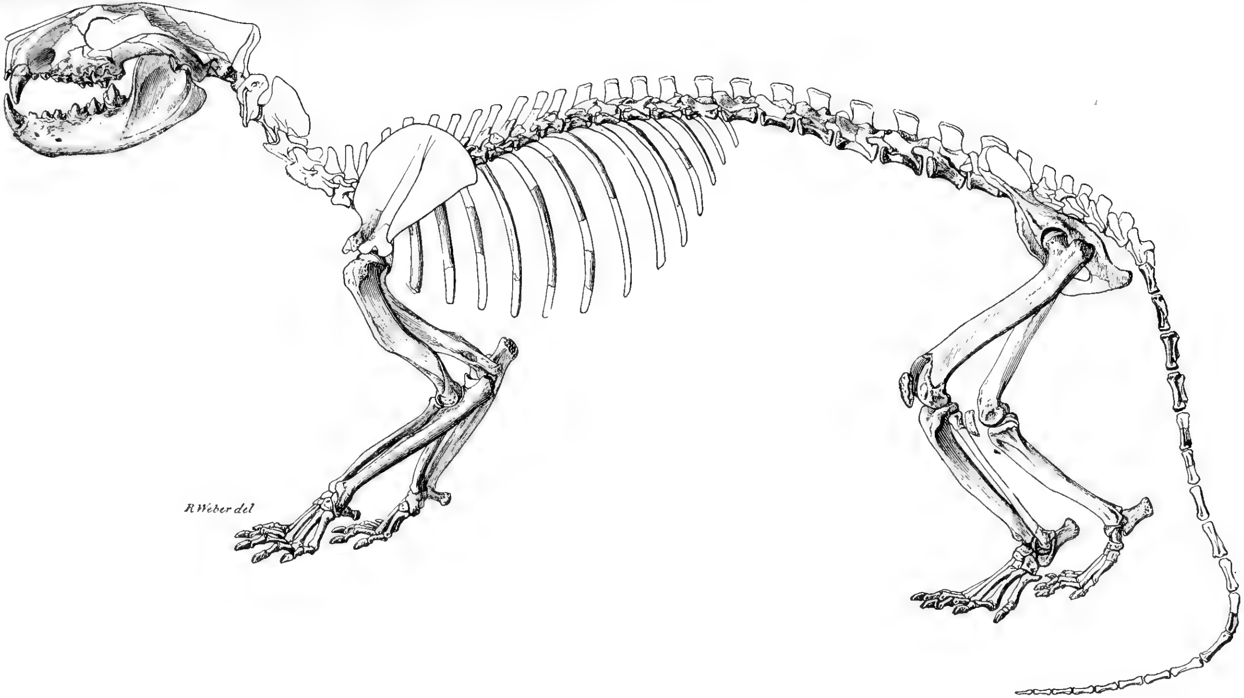
[1] 'Fossil Mammals of the Puerco,' Bull. Amer. Mus. Nat. Hist., Vol. VII, March, 1895, p. 39.
[2] 'Some New and Little Known Creodonts,' Jour. Philad. Acad. Nat. Sci., 1886, Vol. I.

may be that the specimen represents only a smaller variety of *P. ossifraga* and is not entitled to a specific rank, but in view of the fact that it furnishes just the character which, upon general grounds, one would be led to anticipate, I have thought fit to give it the above name.

This virtually completes the series of the *Dissacus-Pachyæna Mesonyx* phylum and establishes a closely connected specific descent reaching in time from the Torrejon to the White River without any important break. The Wind River representative of this series, however, yet remains to be discovered, but in accordance with what we already know its characters can be most accurately predicted.

EXPLANATION OF PLATE VII.

Oxyæna lupina, Cope. Skeleton, 1/6th natural size. No. 107, Am. Mus. Coll. The specimen described and figured as "No. 2" by Prof. Cope in 'Tertiary Vertebrata of the West,' (p. 319, pl. xxiv*c*, figs. 12–15, and pl. xxiv*d*, figs. 1–18) is a part of this individual.



OXYÆNA LUPINA *Cope*.
One-sixth natural size.

Fore and Hind Limbs of Carnivorous and Herbivorous Dinosaurs from the Jurassic of Wyoming. Dinosaur Contributions, No. 3.

By Henry Fairfield Osborn.

AUTHOR'S EDITION, extracted from BULLETIN
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Article XI.—FORE AND HIND LIMBS OF CARNIVOROUS AND HERBIVOROUS DINOSAURS FROM THE JURASSIC OF WYOMING. DINOSAUR CONTRIBUTIONS, NO. 3.

By Henry Fairfield Osborn.

In the Bone Cabin Quarry, opened by the American Museum Expedition of 1898, under the direction of Dr. J. L. Wortman, assisted by Mr. W. W. Granger, were found mingled together bones of all the most characteristic Upper Jurassic Dinosaurs, including six nearly or quite complete limbs and three fore feet, which form the subject of this paper. Four of these are shown, as mounted, upon a subsequent page. They are not only grand objects of their kind, but they bring out a number of new and important facts relating to the limbs of Dinosaurs of the Megalosaur and Cetiosaur divisions or Ornithopoda and Sauropoda.

1. Hind Limbs of Carnivorous Dinosaurs.

Figures 1–5.

The late Professor O. C. Marsh described[1] five genera of flesh-eating Dinosaurs from our Jurassic, namely: *Allosaurus*, the largest of the flesh-eaters; *Creosaurus*, a smaller allied form; *Labrosaurus*, of another type; *Cœlurus*, a very small animal distinguished by hollow bones (related to the somewhat older *Hallopus*); and finally *Ceratosaurus*, a large animal with horned nasals.

Of these, the most nearly allied to *Megalosaurus* of the English Purbeck is *Allosaurus*, distinguished by possessing less than five vertebræ in the sacrum, also by other characters of doubtful value (*op. cit.*, p. 239), and figured (*op. cit.*, Pl. XI.) as possessing *three* digits in the pes, while *Megalosaurus* is assigned *four* digits in the pes (*op. cit.*, p. 239). Whether or not *Allosaurus* is distinct from *Megalosaurus* cannot be positively determined at present. The distinction based upon the number of digits is here shown not to hold good.

Two hind limbs from the Bone Cabin Quarry, which correspond in other respects with those of *Allosaurus*, appear to show that the hallux had been detached in Marsh's specimens. They

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[1] The Dinosaurs of North America, 1896.

(Nos. 290 and 324) both possess four digits in the pes; the first digit or hallux exhibits an interrupted metatarsal, and is turned inwards as a subsidiary grasping toe.

The proportions between these limbs and those of the two Sauropoda described below are well shown in the accompanying photographs (Fig. 1). The heights in the Table include the curvatures; they give us therefore the usual height of the acetabulum, or head of the femur, not the total length of the limb.

Fig. 1. Right Hind Limbs of Dinosaurs. A, Herbivorous Dinosaur, probably *Diplodocus*, No. 251. B, Herbivorous Dinosaur, *Brontosaurus*, Nos. 309, 353. C, Carnivorous Dinosaur, *Allosaurus*, or *Megalosaurus*, No. 290. D, Carnivorous Dinosaur, *Allosaurus* or *Megalosaurus*, Nos. 324, 275. Approximately 1/35 nat. size.

The larger of the limbs (No. 290) is the more perfect, except that it lacks the proximal portion of Mt. I. The smaller (No. 324) has the calcaneum and astragalus restored, and a femur (No. 275), which was found at some little distance, is arbitrarily placed with it. Except for differences in size, due to age or sex, the limbs are practically identical in character.

Measurements.

	No. 290.	No. 324.	No. 275.
Length of femur	985		910
" " tibia	810	698	
" " fibula	764	665	
" metatarsal II	375	315	
" " III	425	352	
" " IV	360	330	
Width of ankle joint			
Calcaneum and astragalus	241		
Total height of limb	2182		1980

Fig. 2. Carnivorous Dinosaur, No. 290. Same Limb as Fig. 1, C, showing proportions to human stature (Dr. J. L. W.). $\frac{1}{48}$ nat. size.

Of greatest interest is the *first digit, or hallux*, not before described. Proximally (Fig. 4 a) its metatarsal fits in a shallow groove of the upper portion of the large metatarsal II. The shaft is entirely interrupted or composed of cartilage in the middle portion. Distally it is fitted to the rounded posterior shaft of Mt. II, demonstrating that this digit was directed inwards like the small hallux of *Apteryx* (Fig. 5). It possesses, however, a complete and functional phalanx and claw, which undoubtedly were of service in grasping.

The digits II, III, IV, with phalanges numbering 3, 4, and 5, respectively, are well shown in the photographs (Figs. 4, 4 a). The lower row of tarsals is represented by two bony elements only, probably tarsalia 3 and 4.

The upper tarsals, astragalus and calcaneum are closely conjoined if not actually co-ossified.

Fig. 3. Right Hind Limb of Carnivorous Dinosaur, No. 290. Oblique internal view. 1/16 nat. size.

The tibia forms the entire back portion of the ankle joint, the fibula lying in front of it; this bone is further distinguished by its curved shaft, and powerful muscular crest projecting towards the fibula at its upper third. There is a very prominent cnemial crest, which has a deep groove upon its outer side towards the fibula; this groove is entirely concealed from the front. This bone is very different from that assigned to *Megalosaurus* by Owen.[1]

The fibula has a slender, subrounded shaft, but expands proximally and distally upon the tibial side.

The femur is distinguished by its marked curvature and well-rounded head, by the laterally compressed and inferiorly placed great trochanter, by an internal trochanter much more elevated than in the Iguanodontia, and by a large rugose area on the inferior front face of the shaft above the internal condyle. The inner trochanter is broken off in the smaller femur, No. 275.

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[1] Fossil Reptilia of the Wealden and Purbeck Formations, Pt. III, 1857, p. 18, Tab. lx.

2. Hind Limbs of Cetiosaurs.

Figure 1.

The *smaller* of these limbs (Fig. 1, A, No. 251) was fortunately found nearly complete and in position, all parts being preserved excepting the head of the femur. It was removed and worked out with the greatest care by Mr. Granger. There is thus absolutely no doubt about the position of the phalanges.

This limb is of a type distinct from the larger one, which is undoubtedly a Brontosaurus. We should unhesitatingly refer it to *Diplodocus*, were it not that the fourth trochanter has a more elevated position than in the *Diplodocus* femur recently described by the writer,[1] and that the pes differs from the pes of *Diplodocus* figured by Marsh ('96, Plate 28). None the less it is a *long-limbed type*, and this we believe to be a characteristic distinction of *Diplodocus*. It has the following characters :

1. Tibia and fibula very long and slender.
2. Femur long with relatively slender shaft.
3. Metatarsals I and II as in *Brontosaurus*.
4. Metatarsal III much more slender than in *Brontosaurus*.
5. Metatarsal IV still more slender, two osseous phalanges.
6. Metatarsal V more slender, no osseous phalanges.

This limb may prove, therefore, to represent merely a form of Brontosaur distinct specifically from *B. excelsus*. But, in spite of the exceptions noted above, the probabilities are that it belongs to *Diplodocus*, for this animal is abundantly represented in the Bone Cabin Quarry by parts of several series of caudal vertebræ, besides pelvic and other bones.

Measurements.

	No. 251.	No. 309.	No. 353.
Total height of limb	e 2920		3040
Femur, height	e 1430		1640
Femur, circumference below tr. 4	560		e 730
Tibia, length	1060	1080	
Tibia, circumference	390		e 480
Fibula, length	1120	1130	
Astragalus, width of	227	280	
Pes, width of proximal metatarsal surfaces,	410	445	

The circumferences of the various shafts are very important

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[1] Osborn, "A Skeleton of *Diplodocus*." *Mem. Am. Mus. Nat. Hist.*, I, Pt. IV, 1899.

when compared with the total lengths. In each case the least circumference is taken. The total height of the limbs is measured *as mounted*—that is, including the curves.

The larger limb (Brontosaurus) is 10 feet high. The smaller limb (? Diplodocus) is 9 feet 7 inches high.

The *larger* limb (Fig. 1, B, Nos. 309, 353) is of the true *Bronto-*

Fig. 4. Right Hind Foot of Carnivorous Dinosaur, probably *Allosaurus* (No. 324, same specimen as Fig. 1, D). Front view. ⅛ nat. size.

saurus type. All of the bones of the lower leg and pes belong to one individual, excepting the terminal claws I and II. The femur was found at some distance and is arbitrarily associated. The phalanges are complete and osseous upon D. I, II, III.

This and the foregoing specimen prove conclusively that Marsh was in error in restoring a complete series of bony phalanges and

Fig. 4*a*. Right Hind Foot of Carnivorous Dinosaur, probably *Allosaurus* (No. 324, same specimen as Fig. 1, D.) Oblique side view. $\frac{1}{6}$ nat. size.

claws upon digits IV and V. The phalanges upon digits IV and V were cartilaginous or incomplete; these outer digits functioned only in supporting the foot pad. Every known Sauropod pes shows the same deficiency upon the outer side.

3. FORE FEET OF CETIOSAURS.

FIGURES 6, 7.

Two restorations of the fore feet of the Sauropoda have been published by the late Professor Marsh, namely those of *Morosaurus* ('96, Plate 38) and *Brontosaurus* (*op. cit.*, Plate 42). It appears probable that both are incorrect; the error apparently has arisen, first, from supplying all the digits with a complete series of phalanges; second, from placing the largest phalanges upon the inner or 1st digit (as in the pes) and grading off the smaller phalanges to the 5th or outer digit. It is now practically certain that in the manus as in the pes a number of phalanges were either cartilaginous or missing entirely. It also appears probable that the three central digits II, III, IV bore a full series of phalanges and claws, while the outer digits were deficient in phalanges.

Fig. 5. *Apteryx.* Internal view of right pes.

FORE FEET OF UNDETERMINED CETIOSAUR.

The strongest evidence comes from the two fore feet of one individual (No. 332), one of which was found with all its parts in

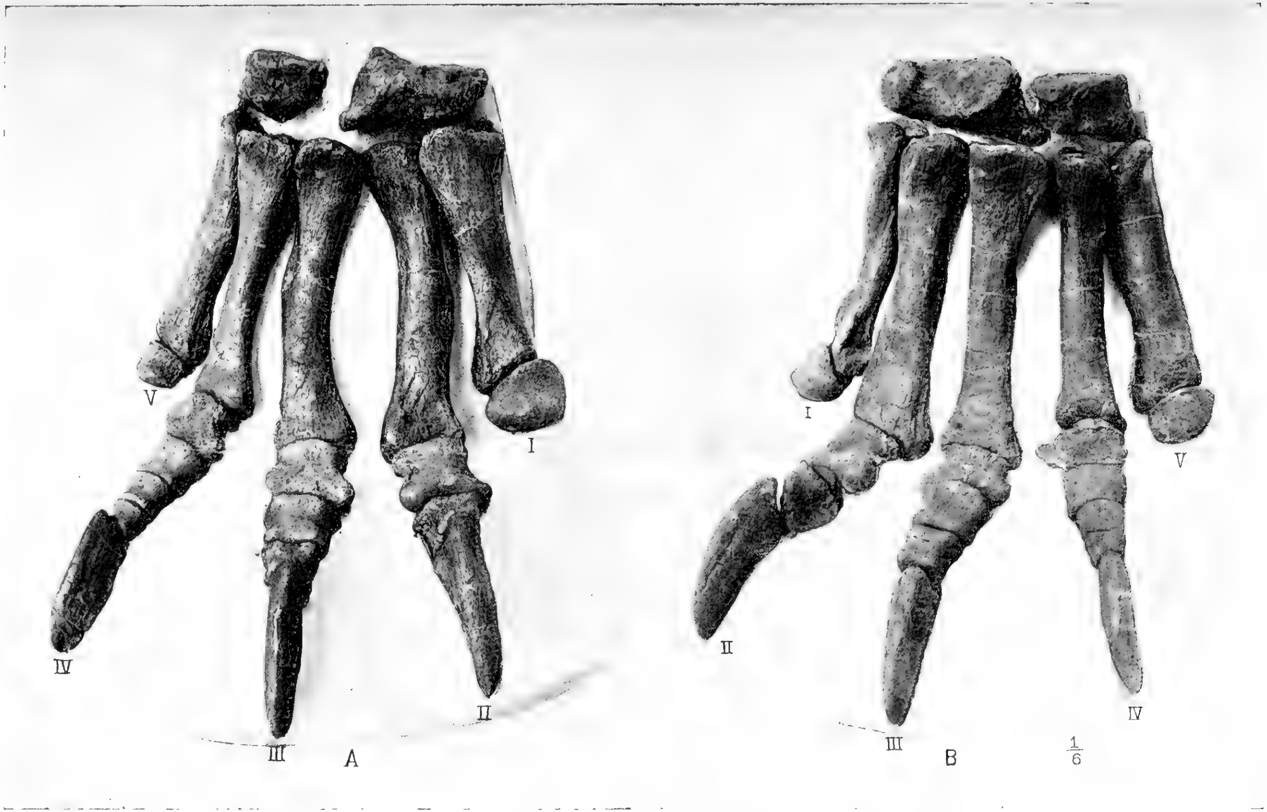

Fig. 6. Right (A) and Left (B) Fore Feet of Herbivorous Dinosaur, No. 332. At present indeterminate. $\frac{1}{6}$ natural size.

position (Fig. 6). The right manus is more complete in certain parts, the left manus in others. The animal is possibly a *Morosaurus agilis.*

The Metacarpal of the first digit is much longer and more slender than in either the typical *Morosaurus* or *Brontosaurus.* A single phalanx was found near it, rounding off distally and quite distinct from the first phalanges of digits II, III, IV.

The second Metacarpal is still longer and is supplied with the characteristic broad phalanx 1, the narrow phalanx 2, and the terminal claw or phalanx 3. This digit is slightly heavier than the 3d.

The third or middle digit is the longest; the 1st phalanx is broad, the 2d and 3d are restored, the 4th is complete, and was found associated in the left manus.

The fourth digit presumably had four phalanges, but only phalanx 1 is preserved in each case; and it has the same broad form as in D. II and III. The fifth digit is of about the same length as the first, and is likewise supplied with a single phalanx unformed or rounded distally, without any distinct facet for a second phalanx.

It thus appears certain that in this animal (No. 332) the middle three digits were fully functional and provided with claws, while the lateral digits were incomplete distally and served only to support the weight of the body.

FORE FEET OF BRONTOSAURUS.

FIGURE 7.

The question now remains whether the fore feet of *Brontosaurus* were also similarly constructed upon a mesaxonic plan.

Marsh restored (*Brontosaurus, Morosaurus*) the manus like the pes with a complete series of claws, the largest being on the inside.

The evidence is very positive in the two feet here mounted that *there was a deficiency of phalanges.* The evidence, however, that the actual construction of the foot is as we have mounted and photographed it (Fig. 7), namely, mesaxonic, is by no means positive. The question, in fact, cannot be definitely settled until a manus is found with all the digits in position, as in the pes above described.

The large fore foot (No. 268) was found with the metacarpals in position, and the phalanges scattered. The two terminal claws of digits III, IV, were not found with this foot, but some distance from it. Phalanges 2, 3, 4, of digit IV are restored in plaster. The foot is therefore nearly but not quite complete.

The broad 1st metacarpal has no distinct distal articular facet, such as are observed upon digits II, III, IV, and it seems probable

Fig. 7. Left Fore Foot of Large *Brontosaurus*, No. 268. The position of the phalanges is somewhat conjectural. ⅙ nat. size.

that we are correct in associating with it the short phalanx with an imperfectly rounded distal extremity.

The 2d metacarpal is very powerful, with a heavy rounded shaft and distinct distal articulation, from which three phalanges extend, the terminal a heavy claw, if our placing is correct.

The 3d digit affords the strongest support for the mesaxonic hypothesis, for it is by far the largest metacarpal, and is obviously the centre of the foot. With it must have been associated (as in the present mounting) the heaviest phalanges and claw.

The 4th metacarpal is considerably lighter and longer, and unfortunately its complement of phalanges is represented only by phalanx 1, the others being added or restored.

The 5th metacarpal is stout but slightly shorter than the 4th. With it was apparently associated the remaining imperfectly formed phalanx 1, which was found with this foot.

If these two imperfect phalanges are not placed upon digits I and V, it is very difficult to place them at all. It thus appears probable that digits I and V were deficient in all the phalanges except the first or first and second, and served merely to support the weight of the animal.

The admirable methods in the field, which have been largely developed by Dr. J. L. Wortman, whereby every piece is kept and transported in the position in which it was found, supplemented by admirable museum methods, will soon render our knowledge of the Dinosaurs not only far more complete, but far more accurate than ever before. The writer is indebted to Dr. Wortman for many hints in the discussion of the carnivorous limbs above described. The writer desires also to express his indebtedness to Mr. Adam Hermann, not only for the skill displayed in mounting these specimens, but for the excellent judgment and knowledge he has shown in locating and bringing together the scattered parts. Owing to the imperfect ossification of the joints, the bones of Dinosaurs are much more difficult to place than those of mammals.

A New Species of Pleistocene Horse from the Staked Plains of Texas.

By J. W. Gidley.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XIII, Article XIII, pp. 111–116.

New York, August 18, 1900.

The Knickerbocker Press, New York

Article XIII.—A NEW SPECIES OF PLEISTOCENE HORSE FROM THE STAKED PLAINS OF TEXAS.

By J. W. Gidley.

Equus scotti, sp. nov.

The type of this species is a nearly complete skeleton (No. 10606), consisting of the skull and lower jaws, the cervical vertebræ, the three anterior dorsal vertebræ, both fore limbs and feet complete, and one hind limb and foot, besides several other vertebræ and some ribs probably belonging with it.

This skeleton was found by the writer associated with four other skulls and parts of skeletons of the same species, in a bed of compact Pleistocene sand at the head of Rock Creek, Briscoe Co., Texas. The bed in which the bones were found is about the middle of the Equus, or Sheridan, beds, which are about 100 feet in thickness at this place.

Bones from the associated individuals have been substituted for the missing bones of the skeleton (No. 10606) which has been admirably mounted by Mr. Adam Hermann, and placed on exhibition in the Tertiary Mammal Hall of the Museum.

The writer has made a very careful study of all the types of the species of *Equus* in this country and has found that an extensive revision is necessary; this will be published in a subsequent paper. It appears that the horse from the true Equus beds of the Plains has not been taken as a type but has been mistakenly identified with other species. A new term is therefore necessary and this is selected in honor of Prof. W. B. Scott, of Princeton University.

The species *E. scotti* differs from *E. caballus* in proportions and size as follows: (1) the skull is relatively larger, (2) the neck is shorter, (3) the body is longer, (4) the lesser curvature of the belly ribs near their heads indicates that the back was not nearly so wide, (5) the limbs are shorter and more slender in proportion than the larger varieties of the recent horse.

Comparing the skeleton of *E. scotti* with the skeleton of a larger draught horse (No. 528) in the osteological collection of

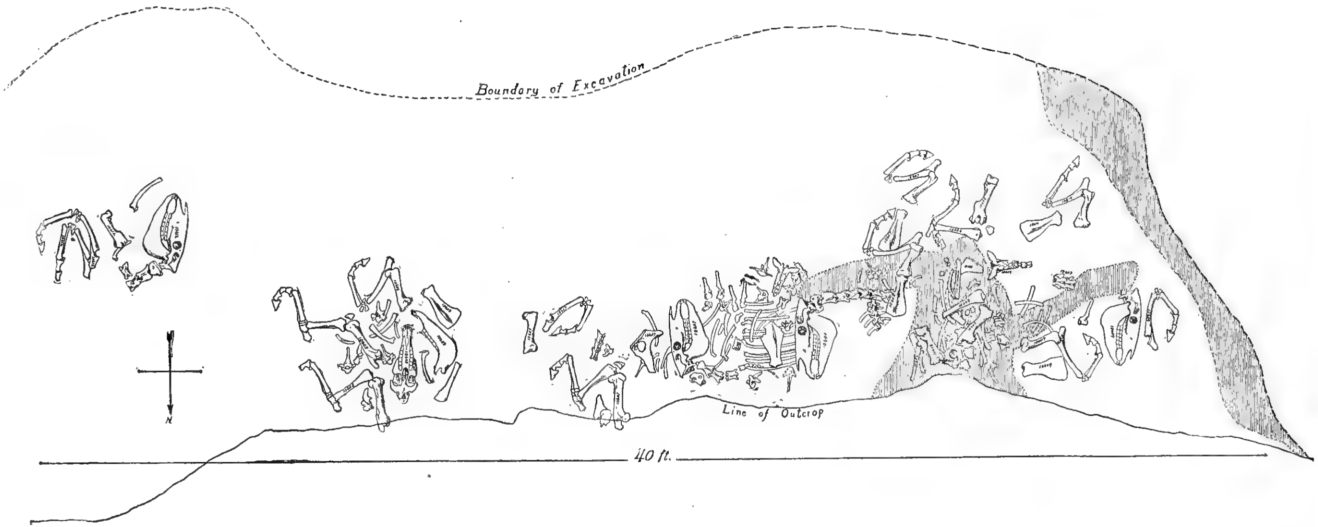

Fig. 1. Sketch showing number and position of remains of *E. scotti.*

the Museum we observe some striking differences. While the skulls are about equal in length and the series of dorso-lumbar vertebræ is only about 1 inch longer in the recent horse, the cervical series of *E. scotti* is about 4 inches shorter and the fore limb, in the standing position, is about 6 inches less in length.

Thus, this skeleton represents an animal with a head about the size of that of a large draught horse, but with the height of body and length of limbs of an ordinary western pony, and with a length of body very similar to that of the Zebra or Quagga.

A comparison of the separate bones of the skeleton reveals very few and unimportant differences, hence it is to the skull and teeth that we have to look for specific differences.

DENTITION.

Unfortunately all the bones of these skeletons, while adult, are of young horses, none of them having shed their last milk molars or external milk incisors. As far as can be made out the teeth differ from those of *E. caballus* only in their much larger size. M¹ of the type skull (Fig. 2), indicates perhaps a little greater degree of complexity of the enamel folding on the triturating surface than is usual in *E. caballus*, but it should be taken into account that this is only a slightly worn tooth and shows a greater degree of complexity than it would at a more advanced stage of wear.

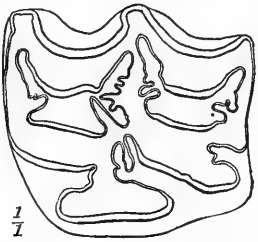

Fig. 2. M¹ of *E. scotti.*

The measurements of the teeth that are enough worn to give their true diameters are as follows :

Diameters of crown of p^3	antero-posterior	33 mm.
	transverse	31 mm.
Diameters of crown of m^1	antero-posterior	32 mm.
	transverse	30 mm.
Long diameter of i^1		23 mm.
Total length of molar-premolar series		190 mm.

Diameters of the corresponding teeth of the large draught horse (No. 528):

Diameters of crown of p^3	antero-posterior	29 mm.
	transverse	27 mm.

Diameters of crown of m^1	antero-posterior	25 mm.
	transverse	25.5 mm.
Long diameter of i^1		18 mm.
Total length of molar-premolar series		172 mm.

Thus it is seen that while the skulls of these individuals representing two species are of about the same size, the teeth of *E. scotti* (Fig. 3) are much larger and the whole masticating apparatus is proportionately shorter and better adapted to grazing than in *E. caballus* (Fig. 4); although the proportion of teeth to skull is not much greater than in the pony. The teeth seem to differ from *E. eous* Hay,[1] a species from Louisiana described by Cope under the name of *E. intermedius*,[2] only in their somewhat larger size.

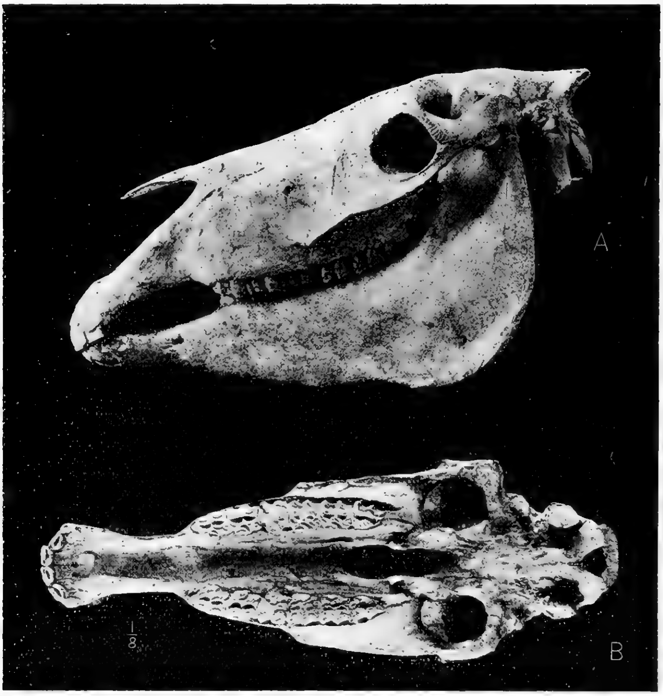

Fig. 3. Skull of *E. scotti*.

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[1] Science, 1899, p. 593.

[2] Proc. Am. Phil. Soc., Vol. XXXIV, p. 463.

COMPARISON WITH E. CABALLUS.

The nose of *E. scotti*, from the anterior premolar forward, is as much elongated as in *E. caballus* and in this character it differs entirely from *E. eous* which has a very much shortened nose. To make up apparently for the longer molar-premolar series, the skull is very much shortened in the portion between the last molar and the occipital condyles and most of this shortening seems to be in the basioccipital region, the orbits being placed much farther back. The maxillary ridge commences about the middle of p^4, while in *E. caballus* this ridge does not usually extend farther forward than the anterior portion of m^1. The vertical thickness of the skull measured immediately behind the last molar is about the same as in the large skull of *E. caballus*, but the thickness of the forward portion of the skull from the face of

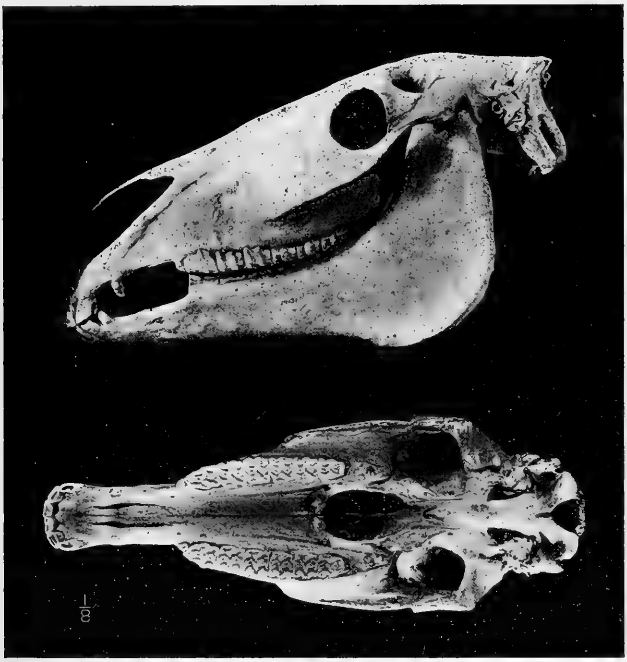

Fig. 4. Skull of *E. scotti.*

the anterior premolar to the top of the nasals is much greater in *E. scotti.* The processes of the frontals inclosing the posterior portion of the orbits, slope more backward and are much narrower than in *E. caballus.* The occiput seems to be more overhanging; this is due probably to the great shortening of the basioccipital bone. The basioccipital ridge is not so compressed and the fossæ inclosed between the paroccipital processes and the condyles are much deeper. In these last two characters *E. scotti* (Fig. 5, *A*) is like *E. occidentalis* Cope (not of Leidy).[1] The posterior region of the skull, the posterior nares and the palate are narrower than in *E. caballus.*

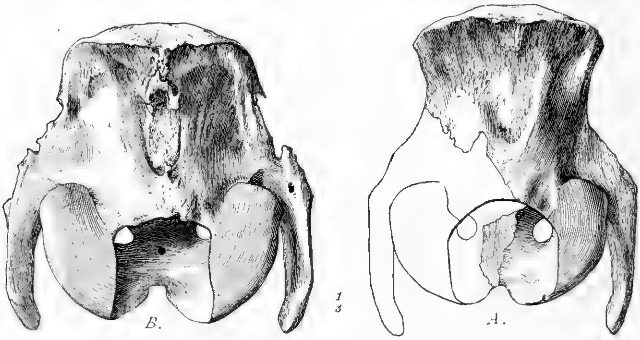

Fig. 5. *A*, occipital view of *E. scotti*; *B*, occipital view of *E. caballus.*

The lower jaw is more massive especially in the dental region. The jaw is much deeper, to accommodate the very long crowns of the molar-premolar series. This, together with the increased vertical thickness of the anterior portion of the skull, gives the whole head a more massive and less graceful form than that of *E. caballus.* Owing to the greater antero-posterior length of the molar-premolar series, the jaw seems to curve upward much more abruptly from the posterior molar. The symphysis mandibuli is heavier and longer than in *E. caballus*, extending back of the mental foramina. The jaw seems compressed laterally at the posterior part of the symphysis, owing to the wide expansion, anteriorly, to accommodate the wide incisors.

The other bones of the skeleton, taken separately, seem to be indistinguishable from those of *E. caballus.*

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[1] Proc. Am. Phil. Soc., Vol. XXII, p. 11.

Phylogeny of the Rhinoceroses of Europe.

Rhinoceros Contributions, No. 5.

By Henry Fairfield Osborn.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XIII, Article XIX, pp. 229–267.

New York, Dec. 11, 1900.

The Knickerbocker Press, New York

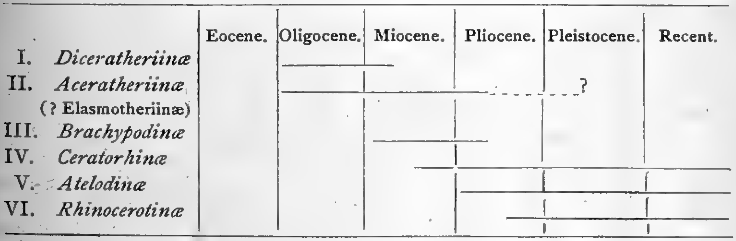
Article XIX.—PHYLOGENY OF THE RHINOCEROSES OF EUROPE.

RHINOCEROS CONTRIBUTIONS, No. 5.[1]

By Henry Fairfield Osborn.

By far the most striking generalization of recent mammalian palæontology is the *early separation*, *absolute distinctness*, *and great age of numerous phyla leading up to modern types.* If confirmed by more detailed research, the phylogeny here proposed will bring the Rhinoceroses also under this *law of early divergence;* the supposed original or stem forms having been pushed steadily back into the older Cenozoic. It sets aside several homoplastic characters heretofore employed in Rhinoceros evolution and attempts to establish a firmer basis *in the fundamental proportions of the skull*, *whether dolichocephalic or brachycephalic*, *in the correlated proportions of the body*, *and in the location of the horn-cores.* These characters are found to be more distinctive of phyla than the pattern of the molar teeth.[2]

Our present hypothesis is that, as distinguished from the Amynodonts and Hyracodonts, *the true tertiary and modern Rhinocerotidæ belong to at least six*[3] *genetic series or phyla which have no known relation to each other.* By Flower and Lyddeker the Rhinoceroses have been placed in one genus, *Rhinoceros*, and divided into five groups, which correspond approximately to our phyla. A characteristic subfamily name is herein given to each phylum, for the sake of clearness, brevity, and convenience, since several of these series have a prodigious range in time, as shown in the following table.



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[1] See Contributions 1-4, in Bibliography.

[2] The grouping proposed by Depéret ('85, p. 268) and by Lydekker ('86) is partly upon homoplastic characters of the teeth.

[3] See Osborn, '98, pp. 77, 121; a division of the Rhinocerotidæ into *four* subfamilies.

If this or some similar phylogenetic hypothesis can be established, it will not elucidate the origin, which remains an enigma, but it will at once simplify the whole problem of the succession, development, migration, and taxonomy of this hitherto baffling group.

PHYLOGENY AND TAXONOMY.

A clear conception of phylogeny is an essential preliminary to taxonomy ; the nomenclature is still, as my friend Schlosser expresses it, "ein wahres Elend"; in no European or American museum are the Rhinoceroses properly identified or catalogued. This paper therefore, besides setting forth an hypothesis of descent, is a preliminary statement of very interesting systematic and comparative results obtained by visits in 1898 and 1900 to the collections of London, Paris, Lyons, Munich, Darmstadt, Stuttgart, Augsburg, Vienna, St. Petersburg, and Moscow. Many kind friends aided in this work, especially the following palæontologists : Messrs. Lydekker, Woodward, Andrews, Gaudry, Boule, Thévenin, Depéret, Filhol, Zittel, Schlosser, Roger, Lepsius, Fraas, and Fritsch. The recent writings of Lydekker, Pavlow, and Roger have been of great service.

This extended comparison was undertaken before writing Part II of 'The Extinct Rhinoceroses' memoir, because in studying the American Rhinoceroses I soon learned that their close relations with those of Europe rendered it necessary for me thoroughly to understand the types of both countries.

The stratigraphical or geological basis is of the utmost importance and is set forth in recent correlation papers (Osborn, '00).

As regards nomenclature : first, the discovery that the type Acerathere, the classic *Aceratherium incisivum* Kaup, has *a rudimentary median frontal horn*, does away with the application of the generic term *Aceratherium* to many of the ancestral hornless types ; second, valid reasons are found for reviving the discarded generic terms *Atelodus*, *Ceratorhinus*, etc., and, third, the final nomenclature will be an expression of phylogeny. The first steps towards clearly attacking the taxonomic problem are :

(1) To conceive of the early adaptive radiation of the Rhinoceroses from an unknown stem.

(2) To conceive of the possibly independent origin of certain

phyla in North America, Europe, Asia, or Africa, and the subsequent intermingling of these phyla by migration.

(3) To recognize the succession of species in separate phyla or lines of descent, designating them as subfamilies by the terminal *inæ*.

(4) To sharply mark off each subfamily or phyletic series of species from its contemporaries as soon as its earliest members appear.

(5) To anticipate within each phylum the probable development of *collateral* as well as of *direct* lines of species, by the laws of local adaptive radiation.

Among the main divergent characters for the discrimination between subfamilies or series of species are :

1. *Proportions :*
   - *a.* Long-skulled (dolichocephalic), and long-footed (dolichopodal), or long-limbed types, *e. g.*, *Atelodus simus.*
   - *b.* Short-skulled (brachycephalic), short-footed (brachypodal), or short-limbed types, *e. g.*, *Teleoceras fossiger.*
2. *Reduction of digits :*
   - *a.* Precociously tridactyl types, *e. g.*, *Cænopus tridactylus.*
   - *b.* Persistently tetradactyl types, *Aceratherium tetradactylum.*
3. *Development of horns :*
   - *a.* In lateral pairs on nasals, *e. g.*, *Diceratherium pleuroceros.*
   - *b.* Single on nasals, *a*, on tips, *e. g.*, *Teleoceras*, *b*, on centre, *e. g.*, *Rhinoceros.*
   - *c.* In longitudinal pairs on nasals and frontals, *e. g.*, *Ceratorhinus.*
   - *d.* Single on frontals, *e. g.*, *Aceratherium incisivum*, *Elasmotherium.*
4. *Cutting teeth :*
   - *a.* 'Megalodine types,' in which the cutting teeth persist, *e. g.*, *Rhinoceros indicus.*
   - *b.* 'Atelodine types,' in which they degenerate, *e. g.*, *Atelodus simus.*

Some of these *divergent* characters also become *convergent* or *homoplastic* and are employed to distinguish the generic and specific stages of several distinct subfamilies or phyla. Thus several 'megalodine' types gradually pass into 'atelodine.' Correlated with the above fundamental divergent characters are numerous minor characters which are of great service; for example, dolichocephalic and brachycephalic Rhinoceroses frequently exhibit also distinctive types of auditory meatus, of occiput, of premolar and molar teeth, and of limbs.

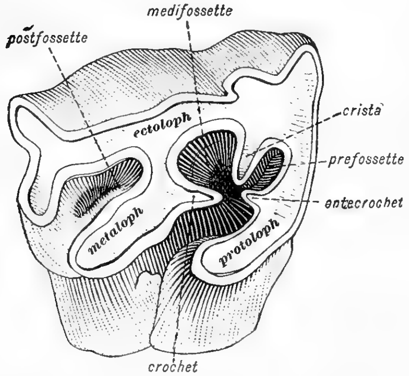

Fig. 1. Typical Rhinoceros molar, showing terminology.

An early division is observed into *heavier* and *lighter* types, correlated with speed; while *collateral brachyodont* (shrub-eating) *and hypsodont* (browsing) *species may arise within the same phylum;* example, *A. simus* and *A. bicornis*.

Family RHINOCEROTIDÆ.

Oligocene phyla.—Two similar lines appear simultaneously in the Oligocene of Europe; the most precocious of these is the subfamily Diceratheriinæ, represented in Europe and America; the less precocious is the Aceratheriinæ, probably represented in both countries also. The characters of both are sharply defined. It is probable but not yet demonstrated that the smaller Rhinoceroses throughout the Oligocene chiefly represent the Diceratheriinæ; nevertheless it is best to leave certain species *incertæ sedis* (*R. velaunum*, *R. gaudryi*), one or both of which may belong to the Amynodontidæ.

Subfamily DICERATHERIINÆ. PHYLUM I.

Smaller Oligocene Rhinoceroses; dolichocephalic, with paired nasal horns, full-sized cutting teeth; cursorial, long-limbed, with relatively slender bodies well raised from the ground.

General characters.—1. Manus precociously tridactyl (as observed in American species), correlated with swift motion. 2. Horns developed in lateral pairs on the nasals, beginning in the Middle and Upper Oligocene stages. 3. Lower canines sub-triangular in section, flattened on outer and upper sides, slightly convex on lower side (as observed in Middle and Upper Oligocene American and European types). 4. First lower premolar early reduced or wanting, as observed in European and American types (also in *R. gaudryi* and *R. velaunum*). 5. Molars quadrate, frequently exhibiting a conical cingule or cusp at the opening of the median valley. 6. Narrow skull, with narrow elevated occiput, expanding and notched above. Zygomatic arches suddenly expanding posteriorly.

These are some of the characteristic features which are observed in both European and American types and reach their full development in the Upper Oligocene. The nomenclature is still uncertain; to the Lower Oligocene forms, which probably possessed upper canine teeth, the generic name *Ronzotherium* Aymard possibly applies. It is possible that the type species, *R. velaunum*, belongs to the Amynodontidæ, in which case it may anticipate the genus *Amynodon* Marsh. If, however, it belongs to the Diceratheriinæ it may anticipate the genus *Cænopus* Cope (primitive hornless Rhinoceroses with precociously tridactyl feet), or the genus *Leptaceratherium* Osborn, or *Trigonias* Lucas (primitive hornless Rhinoceroses with persistent upper canine teeth). To the Upper Oligocene form, *Diceratherium* Marsh is applicable.

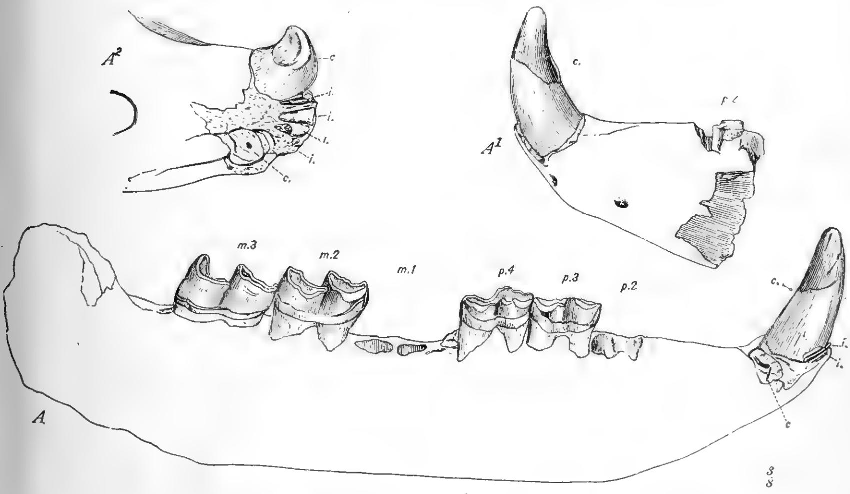

Fig. 2. *Ronzotherium gaudryi*. Type: PARIS. *A*, Internal view of left ramus. *A*¹, External view. *A*², Superior view. × 3/8.

1. LOWER OLIGOCENE. INCERTÆ SEDIS.

Ronzon, Argiles du Cantal, Phosphorites, Cadibona.

A most interesting primitive Lower Oligocene type is :

Ronzotherium gaudryi *Rames.* Type : a lower jaw, Paris Museum. Locality, Brons, Cantal. Definition : dentition $\frac{}{2}\,\frac{}{1}\,\frac{}{3}\,\frac{}{3}$; second pair of lower incisors greatly reduced ; median or first pair typical ; lower canines erect, laterally compressed ; first lower premolars wanting ; premolars 3–4 with internal and external cingulum ; molars 2–3 without internal cingulum ; premolars 2–4 much worn but apparently simple in pattern, *i.e.*, without complete posterior crests.

SYSTEMATIC POSITION.—The *erect* lower canines indicate the existence of upper canines, as in the Amynodontidæ or in *Leptaceratherium trigonodum* Osborn ; the laterally compressed shape of the canines resembles that in *Leptaceratherium* and is distinct from the more triangular form seen in *Amynodon*, but, if a member of the Rhinocerotidæ, this animal was very primitive. Since it is certainly not a member of the genus *Aceratherium* it may be provisionally referred to the genus *Ronzotherium* Aymard, the type of which is a lower jaw from Ronzon, similar in some respects. The absence of the first lower premolar in *R. gaudryi* and *R. velaunum* is also distinctive of the Diceratheriinæ.

According to M. Boule the Argiles du Cantal, containing *R. gaudryi*, are, if anything, a shade older than the Marnes de Ronzon, containing *R. velaunum.*

The jaw is slightly smaller than that of *R. velaunum*,[1] there is a wider space behind the third molar ; the dentition is similar in the simplicity of the premolar teeth ; in fact it may subsequently prove that *R. velaunum* and *R. gaudryi* are allied.

Space occupied by lower grinding series, premolar 2 to molar 3 inclusive		*Ronzotherium gaudryi*.....170 mm.
	(estimated)	*Ronzotherium velaunum*...194 mm.

The lower grinding series of *R. gaudryi* is closely equal in size to that of the Upper Oligocene *D. minutum* series (p2–m3 = 173) in the Paris Museum.

Ronzotherium velaunum *Aymard.*—Type : A lower jaw, Collection Aymard, Puy Museum. The writer has not personally examined the type and must rely upon the descriptions and figures

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[1] M. Filhol gives no measurements but figures the jaw of *R. velaunum* as ¾ natural size (Plate xii, figure 69, pp. 75, 266, Mammifères Fossiles de Ronzon).

(Fig. 3) given by M. Henri Filhol; as above stated the incomplete condition of the jaw leaves it uncertain whether this animal from the Lower Oligocene of Ronzon is a primitive member of the Diceratheriinæ, Aceratheriinæ, or Amynodontidæ.

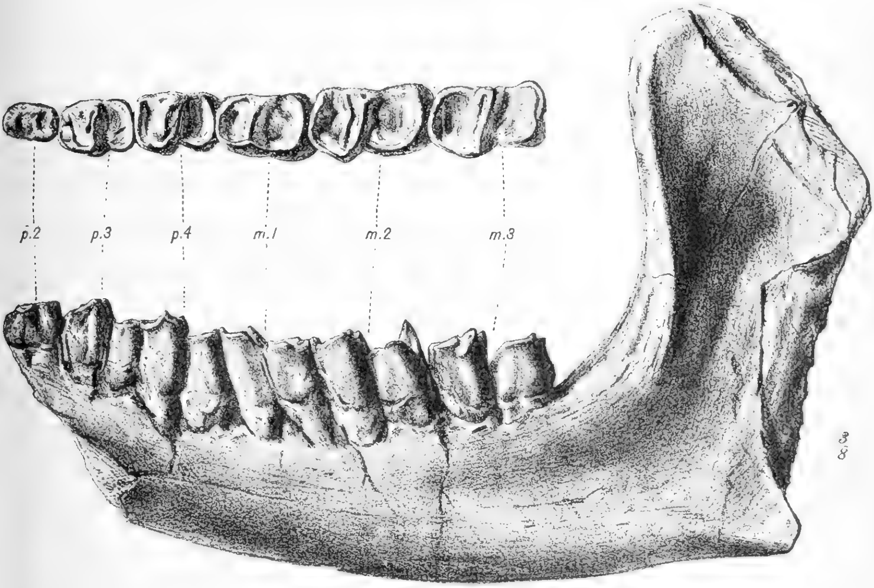

Fig. 3. *Ronzotherium velaunum.* Type: Puy. External view of left ramus. × $\frac{3}{8}$, after Filhol.

Characters.— Premolars 2, 3, 4, with incomplete crests; premolar 1 missing in the type specimen; coronoid and condyle greatly elevated (as in *Amynodon*); tetradactyl, fifth digit of manus believed to be present (as in *Amynodon* and *Aceratherium*).

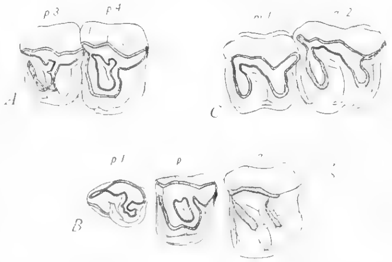

Fig. 4. Superior grinding teeth. *A*, Third and fourth premolars, *Cadibona*, Munich. *B*, First and fourth premolars, first molar, *Phosphorites*, Munich. *C*, First and second molars, *Phosphorites*, Paris. All figures × $\frac{3}{8}$.

It should be noted that the American Diceratheres of the Lower Oligocene are tridactyl; the American Amynodonts (Cadurcotheriidæ or Amynodontidæ) are tetradactyl, but with a much larger fifth digit than that associated by Filhol with *R. velaunum.*

The most primitive species of American Rhinoceros, *Trigonias osborni*, recently described by Lucas, presents an entirely different type of cutting teeth from that seen in *R. gaudryi.*

SUPERIOR MOLARS OF DICERATHERIINÆ.

In London, in Paris, and in Munich are numbers of small extremely primitive molar and premolar teeth from the Middle and Lower Oligocene Phosphorites of Mouillac, Quercy, and Bach, also from the Lignites of Cadibona, which are for the most part erroneously catalogued as *D. minutum* and its synonym, *D. croizeti*, *specific names which were applied originally to much more highly evolved Upper Oligocene types.* In point of evolution all these upper grinding teeth resemble the Lower Oligocene Diceratheres types of America, especially such species as *Cænopus* (*Aceratherium*) *copei ;* but, as in the case of the lower jaws (of *R. gaudryi* and *R. velaunum*) above described, it is not possible to determine their phyletic relations or exact systematic position at present. It is probable that all these teeth belong either to *R. velaunum*, *R. gaudryi*, or some allied species. (See Fig. 4.)

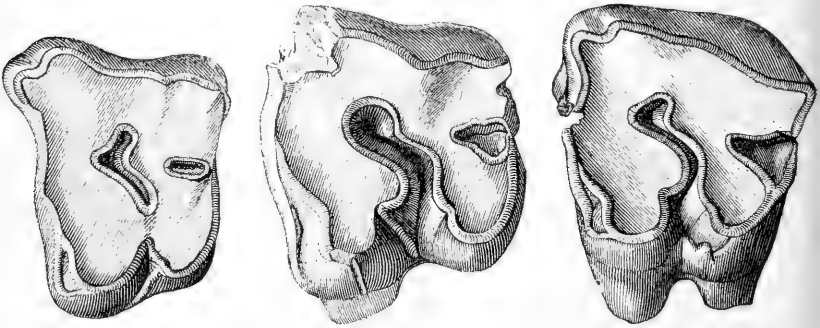

Fig. 5. *Diceratherium minutum.* Type: PARIS. Fourth premolar, first and second molars. × $\frac{1}{1}$. After Cuvier.

Characters.— Dentition: premolars unlike molars; premolars 2–4 with proto- and metalophs confluent upon wear; a crista in premolars 3–4; *milk premolars* dp^2–dp^4 with complete crests resembling the molars; *molars* with rudimentary antecrochet (protoconule fold); more or less marked external cingulum, rudimentary metaconule fold; variable cingulum suggesting a 'cingule' at entrance of median valley (Fig. 4).

LONDON, British Museum Collection: No. M. 1732, superior molars 1 and 2, Loc., Phosphorites, Bach, Lalbenque (Lot), France (see Fig. 17, Lydekker, Cat. Foss. Mamm. Pt. III, p. 142); also No. M. 4507, superior deciduous premolars 1–4, Loc. Phosphorites, Mouillac, France. In the MUNICH collection from *Cadibona* are two small upper premolar teeth, pm 3–4, which answer this description; others from the Phosphorites, Quercy, are found in the Munich collection (m^1, m^2, pm^1, pm^3). In PARIS[1] from *Quercy* (Coll. Massénat) are also small isolated premolar and molar teeth (p^1–m^2) of the same character, found both in the Jardin des Plantes and the École des Mines collections.

Conclusions.—The *small* European Lower Oligocene species of Rhinoceroses, although *incertæ sedis*, are partly Diceratheriinæ, partly Amynodontidæ; they should be referred to *R. gaudryi* or *R. velaunum* or to new species. The *large* Lower Oligocene species of the Phosphorites should be referred to the Aceratheriinæ.

2. UPPER OLIGOCENE.

St. Gerand-le-Puy, Moissac, Gannat, Eselsberg (Ulm), in part.

Diceratherium minutum *Cuvier.*—Type: Upper premolar 4 and molars 1–2. PARIS, No. 2346, Loc., Moissac, Upper Oligocene (Fig. 5).

Definition: Dentition $\frac{1}{1}\,\frac{0}{1}\,\frac{4}{4-3}\,\frac{3}{3}$; upper incisors small; lower canines sub-triangular; with flat outer and sharp inner edge, procumbent; first lower premolars variable; upper and lower premolars 2–4, with two crests resembling the molars; upper premolars with small antecrochet, with crista and crochet; upper molars with crista (soon disappearing), pointed crochet (disappearing in old age), antecrochet and postfossette; cusp or cingule at entrance of median valley. Measurements: type p^4–$m^2 = 100$; p_2–$m_3 = 173$; p^2–$m^3 = 173$–180.

This represents the Upper Oligocene species of the French and German Museums, which are readily distinguished from the Lower Oligocene species by the complication of the teeth; but exhibit little or no increase in size. In PARIS are Cuvier's types described in the 'Ossemens Fossiles'; also a cotype lower jaw No. 2343; also Duvernoy's *R. pleuroceros* (synonym) type skull from Gannat. The finest series of upper and lower teeth are those in the MUNICH collection from Eselsberg and Eckingen near Ulm, which are catalogued as *A. croizeti* Pomel. In the STUTTGART collection from the same localities we find especially Nos. 4757 and 9861, rightly identified as *D. minutum*.

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[1] Unless otherwise stated PARIS refers to the Galerie de Paléontologie, Jardin des Plantes, under the direction of Professor Gaudry.

Additional Characters.—PARIS: *Cuvier's type:* Fourth superior premolar with protoloph and metaloph confluent in old age, small antecrochet; molars with antecrochet, crochet, metaconule fold, postfossette, and median internal cingule. *Duvernoy's type* (*R. pleuroceros*): molars agreeing precisely in size with above; skull and jaws of dolichocephalic type, paired horn-cores on nasals, occiput narrow elevated; zygomatic arch convexity as in *Cœnopus tridactylus* Osborn. In the Paris jaw (Gannat) the first lower premolar is wanting, in Munich and Lyons specimens it is vestigial, indicating that, as in the American Diceratheriinæ, this tooth was variable; m 1–m 3 = 100. Tibia (Gannat) = 260. MUNICH and STUTTGART (Eselsberg, Ulm, specimens): first lower premolar very small; pm 2–4 molariform with elevated posterior crests; lower canines sharp, subtriangular with flattened outer surface, flat upper face partly destitute of enamel, slightly convex lower face and sharp inner edge; canines large in males, small in females (this tooth is very similar to the canines of the American species *C. tridactylus* Osborn); unworn *premolars* (catalogued *A. croizeti*, Munich) as in Cuvier's type without antecrochet, but with crista and pectinate crochet (see Nos. 4757, 9861, STUTTGART, Eggingen); *unworn molars* exhibit crista, crochet, and antecrochet, while *worn molars* lose crista and show greater prominence of antecrochet and crochet, and postfossette (especially in p 4–m 2), also an internal cingule or cusp in the median valley as in American Diceratheres. This animal is exactly the size of *Cœnopus mite* of the American Lower Oligocene. LYONS: A small jaw (catalogued *A. croizeti*) with vestigial pm 1.

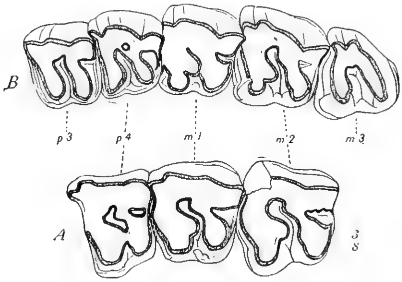

Fig. 5*a*. *Diceratherium minutum*. *A*, Type premolar and molars. $\times \frac{3}{8}$. PARIS. *B*, Part of left superior grinding series. Ulm, MUNICH.

Affinities.—By this comparison there is little question that all these teeth belong to the Upper Oligocene *Diceratherium* and, so far as we know, to the single species *D. minutum* Cuvier, which presents many features of close resemblance to the American Diceratheres. In Paris the skull of the Upper Oligocene *D.* (*Pleuroceros*) *minutum* is now placed in the case side by side with that of the Middle Oligocene *Cœnopus occidentalis* from South Dakota; it exhibits a remarkable similarity in the form of the occiput, the zygoma, and the paroccipital region.

3. LOWER MIOCENE.

Sables de l'Orléanais, Eselsberg (Ulm, in part), Bugti Beds.

The Eckingen, Ulm, formation also contains a Lower Miocene fauna, indicating that the Diceratheres may have persisted into this period.

Other indications as to Miocene persistence are those afforded by a juvenile lower jaw and a maxillary series in the École des Mines collection, Paris, from the Sables de l' Orléanaïs, typical Lower Miocene; these were kindly shown the writer by the Curator, M. Douvillé; they are of about the size of *A. platyodon* Mermier, but they almost certainly constitute a new species which probably belongs in the Diceratheriinæ. The animal is considerably larger than *D. minutum.*

Incertæ Sedis.

Diceratherium douvillei,[1] sp. nov.

Type: A maxillary series Coll. École d. Mines, Paris. Definition: Type: Upper premolars with crenulated anterior border of metaloph, and reduced antecrochet; upper molars with large crochet and antecrochet, crista not apparent in worn teeth.

Fig. 6. *Diceratherium douvillei.* Type: PARIS. After a photograph by M. Douvillé.

This species is placed *incertæ sedis*, phyletically. The indications that it belongs to the Diceratheriinæ are, first, the crenulated or pectinate anterior border of the metaloph in the upper premolars as in *C. tridactylus;* second, the tubercle in the valley of

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[1] Dedicated to M. Henri Douvillé, to whose kindness the author is indebted, both for the permission to describe the type and for the accompanying photograph (Fig. 6).

m³. It is also possible that it represents an ancestor of *R. sansaniensis*, which is placed in the *Ceratorhinæ* below. It certainly is not *Teleoceras aurelianensis*, and it apparently cannot be referred to *Aceratherium platyodon*; these are the only strictly Lower Miocene (Burdigalien) Rhinoceroses hitherto described in France.

Subfamily, ACERATHERIINÆ. PHYLUM II.

Large Oligocene and Miocene Rhinoceroses of Europe; dolichocephalic with long, narrow nasals; smooth or with rudimentary horns at sides of the tips; frontals finally developing horns; large cutting teeth; relatively persistent tetradactyl manus; long-limbed.

Contemporary with the small Diceratheres is this phylum of large Rhinoceroses which appears to rise in a large but primitive species in the Lower Oligocene, *A. filholi*, and pass through *A. lemanense* and *A. tetradactylum* into *A. incisivum* of the Lower Pliocene, which in turn is possibly the ancestor of *Elasmotherium* and the Elasmotheriinæ. The European Lower Oligocene Acerathere is exactly similar in size to *A. platycephalum* Osborn, which is possibly the American representative of this type; but it differs widely in the mode of transformation of the upper premolar teeth; for this reason it is referred to a new species.

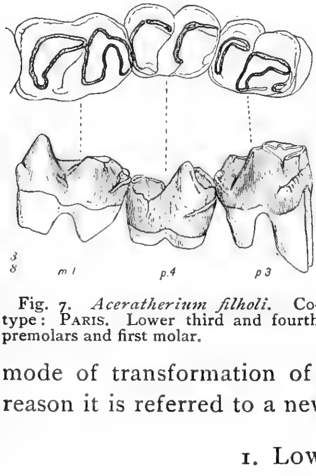

Fig. 7. *Aceratherium filholi.* Cotype: Paris. Lower third and fourth premolars and first molar.

1. Lower Oligocene.

Phosphorites, Quercy, Cazark, Escamps.

Aceratherium filholi,[1] sp. nov.

Type: Left maxilla containing second premolar to third molar inclusive; Paris, Coll. Rossignol, Loc. Phosphorites. Cotype: Paris, lower jaw, containing pm³, pm⁴, and m¹ (Figs. 7, 8*A*).

Definition: Large upper premolars, simple, unlike molars, with incompletely formed crests; upper molars with internal cingulum and strong protoconule fold, small antecrochet, no crochet; depression in posterior face of metaloph of third

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[1] Dedicated to my friend M. Henri Filhol, who has contributed so extensively to our knowledge of the fauna of the Phosphorites.

molar; third and fourth lower premolars with depressed and incomplete posterior crests. Measurements: pm^2–m^3=224.

This new species is well represented by teeth in the Paris, Munich, and British Museum collections from the Phosphorites of Quercy and Cazark, mistakenly catalogued as the Upper Oligocene *A. lemanense*, from which it differs widely. No true *A. lemanense* remains are found in the Phosphorites, which is believed by the writer not to extend into the Upper Oligocene. None the less *A. filholi* is probably ancestral to *A. lemanense* and represents the first known member of the tetradactyl, dolichocephalic phylum which directly or through collaterals leads up to *Aceratherium incisivum* of the Lower Pliocene.

The distinctness of this species was independently recognized by M. Boule, who in recent lectures has compared it with *A. platycephalum*. M. Filhol and M. Depéret also both concur with the writer that it is distinct from *A. lemanense*, and M. Filhol assures me that it is equally distinct from *R. velaunum*, which is a much smaller animal. The name *Aceratherium* may be retained for all members of this phylum, although technically the names *Badactherium* Croizet or *Aphelops* Cope might be applied to the ancestral truly *hornless* Aceratheres.

The entire absence of a crochet and the non-molariform premolars distinguish this species sharply from *A. lemanense;* the internal cingulum is partly a sexual character; it varies in different specimens, although strongly marked in the type.

Besides the admirably preserved and highly characteristic PARIS types, in MUNICH we find two large molar teeth, m^2 and m^3 from the Phosphorites (Escamps, Lalbenque, Dép. Lot); also a single well worn molar, m^2, and two isolated upper molars, m^1 (Phosphorites, Cazark, Dép. Lot), of exactly the same size as the *A. platycephalum* from our Lower Oligocene; also from Cazark two upper premolars, p^3, p^4, which exhibit imperfectly formed crests and a crista. In LONDON (British Museum) are lower premolars and molars (Phosphorites, Caylux, Nos. M. 1457, 1458, 1459, also upper molars M. 1455, m^1–m^2) all catalogued *R. lemanensis*. There can be no question that all these teeth belong to the same species, *A. filholi*, which is far more primitive than the Upper Oligocene *A. lemanense* to which they have been referred; not only the premolars but the molars are simpler. The premolar

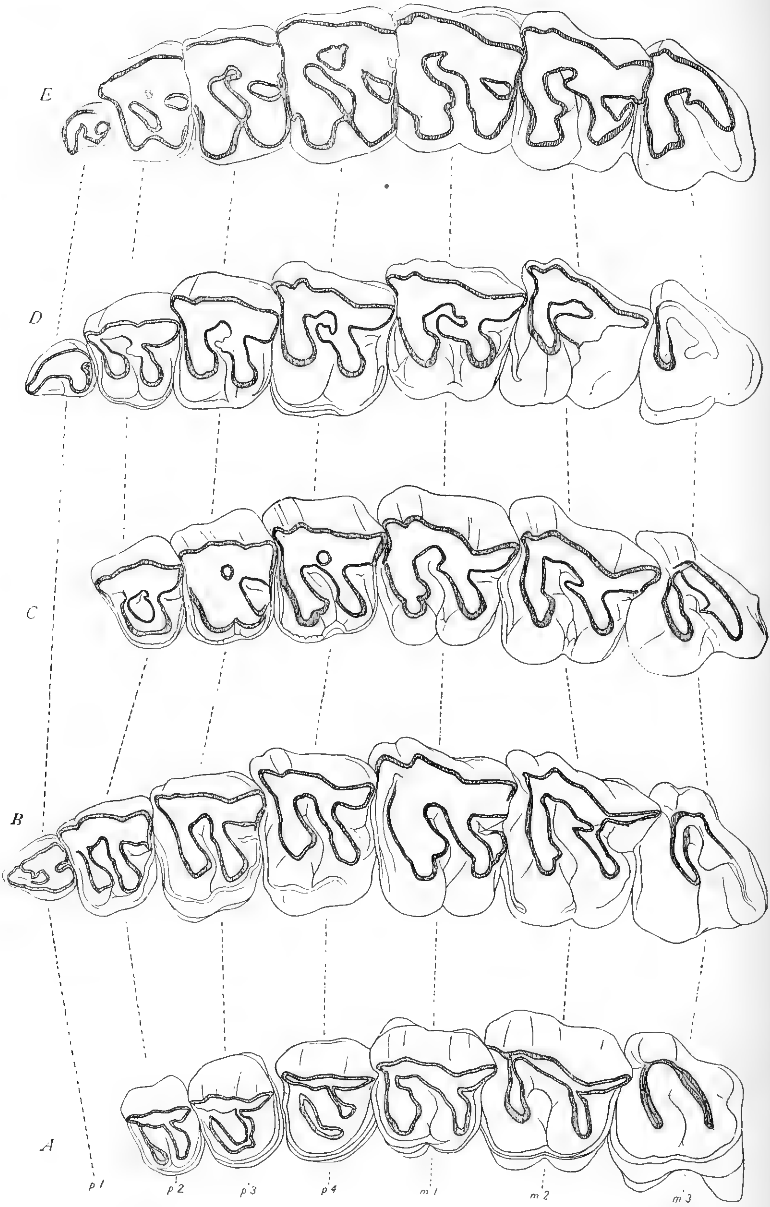

Fig. 8. Evolution of the grinding teeth in the Aceratheriinæ. *A*, *Aceratherium filholi.* Type: PARIS. Lower Oligocene. *B*, *Aceratherium lemanense* (reversed). PARIS. Upper Oligocene. *C*, *Aceratherium lemanense.* Ulm, MUNICH. Upper Oligocene. *D*, *Aceratherium tetradactylum.* PARIS, No. 2379. Middle Miocene. *E*, *Aceratherium incisivum.* Type: DARMSTADT. Lower Pliocene. All contours, $\times \frac{3}{8}$.

evolution differs from that of the American *A. platycephalum* as shown in the diagram above (Fig. 8); other resemblances, however, are so strong that one is tempted to consider the *possibility* that these animals belong to the same Aceratherine race which is distinct from, but contemporary with the Diceratherine race. A fossa representing the vestige of the postvallum in m^3 is seen in these specimens, also in *A. platycephalum.*

2. UPPER OLIGOCENE STAGE.

St. Gerand-le-Puy, Gaillac, Gannat, Randan, Eckingen, (*Ulm*).

A. lemanense *Pomel.*—This well known species is represented by superb materials in Paris, Lyons, Munich, Stuttgart. These specimens represent different (early or primitive and later) stages of development; some are less progressive and probably of Middle Oligocene age, others are more modernized and probably of Lower Miocene age, but in all the premolars and molars are far more advanced than in *A. filholi.*

Sexual differences are pronounced as in the Diceratheriinæ and Rhinoceroses generally; the females have small canine tusks and long very narrow or slender nasals; the males have large tusks and rudimentary rugosities or horn supports on the sides of the extremities of the nasals. Adaptive radiation is also marked and probably certain *collateral species* are given off from the direct line.

All these animals are readily distinguished from the Diceratheriinæ by much larger size.

General Distinctions of Teeth.—Lower canines lance-shaped, lenticular in section; first lower premolar small, usually present; *superior premolars* with crista, producing a medifossette upon extreme wear; large antecrochet; premolars 2–4 with complete crests, which in the more primitive stages unite in extreme wear; an internal cingulum. *Molars* with strong antecrochet, becoming stronger in wear; with crista becoming weaker in extreme wear; crochet also becoming weaker with extreme wear; metaconule fold becoming stronger with wear; protocone small; postfossettes indicated in both m^1 and m^2, with internal cingulum reduced or confined to median valley. Measurements: pm^1–m^3=265.

Effect of age upon molar pattern.—It is extremely important to observe that, exactly as recorded above in the Diceratheriinæ, the *newer characters*, namely the crista and crochet, are formed near the summit of the crests and are thus worn away in old teeth ; while the *older characters*, such as the antecrochet, are at the base of the crests and thus become bolder in extreme wear. The same law applies to the newer and older characters in the molar teeth of the horse.

General Distinctions of Skeleton.—Skull and jaw of dolichocephalic type (measurements, symphysis to condyles=630) ; nasals long and narrow, more or less separate, notched at sides, slender in females ; tetradactyl, a well developed 5th metapodial, lunar wedge-shaped distally ; symphysis of lower jaw varying with sex, short in females, longer in males.

These characters may be verified in the following specimens : PARIS, No. 2372 (*Badactherium*[1] *borbonicum* Croizet, type, loc. Auvergne), an old individual with well worn molars. Duvernoy's fine type skeleton of *A. gannatense* (Gannat, Allier), probably a *female*, with small lower canines and short symphysis of lower jaw, large and powerful skeleton ; skull measuring 630 from symphysis to condyles ; superior teeth partly worn and finely preserved ; pm^1–m^3=265 ; femur measuring 460. Also *A. randanense*, No. 2302 (Randan, Auvergne), lower jaw containing pm 2–m 1, with a very long symphysis (unlike the *A. gannatense* type) ; this is possibly a sexual or *male* character. Also a complete jaw (Gaillac, Tarn) with small lower canines, probably *female*, small pm 1 on left side. Portion of left anterior foot, No. 2373 (Gannat, Allier), showing characteristic tetradactylism.[2] LYONS : (1) *A. lemanense* (Gannat), skull, nasals long and thickened at the ends, but separate in median line, notched at the sides ; this type represents an *early stage*, because the premolar crests are bridged internally and would unite upon extreme wear. (2) Large lance-shaped lower canines of lenticular section, unworn (Allier). (3) Two maxillæ from Gannat exhibit molar and premolar characters entirely agreeing with those above described. (4) A complete skull and skeleton, probably *female*, lower jaw with small canines, medium-sized upper canines, molars agree with Pomel's type in character, size below that of Pomel's type ; nasals extraordinarily long, slender, extend-

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[1] This is possibly a MS. name. It is not recorded in Trouessart's 'Catalogus Mammalium.'

[2] See Duvernoy's Memoir, Plate viii.

ing over premaxillaries, with smooth surfaces (this length, slenderness, and smoothness is also a female character in *C. occidentalis* and *C. tridactylus*) ; a sagittal crest, occiput high and narrow. (5) Another skull (loc. Pyremont between Lyons and Geneva) has the same general characters but the nasals exhibit distinct and quite well marked rugosities at the sides of the tips ; this is evidently a *male ;* the digits are somewhat shorter than in *A. lemanense*, namely, Mtc. III=140, Mts. III=125 ; Depéret regards the animal as a distinct species and will describe it as such. MUNICH : (1) The maxilla from Eselsberg, Eckingen, near Ulm, is beautifully preserved ; it belongs to an *early stage* because the premolar crests are bridged and unite when worn ; the premolars exhibit medifossettes ; the molars show the strong crochet, antecrochet, and metaconule folds. (2) An unworn molar from Eckingen shows a crista, antecrochet, and crochet, and the characteristic small protocone of this species. STUTTGART : (1) Molars of a *later stage* (Eggingen, Ulm) show a more prominent crista and crochet which unite to form a medifossette. (2) A fine pair of lower jaws (Ulm) with large lower canines and no traces of pm 1 probably also represent a later stage (*i. e.*, Lower Miocene).

We thus find that *A. lemanense* is the characteristic Upper Oligocene species, presenting various stages of premolar transformation and probably giving rise to some collateral species.

3. LOWER MIOCENE STAGE.

Sables de l' Orléanais, Royans.

A. platyodon *Mermier*, represents this stage.—LYONS : The type skull, probably belonging to a small female, $pm^1–m^3=207$, exhibits unique, extremely elongate, slender, and slightly separate nasals ; the lower canines, as the specific name indicates, are excessively flattened toward the extremities but exhibit a triangular mid-crown section ; the premolars (Mermier, '96, Pl. II) have a prominent crista and medifossette ; the crests unite early upon wear. The teeth may be readily distinguished from those of the contemporary Brachypodinæ by the small size of the protocone.

A. blanfordi *Lydekker.*—A jaw is ascribed to this species

(Lydekker, '86) from the Lower or Middle Miocene Bugti Beds of Sind. It is *incertæ sedis* here.

4. MIDDLE MIOCENE STAGE.

Sansan, Simorre.

A. tetradactylum *Lartet.*—This is the noble species of Sansan (Nos. 3378 male, 2379 female, 2389 female, etc.) and Simorre, represented finely in the Paris Museum. It shows striking resemblances to *A. lemanense*, together with all the progressive characters which we should expect to find in a descendant, and unquestionably belongs to the same line. The scapula is high and narrow as in dolichopodal types generally. The hind limb (femur and tibia) is of approximately the same length as in *A. lemanense*, but the metapodials are longer, and more stilted (Mtc. III=160–180, Mts. III=135–165), indicating that the phylum was developing a progressive running power. The progressive and retrogressive changes in the skull and jaws are most interesting and significant as seen in a magnificent male specimen (No. 3378, Loc. Sansan). As compared with *A. lemanense* note the following

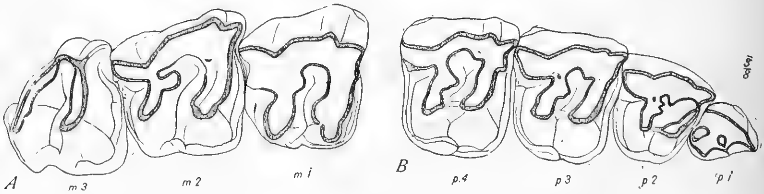

Fig. 9. *Aceratherium* (*incisivum*) *tetradactylum*. Georgensgemünd. MUNICH.

SKELETAL DISTINCTIONS.

Skull.—A slight loss of size, symphysis to condyles of skull = 559, *A. tetradactylum*; symphysis to condyles of skull = 630, *A. lemanense*. Nasals, *males* (No. 3378) slightly less elongated, similarly notched at sides, roughened or rugose distally, but not thickened (a sexual character); *females* (Nos. 2379, 2389, Coll. Lartet) very narrow and elongate, separate in median line, not expanding distally. Premaxillæ slender. Occiput elevated, spreading superiorly. Sagittal crest lower but still well marked. Premaxillæ slender. Jaw with elongate symphysis, wide diastema, angle deep, projecting backwards. Manus tetradactyl (Coll. Lartet, Nos. 2518, 2537), with reduced metacarpal V; lunar of tridactyl type (foreshadowing the loss of metacarpal V, which is now reduced in length to 75), PARIS, Coll. Lartet, Nos. 2518, 2537; long, stilted digits; metacarpal III enlarged; metacarpals II, IV relatively smaller. Scapula vertically elongate, with long neck, as in all long-limbed, speedy types.

Dental distinctions.—Inferior canines less lance-shaped, with internal flare and flattened external section. First lower premolar sometimes present (in the slightly older Sansan specimens). *Sup. premolars* and *molars* (No. 2379) with somewhat reduced antecrochet and very strong crochet placed near ectoloph; this unites with the ectoloph when well worn and forms a conspicuous medifossette (No. 2388). Crista conspicuous in unworn premolars and molars. Antecrochet somewhat reduced and becoming conspicuous only in old or worn teeth. Molars with cingulum entering median valley between crests, a crest in the bottom of median valley (No. 2388), or embracing protoloph only; with postfossette in m^1; and traces of external cingulum; posterior cingulum of m^3 (also observed in *A. platycephalum* and *A. lemanense*) persisting. Measurements, female, $pm^2 — m^3 = 230$.

The scapulæ and limb bones of large size in the Paris Museum (which are catalogued *R. sansaniensis*) undoubtedly belong to *A. tetradactylum.* Some of these indicate an Aceratherine race as large as or larger than the *A. lemanense* type.

PARIS: This species is also represented in the slightly higher levels of Simorre, especially by a very large jaw of a *female*, with small lower canines, first lower premolar absent, formula: p_3—m_3; of marked dolichocephalic type. LONDON: The jaw from Sansan (Hastings Collection, No. 27454, catalogued *R. goldfussi*) also represents this species; it is large and dolichocephalic in type; the lower canines are flattened with a marked internal flare.

5. UPPER MIOCENE STAGE.

Georgensgemünd.

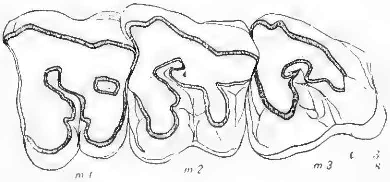

Fig. 9*a*. *Aceratherium tetradactylum.* No. 3378. × 3/8. PARIS.

MUNICH: Upper teeth with closely similar characters (catalogued *A. incisivum*, Georgensgemünd, Bav.) are seen here in a shade *earlier stage* of evolution, because we observe more of a bridge between the premolar crests and somewhat greater prominence of the antecrochet as well as of the internal cingulum of the molars. Another specimen is a characteristic long and straight lower jaw of this race. (A maxilla, mistakenly catalogued *A. incisivum*, Georgensgemünd, belongs to the Ceratorhine or *C. sansaniensis* race.) VIENNA: A large maxilla, containing pm 1–m 3 (without label) has all the distinctions of the Aceratherine race.

6. LOWER PLIOCENE STAGE.

Eppelsheim, Maragha.

Relations of A. incisivum to Elasmotherium.

Aceratherium incisivum *Kaup.*—DARMSTADT: In cranial characters this classic species is less dolichocephalic. In *dental* characters it follows closely upon its predecessors (Fig. 8 *E*); in fact, most writers, beginning with Kaup, have not hesitated to unite the *A. tetradactylum* with this animal. The cranial characters, however, are much more progressive, the nasals are shorter and more upturned, the frontals are thickened and bore a rudimentary horn in the males at least. The latter character (Osborn, 99, p. 162) is very significant. One can imagine that this phylum, having failed in the development of horns upon the mechanically weak nasals (as indicated in the Lyons specimen), began to evolve frontal horns. There is no question that the frontals are not only thickened to support a horn (they are very thin in the contemporary *T. brachypus*), but that they show a well marked rugosity with the characteristic converging depressions of nutrient arteries (Fig. 10). It is this character which led the writer to advance the idea that this animal is an ancestor of *Elasmotherium*, an hypothesis which depends upon the future discovery of intermediate forms. It may be observed here, moreover, that *Elasmotherium* has long, narrow, smooth nasals of a type found only in the Aceratheriinæ and that there is theoretically no

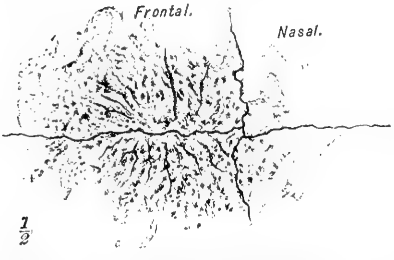

Fig. 10. *Aceratherium incisivum.* Type: DARMSTADT. Rudimentary frontal rugosity, with lines of convergent nutrient arteries.

difficulty in deriving the enormous frontal horn of the Pleistocene species from the vigorous rudiment in *A. incisivum;* or the ptychodont Pleistocene molars from the simple Lower Pliocene stage.

There is a fine skull of *A. incisivum* in HALLE as well as the two in Darmstadt.

7. EASTERN TYPES.

Incertæ Sedis.

The Siwalik Aceratheriinæ have not yet been carefully compared by the writer. *A. perimense* is a very large animal from Perim Island with a skull which, as restored by Lydekker ('81, Pl. X), suggests this phylum, although higher and shorter.

Subfamily BRACHYPODINÆ. PHYLUM III.

Brachycephalic Rhinoceroses, short broad skulls. Teleocerine, horns when developed appear on tips of nasals. Megalodine, large cutting teeth. Brachypodal, short spreading feet, short limbs, body and trunk near the ground. Tridactyl, probable early reduction of lateral digits. Known Geological Distribution, Lower Miocene to Lower Pliocene, inclusive, Europe and America.

These Rhinoceroses, short and broad in all their proportions, including their spreading grinding teeth, represent, so far as we know, the sudden occurrence of a new type in the Lower Miocene of Europe ; for they have no known prototypes in the Oligocene of either Europe or America. Either the original home of this type is Africa, and if so, they came into Europe with the Mastodons, or they represent an offshoot of the Aceratheriinæ. Typical species are *T. aurelianensis* Nouel ; *T. brachypus* Lartet ; *T. goldfussi* Kaup ; *T. fossiger* Cope. Doubtful species are *A. persiæ* and *A. blanfordi.* The phylum Brachypodinæ takes its name from one of the oldest known forms, *T. brachypus* Lartet, although it first appears geologically in the *T. aurelianensis* Nouel of the Lower Miocene (Sables de l' Orléanais of France), and includes a great variety of European and American types, extending to the Lower Pliocene, *T. goldfussi* Kaup. The feet in *T. brachypus* and *T. fossiger* become extremely short. Associated with the shortening of the skull is a shortening and broadening of the grinding teeth—the *very broad fourth upper premolar* distinguishes the higher members of this series, notably as developed in the Lower Pliocene *T. goldfussi* Kaup. In the superior molars the protocone is very prominent and rounded, giving a circular form in extreme wear. The lower and upper cutting teeth attain an enormous size, hence the adjective *megalodine* is appropriate. The shortening of the skull lowers the middle portion of the cranium and in the typical species causes the nasals to project upwards at the tips; thus the irresistible tendency of every Rhinoceros to develop a horn finds expression in the laterally compressed rugosities of the tip of the nasals (*T. aurelianensis*, *T. fossiger*), while an abortive horn may appear on the frontals (*T. aurelianensis*). The strong resemblance of *T. fossiger* to this series was noted by Mme. Pavlow.

The generic name *Teleoceras* Hatcher is the first applied to a member of this series and will be of service to distinguish its members throughout. Valid specific differences are found between the Lower, Middle, and Upper Miocene and Lower Pliocene stages; there are certainly three and possibly four species in Europe.

I. LOWER MIOCENE STAGE.

Sables de l'Orléanais.

Teleoceras (R.) aurelianensis *Nouel.*—Type: A skull. Loc. Neuville-aux-Bois, Loiret.

PARIS: Characters of type. (1) Three lower premolars in jaw associated with skull; also observed in an isolated better preserved jaw, thus: $\mathrm{p}\frac{?-}{4-3}$, $\mathrm{m}\frac{3}{3}$; flattened outer face of inferior molars is another characteristic; superior premolars 3–4 shorter than the molars and provided with antecrochet, as seen also in maxillary series (Collection Vibraye). The strong simultaneous development of antecrochet and crochet distinguishes the molars, as well

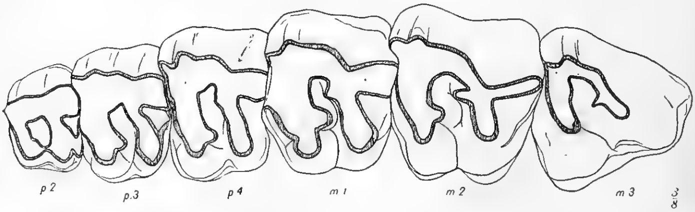

Fig. 11. *Teleoceras aurelianensis.* Type: Superior molars. × $\frac{3}{8}$. PARIS.

as the stout cylindrical protocone. Occiput broad, in a vertical plane; jaw with a decided angle. Front view of nasals is very characteristic (Fig. 12, *D*), a rugosity appears upon each tip with a cleft between (as in *T. fossiger*); there is also a very slight swelling and faint rugosity upon the *frontals* immediately above the eyes which may indicate the rudiment of a median horn. As compared with the Aceratheriinæ the fore and hind limbs and feet in the Paris Museum are relatively short, but they are longer than those of its Upper Miocene relative *T. fossiger* mounted beside them; this species is also distinguished by narrower premolars. (2) A fine lower jaw (Loiret) exhibits premolars with flattened outer wall, also a very small, single-fanged pm_1. (3) The maxillary series (Coll. Vibraye) above alluded to shows a cement layer on the molars as in some Upper Miocene American types.

Lartet in a letter to Nouel expressed the opinion that this species was identical with the Middle Miocene *T. brachypus*. A close comparison of the teeth of these two species in the Paris Museum reveals the following resemblances and differences:

T. aurelianensis.	*T. brachypus.*
Premolars broad	Premolars broad
Antecrochet strong in p 3, p 4	Antecrochet reduced or wanting
Metaloph of p^4 long	Metaloph of p^4 long
Molars, internal cingulum wanting	Cingulum strong

2. MIDDLE MIOCENE STAGE.

Simorre, Sansan (?).

T. brachypus *Lartet.*—PARIS: A fine maxillary series from Simorre, Gers (Coll. Lartet No. 2386); fourth superior premolar (p^4) compressed antero-posteriorly and extending transversely more than in *T. aurelianensis;* superior molars with strong internal cingula; inferior molars with extremely flattened outer faces; enormous upper incisors. This species is generally said not to occur at Sansan, but a single lower canine tooth (catalogued *R. tetradactylum*, Paris Museum) probably represents it on this level.

3. UPPER MIOCENE STAGE.

Grive-St.-Alban, Steinheim.

T. brachypus.—The finest examples of this species are found in the Muséum d'Histoire Naturelle of LYONS and have been described and figured by Depéret. Relying upon his determination ('87, p. 178) we observe the following dental characters:

Superior premolar 1 simple; premolars 3–4 without antecrochet (thus differing from *T. aurelianensis*); premolars 2–3 with small crista and crochet; premolar 4 with crista and forked crochet; molar 1 with small crista, strong crochet, antecrochet reduced (as compared with *R. aurelianensis*); molars 1–3 with internal cingulum extending around inner face. *Inferior* premolars with flattened outer faces. Measurements, Mts. III = 110.

Depéret observes that the true *T. brachypus* always has an internal cingulum upon the upper molars. I do not, however, feel convinced that this specific determination is correct.

HALLE: A distinct variety of this type occurs at Steinheim, and was shown to me in this fine collection through the kindness of Professor Fritsch; it is distinguished by very thick enamel, square posterior fold of ectoloph (due to the antero-posterior compression of the dentition correlated with the brachycephalic skull), crista, crochet, and antecrochet all showing in well worn superior molars; cingulum only around protoloph of molars (in typical *T. brachypus* it embraces metaloph also). This variety may become known as a distinct species, *T. eurydactylus*, for there certainly are some minor differences between this and the typical *T. brachypus*.

MUNICH: The foot bones of manus and pes, Mtc. III = 145, Mts. III = 110, astragalus = 50 (types of *R. eurydactylus* Haushalter), are almost identical in size and proportions with those of our Upper Miocene species, *T. fossiger* Cope, of America. A lower jaw (Steinheim) exhibits the following characters: symphysis, short; diastema very short, first lower premolar vestigial, single-fanged, close to canine; second lower premolar comparatively simple, reduced, single-lobed. There is also a fragmentary skull from the Dinotherium Sands near Günzburg with occiput low and broad as in *T. fossiger*. Also from Steinheim a large collection of isolated upper molars, with the following characters: superior fourth premolar broader than first molar (as in *T. goldfussi*); superior first molar with very thick enamel, a crista, large antecrochet, and broad internal cingulum extending around protoloph only. The Steinheim teeth of Munich therefore agree closely with those in the Halle collection and indicate that the northern (? *T. eurydactylus*) variety differed in a definite particular from the southern typical *T. brachypus* race, namely: *cingulum extends around protoloph only;* this character (cingulum around protoloph only) is also observed in a cast of four molar teeth (Mantscha bei Graz) in the Munich collection, but it is not seen in the Augsburg skull.

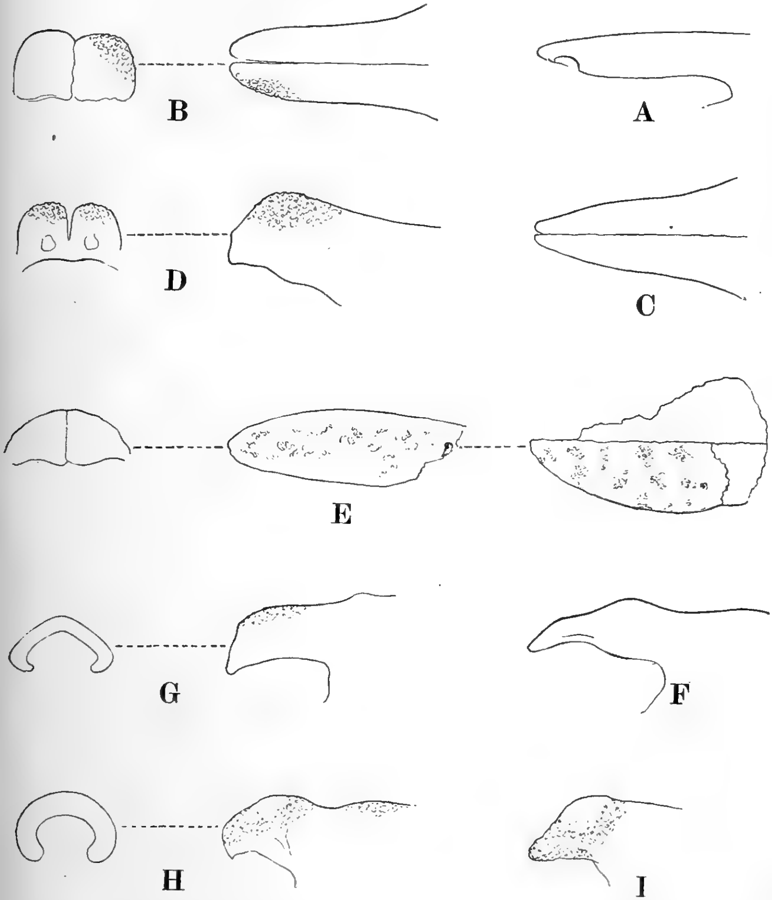

Fig. 12. Characteristic types of nasals and nasal rugosities. A, *Aceratherium tetradactylum*, PARIS. B, *A. lemanense*, LYONS (Pyremont) C, *A. incisivum*, HALLE. D, *Teleoceras aurelianensis*, PARIS. E, *Incertæ Sedis*, AUGSBURG. F, *Rhinoceros sansaniensis* (restored). G, *R. platyrhinus*. H, *Atelodus bicornis*. I, *A. simus*. Mostly after rough sketches by the author.

AUGSBURG: Other characters of this variety are given by the fine specimens in this museum shown to the writer through the kindness of Dr. Otto Roger, also communicated by letter (May 30, 1899), but especially in his very full and valuable paper

(Roger, '00), received just as this paper was going to press. Locality: base of lower Dinotherium Sands, near Augsburg. Very aged skull (Roger, '00), found at base of sands, short and massive; premolars and molars with strong cingulum surrounding three sides of the crown; $p^1–m^3 = 260$. Measurements:

	p. 1	2	3	4	m. 1	2	3
Length	27	29	35	37	40	49	58
Breadth	18	35	48	57	56	56	53

Breadth greatly exceeding length throughout upper grinders; superior diastema i–p = 85; zygomatic arches strong; occiput as broad above as below; supra-temporal crests separated by a median groove; in mid-frontal region bones as thin as paper (an important distinction from *A. incisivum*); nasals a single, compact, laterally compressed bone without trace of median cleft or suture (thus differing from *T. aurelianensis*), thickened at the extremity but not laterally compressed as in *T. aurelianensis* and *T. fossiger;* meatus auditorius open below (resembling *R. sumatrensis*). I am inclined to regard this as a female skull and to believe that a male would show rugose nasal tips; in fact, nasals with rugose tips were described and figured by Roger ('85) (Fig. 12, *E*). This animal shows decided specific differences, but an unmistakable racial resemblance to both *T. aurelianensis* and *T. fossiger.* Other characters of this species observed in Augsburg specimens are, *lower jaw:* short symphysis; very short diastema (10); small coronoid process bending sharply forward; small incisors; first lower premolars always wanting; outer face of lower grinders flattened; total premolar series = 111.5, molar series = 165; dental formula, $\frac{1}{1}$ $\frac{0}{1}$ $\frac{4}{3}$ $\frac{3}{3}$; grinding teeth large in proportion to skull.

STUTTGART: Teeth measurements: Pm^4, breadth, 60, length, 40. Limb measurements: Steinheim collection (Roger, '00, pp. 16–17), humerus, length, 350 to 420; radius, 290 to 370; femur 390 to 540; tibia, 290 to 340; metatarsals, I = 108, III = 112, IV = 96; these measurements indicate that the limbs are somewhat longer than those of *T. fossiger* (*cf.* Osborn, '98, p. 57). The pointed vestigial first lower premolar is preserved in one jaw; lower incisors small and sharply pointed. A maxillary series (Steinheim, No. 6314) is referred by Roger ('00, p. 14) to this species, mistakenly, I believe, because the long narrow measurements of the grinding teeth indicate that they belong to a dolichocephalic type, probably *A. tetradactylum.*

A jaw recently excavated by Professor Fraas himself (Steinheim) exhibits small pointed incisors and a vestigial pointed pm_1.

LOWER PLIOCENE STAGE.

Eppelsheim.

T. goldfussi *Kaup.*—The foregoing studies enable us to determine that the tooth which Kaup selected from the sands of Eppelsheim for the *type* of this species is not a molar, as he supposed, but a *fourth superior premolar ;* this tooth has a broad internal cingulum ('Ossements Fossiles,' Darmstadt ; in 'Akten d. Urwelt,' 1841, he adds as *cotypes*, a lower molar, and upper incisor ; in 'Beitr. z. Näher. Kennt.' he figures an upper molar, Taf. II, fig. 20 ; a lower molar, fig. 15). In the same Eppelsheim sands are found other teeth with characteristic peculiarities of this brachycephalic-megalodine phylum, viz. : greatly enlarged upper incisors, upper molars with crochet and antecrochet projecting into median valley, lower molars with flattened outer wall.

T. goldfussi is very imperfectly known ; it cannot now be distinguished specifically from *T. brachypus*, except by its larger size. So far as we know it was the last member of the subfamily Brachypodinæ.

Types. Incertæ Sedis.

The Siwalik Rhinoceroses have not yet been carefully examined by the writer. The *Aceratherium blanfordi* Lydekker, type, resembles the Brachypodinæ in the structure of its superior molars. From the Lower Pliocene or Maragha is another remarkable interesting form, *A. persiæ* Pohlig, which appears to be distinct from *A. blanfordi.*

Aceratherium persiæ *Pohlig.*—This species is richly represented in VIENNA (Collection Polak) by ten more or less complete skulls ; there is also a fine skull in the HALLE Museum. Characters : Last superior molar quadrate with an exceptional extension of ectoloph, and a vestige of posterior valley ; ectoloph of molars in a nearly straight line ; antecrochets and crochets of molars very prominent, giving a complex pattern upon extreme wear ;

enamel thin; protocone large, strongly constricted off. These dental characters approach those of *Teleoceras fossiger*.

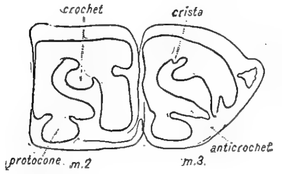

Fig. 12*a*. *Aceratherium persiæ*. Second and third superior molars. Halle.

In some of its cranial characters it approaches *A. incisivum*, except in the extraordinarily broad chin which is hollowed out in the median line (see also lower jaws referred to *A. blanfordi* in British Museum); thus the lower canines diverge and are set widely apart, with the persistent alveoli of lower incisors between; nasals short, straight and smooth; a sagittal crest; occiput higher than broad; zygomatic arch slender. A strong rugosity upon the molars beneath the eyes for the origin of the masseter muscles, which are inserted in a strong ridge on the outer border of the angle of the jaw. Tibia and fibula closely united (as in Brachypodinæ). Limbs of medium length.

Subfamily CERATORHINÆ. PHYLUM IV.

Middle Miocene to recent Rhinoceroses; dolichocephalic, with frontal horns, and nasal horns upon a distinct mid-nasal convexity, not terminal; nasals more or less pointed and recurved anteriorly; cutting teeth large in early members, gradually reduced in certain branch phyla; cursorial limbs.

The first known of this series, *R. sansaniensis* of the Middle Miocene, appears to represent *a new arrival and a new phylum in Europe;* it certainly has no ancestors among the previously known Diceratheriinæ, Brachypodinæ, or Aceratheriinæ, for the structure of the entire upper portion of the skull is different; it is barely possible that some of the teeth referred to *A. minutum* from the Upper Oligocene may represent its ancestors; but this is not probable. Its successors or collateral descendants, however, are probably determined as the *R. simorrensis* of Simorre, the *R. steinheimensis* of the Upper Miocene of Steinheim and Grive-St.-Alban; these animals apparently gave off: (*A*) a *smaller race*, the last of which appears in the Lower Pliocene, Eppelsheim; in Eppelsheim and Pikermi, however, there also appears (*B*) the *larger race* of *R. schleiermacheri* possessing many of the same characters as *R. sansaniensis*, but with certain notable distinctions.

The generic name *Rhinoceros* may be retained at present for members of this series, but in case a relationship to the Sumatran Rhinoceros should subsequently be demonstrated, it would be well to apply Gray's term *Ceratorhinus* throughout.

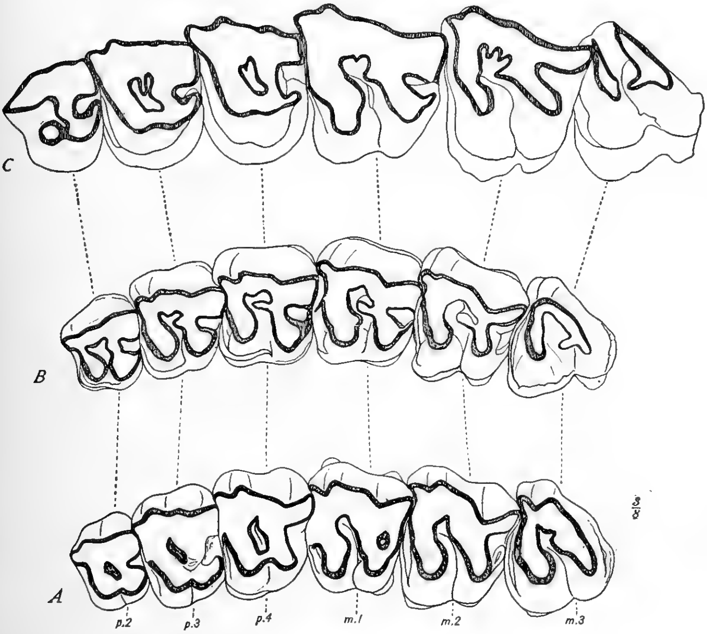

Fig. 13. Superior molar series. *A*, *R. sansaniensis*. Type: PARIS. *B*, *R. simorrensis*, No. 2380. PARIS. *C*, *R. schleiermacheri*. STUTTGART, after Kaup. All × $\frac{3}{8}$.

A. Smaller Race. Middle Miocene to Lower Pliocene.

1. MIDDLE MIOCENE STAGE.

Dental Characters.—Large lower canines (males) in Miocene; first lower premolars relatively persistent (unlike Diceratheriinæ), retained to Middle Miocene, then reduced; upper premolar transformation retarded, crests confluent upon wear in *R. sansaniensis*, free in *R. simorrensis;* upper molars and premolars with internal cingula reduced or absent; molar-premolar series of moderate length ($pm^2 - m^3 = 190$ in *R. sansaniensis*), much shorter than in the contemporary Aceratheriinæ, proportionately longer and narrower than in the Brachypodinæ; molars retaining a feeble antecrochet.

Cranial characters.—Nasals short and broad, triangular when seen from above; median horn precociously (Middle Miocene) developed upon both nasals and frontals; occiput both broad and high (very distinct from Aceratherine, Diceratherine, or Brachypodine types).

a. Lower Level, Sansan.

R. sansaniensis.—PARIS: The type skull (No. 2395, Coll. Lartet, Sansan) is that of a *male*, a small animal; it is very much crushed antero-posteriorly, disguising its real *dolichocephalic* character, which is strongly marked in the uncrushed lower jaw; the first lower premolar has a broad double or grooved fang, while in *R. simorrensis* this tooth is small and single-fanged; the premolars are greatly worn so that the median valley has almost disappeared and the crests are quite confluent: although a male (because of its well developed horns) the inferior canines are smaller than in the *R. simorrensis* jaw; the simple character of the molar crests in this specimen is deceptive, and is due to extreme wear, the crochet (a superficial fold) having been worn off, the protocone and antecrochet are indistinctly marked (quite unlike the Aceratheriinæ and Brachypodinæ of this geological period); the inner face of the molars is without cingulum (unlike Aceratheriinæ and Brachypodinæ); there are indications that young teeth would show both crista and crochet; the nasals and occiput have a very characteristic shape, somewhat similar to that of Gaudry's *R. schleiermacheri* of Pikermi; the nasals are especially distinctive, being broad and rugose behind, where they carry the horn, but converge to a smooth point anteriorly; (See PARIS, Nos. 2395, 551); metatarsals (erroneously catalogued *A. tetradactylum*), of moderate length, probably belong to this species.

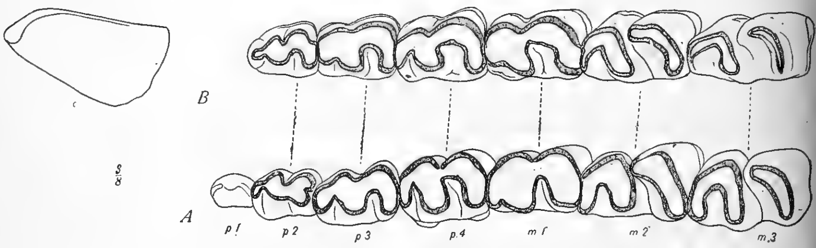

Fig. 14. Lower grinding series. *A*, *R. sansaniensis*. PARIS. *B*, *R. simorrensis*. PARIS.

b. Higher Level, Simorre.

R. simorrensis *Lartet.*—PARIS: (1) In this animal from a higher level (100 metres) we observe distinct specific progression: the size is the same; the lower canine is larger; the first lower premolar is single-fanged, reduced or wanting; the crests of the upper molars (Lartet Collection: No. 2380, catalogued as *A. tetradactylum*) are more distinct; the younger molars have a feebly indicated antecrochet and a very strong crochet; upon extreme wear the antecrochet comes out more strongly. (2) A handsome lower jaw shows the vestigial pm_1 persisting on the left side, wanting on the right (Fig. 14); the lower grinders are small, fine, and delicately built; the diastema is rather short. (3) A maxillary series (Coll. Lartet, No. 2380) is beautifully preserved; the fourth superior premolar is fully molariform, with a prominent antecrochet; the superior molars show a reduced antecrochet and a very prominent crochet. Measurements: $pm^1 - m^3 = 193$ (Coll. Lartet, No. 2380); $pm_2 - m_3 = 195$.

LYONS: Two fine maxillæ of *R. simorrensis* are found in the Muséum d'Histoire Naturelle and present characters exactly similar to the above; strong postfossettes are observed in $pm^2 - m^1$ and strong and prominent crochets on $pm^2 - m^3$; the molars have the internal cingula feeble or wanting. LONDON: Upper jaws and teeth (No. 33525, Villefranche, d'Astarac, Gers, France) a beautifully preserved apparently *female* skull with no trace of median horns on frontals; molar teeth with the same characters, $p^1 - m^3 = 193$. A lower jaw (No. 33526, same locality) exhibits a single-fanged and evidently much reduced first premolar. The *R. austriacum* Peters is represented in Munich by the third superior molar tooth. The type of this species from Eibiswald-Leiding is doubtfully distinct from the foregoing.

2. UPPER MIOCENE STAGE.

Steinheim, Grive-St.-Alban.

The Upper Miocene stage of this small race is the so-called *R. steinheimensis* Jäger, from Steinheim. (1) The finest example of this stage is a maxilla in STUTTGART (Steinheim, No. 6032);

pm^1 is quite simple ; pm^2 shows a crista and small antecrochet ; pm ^{3} shows a prominent crochet ; pms $^{3-4}$ differ from molars in the absence of antecrochet fold ; the molars show a crista, reduced antecrochet, and very prominent crochet. (2) Another maxilla (No. 4230) shows a larger size, pm^1 – m^3 = 200. LYONS : similar teeth are found from Grive-St.-Alban. It is probable that this stage represents a distinct species, in which case it should be termed *R. steinheimensis* Jäger ; at present, however, we know no means of distinguishing it from *R. simorrensis.* MUNICH : A fine example of maxillary series from Georgensgemünd (catalogued *A. incisivum*) exhibits premolars and molars without internal cingulum ; the premolars have complete internal crests.

Conclusions.—There is a gradual advance in size (molars from 190 to 200) and in the evolution of the premolars, as we pass from the Middle to the Upper Miocene Ceratorhinæ.

3. LOWER PLIOCENE STAGE. LAST OF SMALLER RACE.

Eppelsheim.

R. steinheimensis.—Kaup referred the smaller teeth of Eppelsheim to *A. minutum* Cuvier ; this was an error. One of these Eppelsheim teeth, a third superior molar, is in LONDON (British Museum, No. 1257) ; it agrees closely in every particular with those of *R. simorrensis* both in size and character ; it is a much worn tooth and shows a large antecrochet. Casts of the Eppelsheim molars (M. 2739, 2740, 2742) are also identical with those of *R. simorrensis.* DARMSTADT : An examination of Kaup's originals in this Museum confirms the above determination (see Kaup, '62, Taf. II, figs. 6, 10, 11, 13). There is little doubt, therefore, that this smaller race of Ceratorhinæ persisted in the Lower Pliocene ; the specific characters of this stage are undetermined.

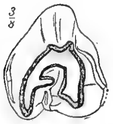

Fig. 15. *R. steinheimensis.* Last superior molar. Steinheim, MUNICH.

B. Larger Race.

4. LOWER PLIOCENE STAGE.

Eppelsheim, Pikermi.

We can imagine that the *smaller race* arrived in Europe (either from Asia or Africa), was arrested in size development and terminated in the smaller Eppelsheim species; then from the same original stock, by subsequent migration, a collateral *larger race* arrived, which in general had developed along the same lines, but had retained certain primitive characters.

Such a collateral species is Kaup's *R. schleiermacheri* of Eppelsheim (Fig. 13, *C*). It exhibits molar-premolar teeth measuring 260; it is thus nearly one-third larger than *R. steinheimensis*; it resembles the *R. sansaniensis* series in the following points: superior molars: antecrochets reduced; a crista (progressively bifid); a prominent crochet; skeleton: metapodials of medium length; tridactyl manus. It differs as follows: premolars with crests internally confluent upon wear (primitive); first lower premolar persistent (primitive); a sagittal crest (primitive); small cutting teeth (progressive); very large nasal and frontal horns (progressive); no postfossettes in the molars; wide distance between orbit and naso-maxillary notch (this space is somewhat shorter in *R. sansaniensis*, indicating a progressive lengthening of the skull in *R. schleiermacheri*).

Therefore, as placed together in the Paris Museum the Middle Miocene *R. sansaniensis* and the Lower Pliocene (Pikermi) *R. schleiermacheri* exhibit first a striking racial similarity in form; second, a difference in size exactly such as one would expect in the progression from a Middle Miocene to a Lower Pliocene type; third, certain primitive and progressive differences which render the theory of direct descent of one from the other impossible. If one compares the skulls closely one sees the striking racial likeness in the form, and especially in the proportions and positions of the horns upon the nasals; the occiput of *R. schleiermacheri* is relatively lower and is somewhat broader below. In both specimens the infraorbital foramen is very close to the naso-maxillary notch; thus it is evident that these species, although not genetically related, represent collateral branches of a similar race. The growth of the skull between the orbit and anterior nares points to progressive dolichocephaly and to correlated elongation of the limbs and feet.

The successors and relatives of this Ceratorhine phylum are, apparently, *R. leptorhinus* Cuvier, Middle Pliocene, represented by a fine skull (Paris Museum, Montpellier, Hérault); the long-limbed *R. etruscus* from the Upper Pliocene of Italy, France, and

England, with a nasal septum ; *R. platyrhinus* of the Pliocene Siwaliks of India (which Lydekker has mistakenly associated with the Atelodinæ); finally, the smaller and somewhat primitive living species, *R. sumatrensis.*

Subfamily ATELODINÆ. PHYLUM V.

Lower Pliocene to recent Rhinoceroses. Dolichocephalic, long low skulls, moderately broad, depressed, backwardly inclined occiput; two large horns developed upon nasals and frontals; nasals square or blunted anteriorly, horns extending to the extremities; Atelodine, cutting teeth vestigial or wanting; mesopodal, moderately long limbs and digits, similar to those of R. indicus.

1. Lower Pliocene Stage.

Pikermi, Maragha.

In the Lower Pliocene of Pikermi there suddenly appears in Europe a fifth type which cannot be derived from any of the preceding ; the cutting teeth are precociously vestigial or wanting (hence the term Atelodinæ) ; the skull is easily distinguished by the form of the temporal fossa and occiput, by the form of the nasals and by the absence of front teeth in the dolichocephalic megalodine *R. schleiermacheri*, which appears in the same beds. The species is not found in the more northern Eppelsheim beds, and in view of the many resemblances which the Pikermi type, *R. pachygnathus*, bears to the existing African species (*R. simus*, *R. bicornis*), we may not consider as unreasonable the hypothesis that this is an African phylum which entered southern Europe with the numerous Antelopes and Giraffes of Pikermi ; the later members of this phylum are the Pleistocene *R. hemitœchus* and *R. antiquitatis* (= *tichorhinus*), and the recent *R. simus* and *R. bicornis.* The main characters of this phylum are given above.

R. pachygnathus *Wagner.*—Paris : A fine skull and skeleton of this type have been described and figured by Gaudry. Even in the young skull there is a decided thickening for a frontal horn ; the nasals are very broad and thick at the extremities ; the lower jaw is without distinct angle, and a single convex sweep from condyle to angle is very characteristic ; correlated with this we observe a weak zygomatic arch and early reduced front teeth ; the most distinctive feature is the backward sweep of the temporal fossa, the low, backwardly inclined occiput. The molars are *brachyodont.* In the older jaw the formula is : $i_{\overline{0}}c_{\overline{0}}p_{\overline{2}}m_{\overline{3}}$.

Duvernoy actually attributed *R. pachygnathus* to the Pleistocene species *R. antiquitatis*, from resemblances in the limb bones, and Gaudry remarks ('62, p. 177) that this was very natural because the bones are extremely similar. Again, as originally remarked by Gaudry, *R. pachygnathus* resembles *R. bicornis* (the smaller brachyodont shrub-eating species of Africa), and ('62, p. 178) closely also *R. simus* (Burchell's Rhinoceros, the larger hypsodont, grass-eating species of Africa); I have verified these remarks by very careful studies of specimens in Paris and London. *R. simus* has a square upper lip, with broadly truncate upper nasals, the horn rugosities being carried to the very extremity, and its cranial resemblance to *R. pachygnathus* is remarkable. *R. bicornis* has, on the contrary, a pointed prehensile upper lip, and its somewhat more pointed nasals may be correlated with this narrower snout, but the horns are carried to the very extremity (at which there is sometimes a slight cleft, British Museum specimen).

Atelodus neumayri, sp. nov.[1]

Type, a large male skull, Vienna Museum, from Pikermi or Maragha (Persia), (erroneously catalogued as *R. schleiermacheri*). This skull resembles *R. pachygnathus* as follows: large frontal and nasal horn cores; auditory meatus closed; zygomatic arch slender (correlated with reduction of angle and masseteric muscles); lower border of jaw convex; dentition: $\frac{?}{?}, \frac{?}{?}, \frac{3}{3}, \frac{3}{3}$. It differs from *R. pachygnathus* as follows: molars elongate, tending to hypsodontism; cement covering sides of molar crowns; the pattern of the premolar and molar teeth unique and without precedent; there is no true antecrochet on the protoloph, but a fold, which might be considered as an aberrant crista, projects into the median valley from its outer portion, that is, *external* to the crochet (whereas the antecrochet always appears *internal* to the crochet); the prominent crochet is placed internally to this; strong hypostyle fold and postfossette on p^3 to m^1.

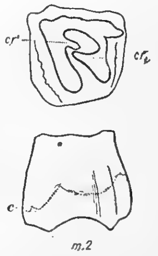

Fig. 16. *Atelodus neumayri.* Type: Second superior molar. VIENNA.

An apparently similar fold is observed in *R. antiquitatis*, and connects the protoloph diagonally with the metaloph; *A. neumayri* therefore resembles *R. antiquitatis* more closely than *R. pachygnathus*, both in the presence of this fold and in the greater hypsodontism of its molar teeth.

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[1] Dedicated to the late distinguished Austrian geologist, Melchior Neumayr.

2. Pleistocene and Recent Stages.

An adaptive parallel to these types is presented in the Middle and Upper Pleistocene species: *R. antiquitatis* resembles *R. simus* (and less closely *R. neumayri*) with broadly truncate nasals, slender zygoma, and hypsodont, small, very narrow molar teeth; while *R. hemitœchus*[1] resembles *R. pachygnathus* and *R. bicornis*, with brachyodont molar teeth. In both *R. hemitœchus* and *R. bicornis* the nasals are somewhat narrower and the upper lips more prehensile and pointed. These large Pleistocene animals (which co-existed for a while) thus differed in details of dentition in adaptation to local differences of feeding ranges and habits, but resembled each other in (1) extreme dolichocephaly, (2) backward inclination of the occiput, (3) powerful nasal septum, (4) horns on extremities of nasals.

The existing African species, *R. simus* and *R. bicornis*, like *R. sumatrensis*, in the Ceratorhine series, are, however, both less specialized than the Pleistocene types.

Subfamily RHINOCEROTINÆ. PHYLUM VI.

Brachycephalic or intermediate between extreme dolichocephalic and brachycephalic types; occiput inclined forwards. Single horns upon mid-nasals; nasals pointed and generally smooth at the extremities. Megalodine, large upper and lower cutting teeth.

No representatives of this phylum have been found in Europe. In Asia, however, the Pliocene Siwaliks yield species which are probably ancestral to the typical *Rhinoceros unicornis* of India. Lydekker ('81, Pl. X) shows that *R. palæindicus* leads into the hypsodont or grass-eating *R. unicornis* type, while *R. sivalensis* leads into the brachyodont or shrub-eating *R. sondaicus* type. All these four species exhibit a skull with forwardly inclined occiput, concave and hornless in the frontal region, nasals with a large horn in the middle portion which does not extend to the smooth and pointed extremities; well developed cutting teeth.

The origin and relationships of this phylum are unknown; it will be noted that it is exclusively south Asiatic in distribution and this (Oriental Region) may ultimately prove to be its home and exclusive centre of adaptive radiation.

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[1] See Geol. Mag. (2), Vol. I, Pl. XV, as figured by Davis.

FAMILY RHINOCEROTIDÆ. THEORETICAL SUCCESSION OF PHYLA I–VI IN EUROPE.

		Subfamily: I. Diceratheriinæ.	II. Aceratheriinæ.	III. Brachypodinæ.	IV. Ceratorhinæ.	V. Atelodinæ.	VI. Rhinocerotinæ.
	Recent				Ceratorhinus sumatrensis	Atelodus bicornis " simus.	Rhinoceros indicus. " sondaicus.
Pleistoc.	Upper		[1] Elasmotherium sibericum			" antiquitatis	" sivalensis. " palæindicus.
	Middle					" merckii	
	Lower						
Pliocene.	Upper				C. etruscus C. platyrhinus		
	Middle				C. leptorhinus		
	Lower		Aceratherium incisivum	Teleoceras goldfussi	C. schleiermacheri. [1] C. steinheimensis.	" neumayri " pachygnathus	
Miocene.	Upper		A. tetradactylum.	T. brachypus	C. steinheimensis.		
	Middle		A. tetradactylum.		C. simorrensis. C. sansaniensis.		
	Lower	? Diceratherium douvillei	A. platyodon	T. aurelianensis.			
Oligocene.	Upper	" minutum	A. lemanense				
	Middle						
	Lower	[1] Ronzotherium velaunum [1] " gaudryi	A. filholi				
	Geographical Districts:	Europe, America.	Europe, Asia, America.	Europe, America.	Europe, Asia.	Europe, Africa.	Asia.

[1] Incertæ Sedis,

CONCLUSIONS.

This phylogeny leaves many species untouched and unsettled. It certainly contains both errors and omissions, and I set it forward mainly as a *method of solution of the Rhinoceros problem.*

1. It disregards homoplastic or convergent characters, which are often entirely misleading.
2. Great stress is laid upon exactness as to stratigraphical or geological succession, the neglect of which has been a fertile source of error.
3. According to our present knowledge, none of the six phyla can be connected by European stem forms, as in the phylogenies previously attempted.
4. The newer hypothesis of foreign (African or Asiatic) invasion into Europe of certain phyla has at present more in its favor than the older hypothesis of the derivation of all Upper Tertiary from Lower Tertiary types of Europe.
5. It is a fact that the earliest known members of each phylum show substantially all its fundamental characters; subsequent modifications are adaptive and may be more or less convergent to other phyla.
6. Generic, specific, and subfamily terms are simply our symbols for clear thinking and description. If the hypothesis of six or more distinct phyla is correct, and these breeds or races have been distinct since the Middle, and in some cases since the Early Tertiary Period, then the actual remote relationships of the individual members of said phyla will be most truthfully and clearly expressed both by the revival of certain disused generic names, and by the use of subfamily names.

BIBLIOGRAPHY.

1885. DEPÉRET, CH. Descriptions Géologiques du Bassin Tertiare du Roussillon. *Annales des Sciences Géologiques* (Hébert et Milne Edwards), XVII, pp. 1–272.

1887. DEPÉRET, CH. Recherches sur la Succession des Faunes Vertébrés Miocènes de la Vallée du Rhône. Lyon, 1887.

1877. FILHOL, HENRI. Recherches sur les Phosphorites du Quercy. *Ann. d. l. Soc. Géol.*, pp. 126 *et seq.*

1881. FILHOL, HENRI. Étude des Mammifères Fossiles de Ronzon (Haute Loire). *Annales des Sciences Géologiques*, 1881, XII, 5, Art. 3.

1862. GAUDRY, ALBERT. Animaux Fossiles et Géologie de l'Attique. Paris, 1862–67.

1894. HATCHER, J. B. On a Small Collection of Vertebrate Fossils from the Loup Fork Beds of Northwestern Nebraska; with Note on the Geology of the Region. *American Naturalist*, March 1, 1894.

1832. KAUP, JEAN-JACQUES. Description d'Ossements fossiles de Mammifères inconnus jusqu' à présent. . . . Premier Cahier. Darmstadt, 1832.

1862. KAUP, JEAN-JACQUES. Beiträge zur Näheren Kenntniss der Urweltlichen Säugethiere. Erstes Heft. Darmstadt and Leipzig, 1862.

1881. LYDEKKER, RICHARD. Siwalik Rhinocerotidæ. *Mem. Geol. Surv. India, Palæontologia Indica*, Vol. II, Pt. II, Dec., 1881.

1886. LYDEKKER, RICHARD. Catalogue of the Fossil Mammalia in the British Museum of Natural History. London, Apr. 5, 1886, pt. iii.

1896. MERMIER, ÉLIE. Étude Complémentaire sur l'Aceratherium platyodon de la Molasse burdigalienne supérieure des environs de Saint Nazaire en Royans (Drôme). *Ann. d. l. Soc. Linnéenne d. Lyon*, Tome XLIII, 1896.

1893. OSBORN, HENRY F. *Aceratherium tridactylum* from the Lower Miocene of Dakota. *Bull. Am. Mus. Nat. Hist.* Vol. V, Apr. 29, 1892.

1898, 1. OSBORN, HENRY F. A Complete Skeleton of Teleoceras fossiger. Notes upon the Growth and Sexual Characters of this Species. *Bull. Am. Mus. Nat. Hist.* Vol. X, Art. IV, March 18, 1898, Pl. IV and IVA, pp. 51–59.

1898, 2. OSBORN, HENRY F. The Extinct Rhinoceroses. *Memoirs of the Amer. Mus. Nat. Hist.* Vol. I, Pt. III, Apr. 22, 1898, pp. 75–165, Pl. XIIA–XX.

1899, OSBORN, HENRY F.. Frontal Horn on Aceratherium incisivum. Relation of this Type to Elasmotherium. *Science*, Feb. 3, 1899, pp. 161, 2.

1900, OSBORN, HENRY F. Correlation between Tertiary Mammal Horizons of Europe and America. . . . *Ann. N. Y. Acad. Sci.* Vol. XIII, No. 1, pp. 1–72, July 21, 1900.

1892. PAVLOW, MARIE. Études sur l'Histoire Paléontologique des Ongulés. VI. Les Rhinoceridæ de la Russie et le dévelopement des Rhinoceridæ en général. *Bull. d. l. Soc. d. Nat. d. Moscou*, 1892.

1866. RAMES, B. Note sur l'âge des argiles du Cantal et sur les débris fossiles qu'elles ont fournis. *Bull. d. l. Soc. Géol. d. France*, Tome XIV, 1866, p. 357.

1900. ROGER, OTTO. Ueber Rhinoceros Goldfussi, Kaup und die anderen gleichzeitigen Rhinocerosarten. *Separatabdruck aus dem 34. Bericht des Naturwissenschaftlichen Vereins für Schwaben und Neuburg in Augsburg.*

Oxyæna and Patriofelis Re-studied as Terrestrial Creodonts.

By Henry Fairfield Osborn.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XIII, Article XX, pp. 269–279.

New York, Dec. 21, 1900.

The Knickerbocker Press, New York

Article XX.—OXYÆNA AND PATRIOFELIS RESTUDIED AS TERRESTRIAL CREODONTS.

By Henry Fairfield Osborn.

Plates XVIII and XIX.

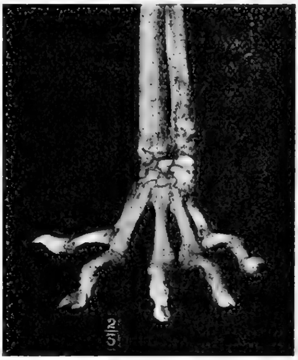


Fig. 1. *Didelphys virginiana*, left fore foot.

Comparatively little was known of the skeletal structure of these animals until the American Museum Expeditions of 1891 and 1893 secured complete skeletons of each, which Dr. J. L. Wortman carefully described and figured. After a searching comparison with modern land and water Carnivora he concluded that *Patriofelis* was probably *aquatic in habit and possibly ancestral to the modern Pinnipedia* and that the much older type *Oxyæna* and the more recent type *Oxyænodon*, bore similar testimony to affinities with the Seals. In describing *Patriofelis* he remarked: "The broad, flat, plantigrade feet with their spreading toes suggest at the first glance their use for swimming" ('94, p. 161).

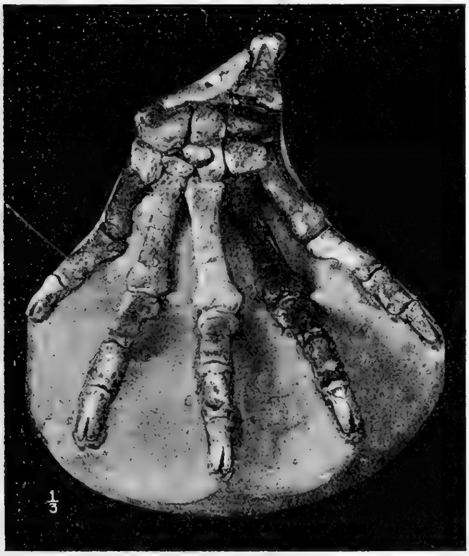


Fig. 2. *Patriofelis ferox*, left fore foot, from mounted skeleton.

Recently, under the direction of the present writer, the *Oxyæna lupina* skeleton has been mounted and the *Patriofelis ferox* skeleton taken apart and remounted by Mr. Hermann, head preparator. At the same time several alterations were made in the restored parts of the skull of *Patriofelis*, the teeth were restored, one dorsal vertebra added, and, for reasons stated below, the feet reset in an angulate subdigitigrade instead of a plane plantigrade fashion. A more thorough study of the dentition of this animal was also made from all the materials in the Museum.

In this connection a careful restudy of all the evidence led the writer to the opposite conclusion, that these were powerful *terrestrial, or partly arboreal, animals, analogous to the Cats in habits of feeding*, with analogous (not homologous) sectorials, clumsy in limb structure, without prehensile claws, and presenting no evidence of successors among the modern Carnivora. The reasoning upon which this conclusion is based is, in brief, that the alleged points of resemblance to the Pinnipedia are in part persistent primitive characters due to the descent of the Oxyænidæ and Pinnipedia from a common Insectivore-Creodont ancestor, in part homoplastic adaptive characters due to similar habits or uses of certain parts of the body, while the main trend of adaptation is divergent from the Pinnipedia as seen both in the teeth and feet, and from all other modern Carnivora, especially as seen in the teeth.

In this paper the principal osteological and dental characters will be briefly restated with a number of corrections and additions, referring the reader back to Wortman's fuller papers for details.

I. Evidence for Terrestrial Habits.

1. *The Feet.*

It was claimed (Wortman, '94, p. 161) that the plantigrade feet with spreading toes indicated a webbed ('94, p. 146) or swimming foot. It will be observed by comparison of the photographs (Figs. 1, 2) that the feet of *Patriofelis* are no more widely spread than those of the terrestrial and arboreal *Didelphys*. Moreover, the planes of the articular facets of the metapodials and phalanges in *Patriofelis* entirely forbid the supposition that this animal was plantigrade.

The writer has pointed out ('00, p. 91) that the angulation of the limbs in Ungulates is expressed in the angles which the proximal and distal facets make with the long axes of the shafts; *considering the shafts as perpendicular, facets in horizontal planes indicate straight limbs; facets in oblique planes indicate angulate limbs.* Exactly similar principles apply to the hand and foot of Unguiculates, as shown in Fig. 3. In the passage from *Otaria* (secondarily plantigrade), *Ursus* (primarily plantigrade), *Procyon* (subdigitigrade), and *Felis* (digitigrade), we see that the planes of the distal facets give certain indication of the modes of progression.

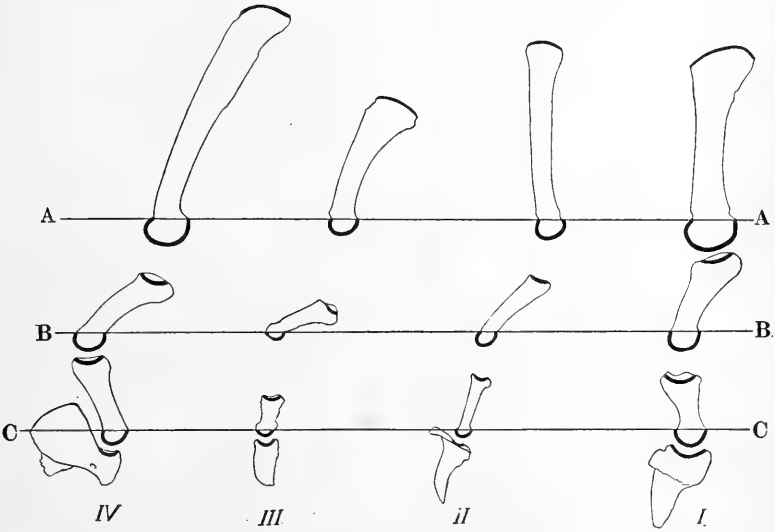


Fig. 3. Angulation of facets in feet of (I) *Ursus*, (II) *Procyon*, (III) *Patriofelis*, (IV) *Felis*, showing increased obliquity in relation to increased angulation.
A, distal facets of metacarpals; B, distal facets of 1st phalanx; C, distal facets of 2d phalanx.

1. As regards angulation, *Patriofelis* is shown to occupy a position intermediate between *Procyon* and *Felis*, with a decidedly *angulate* foot, the angles between phalanges 1 and 2 being especially acute. This proves that the metapodials, as well as phalanges 1 and 2, were raised off the ground by palmar and plantar pads as in *Felis*. Taking a conservative view, the feet of *Patriofelis* may be described as subdigitigrade in position. The straight terminal claws indicate that they entirely lacked the grasping and tearing power developed in *Felis*.

2. As observed by the writer and Wortman in *Oxyæna* ('99, p. 144): "There is reason to believe that the habitual position of the foot was digitigrade, but there is no evidence of any retractility of the claws." Beginning therefore with a subdigitigrade foot, the progression from *Oxyæna* to *Patriofelis* does not indicate an advance toward secondary plantigradism, as would be the case if these animals were becoming more and more aquatic in habit. On the contrary, the analogy of the feet of the known Oxyænidæ with those of *Procyon* and *Didelphys* would indicate that they were used mainly in slow terrestrial or arboreal locomotion, and exceptionally if at all in swimming.

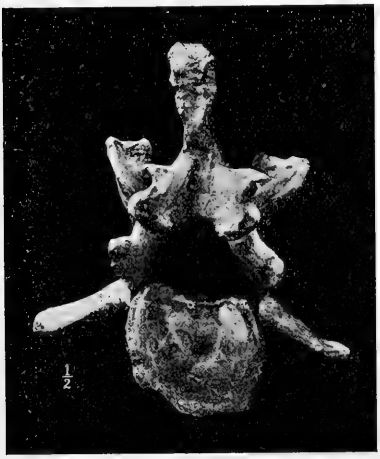


Fig. 4. *Patriofelis ferox*, typical lumbar vertebra, posterior view.

2. *The Dentition.*

The lack of prehensile power in the feet of *Patriofelis* is compensated for in an extraordinary manner by the increased prehensile power in the progressive evolution of the teeth; this again is analogous to that of the Felidæ in its *extreme heterodontism* or specialization, whereas the key-note of dental evolution among the Pinnipedia is a *secondary homodontism* or reduction of the premolars and molars to a common triconodont pattern. The dental parallelism of the Oxyænidæ with the Felidæ is well stated by Wortman ('99, p. 140).

The progression of both skull and teeth in the Oxyænidæ is towards a raptorial type with increasing temporal and masseter muscles, deep zygomatic arch and large temporal fossa, heavy jaw, deep and broad symphysis, with the biting power concentrated at three points, namely, the canines, the fourth lower premolar, and the enormous carnassial teeth; the carnassials

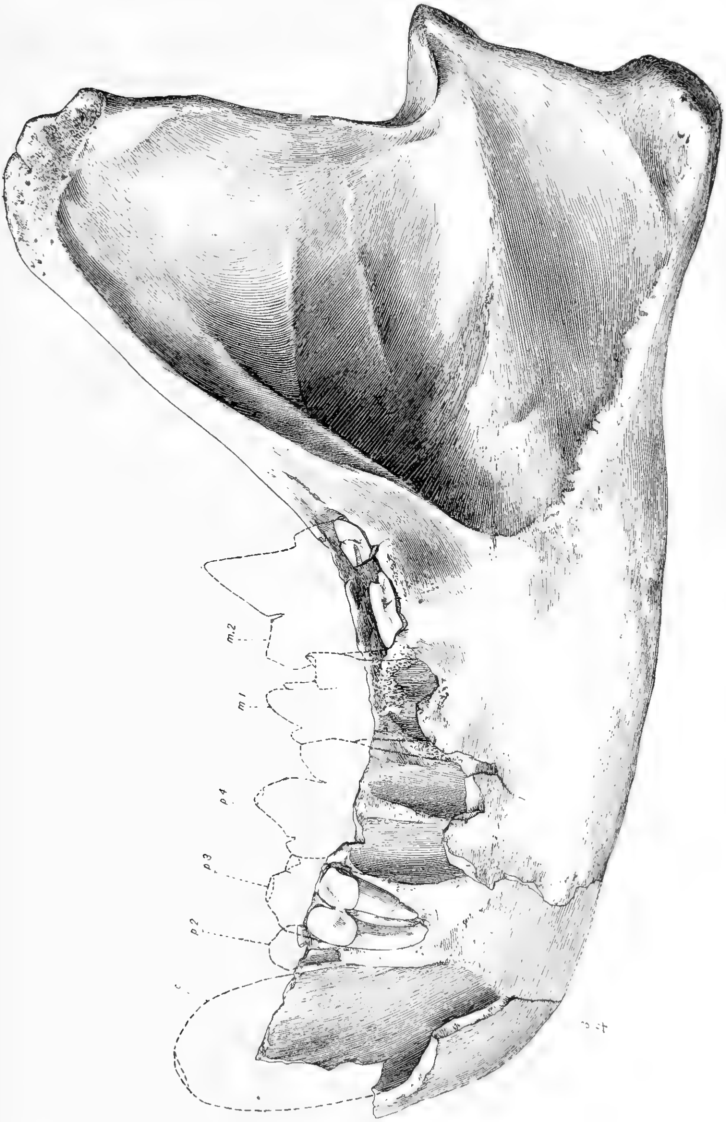


Fig. 5. *Patriofelis ferox.* Left lower jaw, external view (No. 1507 coll. A. M. N. H.). Specimen included in mounted restoration.

are adapted to flesh and bone cutting by the loss of the talonid exactly as in *Felis.* We should emphasize the contrast however :

	Carnassials	
Oxyænidæ	First upper molar	Second lower molar
Felidæ	Fourth upper premolar	First lower molar

II. COMMON CREODONT CHARACTERS OF THE OXYÆNIDÆ.

As stated above, many primitive Insectivore-Creodont characters are found in this family which are also found in other types. Among these are :

An alisphenoid canal ; exposure of mastoid (*Patriofelis*) ; small brain ; large temporal fossa ; cranium constricted behind the orbits (as in Mesonychidæ and Arctocyonidæ) ; powerful caudals ; elbows everted ; prominent deltoid crest and entepicondylar foramen of humerus ; separate scapho-lunar ; free centrale ; large trapezium ; small trapezoid ; femur with 3d trochanter and shaft expanded distally; astragalus with flat oblique tibial trochlea and astragalar foramen (as in Creodonta and Pinnipedia) ; small mesocuneiform (functionally analogous to the small trapezoid) ; distal phalanges cleft distally (as in many Creodonts and Condylarths) ; metapodials I–V relatively well developed.

III. SPECIALIZED CHARACTERS OF THE OXYÆNIDÆ.

Progressive shortening of the face and elongation of cranium with reduction of teeth and development of jaw muscles ; high sagittal crest ; occiput narrow ; a preglenoid process ; a large postmastoid foramen ; no postglenoid foramina ; mandibular condyles scroll-like (as in Felidæ) ; atlas with form and vertebrarterial canal as in Felidæ (Wortman, '94, p. 137) ; axis with elongate spine ; certain dorsals and lumbars with progressively revolute zygapophyses (as in Mesonychidæ and certain Pinnipedia, *Phoca*) ; lumbars with progressively developed anapophyses ; scapula, humerus, and ulna of about equal length ; scapula very large, spreading superiorly (imperfectly known in *Oxyæna*), supra- and infraspinous fossæ subequal; powerful acromion and metacromion processes; humerus with exceptionally elongate and prominent deltoid crest, powerful supinator ridge, large entepicondyle and entepicondylar foramen ; olecranon process of ulna elongate, ulna grooved anteriorly ; limited rotation of forearm owing to proximal expansion of radius ; feet spreading ; trapezium extended transversely (as in Pinnipedia, Wortman) ; dorsal portion of distal metapodial facets hemispherical, ventral portion keeled (as in Fissipedia, Wortman) ; digits angulate, the second phalanges strongly flexed upon first phalanges ; subungual (retractile) processes of distal phalanges well developed (as in Pinnipedia ; in Fissipedia subungual processes small, foramen vestigial, Wortman) ; ilium expanded on superior (post-iliac) border into a broad lamina ; pubic symphysis not anchylosed ; patella large ; fibula unreduced, articulating with side of astragalus but not articulating with calcaneum (progressive) ; tibia with twisted shaft and cnemial spine ; tibio-astragalar facet flat, obliquely placed ; calcaneo-cuboidal facet very oblique ; large astragalo-cuboidal facets ; external calcaneal tubercle large (as in many Creodonts and Amblypods).

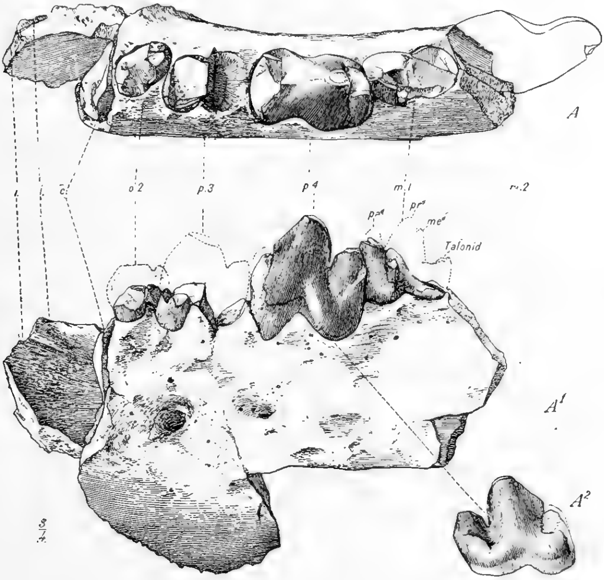


Fig. 6. *Patriofelis ferox.* Lower jaw, left side ; A, crown view ; A¹, external view; A² internal view of 4th premolar (No. 1508 coll. A. M. N. H.).

IV. PROGRESSIVE AND SPECIFIC CHARACTERS.

The above and the following characters show probably the *main trend of evolution in the* Oxyænidæ ; they are derived from a comparison of *Oxyæna lupina* (Wasatch, Sparnacien) and *Patriofelis ferox* (Bridger, Bartonien) ; it is important to note that *O. lupina* is an exceptionally slender species, some of its Wasatch contemporaries were more robust, whereas *P. ferox* is an exceptionally robust species. The differences between these species are therefore partly such as we should expect to find in the comparison of any slender and robust types, and partly truly progressive for the family.

Oxyæna lupina.	*Patriofelis ferox.*
Incisors $\frac{3}{3}$	? Incisors $\frac{?}{2}$
Canines sub-oval.	Canines laterally compressed.
Premolars $\frac{4}{4}$.	Premolars $\frac{3}{3}$.
Molars $\frac{2}{2}$.	Molars $\frac{1}{2}$.
First lower molar tuberculo-sectorial ; second ditto sub-sectorial with talonid preserving three reduced cusps.	First lower molar reduced, tuberculo-sectorial ; second ditto truly sectorial with vestigial talonid.
Second upper molar transverse.	Ditto absent.
First upper molar sub-sectorial, with protocone relatively prominent.	First upper molar blade-like, sectorial, with protocone reduced and para- and metacones greatly elevated and connate.
Skull relatively slender.	Skull broad and massive.
Dorsals 13, lumbars 7 = 20 D.L.	Dorsals 14, lumbars 6 = 20 D.L.
	Sacrals 3 ; 2 sacrals uniting with ilium.
Caudals numerous.	Caudals 28, large chevrons.
Limbs, chest, and back slender.	Ditto robust.
Lumbars typical with simple zygapophyses ; small anapophyses on L 1–2.	Lumbars, massive, heavy, with extremely revolute zygapophyses ; anapophyses on L 1–4.
Tibia with short cnemial spine.	Tibia with elongate cnemial spine.
	Six sternebræ.
	Ribs heavy.

V. SYSTEMATIC REVISION.

Family *Oxyænidæ.* Terrestrial or arboreal Creodonts ; strictly carnivorous in habit ; enlarged canines ; second upper molars when present transverse ; powerful sectorials formed of first upper and second lower molars ; incisors,

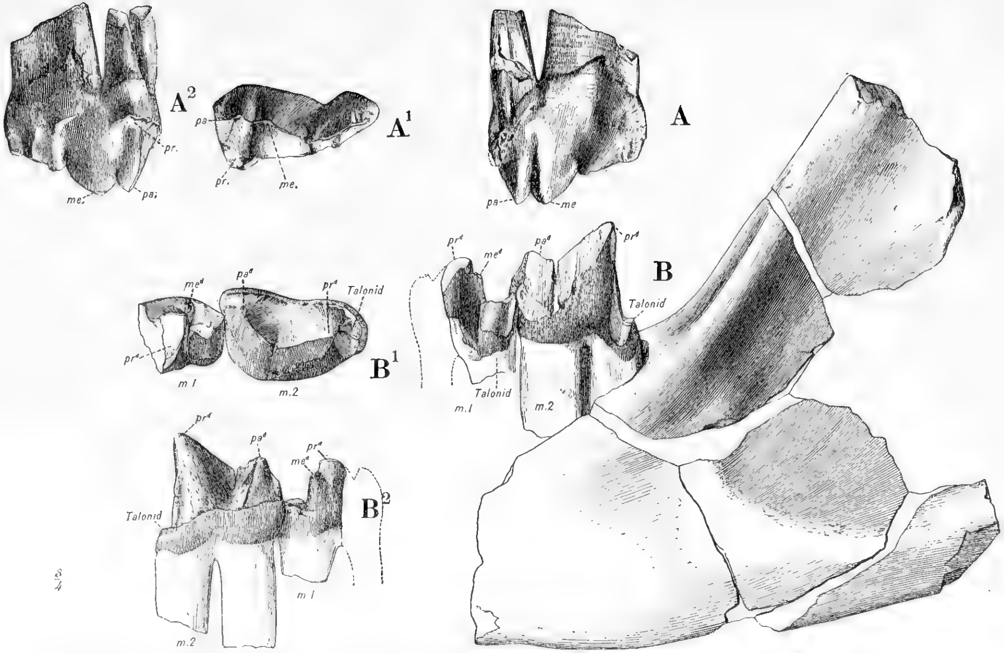


Fig. 7. *Patriofelis ferox.* A, external view; A¹, crown view; A², internal view of isolated 1st superior premolar (No. 2303 coll. A. M. N. H.). B, type of *Protopalsis tigrinus* (No. 4805 coll. A. M. N. H.); external view of jaw; B¹, crown view of 1st and 2d molars; B², internal view of 1st and 2d molars.

premolars, and molars progressively reduced and specialized; subdigitigrade, metapodials 5–5 spreading, not interlocking.

Lower Eocene.	Middle Eocene.	Upper Eocene.
Oxyæna Cope.	*Patriofelis* Leidy. Syn: Limnofelis Marsh. Protopalsis Cope.	*Oxyænodon* Wortman.
Dentition $\frac{3}{3}. \frac{1}{1}. \frac{4}{4}. \frac{2}{2}. = 40.$	$\frac{2}{2}. \frac{1}{1}. \frac{3}{3}. \frac{1}{2}. = ?\ 32.$	$\frac{3}{3}. \frac{1}{1}. \frac{4}{4}. \frac{2}{2}. = 40.$
Premolars with large talonids.	Premolars with talonids.	Premolars with small talonids.

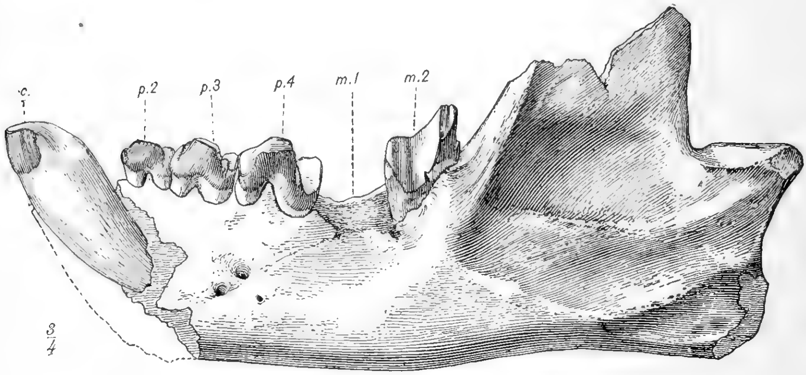


Fig. 8. *Patriofelis ulta.* Lower jaw, left side (No. 2691, coll. A. M. N. H.).

Dentition of Patriofelis.

The teeth of the animal are so distinctive that they deserve a detailed description; they exhibit a very decided evolution beyond those of *Oxyæna*.

Incisors.—The jaw (No. 1508) exhibits alveoli for two incisors, one of which is placed directly behind the other (Fig. 6).

Canines.—The alveolus and fang embedded in jaw No. 1508 indicate marked lateral compression of both fang and crown.

Lower premolars.—First, entirely wanting (Figs. 5, 6); *Second* (No. 1508), close to canine, two-fanged, with crown obliquely placed (see Fig. 6, A); *Third*, a somewhat larger tooth longitudinally placed, two-fanged, crown not preserved; *Fourth* (No. 1508, Fig. 6, A, A^1, A^2), a triconodont type of tooth; enlarged, antero-posterior diameter of fangs = 210 mm.; a large central protoconid, an anterior cusp (broken away in No. 1508), and a posterior cusp, or talonid, with a small basal postero-internal cusp.

Lower molars.—First, a relatively small tooth; antero-posterior diameter of fangs = 170; in No. 4805 the posterior half of the crown only is preserved; it exhibits the protoconid, a small elevated metaconid; the talonid is narrow and feebly tri-cuspidate; in No. 1508 the paraconid is partly preserved; *Second,* a powerful shear (No. 4508, Fig. 7, B) formed of an outwardly placed paraconid and a sharp elevated protoconid; the metaconid vestigial or represented by a very low ridge; the talonid reduced to a cingulum.

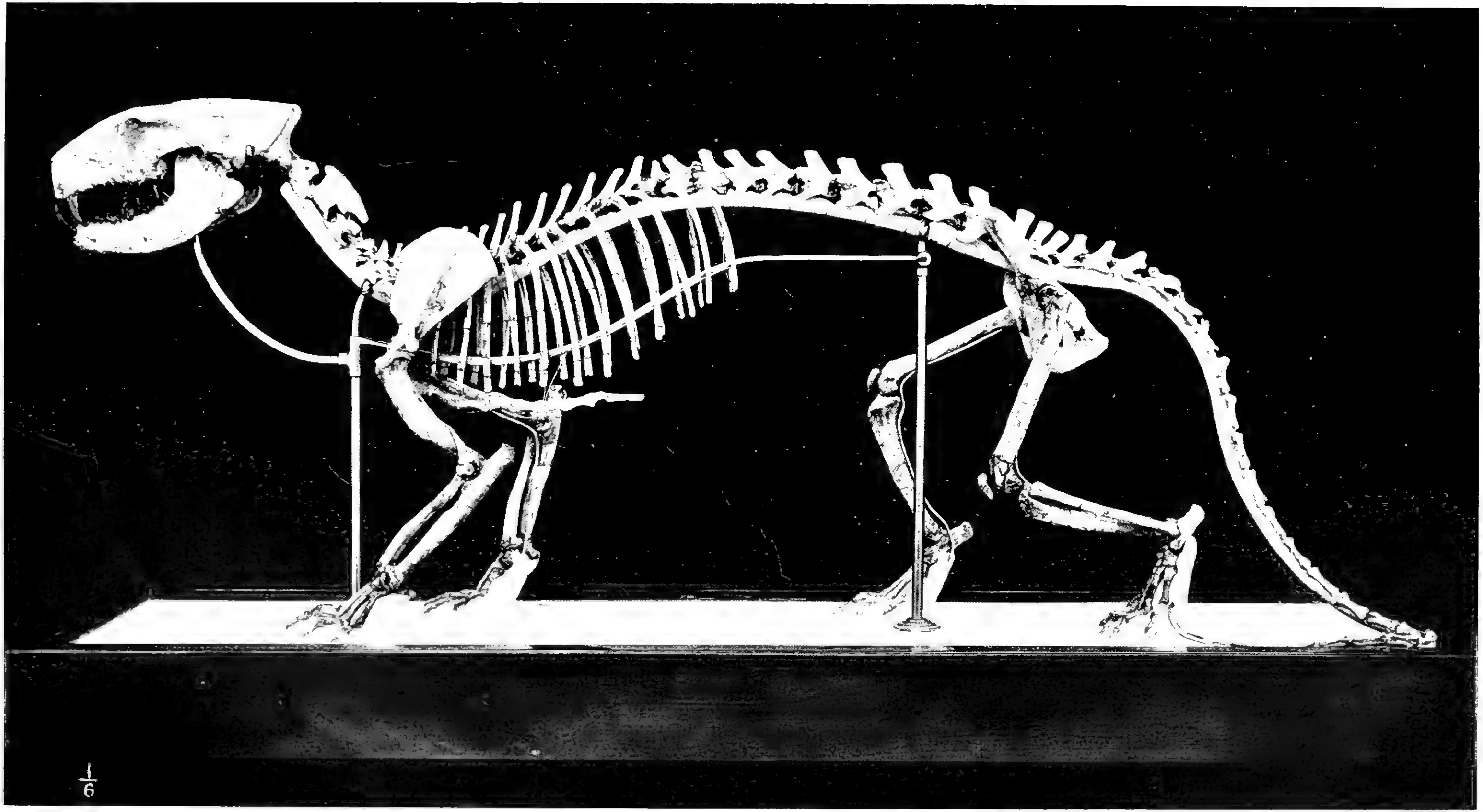
First upper molar.—(No. 2303, Fig. 7, A, and No. 1508, A, both teeth of the left side.) This is a powerful carnassial; the elongated shear (No. 2303) consists of the greatly modified trigon and metastyle; the protocone is depressed and reduced to a basal spur; the paracone and metacone consist of a pair of elevated connate subequal cusps; the metastyle is an elongate less elevated shear. In the greatly worn condition seen in No. 1508, A, as well as in No. 2691, *P. ulta,* the crown of the tooth retains its sharpness, proving that these teeth were employed as in *Felis.*

BIBLIOGRAPHY.

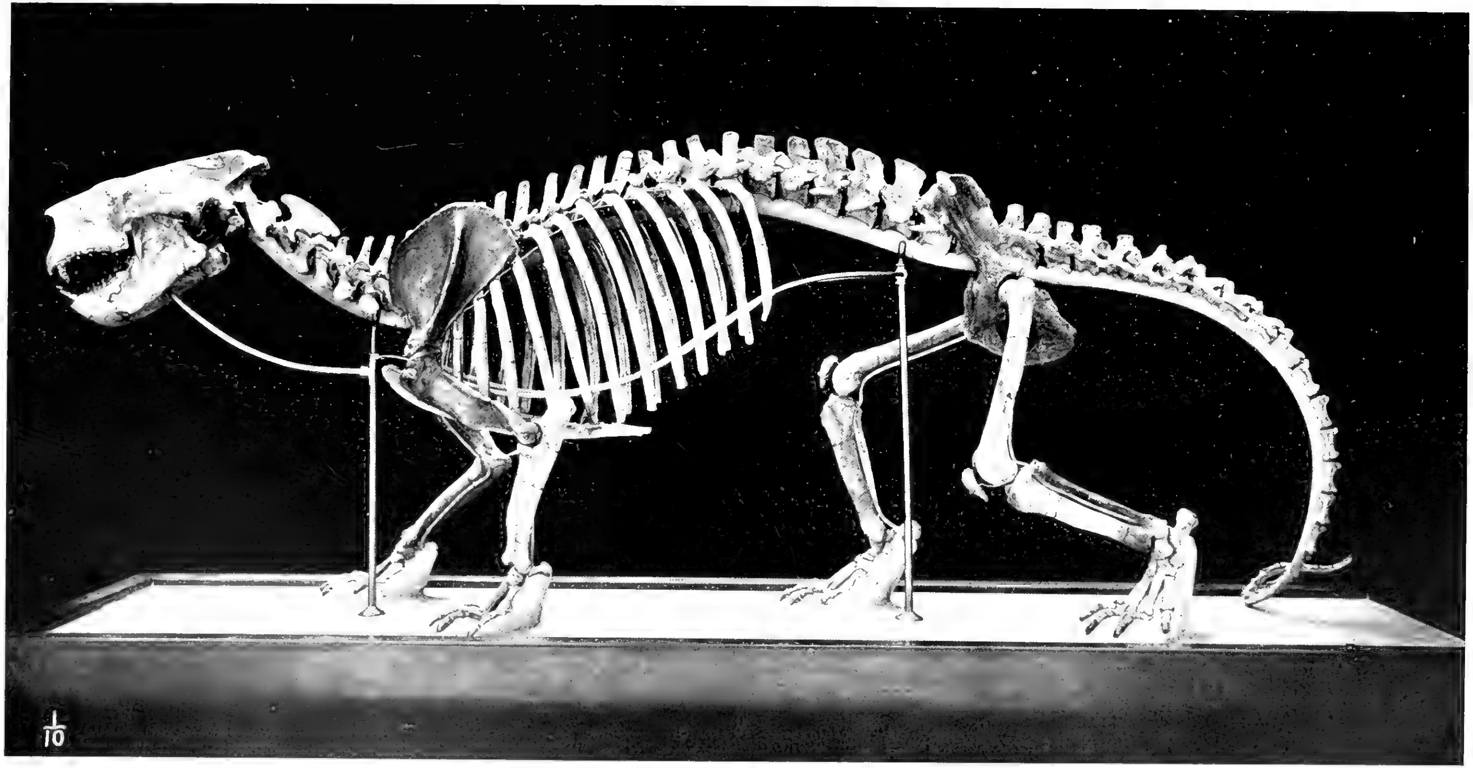
1900. OSBORN, H. F. The Angulation of the Limbs of Proboscidia, Dinocerata, and other Quadrupeds in Adaptation to Weight. *Amer. Nat.* Vol. XXXIV, No. 398, pp. 89–94. Boston, Feb. 1900.

1894. WORTMAN, J. L. Osteology of Patriofelis, a Middle-Eocene Creodont. *Bull. Amer. Mus. Nat. Hist.* Vol. VI, Art. V, pp. 129–164. New York, May 24, 1894.

1899. WORTMAN, J. L. Restoration of *Oxyæna lupina* Cope, with Descriptions of Certain New Species of Eocene Creodonts. *Bull. Amer. Mus. Nat Hist.* Vol. XII, Art. VII, pp. 139–148. New York, June 21, 1899.



Oxyæna lupina, Mounted Skeleton in the American Museum. One Individual.



Patriofelis ferox. Remounted Skeleton in the American Museum. Including Parts of Two Individuals.

Additional Observations on the Creodonta.

By W. D. Matthew.

AUTHOR'S EDITION, extracted from BULLETIN

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New York, January 31, 1901.

The Knickerbocker Press, New York

Article I.—ADDITIONAL OBSERVATIONS ON THE CREODONTA.

By W. D. Matthew.

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I.—Classification.

In classifying any group which includes a large proportion of primitive types we must use some combination of two methods. A division may be considered either as a group of forms resembling a given type within certain limits, or as including a particular line of development. Osborn has termed these two principles of classification the "horizontal" and "vertical"; it appears to the present writer that *group* and *race* would more truly express their intent. By the former method the unspecialized ancestral types of several families are placed in a separate family, from which the later families are derived. This is on the ground that the distinctions between the different lines of descent were not at first wide enough to be of family value, and that the different primitive types resembled each other more than they did any of the later specialized types. The other method of classification divides up these primitive types among the various specialized families to which they are ancestral or approximately ancestral. The group conception — the Latin *familia* = household — is, of course, the original use of the term; the race conception — the English *family* — has been introduced to meet the new conditions brought in by the doctrine of evolution and the development of palæontology.

It seems to the writer that either principle, used exclusively, results in obscuring, or at least imperfectly indicating, the real relationships the expression of which should be its chief purpose. The group method ignores parallelism, and fails to properly emphasize the lines of descent. The race method equally fails to emphasize the near relationship of the primitive root types, and in practice causes much confusion and apparent variance of opinion by the attempt to divide into different families species among which the distinctions have not yet become of generic value.

Among the fossil Mammalia these two methods are used in very varying proportion. In some groups, such as the Perissodactyls, the divisions have been drawn 'vertically,' all the ancestors of a family being placed in that family, so that the primitive Perissodactyls of the Lower Eocene, exhibiting no more difference in the sum of their characters than the different species of modern *Rhinoceros*, are divided among six different families, the typical forms of which are extremely different from any of these primitive forms; and the various species are moved about from one to another of these families with the utmost facility by every author who attacks the problem anew. In fact, constant specific distinctions are not always easy to find among them. In other groups, such as the Creodonta, all the ancestors of the modern types, together with those ancient types which have left no descendants, are placed in a separate suborder, distinguished by the absence of a specialized character common to all the modern families. Similarly among the Creodont families, the primitive types have been grouped separately from the specialized ones by almost all writers, the family distinctions being on points of specialization or non-specialization.

The present writer is in a position to appreciate very much the evil effects of unnecessary changes in nomenclature and is inclined to deprecate most strongly the perpetual changes caused by a too strict adherence to laws of priority which were not designed for palæontology, and do not entirely fit its requirements. With the progress of the science it becomes more and more evident that a very large proportion of the earlier species were founded on indeterminate material; and the vain attempt to find reasons for identifying these fragments with one or another of the species distinguishable by more perfect material has wasted a vast amount of time, and, however valuable from an antiquarian standpoint, adds not one iota to our knowledge of the fossil animals themselves and their place in nature. Scientific names are not different from other names — they are merely arbitrary terms representing each a certain conception; and it appears to the writer that custom should be the chief rule to govern their use.

With classifications the case is different. A classification is not arbitrary, but an expression of the natural relationship as nearly as our knowledge of the species and the limitations of the method used will permit. Conservatism in classification would mean cessation in the increase of our knowledge of a group; uniformity in it would be impossible, unless all observers attached the same relative importance to the same characters. A comparatively slight divergence of opinion on the last point may involve an entire upset in the classification scheme. A graphic method (such as is used on p. 21 in illustrating the relations of three of the Creodont families) would more accurately express the conception; but in such a method it is seldom possible to include all members of a group — the physical difficulties of space of two dimensions prevents the complete representing of polydimensional relationships.

In venturing, therefore, on very considerable changes in classification from that generally accepted, and embodied especially in so accurate and recent a text-book as Prof. Zittel's, I must disclaim any really radical changes in relations, except in a few cases. The recent study of far more complete Creodont material than has ever before been accessible has led American students to perceive the fundamental importance of certain lines of genetic cleavage somewhat less appreciated hitherto, and to make these the primary basis for division rather than differences which are now perceived to be in large part only contrasts between primitive and specialized types.

First in importance among these characters of divergent specialization is the position of the carnassial teeth. In the primitive types the shear between upper and lower molars is absent or rudimentary and about equally developed on all three molars. In some of the specialized types it is chiefly between p^4 and m_1, as in all modern Carnivora. In others it is chiefly between m^1 and m_2, or between m^2 and m_3. A large number of the primitive genera of the Creodonta show, in some of their species at least, a more or less evident tendency towards one of these three specializations.

A primary division on these lines, worked out by Dr. Wortman and the writer, and published by Wortman a year ago ('99, p. 139), had been previously independently elaborated though not published by Prof. Osborn for use in his University lectures, in either case chiefly the result of study of the large series of Creodonta in the American Museum collections.

Another line of cleavage as yet imperfectly known, but which may prove to be of importance equal to or greater than the above, lies in the character of the claw-phalanges. In one group of Creodonts they are short, wide, and split, indicating a more or less hoof-like claw, probably used for locomotion only. In the other they are like those of most modern Carnivores, sharp, laterally compressed, bearing apparently a sharp curved claw which could be used as a weapon. This character is known in the following:

No carnassial	*Arctocyonidæ*	*Clænodon* (both species)	Sharp-clawed.
Carnassial $\frac{p^4}{m_1}$	*Viverravidæ*	*Viverravus* (two species)	
" $m\frac{2}{3}$	*Hyænodontidæ*	*Hyænodon*	Blunt-clawed.
" $m\frac{1}{2}$	*Oxyænidæ*	*Oxyæna*, *Patriofelis*	
No carnassial	*Mesonychidæ*	*Pachyæna*, *Mesonyx*	

Thus, as far as it goes, this distinction coincides with that between the *Creodonta adaptiva* (carnassial $\frac{p^4}{m^1}$) and *Creodonta inadaptiva* (carnassial not $\frac{p^4}{m_1}$). *Arctocyon* must be included with the adaptive types and *Mesonyx* with the inadaptive, although they have no true carnassials, an arrangement which seems to be supported by a variety of minor skeletal characters. But the evidence is entirely inadequate at present to use this as a primary basis of division. Its constancy in both the small and large genera of a family has not been proved, and until this is proved it is always possible that the blunt claws are correlated with the size of the species, not with its true relationships.

Zittel ('94), following Schlosser and Scott in large part, divides the Creodonta as follows (I omit invalid or unimportant genera):

I. *Oxyclænidæ.* Molars tritubercular, pointed cusp, no shear; premolars trenchant. *Oxyclænus*, *Chriacus*, *Protochriacus*, *Tricentes*, *Mioclænus*, *Protogonodon.*

II. *Arctocyonidæ.* Molars quadritubercular, low-cusped, no shear; premolars trenchant. *Arctocyon*, *Clænodon*, *Anacodon.*

III. *Triisodontidæ.* Upper molars tritubercular, lower molars with two high cusps and talonid. No shear. Premolars high and pointed. *Triisodon*, *Goniacodon*, *Microclænodon*, *Sarcothrausten.*

IV. *Mesonychidæ.* Upper molars tritubercular, lower molars with high and low cusp and talonid. No shear. Premolars high and pointed. *Dissacus*, *Pachyæna*, *Mesonyx.*

V. *Proviverridæ.* Upper molars and $p^{\underline{4}}$ tritubercular, protocone far in and well forward. Lower molars with high tricuspid trigonid and low talonid. *Hyænodictis*, *Deltatherium*, *Sinopa*, *Proviverra*, *Quercytherium*, *Didelphodus*, *Prorhyzæna.*

VI. *Palæonictidæ.* Jaw shortened. Third upper and lower molar absent. Molars tritubercular, $p^{\underline{4}}$ and $m_{\overline{1}}$ large. Premolars thick. *Palæonictis*, *Amblyctonus*, *Patriofelis.*

VII. *Hyænodontidæ.* Upper molars with external blade and internal tubercle. Third upper molar transverse or absent. Lower molars sectional with low, trenchant heel. *Oxyæna*, *Protopsalis*, *Hemipsalodon*, *Pterodon*, *Dasyurodon*, *Thereutherium*, *Hyænodon.*

VIII. *Miacidæ.* $p^{\underline{4}}$ and $m_{\overline{1}}$ carnassial. Last upper molar small, transverse. *Miacis* (= *Uintacyon*), *Didymictis* (= *Viverravus*), ? *Vulpavus.*

The following changes, mainly dependent on recent discoveries, seem advisable:

Oxyclænidæ. *Mioclænus* is either Primate or Condylarth, *M. acolytus* certainly the former.[1] *Protogonodon* is Condylarth (although difficult to separate from *Protochriacus* in the lower dentition).

Triisodontidæ should, as Wortman suggests ('99, p. 146), be considered as a subfamily of Mesonychidæ.

Proviverridæ is a heterogeneous group of genera, chiefly unspecialized types of different phyla. I believe it can be broken up with advantage, the more primitive types being placed with the Oxyclænidæ, to which they are very close; the more advanced genera being distributed among the specialized families. *Hyænodictis* has the lower molars of the Mesonychidæ, but the upper teeth are like those of *Pterodon;* I am unable to see how the two styles of tooth could work together in the same jaw, and compelled to suggest incorrect association. *Deltatherium* is very close to *Chriacus* of the Oxyclænidæ. Some of the species of *Sinopa*, though not all, show the specialization of $\mathrm{m}\frac{2}{3}$ as carnassials, and all show characters, in the upper molars especially, allying them with either the Oxyænidæ or Hyænodontidæ. *Proviverra* is rather closer to *Sinopa* than to the Oxyclænidæ; *Didelphodus* and *Prorhyzæna* are unspecialized types with a leaning towards the *Sinopa* characters. *Quercytherium* seems to be a very aberrant Hyænodont.

Palæonictidæ. With this and the succeeding family an entire upset of the classification seems necessary, for *Patriofelis* is rather closely related to *Oxyæna*, which is very far from being closely related to *Pterodon* and *Hyænodon;* the resemblances between them are strictly parallelisms. We therefore divide these families as follows:

PALÆONICTIDÆ. $\mathrm{P}^{\underline{4}}$ and $\mathrm{m}_{\overline{1}}$ carnassial, posterior teeth disappearing. *Palæonictis*, *Amblyctonus*, ? *Ælurotherium.*

OXYÆNIDÆ. $\mathrm{M}^{\underline{1}}$ and $\mathrm{m}_{\overline{2}}$ carnassial, posterior teeth disappearing. *Oxyæna*, *Patriofelis* (= *Protopsalis*), *Thereutherium*, *Telmatocyon.*

HYÆNODONTIDÆ. $\mathrm{M}\frac{2}{3}$ carnassial, $\mathrm{m}^{\underline{3}}$ disappearing. *Hyænodon*, *Pterodon*, *Quercytherium*, *Cynohyænodon*, *Sinopa*, ? *Didelphodus*, ? *Palæosinopa.*

"*Miacidæ.*"—Wortman and the writer have shown in a recent paper ('99, p. 110) that *Miacis* is a synonym of *Vulpavus* and

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[1] The primate skeleton from the Puerco described by Osborn and Earle in 1895, and referred to *Indrodon*, is *M. acolytus*. *M. turgidunculus*, *lemuroides*, *inæquidens*, ? *opisthacus*, and ? *turgidus* may also be placed provisionally among the Primates.

Didymictis of *Viverravus.* The name Miacidæ therefore cannot be used, although the family Viverravidæ there proposed by us may perhaps be extended so as to take in *Vulpavus* and *Uintacyon*, should these prove to have the Creodont carpus.

The analysis of the Creodonta on the primary basis of the specialized carnassial will stand thus :

I. CREODONTA PRIMITIVA. No specialized carnassial ; tritubercular upper and lower molars, shear rudimentary or absent. Claws unknown.

Oxyclænidæ. Includes some genera with Lemuroid affinities in the dentition.

II. CREODONTA ADAPTIVA. Carnassial when present on p^4 and $m_{\overline{1}}$. Claws, where known, of modern type, and probably carried more or less free of the ground. Scapholunar-centrale early uniting (podials tending towards true Carnivore type).

1. Post-carnassial teeth disappearing.......................... *Palæonictidæ.*
2. Post-carnassial teeth becoming tubercular............... *Viverravidæ.*
3. No carnassials, molars becoming flat-crowned, premolars disappearing.. *Arctocyonidæ.*

III. CREODONTA INADAPTIVA. Carnassial when present not on p^4 and $m_{\overline{1}}$. Claws, where known, blunt, hoof-like, resting on the ground. No tendency to union of the carpals (podials tending towards Ungulate type).

1. Carnassials $m\frac{1}{2}$. Shearing teeth........................... *Oxyænidæ.*
2. Carnassials $m\frac{2}{3}$ " " .... *Hyænodontidæ.*
3. No carnassials, teeth with high, round, blunted cusps, upper molars tritubercular, lower molars premolariform................ *Mesonychidæ.*

There is probably a definite correlation between the hoof-like claws and the lack of union among the carpals in *Oxyæna*, *Mesonyx*, and *Hyænodon ;* but that the division in foot-characters coincides with that based on carnassial specialization is not yet proven.

The Creodonta Adaptiva early gave rise to the true Carnivora (by union of the carpals), and are not known to have existed later than the Wasatch, although the Middle Eocene of *Vulpavus* and *Uintacyon* may, when the carpus is known, prove to be Creodonts. The Creodonta Inadaptiva persisted side by side with true Carnivora until the close of the Oligocene, but none of them can be admitted as ancestral to any true Carnivore, unless the supposition that has successively been raised about each of the three families, connecting them with the Pinnipedia, should be proven by satisfactory evidence.

Of the modern Carnivore families we may derive the Viverridæ, Canidæ and Procyonidæ, and perhaps the Mustelidæ, from the Viverravidæ ; the Felidæ and ? Hyænidæ probably from the Palæonictidæ ; the Ursidæ either from Arctocyonidæ or, with the Canidæ, from Viverravidæ—as discussed later in this paper.

As for the Pinnipedia, it appears to me that there is no evidence sufficient to justify our deriving them from any known type of Creodont or Carnivore, and that their ancestors are not very likely to be found in the almost exclusively terrestrial fauna of the fossil beds of the Bad Lands. (See also Osborn, '00.)

II.—Family VIVERRAVIDÆ *Wortman & Matthew.*

Viverravus *Marsh.*

Syn., *Didymictis* COPE.

"The lower jaws in this genus are long, very slender and compressed ; the last two molars are tubercular.[1] Both have the posterior part of the crown quite low and the anterior half elevated and composed of three angular cusps. The four teeth anterior to these[2] are much compressed. The upper flesh tooth closely resembles that in some of the Viverridæ, and the genus should probably be referred to that group."—*Marsh*, '72, p. 7, of separate.

"Inferior molars six, consisting of four premolars and two molars. True molars, a posterior tubercular and an anterior tuberculo-sectorial, *i. e.*, with three elevated cusps and a posterior heel. Premolars with a lobe behind the principal cusp. Canine teeth directed forward, and close together, so that it is doubtful whether there were any incisors. An ungual phalange of the typical species is strongly compressed. Humerus distally expanded transversely and margin pierced by humeral artery. Astragalus exhibits two entire trochlear faces, the wider external and directed interosuperiorly, the inner presenting superointeriorly. They are separated by an obtuse longitudinal angle and are little or not at all concave transversely. The form is depressed. The head supports a single transverse convex facet for the navicular, and with the neck is as long as the trochlear portion."—*Cope*, '84, p. 304.

A fragmentary skeleton found in the Big Horn Valley by the Princeton Expedition of 1884 was described by Prof. Scott ('87, p. 169) under the name of *Didymictis altidens.* As this species is not otherwise known to occur in the Wasatch, it is possible that the specimen should be referred to the closely allied *V.* (*D.*) *protenus.* Two somewhat more complete skeletons found in the Wasatch of the Big Horn Valley by the American Museum Expedition of 1896 further illustrate the

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[1] Meaning, apparently, with tubercular heel. The context favors this interpretation. Marsh apparently meant at this time to include in the genus forms like *Telmatocyon.*

[2] *I. e.*, premolars 1–4.

genus, and by means of the information now available concerning other Creodonts we are able to summarize the characters of *Viverravus* as follows :

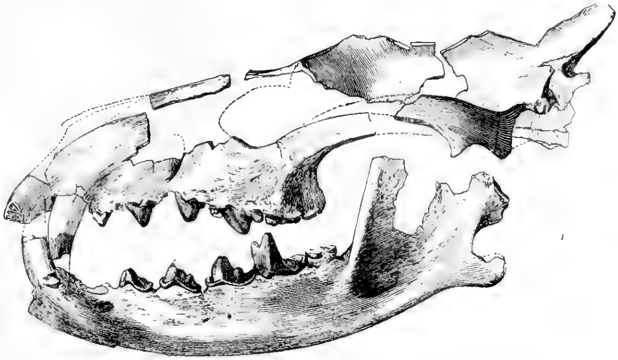

Fig. 1. *Viverravus protenus* Cope. Fragmentary skull and jaws, one-half natural size. No. 2830, Wasatch Beds, Big Horn Basin, Wyoming. Amer. Mus. Exp. 1896.

1.—General Creodont Characters.—Skull very large in proportion to skeleton, brain very small and of low type, tail large (presumably long), neck longer than in most modern Carnivora. Limbs rather short with large joints and heavy muscular attachments. Feet small, spreading, scaphoid and lunar separate. Fibula large, separate from tibia. Radius with oval proximal facet, and trihedral simply concave undivided distal facet. Part of a presternal bone preserved is like that of *Phenacodus wortmani*. Humerus with prominent deltoid crest reaching far down on the bone ; distal extremity broad, not deep, with entepicondylar foramen.

2.—Family and Generic Characters.—$\frac{p^4\text{–}m^1}{m_1}$ carnassials. Lower carnassial with high triangular trigonid shearing against posterior edge of $p^{\underline{4}}$ and anterior edge of $m^{\underline{1}}$, which are extended externally into shearing blades. Molars $\underline{1\text{–}2}$ tubercular, heel of $m_{\overline{1}}$ and all of $m_{\overline{2}}$ tubercular or becoming so, premolars trenchant with posterior cusps in front of heel. Jaws long and slender, incisors reduced and canines approximated. Femur with second trochanter interior instead of posterior, third trochanter well developed on external side, one fourth the length from the head of the bone. A clearly marked facet between fibula and calcaneum. Trochlea of astragalus very flat, distal facet strongly convex from above downward, almost flat transversely,

Fig. 2. *Viverravus protenus*, No. 2830. Cervical vertebræ, from above. One-half natural size.

neck rather long. Tarsals serial; a lunar facet on unciform. Entocuneiform deep, but remarkably short for a Creodont, not as long as the ectocuneiform. Toes 5–5, the first short and stout, not opposable. Claw phalanges compressed, sharp, without hood, middle phalanges asymmetrically excavated on upper side of shaft (? hence claws slightly retractile).

3.—GENERIC CHARACTERS.—Premolars $\frac{4}{4}$. Molars $\frac{2}{2}$. Trigonid of $m_{\overline{1}}$ very high, with antero-external and posterior shearing surfaces. Postero-external shearing blade of $p^{\underline{4}}$ and antero-external blade of $m^{\underline{1}}$ strongly developed.

4.—SPECIFIC CHARACTERS of *V. protenus* and *V. leptomylus* var.—These two species are distinguished from all others of the genus by the elongate low tubercular $m_{\overline{2}}$ with very small trigonid and very long heel. The teeth of *protenus* and *leptomylus* var. show no very constant differences, but may be separated more or less completely on the following characters (averaged from a number of specimens):

	V. leptomylus var.	*V. protenus.*
Length $p_{3-4} : m_{1-2}$	mm. 20.3 : 19.1 = 1.06	25.9 : 21.4 = 1.21
" $p^4 : m^{1-2}$	11.5 : 14.2 = 0.81	14.5 : 16.7 = 0.88
Blade p^4 to length	4.6 : 11.5 = 0.40	6.1 : 14.5 = 0.42
Transv. to longit. diam. $m^{\underline{1}}$	11.8 : 8.1 = 1.45	15.3 : 10.1 = 1.52

The above proportions show *V. protenus* as nearly one fourth larger, with the premolars larger in proportion, somewhat longer shearing blade on $p^{\underline{4}}$, and $m^{\underline{1}}$ more extended transversely. The same character and extent of distinctions are found between different species of Canidæ, but they are much more constant.

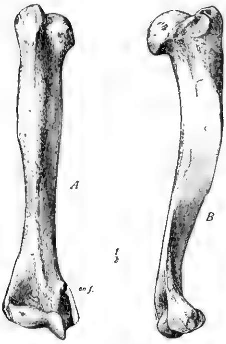

Fig. 3. *Viverravus protenus*, No. 2830. Right humerus; *A*, from in front; *B*, from outside. One-half natural size.

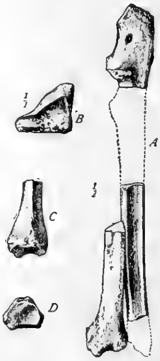

Fig. 4. *Viverravus protenus*, No. 2830. *A*, parts of left radius and ulna, from in front; *B*, right unciform, from in front; *C*, posterior view, and *D*, distal view of distal end of radius. One-half natural size, except *B*, which is natural size.

In the skeleton some striking differences in proportion appear. *V. protenus* has limb bones of the same length as *V. leptomylus* but averaging nearly a third stouter (the dentition of *V. protenus* being one fourth larger). The modern Civet, intermediate between the two in size of skull, has limb bones one fourth longer than the larger species, and stouter in proportion, while the neck is over one half longer.

The cat, in which the back and upper limb-bones are of nearly the same size and the lower limb bones considerably longer, has a head and jaws of about half the dimensions of *V. protenus*, and much shorter neck.

The following table[1] will give an idea of the proportions of these animals:

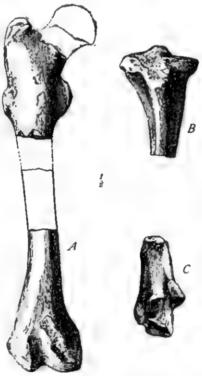

Fig. 5. *Viverravus protenus*, No. 2830. *A*, parts of right femur, from in front; *B*, proximal end of right tibia; *C*, left calcaneum. One-half natural size.

	Viverravus protenus.	*Viverravus leptomylus* var.	*Viverra civetta.*	*Felis catus.*
Humerus, length	94	e.89	117.6	97
" circumference of shaft	27.5	21.5	34.7	25
" diameter of distal end	21			19
Femur, length	e.97.5	97	136	103
" circumference of shaft	27	21	36	26
Radius, length		63	103	91
" circumference of shaft	17	12		
Ulna, length		85.5	131.4	104
" circumference of olecranon	30	23.2		
Calcaneum, length	27	22.5		29
Tarsus, length (including calcaneum)		29		
" width across navicular and cuboid		12.6		
Skull, length	167.5		158	91
Jaw, length	130		111.2	63
Dentition, length	83.7	e.66.4	75	34
Seven cervical vertebræ, length	102		164	

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[1] The measurements are given in millimetres. e = estimated.

III.—Family ARCTOCYONIDÆ (*Gervais*) *Cope.*

The Manus and Pes of Clænodon.

In a previous article ('97, p. 289) I have given some account of the foot structure of this interesting Creodont, now more fully known than when first described by Cope ('83, p. 547). This description can now be supplemented by figures of the fore and hind feet.

It was mainly on the characters of *Clænodon* (*Mioclænus*) *ferox* that Professor Cope based his views as to the position of the genus *Mioclænus* Cope ('84, p. 324), referring it to the Arctocyonidæ, which included this and many other species of divergent affinities, separated by Scott ('92) as distinct genera. Judging from Cope's descriptions of the skeletal material of *M. ferox* at his command, he was evidently strongly impressed with its resemblance to Marsupials, an idea which led him astray in parts of his description. I do not think that this resemblance is wholly a case of parallelism, for all the Creodonta of the Basal Eocene were quite nearly allied, and certain of them show primitive marsupial characters that it is very difficult to explain without admitting a closer connection between Marsupials and Placentals than their modern differentiation would lead one to believe. *Clænodon* has, however, no marsupial characters except such as must be considered an inheritance from the common stock which gave rise to both Marsupials and Placentals. Its progressive characters are placental carnivore.

Several genera of this group have been described. Without discussing the validity of *Hyodectes* and *Heteroborus*, defined by Cope on the basis of descriptions of European Arctocyons, we may say that three genera are sufficiently known for discussion of their relationships. These are :

Arctocyon Blv., type *A. primævus* Blv.; referred species, *A. gervaisi*, *A. deulii* Lem., all Basal Eocene of Europe.

Anacodon Cope, type *A. ursidens* Cope, Lower Eocene of America.

Clænodon Scott, type *C.* (*Mioclænus*) *ferox* Cope ; referred species, *C. corrugatus* (Cope), Basal Eocene of America.

To these should perhaps be added *Arctocyonides* Lem., type *A. sp. innom.* Lem., Basal Eocene of Europe ; referred species?

A. (*Mioclænus, Clænodon*) *protogonioides* Cope, Basal Eocene of New Mexico.

The last genus is distinguished only by the smaller quadrate teeth—simpler than those of *Clænodon* if the reference of *Mioclænus protogonioides* be correct. The type species is little known.

If the foot bones figured by Osborn ('90, p. 60) are correctly referred to *Arctocyon*, there are important differences in foot-structure between it and *Clænodon*, the former having no fibular facet on the calcaneum, while the ungual phalanx is much less compressed. The figure given by Lemoine ('78, pl. IV) of a calcaneum of *A. gervaisi*, is much more like those of *Clænodon ferox* and *C. corrugatus* and appears to indicate a fibular facet. I think it probable that the bones figured by Osborn are those of some other Creodont. The skeletal structure of *Anacodon* is unknown.

The dental distinctions are :

Clænodon.	*Arctocyon.*	*Anacodon.*
Upper premolars moderately reduced, the first one-rooted, second two-rooted, third and fourth three-rooted with high trihedral protocone and weak cingular cusps at the bases of the three solid angles.	*Upper premolars* considerably reduced, first one-rooted, second and third two-rooted, fourth large with strong deuterocone.	*Upper premolars* much reduced, the first and second minute or absent, third two-rooted, fourth small with a strong deuterocone and rudimentary third and fourth cusps.
Upper molars with three low subequal cusps, strong metaconule, somewhat weaker hypocone and very small paraconule. Metaconule weak and hypocone absent on $m^{\underline{3}}$.	*Upper molars* as in *Clænodon.*	Molar cusps obsolete.

These distinctions are based on the typical species of each genus. It is probable that the other species referred to *Arctocyon* are closer to *Clænodon*, but the present evidence seems to warrant holding the three genera separate. *Arctocyonides* if correctly represented by the American species *A.* (*Mioclænus, Clænodon*) *protogonioides* (Cope) is the most primitive of the family, but hardly deserves more than subgeneric separation from *Clænodon.*

This genus, while close to *Arctocyon*, is distinctly less specialized, and the differences seem to warrant generic separation. *Anacodon*, of the Wasatch, is much more specialized than any of the Basal Eocene species. All the genera, as far as known, have long, sharp, serrate canines, somewhat flattened and very little worn, premolars in various stages of disuse and reduction, molars becoming flat-topped and quadrate. The little-used premolars and canines may be contrasted with those of the Mesonychidæ and Oxyænidæ, in which they were well worn, often to enamelless stumps. The canines may have been chiefly for defense against enemies, the animal not being to any extent carnivorous.

The fore and hind feet here figured are of much interest, showing for so early a period an unusual degree of specialization in certain characters.

The Fore Foot.

The carpus is distinguished especially by the large rectangular *centrale*, lying half under the lunar, half under the scaphoid and *fused to the latter bone.* The lunar-centrale facet still persists but the lunar-scaphoid facet has disappeared, replaced by a roughened bony surface; this probably points to an approaching union of scaphoid and lunar. The *lunar* is keeled, and faceted for centrale and magnum on one side, for unciform on the other. The *magnum* has a broad centrale facet and narrow lunar facet separated by a sharp keel. This arrangement would, upon union of the scapho-centrale and lunar give a proximal keeled facet on the magnum fitting into a correspondingly grooved facet on the

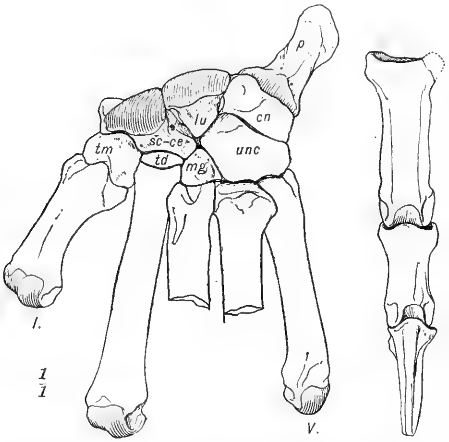


Fig. 6. *Clænodon corrugatus* (Cope). Fore foot, natural size. Specimen No. 2456. Torrejon Beds, Wyoming.

scapholunar, exactly as is found among Ursidæ, instead of a flat facet such as characterizes Canidæ and Felidæ.

The *unciform*, *cuneiform*, and *pisiform* are of the usual primitive type, the former having a broad lunar facet separated by an angle from that for the cuneiform. The *trapezoid* has not been found, but was evidently small, ovate, with a narrow facet for the magnum and pinching out on the radial side so as barely to touch the trapezium. The *trapezium* is large with triangular upper surface and projects in a blunt point underneath the centrale and trapezoid.

There are five *metacarpals*, the first only two thirds as long as the rest, but stout in proportion, and divergent though hardly opposable. Its proximal facet allowed considerable play, and is keeled toward its superior surface. The other metacarpals are narrower, longer, and much closer together, with but little play on the carpus.

The *phalanges* are keeled about as in the bears, a little curved and somewhat angulate in section. The *ungual phalanges* are more specialized than in any known Creodont and the majority of Carnivores. They are large, high, and much compressed, quite as much so as in Ursidæ but with no trace of basal sheath.

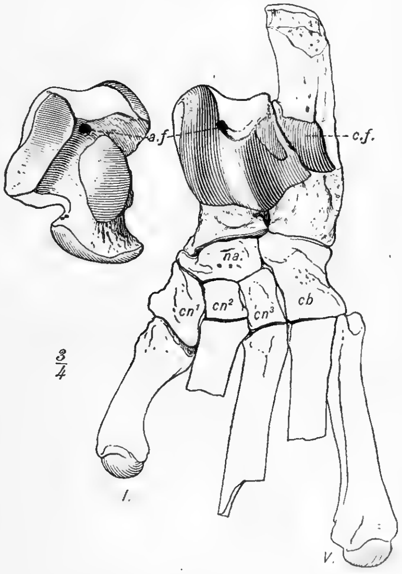


Fig. 7. *Clænodon ferox* (Cope). Hind foot, three-fourths natural size. Type specimen No. 3268. Torrejon Beds, Wyoming.

The Hind Foot.

The *tarsus* shows some interesting characters. The tibial and fibular articulating surfaces are of nearly equal width, and the fibula has a considerable facet on the calcaneum. The ectal astragalo-calcanear facet is oblique as is usual among the earlier

Creodonts, and is separated by a slight angle from the fibulo-calcanear facet. The trochlea of the astragalus is very shallow, the foramen[1] is present, and the notch for the flexor digitorum wide though not very deep. The head of the astragalus is considerably flattened, about as much as in Ursidæ or Felidæ. The *cuboid* has a rather narrow astragalar facet, concave, and separated by an angle from the rather flat calcanear facet. The corresponding facet on the astragalus is not separable from the navicular facet. The *entocuneiform* is large and *metatarsal I* short, stout, and divergent, though with less play than the corresponding metacarpal. The other four metatarsals are of about equal length, the second being wedged in proximally between the ecto- and ento-cuneiforms.

Comparisons.

The union of the centrale with the scaphoid is an interesting stage in the consolidation of the carpus. The position and size of the centrale are peculiar. In *Mesonyx* it lies entirely beneath the scaphoid (Scott, '87, p. 161, pl. VII, fig. 1). In *Dissacus* (Osborn and Earle, '95, p. 33, fig. 9) it is less completely so, but the shape is rhombic instead of rectangular. In *Hyænodon* (Scott, '87, p. 182, pl. VII, fig. 5) the centrale lies partly under the lunar, but is small and triangular, hardly touching the magnum, while the trapezoid is very large, and the unciform has no lunar facet. In *Oxyæna* the carpus is less strongly interlocking, the centrale smaller and rhombic, trapezoid larger, trapezium different in shape. In *Viverravus* the carpus is narrower, foot probably slenderer—little is known as to the arrangement of the carpals. Comparing this carpus with the various primitive Creodonts, Condylarths and Amblypods, shows a great deal of similarity among them all. The progressive characters in *Clænodon* seem to be :

1. Union of centrale with scaphoid ; ? large size of centrale, almost excluding magnum from lunar on upper surface ; sharp keel of magnum.
2. Grooving and inward facing of distal facet of trapezium.
3. Stout semi-opposable first metapodial, and length of fifth.

---

[1] The use of this foramen seems to be unknown. Prof. Osborn has suggested that it may have held an extension of the interosseous ligament, which lies between the two astragalo-calcanear facets and connects the astragalus with the calcaneum. If this ligament originally passed up to the tibia, its disappearance would be directly connected with the keeling of the proximal and flattening of the distal end of the astragalus, all being due to the transference of the main ankle-joint from the distal to the proximal end of the astragalus, *i. e.*, the evolution of the mammal from the reptilian stage of development in this character.

4. High compressed claw; extension upward of distal facets of 1st and 2d phalanges and to some extent of distal metapodial keels.
5. Slender, serrate, unworn canines.
6. Reduction of premolar dentition.
7. Low-cusped quadrate molars, m_3 somewhat reduced.

The first of these characters leads towards the Carnivora generally, except the sharp-keeled magnum, which seems to point especially towards the Bears. It may, however, be merely the additional brace required for large-clawed feet. The semi-opposed thumb is a character pointing towards arboreal types, hardly to any known Ursidæ. The proportions of the phalanges agree with those of the Ursidæ and of some other Carnivora (*Procyon*, etc.). The high compressed claw-phalanx suggests the Ursidæ very strongly; the greater extension of the facets is a modernization common to all the sharp-clawed types.

In the dentition all three characters point to the Ursidæ and to no other Carnivora. The elongation of the second molar after the disappearance of the first is exactly paralleled by the Raccoons in evolving from the Canidæ through *Phlaocyon* — a very similar adaptation not carried so far as in the Ursidæ.

The argument for placing the Arctocyonidæ ancestral to the Ursidæ is, then:

1. They belong by their foot structure to the adaptive Creodonta, the teeth not placing them in either the adaptive or inadaptive group.

2. The three chief progressive characters of the teeth are those which distinguish the bear dentition.

3. The claws are far advanced towards the type found in the Ursidæ and in hardly any other Carnivora.

4. The one marked distinction that I can see to separate the bear-carpus from that of other Carnivora is found in process of formation in *Clænodon.*

5. The proportions of the digits show a specialization found in the Bears and in hardly any other Carnivora.

Against this may be urged:

1. *Clænodon* has the thumb more opposable than in the modern Ursidæ.

2. *Anacodon* has the premolar dentition as much reduced as in the modern Ursidæ.

(In either case, this may indicate that neither *Clænodon* nor *Anacodon* is precisely in the line of Bear descent, but does not seriously weaken the arguments given above as to the derivation of the Bears from the family Arctocyonidæ.)

3. The real objection to the theory lies in the remarkable approximation of certain of the Dog and Bear families in Upper Miocene time. Although, as Schlosser has recently shown, *Hyænarctos* and *Amphicyon* cannot stand in the direct line of descent, yet they exhibit a striking gradation between the two families and might well be considered as survivals of primitive links connecting the two. *Cephalogale* also, among the more ancient Canidæ, shows several approximations to the Ursidæ, and is placed by Dr. Schlosser as ancestral to the family ('99, 146).

There are some characters, however, that have not been bridged, and these are perhaps more important than they appear at first sight.

1. All Canidæ have triangular upper molars. All Ursidæ have quadrate upper molars.

2. All Canidæ have the inner cusp of p^{4} anterior. All Ursidæ have it medial.

The trigonal molar and the anteriorly placed trittocone are indications of a formerly tuberculosectorial dentition, and apparently very difficult to get rid of. *Procyon*, however, seems to show us an earlier stage of their disappearance in a line descended from the Canidæ; so that we may yet discover the intermediate stages in the Ursid phylum.

To sum up—the *Arctocyons* were progressing towards the Bear line in all the most distinctive characters of both teeth and feet. But the wide gap between Lower Eocene and Middle Miocene makes any connection between the two somewhat uncertain. In the Canid line, on the other hand, we have a number of apparently intermediate stages known. But these intermediate stages cannot have been actually in the line of descent, and even if they are unaltered descendants of more ancient types we still have a gap of some importance unbridged. The connection, moreover, is based on teeth alone. Professor Osborn, in discussing the evolution of the Mammalia, remarks: "The teeth and feet, owing to the frequent parallels of adaptation, may wholly mislead us if taken alone; while if considered together they give us a sure key; for no case of exact parallelism in both teeth and feet between two unrelated types has yet been found or is likely to be." (*Osborn*, 1893, p. 10.) If *Clænodon* be totally unrelated to the Ursidæ it is an exception to this statement, and, as far as I recall, the only one. And yet the evidence is very strong for deriving the Ursidæ from primitive Dogs.

IV.—Family HYÆNODONTIDÆ *Cope.*

In this family are included, as Wortman has already indicated ('99, p. 139), most of the genera grouped by Schlosser under the name Proviverridæ. *Deltatherium* belongs with the Oxyclænidæ; the position of *Didelphodus* and *Palæosinopa* is uncertain, as they fail to show the progressive characters of either group. *Sinopa* and *Cynohyænodon* clearly belong in it, *Proviverra* somewhat less clearly, while *Quercytherium* appears to be an aberrant member. The progressive characters of the two families may be contrasted thus:

Hyænodontidæ.	*Oxyclænidæ.*
Upper molars with connate external cusps, developing a shear, especially between $m^{\underline{2}}$ and $m_{\overline{3}}$. Last upper molar becoming transverse and disappearing. Heels of lower molars disappearing, $me^{\underline{d}}$ disappearing, $pa^{\underline{d}}$ advancing to form a cutting blade. Dentition functionally carnivorous (*cf.* Felidæ).	Upper molars becoming quadrate. Fourth lower premolar becoming molariform. A considerable diastema developing behind canines with disappearance of $p\frac{1}{1}$. Dentition functionally insectivorous (*cf.* Lemurs, Opossums, and some Insectivores).

All the above Hyænodont characters are exhibited to a greater or less extent by various species of *Sinopa*, though always in an early stage of progress. Most of them are exhibited by *Cynohyænodon* and *Proviverra*, which besides are extremely close to *Sinopa*. The same is true of *Quercytherium* except for the very peculiar premolars (which are approximated in *Cynohyænodon minor* if the reference to this species be correct of a fine specimen in the Paris Museum). *Palæosinopa* and *Didelphodus* can be placed here only on account of general resemblance to the Proviverrines and lack of the progressive characters of any other group. The generic definitions will be:

Hyænodon. $M^{\underline{3}}$ absent; m^{1-2} without protocone, para- and metacone united; metastyle forming a shearing blade larger than the united *pa.* and *me.*; m_{1-3} without metaconid or heel. Jaw long, slender.

Pterodon. $\mathrm{M}^{\underline{3}}$ transverse reduced; m^{1-2} triangular with well-developed protocone, *pa.* and *me.* connate, metastyle blade smaller; m_{1-3} without metaconid but with small trenchant heel. Jaw short and deep.

Sinopa. $\mathrm{M}^{\underline{3}}$ transverse; m^{1-2} sharply triangular with widely separated protocone, *pa.* and *me.* connate to varying degree, metastyle and parastyle extended into small shearing blades. M_{1-3} with high triangular trigon and low basin heel, $\mathrm{pa}^{\underline{d}}$ and $\mathrm{me}^{\underline{d}}$ of equal size, $\mathrm{pr}^{\underline{d}}$ much higher.

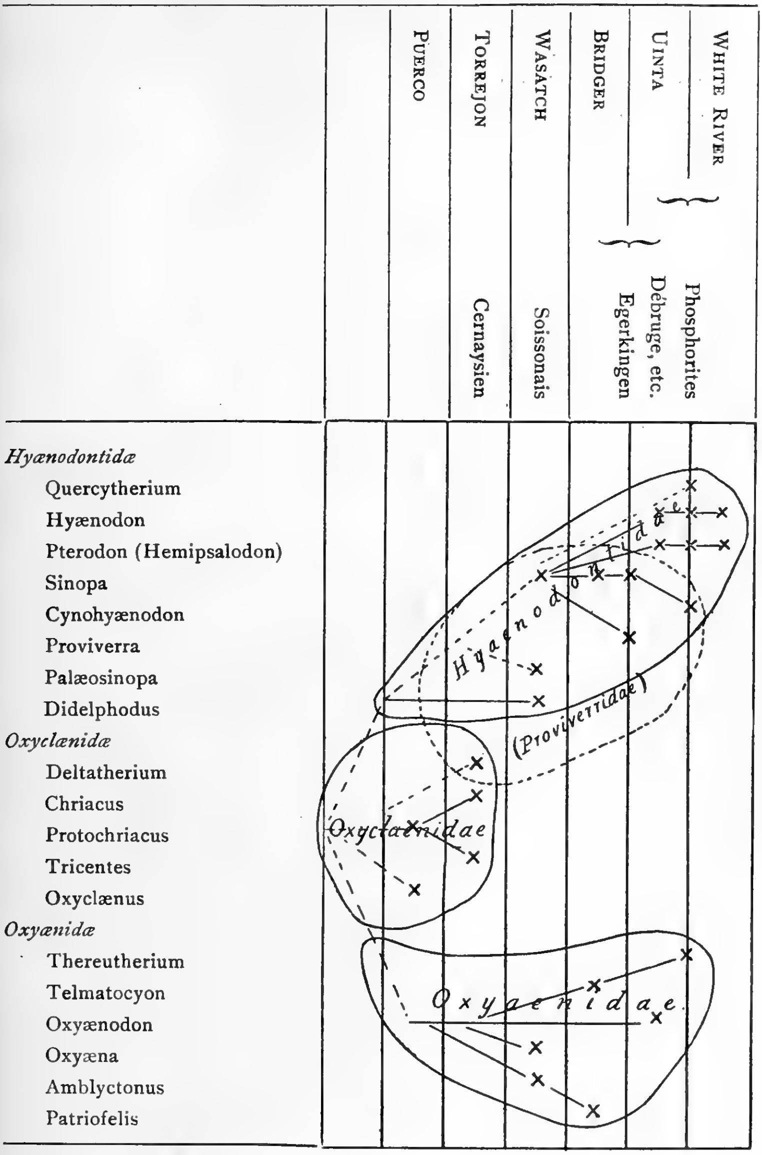
Didelphodus. $\mathrm{M}^{\underline{3}}$ subtransverse unreduced. M^{1-2} sharply triangular with widely separate crescentic protocone, *pa.* and *me.* somewhat connate, para- and metastyles moderately developed. Lower molars with triangular trigonid of three equal cusps ($\mathrm{pa}^{\underline{d}}$ internal), and large heel.

Palæosinopa. $\mathrm{M}^{\underline{3}}$? subtransverse; m^{1-2} somewhat quadrate, external styles not much developed. Lower molars with low trigonid of three equal cusps ($\mathrm{pa}^{\underline{d}}$ anterior) and large bicuspid basin heel.

Quercytherium. Molars much as in *Sinopa.* Premolars distinguished by extreme robustness and large size, $\mathrm{p}\frac{2}{2}$ being the largest.

The genera *Limnocyon* Marsh, *Stypolophus* Cope, and *Prototomus* Cope are, as Scott holds, synonyms of *Sinopa* Leidy, except *L. riparius*, subsequently (Marsh, '99) separated under the name *Telmatocyon.* *Triacodon* Marsh is perhaps founded on incomplete molars of either *Sinopa* or *Viverravus.* The species placed in it by Cope in 1872 was afterwards correctly referred by him to *Stypolophus.* *Proviverra* is very close to *Sinopa*, but, though very imperfectly known, seems to differ from any of the species of *Sinopa* in its short jaw and reduced premolar region, approximating *Prorhyzæna.* *Cynohyænodon cayluxi* is hardly distinguishable in dentition from *Sinopa*, but seems to be somewhat more advanced in skull characters. It is hardly worthy of generic separation. *C. minor*, if correctly represented by the upper and lower jaws referred to it in the Paris Museum, is more nearly allied to *Quercytherium*, having the same proportions in the premolars, which, however, are not nearly so robust. *Hemipsalodon* does not seem separable from *Pterodon;* and *Pseudopterodon*, according to Scott, is probably founded on milk teeth of *Pterodon* (Scott, '92). *Thylacomorphus* is known only by the back of a skull described by Prof. Gervais in 1876, but not figured. It was conjecturally referred by Schlosser to *Cynohyænodon.* It is, however, not a Creodont at all, but an Anoplothere, probably *Diplobune quercyi.*

The accompanying table will show the conception which this paper attempts to explain of the relationship of the genera and limits of the families of Inadaptive Shear-toothed Creodonts, the Oxyænidæ, Oxyclænidæ, and Hyænodontidæ:


Puerco
Torrejon
Wasatch
Bridger
Uinta
White River
Cernaysien
Soissonais
Egerkingen
Débruge, etc.
Phosphorites
Hyænodontidæ
Quercytherium
Hyænodon
Pterodon (Hemipsalodon)
Sinopa
Cynohyænodon
Proviverra
Palæosinopa
Didelphodus
Oxyclænidæ
Deltatherium
Chriacus
Protochriacus
Tricentes
Oxyclænus
Oxyænidæ
Thereutherium
Telmatocyon
Oxyænodon
Oxyæna
Amblyctonus
Patriofelis
Hyaenodontidae
(Proviverridae)
Oxyclaenidae
Oxyaenidae

Palæosinopa veterrima, n. g. et sp.

Palæosinopa veterrima "Wortman," MATTHEW, Bull. Amer. Mus. Nat. Hist., 1899, p. 31. Name only.

Stypolophus whitiæ OSBORN & WORTMAN, '92, p. 110, not *S. whitiæ* Cope.

Generic characters: Dentition $\frac{3\cdot1\cdot4\cdot3}{3\cdot1\cdot4\cdot3}$. Metastyle moderately extended on m^{2}, rudimentary on m^{1}. Trigonid of three subequal cusps; heel larger than trigonid, $hy^{\underline{d}}$ and $en^{\underline{d}}$ strong, $hl^{\underline{d}}$ present on all molars, strong only on $m_{\overline{3}}$. The worn state of the upper molars in the type specimen precludes exact comparison with *Didelphodus*, to which the genus is most closely allied.

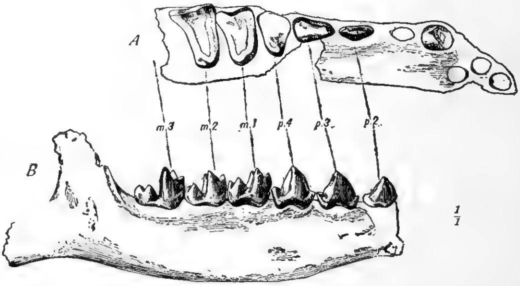


Fig. 8. *Palæosinopa veterrima* Matthew. *A*, upper jaw, from below, type specimen, No. 95; *B*, external view of lower jaw, cotype, No. 150*a*. Both natural size, from the Wasatch Beds, Big Horn Basin, Wyoming. Amer. Mus. Exp. 1891.

Specific characters: Upper incisors rather large, roots not compressed, the third placed behind and within the second, leaving a deep notch for the lower canine between i^{2} and c^{1}. Canines rather small, first upper premolar one-rooted, second two-rooted, third two-rooted, but with the posterior root the wider, crown with robust protocone and rudimentary postero-internal heel; fourth three-rooted with well-separated internal cusp. First and second molars with rudimentary hypocone or postero-internal cingulum, third molar transverse apparently large. First lower premolar one-rooted, others two-rooted, trenchant, with small heels and minute anterior basal cusps.

Type No. 95, upper and lower jaws, teeth badly worn. Associated type, No. 150*a*, a lower jaw with unworn teeth. Referred specimens Nos. 2849, 2851, 2852. All from the Lower Eocene Wasatch Beds of the Big Horn Valley, Wyoming.

Measurements of Type Specimen.

Upper dentition (approximate) $i^{1}m^{3}$	49	
" molars (approximate)	15	
" premolars "	21	
First upper molar, antero-post.	5.3;	transv. 7.4
Second " " "	8	" 8.1
Lower dentition, c_{1}-m_{3}	41	
" true molars	16.6	
" premolars	18	
Depth of jaw below p_{2}	6	
" " " " m_{2}	12	

Palæosinopa didelphoides (*Cope*).

Ictops didelphoides COPE, Bull. Hayden Survey, VI (1881), p. 192; Tert. Vert., p. 268.

Palæictops didelphoides MATTHEW, '99, p. 35.

The lower jaw fragment from the Wind River Beds, referred to *Ictops* by Prof. Cope, more probably belongs in this genus. In absence of characteristic parts its reference is provisional.

Sinopa *Leidy*, 1871.

Stypolophus COPE, Pal. Bull. No. 2, Proc. Am. Phil. Soc. 1872, 466.

Prototomus COPE, Report on Fossil Vert. N. M., Ann. Rep. U. S. G. S. W. of 100th Mer., 1874.

Limnocyon MARSH, in part, Am. Journ. Sci. 1872, Vol. IV, p. 122.

The original types of *Sinopa*, *Stypolophus*, and *Limnocyon* were from the Middle Eocene of Wyoming. Cope afterwards described a number of species from the Wasatch under the name of *Prototomus*, which he afterwards (1877) united with *Stypolophus*. Scott (1892) united both with *Sinopa*, and an examination of the types of *Limnocyon* shows that they also should be referred to this genus.

Besides the characters given on a previous page the following may be noticed:

Dentition $\frac{3\cdot1\cdot4\cdot3}{3\cdot1\cdot4\cdot3}$. First premolar two-rooted. Brain small. Lower premolars composed of principal cusp and trenchant heel (no second posterior cusp). *Me.* of m^2 reduced or absent. Incisors small, the upper ones in a row.

Sinopa rapax *Leidy*, 1871.

From the Bridger Beds, Wyoming. Type, a lower jaw with more or less broken molars, figured in Extinct Vert. Western Terrs. The species is of medium size with apparently a rather large heel on $m_{\overline{1}}$, but with vestigial heel (*fide* Cope, '84, p. 289) on the third. I am unable to find other specific characters in Leidy's figure. Length of $p_{\overline{4}}$–$m_{\overline{3}}$, 31mm.

Sinopa vera (*Marsh*).

Limnocyon verus MARSH, Am. Jour. Sci. 1872, Vol. IV, p. 122.

From the Bridger Beds, Wyoming. A large species with protocones of m^1 and m^2 much compressed. Third premolar narrow and trenchant. Length of $p_{\overline{4}}$–$m_{\overline{3}}$, estimated, 40mm.

Sinopa agilis (*Marsh*).

Limnocyon agilis Marsh, Am. Jour. Sci. 1872, Vol. IV, p. 202 (published Aug. 7).

Stypolophus brevicalcaratus Cope, Pal. Bull. No. 3; Proc. Am. Phil. Soc. 1872, p. 469 (published Aug. 7); Tert. Vert., p. 291, pl. xxiv, fig. 9.

From the Bridger Beds, Wyoming. I have preferred Prof. Marsh's name for this species as based on a much more complete specimen, including upper and lower teeth and many parts of the skeleton. The type of *S. brevicalcaratus* is a fragment of the lower jaw with m_{2-3}. Prof. Cope's determination of the teeth as m_{1-2} is, I think, incorrect.

This species, of medium size, is very close to *S. whitiæ* but may be distinguished by the smaller heels of the lower molars, especially of $m_{\overline{3}}$. It may prove to be identical with *S. rapax* Leidy.

Sinopa pungens (*Cope*).

Stypolophus pungens Cope, Pal. Bull. No. 2; Proc. Am. Phil. Soc. 1872 (Vol. XII), p. 460 (Aug. 3); Tert. Vert., p. 291, pl. xxiv, fig. 8.

Type of the genus *Stypolophus.* Bridger Beds, Wyoming. A rather primitive species of medium size with long tricuspid heel on $m_{\overline{3}}$, approaching *Palæosinopa.* Trigon not very high. Represented by a lower jaw fragment, No. 5015, Cope Collection, Amer. Mus. Nat. Hist.

[? Sinopa insectivora (*Cope*).]

Stypolophus insectivorus Cope, Pal. Bull. No. 3; Proc. Am. Phil. Soc., Vol. XII, 1872, p. 469.

Bridger Beds, Wyoming. The type of this species has been lost or mislaid and its position in the genus cannot now be determined. Prof. Cope's figures in Tertiary Vertebrata are evidently incorrect, the outline of the tooth as viewed from within and from without being different.

[Sinopa aculeata (*Cope.*)]

Triacodon aculeatus Cope, Pal. Bull. No. 1; Proc. Am. Phil. Soc. 1872, Vol. XII, p. 460.

Stypolophus aculeatus Cope, Ext. Vert. N. M. Rep. Wheeler Survey, IV, ii, 112. Not *S. aculeatus*, Tert. Vert., p. 299.

Bridger Beds, Wyoming. This species was founded on part of the crown of a lower molar, subsequently lost or mislaid, and the tip of a premolar crown. It is indeterminate specifically, generically or even in family, and the name has no standing. The upper and lower jaws in the Princeton Museum figured and referred to this species by Prof. Cope in 1884 more probably belong to *S. strenua*.

Sinopa hians (*Cope*).

Stypolophus hians COPE, Rep. Wheeler Survey, Vol. IV, pt, ii, p. 118, pl. xxxviii, figs. 12–20.

Wasatch of New Mexico and Wyoming. The type is an extremely fragmentary and badly preserved skeleton from the Wasatch of New Mexico. The anterior premolars are spaced and the last two lower molars subequal. Fourth premolar wider posteriorly. The other characters given by Prof. Cope are common to the genus.

The most important distinctive character seems to be the subequal second and third molars. On this ground I place here No. 2850 Amer. Mus. Coll., which agrees fairly well in size, has the anterior premolars somewhat less spaced, and a narrower heel to $p_{\overline{4}}$. It is a young individual, with teeth scarcely worn, hence perhaps the less spacing of the premolars. It consists of upper and lower jaws, fragments of the skull, a few vertebræ, and parts of nearly all the limb bones.

Third lower molar as large as second, first considerably smaller. Angle between anterior and posterior shear of lower trigonids averaging 45°. Incisors present but number uncertain. Metastyle on $p^{\underline{4}}$ small. *Pa.* and *me.* rather closely connate. $M^{\underline{3}}$ considerably reduced with vestigial metacone.

The brain is smaller than that of *Cynohyænodon cayluxi* although the dentition is one third longer. Compared with that of *Thylacinus* the brain is much smaller in all dimensions, smoother in surface, and with olfactory and cerebellar lobes smaller in proportion, but not in any degree covered by the cerebral lobes.

The limb bones are for the most part a little stouter than those of the domestic cat, not very different in size from those of *S. whitiæ*. They are apparently shorter and stouter in proportion, resembling those of *Viverravus protenus* on a smaller scale. The vertebræ are too poorly preserved for exact comparison.

Measurements, No. 2850.

c^1–m^3..... 70; c_1–m_3.... 68; m_{1-3}.... 25

Diameters of	$m^{\underline{1}}$,	anteroposterior	8, transverse	9
"	$m^{\underline{2}}$	"	9	10.5
"	$m^{\underline{3}}$	"	4	
"	$m_{\overline{2}}$	"	9.5	
	$m_{\overline{3}}$	"	9	
Depth of jaw under	$m_{\overline{2}}$		19	

Sinopa whitiæ (*Cope*).

Stypolophus strenuus Cope, Bull. Hayd. Sur. No. VI, p. 192.

Stypolophus whitiæ Cope, Proc. Am. Phil. Soc., Vol. XX, 1882, p. 161; Tertiary Vertebrata, p. 292, pl. xxvb, figs. 8–14.

Wind River assise, Wyoming. This species is somewhat smaller than *S. hians*, and is distinguished from it by the reduction in size of the last lower molar and the more anteroposterior direction of the trigonid shear. In the upper molars the protocone appears to be more compressed and placed further backward relatively to the outer cusps, and the metacone of $m^{\underline{3}}$ has entirely disappeared. The species is close to *S. agilis* of the Bridger, which has the heels of the lower molars more reduced. It is the best known species of the genus and was fully described and figured by Prof. Cope in 1884.

Nos. 4780 (type), 4781, and 4782.

Measurements.

c^1m^3.... 63 c_1–m_3.... 66 m_{1-3}..... 22.5

Diameters of	m^1,	anteroposterior	8, transverse	7
	m^2		8	10
	m^3		3	9
	m_2	?	8.3	
	m_3	?	8.3	
Length of heel of	m_3		3	
Depth of jaw below	m_2		19	

Sinopa strenua (*Cope*).

Prototomus strenuus Cope, Syst. Catal. Eoc. Vert. N. M., Rep. Wheeler Survey, p. 10.

Stypolophus, Final Rep. Wheeler Survey (U. S. G. S. W. 100th Mer.), IV, ii, p. 117, pl. xxxix, fig. 11.

Wasatch assise, New Mexico and Wyoming. Type from New Mexico, in National Museum, Washington. Referred specimens

Nos. 97 and 98, from the Big Horn Valley, Wyoming, Am. Mus. Coll. 1891. All fragments of lower jaws.

It is quite impossible to separate this species from *S. whitiæ* on our present knowledge, but when more complete material is found it will probably show some distinctions. In particular I should expect to find the metaconid present on $m^{\underline{3}}$, as it is on all known Wasatch and no known Wind River species of the genus. I therefore hold the species separate provisionally and refer the Wasatch specimens to *S. strenua.* The characters are: size medium, $m_{\overline{3}}$ smaller than $m_{\overline{2}}$, shear of trigonids 55°–60° from transverse; $p^{\underline{3}}$ with small internal and somewhat larger postero-external cusp; teeth compressed with angulate cusps.

A somewhat smaller variety or distinct species has $m_{\overline{3}}$ less reduced and shear more transverse. It may prove to be *S. multicuspis.* (Am. Mus. Nos. 2815, 4220, 96, and 4218, Wasatch assise, Wyoming.)

Sinopa multicuspis (*Cope*).

Prototomus multicuspis Cope, Syst. Cat. Eoc. Vert. N. M., Rep. Wheeler Survey, 1874 (1875).

Stypolophus, Ext. Vert. N. M., Final Rep. Wheeler Survey, IV, ii, p. 116. Tertiary Vertebrata, p. 290.

Wasatch assise, New Mexico. The type is an upper jaw, separable by the much reduced $m^{\underline{3}}$ (if this tooth be complete). The co-type is a piece of a lower jaw, with which the small specimens referred to above most nearly agree.

[Sinopa secundaria (*Cope*).]

Prototomus secundarius Cope, Syst. Cat. Eoc. Vert. N. M., Rep. Wheeler Survey, 1874 (1875), p. 9.

(*Stypolophus*), Ext. Vert. New Mex., Final Rep. Wheeler Survey, IV, ii, 115.

Wasatch assise, New Mexico. All the characters given in the descriptions are common to the genus. The specimen has not been figured. The measurements hardly separate it from *S. multicuspis.*

Sinopa viverrina (*Cope*).

Prototomus viverrinus Cope, Rep. Foss. Vert. N. Mex., Rep. Wheeler Survey, 1874, 13 (125); Syst. Cat. Eoc. Vert. N. M., Rep. Wheeler Survey, 1874 (1875), 9.

(*Stypolophus*), Ext. Vert. New Mex., Final Rep. Wheeler Survey, IV, ii, (1877), p. 112, pl. xxxviii, figs. 1–11; Tertiary Vertebrata, p. 290.

Type of the genus *Prototomus.* Wasatch assise, New Mexico and Wyoming. The small size distinguishes it from any other Wasatch species. Judging from Professor Cope's figures it is also distinguished by the simplicity of p$^{\underline{4}}$, which is little more molariform than p$^{\underline{3}}$ of the larger species. The species appears to be quite primitive in other characters as well, and I am disposed to place with it a few lower jaw fragments in our collections containing molars of appropriate size in which, while the trigonid is high, the metaconid is better developed, the shear more transverse, and the whole tooth wider than is usual in the genus. (Am. Mus. Nos. 94 and ? 2971.)

Sinopa opisthotoma, sp. nov.

Stypolophus sp. innom. OSBORN & WORTMAN, Bull. Am. Mus. Nat. Hist. 1892, 110. "No. 99 is much larger than any described species of *Stypolophus.*"

Wasatch assise, Wyoming.

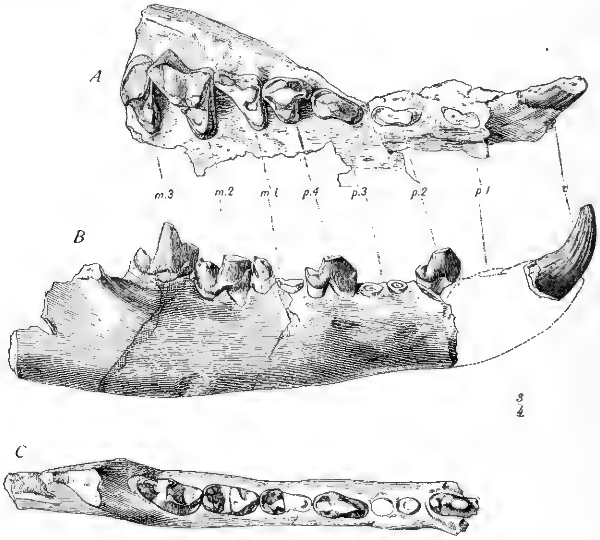


Fig. 9. *Sinopa opisthotoma* Matthew. Upper and lower jaws, three-fourths natural size, type specimen No. 99, Wasatch Beds, Big Horn Basin, Wyoming. Amer. Mus. Exp. 1891. *A*, upper jaw, from below; *B*, lower jaw, from outside; *C*, from above.

With the type (No. 99), upper and lower jaws, teeth well preserved, I associate provisionally No. 101, upper and lower jaw fragments not well preserved, which either is a very large individual of this species or represents a distinct species undescribed.

Anterior premolars spaced; $p^{\underline{3}}$ without distinct accessory cusps; $p^{\underline{4}}$ with main cusp conical-lenticular; internal cusp conical, postero-external cusp not extended into a shearing blade. Outline of $m^{\underline{1}}$ and $m^{\underline{2}}$ obtuse-angled triangles, metastyle especially extended on $m^{\underline{2}}$ *pa.* and *me.* but little connate; $m^{\underline{3}}$ with small metacone, transverse diameter greater than that of $m^{\underline{2}}$. $M_{\overline{2}}$ with well-developed heel; $m_{\overline{3}}$ in type with much reduced metaconid, advanced paraconid forming a shearing blade more nearly anteroposterior than in any other *Sinopa*, and narrow heel. In No. 101 $m_{\overline{3}}$ is normal in character, with more transverse shear and larger heel.

The depth of the jaw is moderate in the type; in No. 101 it is excessive, although the wear of the teeth does not indicate a much older animal. Both have the same rounded cusps, comparatively slight approximation of *pa.* and *me.*, simple $p^{\underline{4}}$, wide $m^{\underline{3}}$, extended blades on $m^{\underline{1-2}}$ and other characters, so that if distinct the two are evidently closely allied.

Measurements.

	No. 99	No. 101
Length $c^{\underline{1}}$–$m^{\underline{3}}$	83	
" $m^{\underline{1-3}}$	26	
" $m_{\overline{1-3}}$	31	32
Diameters of $p^{\underline{4}}$, anteroposterior	10	11
transverse	10	10
" $m^{\underline{1}}$ anteroposterior	9	?11
transverse	10	?11
" $m^{\underline{2}}$ anteroposterior	12	12
transverse	13	14
" $m^{\underline{3}}$ anteroposterior	6	6
transverse	14	14
Length $p_{\overline{3-4}}$ anteroposterior	18.5	23
" $m_{\overline{1}}$	8	
" $m_{\overline{2}}$	10	10
" $m_{\overline{3}}$	13	13
" heel of $m_{\overline{3}}$	4	6
Width " " "	4	5
Depth of jaw at $m_{\overline{2}}$	19	31

V.—Family MESONYCHIDÆ *Cope.*

Triisodon heilprinianus *Cope.*

Two very incomplete and poorly preserved skulls of this species are of especial interest as the first skulls described from the lower or true Puerco Beds, and hence the *oldest mammal skulls known.*

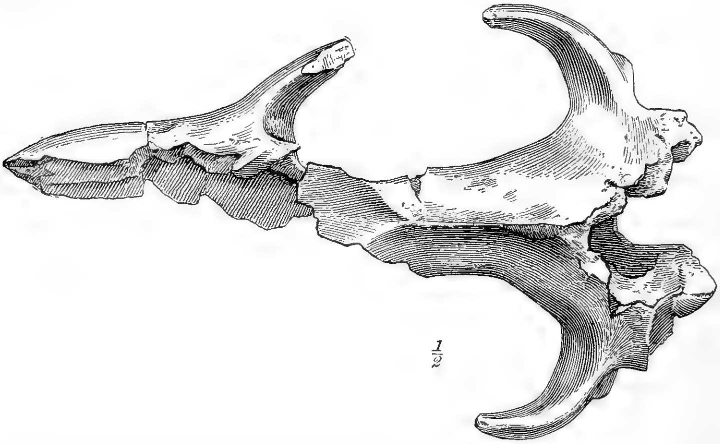


Fig. 10. *Triisodon heilprinianus* Cope. Part of skull, from above, one-half natural size. No. 764, Lower or True Puerco Beds, San Juan Basin, New Mexico. Amer. Mus. Exp. 1892.

The skull compares most nearly with those of *Arctocyon* (Cernaysien), *Mesonyx* (Bridger and Uinta), and *Periptychus* (Torrejon). All have many characters in common :

Brain small, of low type ; zygomatic arches broad ; occipital and sagittal crests very high ; palatal and basicranial axes parallel (*i. e.*, face not at all bent down on basicranial axis) ; mastoid well exposed, tympanic bulla rudimentary or absent ; basisphenoid broad and slightly convex downward ; glenoid fossa deep and long, post-glenoid process moderately developed ; paroccipital process stout not long, confluent with mastoid, projecting laterally rather than downwards ; muzzle thick and heavy, premaxilla with wide ascending process and long contact with nasals. (Nares terminal.)

All the above characters are primitive ones which will probably be found in nearly all Basal Eocene Placentals. The following characters, more or less peculiar to *Triisodon*, I judge to be also primitive.

Zygomatic process of the squamosal moderately stout, as in *Periptychus*, placed well back on the side of the skull (its anterior edge one fourth the skull-length from the occipital condyle) as in *Mesonyx*. In *Arctocyon* it is placed further forward, besides being more massive, reducing the length of the zygomata, which are increased in width though not proportionately.

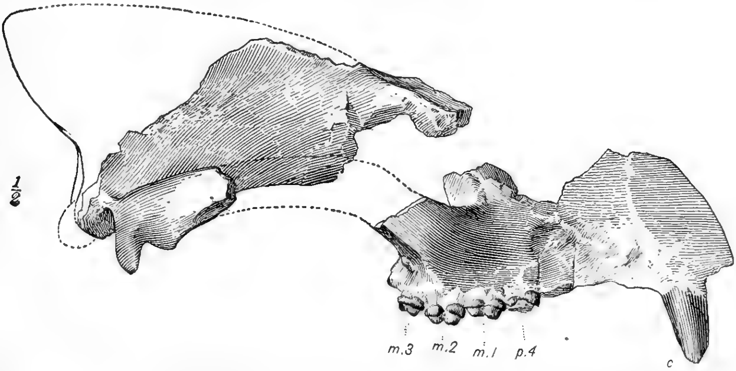


Fig. 11. *Triisodon heilprinianus.* No. 764. Side view of skull, one-half natural size. Outline of occiput from No. 3181.

The postorbital process on the frontal appears to have been less developed than in *Mesonyx ;* on the malar it appears to have been absent. The postorbital constriction of the skull is very marked, as much so as in *Arctocyon*, more than in *Mesonyx* or *Periptychus*.

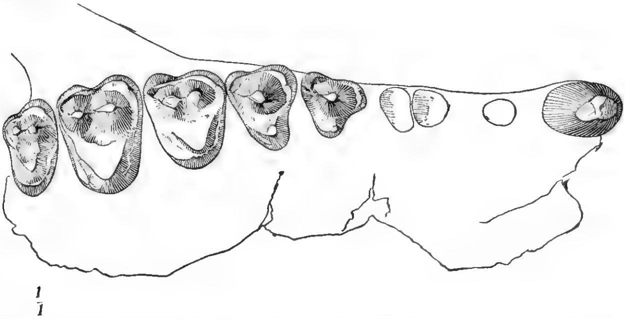


Fig. 12. *Triisodon heilprinianus*, No. 764. Upper dentition, crown view, natural size.

The occipital bones seem to have been firmly sutured together, breaking away rather easily from the rest of the skull.

With the skull were found a few fragments of the skeleton. A *humerus* resembles that of *Arctocyon*, but is smaller and shorter, deltoid crest hardly as prominent, supinator crest somewhat more so, distal trochlea wider but quite as deep. The form of the distal trochlea approximates that of *Pantolambda* and *Periptychus*, but the bone is smaller and slenderer than in either of these, the skulls being of nearly equal size.

Pachyæna gigantea *O. & W.*

" Founded upon a series of finely preserved upper cheek teeth lacking only the first premolar. The specific distinctions from *P. ossifraga* are very marked— (a) the presence of a metacone upon the third upper molar ; (b) the more complex structure of the third and fourth premolars ; (c) the very broad crenate external cingulum ; (d) the relatively smaller size of the metacone in the molars."—*Osborn & Wortman*, 1892, p. 113.

This is one of the largest of the Creodonta, being exceeded in size of skull only by some undescribed specimens of *Mesonyx* in the Museum collections. *Hemipsalodon grandis* Cope, though much larger in skeleton,[1] seems to have had a somewhat smaller skull. Part of a skull and jaws (No. 2823) and a fragmentary skeleton (No. 2959) are here described. Both are from the Wasatch beds of the Big Horn Valley, Wyoming, collected by the Expedition of 1896.

The skull preserves the second premolar and third molar, and alveoli of all the upper teeth except the incisors, also most of one ramus of the lower jaw. The fragmentary skeleton includes parts of the upper jaws with the molars in place, and parts of the lower jaw with the molars in position and the canines and third premolar emerging from the jaw. With it are several loose teeth, most of the limb bones, but all more or less broken, the astragalus and calcaneum and several vertebræ. The epiphyses are missing from the majority of the bones.

Upper Teeth.— First premolar one-rooted, the second and third two-rooted and simple crowned, the fourth three-rooted, moIariform, with two well separated cusps of equal size and a widely separated internal cusp. Its peculiar shape, small size, and unusual wear suggest that it is a persistent milk tooth ; this view is strengthened by the fact that the corresponding premolar in the

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[1] If the femora referred to it by Professor Cope really belong to the species, which I consider very doubtful, as the proportion of skull and body would be most unusual for a Creodont.

lower jaw has dropped out early, its alveolus being closed up. Median (? upper) incisors with large very much compressed root and small crown. Lateral incisor with large root of oval section and small pointed crown. Canine large of round-oval section.

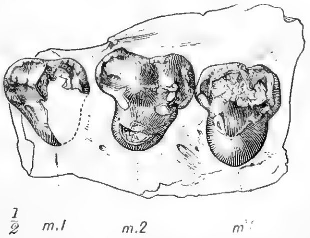

Fig. 13. *Pachyæna gigantea* Osborn & Wortman. Three upper molars in place. Crown view, one-half natural size. Young individual. No. 2959, Wasatch Beds, Big Horn Basin, Wyoming. Amer. Mus. Exped. 1896.

Lower Teeth.—Canines large, moderately stout, regularly oval in section, set near together (interspace about half width of canine). First premolar one-rooted, second two-rooted, third true premolar emerging from the jaw, stout, with protoconid directed strongly backward, wide, square-based, low trenchant heel and no anterior basal cusp. No indication of a fourth permanent premolar could be found in the immature individual, but the state of preservation of the specimen does not make it possible to disprove the existence of one. The temporary premolar is indicated by some remains of an alveolus. In the adult jaw, as already observed, the temporary fourth premolar had fallen out and its alveolus closed without replacement. The first and second molars have a vestigial metaconid ; traces of it are discernible also on the third. All three are shaped like those of *P.*

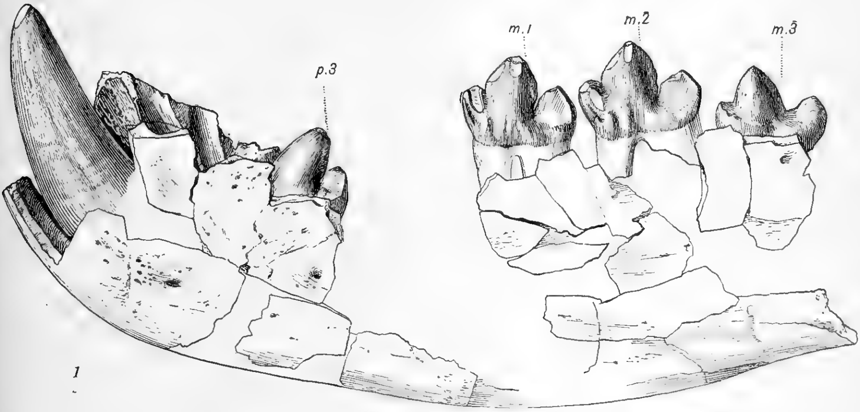

Fig. 14. *Pachyæna gigantea*, No. 2959. Fragmentary lower jaw, external view, one-half natural size.

ossifraga, rectangular in outline when seen from above with high stout protoconid ridged before and behind, large well separated trenchant heel, and smaller less trenchant paraconid. The protoconid is vertical in $m_{\overline{2}}$, projects slightly forward in $m_{\overline{3}}$, and somewhat more backward in $m_{\overline{1}}$. The second molar is the largest and the third the smallest of the three.

The angle of the lower jaw is inflected, more so than in *Dissacus* or *P. ossifraga*, less than in *Mesonyx uintensis*. In *M. obtusidens* "the angle is prolonged into a stout hook much like that of *Stypolophus*" (Scott, '87, p. 157), hence is quite different from the other Mesonychidæ, in which there is a progressively increased inflection of the angle, reaching a maximum in the Upper Eocene *Mesonyx uintensis* where it is almost like that of a Marsupial.

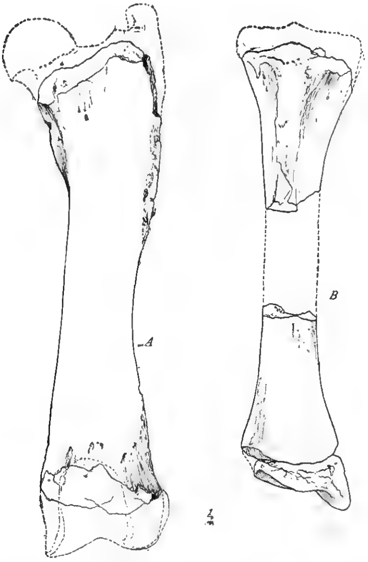

Fig. 15. *Pachyæna gigantea*, No. 2959. Left femur and right tibia, from in front, one-fourth natural size.

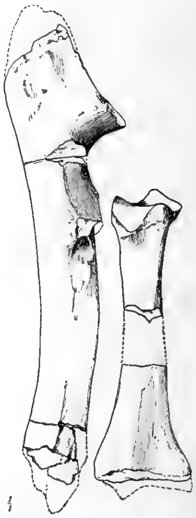

Fig. 16. *Pachyæna gigantea*, No. 2959. Right ulna and radius, one-fourth natural size.

The skeleton is very massively proportioned; the limb bones are somewhat shorter than those of *P. ossifraga*, but one-fourth thicker in the shaft, although the animal is not full grown. The few dorsal vertebræ preserved are short and thick in the centra, and heavy in the arches — apparently short-spined. The calcaneum has a small fibular facet. The astragalus is very short and wide, with flatter trochlea, shorter neck, and smaller sustentacular process than in *P. ossifraga;* it has the distinct cuboidal facet common to the Mesonychidæ, and the navicular facet is flat transversely (slightly concave in *P. ossifraga*, flat in *Dissacus*, convex in *M. obtusidens*).[1]

The most interesting point in regard to this animal is the question of the succession of the teeth. If, as our specimens seem to indicate, the fourth premolar belongs to the milk series, and is not replaced by a permanent tooth, then *this species approximates the marsupial dental formula*, with four true molars and three premolars. The progressive inflection of the angle of the jaw in the Mesonychid phylum is another character of some importance approximating them to the Marsupials. From what we know of the phylum we must regard both these characters as acquired in the Mesonychidæ ; the question then arises — are they not also acquired in the Marsupialia ? This is a matter hardly suitable for discussion within the limits of this paper ; I present the evidence for what it is worth. That there is a progressive inflection of the lower jaw in the Mesonychidæ is certain; the evidence for the retention of the fourth milk molar may be summarized as follows :

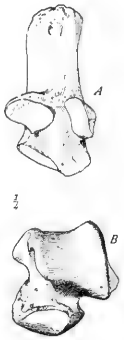

Fig. 17. *Pachyæna gigantea*, No. 2959. Left calcaneum and astragalus, from above, one-fourth natural size.

1. In the upper jaw the last premolar has the ordinary character of a milk molar (small size, short roots, thin enamel, precocious molarization) and is more worn than the first molar or the third premolar, hence probably appeared before either of them.

2. In the lower jaw the fourth premolar has disappeared and its alveolus closed up in an adult specimen, while in a young individual indications exist of an early protruded tooth, but none of a replacing tooth although the third permanent premolar is completely formed and emerging from the jaw.

This evidence cannot be considered satisfactory, especially in

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[1] Professor Scott's statement regarding the last species is that the navicular is concave in both directions. This involves apparently an astragalus convex both ways.

view of the fact that in *Triisodon*, the only other Mesonychid in which the replacement of the teeth has been observed, there is a permanent fourth lower premolar, though protruded rather late in life, considerably after $m_{\overline{3}}$ (Cope, '84, 270).

COMPARATIVE MEASUREMENTS

	Pachyæna gigantea			*P. ossifraga*	*Mesonyx obtusidens*	*M. uintensis*
	No. 72	2823	2959			No. 1892
Length of skull		e. 450		e. 380	279	e. 440
p^1 m^3	e. 162	163		135	98	137
m^{1-3}	e. 79	78	75	54		
Breadth palate at m^2		135		e. 101	78	121
Depth jaw below $m_{\overline{2}}$		94	73	68	50	
Length $m_{\overline{1}-\overline{3}}$			99	63	51	(88[1])
Humerus, width distal end			93	62		
Femur, length			e. 290	315		
" circumference of shaft			108	86		
Ulna, length			e. 293	286	207	
" circumference of shaft			87	65		
Radius, diameter of head			49	34	23	
" circumference of shaft			67	53		
Tibia, length			e. 265	275	205	
" diameter of distal end			58	43	25	
" circumference of shaft			87	74		
Calcaneum, length			98	77	56	
" width			49	41		
Astragalus, length			61	44	31	
" width			58	41	18	
Posterior dorsals, av'ge length of 4 centra			34		e. 30	
Posterior dorsals, av'ge width of 4 centra			58		e. 25	

REFERENCES CITED.

COPE, E. D.

'72. 1. Descriptions of some New Vertebrata from the Bridger Group of the Eocene. *Proc. Amer. Philos. Soc. Philadelphia*, Vol. XII, p. 460 = Palæontological Bulletin No. 1, published July 29.

2. Second Account of New Vertebrata from the Bridger Eocene. *Ibid.*, p. 466 = Pal. Bull. No. 2, published Aug. 3.

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[1] From type specimen. 'e.' = estimated from an incomplete specimen.

3. Third Account of New Vertebrata from the Bridger Eocene of Wyoming Terr. *Ibid.*, p. 469 = Pal. Bull. No. 3, published Aug. 7.

'74. Report on the Fossil Vertebrata of New Mexico. Annual Report U. S. G. G. S. West of 100th Meridian.

'75. Systematic Catalogue of the Eocene Vertebrata of New Mexico. Annual Report for 1874 U. S. G. G. S. W. of 100th Mer.

'77. Report upon the Extinct Vertebrata obtained in New Mexico by Parties of the Expedition of 1874. Final Report U. S. G. G. S. W. of 100th Mer., Vol. IV, part ii.

'81. 1. Eocene Vertebrata of the Wind River Valley. *Bull. U. S. G. S. Terr.*, Vol. VI, Feb. 26.

2. The Temporary Dentition of a New Creodont. *American Naturalist*, Vol. XV, p. 667. August (published July 27).

'82. Contributions to the History of the Vertebrata of the Lower Eocene of Wyoming and New Mexico made during 1881. *Proc. Amer. Philos. Soc.*, Vol. XX, pp. 139–194 (printed Mar. 11, 1882).

'83. First Addition to the Fauna of the Puerco Eocene. *Proc. Amer. Philos. Soc.*, Vol. XX, pp. 545–563. Palæontological Bulletin No. 36.

'84. Vertebrata of the Tertiary Formations of the West. Final Report U. S. G. S. Terr., Vol. III.

LEIDY, J.

'71. *Proc. Acad. Nat. Sci. Phila.*, 1871, p. 115.

LEMOINE, V.

'78. Recherches sur les Ossemens Fossiles du Terrain Tertiaire Infér. de Reims ; 1^{e} Partie — Étude du Genre Arctocyon. *Annales des Sciences Naturelles* (*Zool.*) 6^{e} Sér., Vol. VIII.

MARSH, O. C.

'72. Preliminary Description of New Tertiary Mammals. *American Journal of Science*, Ser. 3, Vol. IV, pp. 122–140, 202–224. Parts I, II, III, and IV issued as separata July 22, Aug. 7, Aug. 13, and Aug. 17, respectively.

'99. Note on a Bridger Eocene Carnivore. *American Journal of Science*, Ser. 4, Vol. VII, May, 1899.

MATTHEW, W. D.

'97. A Revision of the Puerco Fauna. *Bull. Amer. Mus. Nat. Hist.*, Vol. IX, pp. 259–323, Nov. 16, 1897.

'99. A Provisional Classification of the Fresh-Water Tertiary of the West. *Bull. Amer. Mus. Nat. Hist.*, Vol. XII, pp. 19–75, published April 8.

OSBORN, H. F.

'90. A Review of the Cernaysian Mammalia. *Proc. Acad. Nat. Sci. Phila.*, 1890, pp. 51–67.

'93. The Rise of the Mammalia in North America. Vice-Presidential Address, Amer. Assoc. Adv. Sci., Sec. Zoölogy.

'95. Fossil Mammals of the Uinta Basin, Collection of 1894. *Bull. Amer. Mus. Nat. Hist.*, Vol. VII, pp. 71–105, pub. May 18.

'00. Oxyæna and Patriofelis Restudied as Terrestrial Creodonts. *Bull. Amer. Mus. Nat. Hist.*, Vol. XIII, pp. 269–279.

OSBORN, H. F., and EARLE, CHAS.

'95. Fossil Mammals of the Puerco Beds, Collection of 1892. *Bull. Amer. Mus. Nat. Hist.*, Vol. VII, pp. 1–70, published March 8.

OSBORN, H. F., and WORTMAN, J. L.

'92. Fossil Mammals of the Wahsatch and Wind River Beds, Collection of 1891. *Bull. Amer. Mus. Nat. Hist.*, Vol. IV, pp. 81–148, published Oct. 20.

'94. Fossil Mammals of the Lower Miocene White River Beds. Collection of 1892. *Bull. Amer. Mus. Nat. Hist.*, Vol. VI, pp. 199–228, published July 28.

SCHLOSSER, MAX.

'87. Die Affen, Lemuren, Chiropteren, Insectivoren, Marsupialer, Creodonten und Carnivoren des Europäischen Tertiärs. *Beit. zur Paläont. Oesterr.-Ungarns*, Bd. VI, Wien, 1887–90.

'99. Ueber die Bären und Bärenähnlichen Formen des Europäischen Tertiärs. *Palæontographica*, Bd. XLVI, pp. 95–146, Taf. xiii, xiv.

SCOTT, W. B.

'87. On Some New and Little Known Creodonts. *Journ. Acad. Nat. Sci. Phila.*, Vol. IX, pp. 155–185, pl. v–vii.

'92. A Revision of the North American Creodonta. *Proc. Acad. Nat. Sci. Phila.*, 1892, pp. 291–323.

WORTMAN, J. L.

'99. Restoration of *Oxyæna lupina* Cope, with Descriptions of Certain New Species of Eocene Creodonts. *Bull. Amer. Mus. Nat. Hist.*, Vol. XII, pp. 139–149, published June 21.

WORTMAN, J. L., and MATTHEW, W. D.

'99. The Ancestry of Certain Members of the Canidæ, the Viverridæ, and the Procyonidæ. *Bull. Amer. Mus. Nat. Hist.*, Vol. XII, pp. 109–139, published June 21.

ZITTEL, K. v.

'94. Lehrbuch der Paläontologie, Pt. I, Vol. IV, Mammalia.

Tooth Characters and Revision of the North American Species of the Genus Equus.

By J. W. GIDLEY.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,

VOL. XIV, ARTICLE IX, pp. 91–141.

New York, May 31, 1901.

The Knickerbocker Press, New York

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

By J. W. Gidley.

Plates XVIII-XXI and 27 Text Figures.

CONTENTS.

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

Fossil remains of the genus *Equus* (indigenous to North America) were reported as early as 1826 by Mitchell,[1] who referred to this genus some teeth and vertebræ found near the Neversink Hills in New Jersey, without assigning them to a species. Since that time about twenty different species have been proposed by various authors, based on material found in different localities of the United States and Mexico.

Although the remains of this genus have been found widely

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

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

This is the conclusion reached by the writer after a careful study of the abundant *Equus* material from the Niobrara River (collected by the American Museum expeditions of 1893 and 1897[1]), together with the skulls and associated partial skeletons from the Staked Plains of Texas, and of numerous specimens of the living species.

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

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

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

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

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

I. Principles of Tooth Structure. Characters Due to Individual Variation and to Age or Degree of Wear Distinguished from truly Specific Characters.

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

Tooth Characters.

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

Skull Characters Relative to the Teeth.

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

More importance has been attached to most of these characters, apparently, than their merits warrant; evidently, therefore, the only way of forming an estimate of their true value is to find out, in a large series of specimens, in what way and how much these characters may be affected in the individual and in different individuals of the same species.

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

A.—Tooth Characters as Altered by Age or Degree of Wear.

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

When a molar or premolar tooth first comes into use, the face, as well as the sides of the crown, is completely covered with enamel (Fig. 2, *A*), which folds in and out, and (though somewhat hidden by cement) presents the same general appearance as that seen in the much more primitive forms, *Anchitherium* and *Mesohippus.* Soon the enamel on the tips of the cones and along the ectoloph wears through, and small patches and ridges of dentine completely surrounded by a border of enamel are exposed. (Fig. 2, *B.*) As the tooth is further worn away, these patches and irregular ridges broaden and rapidly lengthen until when about one-half to three-quarters of an inch of the crown

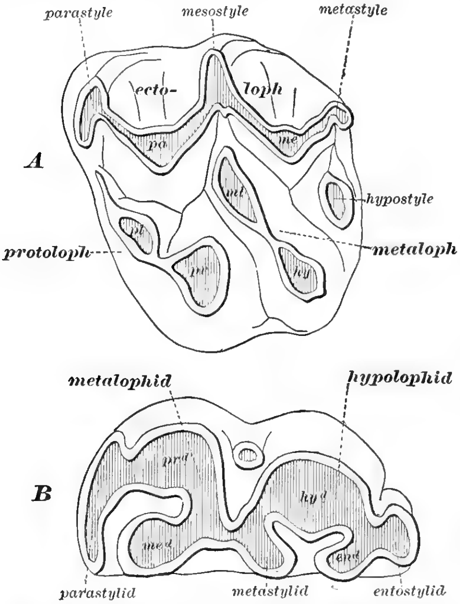

Fig. 1. Molars of Horses showing terminology. *A*, Upper molar, *Anchitherium. B*, Lower molar, *Merychippus.* (After Osborn.)

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

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

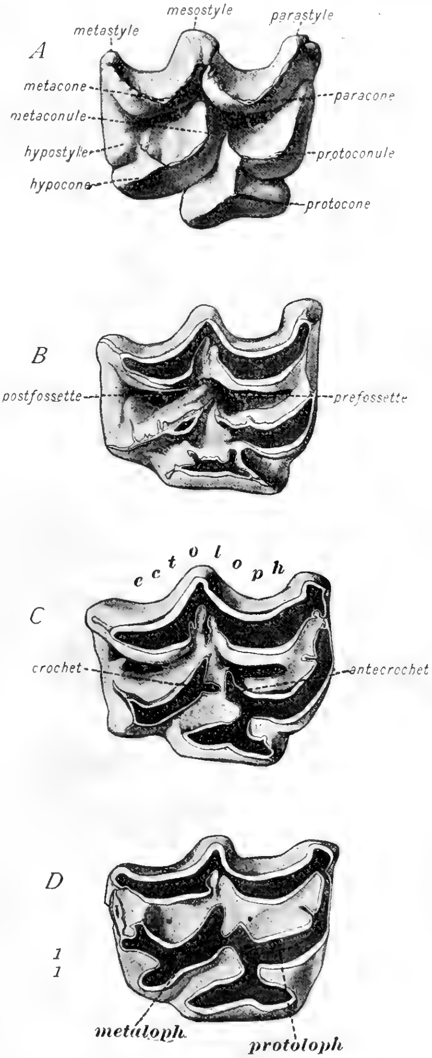

Fig. 2. Cusps, Crests, Styles, Crochets, and Fossettes in the molar teeth of the Horse (*E. complicatus*). *A*, unworn crown. *B–D*, successive stages of wear.

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

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

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

1. The Teeth Taken Individually.

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

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

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

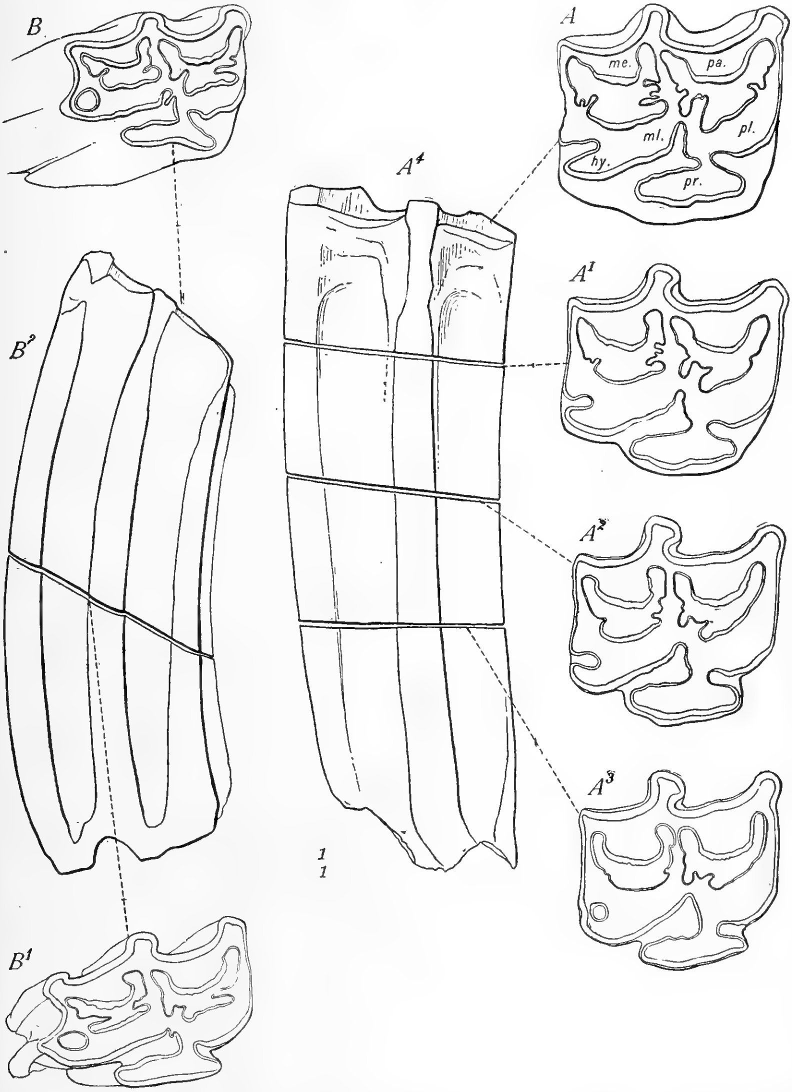

Fig. 3. Superior molars of *Equus complicatus*, sectioned to illustrate changes in dimensions and pattern at different stages of wear. *A*, triturating surface of m^1. A^1, A^2, and A^3, sections cut parallel to triturating surface. A^4 shows where sections were cut; *B*, triturating surface of m^2; B^1, section; B^2 shows where section was taken.

TABLE I. MEASUREMENTS ON THE TRITURATING SURFACES OF THE UPPER TEETH OF EQUUS CABALLUS AND EQUUS ASINUS.

	DESCRIPTION.	APPROXIMATE AGE.	CATALOGUE NUMBER.	DIAMETERS IN MM.[1]						
					p²	p³	p⁴	m¹	m²	m³
Series 1.	*Large draught Horse* ♀	5 years	16274	Antero-posterior	40	32	30	30	30	29
				Transverse	27	28.5	27.5	27	26.5	21.5
				Antero-posterior, Protocone	11	14.5	15	13.5	15.5	16
	" " " ♂	8 "	14131	Antero-post.	36.5	29	28	25.5	25.5	29.5
				Transverse	25.5	28	27	26.5	26	22
				Antero-post., Protocone	10	13.5	14	13	15	16
	" " " ♂	15+"	289	Antero-post.	38.5	29.5	28.5	24	25	30
				Transv.	23	27.5	28	26	25.7	22.5
				Antero-post., Protocone	9.3	13	13	11.5	12.5	12.8
	" " " ♂	12+"	No number	Antero-post.	40	30.5	30	27	27	29
				Transv.	28	30	28.5	28	26.5	23
				Antero-post., Protocone	10	14	14	13	13.5	13
Series 2.	♀	20 ± years	16277	Antero-post	36	26	25	21.5	21.5	30
				Transv	24	26.5	27	25	25	22.5
				Antero-post., Protocone	9	10	11	10	12.5	14.5
	♂	20 ± "	16275	Antero-post	33.5	25.5	25.5	22.5	23.5	26.5
				Transv	23	26.3	26	25	25	23
				Antero-post., Protocone	10	12	13.5	13.5	15	14
	Thoroughbred ♀	6 "	Loaned by C. R. Knight	Antero-post	33.5	27.5	28	25	25.5	27.5
				Transv	25	26.5	26.5	25.5	25	21.5
				Antero-post., Protocone	8.5	13	13.5	13.5	13.5	15
	Texas Pony ♂	7 "	No number	Antero-post.	35	28	26	24	24.5	28.5
				Transv	23	25.5	25	25	24	21.5
				Antero-post., Protocone	8	10.5	10.7	10.5	10.5	11
Series 3.	*Domestic Ass* ♀	5 years	15675	Antero-post	33	26	25	22	23	23
				Transv	24.7	25	24	22.5	22.5	18.5
				Antero-post. Protocone	6.5	9.5	10.5	8.5	9.5	10.5
	Mexican Burro ♂	6 "	No number	Antero-post.	31	24.5	23.5	21.5	21.5	22
				Transv	23	24.3	24	23.3	21.5	18
				Antero-post., Protocone	6.5	8.5	9	9	9	10.5

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

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

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

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

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

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

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

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

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

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

It will be seen from the foregoing that owing to the very slight variation of the transverse diameters of the crowns of $p^{\underline{3}}$ to $m^{\underline{2}}$ inclusive, for almost their entire length, and to the great shortening of their antero-posterior diameters, the ratio of these diameters in these teeth is very different in old and in young individuals of the same species. Thus in the little worn condition of these teeth in a young horse, especially before the teeth have worn to that stage where the transverse diameter is greatest, the antero-posterior diameter is always greater than the transverse. As the crown wears away, the antero-posterior diameter diminishes and a stage is reached where the two diameters are about equal, then, as the antero-posterior becomes still more shortened, the transverse exceeds it. In every series this variation in ratio seems always to be most advanced in $m^{\underline{1}}$ and $m^{\underline{2}}$. This is evidently due not only to the order in which the teeth of the horse come into use, whereby the first to appear would at a given stage be most worn, but also, as is shown by an examination of Table I (p. 98), because the range of reduction of the antero-posterior diameters is greater in the molar than in the premolar teeth. $M^{\underline{1}}$ is always the most advanced, as it comes into use before any of the others of the permanent set.[1]

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

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

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

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

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

marks the posterior extension of the maxillary bone beyond $\text{m}^{\underline{3}}$; hence the length of this posterior extension of the maxillary depends principally upon the age of the horse. In passing from the young to the old stage, there is also a marked change in the relative position, with respect to the molar teeth, of the anterior projection of the maxillary ridge, the post-palatal foramina, and the anterior projection of the post-palatal notch,—all appearing relatively more posterior in the old individual.

B.—INDIVIDUAL VARIABILITY.

a. *Degree of complexity of the enamel foldings of the teeth.*—The examination of a large number of specimens of *E. caballus*, many of them of about the same age, shows a great variability in this character aside from that caused by wear; this indicates that individual variability also has a very wide range, and no two specimens can be found, even of the same age and species, in which the enamel foldings of the corresponding teeth are exactly alike, and even corresponding teeth of the opposite sides of the same skull often show slight differences in the number and style of the minor enamel folds. Fig. 4 (*A* and *B*) represents the corresponding teeth ($\text{m}^{\underline{2}}$) of two very large draught horses of the same variety, with apparently only about a year's difference in age, the one represented by *A* being the younger. These teeth show considerable difference in the degree of complexity of the enamel folding, which may be due in part to their difference in age, but specimens can be found in individuals of the same age in which the difference is just as great. The corresponding tooth of the Texas pony (Pl. XIX, Fig. *D*) is much simpler than either of the above, yet the degree of wear of the teeth shows that this tooth was apparently intermediate in age between those of *A* and *B*, Fig. 4.

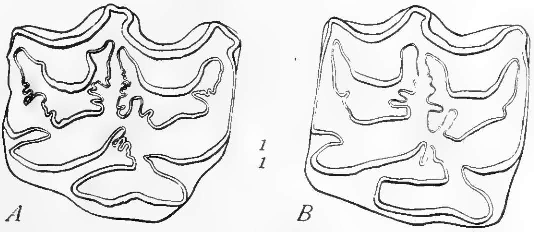

Fig. 4. Superior molars m^2, *E. caballus*. *A* and *B* of different individuals of about the same age, showing variation in plication.

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

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

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

It seems reasonable that much greater variations of the comparatively constant characters of the teeth would be found in *E. caballus* than in the extinct species, since in this species domestication and breeding have caused such a very wide range in size and proportions of the individuals; hence, when, in two lots of fossil horse teeth, the difference between the transverse diameters of corresponding teeth is on the average greater than that between the large and small varieties of *E. caballus*, it would seem that the teeth of the two lots could scarcely belong to the same species, and although the character of size, alone, could hardly be considered sufficient ground for establishing a species, yet where this difference exists, it seems reasonable to expect that when skulls which represent such two lots of teeth are known, other differences will be found which will clearly mark them as distinct species.

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

The Lower Teeth.

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

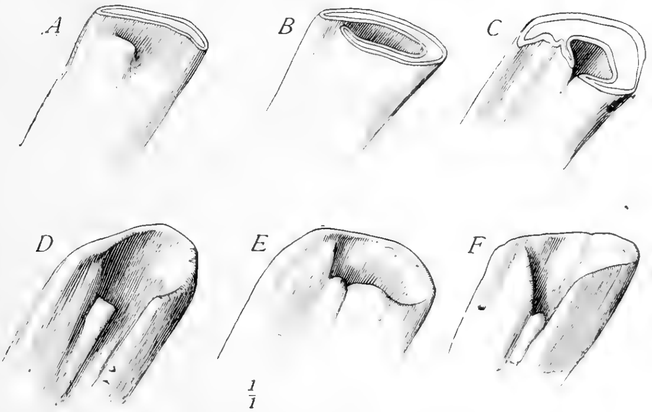

Fig. 5. External lower incisors showing development of cups. *A*, *B*, *C*, *E. caballus*; *D*, *E*, *F*, *E. scotti*.

hand shows: (1) that the fully developed cup is usually present in *E. caballus*, though not always, the writer having examined three specimens in which it is entirely wanting (Fig. 6, *C*); (2) in the two jaws of *E. asinus* in the Museum collection there is no indication of even a tendency toward cupping of the external incisors; and (3) the fossil species of *Equus* in which this character can be made out

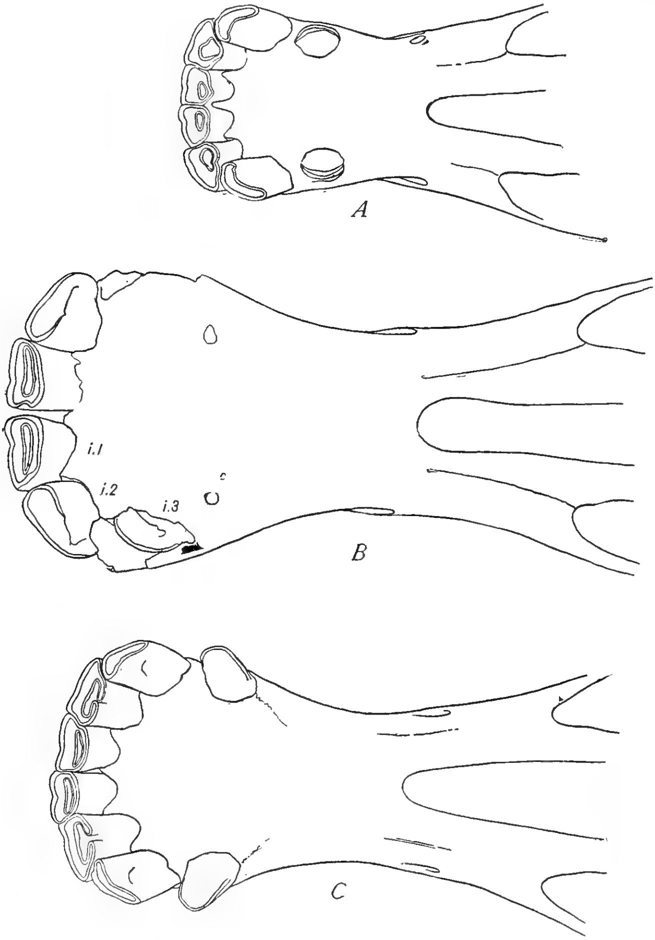

Fig. 6. Mandibular symphyses. *A*, *E. asinus*; *B*, *E. scotti*; *C*, *E. caballus*.

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

SUMMARY.

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

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

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

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

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

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

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

α Crowns more or less curved.

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

$\alpha\ \alpha$ Crowns straight or nearly so.

β Diastemata longer.

" Crowns nearly square, enamel not very complex; no facial fossa; maxillary bone produced much beyond $m\frac{3}{}$ ....*E. caballus.*

$\beta\ \beta$ Diastemata shorter.

Υ No facial fossa.

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

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

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

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

Υ A facial fossa.

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

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

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

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

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

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[1] Proc. Am. Phil. Soc., Vol. XXII, 1884, p. 10.

CHRONOLOGICAL TABLE OF PROPOSED SPECIES REPORTED FROM THE UNITED STATES.

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

II.—REVISION AND DISCUSSION OF SPECIES.[1]

(2) *Equus curvidens* Owen.

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

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

Type.—Superior $m^{\underline{2}}$; little worn.

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

Measurements.

$m^{\underline{2}}$	Antero-posterior diameter	27 mm.
	Transverse "	24 "

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

(3) *Equus major* De Kay.

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

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

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

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

(4) *Equus americanus* Leidy.

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

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

(6) **Equus complicatus** (*Leidy*).

E. americanus Leidy (non Gervais).

Type Locality.—Near Natchez, Mississippi.

Horizon.—Tenaceous blue clay underlying a diluvial deposit.

Type.—A second superior molar of the left side. *Cotypes:* Two third superior molars of the right side.

Author's description. — "The enamel folds are one-fourth thicker than in the recent horse and the isolated enamel folds of the superior molars are much more plicated, resembling in this respect the *Equus plicidens*, Owen."

Measurements.

$$\mathrm{m}^{\underline{2}}\begin{cases}\text{Antero-posterior diameter} = 1.2 \text{ of an inch} = 30\text{ mm.}\\ \text{Transverse diameter} = 1.1 \text{ of an inch} = 27\text{ mm.}\end{cases}$$

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

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

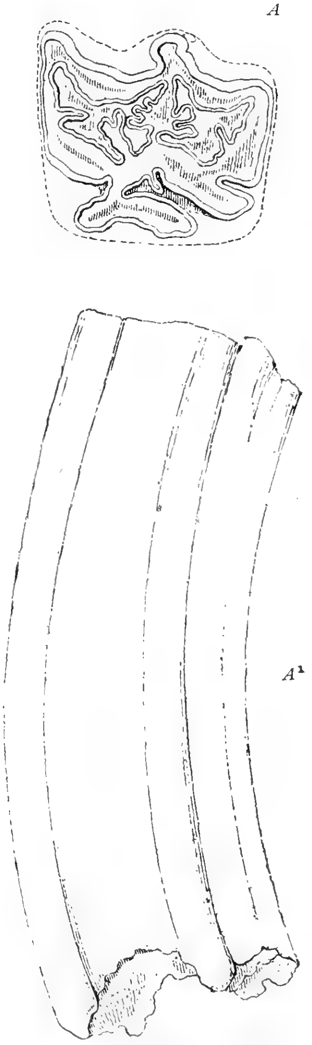

Fig. 7. Type of *Equus complicatus*. *A*, triturating surface; *A*¹, side view of crown. (After Leidy.)

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

[2] Holmes's Post-Pleiocene of So. Carolina, 1860.

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

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

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

(5) **Equus fraternus** Leidy.

Type Locality.—Near Charleston, S. C.
Horizon.—Phosphate Beds.
Type.—Superior p^2.

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

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[1] Proc. Am. Phil. Soc., Vol. XXXIV, 1895, p. 467.
[2] Holmes's Post-Pleiocene of S. C., 1860, pp. 100 to 105, Pl. xv and xvi.

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

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

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

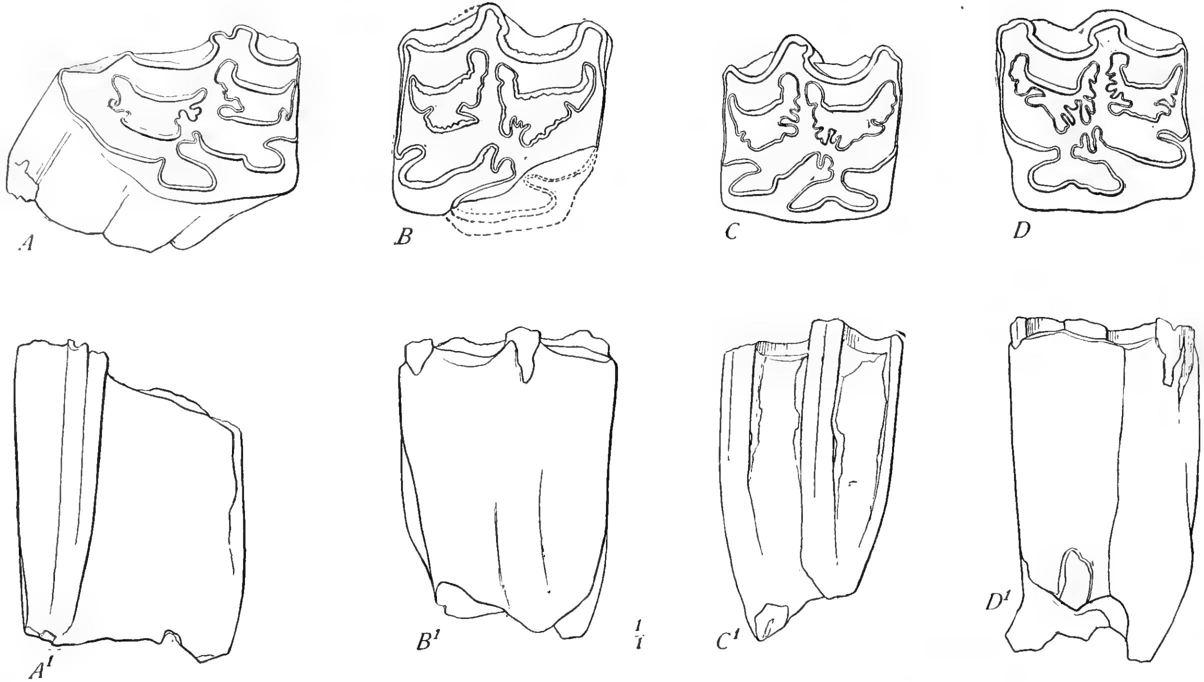


Fig. 8. Superior molars of *E. fraternus* and *E. complicatus.* *A*, crown view; *A*^{1}, external view of p^2, *E. fraternus*, type. (No. 9200, Coll. A. M. N. H)
B, crown view; *B*^{1}, external view of m^1, *E. complicatus* ("type" Cope, *E. fraternus* Leidy, No. 9202, Coll. A. M. N. H.).
C, crown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

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

Measurements of type tooth.

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

Measurements of Nos. 9203 and 9217.

p^3 (So. Carolina)	Antero-posterior diameter	25 mm.
	Transverse "	24 "
m^1 (Florida)	Antero-posterior "	23.5 "
	Transverse "	24.5 "

(7) *Equus excelsus* Leidy.

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

Type.—A fragment of the right side of an upper jaw, containing $p^4 - m^3$ inclusive.

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

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

Measurements of Teeth.

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

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

The teeth of the type specimen are little worn and hence the simplicity of the enamel folding is not due to age. A feature shown in this specimen which may distinguish it from the other species of its size is the extreme anterior position of the postpalatal foramen and the anterior extension of the palatal notch. These are placed about 15 mm. farther forward than in any of the Nebraska specimens of the same size in the American Museum collection, and indeed their position is more anterior than in even very young individuals of the domestic horse. However, to make this character a strong distinguishing feature, it would be desirable to obtain several other specimens from the same locality showing this same character.

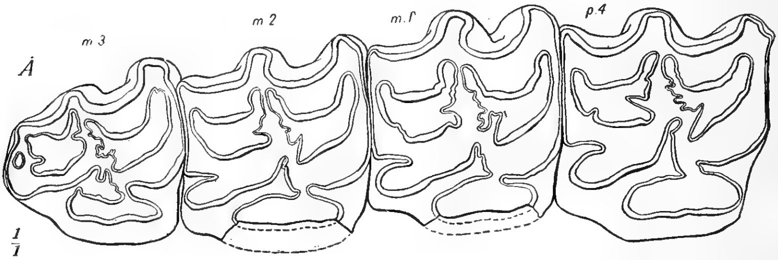
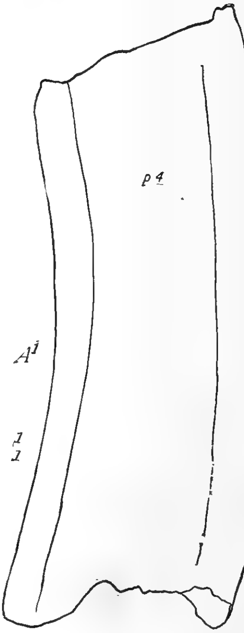


Fig. 9. *Equus excelsus* Leidy. Type. *A*, crown view of upper first, second, and third molars, and fourth premolar. *A*¹, anterior view of p⁴.



(9) **Equus occidentalis** *Leidy.*

Type Locality.—Tuolumne Co., California.

Type.—Superior p^3.

Author's Description.—In describing the teeth from California Leidy said: "Two of them are second upper molars of different individuals. . . . These two upper molars, strongly resembling each other, differ from the more recent looking specimens, and from the corresponding teeth of the domestic horse, in the remarkable degree of simplicity of the enamel folding, as seen on the triturating surface."

Measurements given.

Second upper molar (? m$^{\underline{2}}$)	Antero-posterior diameter	—	14¾ lines	(31 mm.).
	Transverse "	—	12½ "	(27 mm.).
" " " (? p^3 Type[1])	Antero-posterior "		15¼ "	(32 mm.).
	Transverse "		13½ "	(28.5 mm.).

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

In 1869[2] Dr. Leidy united these two species on the ground of the absence in both, of the little enamel fold, near the bottom of the deep valley between the protocone and the hypocone. This,

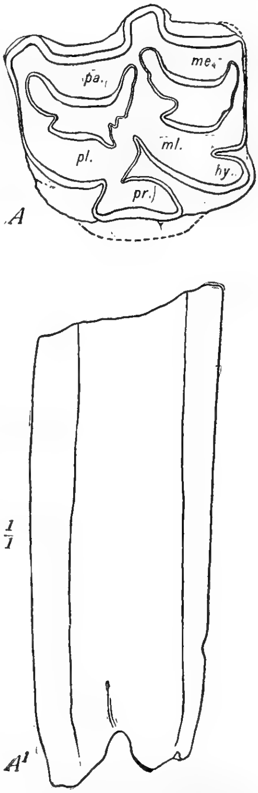


Fig. 10. *Equus occidentalis* Leidy. Type. Superior third premolar. *A*, crown view; *A*¹, external view.

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

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

however, would seem to be scarcely a sufficient reason for uniting them, as, in addition to this being a somewhat variable character, the type specimen of *E. excelsus* shows a deep notch in $m^{\underline{3}}$ and a slight though well marked one in $m^{\underline{1}}$. (The notch in $m^{\underline{1}}$ is not shown in Leidy's figure of the type.)

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

(10) **Equus pacificus** *Leidy.*

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

Type.—Superior $p^{\underline{3}}$.

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

Length along the outer median column to the origin of the fangs, 26 lines 56 mm.). Breadth of triturating surface fore and aft, 16½ lines (35 mm.). Thickness independent of cementum, 15 lines (32 mm.)."

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

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

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

If these Silver Lake specimens can be regarded as representative of *E. pacificus* as described by Leidy, this species can now be pretty clearly defined. Figure 11, *A*, *B*, *C* (Nos. 8601, 8602, and 8603, Coll. Am. Museum Nat. Hist.), are representative teeth of the Oregon collection. Their measurements are as follows:

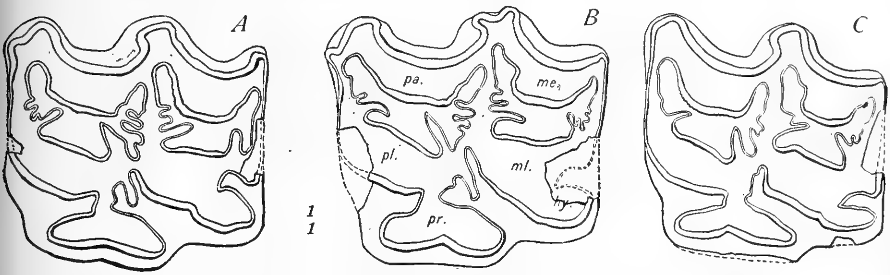

Fig. 11. *Equus pacificus.* *A*, superior fourth premolar, p^4 (No. 8602, Coll. A. M. N. H.); *B*, superior third premolar, p^3 (No. 8601, Coll. A. M. N. H.); *C*, superior second molar, m^2 (No. 8603, Coll. A. M. N. H.)

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

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

It may be added to the description already given by Cope, (1) that the teeth are actually and proportionally much larger, while the bones of the skeleton about equal in size the larger varieties of *E. caballus;* (2) the occipital region seems to be narrower transversely, and the muzzle, judging from the front portions of lower jaws in the collection, seems to be proportionally shorter.

(12) Equus conversidens *Owen.*

Type Locality.—Valley of Mexico.

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

Author's description.—In describing the specimens to which he gave the name *E. conversidens*, Owen considered the following to be the distinguishing characters: They correspond closely in "size, curvature, and pattern of the grinding-surface of the upper molar teeth, with *Equus curvidens*. . . . There is "a curved convergence of the two series of upper grinders towards the fore part of the palate to a degree exceeding that in other Equines. . . The last molar, $m^{\underline{3}}$, is relatively smaller than in any old-world Equines. The first premolar, $p^{\underline{2}}$, resembles in the minor production of the anterior lobe that tooth in *Equus asinus*, *Equus quagga*, and differs in this respect from *E. caballus.* The grinding-surface, however, retains, as in *Equus* aff. *caballo*, Ld., and in *E. curvidens*, the general conformity of character of enamel-folding so remarkable in all the modern and in the European Pleistocene Equine species hitherto described. . . . But the most distinctive character of the upper grinders of *E. conversidens* is their disposition in the jaw, denoted by the *nomen triviale* of the extinct Mexican horse; and to the character of the curvature of the molar series of alveoli may be inferentially added a concomitant modification of the shape of the upper jaw itself, involving that of the lower one."

Measurements.

$p^{\underline{2}}$	Antero-posterior	diameter	30 mm.
	Transverse	"	25 "
$p^{\underline{3}}$	Antero-posterior	"	25 "
	Transverse	"	25 "
$m^{\underline{1}}$	Antero-posterior	"	22 "
	Transverse	"	21 "
$m^{\underline{3}}$	Antero-posterior	"	19 "
	Transverse	"	18 "

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

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[1] Proc. Am. Phil. Soc., 1884, p. 13.

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

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

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

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

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

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

(13) **Equus tau** *Owen.*

Synonym, *Equus barcenæi* Cope.

Type Locality.—Valley of Mexico.

Type.—A superior molar-premolar series lacking $p^{\underline{2}}$.

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

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

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

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

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

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

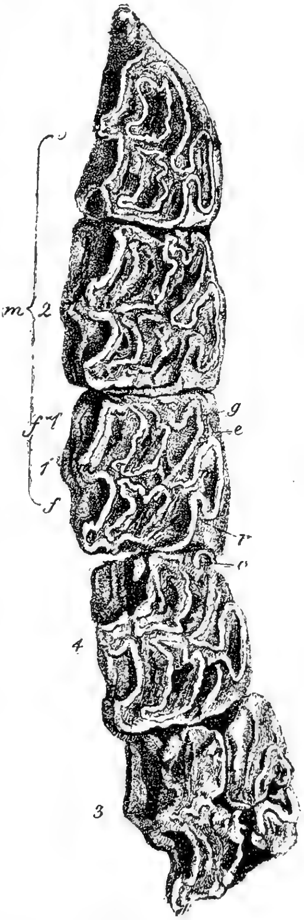

Fig. 12. *Equus tau* Owen. Type. Upper molar-premolar series, lacking second premolar, p^2. (After Owen.)

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

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

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

(14) *Equus crenidens* Cope.

Type Locality.—Tequixquiac, Valley of Mexico.

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

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

Measurements given.

p^2	Antero-posterior diameter	43	mm.
	Transverse "	30.5	"
p^3	Antero-posterior "	33.5	"
	Transverse "	34	
p^4	Antero-posterior "	31	"
	Transverse "	35	"

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

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

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

(15) *Equus barcenæi* Cope.

Type Locality.—Valley of Mexico.

Type.—Two superior molars.

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

Measurements.

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

In 1893[1] Cope made this species a synonym of *E. tau.* It is difficult to make out whether, in doing so, he referred to *E. tau* Cope (not of Owen),[2] which has been shown to be the equivalent of *E. conversidens*, or whether he now regarded *E. tau* in the light of the original description given by Owen. It seems probable, however, that the latter view is the correct one, as in this connection he referred to Owen's description of *E. tau* and not to his own. Taking into account the fact that the transverse diameters of the teeth of *E. barcenæi* given by Cope probably include the cement, there seems to be no distinction between this species and *E. tau* Owen, and therefore it may be considered, as Cope has already placed it, a synonym of this species.

(16) **Pliohippus simplicidens** *Cope.*

Equus simplicidens Cope.

Type Locality.—Mt. Blanco, Texas.

Horizon.—Blanco Beds (Upper Pliocene).

Type.—Superior molar.

Author's description.—"The size of the teeth is about that of the *E. occidentalis* and *E. caballus.* The internal column is of moderate antero-posterior extent, its posterior border marking the anterior third of the posterior lake. Its

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[1] Report Geol. Surv. Texas, 1893, p. 79.

[2] Proc. Am. Phil. Soc., 1884, p. 12.

long diameter is considerably less than half that of the crown. A peculiarity found in two of the superior molars, but not in two others, is that the median dental connection between the external and median crescents is interrupted by the continuity of the enamel plates bordering the lakes from the one to the other. This arrangement is frequently seen in the large $pm^{\underline{3}}$, in the species of *Equus*, but does not occur in the other premolars and molars. It is a reversion to the condition seen in *Anchitherium*. A principal character of the species is seen in the extreme simplicity of the enamel borders of the lakes."

Measurements not given.

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

It seems exceedingly doubtful, however, whether this species can be properly placed in the genus *Equus*. Cope did not point out or suggest any characters that mark it as belonging to this genus, nor are there any such characters shown in any of his figures. On the contrary, there are in his descriptions and figures, and also in three teeth collected by the writer from the same locality (No. 10624, Am. Mus. Nat. Hist. Collec.) and probably belonging to the same species, several indications of primitive characters linking this species much more closely with *Pliohippus*, as this genus is understood, than with *Equus*. The character of the very small protocone and the tendency to a sharp entrant-angular groove between the metaconid and metastylid columns, a distinguishing character given by Cope[1] for the lower teeth, are both like the Loup Fork genera and unlike any of the Pleistocene or recent species of *Equus*. Besides these characters the American Museum specimens show other characters which seem

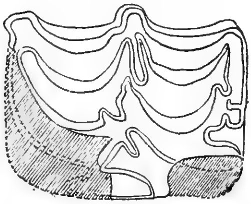

Fig. 13. *Pliohippus simplicidens*. Type. (*Equus simplicidens* Cope). Superior premolar. (After Cope.)

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

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

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

(17) **Hipparion eurystylus** (*Cope*).

Equus eurystylus Cope.

Type Locality.—Paloduro Cañon, Texas.

Horizon.—(?) Goodnight Beds.

Type.—Lower molar.

Author's description.—"This species belongs with *E. minutus* Cope, to a section of the genus characterized by the relatively great width of the metaconid-metastylid column of the inferior molars, and its close appression to the protoconid and hypoconid, and hence by the relatively narrow molar crown; and also by the small size." (For further description see Report Geological Survey of Texas, 1893, pp. 44, 45.)

Measurements given.

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

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

An examination of the horse teeth from the true Loup Fork Beds (in the American Museum collections) indicates that the character of "the relatively great width of the metaconid-metastylid column of the inferior molars" is only a feature of individual variability, as this column is very variable in size. The characters that seem to point most strongly to the association of this species with the genus *Hipparion* are as follows: (1) The appression of the metaconid-metastylid column to the protoconid and hypoconid, which seems to be characteristic of *Protohippus* and *Hipparion* and not of *Equus*; (2) the presence of a well-defined enamel keel or loop in the anterior border of the protoconid; (3) the greater extension of the transverse ridge of enamel thrown out from the parastylid, which extends beyond the middle and usually to the outer edge of the metaconid, and marks the antero-internal corner of the tooth in *E. eurystylus* and all the three-toed horses; and which in *E. caballus* and the fossil species of *Equus* seems seldom to extend beyond the middle of the metaconid and often only as far as its inner margin:

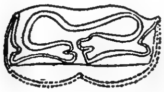

Fig. 14. *Hipparion eurystylus.* Type of *Equus eurystylus* Cope. Superior premolar. (After Cope.)

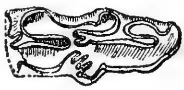

Fig. 15. *Hipparion eurystylus* (*Equus eurystylus* Cope). Lower molar. (After Cope.)

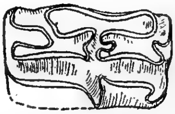

Fig. 16. *Hipparion eurystylus* (*Equus eurystylus* Cope). Lower premolar. (After Cope.)

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

(18) **Protohippus cumminsii** (*Cope*).

Equus cumminsii Cope.

Type Locality.—Mt. Blanco, Texas.

Horizon.—Blanco Beds.

Type.—Superior molar.

Author's description.—"The enamel borders are entirely simple. . . . It differs from the *E. simplicidens* and *E. tau* in the prominent concavity of the internal wall of the paracone and metacone, from which it results that the exterior border of each of the lakes is deeply concave, and the horns appear to be strongly produced. The protocone has a very short antero-posterior diameter, in which it resembles the *E. simplicidens*, *E. crenidens*, and *E. stenonis*, and differs radically from the *E. tau* and the other species of the Equus beds. It is not bilobate or grooved on the internal face. . . . The subcylindric character of the paracone and metacone approach what exists in 'Hippidium' and some species of the three-toed horses."

Measurements given.

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

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

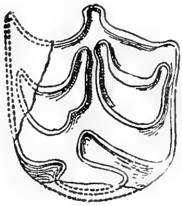

Fig. 17. Type of *Protohippus cumminsii* (*Equus cumminsii* Cope). Superior molar. (After Cope.)

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

Equus phlegon Hay.

Synonym, *Equus minutus* Cope.

Type Locality.—Mount Blanco, Texas.

Horizon.—Blanco Beds.

Type.—An inferior molar—(?) $m_{\overline{2}}$.

Author's description.—"The inferior molar is narrowly hypsodont, and has apparently had but a thin cementum investment. . . . The inner side of the crown shows marked peculiarities. The metaconid and metastylid are appressed to the hypoconid and protoconid, and are spread widely apart so as to be connected by a narrow antero-posterior isthmus, and separated on the internal face of the crown by a wide channel which has a greater antero-posterior diameter than the metaconid and metastylid respectively, near the apex of the crown, and an equal width at the base of the crown. The hypostylid (entoconid) is also appressed to the hypoconid and has a recurved postero-internal angle, which forms an acute ridge bounding the internal face of the crown posteriorly. This encloses with the metastylid a flat open gutter as wide as the metastylid. A sharp ridge marks the internal face of the anterior border, but it is closely appressed to the metaconid, which it does not equal in elevation."

Measurements given.

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

This tooth shows the same characters pointed out in Cope's *E. eurystylus* to distinguish it from the genus *Equus* except that the little fold of enamel at the anterior border of the protoconid is wanting. A comparison of Cope's figure (reproduced in Figure 18, and Figure 19 which represents a corresponding lower molar of *Protohippus*, No. 10579, Coll. Am. Mus.,) shows the very close relationship of the species to which the teeth represented by these figures belong, and were it not for the little enamel fold mentioned above, in the one, they would undoubtedly be referred to the same species if their different localities were not known. In a series of five lower teeth (No. 10626, Coll. Am. Mus.) of this species, found in the exact locality in the Blanco beds from which Cope's type specimen was taken, the same general Protohippus-like characters are shown as in the type tooth, and a rudiment of the enamel fold of the protoconid is shown in all of them.

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

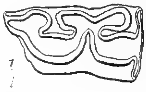

Fig. 19. Lower molar of *Protohippus sp.* (Loup Fork).

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

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

(20) **Equus semiplicatus** *Cope.*

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

Horizon.—Sheridan Beds.

Type.—Superior molar m^2 (?).

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

Measurements given.

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

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

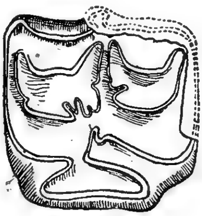

Fig. 20. *Equus semiplicatus* Cope (type). Superior molar. (After Cope.)

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

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[1] Am. Naturalist, 1891, p. 912.

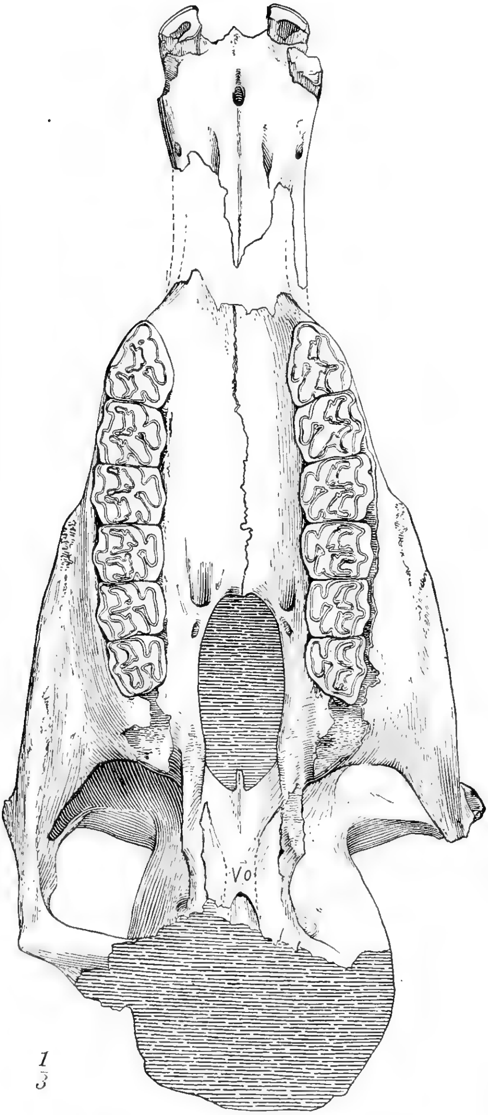

Fig. 21. Skull of *Equus semiplicatus* (No. 8600, Coll. A. M. N. H., San Diego, Texas). Palate view.

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

(21) *Equus intermedius* Cope.

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

Type Locality.—Petite Anse, Louisiana.

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

Author's description.—Cope's description of this species is given at considerable length, and as much of it is a discussion of characters that have no standing, only the most important of the characters mentioned will be repeated here. "The molar teeth are as large as those of the *E. major* and large forms of the common horse. The enamel folds are less complex than those of the former, but are more complex than is usual in the *E. caballus*. . . . A transverse crest connects the paroccipital processes and the basisphenoid, bounding the precondylar fossa in front, so as to convert it into a basin. . . . The *E. intermedius* is a shorter-nosed species than the *E. caballus*, the distance from the anterior lower premolar forwards only equalling the corresponding length in the quagga, while the parts are in other respects as large as those of the domestic horse."

Measurements given for the teeth.

Diameters of $p^{\underline{2}}$	Antero-posterior	30 mm.
	Transverse	31 "
Diameters of m^1	Antero-posterior	25 "
	Transverse	30 "
Diameters of $m^{\underline{3}}$	Antero-posterior	36 "
	Transverse	29 "
Length of mandible from $pm^{\underline{3}}$ to external border of incisors		130 "

Measurements of occipital condyles.

Transverse diameter	92 "
Antero-posterior diameter above	50 "

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

One of the specimens, at least, figured by Leidy in the work above cited is more complicated in tooth pattern than is indicated by the figure of his type specimen of *E. complicatus*, and the specimens described by Cope seem not to differ at all in this respect from the *E. complicatus* type. But even if this lot of teeth described by Cope are somewhat simpler, a character so variable as this one seems hardly sufficient grounds for founding a new species. The specimen figured by Cope (see Cope's figure[2]) shows every indication of belonging to an old individual, which would account for much of the simplicity of these teeth. Cope attempted no other distinction, nor does there seem to be any. On the other hand there seem to be good reasons for considering the two species as identical. There seems to be no difference in size and practically no difference in tooth pattern; the type

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

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

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

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

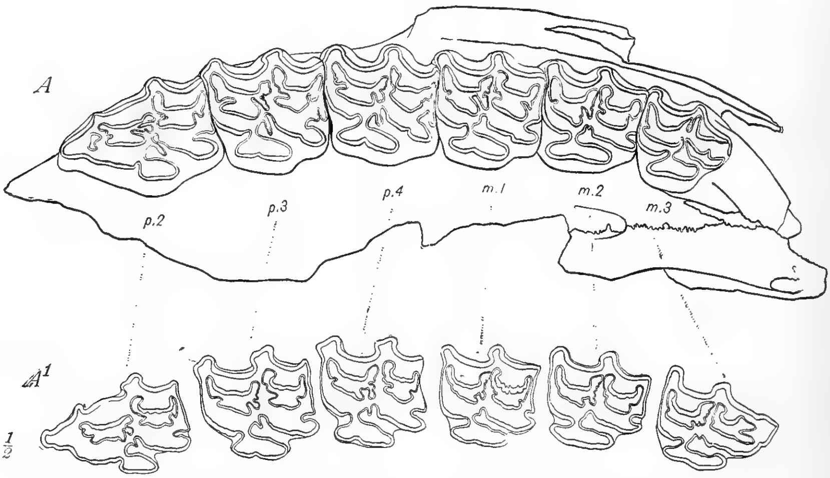

Fig. 22. *E. complicatus.* (Tule Cañon, Texas.) Superior molar-premolar series of right side sectioned to show change in teeth due to wear. *A*, triturating surfaces; *A*^{1}, sections cut parallel to the triturating surface about the middle of the crowns. (No. 10611, Coll. A.M.N.H.).

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

(22) Equus pectinatus (*Cope*).

Type Locality.—Port Kennedy, Penn.

Horizon.—Megalonyx Beds. (Cave deposits).

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

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

Measurements [1] :

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

The Port Kennedy specimens seem to represent two distinct species as suggested by Cope; however, it seems highly improbable that either bears any close relationship with the South Carolina species, *E. fraternus*, which is one of the smallest American species, while *E. pectinatus* is large, comparing in size with *E. complicatus* or *E. scotti.* The teeth of the type specimen are much worn, yet they show an unusual degree of complication in the enamel foldings (see Fig. 23). As pointed out by Cope the protocones of the type specimen are unusually small. The skull characters are not known and until they can be made out this species cannot be clearly defined. Leidy described and figured some teeth from Illinois [2] (see Fig. 24) which he referred to *E. complicatus*, but which seem to agree more closely with *E. pectinatus.*

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

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

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

Horizon.—Sheridan Beds.

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

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

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

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

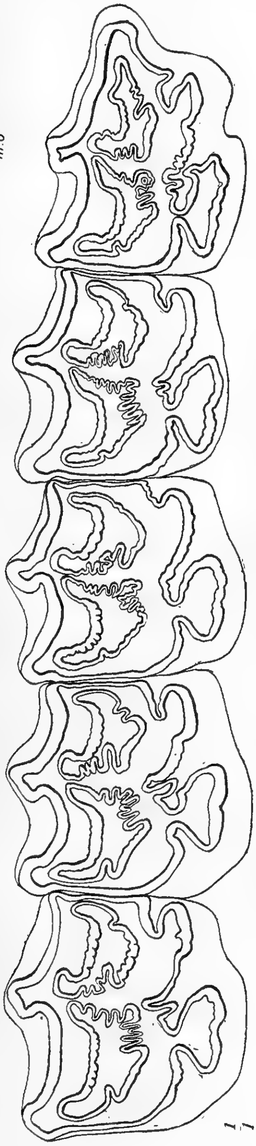


Fig. 23. *Equus pectinatus* Cope. Type. Superior molars m^1, m^2, and m^3, and premolars, p^3 p^4.

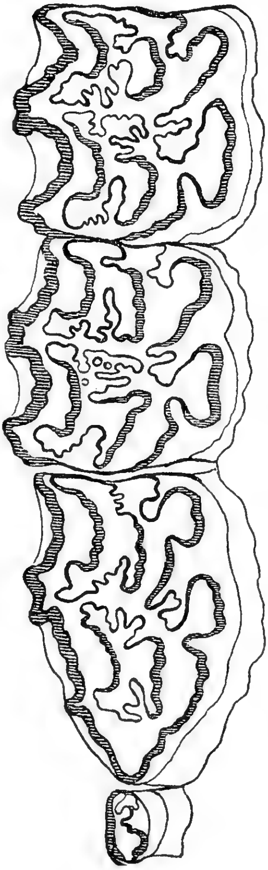


Fig. 24. *Equus pectinatus.* Superior premolars, p^1, p^2, p^3, and p^4. (After Leidy.)

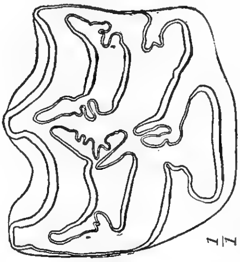


Fig. 25. *Equus scotti.* Superior molar, m^1 of type skull (No. 10606, Coll. A. M. N. H.)

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

Measurements given.

Diameters of crown of p^3	Antero-posterior	33	mm.
	Transverse	31	"
Diameters of crown of m^1	Antero-posterior	32	"
	Transverse	30	"
Long diameter of incisor		23	"
Total length of molar-premolar series		190	"

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

Diameters p^2	Antero-posterior	43	mm.
	Transverse	30.5	"
Diameters p^3	Antero-posterior	34	"
	Transverse	33	"
Diameters p^4	Antero-posterior	33	"
	Transverse	33	"
Diameters m^1	Antero-posterior	30	"
	Transverse	30	"
Diameters m^2	Antero-posterior	31	"
	Transverse	29	"
Diameters m^3	Antero-posterior	31	"
	Transverse	24	"
Long diameter of i^1		24	"
Total length of molar-premolar series		204	"

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

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

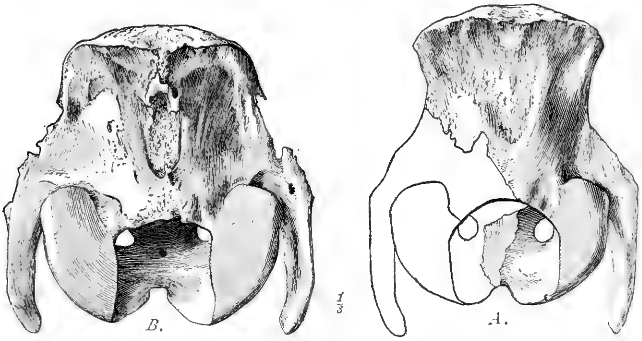


Fig. 26. Occiputs of—*A*, *Equus scotti*; *B*, *Equus caballus*.

Equus giganteus, sp. nov.

Type Locality.—Southwest Texas.

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

Description.—There is a very large tooth, now in the American Museum (Cope) collection, from southwest Texas which Cope described and figured, referring it to *E. crenidens*, but which differs in every respect, except the small size of the protocone, from the description of the Mexican tooth upon which this species was founded. Its very much larger size; the lack of the charac-

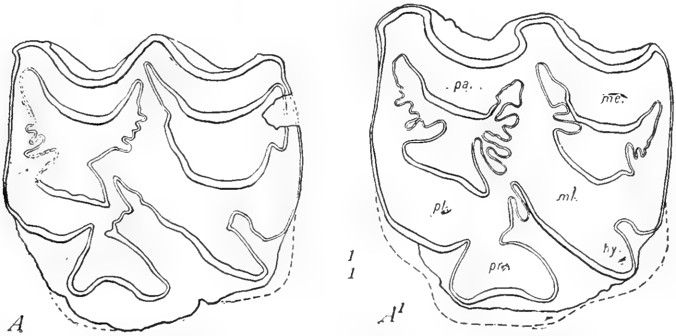


Fig. 27. *Equus giganteus*, sp. nov. Type. Superior second molar m^2 (No. 8616, Coll. A. M. N. H.). *A*, triturating surface; A^1, section cut about three-fourths of an inch below.

ter given by Cope as the one by which *E. crenidens* could be distinguished, that of the crimping of the enamel of the lakes; the comparatively complex folding of the enamel, all prevent the identification of this tooth with that species. Its grinding-surface is much weathered and the enamel foldings of the lake borders are so obliterated that they cannot be made out and appear to be very simple. This evidently led Cope to the belief, as shown in his figure and description, that the tooth pattern was very simple. A section (Fig. 27 A^1) made about three-fourths of an inch below the grinding-surface shows very plainly the true character of the enamel foldings.

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

The measurements are as follows:

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

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

SUMMARY AND CONCLUSIONS.

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

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

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

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

E. FRATERNUS.—Southeastern United States, probably a valid species, but still imperfectly known. It represents a very small horse with teeth scarcely as large as those of the Mexican donkey and of very complex pattern.

E. COMPLICATUS.—West Southern and middle Western States; embraces as synonyms, *E. intermedius*, *E eous* and probably *E. excelsus* (which is now indeterminate). Now well characterized, representing a species with teeth about the size of those of the ordinary draught horse and of moderately complex pattern, but with the bones of the skeleton about the size of those of the smaller varieties of the western pony. The species is especially characterized by its short muzzle, in this respect resembling the ass.

E. *excelsus.*—Nebraska. Very imperfectly known from the teeth only; although now indeterminate, may prove to be a valid species.

E. OCCIDENTALIS.—California or Pacific slope. Other species and specimens have been mistakenly referred to this type. The characters other than those of the teeth are not now known, but these indicate a horse about the size of *E. complicatus* with uniformly simple patterned teeth.

E. PACIFICUS.—A large Oregon species, although middle California is the type locality. A well characterized species. With the exception of *E. giganteus* from southwestern Texas, the largest American horse. The skeleton indicates a horse about the size of the ordinary draught horse, but the skull is proportionately larger.

E. CONVERSIDENS. Valley of Mexico. Apparently well established; of medium size.

E. TAU.—Valley of New Mexico, the smallest true horse known in America. This embraces the *E. barcenœi* as a synonym.

E. crenidens.—Valley of Mexico; indeterminate.

E. SEMIPLICATUS.—Western Texas, from the Sheridan beds of Paloduro Cañon, probably a valid species. The great posterior extension of the vomer over the presphenoid, together with its size and the proportions of the teeth, seem to show a close relationship to *E. asinus*.

E. PECTINATUS.—Port Kennedy Bone Cave of eastern Pennsylvania. Probably a valid species.

E. SCOTTI.—Staked Plains of Texas, Tule Cañon. Intermediate in size between *E. complicatus* and *E. pacificus*. A long-faced type of horse. This species represents a horse about the size of the largest western pony, but with a longer body, a much larger head, a shorter neck, and a back and steeply sloping sides shaped very much as in the ass or quagga.

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

Pliocene species wrongly referred to Equus.

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

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

BIBLIOGRAPHY.

COPE, E. D.

'84. The Extinct Mammalia of the Valley of Mexico. (Palæont. Bull. No. 391, 884.) *Proc. Am. Phil. Soc.*, Vol. XXII (1884), 1885, pp. 1–15.

'85. Pliocene Horses of Southwest Texas. *Am. Naturalist*, Vol. XIX, 1885, p. 1208, pl. xxxvii.

'92. Report on Palæontology of the Vertebrata. *Third Ann. Rept. Geol. Surv. Texas* (1891), 1892, pp. 251–252.

'92. A Contribution to the Vertebrate Palæontology of Texas. *Proc. Am. Phil Soc.*, Vol. XXX, 1892, pp. 123–125.

'93. A Preliminary Report on the Vertebrate Palæontology of the Llano Estacado. *Fourth Ann. Rep. Geol. Surv. Texas*, 1893, pp. 1–137.

'95. On Some Pleistocene Mammalia from Petite Anse, La. *Proc. Am. Phil. Soc.*, Vol. XXXIV, 1895, pp. 458–468, pll. xi and xii.

'99. Vertebrate Remains from Port Kennedy Bone Deposit. *Journ. Acad. Nat. Sci. Phila.*, Vol. XI, 1899, pp. 193–289.

De Kay, J. E.

'42. Zoölogy of New York. Nat. Hist. N. Y., Zoöl., Part I, 1842, p. 108.

Gidley, J. W.

1900. A New Species of Pleistocene Horse from the Staked Plains of Texas. *Bull. Am. Mus. Nat. Hist.*, Vol. XIII, 1900, pp. 111–116.

Hay, O. P.

'99. On the Nomenclature of Certain American Fossil Vertebrates. *Am. Geologist*, Vol. XXIV, 1899, p. 345.

'99. On the Names of Certain North American Fossil Vertebrates. *Science*, N. Ser., Vol. IX, 1899, p. 593.

Leidy, Joseph.

'47. On the Fossil Horses of America. *Proc. Acad. Nat. Sci. Phila.*, Vol. III, 1847, p. 265, pl. ii.

'58. Notice of Remains of Extinct Vertebrata, from the Valley of the Niobrara River. *Proc. Acad. Nat. Sci. Phila.*, Vol. X, 1858, pp. 11 and 20–26.

'59. Description of Vertebrate Fossils. Post-Pleiocene Fossils of S. C. (Holmes), Nos. 8, 9, and 10, 1859, pp. 99–110, pll. xv and xvi.

'65. Remarks on Fossil Remains of Horses. *Proc. Acad. Nat. Sci. Phila.*, Vol. XVII, 1865, p. 94.

'69. Extinct Mammalian Fauna of Dakota and Nebraska, *Journal Acad. Nat. Sci. Phila.*, 1869, pp. 257–331 and 399–401, pll. xvii–xxi.

'73. Contributions to the Extinct Vertebrate Fauna of the Western Territories. *Report U. S. Geol. Survey of the Territories* (F. V. Hayden), Vol. I, Fossil Vertebrates, 1873, pp. 242–246 and 321–332, pl. xxxiii.

'89. Notice of Some Mammalian Remains from the Salt Mine of Petite Anse, Louisiana. *Trans. Wag. Free Institute*, Phila., Vol. II, 1889, pp. 33–40.

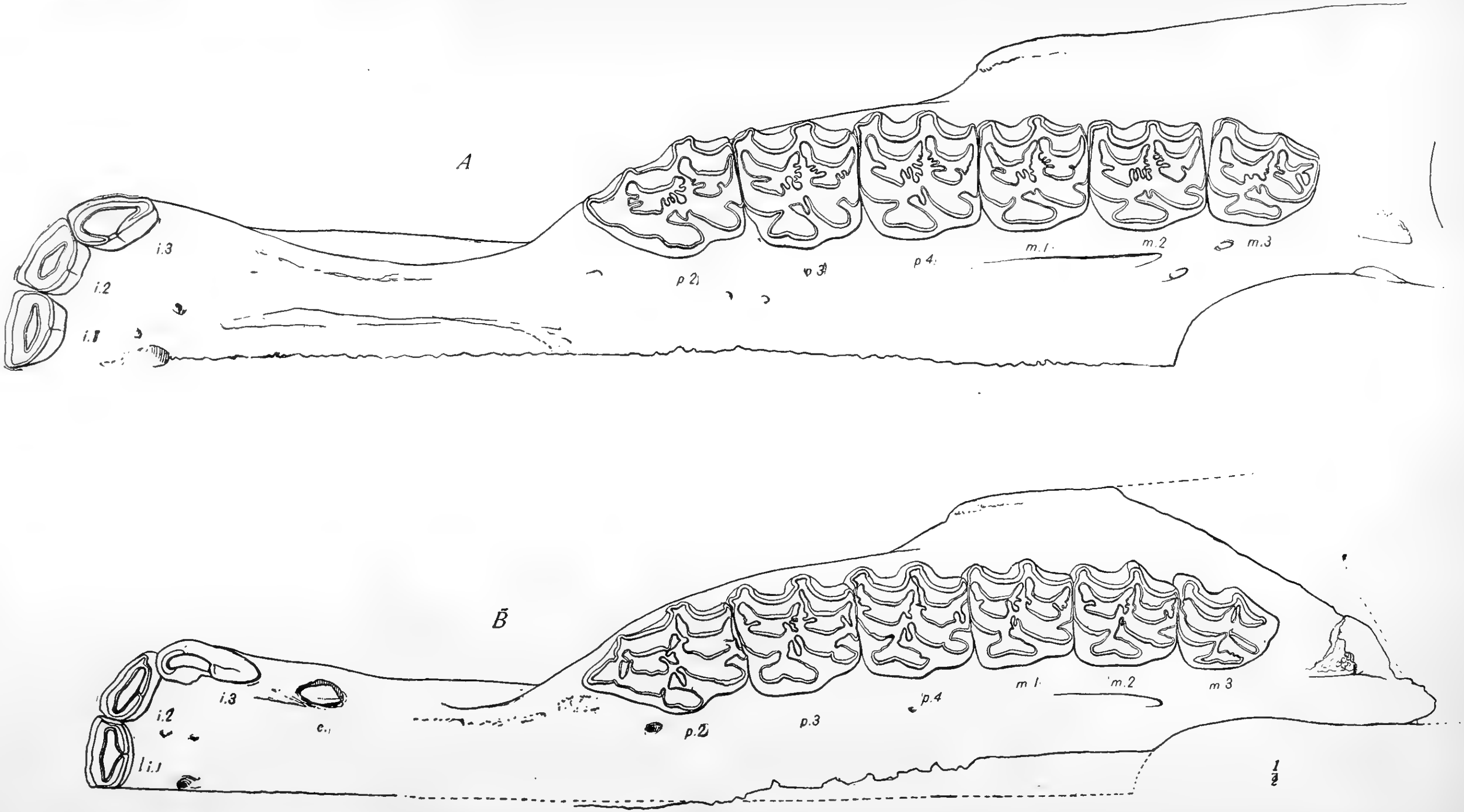
Mitchell, Samuel L.

'26. Catalogue Organic Remains, New York, 1826, pp. 7, 8.

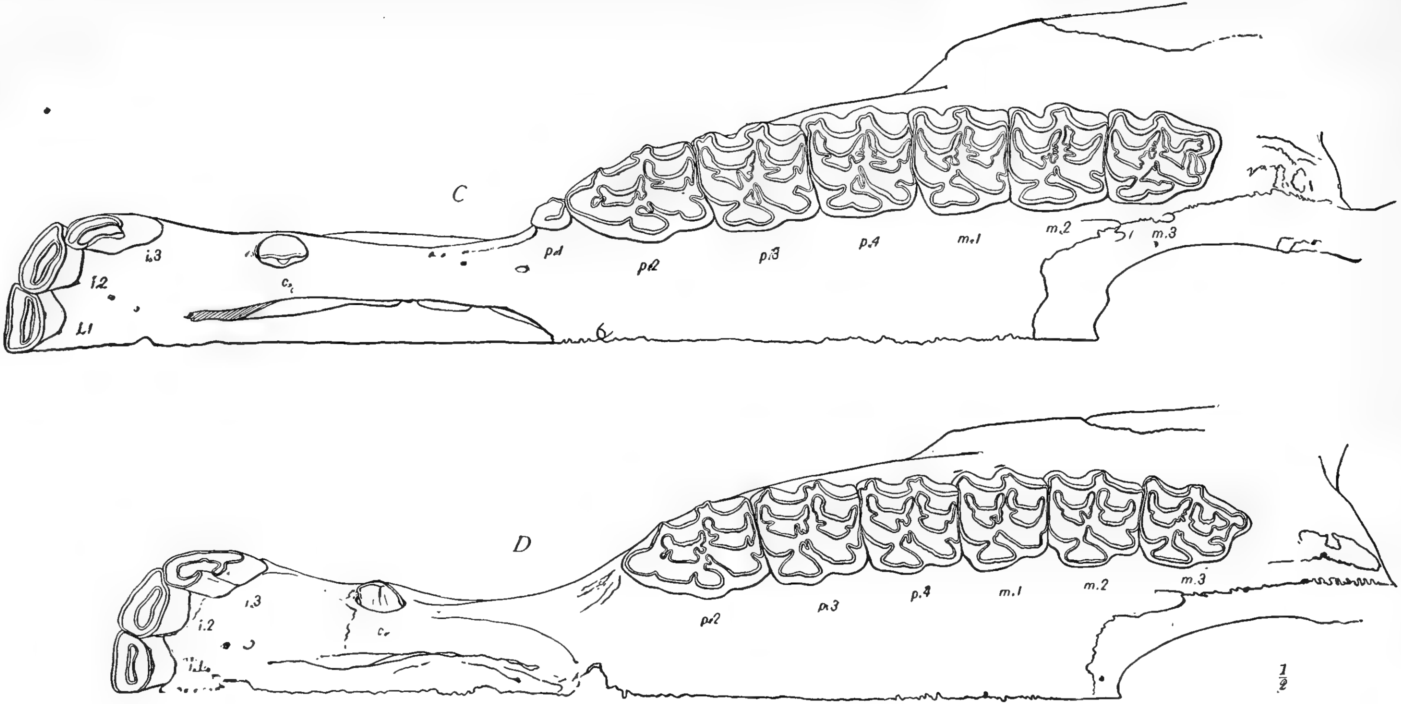
OWEN, RICHARD.

'40. Notice of the Remains of a Species of Equus. Voyage H. M. S. Beagle, Fossil Mammalia, 1840, pp. 108, 109, pl. xxxii.

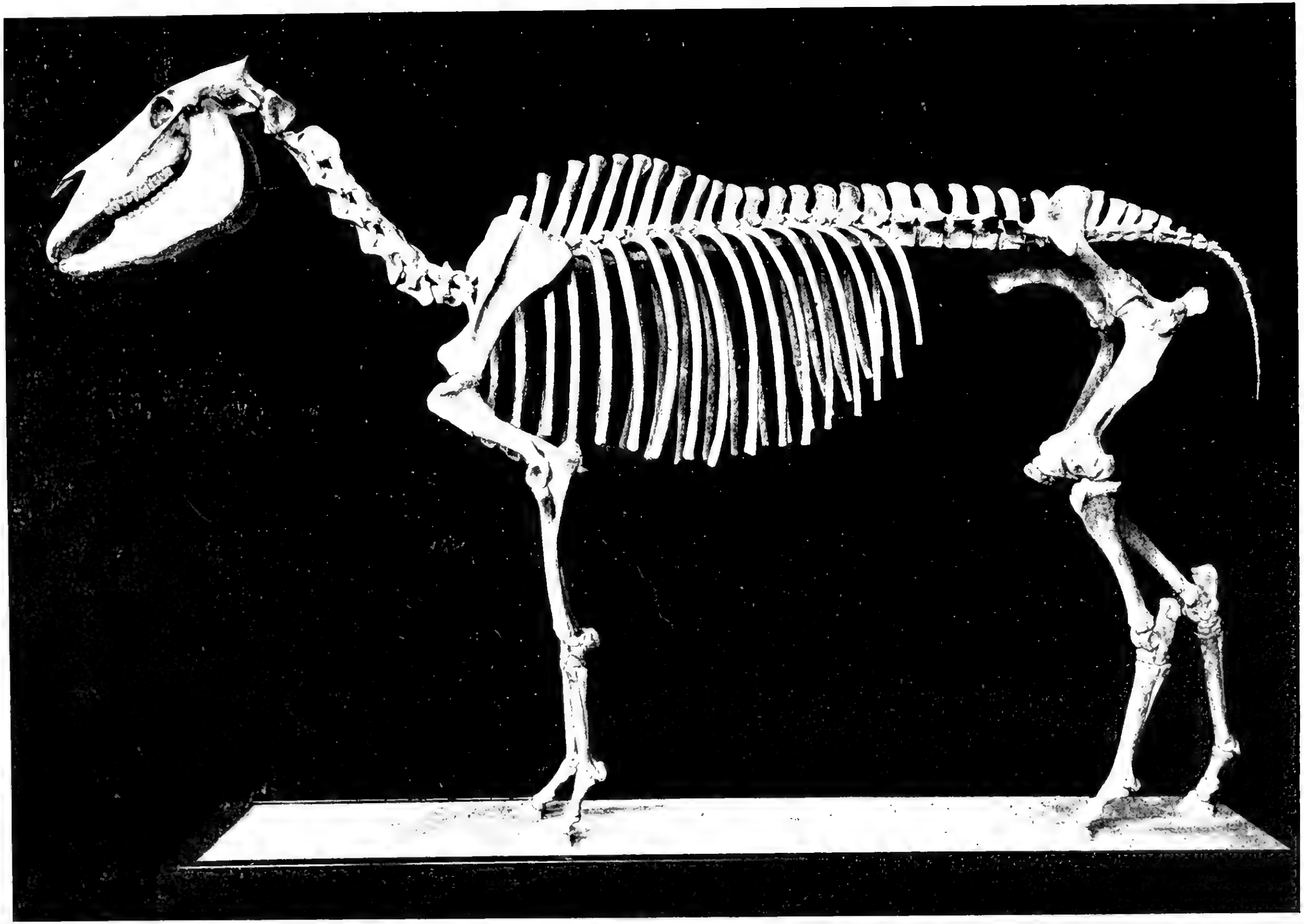
'69. On Fossil Remains of Equines from Central and South America. *Phil. Trans.*, London, 1869, pp. 559-573, pll. lxi, lxii.



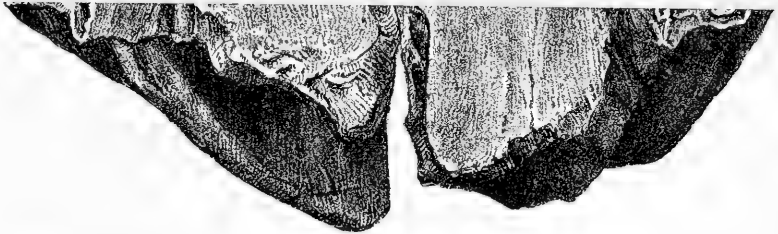
A, *Equus scotti* ; *B*, *Equus complicatus*.



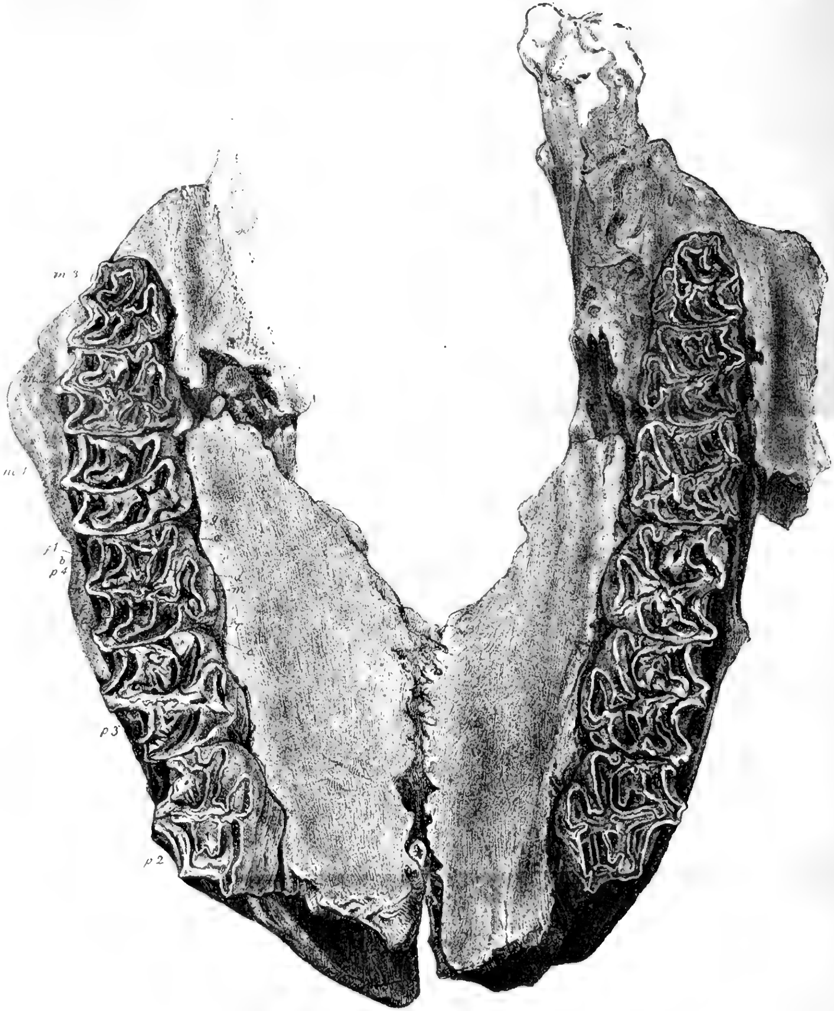
C, *Equus caballus*, DRAUGHT HORSE; *D*, *Equus caballus*, TEXAS PONY.



Equus scotti Gidley (Type). Mounted Skeleton in the American Museum. Includes Parts of Two Skeletons.



Equus conversidens Owen (Type). Probably Composed of Two Individuals.



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

On Jurassic Stratigraphy in Southeastern Wyoming.

By F. B. Loomis.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XIV, Article XII, pp. 189–197.

New York, June 17, 1901.

The Knickerbocker Press, New York

Article XII.—ON JURASSIC STRATIGRAPHY IN SOUTHEASTERN WYOMING.

By F. B. Loomis.

Plates XXVI and XXVII.

The purpose of this paper is to give some details in regard to the Jurassic strata of Wyoming, in which, for the last four years, the American Museum of Natural History has collected Dinosaur remains. Very little detail geological work has been done in the region. Prof. W. C. Knight published a map of southeastern Wyoming showing the Jurassic exposures[1]; and this is in part reproduced, with his consent, in Plate XXVI, Fig. 1, to show the location of the area in which the succeeding maps and sections are located. Prof. W. N. Logan[2] has also published a section made in the Freezeout Hills. The area studied, lying along the county line between Albany and Carbon Counties, includes all of the quarries worked for the American Museum; and, incidentally, a considerable number of Marsh's localities, where they were within the area mapped, are indicated.

Referring to Plate XXVI, Fig. 1, the axis of the Laramie Mountains is seen in the eastern part of Albany County, extending nearly north and south; but in Converse County it bends until it extends nearly west. In the angle thus formed are situated four short (8–20 miles in length), sharp folds, known as the Medicine, Como, Prager, and Miser anticlines. Their axes lie northeast and southwest, and each fold is thrust over beyond the vertical on its northern side. These folds are radial folds formed at the edge of the territory affected when the Freezeout Hills were thrown up. While the Laramie Mountains seem to be due to a thrust from the east, there must have been a force acting from the north in the neighborhood of the Freezeout Hills. This thrust from the north seems to have affected locally the axis of the Laramie Mountains, bending it to an east and west direction. The four short anticlines above named die out on the eastern boundary of the territory affected by the thrust from the north. How far west this thrust from the north, to which the Freezeout Hills are due, acted I cannot say.

It is along the southern exposures of Medicine and Como anti-

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[1] Bull. Geol. Soc. America, Vol. XI, p. 377, 1900.
[2] Kan. Univ. Quart., Vol. IX, p. 109, 1900.

clines that the American Museum parties have worked, where the dip is 14–18°. The north sides of these folds stand too nearly vertical to be worked. Plate XXVI, Fig. 3, shows a section reconstructed to show the appearance of these folds had no erosion taken place. The position of this section is shown on Plate XXVI, Fig. 2, by a line from H to L running N. 25° W. The line starts on the Little Medicine River, about one and one half miles below the mouth of Sheep Creek. For ten rods on either side of the river all rocks are covered by river deposits. At the locality *c*, a collection of fossils[1] showed the presence of the Cretaceous (Fort Pierre); while within three rods to the south undoubted basal beds of the Jurassic[2] are found. A fault is thus indicated. While in the field I did not trace it out, so cannot speak in regard to its extent. The Jurassic is here inverted so that its basal member is uppermost. Between the Jurassic and the typical Triassic occurs a bed of creamy white sandstone, 40 feet thick, the same as is found in the Freezeout Hills, but this sandstone is lacking on the exposures situated further south. The Jurassic dips 60° S. (strike N. 53° E.), but proceeding south the dip quickly becomes vertical, changes to the north, and gradually diminishes till in the midst of the Triassic it becomes horizontal. The strata soon dip to the south increasing to about 14°, at which angle most of the rocks, as far as the Fort Pierre bed, dip.

At G the section changes its course to N. 5° W., crossing the Jurassic of the south side of the Medicine anticline. The Jurassic beds are here 274 feet in thickness and are overlaid by the coarse sandstones of the Dakota to the extent of 275 feet. Above these in turn lie the Fort Benton shales, the lower 80 feet of which consist of dense sandy limestone; while the upper 320 feet are thin bedded argillaceous shales, characterized by abundance of teleost fish scales. Above the Fort Benton are about 800 feet of slate-colored clay in which the stratification is obscure. On account of their soft texture these clays are easily eroded and the exposure is usually occupied by a long 'draw.' On weathering the clay turns black. As this clay overlies the Fort Benton

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[1] The collection included *Inoceramus*, *Gryphæa*, *Lucina subundata* H. and M., *Tellina*, cf. *scitula* M. and H., *Anisomyon shumardi* W., *A. Patellaformis* W., and *Scaphites warreni* M. and H.

[2] The Jurassic layers carried *Belemnites densus* M. and *B. curtus L.*

and underlies the Fort Pierre, I consider it the representative of the Niobrara, although it is non-fossiliferous. A bed of gray sandstone comes next, making a prairie about three miles wide, so that to estimate its thickness is difficult, though there can scarcely be less than 300 feet. The sandstone furnished several badly preserved fossils among which were *Inoceramus*, *Gryphæ*, and *Scaphites warreni* M. & H. While the Ammonites are described as Fort Benton, inasmuch as I found the same at locality *c* mixed with the Fort Pierre Gasteropoda and Lamellibranchiata, and being strongly influenced by the stratigraphy, I am inclined to consider the sandstone bed Fort Pierre. Across the sandstone the Niobrara clay reappears, on its northern boundary nearly horizontal, but on the southern side overthrust, so that the Fort Benton lies inverted over the Niobrara. The Fort Benton dips 60° to the south (strike N. 48° E.). The change to the vertical occurs in the Dakota, which at this exposure (Carleton ridge) is only about one-half its usual thickness. The Jurassic dips 80° N. but as the Triassic is crossed the dip decreases to horizontal, changes to south, and gradually increases to about 17° S., at which angle most of the rocks, as far as the Prager anticline, dip. The section goes only to Como Bluff but the rocks at Prager anticline again show overthrust characteristics.

Three sections of the Jurassic are shown in Plate XXVII, Figs. 1, 2, and 3, giving the details of the series of rocks on the south side of Medicine anticline, and the north and south sides of the Como anticline. These sections are also tabulated on page 192 so that each layer can be traced in its variations across the two anticlines.

The base of the Jurassic I have located at the beginning of the series of clays. The Triassic is a great bed of sandstones, usually alternating red and gray. The first change from this to Jurassic is a layer of brown clay (No. 2), always of considerable thickness, and carrying *Belemnites densus* M. and *B. curtus* L. in such abundance that the ground is in many places so strewn with the shells that one can scarcely step without treading on one. The layer is widespread, occurring on Sheep Creek,[1] Medicine and Como anticlines, and is identical with Knight's No. 14,[2] and the lower part of Logan's No. 13.[3] It is usually designated as the Belemnite layer.

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[1] The Sheep Creek exposures are 12 miles northeast of Bone Cabin Quarries.

[2] Bull. Geol. Soc. Amer., Vol. XI, p. 382.

[3] Kan. Univ. Quart., Vol. IX, p. 112.

PLATE XXVII, FIG. 3.			PLATE XXVII, FIG. 1.		PLATE XXVII, FIG. 2.	
Bed.	Section A–B.	Thickness.	Section C–D.	Thickness.	Section E–F.	Thickness.
			Dakota.			
		Feet.		Feet.		Feet.
No. 33	Yellowish sandstone........	243	Straw yellow sandstone.....	120+	Sandstone.......	200+
" 32	Black sandstone	2	Black sandstone.	3	Black and red sandstone.....	4
" 31	Gray sandstone.	30	Yellow sandstone	12	Straw yellow sandstone.........	20
			Jurassic.			
" 30	Bluish green clay	21	Bluish green clay.	20	Maroon clay.....	10
					Bluish green clay.	15
" 29	Green clay.....	20	Green clay......	40	Yellow green clay	13
					Bluish green clay.	15
" 28*a*	Flint..........	⅓	Flint...........	⅓		
" 28	Gray sandstone.	10			Sandy clay......	5
" 27	Concretions	2				
" 26	Green clay.....	3	Green clay......	15	Green clay......	2
" 25	Concretions	1½	Concretions	2	Concretions	1
" 24*a*	Green clay.....	8	Green clay......	9	Green clay......	15
" 24*b*					Sandstone.......	4
" 24*c*					Green clay......	10
" 23	Green clay with small concretions...... ..	10	Green clay with small concretions	9	Green clay with small concretions.........	25
" 22	Maroon clay with small concretions.	10	Maroon clay with small concretions.........	28	Maroon clay with small concretions.........	20
" 21	Sandstone	3				
" 20	Green clay.....	8	Green clay......	20	Green clay......	9
" 19	Sandstone	1	Sandstone.......	2		
" 18	Red clay.......	5			Red clay........	5
" 17	Sandstone......	2				
" 16	Green clay.....	6	Green clay......	9	Maroon clay.....	7
" 15	Sandstone......	1½	Sandstone.......	2		
" 14	Red, green, maroon clay.....	12	Green, maroon, red clay.......	26	Red clay........	8
" 13	Sandstone	2	Sandstone.......	1½	Gray sandstone..	28
" 12	Maroon, green, red clay......	10	Green clay......	20	Dark green clay.	10
" 11	Sandstone......	2	Sandstone.......	2	Sandstone.......	1½
" 10	Green clay.....	22	Green clay......	60	Red and green clay	10
" 9	Sandstone	1	Sandstone.......	1½	Sandstone.......	2
" 8	Green clay......	20	Maroon clay. ...	20	Green clay......	25
" 7	Reddish clay...	20				
" 6	Sandstone......	1½	Sandstone.......	1½	Sandstone.......	12
" 5	Green sand shale	6				
" 4	Purple clay with limestones....	22	Purple clay with limestones	20	Purple clay with limestones	15
" 3	Nucula limestone	1				
" 2	Brown clay.....	43	Brown clay with limestone beds.	70	Gray brown clay.	55
	Total of Jurassic	274⅚	....	378⅚	....	332½
" 1	Triassic sandstones.		Triassic sandstones.		Triassic sandstones.	

On the surface of this, in Bone Cabin Draw, is found a one-foot bed of limestone (No. 3) made up mostly of *Nuculas*,[1] with occasionally a *Tancredia* and *Ostrea*. The band is not continuous, but similar layers at the same horizon occur both on Sheep Creek and in the Freezeout Hills.

No. 4 is a purplish clay with large limestone nodules scattered through it. It is in or on these nodules that the specimens of *Baptanodon* are found. That of the American Museum was found at locality *b*, at the foot of Bone Cabin Draw. It seems best to confine Marsh's[2] term, Baptanodon beds, to this layer instead of designating the whole lower Jurassic by that term. The bed is universally present in neighboring localities; and is Knight's 12 and the upper part of Logan's 13.

No. 5, green sand shale, is local.

No 6, sandstone. This first sandstone bed seems to be widely distributed, and marks the beginning of a series of alternations between sandstone and clay. The clays are variously and brightly colored and often designated as the 'variegated clays.' The layers from 6 to 20 inclusive form a series of variegated beds in which there may be eight sandstone layers or only three. Very few of the clays seem to form wide horizons. Inside of a quarter of a mile I have seen three of the sandstone beds unite into one thick sandstone, the intervening clays being pinched out. These indicate a period of shallow water in which there were continually changing currents, so that deposits from any given source are laid down first in one place, later in another. In the Bone Cabin section there are 120 feet of these variegated clays, and it is somewhere in these layers that the change from marine to brackish (or freshwater) deposits occurs. In the Como section there is a 28 foot bed of sandstone, corresponding apparently with No. 13, in which a Dinosaur quarry (12) is located. This bed seems to represent the beginning of the freshwater (or brackish) series, and as such is the first member of the Como stage (Atlantosaurus beds). This sandstone (No. 13) is variable in

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[1] At the foot of Bone Cabin Draw, locality *b*, were found in this layer *Nucula* nov. sp., *Tancredia inornata*, *Avicula mucronata*, and *Ostrea strigilecula*. A similar band near Sheep Creek furnished all of the above with also *Cardioceras cordiformis* M., and *Pseudomonotis curta*; see also Logan's No. 13, which furnished some of these and several other forms.

[2] Sixteenth Ann. Rep. U. S. Geol. Surv., 1896, p. 145.

thickness but there is no unconformity such as Logan seems to have found in the Freezeout Hills.

No. 22 is a bed of maroon colored clay with small limestone concretions scattered through it, and is a most excellent horizon indicator, for it is everywhere present, and its brilliant color makes it a conspicuous feature for miles. At Bone Cabin it is but 10 feet thick but increases to 30 feet in the Como Bluff. The considerable amount of concretionary limestone would seem to indicate brackish water.

The maroon clay graduates into a bed of green clay with similar small limestone concretions (No. 23). This layer like the maroon bed is widespread and thicker as one goes south.

The green clay with concretions is invariably covered with smooth green clay (No. 24). In the Como Bluff this layer has sandwiched into it a 4-foot bed of sandstone (24*b*). The sandstone is of interest as marking the horizon at which the few known Jurassic mammals were found. The mammal layer is the 6 inches of clay immediately underlying this sandstone. Most of the American Jurassic mammal remains thus far found have come from one quarry,[1] worked most successfully by Marsh and later by the American Museum. This pocket seems to be exhausted.

Above 24 is a constant layer of large nodular limestone concretions (No. 25). Single concretions may occur anywhere in the clay but this layer and No. 27 are definite layers of almost uninterrupted limestone nodules. The concretion layers are of considerable importance as, when weathered out, they make a prominent line on the bluffs just above which the most important bone bed occurs. In this limestone layer Logan found five species of fresh or brackish water mollusks.[2]

No. 27 is a green clay of varying thickness in which the most numerous quarries are located. On weathering, or having been dried out, this clay breaks into angular fragments and is therefore known as 'joint clay.' The 'Nine Mile Quarry,' the 'Aurora 1900 Quarry,' the 'Diplodocus 1897 Quarry,' and several of Marsh's quarries are in this layer. Most of the fossils are *Diplodocus* and *Brontosaurus* species.

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[1] See Pl. XXVI, the S.E. corner of the map.

[2] *Unio knighti* L., *U. willistoni* L., *U. baileyi* L., *Valvata leei* L., and *Planorbis veternus* L.

In Bone Cabin Draw this green clay is overlaid by a second layer (No. 27) of concretions, so that the 'Nine Mile Quarry' is between two such layers.

No. 28 is a gray sandstone in which the rich Bone Cabin Quarry is situated, and also the Stegosaurus Quarry. The sandstone varies extremely in hardness, being, in the south part of Bone Cabin Quarry, soft and mixed with considerable clay so that it is workable with an awl. In the northern part of the quarry, however, there are bands of the firmest sort of sandstone. In Como Bluff the layer is clay with merely an admixture of sand. Bone Cabin Quarry has yielded a great variety of genera: *Diplodocus*, *Morosaurus*, *Brontosaurus*, *Allosaurus*, *Ceratosaurus*, *Camptosaurus*, *Stegosaurus*, as well as several genera of carnivorous Dinosaurs; also *Compsemys* and *Goniopholis*.

On the surface of this sandstone is usually a 4-inch layer of flint, No. 28*a*.

No. 29 is another green clay showing the 'joint' structure similar to No. 26. Several of Marsh's quarries are in this layer.

The series ends with a soft bluish green clay in which I have never seen fossils. This completes the Jura.

A cap of Dakota sandstone overlies the Jura, near the base of which is a narrow (2–6 feet) band of soft black, or occasionally red, sandstone. This band is colored by iron and of interest as having lately yielded a collection of bones probably crocodilian.

There is some difficulty in comparing the foregoing sections with those of Logan and Knight, as these authors give fewer beds. Marsh divided the Jura into three horizons, Hallopus, Baptanodon, and Atlantosaurus beds. The Hallopus beds do not occur in southeastern Wyoming. The Baptanodon beds, according to Marsh, included all of the lower Jurassic, which has since been subdivided, but the term Baptanodon is now applied to a single layer (No. 4) in which these reptiles occur. When this term is restricted to a single layer, the lower strata are without designation; so for these, Knight has proposed the term Shirley stage, which shall include all the marine Jura; that is, beds 2–12 inclusive. The exact boundary between marine and non-marine is difficult to locate, but bed 13 has furnished some Dinosaur remains and may therefore be associated with the beds in which Dinosaurs are abundant. Then beds 13–30, inclusive, would form the non-marine upper Jura. There are no invertebrate forms of decisive character in these beds to determine between brackish and fresh water, but those found in bed 24 would incline toward fresh water. The change is clearly a gradual one. These upper beds Marsh calls Atlantosaurus beds, but as that genus has proved to be a synonym with *Camarosaurus*, a less misleading term is desirable; and Scott[1] has introduced the name Como stage for exactly these beds. He suggests that they belong to the Lower Cretaceous; and Logan also uses the term Atlantosaurus beds as distinct from Jurassic. There is no available invertebrate material in these upper beds for comparisons; but the strikingly close relationships between the British Purbeck mammalian fauna and the Wyoming mammals cannot be left out of consideration. The considerable number of British and Wyoming genera which are closely related will compel us to consider the Como stage of nearly if not just the same age[2] as the Purbeck and retain the Como in the Jurassic series. It is true there is no apparent unconformity between the Como and Dakota, as would be expected if this Como stage were dry land for a period as long as the Lower Cretaceous.

During the Shirley period, the deposits on the Medicine and Como anticlines were being laid down quite close to shore, as appears from the fact that within 30 miles to the south the Shirley is unrepresented, and all of the deposits are strictly shallow water sediments. However, during and especially at the beginning of the Como stage, a considerable transgression took place (see Knight's map) toward the south, removing the shore line to over 100 miles south. The deposits are also of shallow water.

The Dinosaur remains could, however, have travelled such considerable distances by floating. There could have been no currents in the Como lake strong enough to transport gigantic bones, for they were depositing clay. The bones are clearly floated out to sea by the presence of considerable meat on them. Most specimens must have started as complete carcasses, which with decay of the flesh (or its consumption by crocodiles and fish) have fallen apart, often making series of vertebræ, etc. Doubtless such quarries as the Bone Cabin Quarry mark an eddy, as there all sorts and sizes of animals are collected together.

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[1] W. B. Scott, Introduction to Geology, p. 477.

[2] Osborn, Jour. Acad. Nat. Sci. Phila, (2) IX, p. 187, 1888.

In summary it may be said that the Dinosaur remains are mostly confined to beds from 26 to 29, although occasionally remains are found lower. The bones are usually nearly perfect, though in some localities pieces of the more delicate spines are broken away. The clay usually preserves bones much better than the sandstone.

EXPLANATION OF PLATE XXVI.

Fig. 1.—Map of southeastern Wyoming, showing exposures of Jurassic. The shaded area represents the accompanying map, Fig. 2. This map is a reproduction of Knight's (see page 189).

Fig. 2.—Map as indicated on Figure 1, showing position of quarries and fossil localities on Medicine and Como anticlines; also positions of sections made through the Jurassic, as follows:

A–B, section of Jurassic on Plate XXVII, Fig. 3.
C–D, section of Jurassic on Plate XXVII, Fig. 1.
E–F, section of Jurassic on Plate XXVII, Fig. 2.
L–H, section across Medicine and Como anticlines, Plate XXVI, Fig. 3.
16, quarry of the American Museum (Dinosaur).
13, Marsh's Stegosaurus quarry.
12, quarry in bed No. 13, author unknown.
10, 11, 14, 15, quarries made by Marsh.
* Quarries of American Museum.

Fig. 3.—Ideal section across Medicine and Como anticlines, as the strata would have appeared had no erosion taken place.


SHEEP CREEK TRAIL
ONE CABIN DRAW
BONE CABIN CAMP
BONE CABIN QUARRY
STEGOSAURUS QUARRY 1899
EASE WOOD
DRAW
LARAMIE PEAK TRAIL
ROCK CREEK TRAIL
LINE OF SECTION
ROCK CREEK
CARLTON RANCH
BERRY RANCH
OLD TRACK
ROCK CREEK TRAIL
MAMMAL QUARRY
DIPLODOCUS 1897
BRONTOSAURUS 1897
12
14
15
MO. BLUFF

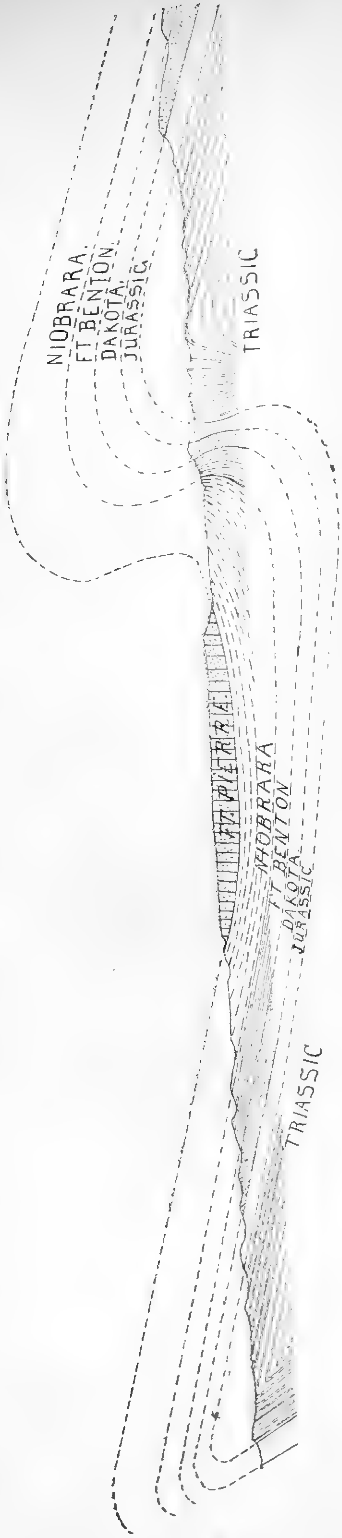
NIOBRARA
FT BENTON
DAKOTA
JURASSIC
TRIASSIC
FT. PIERRA
NIOBRARA
FT BENTON
DAKOTA
JURASSIC
TRIASSIC

FIG. 3.

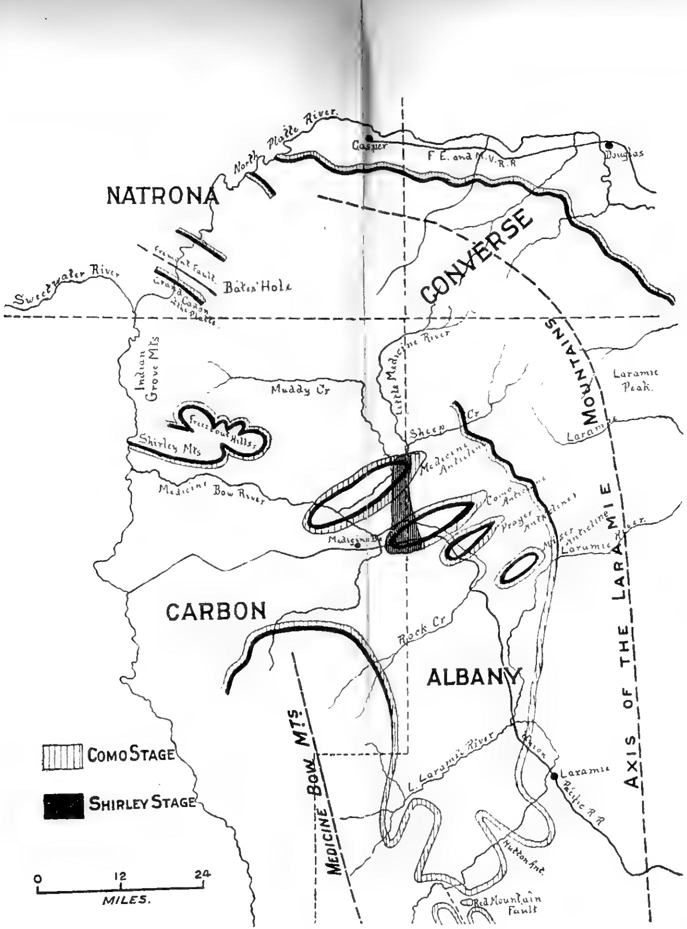

Fig. 1.

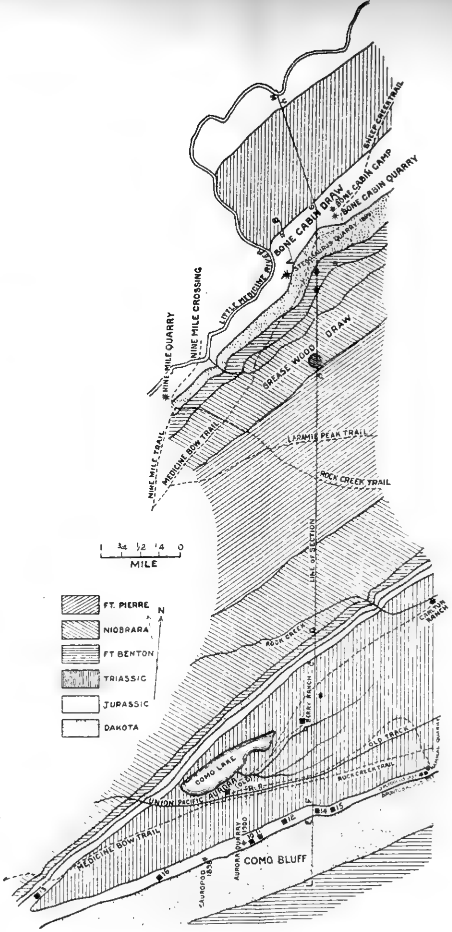

Fig. 2.

Fig. 3.

EXPLANATION OF PLATE XXVII.

Fig. 1.—Jurassic section across Carleton ridge, north side of Como anticline; C–D on Plate XXVI, Fig. 2.

Fig. 2.—Jurassic section across Como Bluff, south side of Como anticline; E–F on Pl. XXVI, Fig. 2.

Fig. 3.—Jurassic section across Bone Cabin Draw, south side of Medicine anticline; A–B on Pl. XXVI, Fig. 2.

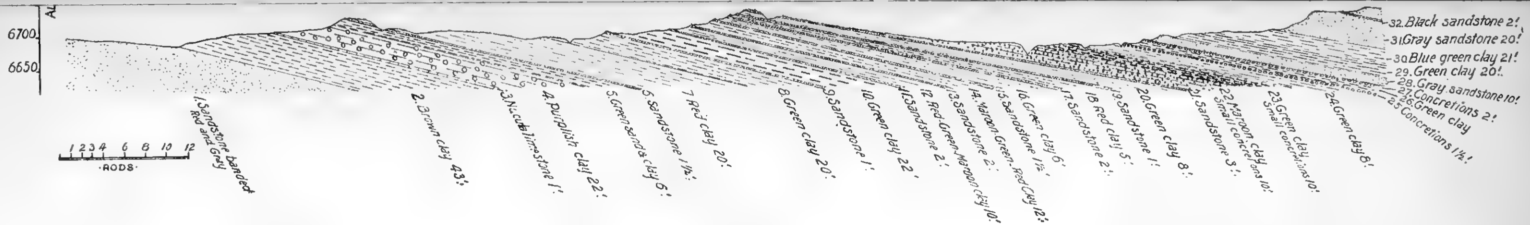
AL
6700
6650
1. Sandstone banded Red and Gray
2. Brown clay 43'.
3. Nucula limestone 1'.
4. Purplish clay 22'.
5. Green sand & clay 6'.
6. Sandstone 1½'.
7. Red clay 20'.
8. Green clay 20'.
9. Sandstone 1'.
10. Green clay 22'.
11. Sandstone 2'.
12. Red-Green-Maroon clay 10'.
13. Sandstone 2'.
14. Maroon-Green-Red Clay 12'.
15. Sandstone 1½'.
16. Green clay 6'.
17. Sandstone 2'.
18. Red clay 5'.
19. Sandstone 1'.
20. Green clay 8'.
21. Sandstone 3'.
22. Maroon clay Small concretions 10'.
23. Green clay Small concretions 10'.
24. Green clay 8'.
25. Concretions 1½'.
26. Green clay
27. Concretions 2'.
28. Gray sandstone 10'.
29. Green clay 20'.
30. Blue green clay 21'.
31. Gray sandstone 20'.
32. Black sandstone 2'.
1 2 3 4 6 8 10 12
RODS

FIG. 3.

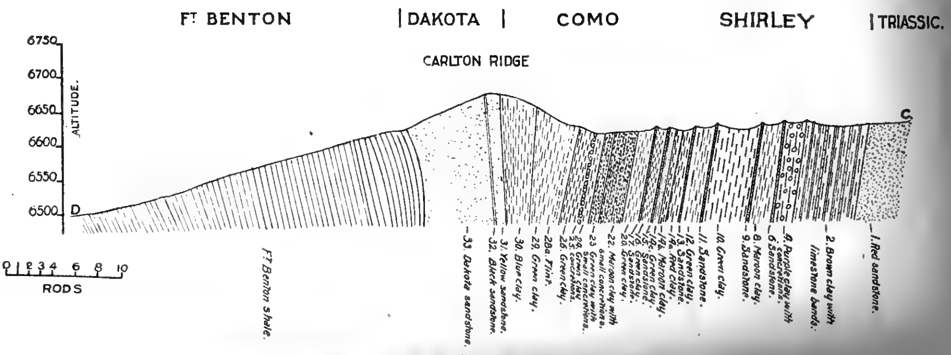

FIG. 1.

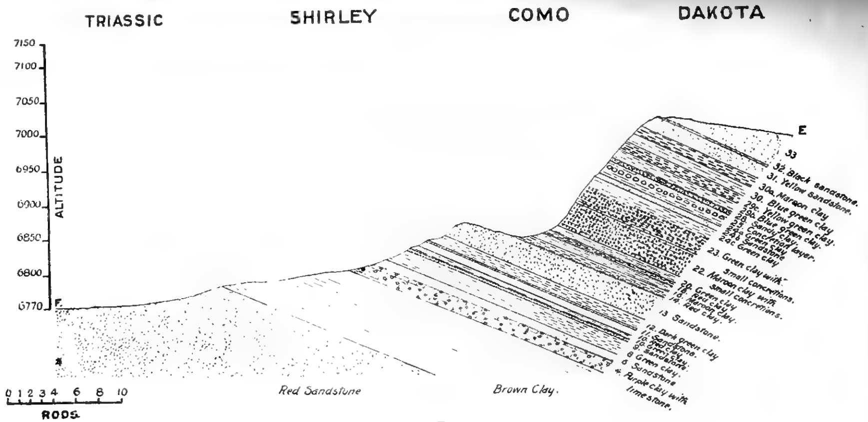

FIG. 2.

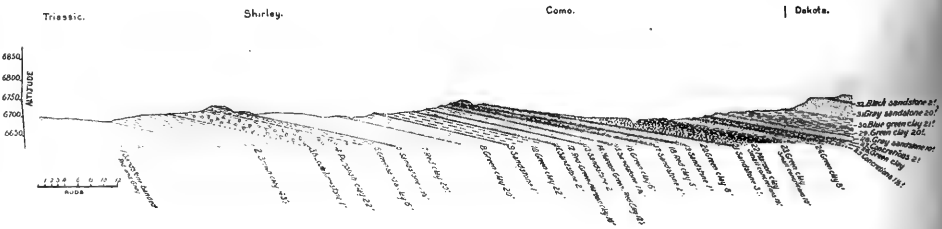

FIG. 3.

Fore and Hind Limbs of Sauropoda from the Bone Cabin Quarry.

By Henry F. Osborn and Walter Granger.

AUTHOR'S EDITION, extracted from BULLETIN

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New York, July 9, 1901.

The Knickerbocker Press, New York

Article XIII.—FORE AND HIND LIMBS OF SAUROPODA FROM THE BONE CABIN QUARRY.

DINOSAUR CONTRIBUTION NO. 6.

By HENRY F. OSBORN and WALTER GRANGER.

During the early months of 1900 the large collection of limb bones from the Bone Cabin Quarry was measured and compared by Mr. Granger in preparation for this paper. Measurements are chiefly of value in determining *proportions;* size, of course, constantly increasing with age. Further studies during the present year enable us to establish the following points:

1. The proportions and relations of the radius and ulna in the Sauropoda are remotely analogous or parallel with those of the Proboscidia, owing to the marked extension of the ulna, the similar weight, and the perfected quadrupedal progression in the two types.

2. The chief characters of the fore and hind limbs and of the upper part of the manus of *Diplodocus.*

The conclusion reached provisionally by Osborn,[1] that Diplodocus was a distinctively long-limbed type, is abundantly confirmed. The bones of the fore and hind limbs of *Diplodocus* can, in fact, be readily identified by their relative length and slenderness as compared with those of *Morosaurus* and *Brontosaurus* (see Fig. 6).

3. The carpus in the Sauropoda includes the probable coösification of the radiale and intermedium into a "scapho-lunar"; also a large ulnare, and from two to three small osseous carpalia in the distal row.

In his numerous and valuable contributions to this group the late Professor Marsh left the homologies of the carpals undetermined; his figures (of the *Morosaurus* and *Brontosaurus* fore limb) do not indicate the anterior crossing of the radius and ulna; he also left the limb structure of *Diplodocus* practically unknown.

In general, the limbs of the three contemporary Sauropoda of the Como district can be distinguished as follows:

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[1] Fore and Hind Limbs of Carnivorous and Herbivorous Dinosaurs from the Jurassic of Wyoming. Bull. Amer. Mus. Nat. Hist., Vol. XII, 1899, pp. 161–172.

Morosaurus, scapula relatively short, spreading superiorly ; scapulo-coracoid plate relatively broad ; limbs intermediate in length ; tibia, fibula and metapodials relatively slender.

Brontosaurus, scapula long, narrow superiorly ; scapulo-coracoid plate relatively narrow ; limbs long and heavy ; tibia, fibula and metapodials relatively robust.

Diplodocus, scapula expanding superiorly with intermediate scapulo-coracoid extension, limbs long and relatively slender, tibia and fibula, radius and ulna, and metacarpals especially elongated.

Camarasaurus, thus far found only in the Colorado Jurassic, is not related to *Brontosaurus*, as Osborn formerly supposed, but is a *Morosaurus* of immense size. The type skeleton will shortly be described.

The distinctive scapulo-coracoid characters are clearly brought out in the accompanying figures (Fig. 1, A, B, C).

Fig. 1. Scapulo-coracoid of : A. *Morosaurus*, Amer. Mus. Coll. No. 332 ; B. *Diplodocus*, Amer. Mus. Coll. No. 221 ; C. *Brontosaurus*, Amer. Mus. Coll. No. 222. All from the Bone Cabin Quarry. $\frac{1}{24}$ nat. size.

Fore Limb of Diplodocus, No. 594.

In the portion of the quarry explored during 1900, within an area of about 20 feet, were found a scapula and a coracoid which

Fig. 2. Fore limbs of *Morosaurus* Amer. Mus. Coll. No. 332, and of *Diplodocus* Amer. Mus. Coll. No. 594. $\frac{1}{20}$ nat. size.

fits closely to it, a humerus, ulna and radius lying together on the right side associated with a humerus of the left side; five metacarpals at some little distance associated with metatarsals and a hind limb of *Diplodocus.* These bones were considerably scattered and assigned separate field numbers, but they belong in all probability to one individual of medium size. They have been prepared and mounted (Fig. 2) under the direction of Mr. Hermann and afford for the first time a fine example of the fore limb of this stilted Dinosaur. Although the scapula is inclined backwards, the upward portion of the blade is 10 feet 6 inches, or 3195 mm. from the ground. The scapula is practically identical in measurement with that of the skeleton described in Osborn's Memoir upon *Diplodocus.*

The principal measurements (in millimeters) are as follows:

Scapula, length	1285
" greatest breadth	500
Scapulo-coracoid conjoined	1650
Coracoid, breadth from glenoid border	425
Humerus, length	1080
" least circumference	470
Ulna, length	870
" least circumference	285
Radius, length	840
" least circumference	255

Metacarpals	I,	II,	III,	IV,	V.
Proximal facets, antero-posterior	105 e.[1]	113	76 e.	63	85
" " transverse	51	64	83	85	43
Length	260	290	315	290	285

The *scapula* is very similar in form to that already described by Osborn. The *coracoid* is short, not yet conjoined to the scapula, and fortunately retains its natural curvature; on its postero-inferior surface is the rough facet, observed by Marsh, for articulation with the sternal plate. The sternals were also found, but have not been placed in position. The head of the upper portion of the shaft of the *humerus* is crushed, so that it extends unnaturally beyond the line of the glenoid facet; the deltoid or lateral crest (processus lateralis) extends well down upon the outer side of the shaft; distally the shaft terminates on the outer side in a prominent radial condyle which is readily

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[1] e = estimated.

distinguished by the deep groove upon its anterior face; the lower articulation of the humerus indicates that the limb was not greatly flexed at the elbow in the standing position, a fact in keeping with the great weight of the anterior portion of the body. In an uncrushed humerus the ulnar condyle is also well defined; the ulna, however, extends around and behind the radius.

Proximally the *radius* articulates on the anterior outer side of the humerus with the radial condyle; it fits in the broad anterior groove of the *ulna*, which element supports the entire posterior as well as the inner portion of the humerus, while the radius supports the anterior and outer portion only. The analogy of these elements with the fore limb of the elephant is obvious, because in both the proboscidian and dinosaurian the ulna is a stouter element than the radius, as shown by reference to the respective circumferences of the shafts, namely :

Diplodocus.		No. 594	No. 588
		mm.	mm.
Ulna	=	285	290
Radius	=	255	265

The shaft of the radius also crosses that of the ulna completely, as in the elephant and other ungulate mammals. On the posterior face of the radius, in its upper fourth, is a stout tuberosity for the ligaments and muscles connecting this bone with the ulna. Distally, the radius and ulna present approximately equal facets for the carpals.

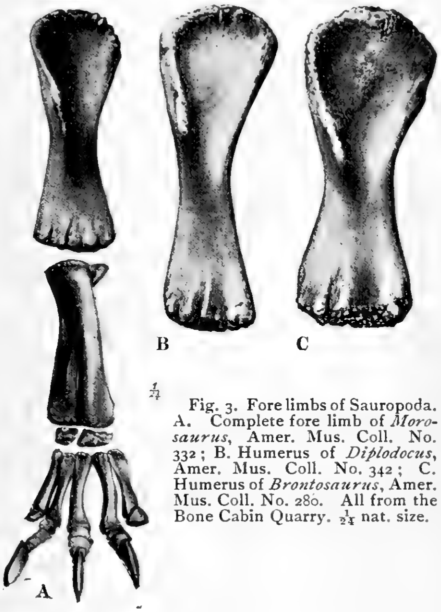

Fig. 3. Fore limbs of Sauropoda. A. Complete fore limb of *Morosaurus*, Amer. Mus. Coll. No. 332; B. Humerus of *Diplodocus*, Amer. Mus. Coll. No. 342; C. Humerus of *Brontosaurus*, Amer. Mus. Coll. No. 280. All from the Bone Cabin Quarry. $\frac{1}{24}$ nat. size.

Two *carpals* were found entirely out of position, making it difficult to determine their homologies; the larger of these apparently belongs to the opposite side and, as the evidence is conflicting, reference must be made to another fore limb, No. 588, described below.

There is little question that the *metacarpals* belong to this fore limb, although they were found mingled with metatarsals of a hind limb of corresponding size. By comparison with several series of metatarsals belonging to *Morosaurus* and *Brontosaurus* in the American Museum Collection, their homologies can be determined. Examination of the proximal facets for articulation with the carpals, shows that Mtc. I is deep and relatively narrow; Mtc. II is somewhat deeper and broader, and increases in size; Mtc. III is less deep, but much broader in front; Mtc. IV is still shallower, but of equal front breadth; Mtc. V, like Mtc. I, is deep, but narrow in front. The measurements given above are much affected by crushing, but indicate that Mtc. III is the largest and stoutest of the metacarpals, while Mtc. I and Mtc. V are relatively short.

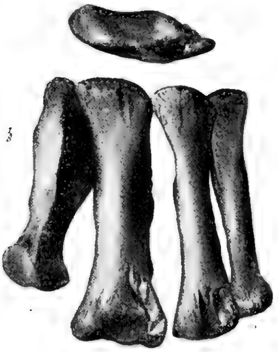

Fig. 4. Metacarpals, left manus, of *Diplodocus*, with supposed radiale plus intermedium. Amer. Mus. Coll. No. 588. 1/8 nat. size.

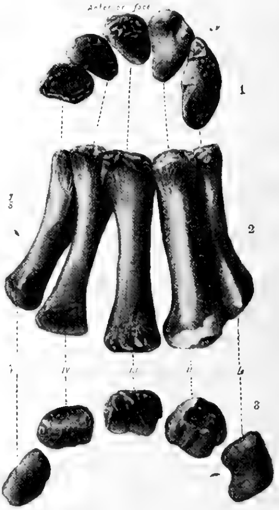

Fig. 5. Metacarpals of right manus of undetermined Sauropod, probably *Morosaurus*.

1. Proximal view of metacarpals.
2. Anterior view of metacarpals.
3. Distal view of metacarpals.

Amer. Mus. Coll. No. 462. 1/8 nat. size.

FORE LIMB OF DIPLODOCUS, No. 588.

The above characters are supplemented and confirmed by those of another fore limb (No. 588), consisting of ulna, radius, supposed scapho-lunar, supposed cuneiform, metacarpals I, II, III, IV, and a terminal phalanx. The metacarpals correspond approximately with those figured by Marsh.

Measurements.

	mm.
Radius, length	870
" least circumference	265
Ulna, length	910
" least circumference	290
Supposed scapho-lunar, transverse	151
Metacarpal I, length (vertically crushed)	235
" II, "	280
" III, length	280
" IV, "	265
Terminal phalanx (claw)	200

Carpals.—There can be little question as to the correctness of the association of these bones since they were found close together, and near by was a long series of *Diplodocus* caudals. Beneath the radius was found a large flattened carpal which from its connection with both radius and ulna is believed to represent a conjoined radiale and intermedium or scapho-lunar bone ; this bone is much thicker behind than in front ; it has a large radial facet, slightly concave, and a smaller oblique ulnar facet ; inferiorly there is a single convexity with ill-defined areas for the cartilaginous trapezium, trapezoid and magnum ; the cuneiform in this specimen is crushed beyond recognition ; there is a small ossicle which may represent the unciform or one of the other carpalia of the second row.

Fore Limb of Diplodocus, No. 380.

This generic reference is somewhat uncertain. The associated parts, consisting of radius, ulna, supposed scapho-lunar, cuneiform and two ossicles probably belong to a young *Diplodocus.* This limb is important, because it includes the terminal phalanges. The position of the latter, however, was not positively determined.

Fore Limbs of Morosaurus, No. 332.

Figs. 1, 2, 3.

The right and left manus found with these limbs have already been described by Osborn (*l. c.*, p. 168) ; the elements were found in position and therefore yield important information, although the limb bones are much crushed. As in *Diplodocus*, the radius crosses the ulna completely and rests upon the enlarged flattened scapho-lunar, which also presents a narrower face for the ulna; as in *Diplodocus* this carpal is much thinner in front than behind.

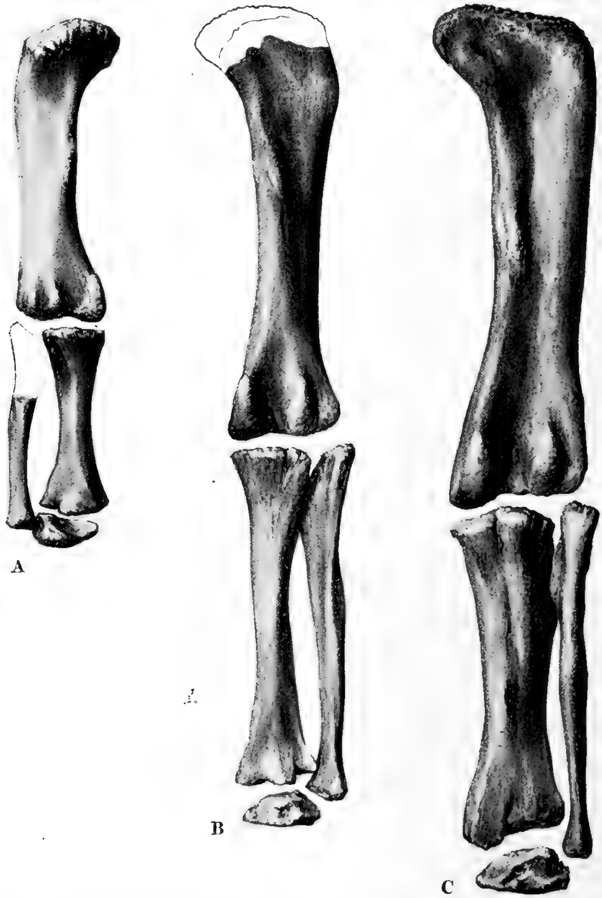

Fig. 6. Hind limbs of Sauropoda, posterior view. A. *Morosaurus*, Amer. Mus. Coll. No. 461; B. *Diplodocus*, Amer. Mus. Coll. No. 251; C. *Brontosaurus*, Amer. Mus. Coll. No. 353. All from the Bone Cabin Quarry. $\frac{1}{24}$ nat. size.

The cuneiform is a smaller bone, oval and flattened as seen from above, cyclindrical in anterior view, with an irregular projection on the lower face. The three median metacarpals are long and slender, decidedly exceeding in length the outer pair, Mtc. I and Mtc. V. The doubt expressed in the earlier description of this manus as to the presence of terminal phalanges and a claw upon the first digit still remains; the proximal phalanx associated with Mtc. I indicates that the terminal phalanx was missing.

Measurements.

	Morosaurus. mm.	*Camarasaurus, type.* mm.
Scapulo-coracoid, total length	910	2060
Coracoid, breadth opposite glenoid border	400	760
Humerus, total length	770	
Ulna, total length	560	
Radius, " "	550	
Scapho-lunar, transverse	120	
Mtc. I, length	205	
Mtc. II, "	250	
Mtc. III, "	250	
Mtc. IV, "	225	
Mtc. V, "	205	

CARPALS OF SUPPOSED MOROSAURUS, NO. 462.

These are especially interesting and valuable because of the absence of crushing, which gives the rounded or radial disposition of these bones as seen from above and in front (Fig. 5).

Measurements.

	mm.
Mtc. I, length	191
Mtc. II, "	218
Mtc. III, "	219
Mtc. IV, "	209
Mtc. V, "	186

The lateral metacarpals, I, V, have a more flattened section, the median metacarpals II, III, IV, present a more rounded section. Portions of the proximal and distal facets are well illustrated in the figure. As in *Diplodocus* the proximal facets decrease steadily in antero-posterior diameter as we pass from I to V. The posterior faces exhibit rugose areas for retractor tendons.

FORE LIMB OF BRONTOSAURUS, NO. 276.

In our collection are mounted two fore limbs of *Brontosaurus*, neither of which is complete. No. 276 is a young *Brontosaurus* carpus with which have been associated arbitrarily No. 318, ulna and radius, with extensive restoration. The carpals, as compared with those of *Diplodocus*, Nos. 594, 588, or 380, above described, are shorter and more robust. The manus of No. 268 has already been described (Osborn, 1899, p. 171). The metacarpals attain a very considerable length, but also acquire robust proportions, which enable us to readily distinguish them from those of *Diplodocus ;* the placing of these elements is, however, somewhat conjectural. With the carpus is found the supposed scapho-lunar and three ossicles, which probably represent the carpals of the second row.

Dolichocephaly and Brachycephaly in the Lower Mammals.

By Henry Fairfield Osborn.

AUTHOR'S EDITION, extracted from **BULLETIN**

OF THE

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New York, Feb., 3, 1902.

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Article VII.—DOLICHOCEPHALY AND BRACHYCEPHALY IN THE LOWER MAMMALS.[1]

By Henry Fairfield Osborn.

> Skulls are classified according to their cephalic indices into three groups: dolichocephalic, mesaticephalic, and brachycephalic.—*Nature*, XXXIII, 4.

Dolichocephaly and brachycephaly are familiar terms in anthropology. The cephalic index, or ratio of breadth to length, marks a profound distinction between different races of man; it is one of the most stable of all racial characters, although no satisfactory theory or explanation of what it signifies has thus far found general acceptance among anthropologists.[2]

These facts render it all the more surprising that *skull* proportion, distinguished from *cranial* or brain-case proportion in man, has not been considered more generally by students of the lower mammals as of great value in the separation of races, as well as of profound morphological significance. It is true that certain mammals have been described as short- or broad-skulled, others as long- and narrow-skulled. As early as 1873 Kowalevsky demonstrated the elongation of the face in Ungulates for the accommodation of long-crowned teeth, but this does not explain the long free space or diastema in front of these teeth; the studies of Nathusuis (1864) on the proportions of the skull in races of pigs,

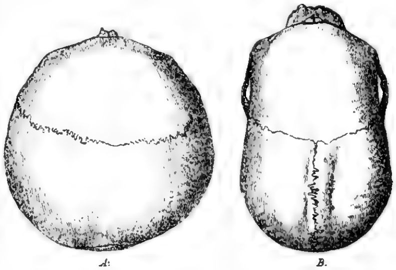

Fig. 1. Human Crania of dolichocephalic and brachycephalic type. After Huxley.

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[1] Presented in Abstract before the New York Academy of Sciences, Nov. 8, 1901, and before the National Academy of Sciences, Nov. 13, 1901.

[2] I make this statement on the authority of Dr. A. Hrdlička of the American Museum of Natural History.

are well known; in 1895 Nehring referred to the long- and short-skulled races of dogs associated with early races of man; quite recently also Wortman (1899) has distinguished between short- and long-jawed races of Tertiary dogs, and Matthew (1901) has distinguished between the long- and short-skulled races of Oreodonts, as a basis of classification. These are a few examples, among many which might be found, of attention directed to such facts; but I am not aware of any general application of *dolichocephaly and brachycephaly as factors in cranial and dental evolution, and as correlated with the proportions of the limbs and habits of feeding.*

At all events the principle has not found its way into palæontological literature, with which I am fairly familiar, and was reached by myself independently and purely inductively while engaged upon the phylogeny of the Rhinoceroses (1900). After accumulating a great number of facts on the evolution of this baffling group the correlation of long limbs with long skulls (dolichopody and dolichocephaly) and short limbs with short skulls (brachypody and brachycephaly) suddenly appeared as a key, and was expressed in the following statement:

"It [the classification adopted] sets aside several homoplastic parallel characters heretofore employed in Rhinoceros evolution and attempts to establish a firmer basis *in the fundamental proportions of the skull, whether dolichocephalic or brachycephalic, in the correlated proportions of the body, and in the location of the horn cores.* These characters are found to be more distinctive of phyla than the pattern of the molar teeth."

The full bearings of the principle were only partly perceived at this time, and singularly enough I turned to the study of the Titanotheres for the Geological Survey Monograph without reference to my previous work on the Rhinoceroses and wholly unbiassed by any theory. Aided by Mr. W. K. Gregory about eighty-five skulls were measured and studied, hundreds of facts were noted which seemed to have no particular significance; finally all these data were put together and the conclusion was reached again, inductively, that *dolichocephaly and brachycephaly are among the dominat-*

ing factors in the skull of the Titanotheres, and that they are probably correlated with similar proportions in the trunk and limbs. This result, as in the case of the Rhinoceroses, placed the whole evolution of the family from its beginning in the Eocene period in a new light and directly contradicted the phylogenetic conclusions I had reached in 1896.

Considering the principle, however, as only a working hypothesis I read through various memoirs of Cope, Marsh, Earle, and others on the structure of the skull in the Rhinoceroses and Titanotheres and was delighted to find that dolichocephaly and brachycephaly explained a vast number of detailed facts which had been recorded abstractly by these authors without reference to their significance, not only in all parts of the skull but in the teeth. In many respects the teeth were proved to conform to the skull rather than the skull to the teeth.

In brief, the proportions of the skull were found to involve, as one might anticipate, every bone in the skull, but more particularly nasals, horns, zygomatic arches, palate, relations of the foramina in the base and side of the skull, the occiput, the mastoid and other bones around the auditory meatus, the premaxillary and mandibular symphyses, the jaw, the diastemata between and behind the teeth, the number and shape of the teeth, the shape, number, and relations of the cusps, and even, it would appear, the cingulum around the teeth. In other words all these characters were found correlated in many animals with the proportions of the skull, and consequently with the structure of the limbs and feet,—a quite unlooked for illustration of Cuvier's famous law of correlation.

This gratifying result suggested a superficial review of the mammals in general in respect to the same factors. The conclusions reached in this paper are therefore of a preliminary character.

We may first consider the skull in itself, then the correlation of its proportions with similar proportions in other parts of the body, the exceptions to such correlation and special reasons for them, some of the apparent causes of dolichocephaly and brachycephaly, and finally some of the facts which await explanation.

In applying these terms to the lower mammals we refer to the *skull as a whole*, whereas in man the reference is only to the *cranium.*

THE LONG AND THE BROAD SKULL.

The three skulls photographed below from the American Museum collection (Fig. 2) are three nearly contemporary species of Eocene Titanotheres which illustrate admirably dolichocephaly, brachycephaly, and the neutral or intermediate condition of mesaticephaly. The species are the classic *Palæosyops paludosus*, the extremely long and narrow *Telmatotherium cornutum*, and the moderately broad *Limnohyops manteoceras*. The first and second species are believed to belong to side lines which became extinct; the third, more generalized, form is now believed to have given origin to the Oligocene Titanotheres, although this inference

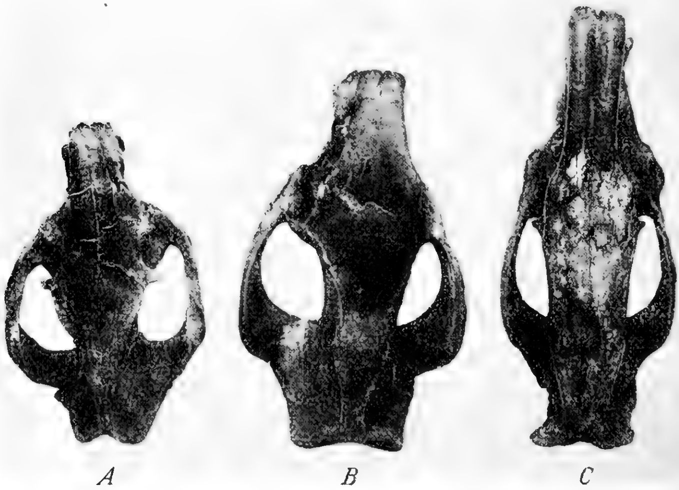

Fig. 2. Eocene Titanotheres. *A*, Brachycephalic, *Palæosyops paludosus*. *B*, Mesaticephalic, *Limnohyops manteoceras*. *C*, Dolichocephalic, *Telmatotherium cornutum*.

awaits confirmation. The skulls of these Titanothere species differ from those of man and of Rhinoceroses in the fact that the cranium, or skull proper, does not vary in width so widely as the cheek arches or zygomata. It is chiefly the enormous expansion of the latter bones in *Brontotherium elatum* which makes the skull actually as broad as it is long. But while mainly a zygomatic expansion, that there is a very pronounced cranial and facial expansion is attested by the broad palate, relatively short and crowded dental series, transversely expanded horns, abbreviated nasals, short malar bridge in front of the orbit, abbreviated mastoid and paroccipital portion behind the external auditory meatus, transversely expanded occiput and occipital condyles, broad exoccipital and postglenoid processes, short, deep, and thick lower jaw with less prominent angle. There is no mistaking a typical brachycephalic for a dolichocephalic jaw, every contour and proportion is different. Analogous differences are observed among the Rhinoceroses.

The above are only a few of the correlated effects of skull proportion. In the comparison of all the Titanotheres from the beginning to the end of their remarkable history it is found that the primitive and central types are mesaticephalic, and the divergence is into brachycephaly and dolichocephaly. The following table presents the extremes of structure as observed especially in the Titanotheres.

CORRELATED SKULL CHARACTERS.

	BRACHYCEPHALY.	DOLICHOCEPHALY.
	Teeth.	
Dental series	Crowded	Elongate.
Diastemata	Closed	Increased.
Anterior premolars, pm $\frac{1}{1}$	Suppressed. One fang suppressed.	Persistent and spaced. Two fangs retained.
Intermediate tubercles of molars	Persistent	Reduced.
Opposite dental series	Convergent or arched	More parallel.

	BRACHYCEPHALY.	DOLICHOCEPHALY.
	Teeth.	
Grinding teeth.	Shortened and widened.	Lengthened and narrowed.
Cingula between teeth.	Suppressed.	Persistent.
Canine teeth	Rounded and broadened.	Elongate compressed.
Incisor series.	Placed transversely. .	Converging anteriorly.
	Skull.	
Whole skull.	Shortened and broadened.	Lengthened and narrowed.
Most of the constituent bones.	Shortened and broadened.	Lengthened and narrowed.
Palate.	Broadened and flattened.	Narrowed and transversely arched.
Nasals.	Shortened and spreading.	Long with incurving or straight sides.
Malar and maxillary bridge over infra-orbital foramen.	Narrowed	Broadened.
Infra-orbital foramen.	Not seen on side of face.	Conspicuous on side of face.
Lachrymal bone. . . .	Crowded into orbit. .	Exposed on side of face.
Lachrymal canal. . . .	Crowded into orbit..	Seen on edge of orbit.
Zygomata.	Broadened, especially in the "buccal plates"; in section broad rather than deep.	Elongate and vertically deepened; in section deep rather than broad.
Areas of insertion of masseteric and temporal muscles.	Increased.	Balanced or retained.
Mastoid portion of periotic.	Abbreviated.	Exposure persistent.
Exoccipital, post-glenoid, and post-tympanic processes.	Broadened	Deepened and narrowed.
Post-glenoid and post-tympanic processes.	Approximated, especially below, enclosing the external auditory meatus.	External auditory meatus not closed below.

	BRACHYCEPHALY.	DOLICHOCEPHALY.
	Skull.	
Tympanic bulla	Thrust inward	Exposed laterally.
Foramen ovale and f. lacerum medius	Approximated	Separated by a bridge of bone.
Foramen lacerum medius and f. lacerum posterius	Approximated	Separated by periotic.
Alisphenoid canal	Abbreviated	Elongate.
Presphenoid	Abbreviated	Elongate.
Vomer	Thrust backward	
Premaxillary symphysis	Abbreviated	Elongate.
Horns	Transversely expanded	Not so expanded.
	Jaw.	
Jaw	Shortened, thickened, deepened.	Elongate, with straight lower border and backwardly produced angle.
Area of insertion for temporal muscle	Reduced	Balance maintained.
Coronoid process	Reduced	Lengthened antero-posteriorly.
Mandibular symphysis	Abbreviated	Elongate.

The above characters are chiefly observed in the Titanotheres, in which the most careful comparison of dolichocephalic and brachycephalic skulls has been made.

Many characters in the first column apply with equal force to the Primates which are progressively brachycephalic, marking the passage from the more dolichocephalic Lemurs and Baboons to the more brachycephalic Lemurs, Monkeys, and Apes.

On the other hand many characters in the second column apply also among the Horses, which are progressively dolichocephalic.

Many of these characters also distinguish the brachycephalic from the dolichocephalic Rhinoceroses.

There are, however, notable exceptions, as shown below.

UNEQUAL ELONGATION OF FACE AND CRANIUM.

When we compare a long-skulled with a short-skulled Rhinoceros the skull of the latter appears compressed antero-posteriorly, as if composed of india-rubber, all the parts being affected alike (Fig. 3). But although both the face and the cranium in the Rhinoceroses and Horses appear to be affected, this is by no means a general principle. In the Titanotheres the face is shortened and the cranium greatly elongated, so that the distance between the orbit and the external auditory meatus is very great, the molar teeth extending back beneath the orbit. In the Horses, on the other hand, the face is greatly elongated and the cranium only moderately so, and this is true of by far the greater number of long-skulled Ungulates. Such unequal elongation of different regions of the skull will

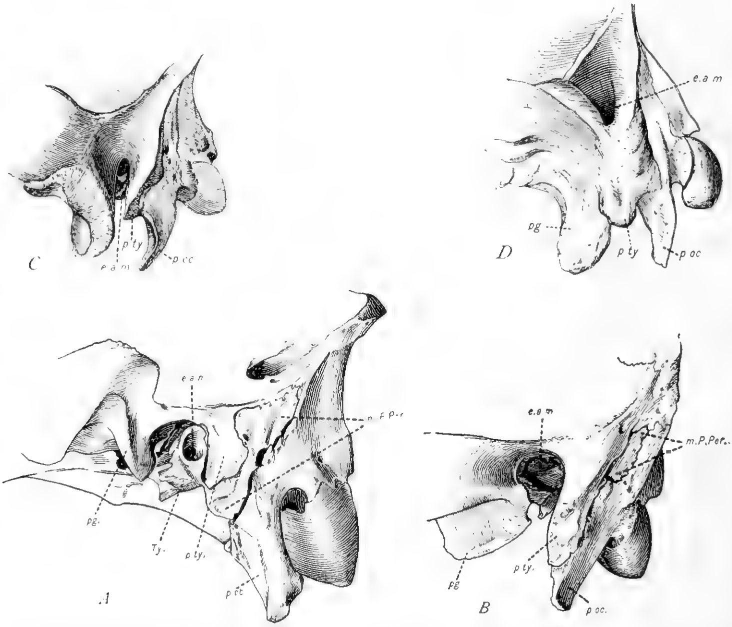

Fig. 3. Influence of progressive brachycephaly upon the ear region of Perissodactyla. *A*, Dolichocephalic, *Equus caballus*. *B*, Mesaticephalic, *Tapirus*. *C*, Dolichocephalic, *Ceratorhinus sumatrensis*. *D*, Brachycephalic, *Rhinoceros sondaicus*. Disappearance of mastoid portion of periotic, *m. P. Per*, and enclosure of auditory meatus, *e. a. m.*, inferiorly.

no doubt be found by examination in every family of mammals.

But every exception has some special adaptive significance. For example, the nasals in the Tapirs and the Proboscidea are abbreviated not as an expression of brachycephaly but in correlation with a prehensile upper lip or proboscis. The mastoid portion of the periotic, generally exposed in dolichocephalic types such as the Horses, persists also in the brachycephalic Primates, for the insertion of one of the most important muscles of the neck. The contrasts of brachycephalic with dolichocephalic characters, brought out in the above table, therefore are limited in the various mammalian families by special adaptive conditions.

SIGNIFICANCE OF DOLICHOCEPHALY.

The earliest known Ungulates have moderately elongate or mesaticephalic skulls, from which it follows that brachycephaly and dolichocephaly are for the most part secondary. In Titanotheres and Rhinoceroses they are definitely progressive characters. The earliest horses (*Protorohippus*, *Hyracotherium*) are already specialized in the direction of

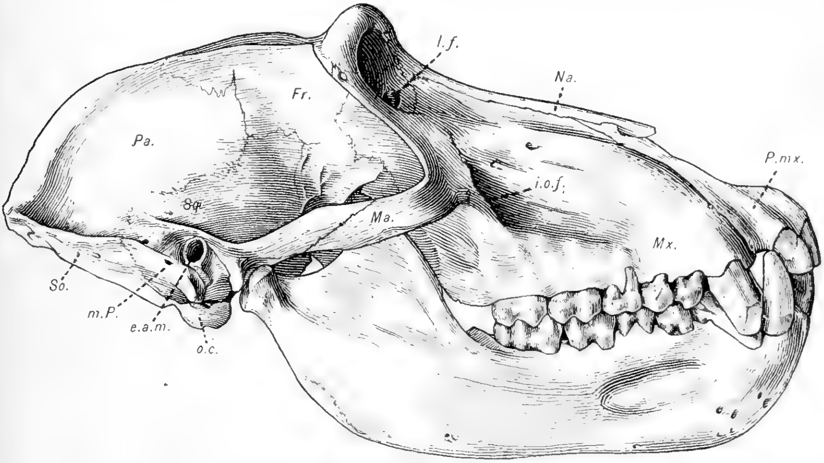

Fig. 4. Dolichocephalic skull of Baboon, *Cynocephalus olivaceus.*

dolichocephaly, which, it is important to note, is here accompanied by progressive lengthening of limb.

In fact, dolichopody, in the broad sense of lengthening of limb, is in general an adaptation to cursorial habits and speed, associated with life on the plains, cropping front teeth, absence of defensive weapons.

The lengthening of the limb for the purpose of speed appears in fact to have been the prime correlate of the lengthening of the skull. There are numerous cases where the elongation of the limbs and of the skull have developed *pari passu*, notably in the case of the long-limbed Rhinoceroses as well as in the Horses. It is also very characteristic of the long-limbed Elotheres, which have extraordinarily long skulls, in contrast with the remotely related Pigs. We reach the conclusion that both dolichocephaly and lengthening of neck, in order to enable grazing animals to reach the ground, may be primarily due to lengthening of limb.

EXCEPTIONS TO THE CORRELATION OF DOLICHOCEPHALY WITH DOLICHOPODY AND OF BRACHYCEPHALY WITH BRACHYPODY.

There are, however, many exceptions to the correlation of long limbs and long skulls. Among the races of men, although there are notable cases of such correlation, there are also notable exceptions; the bipedal Primates generally offering an exception to quadrupedal mammals.

Again, the cursorial long-limbed Hyracodonts are a family of Rhinoceroses with very long limbs and short skulls. Here, however, brachycephaly is compensated for in a measure by length of neck, possibly also by a substitution of browsing for grazing habits. The most remarkable elongation of the limbs and neck, in connection with an only moderately elongate skull, is in the Giraffes, which are typical tree-browsers. The opposite combination of long limbs with very long head and short neck is exemplified in the Moose (*Alces*), habitually a browser, which, like the giraffe, extends its mouth to the ground with great difficulty. Whenever an animal acquires the shrub- or tree-browsing habit, therefore, as in the case of *Rhinoceros bicornis*, a new factor is introduced. Other families in which the browsing habit appears to have been acquired secondarily are the Chalicotheriidæ, Agriochœridæ, and Anoplotheriidæ.

Again, among the Carnivora the Dogs are typically long-skulled and long-limbed or cursorial animals. A dog feeds in a standing position, the food held upon the ground by the fore feet, the limbs being somewhat flexed. In this family the skull and limb correlation seems to hold good. Moreover, the short-faced dogs are generally short limbed. Cats, on the other hand, present a decided exception, because they are brachycephalic and dolichopodal, the Cheetah, for example, having an exceptionally short skull and elongate limbs. We should recall, however, that cats always feed in the recumbent or semirecumbent position, crouching or lying down. Thus the abbreviation of the Cat skull is correlated with the functions of the teeth and not with those of the limbs, because the Cats have a special position in feeding. Similarly the Proboscidea are extremely brachycephalic and long-limbed, but the exceptional elongation of the limbs is compensated for by the development of a proboscis.

To sum up, the numerous exceptions to the correlation of skull and limb proportions are mostly capable of special adaptive explanations, and, as we shall see below, when correlation does occur it is probably adaptive also. In brief, there is no innate, invariable law of correlation; skull and limbs may or may not be dependent upon each other.

But when such correlation does occur, as in *Telmatotherium* or *Hyopotamus* on the one hand, or in *Teleoceras* on the other, it is likely to affect the whole skeleton: length of the cervical and dorsal vertebræ, form of the scapula and ilium, length

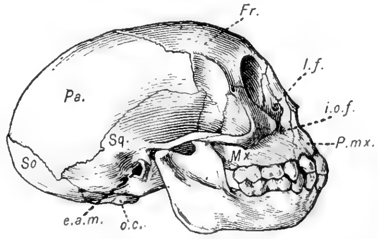

Fig. 5. Brachycephalic skull of Monkey, *Maccacus* sp., juv.

of the metapodials. So complete is the correlation that we can, for example, immediately distinguish between the elements of the pes of a long-skulled and of a short-skulled Rhinoceros.

Eliminating all the exceptions, there appear to have been two general causes for the elongation of the skull. First, the elongation of the face for the accommodation of very long hypsodont grinding teeth in front of the orbit, as observed by Kowalevsky. Second, the elongation of the skull as a whole, correlated with the elongation of the limbs, an adaptation to grazing and cursorial habit.

NO ADEQUATE THEORY OF BRACHYCEPHALY.

It is much more difficult to account for progressive brachycephaly. An adequate theory of its causes is still wanting, as shown by the following examples:

Among Primates the shortening of the skull takes place *pari passu* with the increasing use of the manus in conveying food to the mouth; this is well illustrated by the contrast between the quadrupedal, long-skulled baboons and the more bi-pedal short-skulled monkeys.

We are especially at a loss to offer any adequate explanation of the causes of progressive brachycephaly in mammals which seem to suffer thereby a reduction and compression of the dental series. In certain Titanotheres and Rhinoceroses the shortening of the skull seems to crowd and diminish the usefulness of the teeth, an apparently inadaptive process.

The observations of Nathusius led him to the conclusion that among the Suidæ abundant food tended to shorten and broaden the head and the face. Darwin observes that domestication tends to shorten the bones of the face in many animals.

Among Carnivores, and among the long-horned Titanotheres, abbreviation of the skull favors the effective use of the canine tusks and of the paired horns respectively. But brachycephaly also develops to an extreme in certain defenceless types, such as *Cyclopidius* among the Oreodonts.

Further investigation and comparison may produce some general law.

BIBLIOGRAPHY.

1867. HUXLEY, THOMAS H. On Two Widely Contrasted Forms of the Human Cranium. *Journ. Anat. Phys.*, Vol. I, 1867, pp. 60–77, Figs. 3–7.

1873. KOWALEVSKY, W. Monographie der Gattung *Anthracotherium*. *Palæontographica*, N. F. II, 3 (XXII).

1901. MATTHEW, W. D. Fossil Mammals of the Tertiary of Northeastern Colorado. *Mem. Amer. Mus. Nat. Hist.*, Vol. I, Part V, Nov., 1901.

1864. NATHUSIUS. Vorstudien zur Geschichte und Zucht der Hausthiere, zunächst am Schweinschädel. Berlin, 1864.

1897. OSBORN, HENRY F. The Cranial Evolution of Titanotherium. *Bull. Amer. Mus. Nat. Hist.*, Vol. VIII. Art. IX, pp. 157–197, 1897.

1900. OSBORN, HENRY F. Pylogeny of the Rhinoceroses of Europe. *Bull. Amer. Mus. Nat. Hist.*, Vol. XIV, 1900, p. 229.

1885. TOPINARD.—"General Anthropology." Reviewed in *Nature*, 1885, Vol. XXXIII, p. 4.

1899. WORTMAN, J. L., and W. D. MATTHEW. The Ancestry of Certain Members of the Canidæ, Viverridæ, and Procyonidæ. *Bull. Amer. Mus. Nat. Hist.*, Vol. XII, Art. VI, pp. 109–138, 1899.

The Four Phyla of Oligocene Titanotheres

By Henry Fairfield Osborn.

AUTHOR'S EDITION, extracted from BULLETIN
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American Museum of Natural History,
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New York, February 18, 1902.

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Knickerbocker Press, New York

Article VIII.—THE FOUR PHYLA OF OLIGOCENE TITANOTHERES.[1]

TITANOTHERE CONTRIBUTIONS, No. 4.[2]

By Henry Fairfield Osborn.

My first review of this group, entitled 'Cranial Evolution of Titanotherium' (Titanotherium Contributions No. 3), was based upon examination of only part of the original material; it included a preliminary revision of the species by the distinction of growth, sexual and variable characters, and by the method of sections of different parts of the skull.

Two errors invalidated this review. First, the stratigraphical or geological sequence of the types examined was not fully known, and, second, as a consequence, the group was treated as more or less monophyletic with certain side branches.

This second review is an abstract of a portion of the results obtained for the U. S. Geological Survey monograph, 'The Titanotheres,' now in preparation. It covers practically all the type material in the Yale, National, American, and Harvard Museums, and advantage has been taken of the invaluable field observations by Hatcher of the levels on which the different skulls in the National Museum collection were discovered. The section method also has been very greatly extended and, taken in connection with the teeth and the detailed structure of the skull, has proved to be a sure criterion of specific and phyletic character.

Beginning in January, 1901, the work for the monograph advanced uninfluenced by any theory as to the evolution of these mammals until finally, in July, all the data were put together with most interesting results, which may be briefly summarized as follows:

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[1] The late Professor O. C. Marsh of Yale University devoted many years to the collection of materials and preparation of plates and figures for a monograph on the group treated in this paper. He also completed several valuable papers, but left no manuscript. Full acknowledgment of this important service to palæontology will be made by the writer in the final treatise.

[2] See contributions 1–3 in Bibliography.

I. THE ADAPTIVE RADIATION.

The Oligocene Titanotheres consisted of at least four contemporary phyla, to which the prior generic names *Titanotherium*, *Megacerops*, *Symborodon*, and *Brontotherium* may be applied.

They represent an adaptive radiation for different local habitat, different modes of feeding, fighting, locomotion, etc., which took origin, in part at least, in the Middle or Upper Eocene. Europe and Asia also may have shared in this radiation, since Titanotheres are now definitely known in the Balkan region.

The main phyletic characters are analogous to those recently (Osborn, 1900, p. 231) determined among Rhinoceroses; the great antiquity of the lines leading to the existing species of Rhinoceroses necessitated the revival of a number of discarded generic names to distinguish them. Similarly the separateness of four of the Titanothere phyla, throughout the Oligocene and possibly from the Eocene, render it desirable to revive certain generic names which in my first review I considered undefinable.

Radiation involved three main sets of characters, two of which were correlated:

First, dolichocephaly and brachycephaly, associated with numerous changes in the skull and teeth, and, in at least two phyla, with longer and shorter limbs.

Second, four distinct types in the shape and position of the horns, correlated with the structure of the nasals and frontals and indicative of different modes of combat among the males.

Third, canines of different form; and, finally, the presence of one or two pairs of functional incisor teeth, or the total degeneration of these teeth.

2. THE FOUR GENERA.

Titanotherium Leidy applies to long-limbed animals with long skulls, persistently long and broad nasals, short triangular horns placed slightly in front of the eyes, vestigial incisors, $\frac{2-0}{2-0}$, large canine teeth. Known from the base to the summit of the Oligocene.

Megacerops Leidy applies to Titanotheres with broad skulls, nasals progressively shortening, short horns rounded or oval in section, shifting anteriorly, one or two pairs of incisor teeth, $\frac{2-1}{2-1}$, medium sized canine teeth. Known from the base to the summit of the Oligocene.

Probably related to this are the subgenera of the types named *Allops* and *Diploclonus* by Marsh, differing from the above in horn characters. Known chiefly from the Upper Beds.

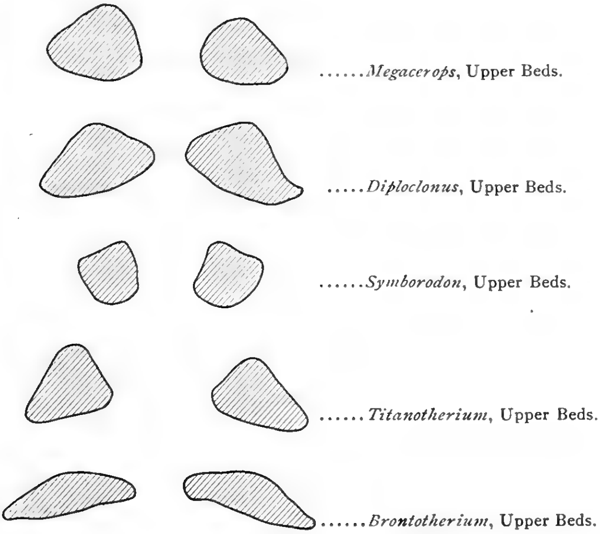

Fig. 1. Characteristic basal horn sections.

Symborodon Cope includes Titanotheres with skulls of varying proportion, nasals slender and progressively shortening, horns elongate and peculiar in being placed above the eyes instead of shifting forwards, incisors vestigial $\frac{2-0}{2-0}$, canines small, approximated. Known only from the Middle and Upper Beds.

Brontotherium Marsh embraces the largest Titanotheres, with very broad zygomatic arches, nasals shortening while horns elongate and shift forwards; incisors persistent, $\frac{2}{2}$ in the males, canines stout and obtuse.

Representatives of *Titanotherium* and *Megacerops* can now be continuously traced from the base to the summit of the Oligocene. Primitive species of *Brontotherium* also appear at the base, although the phyletic sequence through the Middle to the Upper Beds is not so clear. *Symborodon* suddenly appears in the Middle Beds.

3. NEWLY OBSERVED PROGRESSIVE CHARACTERS.

In addition to the progressive and retrogressive characters previously recorded by various writers (Osborn, 1896, pp. 162–174), are several of great value in the determination of species. (1) In the complication of the premolar teeth, one or more phyla progress in common, although the rate is unequal; for example, the double internal cones of the upper premolars are precociously developed in *Titanotherium* and very gradually so in *Megacerops*. (2) The cranial and many of the dental characters are profoundly affected by the progressive shortening or lengthening of the skull as recently explained in some detail by the writer (Osborn, 1902). (3) The cingulum around the molar and premolar teeth becomes progressively stronger in *Titanotherium* and *Megacerops*, and progressively weaker in *Symborodon* and *Brontotherium*. (4) The persistence or degeneration of incisor teeth are far more constant systematic characters than appeared to be the case in my first review.

In brief, each genus or phylum has its distinctive, persistent, progressive, and retrogressive characters, of which the above are a few examples out of many.

4. THE SUCCESSION OF SPECIES.

Phylum I.

Dolichocephalic Titanotheres with short, divergent, triquetrous horns placed slightly in advance of the orbits; nasals elon-

gate and square; incisors vestigial; canines very long and pointed; cingulum progressively developing; premolars $\frac{4}{4}$; buccal processes of zygomata deep rather than broad.

GENUS TITANOTHERIUM LEIDY.

The type of the genus is *T. proutii* Leidy, represented by the posterior portion of a jaw fortunately preserved in the National Museum, recorded from the base of the Titanotherium Beds. The genus is further characterized by a comparison of *T. heloceras*, *T. trigonoceras*, and *T. ingens*. It may have taken origin from *Diplacodon elatus* or *D. emarginatus* of the Upper Eocene or Uinta Beds.

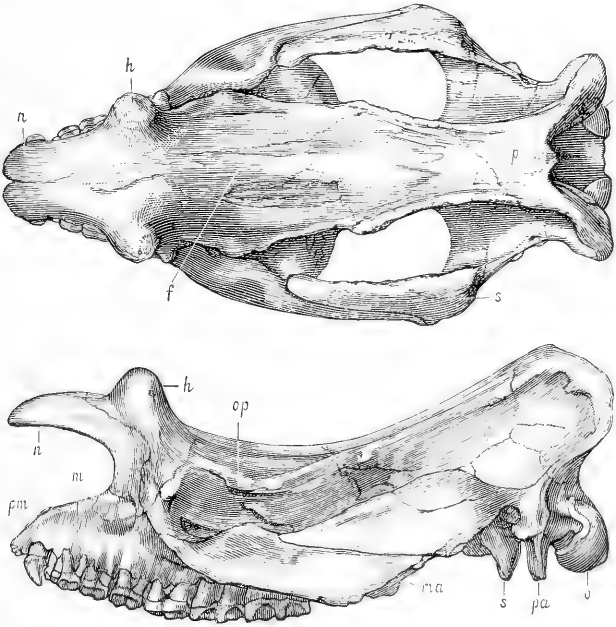

Fig. 2. *Titanotherium heloceras* (Cope). (U. S. Nat. Mus. No. 4260, Sk. Q.) × $\frac{1}{8}$.

LOWER BEDS.

T. heloceras *Cope.*—This is probably the earliest and most primitive representative of the long-skulled series. The doubt arises from the imperfect condition of the type. With this species, however, is probably associated a skull (Nat. Mus. No. 4260) definitely recorded by Hatcher as from the Lower Beds and exhibiting a number of undoubted *Titanotherium* characters.

MIDDLE BEDS.

T. trigonoceras *Cope.*—Animals of middle size with long metapodials, represented by numerous specimens in the American and National Museums, show the state of evolution of this phylum in the Middle Beds. As compared with *T. heloceras* there is a marked progression in size, in the shaping of the horns, the development of the paired premolar cones, and of the cingulum on the grinding teeth.

UPPER BEDS.

T. ingens *Marsh* (Syn., *Menops varians* Marsh).—These very large, long-skulled and long-footed Titanotheres, first described by Marsh as *Brontotherium*[1] *ingens*, are definitely recorded by Hatcher from the Upper Beds, and show a corresponding increase in size and in all other progressive characters. The incisors are vestigial, the canines very long and powerful; the cingulum on the grinding teeth is very pronounced in both males and females. There is a marked difference between the sexes in the size of the horns and canines.

Phylum II.

Brachycephalic Titanotheres with short horns shifting forwards, rounded to oval at summits; nasals progressively reduced in length and broadening at the extremities; one or two pairs of persistent incisor teeth, above and below; canines pointed, of medium length; premolars, $\frac{4-4}{4-3}$; *zygomata progressively expanding into convex buccal processes; cranium not greatly produced behind zygomata.*

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[1] As explained below, the name *Brontotherium* applies to the animals called *Titanops* by Marsh.

GENUS MEGACEROPS LEIDY.

This genus may have taken origin in the broad-skulled *Limnohyops manteoceras* or *Palæosyops paludosus* of the Eocene, although no horned type of the latter is known. It is known from the imperfect type of *M. coloradensis* and a very rich variety of species from the Lower, Middle, and Upper Beds, which have previously been referred to other genera. In the typical members the horns are slightly divergent and retroverted. There is a wide variation in progressive character between such species as *M. brachycephalus* and *dispar*, *M. bicornutus*, *M. selwynianus*, *M. tichoceras*, *M. robustus*, but it is found that the variations of age, growth, and sex, especially in species such as *M. dispar* and *M. robustus*, bridge over the differences between the types of said species and present intermediate forms. Furthermore these species are much more closely united to the general type of *Megacerops* than to any other genus.

LOWER BEDS.

Megacerops brachycephalus, sp. nov.

The type of this species is No. 4261, U. S. Nat. Mus. It includes very small, broad-skulled Titanotheres with very rudimentary second internal cones upon the upper premolars; nasals elongate, narrowing anteriorly, as in *Palæosyops*. Horns of anteroposterior oval section placed above orbits. It is represented in the National Museum by numerous skulls besides the type, all

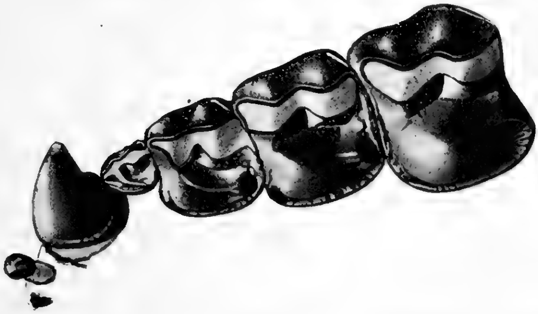

Fig. 3. *Megacerops brachycephalus.* (U. S. Nat. Mus. No. 4258, Sk. F.) Not the type. × ½.

collected and recorded by Hatcher. One of these skulls was provisionally referred by him to *Teleodus avus*, from which this species is quite distinct.

MIDDLE BEDS.

Megacerops dispar *Marsh* (Syn., *Brontops validus* Marsh). —Represented by the type, No. 4941, U. S. Nat. Mus., and numerous fine male and female skulls in the National Museum, collected and accurately recorded as to level by Hatcher. The incisors vary from two to one. Canines prominent, pointed. Premolars, $\frac{4-3}{4-3}$, with internal cones more distinct than in *M. brachycephalus*. Nasals shorter; horns longer, broader in section at the base; zygomata more expanded.

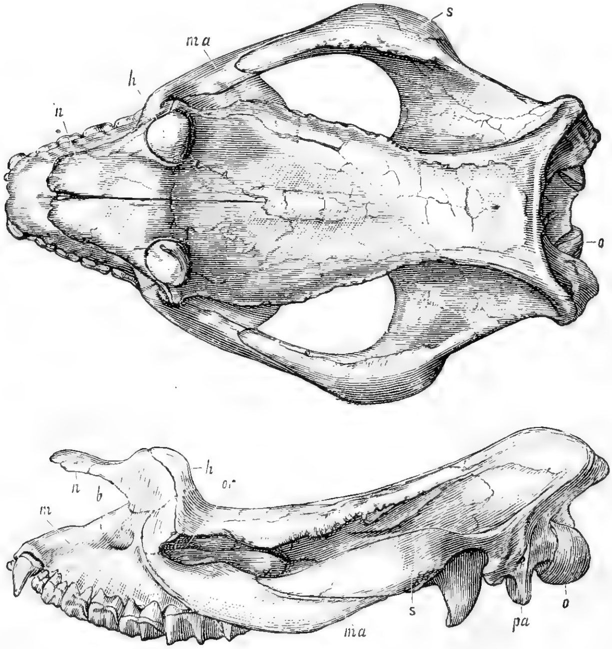

Fig. 4. *Megacerops brachycephalus.* (U. S. Nat. Mus. No. 4258, Sk. F.) Not the type. This skull was figured by Marsh (Amer. Jour. Sci., Oct., 1887) as *Brontops dispar.* × $\frac{1}{8}$.

LEVEL NOT RECORDED

Megacerops avus *Marsh.*—This type jaw, distinguished by the presence of three lower incisors, belongs to a much larger animal than *M. brachycephalus.* The presence of an outer lower incisor may be due to reversion or to the retention of a milk tooth; all young Titanotheres have three milk incisors. The formula, $I_{\overline{3}}$, $P_{\overline{3}}$, does not appear sufficient to remove this type generically, because the form of the canine, shape of the jaw, feeble development of the cingulum, etc., lead to placing it in *Megacerops.*

M. coloradensis *Leidy.*—Horns of medium length, of relatively slender cylindrical section. Nasals elongate, decurved, and narrow anteriorly. This is the type species.

M. angustigenis *Cope.*—Type in Ottawa Museum. Horns as in *M. coloradensis*, but nasals abbreviated and expanding anteriorly.

M. ? selwynianus *Cope.*—Level not recorded, probably Middle Beds. Type in Ottawa Museum. Nasals extremely narrow, elongate, with highly arched inferior surface as in the species next to be described.

MIDDLE BEDS.

Megacerops bicornutus, sp. nov.

Type No. 1476, cotype No. 1081, Amer. Mus. Horns directed anteriorly. Hornlets upon the inner and anterior mid-portion of the horn. Basal section of the horn slightly oval, subtransverse. Nasals narrow and relatively elongate. Sharp malar bridge in front of orbit. Orbit large.

This animal stands nearest *M. selwynianus*, although distinguished by the greater size and slightly greater width of the nasals. The sharp malar bridge is the most absolute character. The two hornlets are possibly variations.

UPPER BEDS.

Megacerops tichoceras *Scott & Osborn.*—Type skull in Harvard Museum. This is distinguished from *M. dispar* by the somewhat abbreviated nasals, greater expansion of the buccal processes, and two distinct internal cones upon the superior premolars. It is represented also by a number of large skulls in the National Museum definitely recorded by Hatcher from the Upper Beds.

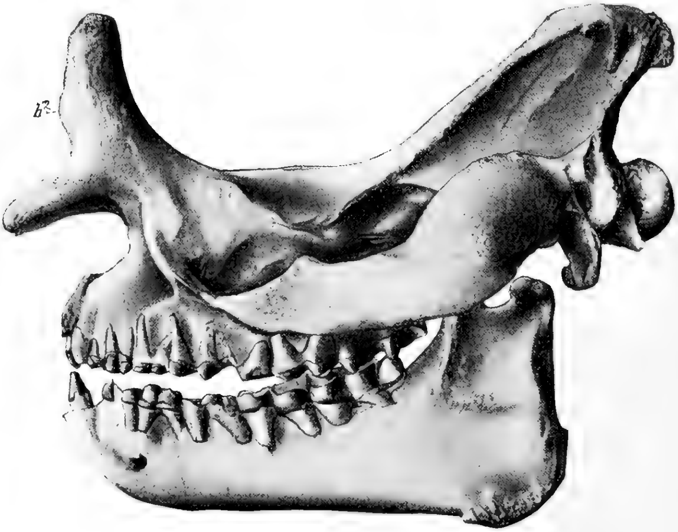

Fig. 5. *Megacerops bicornutus.* (Amer. Mus. Nat. Hist. No. 1476.) Type. × $\frac{1}{8}$.

Megacerops marshi, sp. nov.

Type, Skull No. 501, cotype, skull No. 1445, Amer. Mus. Nasals elongate and square distally, horns short, of oblique oval basal section, overhanging the maxillæ, or projecting forwards or outwards. Incisors, $\frac{?2}{?2}$. Canines short, tetartocones of premolars moderately developed.

These skulls were previously confused by the writer with *T. trigonoceras*, from which they are readily separated by the horn section, which relates them to some of the primitive types of *M. brachycephalus* and equally to *M. robustus*. The canines are more obtuse than in *M. dispar*, and the superior incisors resemble those in *Brontotherium* rather than in *M. robustus*.

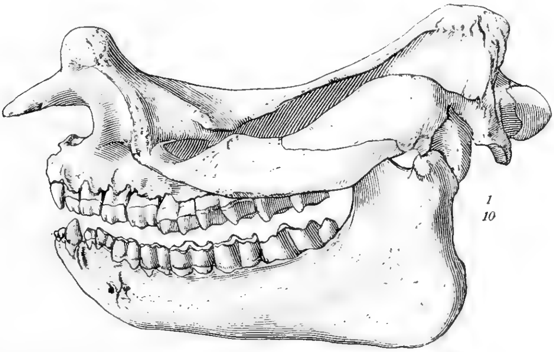

Fig. 6. *Megacerops marshi*. (Amer. Mus. Nat. Hist. No. 501; jaw No. 516.) Type. This skull was figured by Osborn (1896, p. 181) as *Titanotherium trigonoceras*.

Megacerops robustus *Marsh*.—Type in Yale Museum. Numerous skulls in the American, Princeton, and National Museums. Recorded by Hatcher from very summit of the Upper Beds. In skull development this represents an extreme evolution of the *M. brachycephalus-M. dispar* series. It is, however, distinguished from *M. dispar* by the presence of diastemata behind the canines, retarded development of the tetartocones on the superior premolars, broadly transverse horn-section, procumbent position of the horns.

The above-described new species, *M.* (? *Diploclonus*) *bicornutus*, from the Middle Beds is possibly a connecting form between *Megacerops* and the aberrant species from the Upper Beds termed *Diploclonus amplus* by Marsh. The latter is distinguished by short, divergent horns of peculiar triquetrous section, with incisors $\frac{1}{?}$, and elongate canines flattened posteriorly. The animals called *Allops* are certainly more closely related to *Megacerops* than to either *Titanotherium*, *Symborodon*, or *Brontotherium*, but their phyletic position is uncertain.

GENUS ALLOPS MARSH.

Syn. ? *Diploclonus* Marsh.

Canines lanceolate, flattened posteriorly, incisors $\frac{1}{?}$. Horns with greatest diameter progressively transverse, pointed outwards and forwards.

The distinctness of this genus is doubtful.

UPPER BEDS.

Allops serotinus *Marsh.*—Superior premolars with small postero-internal cusps (tetartocones). Represented by two skulls in the National Museum, recorded from the Upper Beds. No connecting crest between the horns.

Allops crassicornis *Marsh.*—Type No. 4289, Nat. Mus. Superior premolars with large postero-internal cusps; cingula more prominent; zygomata with flattened buccal processes. No connecting crest between the horns.

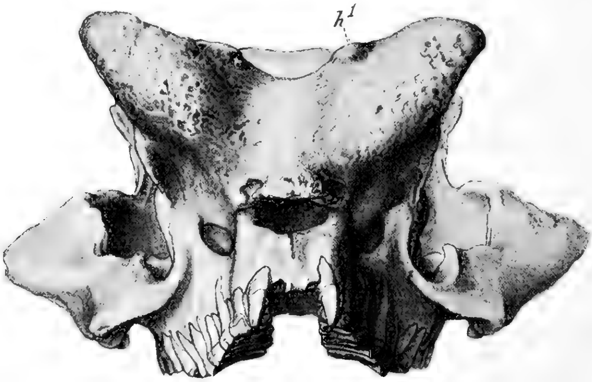

Fig. 7. *Diploclonus amplus* (Marsh). (Yale Museum.) Type. × $\frac{1}{8}$.

Allops amplus *Marsh.*—Type in Yale Museum. Characters similar to the above with the exception of a strong connecting crest between the horns and a pair of rugose internal hornlets on the horns, hence the term 'Diploclonus.' It is possible that this species descended from *M.*

bicornutus as a member of a collateral phylum distinguished by internal hornlets. In such case *Diploclonus* may prove to be a valid subgenus.

Phylum III.

Medium-sized Titanotheres with long horns placed more directly above the orbits, of deep anteroposterior diameter at the base, oval at tip ; connecting crest feeble or wanting. Nasals thin; skull proportion varying in the species. Incisors degenerate. Canines very small, approximated.

Genus SYMBORODON Cope.

Syn., *Anisacodon*, *Diconodon* Marsh.

This genus is characterized from the types of *S. torvus*, *S. acer* in the American Museum, and of *S. montanus* in the Yale and National Museums. It is known only from the Middle and Upper Beds, but is entirely distinct. It agrees with *Titanotherium* in the disappearance of incisor teeth, but differs from it absolutely in the horn and nasal structure. It is also widely separate, both in cutting teeth and horn structure, from *Megacerops* and *Brontotherium.*

PROBABLY UPPER BEDS.

Symborodon torvus *Cope.* — Brachycephalic, incisors $\frac{0}{0}$, nasals thin, buccal processes of zygomata broad and flat, occipital pillars broad.

Symborodon acer *Cope* (Syn., *S. altirostris* Cope).—Dolichocephalic, nasals thicker, abbreviated. Horns of male long, recurved, low connecting crest, incisors vestigial.

MIDDLE AND UPPER BEDS.

Symborodon montanus *Marsh.*—Type in Yale Museum. Nasals thin, of medium length, upper incisors vestigial.

Two skulls in the National Museum (Nos. 4711, 4705) exhibit smaller canines than in Marsh's type, and possibly represent a fourth species, because the canines are exceptionally small, the nasals excessively thin, the horns elongate, set wide apart and very far back, oval in section at the top.

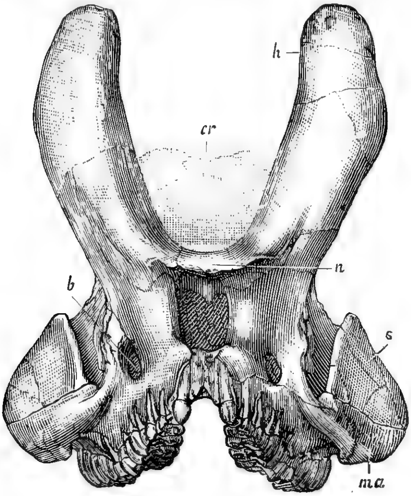

Fig. 8. *Symborodon ? montanus* (Marsh). (U. S. Nat. Mus. No. 4711, Sk. V^1.)

Phylum IV.

Titanotheres attaining the largest size, with vertex of cranium greatly elongated by extension of horns in front of orbit and of occiput behind zygomata. Skull, however, as measured along the basal line and across the zygomata progressively brachycephalic. Horns transverse oval in section from base to summit, shifting forward and progressively elongating and flattening. Nasals abbreviating. Incisors $\frac{2}{2}$. *Canines stout, blunt, obtuse. Premolars* $\frac{4-3}{4-3}$, *cingulum degenerating.*

GENUS BRONTOTHERIUM MARSH.

Syn., *Titanops* Marsh.

The type of this genus is the *Brontotherium gigas* jaw (Yale Museum), with which the type jaw of *Titanops elatus* (Yale Museum) is practically identical. The succeeding species (*B. curtum*, *B. ramosum*, *B. dolichoceras*, *B. platyceras*) of very long, flat-horned Titanotheres therefore belong to *Brontotherium.*

A discovery of great interest is a very primitive skull of the same general type, but with rudimentary horns, in the Lower Beds, to which the name *B. leidyi* may be given. A successor of this species from the Middle Beds proves to be identical with Cope's *Symborodon hypoceras*.

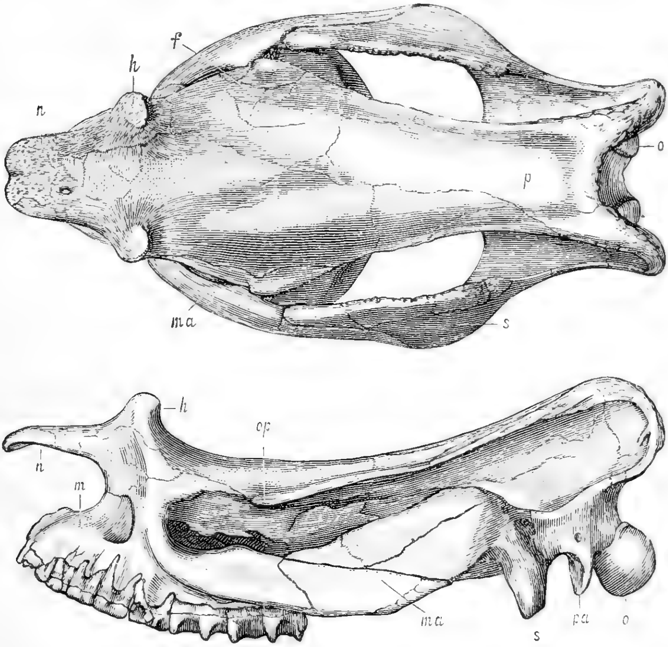

Fig. 9. *Brontotherium leidyi.* (U. S. Nat. Mus. No. 4249, Sk. R.) Type. × $\frac{1}{8}$. The side view of this skull was figured by Marsh (Amer. Jour. Sci., Oct., 1887) as *Menops varians*

LOWER BEDS.

Brontotherium leidyi, sp. nov.

Type, Skull No. 4249, U. S. Nat. Mus. Nasals elongate, narrowing anteriorly. Horns very short, slightly recurved, of transverse oval section. Canines stout and blunt. Premolars non-cingulate, with rounded contours and well-developed tetartocones. Incisors $\frac{2-1}{-}$.

This rare skull was discovered by Hatcher and is positively recorded from the Lower Beds, Middle Level. It is of exceptional importance because it is so clearly distinct from its contemporaries in the Lower Beds, namely, *Titanotherium heloceras* and *Megacerops brachycephalus.* It has numerous resemblances in the shape of the nasals, horns, canines, and back of the occiput to the great *Brontotherium* of the Upper Beds.

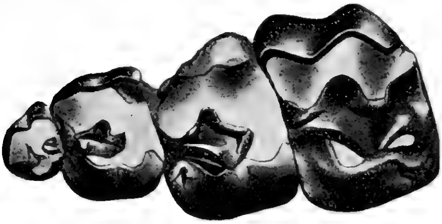

Fig. 10. *Brontotherium leidyi.* (U. S. Nat. Mus. No. 4249, Sk. R.) Type.

MIDDLE BEDS.

B. hypoceras *Cope.*—Cope's extremely fragmentary type of this species (No. 6361, Amer. Mus., Cope Coll.) is happily supplemented by two skulls found by Hatcher (Nos. 4702, 4273, U. S. Nat. Mus.), one of which is complete though crushed. These prove that this animal is undoubtedly a successor of *B. leidyi,* but separated by certain progressive characters, such as the more anterior position of the horns, and the entire loss of the median incisors.

Fig. 11. *Brontotherium hypoceras.* (U. S. Nat. Mus. No. 4273), cotype.

Specific Characters.—Horns of medium length, transverse oval section; nasals shorter than in *B. leidyi;* zygomata with flattened buccal processes; incisors reduced to $\frac{1}{-}$.

This species, although exhibiting generic resemblances, is not ancestral to *B. gigas.*

UPPER BEDS.

The following species, beginning with *B. gigas*, form a closely related progressive series which is chiefly confined to the Upper Beds. One of the most distinctive characters is the persistence of the large pair of upper incisors in all the male specimens thus far observed. Certain females apparently lack incisors. The horns are very long; the nasals gradually disappear.

B. bucco *Cope.*—In the writer's first review the type of this species was confused with the types of *Symborodon torvus*. It is actually represented by the posterior portion of a cranium in the American Museum (No. 6346). The buccal section of the zygomata is more convex than in the succeeding species.

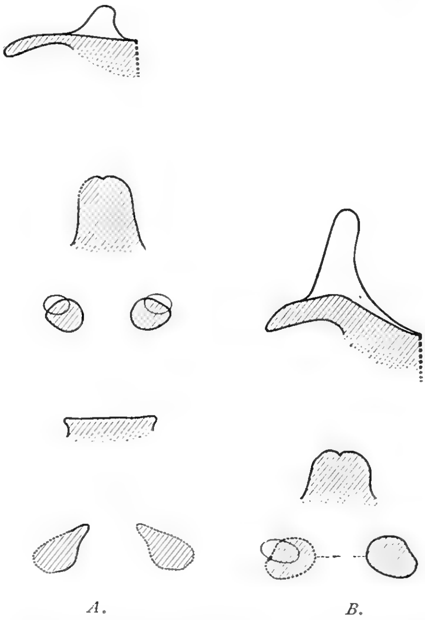

Fig. 12. Sections of nasals, horns, occiput, zygomata. *A*, *Brontotherium leidyi*, type. *B*, *Brontotherium hypoceras*, cotype.

B. gigas *Marsh.* (Syn., *Titanops elatus* Marsh).—This is now one of the best-known species, including the type in the Yale Museum, and numerous specimens in the American and National Museums previously referred to *B. elatum*.

Smaller and somewhat more primitive varieties of *B. gigas* are recorded by Hatcher from the Upper Levels of the Middle Beds.

B. dolichoceras *Scott & Osborn.* (Syn., *Titanops medius* Marsh).—Represented by types in the Harvard and National Museums. This species is intermediate in many characters between *B. gigas* and *B. curtum*.

B. curtum *Marsh.* (Syn., *Menodus peltoceras* Cope).—The type in the Yale Museum is supplemented by the female horns named by Cope *Menodus peltoceras*, also by several specimens in the American, Harvard, and National Museums.

B. ramosum *Osborn.*—There is some question whether this is really distinguishable from *B. curtum.*

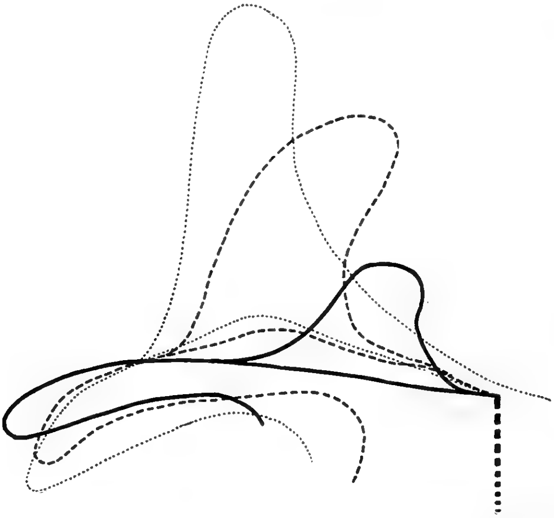

Fig. 13. Comparative fronto-nasal sections and horn contours. Showing progressive shifting forward of horns, and abbreviation of free portion of nasals. *Brontotherium leidyi*, Lower Beds. *Brontotherium hypoceras*, Middle Beds. (Nat. Mus. No. 4702.) *Brontotherium hypoceras.* (Nat. Mus. No. 4273.) The dotted vertical line shows the position of the orbit.

B. platyceras *Scott & Osborn.*—Type in the Harvard Museum.

BIBLIOGRAPHY.

1887.—Scott, W. B., and H. F. Osborn. Preliminary Account of the Fossil Mammals from the White River Formation contained in the Museum of Comparative Zoölogy. [Titanothere Contributions No. 1.] *Bull. Mus. Comp. Zoöl.*, Vol. XIII, No. 5, pp. 151–171, pll. I–II, Aug., 1887.

1893.—Hatcher, J. B. The Titanotherium Beds. *Amer. Nat.*, March 1, 1893, pp. 204–221.

1895.—Osborn, Henry F. Perissodactyls of the Lower Miocene White River Beds. [Titanothere Contributions No. 2.] *Bull. Amer. Mus. Nat. Hist.*, Vol. VII, Art. XII, pp. 343–375, pll. VIII, IX, Dec. 23, 1895.

1896.—Osborn, Henry F. The Cranial Evolution of Titanotherium. [Titanothere Contributions, No. 3.] *Bull. Amer. Mus. Nat. Hist.*, Vol. VIII, Art. IX, pp. 157–197, July 31, 1896.

1900.—Osborn, Henry F. Phylogeny of the Rhinoceroses of Europe. *Bull. Amer. Mus. Nat. Hist.*, Vol. XIII, Art. XIX, pp. 229–267, Dec. 11, 1900.

1902.—Osborn, Henry F. Dolichocephaly and Brachycephaly in the Lower Mammals. *Bull. Amer. Mus. Nat. Hist.*, Vol. XVI, Art. VII, pp. 77–89.

A Skull of Dinocyon from the Miocene of Texas.

By W. D. Matthew.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XVI, Article XI, pp. 129–136.

New York, April 7, 1902.

The Knickerbocker Press, New York

Article XI. — A SKULL OF DINOCYON FROM THE MIOCENE OF TEXAS.

By W. D. Matthew.

Among the valuable specimens brought back by Mr. J. W. Gidley from his collecting trip for the American Museum last summer, were the skull and part of the skeleton of an enormous carnivore which on extraction from its matrix proves to be a Canid of the Amphicyonine group. It appears to be a very aberrant species of *Dinocyon*, a genus hitherto known by teeth and fragments of the jaw of *D. thenardi* described by Jourdan in 1862[1] from the Upper Miocene beds of Grive St.-Alban.

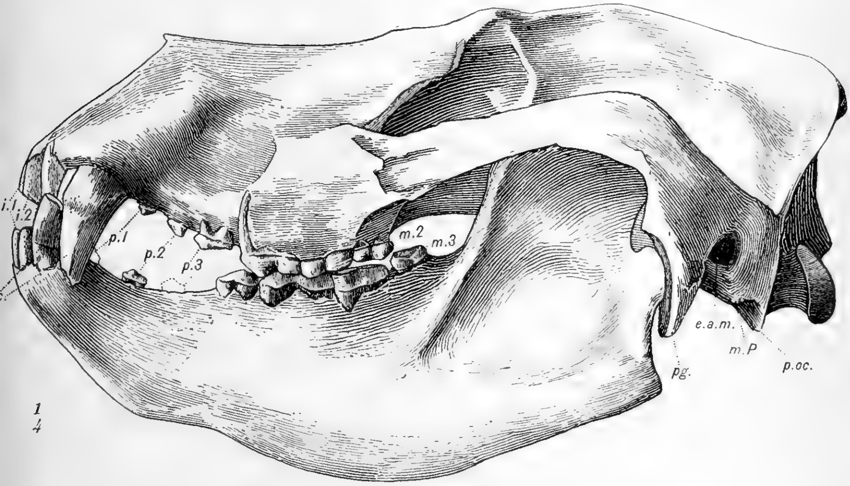

Fig. 1. Side View of Skull × ¼.

This specimen is more complete than any Amphicyonine hitherto described, not only in this country, but in Europe, where Amphicyons have long been known. The skull and

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[1] Comptes Rendus de l'Institut, LIII; Bull. des Sociétés savantes (1862). Another species, *Amphicyon göriachensis* Toula, is referred to this genus by Prof. Deperet. Dr. Schlosser prefers to place it with *Hemicyon*, probably identical with *H. sansaniensis* Lartet. It would seem to be an intermediate form, like *Dinocyon* in the carnassial, like *Hemicyon* in the tuberculars.

jaws are complete although crushed, and the first eight vertebræ are in place. The succeeding nine vertebræ and parts of the hind limb were found close by. All were enveloped in hard flinty concretion, which has been removed from one side only of the specimen. The horizon is the Loup Fork terrane, which, in the part of Texas in which this specimen was found, contains a fauna approximately Upper Miocene in age so far as comparisons have been instituted.

It is only within the past two years that true Amphicyons have been recognized in this country, the species referred to that genus by Leidy and Cope being, as Prof. Scott has shown,[1] much more primitive, and nearly or quite in the line of descent of the modern Canidæ, while the true Amphicyons are an aberrant branch of dogs, related to the Ursidæ, but not directly ancestral to them, according to Dr. Schlosser's recent studies on the group.[2] In the 'American Journal of Science' for January, 1901, however, Dr. Wortman has described a true *Amphicyon* from the Loup Fork beds of Nebraska. Mr. Earl Douglas has recognized the genus in the same terrane in Montana. The American Museum Expeditions of 1901 obtained remains of Amphicyons both in the older Loup Fork of Colorado (Middle Miocene) and the newer Loup Fork of Texas (Upper Miocene). To this group may also be referred three species of Canidæ described some time since, but whose position has not been recognized. These are:

Canis (*Ælurodon*) *ursinus* Cope,[3] from the Loup Fork of New Mexico.

Borophagus diversidens Cope,[4] from the Blanco of Texas.

Ælurodon mæandrinus Hatcher,[5] from the Loup Fork of Kansas.

The specimen here described represents a species distinct from any of those above mentioned, and is named in honor

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[1] Notes on the Canidæ of the White River Oligocene, Trans. Amer. Phil. Soc., Vol. XIX, 1898, p. 326 *et seq.*

[2] Ueber die Bären und bärenähnlichen Formen des europäischen Tertiärs. Palæontographica, Bd. XLVI, 1899, p. 95 *et seq.*

[3] Proc. Acad. Nat. Sci. Phila., 1875, p. 256; Rep. Wheeler Survey, 1877, p. 304, pl. lxix, fig. 1.

[4] American Naturalist, 1892, p. 1028; Rep. Tex. Geol. Sur., 1892, p. 52, pl. xiii, fig. 4.

[5] American Naturalist, 1894, p. 239 and fig.

of Mr. J. W. Gidley, the discoverer of many of the choicest specimens of fossil mammals in the collections of the American Museum and of Princeton University.

Dinocyon (? Borophagus) gidleyi, sp. nov.

Generic and Subfamily Characters. — Dentition, $\frac{3.1.4.2}{2.1.?\,4.3}$. Premolars much reduced, without posterior accessory cusps, one or two of the inferior series perhaps absent. Carnassials small and low with reduced shear, tubercular teeth very large with low cusps. Jaw very deep and massive, facial part of skull elongated, sagittal and occipital crests high, brain-case small. Bullæ inflated, but smaller than in typical Canidæ, mastoid process small, paroccipital process moderately long, coössified with the bulla. (In the bears the mastoid process is much enlarged, the paroccipital reduced, and the tympanic bulla not inflated.)

Subgeneric Characters.—Teeth like those of *Amphicyon* in form, especially such species as *A. americanus* Wortman. Upper molars much wider transversely, and the first more trigonal in outline than in *Dinocyon thenardi.*

Specific Characters.—Size somewhat greater than in *D. thenardi* or *D.* ("*Aelurodon*") *mæandrinus*, premolars more reduced and premolar region of the jaw longer than in the latter species or in *Borophagus diversidens.*

It is difficult to place this fine species in any of the described genera. In form and character the carnassials and molars (Fig. 2) are like those of *Amphicyon.* But the third upper molar, a well developed tooth in *Amphicyon*, is absent from either side of the Texas skull, as it is in *Dinocyon* and *Hemicyon*, and probably in *Pseudamphicyon.*[1] The size is near that of *D. thenardi*, with which the proportions of the lower teeth, so far as they can be seen, agree fairly well. But the first and to some extent the second upper molars, are trigonal and much extended transversely, while in *Dinocyon*, and still more in *Hemicyon*,

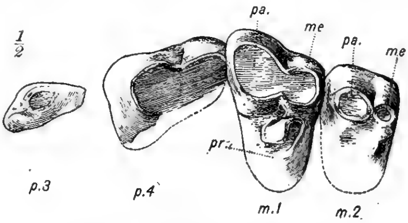

Fig. 2. Crown View of Teeth × $\frac{1}{2}$.

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[1] Schlosser, *l. c.*

these teeth approach the round quadrate shape characteristic of *Hyænarctos*. *D. gidleyi* may be considered as an aberrant member of the genus *Dinocyon*, but its relationship to the type species is perhaps rather formal than real.[1]

The skull (Fig. 1) is the most complete one yet described of an Amphicyonine dog. Professor Filhol[2] has described and figured a skull of *A. lemanensis*, but it was by no means complete. The Texas skull, although crushed, is quite complete, and the parts of the skeleton preserved enable us to determine the proportions and general character of this great carnivore.

The size of the skull equals or exceeds that of any living carnivore of which I can find record. It is longer, wider, and deeper than the largest *Ursus maritimus* skull in our collection, and its measurements slightly exceed those given for the Kadiak bear in length and depth (including the jaw). The crushing of the skull prevents any exact comparison in width; but the Kadiak skull is probably much wider than was that of *D. gidleyi*.

The most striking characters of the skull are the size and depth of the jaw, and the heavy zygomatic arches. The nasal openings are large and cavernous, as in the polar bear, unlike the smaller and more slender muzzle of the lesser bears and of the dogs. The inferior postorbital process is hardly as prominent as in the wolf, much less than in any of the bears. The tympanic bullæ are inflated, although of proportionately smaller size than in the wolf. The teeth are larger in proportion to the size of the skull than in the bears, especially the molars, which exceed those of *U. maritimus* in length and are more than twice as wide. The cranium bears a high crest, as in *Amphicyon*, giving attachment for the powerful jaw-muscles; and the brain is decidedly smaller than in the modern Ursidæ. Compared with *Amphicyon*

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[1] Should further study of the American Amphicyons render it advisable to remove *D. gidleyi* and the probably nearly allied *D. mæandrinus* to a different genus, Cope's name *Borophagus* may perhaps be used. But as the type of *Borophagus* is from the Blanco beds it would be desirable to know more than we do at present about the Blanco Amphicyons before making any such change. All that can be said at present is that there were two or more species of the group in this horizon, of unknown dental formula.

[2] Arch. Mus. Lyons, III, 1883, pl. i, figs. 3–5.

lemanensis of the Upper Oligocene, the premolars are more reduced, the muzzle larger, the sagittal crest not so high, and the brain-case fully as large in proportion (although, as the skull is so much larger, one would expect to see a proportionately smaller brain-case). The arches are heavier and the jaw much deeper. In the outline sketch of the skull (Fig. 3) the crushing of the specimen has been corrected, as nearly as could be estimated.

The cervical vertebræ are of the size of those of the polar bear, but differ rather widely from both bears and modern Canidæ, suggesting some of the more primitive Canidæ, such as *Daphænus*. The *atlas* is not very perfectly preserved, and does not show any very significant characters. The *axis* is not unlike that of the bears, the spine ending posteriorly in a short heavy process directed equally upward and backward. The anterior prolongation of the spine as a thin high lamina, carried far forward in the dogs and still further in the cats, is much reduced, as it is in the Ursidæ. The hæmal surface of the centrum bears a strong median ridge. The remaining *cervicals* bear spines of much greater height than in *Canis* or *Ursus*, and of quite different form; they are flat, slender at

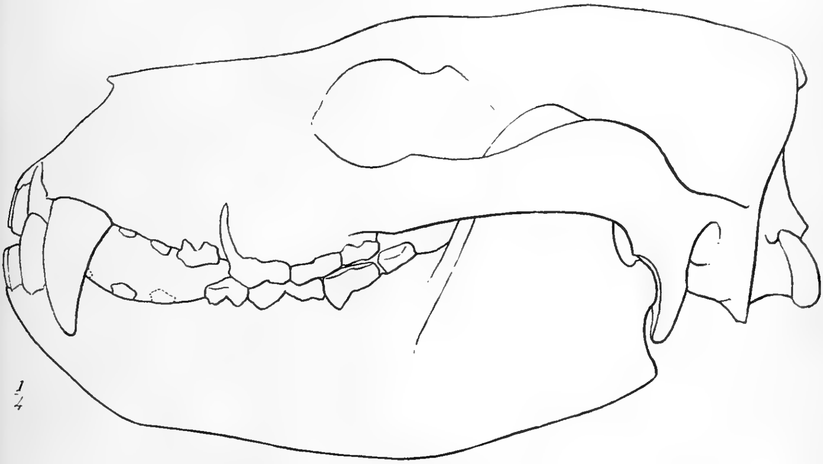

Fig. 3. Outlines of skull restored × ¼.

the base, and carry a nearly uniform width to the tip, where they are slightly enlarged. This form of spine in the cervicals, resembling the usual form of a dorsal spine, is seen to a less extent in *Daphœnus*, but not in any of the large modern carnivora, among which the bears offer the nearest approach. The zygapophyses are considerably smaller than in *U. maritimus;* the transverse processes are as long, but quite slender,—their inferior lamellæ quite well developed on the one or two vertebræ in which they have not been broken off.

The centra of probably the first nine *dorsals* are preserved, of which the first was found in position. They are somewhat narrower and a little longer than in *U. maritimus;* the first three are strongly keeled, the others are round inferiorly, as in the bear. No part of the arches or spines is preserved.

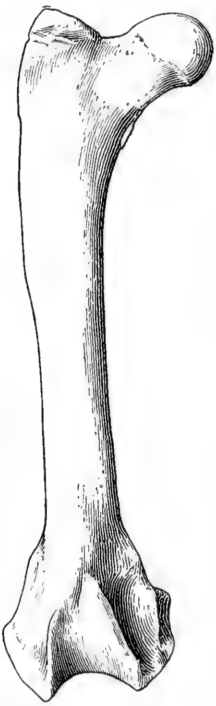

Fig. 4. Femur × ¼.

The *femur* (Fig. 4) is smaller than that of *U. maritimus*, and resembles much more that of the wolf in its characters. The ball faces more laterally than in the bears, and is well to one side of the axis of the shaft; the shaft is somewhat curved, less so than in *Canis*, much more than in *Ursus;* the condyles project more posteriorly, the trochlea is narrow and deep, as in the wolf, not broad and shallow as in the bear. The lesser trochanter appears to be less prominent than in either *Canis* or *Ursus;* the greater trochanter projects to a level with the top of the ball, and is considerably more prominent than in *Ursus*.

The upper end of the tibia is preserved, but considerably crushed. It appears to have the high cnemial crest and narrow proximal facets of the dog, not the lower crest and broad facets of the bear.

Nothing is preserved of the feet, an unfortunate defect, for the best generic distinction between *Dinocyon* and *Hemicyon* lies in the foot characters, the former genus being plantigrade with short metapodials like the bears, the latter digitigrade with long metapodials like the dogs.[1] If indeed the closer resemblance to the Canidæ which we find in the femur and tibia of *D. gidleyi* is equally marked in the distal parts of the limbs, then our species is not related to *Dinocyon*, but must be placed in a distinct genus allied to *Hemicyon*.

Measurements.	D. gidleyi.	D. thenardi.	A. lemanensis.	U. maritimus.	D. mæandrinus Type spm.	D. mæandrinus Texas spm.
Length of skull, incisors to occipital crest	450		323	397		
Length of upper dentition ($i^{\underline{2}}$–$m^{\underline{2}}$ in *Dinocyon* and *Ursus*)	204		144	147		
Length of upper $p^{\underline{4}}$–$m^{\underline{2}}$	79		52	64		
“ “ “ $p^{\underline{4}}$ longit	34		17	16		
“ “ “ $m^{\underline{1}}$ “	26	33	15	19		
“ “ “ $m^{\underline{2}}$ “	21	29	13	27		
Width “ “ $m^{\underline{2}}$ transverse....est.	32	33	18	15		
“ “ “ $m^{\underline{1}}$ “ ....est.	40	34	19	13		
“ “ “ $p^{\underline{4}}$ “	22		12	8		
Length of jaw	363			252		
Depth “ “ beneath $p_{\overline{4}}$	82			50	55	69
“ “ “ “ $m_{\overline{2}}$	103			50		
Post-canine diastema ($c_{\overline{1}}$–$p_{\overline{4}}$ exclusive)						
Length $p_{\overline{4}}$–$m^{\underline{3}}$	101			76		
“ $m_{\overline{1}}$	40	45		25	47	47
“ $m_{\overline{2}}$	31	32		21		24
“ $m_{\overline{3}}$	17	19		17		
Width of skull (as crushed)	270		180	197		
Length of seven cervical vertebræ	347			330		
Width of centra of same, average	44			46		
Length of ten dorsal vertebræ	398			345		
Average width of centra	39			40		
Length of femur	391			438		
Least diameter of shaft	32			34		
Diameter of distal end	87			98		
“ “ ball	46			56		

Although more specialized than *Amphicyon*, *D. gidleyi* is apparently not nearer to the bears; the characters of the

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[1] Filhol, Mammifères fossiles de Sansan, p. 151.

femur are considerably less bear-like than in *A. major*, judging from Filhol's description and figures;[1] the vertebræ are bear-like in many respects, but quite peculiar in the length and form of the spines. The skull and teeth suggest an independent specialization, parallelling that of the bears in a few characters, but in most respects peculiar. A further discussion of its relationship is reserved for a later paper.

The animal must have been of peculiar appearance, not greatly resembling either bears or dogs. The enormous head was carried very low (if this is the correct interpretation of the high cervical spines), more so than in the bears, much more than in the wolves; the muzzle was long and heavy; the contour of the head was straight, and continuous with the neck; the ears of moderate size, jaw very long and deep, wide gaping, cheeks rather wide. The neck was as massive as in *U. maritimus*, the trunk longer and slimmer, the legs shorter, sharply flexed at the knees, the thigh not as free from the trunk as in Ursidæ, but much more like the condition seen in the Canidæ.

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[1] Mammifères fossiles de St. Gerand le Puy.

On the Skull of Bunælurus, a Musteline from the White River Oligocene.

By W. D. Matthew.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XVI, Article XII, pp. 137-140.
New York, April 7, 1902.

The Knickerbocker Press, New York

Article XII. — ON THE SKULL OF BUNÆLURUS, A MUSTELINE FROM THE WHITE RIVER OLIGOCENE.

By W. D. Matthew.

Bunælurus was described by Prof. Cope in 1873[1] from fragments of the lower jaw, which until now have remained the only representation of the genus. Cope referred it to a position in the Mustelidæ near *Putorius* and *Plesiogale;* Dr. Schlosser in his later revision of the European carnivora[2] considered it close to or identical with *Palæogale* (in which he includes part of *Plesiogale*). Dr. Wortman has recently suggested[3] that it might not improbably prove to be a direct descendant of certain of the Viverravidæ.

A finely preserved skull found by Mr. Thomson of the American Museum Expedition of 1901, in the Upper Oreodon beds of East Pawnee Butte, Northeastern Colorado, is the subject of the present description. No lower jaw is with it, so that it cannot be positively identified. But the close correspondence in point of size with *B. lagophagus*, the type of which is from the same horizon and region, and the correspondence of the teeth of our skull with the upper teeth of the more carnassial section of the Mustelinæ and of the teeth of *Bunælurus* with the lower teeth of the same group,

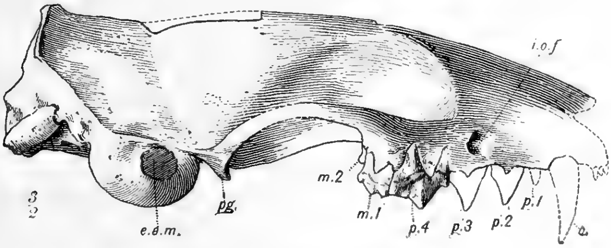

Fig. 1. Side View of Skull.

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[1] Synopsis New Vert. Col., p. 8; Ann. Rep. Hayd. Sur., 1873 (1874), 507; Tert. Vert., p. 946, pl. lxvii a, figs. 13, 14.

[2] Affen Lemuren, u. s. w. d. Europ. Tertiärs, p. 386.

[3] Amer. Jour. Science, 1901, Vol. XII, p. 145, footnote.

make the identification reasonably safe. No other Musteline is known from the White River.

The characters of the skull confirm the views expressed by Cope and Schlosser as to the position of the genus. It is *Palæogale* with a minute second molar still retained. It belongs to the primitive division of the Mustelinæ, with triangular first molar, no posterior flange on the protocone. The carnassial is primitive in character, somewhat resembling that of *Cynodictis gregarius*, the protocone very large, the shear more oblique than in modern Mustelinæ, less so than in *Cynodictis*, the fissure between protocone and postero-external blade still quite well marked. There is a small antero-internal basal cusp and a less marked antero-external one. The second and third premolars are of moderate size without trittocones, much higher than in *Mustela*, higher and proportionately larger than in *Putorius*. The first premolar is a single-rooted tooth of small size; first and second premolars are spaced. Alveoli of canines, of moderate size, are preserved.

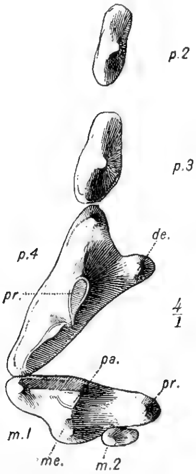

Fig. 2. Crown View of Teeth.

The bullæ are of primitive character, inflated, short and prominent, instead of flattened and elongated as in *Mustela* and *Putorius*. The palate extends backward only to opposite the anterior edge of the first molar, while in modern Mustelines it extends considerably behind the teeth. The shorter bullæ leave a much larger surface of the sphenoids and occipitals exposed; the short stout paroccipital process is entirely free of the bulla. The occipital and sagittal crests have the same outlines as in *Putorius ermineus*, but the posterior lobes of the brain are separated from the cerebral lobes by a strongly marked depression; the arches are much heavier, muzzle much longer, resembling that of *Mustela* more nearly, but flatter, longer, more slender toward the tip; infraorbital foramen smaller, postorbital process of the frontal less prominent.

Postorbital constriction much more narrow than in *M. americana*, somewhat more than in *P. ermineus*. Size slightly greater than the weasel.

Bunælurus is one of the primitive group of Mustelinæ found chiefly in the Oligocene of Europe. It belongs to the Putoriine section, which more nearly approaches the Felidæ (through *Proailurus*) in dental reduction (the typical Musteline section more nearly approaching *Cynodictis* and the Viverridæ), but shows little indication of the shortening of the face characteristic of modern *Putorius*.

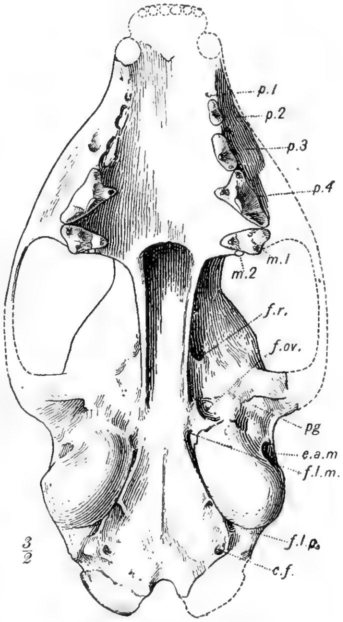

Fig. 3. Inferior View of Skull.

Following are the more important primitive characters:

1. Dentition less reduced, four premolars and two molars in upper jaw.
2. Fourth premolar more triangular, shear more transverse, notch behind protocone deeper.
3. First molar more viverrine in shape, protocone not expanded transversely, para- and metacones more distinct.
4. Second molar present although minute.
5. Posterior nares not roofed over behind m^1.
6. Bullæ short, round, and prominent, instead of long and flattened.
7. Paroccipital process free.
8. Cerebrum small and not extending over cerebellum, transverse sulcus strongly marked on external surface of skull by a wide depression.
9. Postorbital processes very rudimentary, postorbital constriction narrow.
10. Infraorbital foramen small.

The skull is identified with *Bunælurus* upon the following evidence: *Bunælurus* appears to belong to the more carnassial section of the Mustelinæ, typified among modern genera by *Putorius*, among ancient ones by *Palæogale*, rather than to the section with more tubercular teeth, typified among modern genera by *Mustela*, among ancient ones by *Plesictis*, *Stenoplesictis*, etc. The latter group retains the metaconid on $\mathrm{m}^{\underline{1}}$, and correspondingly the paraconule on $\mathrm{m}^{\underline{1}}$. The former group has no metaconid on the lower carnassial, and on the upper tubercular there is no trace of conules, and the protocone is smaller in proportion. The primitive members of this Putoriine group are hardly distinguishable from primitive felines; *Proailurus*, considered by most writers as a Felid, is placed by Dr. Schlosser (advisedly as it seems to the present writer) among the Mustelids of this group. *Bunælurus* presumably belongs to the primitive division of the Putoriine group.

The White River skull under discussion belongs unquestionably to the Putoriine group, and with the primitive members thereof. It has the strongly transverse tubercular, with reduced protocone and no paraconule. The upper teeth correspond in size and in proportions with the lower teeth on which *Bunælurus* is based. These were found in the same formation and horizon as the skull, at a locality about fifty miles further to the eastward.

American Eocene Primates, and the Supposed Rodent Family Mixodectidæ.

By Henry Fairfield Osborn.

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The Knickerbocker Press, New York

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.

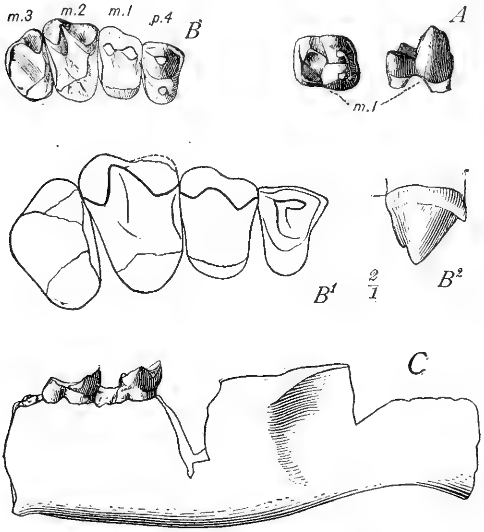

Fig. 1. *A*, *Mioclænus acolytus*. Amer. Mus. No. 829*a*. Lower molar. *B*, supposed Primate. Am. Mus. No. 823. *B*, superior molars, enlarged 2 diam., B^1, contour of same still more enlarged. *C*, lower jaw of same specimen, 2 diam. Compare Fig. 2. Twice natural size.

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.

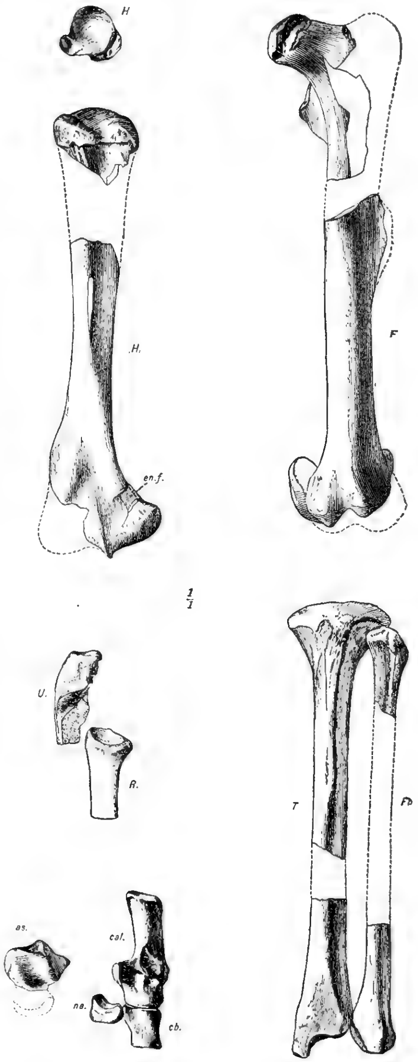

Fig. 2. Supposed Primate. Am. Mus. No. 823. Fore and hind limb bones and tarsals. All natural size. Compare Fig. 1.

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. = *Leptochœrus 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. = *Leptochœrus 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) *Microsyops 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 crassiusculus* 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 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.

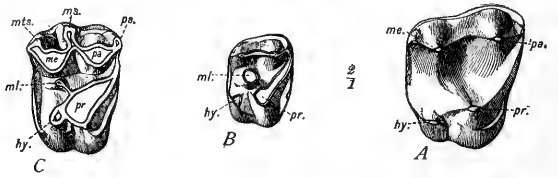

Fig. 3. Superior molars. *A*, *Adapis magnus*; *B*, *Hyopsodus uintensis*, type; *C*, *Notharctus* sp.

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.

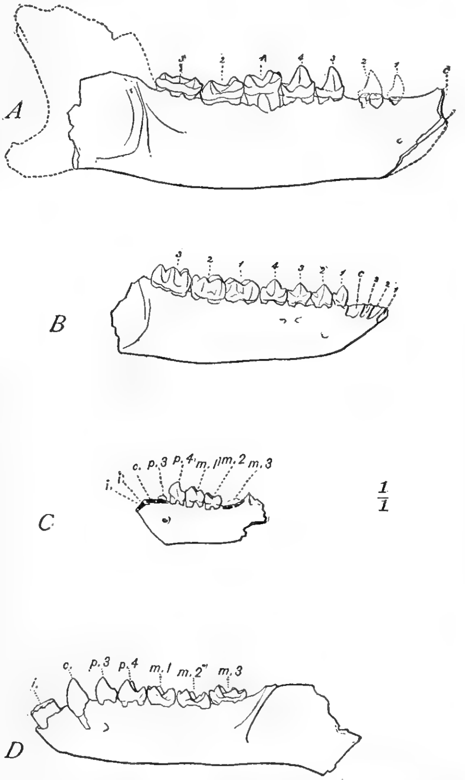

Fig. 4. Jaw outlines. All natural size. *A*, *Pelycodus tutus*; *B*, *Hyopsodus paulus*; *C*, *Anaptomorphus æmulus*; *D*, *Microsyops*.

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[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.	2. *Notharctidæ* Osborn.	3. *Anaptomorphidæ* Cope.
i. $\frac{3}{3}$, c. $\frac{1}{1}$, p. $\frac{4}{4}$, m. $\frac{3}{3}=44$.	i. ? $\frac{3-2}{3-2}$, c. $\frac{1}{1}$, p. $\frac{4}{4}$, m. $\frac{3}{3}=40$;	i. $\frac{}{2}$, c. $\frac{1}{1}$, p. $\frac{2}{3-2}$, m. $\frac{3}{3}=36-32$.
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.	Dolichocephalic. Premolars persistent. Superior molars triangular to quadrate, tritubercular, progressively sexitubercular. Inferior molars with depressed, crenulate talonid.	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	"

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[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 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

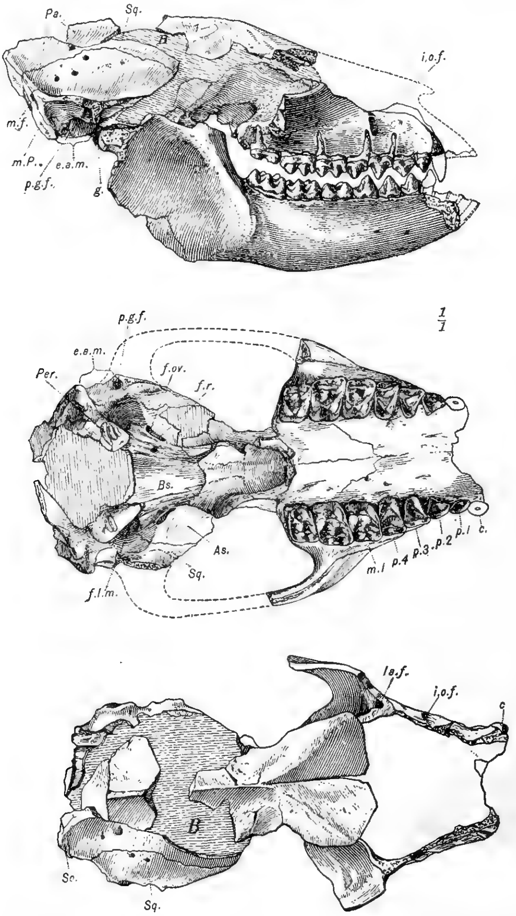

Fig. 5. *Hyopsodus paulus*. Am. Mus. No. 2301. Lateral, palatal, and superior views of skull. See page 186. Natural size.

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).

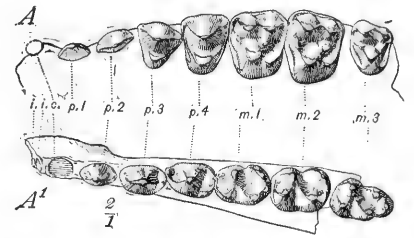

Fig. 6. *Hyopsodus ? miticulus.* Am. Mus. Cope, No. 4128. Twice natural size.

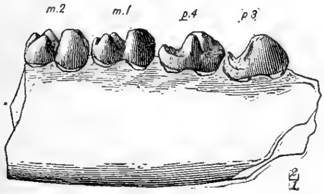

Fig. 7. *Hyopsodus lemoinianus.* Type: Am. Mus. Cope, No. 4139. Left ramus, internal view. Twice natural size.

(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 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.

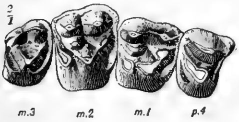

Fig. 8. *Hyopsodus lemoinianus.* Am. Mus. No. 4100. Twice natural size.

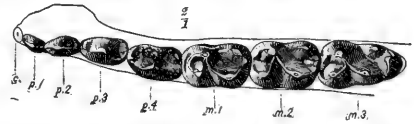

Fig. 7*a*. *Hyopsodus lemoinianus.* Am. Mus. No. 1. Twice natural size.

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

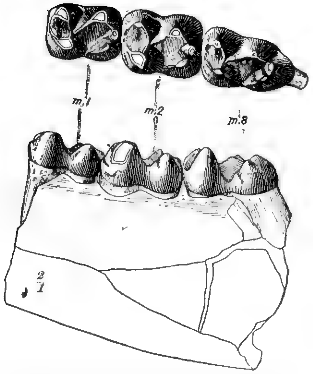

Fig. 9. *Hyopsodus powellianus.* Am. Mus. No. 4147. Slightly less than twice natural size.

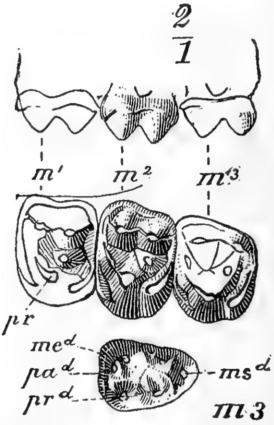

Fig. 10. *Diacodexis laticuneus.* Type. Am. Mus. No. 4202. Twice natural size.

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.

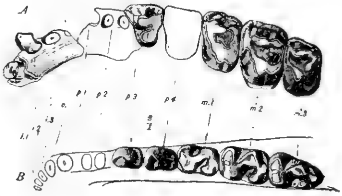

Fig. 11. *Hyopsodus wortmani.* Type. Am. Mus. Cope, No. 4716. Superior and inferior teeth. Twice natural size.

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.

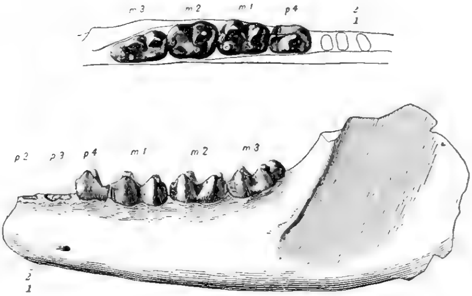

Fig. 12. *Hyopsodus? vicarius.* Am. Mus. No. 1730. Slightly less than twice natural size.

(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.

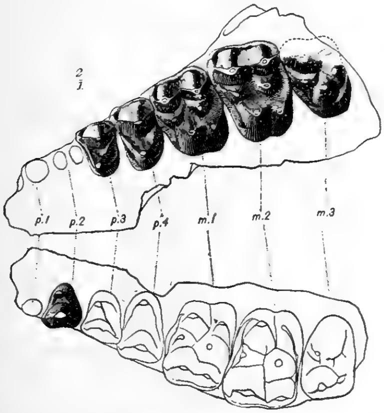

Fig. 13. *Hyopsodus marshi.* Am. Mus. No. 1706*a*. Slightly less than twice natural size. Dental series too convergent in figure.

(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.

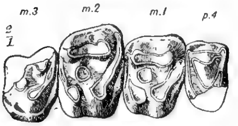

Fig. 14. *Hyopsodus uintensis.* Am. Mus. No. 2079. Twice natural size. Type.

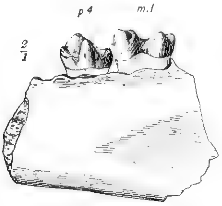

Fig. 15. *Hyopsodus uintensis.* Am. Mus. No. 2078*a*. Twice natural size.

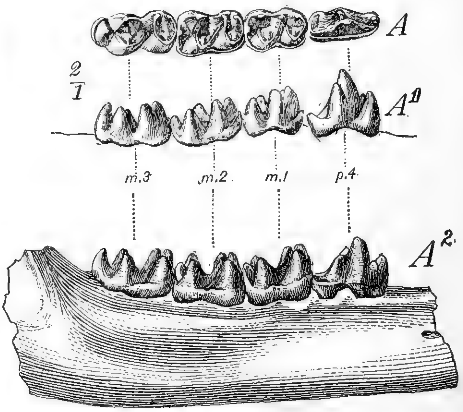

Fig. 16. *Sarcolemur furcatus.* Type. Am. Mus. Cope, No. 5008. *A*, superior, A^1, internal, A^2, external views of teeth and jaw. Twice natural size.

(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.*

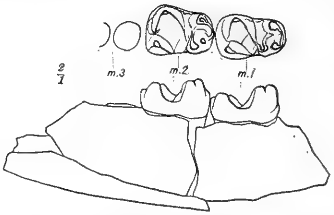

Fig. 17. *Sarcolemur pygmæus.* Co-type. Am. Mus. No. 5007. Left ramus, internal and superior views. Twice natural size.

(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.

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*.

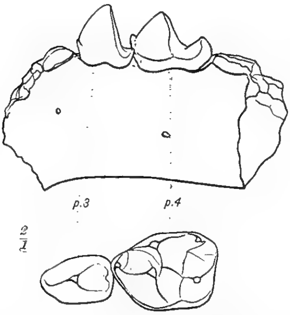

Fig. 18. *Sinopa* (*Prosinopa*) *eximia*. Type. Phila. Acad. Twice natural size.

To be compared with this family are the small animals, *Omomys carteri*, Leidy (?i. $\frac{\ }{2}$, c. $\frac{\ }{1}$, p. $\frac{3}{\ }$); and *Hemiacodon gracilis* Marsh ($\frac{\ }{2}$, $\frac{\ }{1}$, $\frac{\ }{3}$, $\frac{\ }{3}$.), 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*.

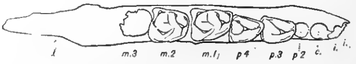

Fig. 19. *Omomys carteri*. Type. Superior view of right ramus, traced from a photograph. Twice natural size.

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.	NOTHARCTUS.
Jaw elongate. Mandibular symphysis uncoössified. Superior molars triangular with rudimentary hypocone; no mesostyle.	Jaw stout. Symphysis typically coössified. Superior molars quadrate, with pronounced hypocone; a mesostyle.

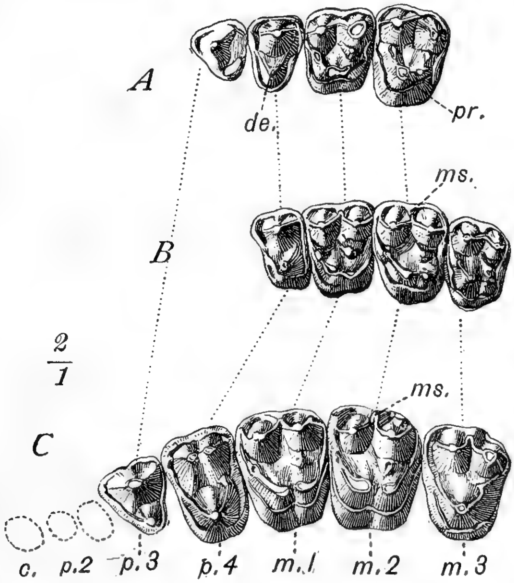

Fig. 20. Evolution of molars in Notharctidæ. *A*, *Pelycodus frugivorus*, Wasatch; *B*, *Notharctus nunienus*, Wasatch; *C*, *Notharctus* sp. indet. Bridger.

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.

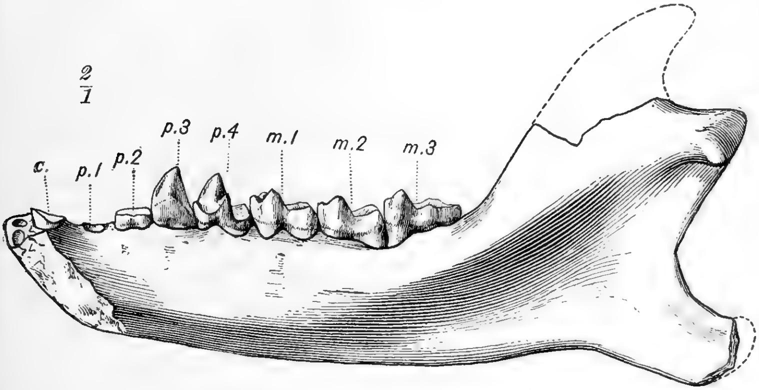

Fig. 21. *Pelycodus frugivorus.* Am. Mus. No. 65. Slightly less than 2 diam.

(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.

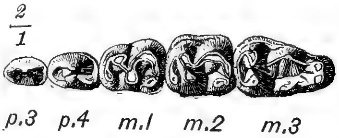

Fig. 22. *Pelycodus nunienus.* Type. Am. Mus. Cope, No. 4734.

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.

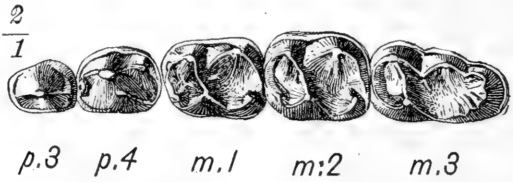

Fig. 23. *Notharctus* sp. indet. Princeton Mus. No. 10,020.

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.

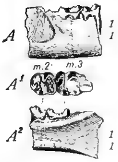

Fig. 23*a*. *Washakius insignis.* Type. Phila. Acad. External, superior, and internal views.

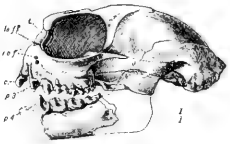

Fig. 24. *Anaptomorphus homunculus.* Type. Am. Mus. Cope. Skull, No. 4194; partly reconstructed from the two sides. Jaw from another specimen, Am. Mus. No. 43. Natural size.

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.

I. WASATCH (SPARNACIEN, YPRÉSIEN) STAGE.

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

Definition.—i. $\frac{?}{?}$, 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.

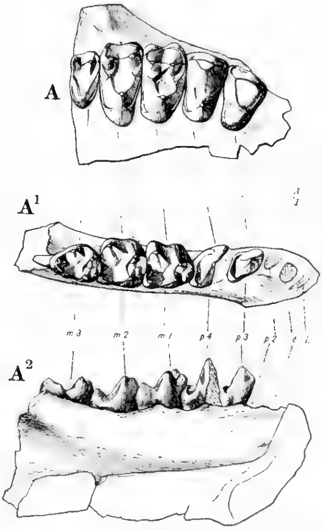

Fig. 25. *Anaptomorphus homunculus.* Am. Mus. No. 41. This specimen has unfortunately been misplaced.

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.

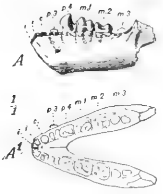

Fig. 26. *Anaptomorphus æmulus.* Type. Am. Mus. Cope, No. 5010. *A*, from side; *A*¹, reconstructed from above.

(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. $_{\overline{2}}$, C. $_{\overline{1}}$, P. $_{\overline{2}}$, M. $_{\overline{3}}$; paraconid especially on $m_{\overline{2}}$ is also slightly more reduced, while the deuteroconid on $p_{\overline{4}}$ 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.

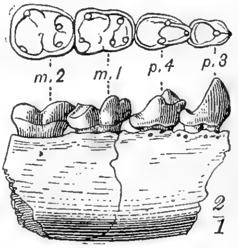

Fig. 27. "*Microsyops*" *uintensis.* Type. Am. Mus. No. 1899.

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

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[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.

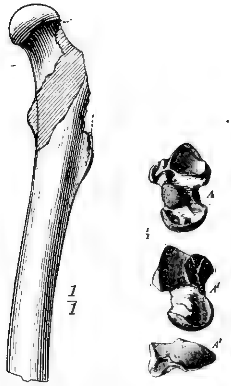

Fig. 28. *Mixodectes pungens.* Am. Mus. No. 2451. Left femur. Natural size. Astragalus, *A*, posterior; *A*¹, anterior; *A*², inferior or distal aspect. Natural size.

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

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

WASATCH.

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

WIND RIVER AND BRIDGER.

Microsyops.—$\overline{1}, \overline{1}, \overline{2}, \overline{3}$. 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.

I. TORREJON (THANÉTIEN) BASAL EOCENE.

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

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

Dentition.—$\overline{3}, \overline{1}, \overline{2}, \overline{3}$. 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. 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*.

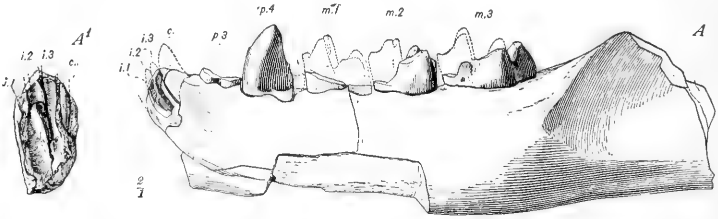

Fig. 29. *Olbodotes copei.* Type. Am. Mus. No. 2385. *A*, lateral view, *A*¹, anterior view, of left ramus.

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

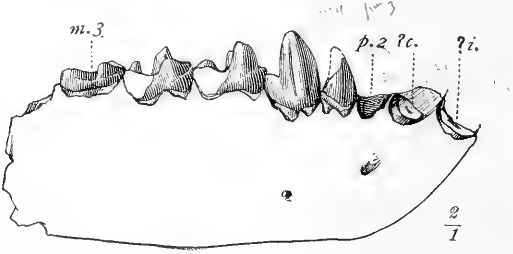

Fig. 30. *Mixodectes pungens.* Type. Am. Mus. Cope, No. 3081.

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

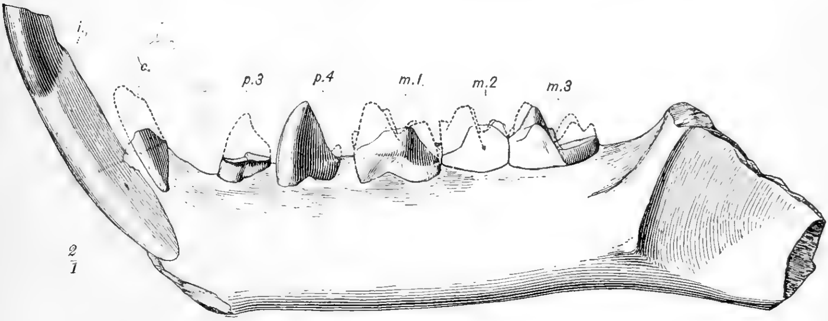

Fig. 31. *Mixodectes pungens.* Am. Mus. No. 2557*b*. Left lower jaw. Median incisor partly displaced.

(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.

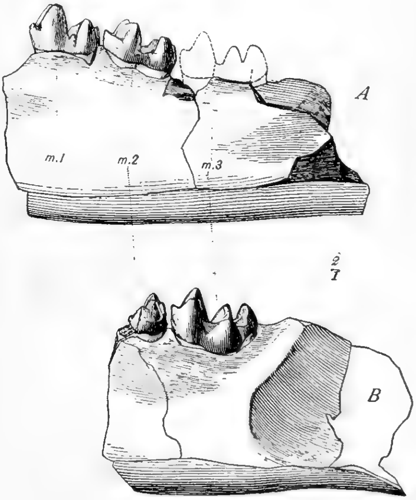

Fig. 32. *Mixodectes crassiusculus.* Am. Mus. Cope, No. 3087. Parts of right and left rami.

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*.

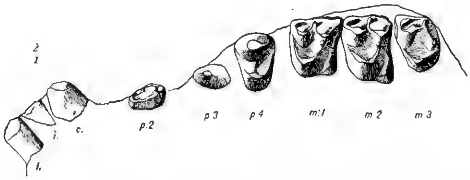

Fig. 33. *Indrodon malaris.* Type. Am. Mus. Cope, No. 3080. Left maxilla.

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.

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).

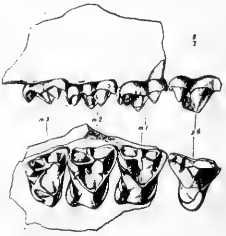

Fig. 34. *Indrodon* sp. Am. Mus. No. 833. Fourth premolar transposed from left side.

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. 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.

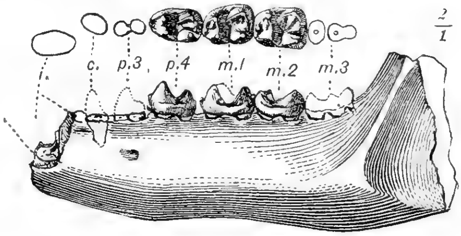

Fig. 35. *Cynodontomys latidens.* Type. Cope Coll. No. 4195 Wasatch. Big Horn Valley, Wyoming. Twice natural size.

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: $\overline{1}, \overline{1}, \overline{2}, \overline{3}$.

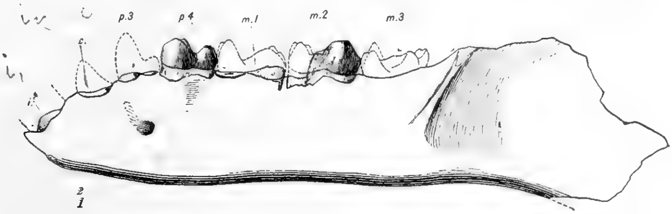

Fig. 36. *Microsyops scottianus.* Am. Mus. No. 4748. Slightly less than 2 diam.

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).

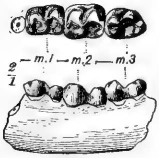

Fig. 37. "*Microsyops*" *speirianus.* Type. Am. Mus. Cope, No. 4190. Portion of right ramus.

(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.

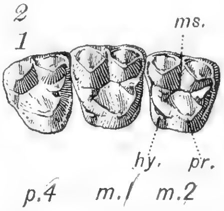

Fig. 38. *Microsyops*. Princ. Mus. Superior molars, isolated.

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

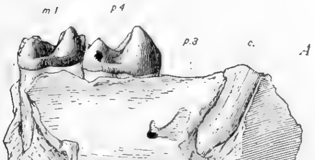

Fig. 39. *Microsyops*. Am. Mus. No. 1732. *A*, external, *A*¹, internal aspect of right ramus.

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

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[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 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.

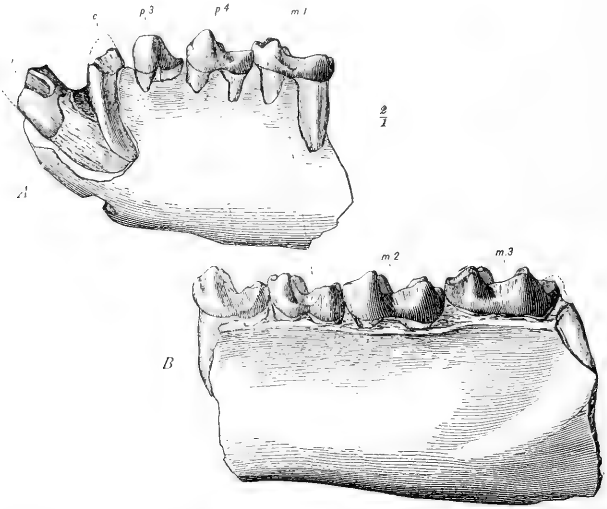

Fig. 40. *Microsyops ? annectens.* Princ. Mus. Portions of rami of two individuals. Lower figure slightly exceeding 2 diam.

(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.

BIBLIOGRAPHY.

(The references to the descriptions of the types will be found in the table, pp. 172–175.)

1884. Cope, E. D. Tertiary Vertebrata. 4to. Washington, 1884.

1897. Earle, Charles. On the Affinities of Tarsius: A Contribution to the Phylogeny of the Primates. *American Naturalist*, Vol. XXXI, No. 367, July, 1897, pp. 569–575; *ibid.*, August, 1897, pp. 680–689.

1896. Leche, W. Untersuchungen ueber das Zahnsystem lebender und fossiler Halbaffen. *Festschrift für Carl Gegenbaur*, pp. 128–166, Leipzig, 1896.

1901. Major, C. I. Forsyth. On Some Characters of the Skull in the Lemurs and Monkeys. *Proc. Zoöl. Soc. London*, Feb. 19, 1900, pp. 129–153, pll. xi–xiii.

1897. Matthew, W. D. A Revision of the Puerco Fauna. *Bull. Amer. Mus. Nat. Hist.*, Vol. IX, Art. xxii, Nov. 16, 1897, pp. 259–323.

1895. Osborn, Henry F., and Charles Earle. Fossil Mammals of the Puerco Beds. Collection of 1892. *Bull. Amer. Mus. Nat. Hist.*, Vol. VII, Art. i, March 8, 1895, pp. 1–70.

1892. Osborn, Henry F., and J. L. Wortman. Fossil Mammals of the Wasatch and Wind River Beds. Collection of 1891. *Bull. Amer. Mus. Nat. Hist.*, Vol. IV, No. 1, Art. xi, Oct. 20, 1892, pp. 81–148.

1895. Osborn, Henry F. Fossil Mammals of the Uinta Basin. Expedition of 1894. *Bull. Amer. Mus. Nat. Hist.*, Vol. VII, Art. ii, May 18, 1895, pp. 71–105.

1887. Schlosser, Max. Die Affen, Lemuren, Chiropteren, Insectivoren, Marsupialier, Creodonten und Carnivoren des Europäischen Tertiärs und deren Beziehungen zu ihren lebenden und fossilen aussereuropäischen Verwandten. *Separat-Abdr. aus: "Beiträge zur Paläontologie Osterreich-ungarns," VI. Band*, Theil I, s. 1–224. 4to. Wien, 1887.

1901. Wortman, J. L. The Probable Successors of Certain North American Primates. *Science*, N. S., Vol. XIII, No. 319, Feb. 8, 1901, pp. 209–211.

New Canidæ from the Miocene of Colorado.

By W. D. Matthew.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XVI, Article XXI, pp. 281–290.
New York, Sept. 18, 1902.

The Knickerbocker Press, New York

Article XXI.—NEW CANIDÆ FROM THE MIOCENE OF COLORADO.

By W. D. Matthew.

Cynarctus, new genus.

Family *Canidæ*, Subfamily *Amphicyoninæ.*

Dentition $\overline{3.1.4.3}$. Carnassials reduced and molars enlarged, talonids bicuspid in the type species, and two accessory cusps on the trigonids. Jaw long and slender as in the dogs, premolars cynoid.

Cynarctus saxatilis, n. sp.

Size of the Coyote. *Jaw* somewhat more slender anteriorly, inferior border more convex, angular process longer, curving more upward and inward. Coronoid process more triangular, the tip narrow, the anterior border with slight uniform backward curvation, while in the coyote it is straight until near the tip and then curves suddenly backward. Masseteric fossa deeper and wider, its inferior border much more marked.

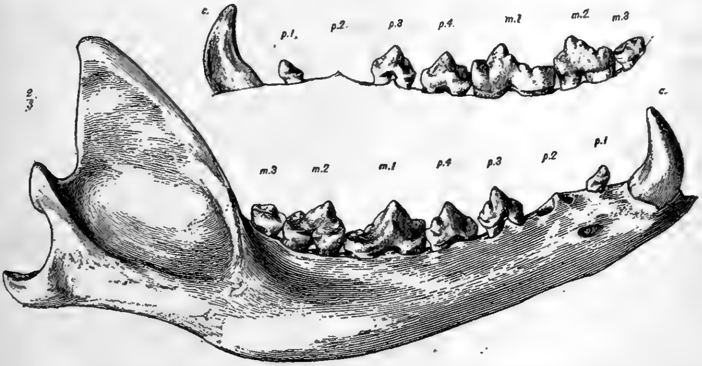

Fig. 1. *Cynarctus saxatilis.* Lower jaw, outer side, x ⅔, and inside view of teeth. Type, No. 9453. Loup Fork (Pawnee Creek Beds), Colorado.

Teeth. Incisors not preserved. Canine and premolars little worn, molars much worn. Premolars somewhat smaller than in *C. latrans*, carnassial nearly one-fourth smaller, molars over one-fourth larger.

The trigonid of the *carnassial* is low, and reduced in size, and two accessory cusps are added to it, one external to the protoconid, one behind the metaconid. The protoconid is central in position, greatly reduced in proportionate size compared with *Canis* or even with *Amphicyon*, and the shearing edges of pr^d and pa^d are reduced and little used. The accessory cusps and heel are nearly as high as the pa^d. The heel consists of a larger external and smaller internal cusp, both greatly worn, but apparently low and rounded. The external cingulum is strong and crenulate.

The second molar has the same composition as the first, except that the paraconid is small and connate with the protoconid, which is of the same size as the well-separated metaconid. The external cingulum is very broad in the anterior half of the tooth and bears one well-defined cusp external to the protoconid. The heel is nearly as long as the trigonid.

The third molar is obovate with shallow basin heel, and larger trigonid too much worn for distinction of cusps. The cusps of the heel are mostly obsolete, the surface wrinkled.

The premolars are shorter than in *C. latrans*, all except the first bearing the posterior accessory cusp, characteristic of the dogs, but absent in the bears. The first premolar is single rooted, spaced equally between the canine and second premolar. (In the dogs it approaches the other premolars, in the bears usually the canine.)

Canine slightly more slender than in *C. latrans*, more curved at base, less curved toward tip.

The deep masseteric fossa, long angular process, and strong metaconid suggest *Daphœnus*, which, however, has the normal canine proportion of carnassial and molar teeth, and, like all the more ancient genera, has the shear more oblique to the tooth-line than in the later Canidæ.

From the more ancient genus *Cephalogale* it differs in the presence of the accessory premolar cusps, slender jaw, larger molars, the posterior molars less unlike to the carnassial, and in the presence on the carnassial of two accessory cusps. All the modern microdont Canidæ except *Otocyon* have a more typical proportion of carnassial and tubercular teeth, and lack the accessory carnassial cusps. Their premolars are narrower. *Cynarctus* is near to *Haplocyon* Schlosser, founded on the jaw-fragment with pms 2 to 4 from St. Gérand-le-Puy, described by the late Prof. Filhol under the name of *Amphicyon crucians*. But the premolars are more cynoid, not so high, and the posterior accessory cusp is present on p_3. The horizon of the two is different, and I hardly think that they are really allied, although the distinctions on known parts may appear rather slight.

From *Pseudarctos* it differs in the presence of the two accessory cusps on the trigonid of the carnassial, in the larger premolars with well-marked deuteroconid, the slender jaw and small third molar.

From *Amphicyon* the genus differs in the bicuspid heels of the molars, greater reduction of pr^{d}, and presence of accessory external and internal cusps, long slender jaw, and cynoid premolars.

From *Ursavus* it differs in the less reduction of the premolars, presence of accessory cusps on p_2, p_3, and p_4, and the much more cynoid character of molars 2 and 3. In *Ursavus*, judging from Dr. Schlosser's figures and description, the cusps on m_2 are nearly obsolete, and the surface flat and wrinkled, while m_3 is a round, peg-like tooth with flat, wrinkled crown. The jaw of *Ursavus* is deep and short like that of the bears, and the coronoid directed nearly upward as in the Ursidæ.

The foregoing description is based on a nearly perfect pair of lower jaws found in the Loup Fork (Pawnee Creek beds) of Cedar Creek, Colorado, by Mr. Brown of the American Museum Expedition of 1901. A single lower carnassial in the Cope Collection from the Colorado Loup Fork probably represents the same species. No upper teeth are known, and the position of the genus is therefore uncertain. Judging from the characters of the lower teeth it would seem probable that it must be placed with the Canidæ, and cannot be considered as near to *Ursavus*, which is unmistakably a bear. As far as can be determined from the lower jaw characters, it seems to be partly intermediate between *Ursavus* and *Canis*, with some primitive characters retained, no doubt, from its Oligocene ancestors. If this be borne out by the characters of the upper teeth, *Cynarctus* will help to bridge the most serious gap in the series of extinct genera connecting the Ursidæ and Canidæ. *Amphicyon*, as Dr. Schlosser has shown, does not fulfil the requirements for a direct ancestor of the bears, but must be considered as a side branch paralleling them. *Cynarctus* would seem somewhat more but by no means exactly in the line of descent. The slender jaw excludes it from direct relationship.

In a previous paper the writer has discussed an alternate hypothesis of the origin of the Ursidæ which derives them from the Creodont family Arctocyonidæ, instead of from the Canidæ. It was then stated that the apparent chain of extinct types connecting the Canidæ and Ursidæ formed a most serious objection to considering any other hypothesis as possible, but it was pointed out that there was a wide gap in the series between such genera as *Amphicyon* and *Dinocyon*—unmistakable dogs although bear-like—and *Hyænarctus* and *Ursavus*, unmistakable bears, although with the primitive carnivore formula lost by the modern bears. Dr. Schlosser has shown that *Amphicyon* is a side branch of the Canidæ and *Hyænarctus* of the Ursidæ and that the wide gap between the primitive Oligocene dogs, such as *Cephalogale* and the earliest true Ursidæ cannot be filled by any genera hitherto known. The genus here described reduces this gap, as its close resemblance to *Ursavus* in the composition of the teeth seems hardly explicable except on the ground of a near relationship; while in most characters it is as unquestionably a dog as *Ursavus* is a bear. It does not seem, however, to point especially to *Cephalogale* as an ancestor. Its relationship to the direct line of descent is uncertain.

Nevertheless this additional evidence in favor of the derivation of the bears from early Canidæ seems to render untenable any other hypothesis. The Arctocyonidæ must then be considered as a case of parallelism not confined to the general characters of teeth and feet, but extending to the detailed structure of both, the rather exceptional cusp composition of carnassial and molar teeth, the relative proportions of the digits, even certain details in the character of the carpals and tarsals being common to both, besides the more general characters of large quadrate, flattened molars, reduced premolars, slender canines, plantigrade, large-clawed feet.

?? **Ursavus** sp.

Another small Amphicyonoid of about the same size as *C. saxatilis* is indicated by No. 9454, a lower carnassial, and a few fragments from Pawnee Buttes. The tooth is composed of very low trigonid of three cusps, paraconid nearly as large as protoconid, me^{d} well developed, more internal than posterior, long basin heel completely enclosed by a well-marked ridge, which begins at the metaconid and swings around the margin nearly to the protoconid, the heel-cusps being scarcely seen. Trigonid is proportioned much as in *Ursavus*, but no accessory cusps, and heel without well-marked cusps. Trigonid and especially the protoconid lower than in *Amphicyon*, and marked basin heel.

? **Cyon** or **Icticyon** sp.

A palate and a ramus of the lower jaw, both young individuals showing the milk dentition, are referred here. The permanent sectorials are formed within the jaw, but not extruded. The character of the milk dentition proves that the specimens belong to the Canidæ, but to the division of the family with most highly secant teeth. This is confirmed by the metaconid; in the superior one the deuterocone is minute, and there is no anteroexternal cusp. I am unable to make comparisons with the milk dentition of either *Cyon* or *Icticyon;* the permanent upper carnassials differ from the figures of *Icticyon* and from specimens of *Cyon alpinus* in the greater reduction of the anterointernal cusp and presence of two strong ridges on the anterior slope of the protocone, diverging from the point, one running to the anteroexternal corner of the base, the other to the base of the anterior internal cusp.

The permanent incisors are trifid, the lateral cusps being stronger than in any Canid that I have seen, equal almost to the median cusp. The external temporary incisor has but one strong lateral cusp, the external one minute; a posterior cusp is also present. The temporary canine is short and small with prominent posterior ridge. The permanent first premolar is one-rooted, with anterior and posterior cusps and small posterior cingular cusp. The second temporary premolar is smaller, more compressed, two-rooted, with rudimentary posterior cusp. The third is the carnassial, and is three-rooted, composed of large protocone and strong posterior blade, with a minute anterointernal basal cusp situate between the anterior and internal roots. The fourth milk premolar is molariform, with no protoconule, strong hypocone (in reality probably a metaconule), besides the three main cusps. The second lower milk premolar is two-rooted, set obliquely in the jaw, and has a small posterior cusp. The fourth (carnassial) has the trigonid of shearing protoconid and paraconid blades, small metaconid, and three-cusped basin heel. Compared with the corresponding teeth in the Coyote these teeth differ in larger size, greater robustness, more sectorial character in the carnassials, proportionately smaller and narrower heel on dp_4, dp^4 of less transverse and greater longitudinal width, the inner cusps less marginal, reducing the size of the basin enclosed by them. The anterointernal cusp on dp^3 is smaller and situated much more anteriorly; the anteroexternal cingular cusp is hardly noticeable. The jaw is very much shorter and deeper, the premaxilla is carried much farther back between maxilla and nasal. The cusp composition is the same in both.

No Canid has been described with which this can well be identified. It is of the size of *Ælurodon*, but differs in absence of anteroexternal cusp on p^4 (and other characters). It is much more modernized than any of the John Day dogs, and the size is too great for *C. brachypus* Cope, *temerarius* or *vafer* Leidy, *anceps* Scott, all of which, moreover, seem more typically cynoid.

In a previous article Dr. Wortman and the writer attempted to trace a line of descent from the Eocene *Uintacyon* and *Prodaphænus* through the Oligocene *Daphænus* and *Temnocyon* to the modern *Cyon*. It seems not unlikely that the Canid here described may nearly represent the Upper Miocene stage of evolution of this race. *Icticyon* seems also to be more or less nearly connected with it—and if this hypothesis of descent be correct, this group parallels the Camels in their present and past distribution, originating in North America, spreading to South America and Asia, and becoming extinct in their old home while still surviving in the two widely separated districts to which they had wandered.

In this as in other cases the writer desires to guard against expressing any belief that the evolutionary series worked out in various lines represent the actual species through which descent has occurred. They represent indeed the history of the evolution of certain parts; they may in some cases be not far from the direct line of descent. But it appears probable that each 'stage' represents in most cases a migration rather than a mutation of species. Believing that the principal causes of the evolutionary changes among the Tertiary mammalia lay in the secular world-wide alteration in climatic and geographic conditions, it seems improbable that in any given locality a change in the fauna occurred directly without a change in the area over which the species flourished. It seems much more likely that most of the changes in fauna in a locality were due to successive waves of migration, setting out from the region in which the new climatic conditions first appeared. This would involve in general a succession of waves of migration spreading from the north into America on one hand, Europe, southern Asia, and Africa on the other, differentiating to some extent as the separation increased, and driving the older faunas southward before them. Hence the Tertiary aspect of so large a part of the South American and African faunas, and hence the primitive aspect of forest faunas in general, the new conditions of cold and arid climate which culminated in the Glacial Epoch involving the spread of open plains, and diminution of the forest areas.

Amphicyon americanus *Wortman.*

Amphicyon americanus WORTMAN, Amer. Journ. Sci., Vol. XI, 201, Sep. Jan. 25, March, 1901.

This species is of moderate size in the genus and of rather primitive character, in some respects approaching the species of the European Oligocene (*A. lemanensis*, etc.). Dr. Wortman gives the following measurements:

Length of superior molar series, including canine...	134 mm.
Anteroposterior diameter of canine at base........	24
Length of true molar series.....................	46
Transverse diameter of first superior molar........	27
Anteroposterior diameter of superior sectorial.....	27
Width of palate at first molar, including crowns...	98

Amphicyon sinapius, n. sp.

? *Canis, sp. incerta,* Cope, Rep. Vert. Pal. Col. U. S. G. S. Terrs. Ann. Rep. 1873 (1874), 519.

A larger American species of *Amphicyon* is represented by a number of fragmentary specimens from the Colorado Loup Fork.

Am. Mus. No. 9358.	Jaw fragment with broken carnassial and complete first tubercular molar. Type.
" 9357.	Carnassial tooth, unworn. Co-type.
" ?9356.	Twenty-three vertebræ, ribs, humerus, and ulna.
" ?9355.	Astragalus, parts of tibia, humerus, radius, and several metapodials, of uncertain association.
" ?8248.	(Cope Coll.). Astragalus, and anterior part of a lower jaw, without teeth.

Our material unfortunately does not enable us to determine the dental formula, but the characters of the teeth agree best with those of *Amphicyon*, and are more primitive than those of *Dinocyon*. It is much larger than *A. lemanensis*, but resembles rather nearly the figures of that genus given by Dr. Schlosser. It somewhat exceeds *A. major* and *A. giganteus* in size, the heel of m_1 is broader, m^2 is much larger and broader comparing it with de Blainville's figures, and on both molars the entoconid is represented only by a broad cingular ridge. Both in size

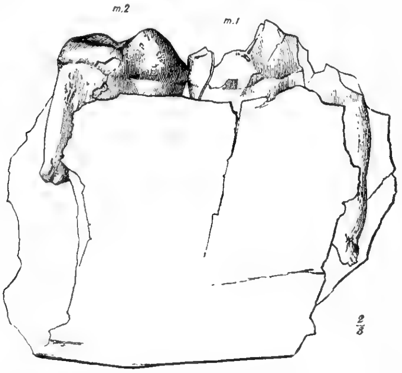

Fig. 2. *Amphicyon sinapius.* Part of lower jaw, inner side, x $\frac{2}{3}$. Type, No. 9358. Loup Fork (Pawnee Creek Beds), Colorado.

and characters the second lower molar is very like that figured by Dr. Schlosser in 'Palæontographica' and referred doubtfully to *A. major*. Without more complete material the position of this species cannot certainly be determined.

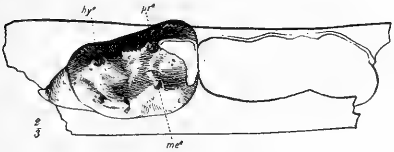

Fig. 3. *Amphicyon sinapius*. Crown view of m_1 in jaw, x $\frac{2}{3}$. Type, No. 9358.

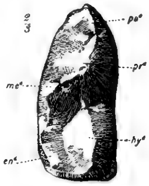

Fig. 4. *Amphicyon sinapius*. Lower carnassial x. $\frac{2}{3}$ No. 9357. Loup Fork (Pawnee Creek Beds), Colorado.

? **Dinocyon (Borophagus) mæandrinus** (*Hatcher*).

Ælurodon mæandrinus HATCHER, Amer. Nat. 1893, 240.

The type consists of part of a lower jaw, with the second and third premolars greatly worn, and roots of fourth premolar and sectorial. It differs from other Ælurodons, according to Mr. Hatcher's description and figure, in the much greater size, extremely short jaw, and reduced premolars, large posterior root to the sectorial. All these characters point to the Amphicyoninæ rather than to the true dogs; the second molar, whose proportionate size would make the position of the species certain, is unfortunately not indicated in the type.

To this species may be referred provisionally Am. Mus. No. 10583, a fragmentary lower jaw with roots of the teeth, associated with parts of tibia, etc., found by Mr. Gidley of the American Museum Expedition of 1899 in the Loup Fork formation of Donley Co., Texas.

Measurements.

	Type.	*10583*
Post-canine diastema	19	14
Premolar dentition	60	62
Carnassial, length	47	47
Second molar	—	24
Carnassial, width ant. root	—	15
" " post. "	—	20
Depth of jaw behind p_4	55	69

? **Dinocyon (Borophagus) diversidens** (*Cope*).

Borophagus diversidens Cope, Amer. Nat., 1892, 1028; Vert. Pal. Llano Estac. (4th Ann. Rep. Geol. Surv. Tex., 1892), 54, pl. xiii, fig. 4.

Blanco horizon (Upper Pliocene). Referred to the Hyænidæ by Professor Cope. The type is a fragment of a lower jaw, with two premolars preserved and the root of a third. It agrees with *Amphicyon* more nearly than with *Hyæna* in the form of the individual teeth, as well as in their proportion one to another; the second premolar is smaller, apparently, than in the Loup Fork species.

? **Dinocyon** (? **Borophagus**) **gidleyi** *Matthew.*

Dinocyon (? Borophagus) gidleyi Matthew, Bull. Am. Mus. Nat. Hist., Vol. XVI, 1902, 129–136.

? **Amphicyon ursinus** *Cope.*

Canis ursinus Cope, Proc. Phila. Acad. Nat. Sci. 1875, 275; Rep. Wheeler Survey, Vol. IV, pl. ii, p. 304, pl. lxix, fig. 1.

The reduction of the premolars, proportionately large tubercular teeth, deep, massive jaw with comparatively straight inferior margin, large heel on the lower sectorial, etc., place this species with the Amphicyons. Professor Cope remarks on the probability that *C. ursinus* is very close to *C. haydeni*. Leidy's species is, however, much more like the wolf in proportion of sectorial to tubercular teeth, and the heel of the sectorial is comparatively small, as in *C. lupus* or in the Ælurodons.

A. ursinus is about the size of *A. americanus*, and is perhaps synonymous with it.

A Horned Rodent from the Colorado Miocene. With a Revision of the Mylagauli, Beavers, and Hares of the American Tertiary.

By W. D. Matthew.

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Article XXII.—A HORNED RODENT FROM THE COLORADO MIOCENE. WITH A REVISION OF THE MYLAGAULI, BEAVERS, AND HARES OF THE AMERICAN TERTIARY.

By W. D. Matthew.

Ceratogaulus rhinocerus, n. g. et sp.

The writer has recently described part of the skull of a *Mylagaulus* from the Colorado Loup Fork beds, found in 1898. A nearly complete skull, with one ramus of the lower jaw, found by Mr. Brown of the Expedition of 1901, indicates a new genus of this family, distinguished by the unique character (for a rodent) of a pair of large connate processes on the nasals resembling the horn-cores of some Ungulata, and giving the skull a profile absurdly like that of a miniature rhinoceros.

The skull is a little larger than that of *Mylagaulus*, and displays considerable modifications, chiefly conditioned by the development of the horn-like processes on the nasals. The muzzle is much wider and tapers forward; the nasals are much wider throughout, and especially in the middle, where they bear the horn-cores. The postorbital processes of the frontal and jugal bones are considerably less prominent and placed farther back, making the orbit larger and more extended anteroposteriorly. The zygomata are deeper. The enlarged molar in the upper jaw differs a little in form, and considerably in the pattern of the crown. The penultimate upper molar appears to be considerably larger in proportion, but is so much damaged in the *Mylagaulus* skull that it cannot be closely compared. The enlarged molar of the lower jaw displays a crown pattern with the usual lakes in three longitudinal rows, instead of four as in *Mylagaulus*. The alveoli of the second and third molars are of nearly equal size, while in *Mylagaulus* the penultimate alveolus is much larger. The type specimen No. 9456, is of nearly the same age as the *Mylagaulus* skull with which it has been compared, the wear of

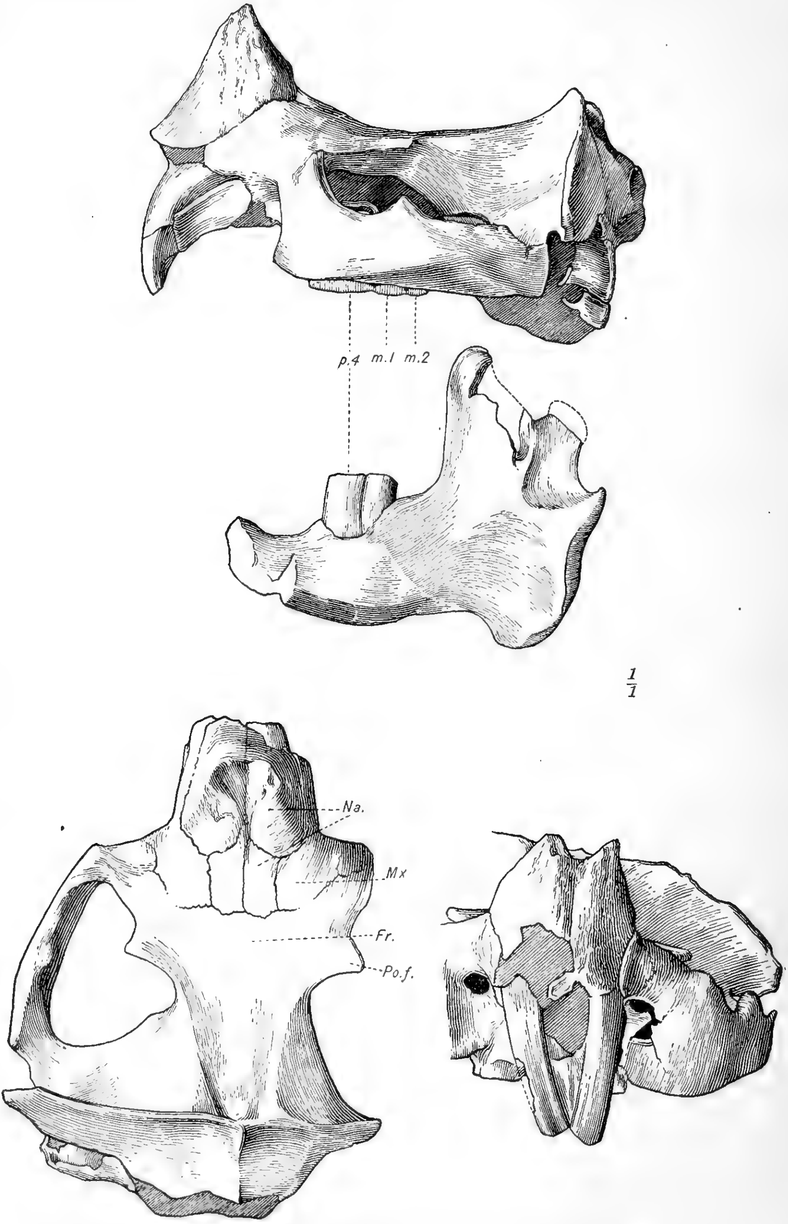

Fig. 1. *Ceratogaulus rhinocerus.* Skull and jaw, natural size. Superior, lateral and anterior views. No. 9456 (type). Loup Fork, (Pawnee Creek Beds) Colorado.

the teeth being slightly less advanced. The distinctions, therefore, cannot be due to age. The horn-like processes might be sexual, although I can find no parallel among the rodents for such a wide divergence between male and female; but the marked distinctions in the teeth and other characters are not likely to be sexual, although in themselves they are not of generic importance.

The height of the horn-cores is about one-fifth the length of the skull, their length a little more, and their conjoined width about one-fourth the skull-length. The longer axis of each process is diagonal, posteroexternal and anterointernal; the conjoined process is subtrigonal, the angles posteroexternal and anterior.

A character so marked as this would seem a good basis for a separate genus. Nevertheless, the resemblance to the skull of *Mylagaulus* obtained in 1898 is considerable in most characters, except in the horn-cores, the position of the postorbital processes, and the pattern of the enlarged grinding teeth.

The occiput is extraordinarily wide and low, its width equalling the entire length of the skull. The postorbital crests do not unite behind; the top of the skull is flat transversely, concave anteroposteriorly, and the occipital surface slopes 30° forward from the condyles to the top of the crest. The zygomatic arches are stout, deepest in front, somewhat wider than the occiput, both postorbital processes (on the frontal and jugal) moderately strong. In both upper and lower jaws the alveoli of two smaller molars are preserved, but no clear indication of a third, behind the enlarged tooth.

Measurements.

Length of skull (condyle estimated)	68 mm.
Width across arches	64
" of occiput	65
Height of horn-core	13
Length " "	17
Conjoined width of horn-cores	19
Width across postorbital processes of frontals	32
Width across postorbital constriction	18
Least depth of zygomatic arch beneath orbit	9

Length of diastema	20 mm.
" " three upper molars (? p^4–m^2)	15
" " enlarged " molar (? p^4)	8
Width of " " " "	6.5
Height of same (root and crown)	12
Estimated length of lower jaw	58
Depth of jaw beneath molars	15
Height " " (angle to tip of coronoid process)	41
Length of enlarged lower molar (? p_4)	10
Width of " " " "	5.5

This remarkable skull has no parallel among the Rodentia. *Haplodontia* most nearly approaches it in width, but the horn-cores and the specialized teeth are unique.

HIND LIMB AND FEET OF MYLAGAULIDÆ.

We know but little as yet of the skeleton of this family. The pelvis was very massive, and beaver-like on a smaller scale, the tail probably not flattened, and the scaphoid and lunar were united. A metacarpal associated with two teeth of *Mylagaulus* shows some remarkable characters. It is nearly as large as the metacarpals of *Castor canadensis* and much stouter. The distal facet is strongly keeled on the inferior surface, in a manner recalling the distal ends of metapodials of *Chalicotherium* or metacarpals of *Dasypus*. The facet is limited superiorly, so that it is not at all reflexed over the superior surface of the metacarpal, but faces entirely inferiorly and distally. The characters of the bone may be taken to indicate the presence of large digging claws on the manus.

I refer also to this family a remarkable specimen in the Cope Collection from the Loup Fork beds of the Republican River, Nebraska, consisting of a nearly complete hind limb and foot, with an ungual phalanx of the fore foot, not associated with any parts of the skull. This specimen combines characters of a Castoromorph rodent, with a resemblance to the modern armadillo so striking that I am unable to state positively that it is not edentate.[1] As nearly as I can judge, however, the ar-

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[1] Professor W. B. Scott, whose recent extensive and thorough studies of the Santa Cruzian fauna give especial weight to his authority, has examined this specimen and pronounces it probably rodent and certainly not edentate.

madillo resemblances may be explained as all associated with the development of digging claws, chiefly on the fore foot, and walking on one side of the foot in consequence. The Castoromorph characters, on the other hand, appear to be such as would indicate real relationship, although not close relationship to any living form. From the phalanx just described we have reason to infer that *Mylagaulus* developed large digging claws on the fore foot, and this specimen is of appropriate size and proportions to belong to the *Mylagaulus*. It is found in the same horizon, and could not belong to any other rodent known from those beds, for all the others are quite nearly allied to still existing genera. Edentates have not been found in the Loup Fork,[1] and our specimen shows no resemblance to

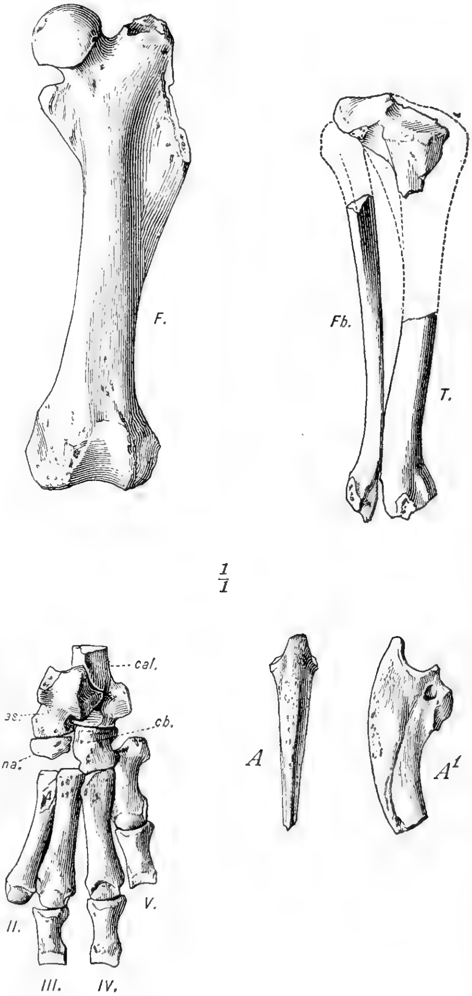

Fig. 2. Mylagaulid, indet. Hind limb bones and claw, natural size: *F*, anterior view of femur; *Fb. T.* posterior view of tibia and fibula; superior view of pes; *A*, *A*,[1] superior and lateral views of ungual phalange of fore foot. No. 8336. Loup Fork, (Republican R. Beds) Kansas.

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[1] The supposed exception, *Caryoderma snovianum*, is, according to Williston, a turtle.

any known fossil edentate, the resemblance being only to *Dasypus*, and to a much less extent to *Tatusia*. From this it seems reasonably safe to infer that it is a Mylagaulid, and that this family paralleled the Armadillos in the structure of their feet.

The *femur* (Fig. 2, *F*) is nearly complete; it differs from either beavers or armadillos in the position of the very large and powerful third trochanter, which is placed high up on the shaft, nearly opposite the second trochanter, instead of in the middle of the shaft as is usually the case. The greater and lesser trochanter are much as in *Castor*; the distal condyles are wide and low, and the trochlea short, broad, and shallow.

Most of the *tibia* and *fibula* (Fig. 2, *Fb.*, *T.*) are preserved; the tibia is short and stout, beaver-like at the lower end; the fibula as strong as in *Castor*, separate from the tibia, with a vertical internal facet for the astragalus, but no distal facet, and no contact with the calcaneum. The astragalus (Fig. 2), is quite rodent-like, with moderately broad trochlea defined by sharp keels internally and externally, rather small neck, and broad, flattened head. Metatarsals II to V are present, but the hallux was rudimentary or absent. The second metatarsal is much more slender than the third and fourth, but of about the same length. Mt. V is only three-fifths as long as the others, but fully as stout as mt. III and IV. The phalanges of the first row are rather short, their distal facets wide, not deep, moderately concave from side to side. The size and strength of the metatarsals and proximal phalanges does not appear adequate to bear the very large claw (Fig. 2, *A*, A^1) with which they are associated, and I therefore suppose that it belongs to the fore foot, where the much stouter and more specialized metacarpal, such as has been described as occurring with teeth of *Mylagaulus*, could very ap-

Fig. 3. Humerus of ? *Ceratogaulus*, natural size. No. 9457. Loup Fork (Pawnee Creek Beds), Colorado.

propriately bear it. This claw phalange is long, compressed, the proximal facet very little keeled, the distal end slightly fissured but not symmetrically so, and shows no hood at the base.

The hind foot when set in position on wax shows an unmistakable twist, the external side being bent down distally as if the animal walked on the outside edge of the foot, turning the claws inward underneath. This may serve to explain the short, stout fifth digit, as contrasted with the long, slender second; a proportion seen also in the armadillo and some other modern Edentates.

REVISION OF THE SPECIES.

On comparing the two skulls and three other more fragmentary specimens from Colorado with five specimens of *Mylagauli* from Nebraska in the Cope Collection, it appears that a considerable number of species are represented. On reviewing the description of *Mesogaulus ballensis* Riggs I find that I was in error in identifying it with *Mylagaulus monodon*, but its position can hardly be determined until more is known of the milk dentition and the history of the changes in tooth pattern in this curious family. As far as at present determinable the characters of the known species are:

Mylagaulus monodon *Cope*. Type, a jaw with the enlarged molar and two alveoli posterior to it, from the Loup Fork of the Republican River Valley. A second specimen, a lower tooth from the same locality, referred to it by Professor Cope, is considerably larger. Enamel lakes in four rows. There are seven lakes in the type; nine in the associated specimen. No cement outside external enamel ring.

	No. 8327 (type).	No. 8328
Extreme anteroposterior diam. of molar	? 11.5 mm.	13.5 mm.
transverse " " "	——	6.5
Anteroposterior diam. of grinding surface	10.5	11
Transverse " " " "	6	6

Mylagaulus sesquipedalis *Cope*. Type, an upper molar, No. 8329. Referred specimen a lower molar and incisor and a metacarpal, No. 8330. Both from the same locality as *M.*

monodon. They are much smaller, and the pattern of the enamel lakes simpler and more irregular. Those of the lower tooth are six in number, corresponding in position to the lakes in *M. monodon*, but less elongated, fewer in number, and less regularly arranged. Grinding surface of upper molar regularly oval, with six lakes irregularly arranged.

	No. 8329 (type).	No. 8330
Upper molar, extreme anteroposterior diameter..	10 mm.	
" " transverse..............	5.5	
" anteroposterior diam. of grinding surface........................	8	
" transverse diam. of grinding surface.	5.5	
Lower molar, anteroposterior diam. (estimated)..		8.5
" transverse "		4.5

Mylagaulus (Mesogaulus) ballensis *Riggs.* Type, a lower jaw containing three teeth, from the Deep River beds of Montana. Size of *M. sesquipedalis*, but with only four enamel lakes and, according to Mr. Riggs's drawing, a heavy band of cement surrounding the grinder. Our specimens show nothing like this; several have a thin layer of cement over parts of the outside, but never at the grinding surface, except in a supposed milk-tooth in which the enamel ring does not come up to the grinding surface.

Dimensions, from Riggs's Description.

Anteroposterior diameter of grinder....................	9 mm.
Greatest lateral breadth of "	4.2

Mylagaulus lævis, n. sp.

M. monodon MATTHEW, Mem. Am. Mus. Nat. Hist. I, 1901, 377. Not *M. monodon* Cope.

Type, front half of skull and jaw, pelvis, and other fragments from the Loup Fork of Colorado. Smaller and less robust than *M. monodon*, pattern of lower molar similar, with seven lakes arranged in four rows. Upper molar flattened externally, not regularly oval like that of *M. sesquipedalis*, lakes longer, narrower, and lying more regularly parallel. Nasals smooth.

Dimensions.

Lower jaw, diameter of enlarged molar, anteroposterior (grinding surface)	9 mm.
Lower jaw, diameter of enlarged molar, transverse (grinding surface)	5
Upper jaw, diam. of enlarged molar, anteroposterior (grinding surface)	9
Upper jaw, diam. of enlarged molar, transverse (grinding surface)	5.8

Ceratogaulus rhinocerus, n. sp.

Generic characters: Nasals bearing a large pair of horn-like processes, closely twinned. *Specific characters:* Size somewhat larger than that of *M. lævis*, less than that of *M. monodon.* Enamel lakes of lower molar simpler, seven in number, arranged in three rows, less regular than those in *M. monodon* or *M. lævis.* Alveoli of last two molars of subequal size. External side of upper grinder flat, internal strongly convex. Second upper grinder larger than third. Muzzle broader than in *M. lævis*, postorbital processes shorter and more posterior.

Dimensions of the Enlarged Grinders.

	Upper.	Lower.
Anteroposterior diameter	8.7 mm.	9.7 mm.
Transverse "	6.5	5.5

Mylagaulus paniensis, n. sp.

Fig. 4. *Mylagaulus paniensis*, part of lower jaw. No. 9361 (type) Loup Fork (Pawnee Creek Beds), Colorado.

A small and simple species indicated by half a lower jaw and a few fragments. There are five enamel lakes, of which the three interior ones are arranged in a row as in *M. ballensis;* and external to these are a large and a small lake, the latter corresponding to the fourth lake of *ballensis.* The tooth is worn well down, while that of *ballensis* appears to be a comparatively young individual, so that the less number of lakes in Mr. Riggs's species can hardly be due to greater age; and on our specimen is no trace of external cement. This specimen comes from the base of the Loup Fork beds at Courthouse Butte, near Pawnee Buttes, Colorado.

Dimensions, No. 9361.

Anteroposterior diameter of lower molar	7.4 mm.
Transverse " " " "	4
Length of diastema	7
Transverse width of incisor	3
Anteroposterior diameter of incisor	4

CASTORIDÆ.

Steneofiber *Geoffroy.*

The pattern of the molars in this genus is so evanescent that it is almost impossible to make satisfactory comparisons of species on the limited number of specimens available. The essential pattern of the upper teeth consists of a deep internal enamel inflection and three external ones, the anterior and posterior of which quickly become fossettes. In the lower teeth the pattern consists of a simple external and three internal inflections, the anterior and posterior internal inflections soon becoming fossettes. With moderate wear the crown is divided transversely, by the internal and external inflections, into an anterior and a posterior column, united at the base, each column containing a fossette, sometimes more than one. The teeth become broader transversely with wear, and much less in their anteroposterior diameter; the anterior column increases and the posterior one diminishes in size in the upper teeth, while the converse holds true in the lower teeth. The enamel folds become closer, and their direction changes with wear; the internal one in the upper teeth, the external one in the lower, becoming more nearly anteroposterior in direction. The principal inflections in old individuals have become fossettes, while the minor inflections have disappeared. The last molar in young individuals appears small in proportion, because of the small area of the grinding surface; in older individuals it appears larger in proportion. The fourth premolar of young individuals likewise appears small in proportion to the first and second molars, but reaches its maximum of size earlier than does the third molar.

These observations are based on the American species, which are a rather closely allied group, characteristic of the Oligocene, and more primitive than the European assemblage of species, which are characteristic of the Miocene epoch, and in general larger, longer-toothed, and nearer to the modern branches. The *S. viciacensis* of the Upper Oligocene (St. Gérand-le-Puy) appears to be the nearest to the American group. The distinctions between our species have been based, unfortunately, chiefly on the evanescent pattern of the teeth, not sufficiently considering the great alteration due to a comparatively slight difference in their wear. Seven species have been described, as follows:

1. *S. nebrascensis* Leidy. White River, S. Dakota, skull and jaws.
2. *S. pansus* Cope. Loup Fork, N. Mexico, upper and lower jaws, etc.
3. *S. peninsulatus* Cope. John Day, Oregon, skull.
4. *S. gradatus* Cope. John Day, Oregon, skull.
5. *S. montanus* Scott. White River, Montana, teeth and skeleton fragments.
6. *S. hesperus* Douglas. White River, Montana, lower jaw.
7. *S. complexus* Douglas. White River, Montana, part of skull and jaws.

I have at hand for comparison the types of all the species except the first two, besides three other skulls and some less complete material. I am indebted to the courtesy of Professor Scott and Mr. Douglas for the loan of the type specimens of the species described by them. In revising these species it has been necessary to reject a large part of the distinctions made by their authors, as being merely a matter of different age in the type specimens.

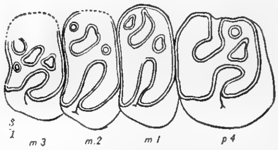

Fig. 5. *Steneofiber nebrascensis.* Upper molars x $\frac{2}{1}$. No. 1428. White River (Protoceras Beds), South Dakota.

1. **S. nebrascensis.** I refer here a skull, No. 1428, which, like Leidy's type, comes from the Protoceras beds, and part of a lower jaw, No. 1028*b*, in our

collections. The former is an older animal than Leidy's type, the latter younger. The species appears to be distinguishable by the long, narrow muzzle, small bullæ, sharp sagittal crest, and small brain-case. The postorbital constriction is moderate, the pattern of the teeth rather complicated, two deep fossettes anterior to the external inflection on p^4 remaining in the well-worn teeth of No. 1428.

2. **S. peninsulatus.** Besides the type skull, another skull, less crushed, a skull and jaws, and several parts of jaws, etc., referable to this species, are in the Cope Collection in this museum. It is a more robust species than the last, distinguishable by the large bullæ and probably by the broader muzzle, wide occiput, larger brain-case, and wider sagittal crest. The postorbital constriction is very narrow in the type, but not in the second specimen. The teeth are much like those of *S. nebrascensis*, but the second anterior fossette of p^4 apparently remains longer as a branch from the medial external enamel inflection. The fossette remaining from the posterior external enamel inflection of p^4 has almost disappeared in the type and another specimen, but shows no signs of breaking up into three little fossettes, as it apparently has done in the type of *S. nebrascensis*. The specific validity of these distinctions in the tooth pattern is very questionable; the two sides of a single skull seldom agree at all closely, and this may well be an advanced mutation or subspecies of *S. nebrascensis*, the large bullæ being the clearest distinction.

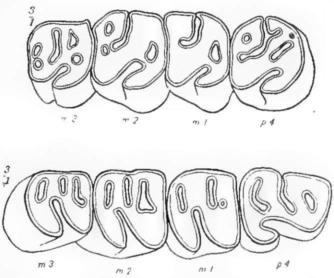

Fig. 6. *Steneofiber peninsulatus.* Upper and lower molars. x $\frac{2}{1}$. Type. No. 6998. John Day (? Diceratherium Beds), Oregon.

3. **S. gradatus.** The type skull, and the palate of a somewhat older individual are in the Cope Collection. It is a smaller animal than the two preceding species, with short, wide muzzle, postorbital constriction moderate, brain-case short and rounded, temporal crests not uniting to form a single

sagittal crest for some distance back of the postorbital constriction. Bullæ of moderate size; grinding series of teeth near together anteriorly, divergent posteriorly. The teeth decrease in size from p⁴ to m³ more than they do in *S. nebrascensis* or *S. peninsulatus;* there is but one fossette anterior to the external enamel inflection on the type, while our referred specimen of *S. nebrascensis* shows two, neither near extinction, although the teeth have attained the same stage of wear. The external enamel inflection has given off a small fossette on the left premolar of the type, but not on the right one; in both type and referred specimen the fossette of the posterior enamel inflection has disappeared.

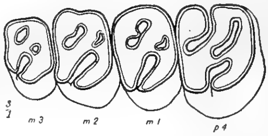

Fig. 7. *Steneofiber gradatus.* Upper molars x $\frac{3}{1}$. Type. No. 7007. John Day (? Diceratherium Beds), Oregon.

4. **S. pansus.** The upper and lower jaws are the only parts of the head known, and I have no certainly referable material to asisst in determination of the characters. Professor Cope's figures indicate an old individual, and apparently that the posterior enamel inflection of the upper teeth was more deeply impressed than in *S. gradatus*, which it resembled in the presence of but one fossette anterior to the median enamel inflection. The form and proportions of the molars, on which Professor Cope relied to distinguish it from other species, are merely a matter of age, as far as any separation from *S. peninsulatus* and *nebrascensis* is concerned. The bullæ are very large, as in *peninsulatus*, which it most nearly approaches as far as known, although presumably distinct, as it is recorded as found at a much higher horizon.

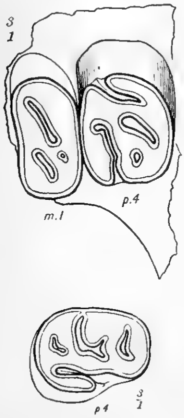

Fig. 8. *Steneofiber montanus.* Upper and lower molars x $\frac{3}{1}$. Type. Lower Beds of Smith Creek, Montana (Lower Miocene).

5. **S. montanus.** Allied to *S. nebrascensis*, but larger, with somewhat longer teeth, and enamel inflections deeper and more complex. The type is an old individual, whence the antero-

posterior direction of the internal upper and external lower enamel inflections, on which Professor Scott largely relies to distinguish the species. Two anterior fossettes are preserved on p^4, while the posterior fossette has already disappeared.

6. **S. hesperus.** Founded on the lower jaw of a young individual which is certainly close to *S. montanus* if not identical; the difference in age prevents any accurate comparison. The size is the same at similar points of wear; the upper incisors are more rounded externally, but the value of this character is doubtful. The depth and complexity of the enamel folds, as nearly as I can judge on the specimens, correspond fairly well.

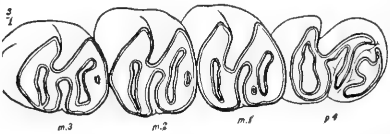

Fig. 9. *Steneofiber hesperus.* Lower molars x $\frac{3}{1}$. Type. White River, Montana.

7. **S. complexus.** Founded on the anterior half of the skull and jaws of an animal younger than any of the preceding types, still retaining the milk premolars. The skull has the long, slender muzzle of *S. nebrascensis;* the postorbital constriction is moderate, and the temporal crests do not unite into a sagittal crest, but are separate, as in *S. gradatus.* The difference in wear precludes comparison of the teeth with those of the remaining species; the dimensions of the masseteric scar and coronoid process given by Mr. Douglas as distinguishing characters likewise change with age so much as to be unsafe specific distinctions. The separate temporal crests may constitute a valid specific distinction.

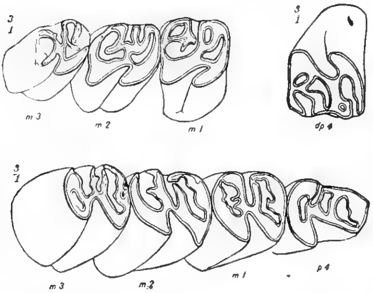

Fig. 10. *Steneofiber complexus.* Upper and lower molars. x $\frac{3}{1}$. Type. White River (?), Montana.

Eucastor (*Leidy*) *Allen.*

This genus is represented by a single species found as yet only in the Nebraska Loup Fork. The teeth are considerably more hypsodont than in the American *Steneofibers;* the molars have but one internal and one external enamel inflection (fossettes in the type specimen). The upper premolar has three external and the lower premolar three internal inflections, as in *Steneofiber* and *Castor.* The position of *Eucastor* is very doubtful; if, indeed, it is a true Castorid at all, it cannot be very nearly allied to either *Castor*, or *Steneofiber.* To this genus and species probably belong, besides the type, parts of two lower jaws in the Cope Collection.

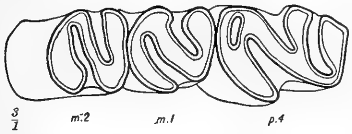

Fig. 11. *Eucastor tortus* Leidy. Lower molars x $\frac{2}{1}$. No. 8332 (Cope Coll.) Loup Fork (Republican River Beds), Nebraska.

OTHER CASTORIDÆ FROM THE LOUP FORK.

The two isolated teeth which form the type of Leidy's *Hystrix venustus*, if they are really from the Loup Fork, are much more likely to be Castorid than Hystricid, the latter not being likely to occur as far down in the Tertiary of the Western States as the Miocene. Possibly with these species should be associated a broken tooth from the Colorado Loup Fork, of the same size and general proportions and pattern as *H. venustus.* Another isolated tooth from the same beds, No. 9364, represents a species probably undescribed, a little larger than *S. montanus*, more hypsodont and of more complicated pattern. A third specimen is part of a lower jaw with m_2–$_3$, the latter just emerging. This is much more brachydont than *Steneofiber*, although of somewhat the same general pattern, and somewhat smaller than the described species. The style of the teeth suggests *Spalax* rather than any other genus of Rodentia with which I am acquainted.

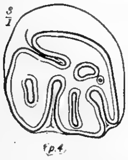

Fig. 12. *Steneofiber* sp. indesc. Upper premolar x $\frac{3}{1}$. No. 9364. Loup Fork (Pawnee Creek Beds), Colorado.

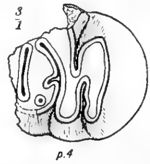

Fig. 13. ? Castorid, indet. x $\frac{2}{1}$. Loup Fork (Pawnee Creek Beds), Colorado.

Fig. 14. ? Castorid, indet. Last two lower molars x $\frac{3}{1}$. Loup Fork (Pawnee Creek Beds), Colorado.

LEPORIDÆ.

Palæolagus *Leidy.*

The genus was based on the division of the anterior lower premolar into two columns, instead of three as in *Lepus*. The dentition and characters of the front of the skull and of parts of the skeleton were fully figured and described at length by Professor Cope in his 'Tertiary Vertebrata,' and have been further discussed and revised in recent papers by Dr. Forsyth-Major on the Lagomorpha. We are now enabled to add certain skull characters, not hitherto known.

Palæolagus has a well-developed postfrontal process in all four species, scarcely less than in *Lepus ennisianus*, but much less than in modern Lepores. The angle between basicranial and basifacial axes varies considerably in the different species, but in none is it as great as in the modern species of *Lepus*. The brain is relatively smaller than in *Lepus*. The tooth pattern varies greatly during life; in the young it approximates that of *Lepus*, especially in such species as *L. ennisianus;* in the old animal it becomes much simpler. *P. agapetillus* is the most advanced in tooth, but least in skull, characters; *P. intermedius* most nearly approaches the John Day *Lepus*.

The pattern of the teeth changes greatly in *Palæolagus*, apparently from the superposition of a new pattern (that of *Lepus*) on an older and simpler one. The young individuals show an internal inflection on the upper molars, whose depth and persistence varies in the different species; there is also an external inflection, never deep, but rather persistent, and a median crescent which originates as an anterior marginal inflection on p^2, an anteroexternal one on p^3 (apparently median-external on p^4 and m^1), a postero-

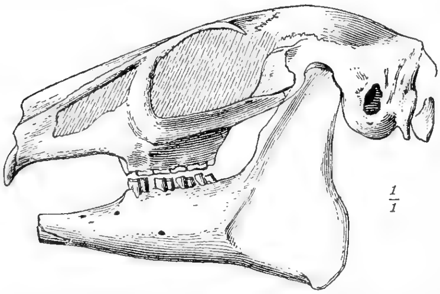

Fig. 15. *Lepus ennisianus.* Cope. Skull and lower jaw natural size. Type specimen No. 7190. John Day, Oregon. Muzzle supplied from another individual.

external one on m², and a posterior one on m³. The median crescent is somewhat less persistent than the internal inflection. Enamel is lacking on the external side of the teeth except in very young animals.

The internal inflection is that which has become deeper and more persistent in *Lepus;* the crescent has disappeared in modern species of *Lepus*, and in the John Day *L. ennisianus* apparently does not persist as long as in *Palæolagus*. The enamel fails on the external side of the upper teeth of *Lepus* except for a little while after they are protruded.

Dr. Forsyth-Major has suggested that the second upper incisor of the Lagomorpha has originated from the posterior cusp of such a tooth as that of *Plesiadapis;* the bifanged tooth splitting in two and the large anterior cusp giving rise to the large incisor of the modern lagomorph. *Palæolagus*, he thinks, might help to verify this theory. But the incisors of *Palæolagus* are quite of modern type. It is to the lower Eocene Rodentia, including the Mixodectidæ, or to the as yet little-known fauna of the Cretaceous, that we must look for light on the method of evolution of their teeth. But Eocene Lagomorpha have not yet been discovered.

Palæolagus approaches most nearly to Forsyth-Major's *Caprolagus* group among modern Leporidæ. These species are less specialized for speed, and in consequence the head is carried lower and more forward, and the basicranial and basifacial axes are at a smaller angle.

Angle between basifacial and basicranial axes in different species of Palæolagus and Lepus.

P. agapetillus	7°
P. intermedius	20°
P. haydeni	22°
L. ennisianus	33°
L. campestris	47°

Palæolagus ? agapetillus *Cope.*

Professor Cope held this species as distinct in 1874, but in 1884 united it with *P. haydeni*. A skull found by our party in 1898 in the upper levels of the White River beds appears distinct from *P. haydeni.* It is smaller, more narrow and elongated, the muzzle more slender. The anterior half of another skull and several jaws, chiefly or all from the same upper horizon, may be referred here, although they approach *P. haydeni* somewhat more nearly than does the complete skull. The distinctive characters are: slender and narrow muzzle, small teeth, internal median fold of enamel on upper molars more deeply incised and more persistent than in *P. haydeni.* The species appears to be good, on the evidence of some half-dozen specimens referred to it and compared with the very numerous *P. haydeni* specimens in our collections. Whether the type of *P. agapetillus* is properly referred to it, I am unable to decide; but leave it provisionally.

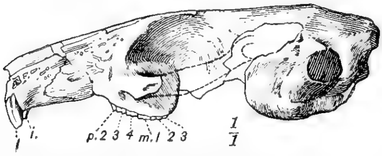

Fig. 16. *Palæolagus ? agapetillus.* Skull, natural size. No. 8704. White River (Martin Cañon Beds), Colorado.

Palæolagus haydeni *Cope.*

Tricium annæ Cope; *Tricium avunculus* Cope; *Tricium leporinum* Cope.

The additional specimens collected by American Museum parties include no complete skull of this species. The best one, No. 9327, shows a skull shorter and wider than *P. agapetillus* or *intermedius*, brain-case rounder than in either, basifacial axis bent down about as in *P. intermedius*, arch heavier than in *Lepus ennisianus*, the jugal a band of uniform width, thickened at the upper and lower margins. Teeth larger than in *P. agapetillus*, less transversely broadened, medial internal furrow less deeply incised or persistent. A scapula, vertebra, and metapodial, associated with this specimen, agree in size with Cope's skeleton material of *P. haydeni.*

Palæolagus intermedius *Matthew.*

Type, a nearly complete skull from the upper levels of the White River, at Castle Rock, Cedar Creek, Col. Associated type, upper and lower jaws and fragments of skeleton from same level and region.

This skull is much more depressed on the basicranial axis than *P. agapetillus;* it has a long and heavy muzzle, unlike the slender, sharp muzzles of the two preceding species; the teeth are larger than those of *P. haydeni*, but resemble them in pattern; the length of the diastema is equal to that in *P. turgidus*, but the teeth are much smaller, and of more *Lepus*-like pattern; the skeleton appears to be as large as that of *P. turgidus*, and of similar proportions. The postfrontal process is nearly as large as in *Lepus ennisianus;* the muzzle is of the same length as in that species, but heavier; the basifacial axis is somewhat less depressed, and the brain-case is distinctly smaller.

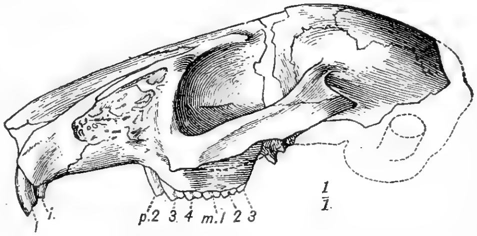

Fig. 17. *Palæolagus intermedius.* Skull, natural size. Type. No. 8722. White River (Martin Cañon Beds), Colorado

Palæolagus turgidus *Cope.*

P. triplex Cope; ? *Tricium paniense* Cope.

Young jaws of this species show a third lobe on the p_4–m_2 and a third lobe on p_3, both of which disappear in the old animal. The jaw on which *P. triplex* was founded appears to be a juvenile stage of *P. turgidus*, in which these characters are very marked. We have no other jaws of the same age; but if the twelve or fourteen examples of lower jaws be arranged according to age (determined by wear on end of p_3) they form a perfect series from *P. triplex* to the type of *P. turgidus*. Cope, in comparing the series, came to the conclusion that the difference between *P. turgidus* and *P. triplex* could not be entirely explained as a matter of age; but the present writer is unable to see sufficient difference to warrant the retention of the species.

Part of a skull, No. 1429*a*, is referred here; it belongs to a very old individual, and the tip of the muzzle and brain-case are missing. It appears to be a short-skulled species, considerably broader but not much longer than *P. intermedius;* the angle of the basifacial axis cannot be determined, and the teeth are very much worn, so that the internal inflection of the enamel has disappeared on the molars, although it persists on pm_4.

Very little additional material of this species has been found by our party, and none that throws any new light on the younger stages of tooth-change, so that Professor Cope's provisional reference of *Tricium paniense* (juvenile *P. turgidus*) cannot be confirmed.

Palæolagus temnodon *Douglas.*

Allied to *P. haydeni* but probably distinct, as it comes from a lower horizon and a widely separate locality.

The Skull of Hypisodus, the Smallest of the Artiodactyla, with a Revision of the Hypertragulidæ.

By W. D. Matthew.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XVI, Article XXIII, pp. 311–316.

New York, Sept. 25, 1902.

The Knickerbocker Press, New York

Article XXIII.—THE SKULL OF HYPISODUS, THE SMALLEST OF THE ARTIODACTYLA, WITH A REVISION OF THE HYPERTRAGULIDÆ.

By W. D. Matthew.

A very well-preserved skull of this tiny Artiodactyl was found by the writer at Pawnee Buttes, northeastern Colorado. In connection with the fragments of the skeleton already described from the same region, it gives a fairly complete idea of the characters.

The animal was not larger than a 'cottontail' rabbit. The orbits are remarkably large, as are likewise the tympanic bullæ. The tip of the muzzle is unfortunately missing, but enough is preserved to show that it was slender and short. The whole skull is distinctly more brachycephalic than in any other White River selenodont—more so, indeed, than in any of the modern Cervidæ or Antilopidæ with which I have compared it. The molar dentition consists of five teeth in each jaw, p$\frac{3}{3}$ — m$\frac{3}{3}$; p$\frac{2}{2}$ is present in young individuals and represented by an alveolus in the older animals. A considerable diastema is in front of this alveolus in the upper jaw, and

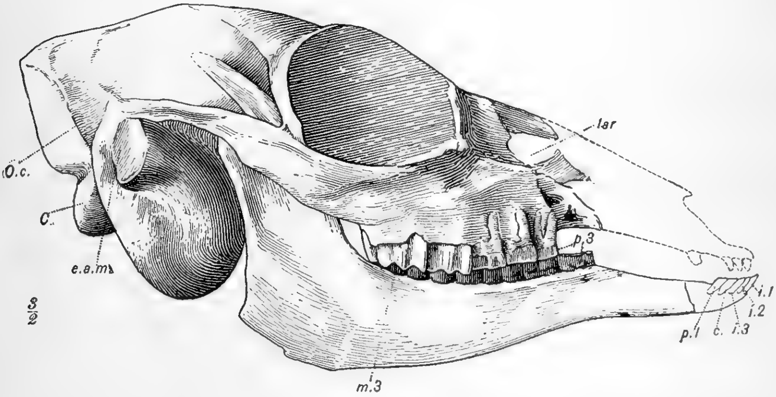

Fig. 1. *Hypisodus minimus* Cope. Skull, x $\frac{3}{2}$. No. 9354. White River (Cedar Creek Beds), Pawnee Buttes, Colorado.

anteriorly to this the muzzle is broken off on both sides (or is not calcified). A longer diastema precedes the alveolus of p_2 in the lower jaw, and in front of that, on evidence of other specimens, it is known that there are five small subequal teeth, probably incisiform.

The antorbital foramen is double, opening above the diastema in front of the molar series. There appears to be a small prelachrymal vacuity. The postorbital bar is complete. The orbit is surrounded by a thin prominent ring, of which the inferior and anterior parts (jugal and lachrymal) are more prominent, and the superior part (frontal) less prominent than in *Hypertragulus* or *Leptomeryx.* The eye, therefore, faced much more upward than in these genera; it was more prominent and much larger in proportion. The basifacial axis is much more bent down on the basicranial axis than in other Hypertragulidæ. The bullæ are very large, connate anteriorly, with a long, prominent, enclosed meatus opening behind the origin of the zygoma. The occiput projects much more backward than in *Hypertragulus* or *Leptomeryx.* The paroccipital processes are slender, and are coössified with the bullæ except just at the tip.

The lower jaw is slender, its condyle set high up, and the long coronoid process is slightly curved. It does not possess the angular hook seen in certain of the Camelidæ.

The limbs and feet I have described in a previous article. The ulna and radius are coössified, and the distal end of the fibula is coössified with the tibia. The cuboid and navicular were coössified, the median metatarsals distinct though appressed, the laterals thread-like but still complete.

Hypisodus was much less *Tragulus*-like than *Hypertragulus* or *Leptomeryx*, and superficially resembled rather the dwarf antelope *Madoqua.* Its real relationships are more nearly with *Hypertragulus* than anything else, but it is a remarkably modernized animal for the formation in which it is found. The resemblance to *Madoqua* is a striking instance of parallel adaptation.

FAMILY HYPERTRAGULIDÆ COPE.

(LEPTOMERYCIDÆ *Scott.*)

Leptomeryx *Leidy.*

Dentition, $I\frac{?}{3}\ C\frac{0-1}{1}\ P\frac{3}{4}\ M\frac{3}{3}$. Lower canine incisiform, first premolar small, caniniform, with a long diastema in front of it and a somewhat shorter one behind. Upper canine small or absent. Second, third, and fourth premolars in series with molars, p^4 with two crescents, p^{2-3} with anterior, posterior, and internal accessory cusps. Mesostyle prominent on upper molars. Second, third, and fourth lower premolars in series with molars, trenchant, with anterior basal cusp, basin heel, and accessory ridges from the protoconid. Last molar with heel composed of a large posteroexternal crescent and a small anterointernal flattened cusp (as in *Palæomeryx*).

Skull of moderate length, muzzle slender, elongated, orbits not very prominent. Prelachrymal vacuity diamond-shaped, situated rather above than in front of the lachrymal. Bullæ small, not filled with cancellous tissue.

Ulna and radius separate; tibia and fibula separate; navicular and cuboid united. Manus of four usable digits, the lateral pair smaller, no cannon-bone. Pes with cannon-bone and no lateral digits (? the small proximal splints of metatarsals II and V fused to the cannon-bone). Hoofs small, pointed.

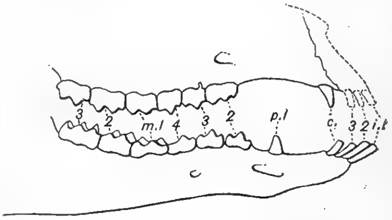

Fig. 2. Dentition of *Leptomeryx.*

1. **L. evansi** Leidy. White River (Oreodon Beds). S. Dak.

LEIDY, Ext. Mam. Dak. and Neb., p. 165, pl. xiv, figs. 1–8.— SCOTT, Jour. Morph., V, Dec. 1891. SCOTT, Trans. Wagn. Inst. Sci., 1899. 15.

2. **L. mammifer** Cope. White River (? Titanotherium Beds), Swift Current Creek, Canada.

COPE, Rep. Geol. and Nat. Hist. Surv. Canada, I, 1885 (1886), 84*c*.

One and a half times the linear dimensions of *L. evansi.* Prof. Cope distinguished it by the presence of a separate cusp between the entoconid and the heel of m^3; this appears, however, to be only the anterointernal cusp common to all species of *Leptomeryx.*

3. **"L." esulcatus** Cope. White River (? Titanotherium Beds), Swift Current Creek, Canada.

Cope, Mem. Geol. Sur. Can. III, 1891, 22, pl. xiv fig. 5.

Based on a single upper molar, which, judging from Cope's figure, is not *Leptomeryx*, suggesting rather an ally of *Palæomeryx*, so far as such slight evidence is worth consideration.

4. **"L." semicinctus** Cope. White River (? Titanotherium Beds), Swift Current Creek, Canada.

Cope, *l. c.*, p. 23, pl. xiv, fig. 8.

This species is also known by a single upper molar. It has twice the linear dimensions of *L. evansi;* tooth broader transversely, with heavy cingular ridge (protostyle) internal to protocone and strong cusp (hypostyle) anterointernal to hypocone. This is clearly not *Leptomeryx*, and is distinct from any described White River genus (except possibly *Calops*, with which I am unable to compare it; Prof. Marsh states, however, that the molars of *Calops* are like those of *Protoceras*, in which case it is not "*L.*" *semicinctus*). Two upper molars in the Am. Mus. Collection from the Protoceras Beds of South Dakota probably represent this species.

5. **Leptomeryx** sp. indesc.

A smaller species occurs in the Leptauchenia clays in Colorado and in the Protoceras Beds of South Dakota distinguished by simpler premolars, narrower, more hypsodont molars. The deuteroconid of p_4 is not distinct as in *L. evansi*, but represented only by a ridge descending anterointernally from the point of the protoconid; p_3 is smaller and more trenchant; the internal faces of the molar cusps are more convex. This may prove varietal when *L. evansi* is examined from more localities and regions.

6. **Leptomeryx** sp. indesc.

A larger, somewhat more brachydont species or variety, characteristic of the Protoceras sandstones. Premolars proportionately larger, longer, and more complicated; anterointernal cusp of p_4 less prominent, posterointernal (hypostylid) more so; hypoconid ridge bifid posteriorly, into a posterior branch which passes backward to the posterior margin, and a posterointernal branch projecting into the basin of the heel. P_1 more anterior in position than in *L. evansi*, probably near anterior end of diastema, while in *L. evansi* it is nearer to p_2 than to c_1.

Hypertragulus *Cope.*

Dentition, $I\frac{?}{?}\ C\frac{1}{1}\ P\frac{4}{4}\ M\frac{3}{3}$. Lower canine incisiform, first premolar large, fully caniniform, with a short diastema in front and a long one behind. Upper canine enlarged, first upper premolar two-rooted, with diastema before and behind. Second lower premolar spaced, simple, without accessory cusps; third with heel; fourth with anterior cusp and heel; but all though equally trenchant simpler than the corresponding teeth in *Leptomeryx*. Second upper premolar simple, two-rooted; third with internal cusp; fourth with two crescents. No mesostyle on upper molars. Heel of last lower molar composed of two equal opposite crescents. Molars somewhat more hypsodont than those of *Leptomeryx*.

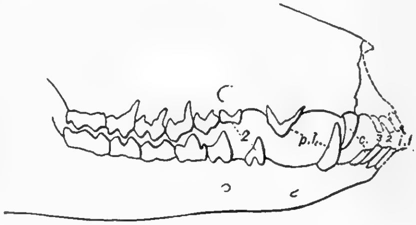

Fig. 3. Dentition of *Hypertragulus*.

Skull much like that of *Leptomeryx*, but somewhat shorter, muzzle slenderer, supraorbital ridges much more prominent. Prelachrymal vacuity as in *Leptomeryx*, bullæ somewhat larger.[1]

Ulna and radius coössified; tibia coössified with distal end of fibula; navicular and cuboid united. Manus of four separate usable digits; pes with two separate digits and splints representing the lateral metatarsals.

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[1] In his recent discussion of this genus Prof. Scott interprets the dentition as $I\frac{?}{3}\ C\frac{1}{1}\ P\frac{4}{3}\ M\frac{3}{3}$, the first premolar absent and lower canine caniniform. It would appear rather that, as in most other selenodonts, the canine is incisiform. The number of incisors is not certainly known; but it seems certain that both in the John Day skulls on which Prof. Scott's description and figures were based, and in the White River skulls in the Amer. Mus. collection, the inferior tooth, which Prof. Scott considers as a canine, closes behind, not in front of, the upper canine; his drawing does not agree with the specimen in this respect. The one skull from the White River in which this part is preserved shows the lower caniniform tooth shutting unmistakably behind the upper canine; it is, therefore, a premolar, and the canine is incisiform as in *Leptomeryx*.

1. **Hypertragulus calcaratus** Cope. White River, Oreodon Beds.

H. tricostatus Cope.[1] Not *H. calcaratus* "Cope" Scott, Trans. Wagn. Inst. Sci., 1899.

2. **Hypertragulus** sp. indesc. John Day.

Hypertragulus calcaratus Scott, Trans. Wagn. Inst., 1899, pl. i, figs. 3–4.

The John Day specimens referred by Profs. Cope and Scott to *H. calcaratus* are a larger, more brachydont species, with heavier muzzle, etc.

3. "**Hypertragulus**" **transversus** Cope. White River, Titanotherium Beds (?), Swift Current Creek.

Cope, Mem. Geol. Sur. Can. III, 1891, 22.

Twice the linear size of *H. calcaratus*, para- and metacones uniformly convex externally, small para- and metastyles and prominent hypostyle anterointernal to hypocone. It is not at all probable that this species is *Hypertragulus* or related thereto.

Hypisodus *Cope.*

Dentition, $I\frac{?}{3}$ $C\frac{?}{1}$ $p\frac{?(3-4)}{3-4}$ $M\frac{3}{3}$. Lower canine incisiform, first premolar small, probably incisiform. Second upper and lower premolars decadent at anterior end of grinding series. Teeth hypsodont, skull very brachycephalic, but muzzle rather long and slender. Prelachrymal vacuity irregular, orbits very prominent, bullæ very large. Lateral digits of pes extremely slender although still entire; no cannon-bone; ulna and radius united.

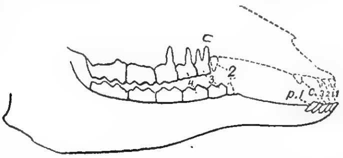

Fig. 4. Dentition of *Hypisodus*.

1. **Hypisodus minimus** Cope. White River (Oreodon clays).

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[1] ". . . I know but the one species, the *H. calcaratus* Cope."—Cope, Proc. Amer. Phil. Soc., 1884, Vol. XXII, p. 24. This statement invalidates *H. tricostatus*, and quite correctly so.

List of the Pleistocene Fauna from Hay Springs, Nebraska.

By W. D. Matthew.

AUTHOR'S EDITION, extracted from BULLETIN

OF THE

American Museum of Natural History,

Vol. XVI, Article XXIV, pp. 317–322.

New York, Sept. 25, 1902.

The Knickerbocker Press, New York

Article XXIV.—LIST OF THE PLEISTOCENE FAUNA FROM HAY SPRINGS, NEBRASKA.

By W. D. Matthew.

In 1893 and 1897 field-parties from the American Museum were sent out by Professor Osborn to collect in the Pleistocene at this locality, a bone-bed near the Niobrara River, not far from Hay Springs. A large collection of horse and camel remains was obtained, and a few specimens of other animals. The horses have been carefully studied by Mr. Gidley, the camels by Dr. Wortman; the remainder of the fauna has been revised and partially studied by the writer, but no results have hitherto been published. A list of the fauna may be of some interest to compare with that found in the Sheridan or Equus Beds at other localities. The appended lists, when based on materials in the Cope Collection, are from determinations by Professor Cope, revised in a few cases by the writer.

Hay Springs, American Museum Collection, 1893 and 1897.

Canis ? latrans. Lower jaw.

? Dinocyon or large Ursid. Metacarpal. This bone appears to exceed in size the corresponding parts in any living species of bear. The character of the diaclasts excludes it from the Felidæ or typical Canidæ, but the Amphicyonine Dogs are somewhat similar, and if not a bear it might represent a very large species of *Dinocyon* (*Borophagus*), a genus known to occur in the late Pliocene (Blanco).

? Felidæ indet. Several species are represented by foot-bones and fragments of limb-bones.

Fiber zibethicus. A skull and several jaws, all of which come within the limits of variation of the modern muskrat.

Arvicola, cf. **amphibius.** Upper and lower jaws.

Cynomys, cf. **ludovicianus.** Palate.

Thomomys sp. indet. Upper and lower jaws.

Castoroides sp. indet. Teeth, limb-bones, and astragali.

Mylodon sp. indesc. A complete skull, jaw, and large part of the skeleton of a sloth allied to but distinct from *Mylodon harlani.* Description is reserved for the present.

Equus complicatus Leidy. This, the first-described and most characteristic of American fossil horses, is by far the most abundant fossil at the Hay Springs locality. Numerous bones of all parts of the skeleton were obtained.

Equus fraternus. Smaller and not nearly as abundant as *E. complicatus.*

Equus ? scotti Gidley. Upper and lower jaws.

Elephas primigenius columbi. Tusk, several foot-bones, and grinders.

Platygonus vetus Leidy. Palate.

Platygonus compressus Leconte. Upper and lower jaws.

Undescribed Porcine, cf. ? *Leptochœrus.* Upper premolar (obtained in digging a well near Hay Springs).

Camelops kansanus Leidy. Parts of jaws, teeth, vertebræ, limb- and foot-bones. More than one species is quite probably represented, but the material does not warrant attempt at separation.

Camelops vitakerianus Leidy. Teeth, jaw fragments, etc.

Camelus americanus Wortman. Lower jaw.

Antilocapra, cf. **americana.** Parts of jaws, limb- and foot-bones.

Capromeryx furcifer, n. g. et sp.

A small jaw containing p_2–m_3 indicates an animal allied to *Antilocapra* and somewhat more nearly to *Merycodus*, but generically distinct from either. The premolars are most nearly like those of *Merycodus;* p_4 is long, trenchant, simple, lacking the deuteroconid; p_3 and especially p_2 are more complicated. In *Antilocapra* p_4 is shorter, with prominent deuteroconid, and the anterior premolars are short and simple, thus approaching the premolar characters of goats and sheep. The molars in *Capromeryx* are fully as hypsodont as in *Antilocapra*, much more so than in *Merycodus*, which more nearly approach the brachydont teeth of the deer.

The species was of about two-thirds the (lineal) dimensions of the American antelope.

This unexpected addition to the short list of Ruminants of the American Pleistocene is rather interesting despite its fragmentary character. It is, much more certainly than *Antilocapra*, descended from the little group of antelopine deer of the American Miocene, of which *Blastomeryx*, *Cosoryx*, and *Merycodus* are the known forms. This group is characterized by the combination of antlers approaching those of the deer and teeth approaching those of the antelopes. The antlers are forked or several times branched, provided usually (if not always) with a burr,—hence, in Professor Cope's opinion, deciduous; smooth surfaced,—hence probably covered permanently with 'velvet.' The teeth are more hypsodont than in any of the deer, less so than in *Antilocapra*, and the premolars have preserved somewhat of that primitive, long, trenchant character seen among modern genera only in *Tragulus*, but generally present among the older Tertiary selenodonts. *Blastomeryx* (*B. gemmifer*) is the oldest, smallest, and most brachydont genus; *Merycodus* is more hypsodont. *Cosoryx* has a simple forked antler, just above the eyes, like the horn of *Antilocapra*, with a burr at base, and quite hypsodont teeth.

Blastomeryx has antlers like those of the Virginia deer, but I have not seen more than four tines; the face is very short and the antlers more nearly over the eyes than in modern deer, less so than in *Antilocapra*. The position of *Merycodus* is uncertain; present evidence indicates that it may be distinct from *Cosoryx*. The large, completely brachydont species referred by Cope and Scott provisionally to *Blastomeryx* and by Douglas to *Palæomeryx* are distinct from any of these antelopine deer (and from any European genus as well), forming a transition between them and the contemporary and later true deer of Europe and America. The new genus, *Capromeryx*, may, when better known, prove to be a transition between the antelopine deer and *Antilocapra*.

The above list is obviously a plains fauna. Horses and camels are the most abundant. There are antelopes, but no deer; Canidæ are found, but few if any Felidæ. *Platygonus* is much more swift-footed and more advanced in dentition than is the modern peccary, and may be supposed to have lived more in the open. Prairie-dogs, gophers, and field-mice are now to be found on the plains in the same region, and muskrats along the streams. Of the habits of *Mylodon* we know little; perhaps it, like the mammoth, frequented the watercourses and valleys of open country, rather than the denser forest regions which were the home of the contemporary mastodons. The *Castoroides* remains are too fragmentary to tell whether it was the same as the eastern species.

SILVER LAKE (LAKE CO.), OREGON.[1]

Canis ? *latrans*, jaws, limb- and foot-bones.
Canis, cf. *occidentalis*, limb- and foot-bones.
Vulpes, cf. *pennsylvanicus*, femur and tibia.
Lutra canadensis, front of skull, jaws, limb-bones.
Fiber zibethicus, jaws, limb-bones.
Arvicola sp. div., jaws, limb-bones.
Thomomys sp., skeleton nearly complete.
Geomys sp., jaws, limb-bones.
Castor sp., one molar.
Castoroides sp., teeth.
Lepus sp. (cf. *campestris*), parts of jaws, limb-bones, etc.
Mylodon sodalis Cope (? = *M. harlani*), phalanges.
Equus pacificus, numerous bones from all parts of skeleton.
Elephas primigenius ? *columbi*, teeth, foot-bones, vertebræ, etc.
Platygonus, cf. *vetus*, teeth.
Platygonus sp. minor, teeth.
Eschatius conidens, parts of jaws.
Camelops kansanus, parts of jaws, limb- and foot-bones.
Camelops vitakerianus, upper jaw, ? foot-bones.
? *Camelops* sp. max., teeth, foot-bones, etc.
Antilocapra, fragments of feet.

With the above mammalia were found numerous bird remains, which have been studied by Dr. Shufeldt.

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[1] Revised from Prof. Cope's list.

This is equally a plains fauna, with two aquatic mammals, *Castor* and *Lutra*, not found at Hay Springs. Otherwise the list is very similar to that of Hay Springs, and, like it, is characterized by the absence of the forest types found in the Pleistocene cave deposits, river-gravels, and peat-bogs of the East.

OREGON DESERT.

A collection made by Geo. C. Duncan at some point or points of which I can find no exact record. The collection was considered as of Pliocene age by Professor Cope, because it contained *Equus*, *Hipparion*, and *Teleoceras*, along with less characteristic remains referred to *Holomeniscus* (= *Camelops*) and *Elephas*. The *Equus* and *Elephas* bones, however, are from a different matrix from the other bones, and the *Holomeniscus* is more probably *Pliauchenia* or *Procamelus*. They are, therefore, probably from two distinct formations, the older one of the age of the later Loup Fork, the newer one of the age of, if not identical with, the Silver Lake Equus Beds.

WASHTUCKNA LAKE, WASHINGTON.

Taxidea sulcata (= *americana*), parts of skulls, jaws, limb- and foot-bones.
Felis, cf. *imperialis*, parts of limb-bones.
Felis, cf. *concolor*, parts of limb-bones.
Felis, cf. *canadensis*, parts of limb-bones.
Mylodon sp., astragali and foot-bones.
Equus sp., bones of feet and some teeth.
? *Camelops*, cf. *kansanus*, foot-bones.
? *Camelops*, cf. *vitakerianus*, foot-bones.
? *Camelops*, sp. max, foot-bones.
Alces brevitrabalis, parts of antlers, foot-bones, etc.
Alces semipalmatus, parts of antlers, foot-bones, etc.
Cariacus ensifer, parts of antlers, foot-bones, etc.
Oreamnus, parts of horn.

This fauna shows a large proportion of forest and mountain types, and no aquatic mammals. It is a very inadequate list, and I have seen no description of the locality where the specimens were found, but it is probable that the physical conditions were quite different from those prevalent in the Silver Lake and Hay Springs localities.

On Jurassic Stratigraphy on the West Side of the Black Hills — Second Paper on American Jurassic Stratigraphy.

By F. B. Loomis.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XVI, Article XXXI, pp. 401–407, Pll. liv–lv.

New York, Nov. 3, 1902.

The Knickerbocker Press, New York

Article XXXI. — ON JURASSIC STRATIGRAPHY ON THE WEST SIDE OF THE BLACK HILLS — SECOND PAPER ON AMERICAN JURASSIC STRATIGRAPHY.

By F. B. Loomis.

Plates LIV and LV.

During June, 1901, a party, sent out by Professor Osborn, from the American Museum of Natural History, prospected the Jurassic exposures of the west side of the Black Hills for Dinosaur remains. In connection with this work sections were made by the writer at six of the best and most characteristic exposures, to show the stratigraphy of these deposits. These were made at Professor Osborn's request for comparison with the sections previously made by the writer in the Como district of Wyoming.

The area covered extends from a little north of Hulett to fifteen miles south of Newcastle; the exposures stretching some 125 miles in length, and varying from a fourth of a mile to ten or twelve in width. The distribution of the Jurassic in the region is shown in the map accompanying the paper, as is also the location of the individual sections. The Jurassic is exposed mostly in escarpments, capped by the heavy Dakota sandstone, which makes the 'rim.' These escarpments generally face toward the centre of the Hills and continue on around the north and east sides as well as on the west side. The soft clays which predominate in the Upper Jurassic are the cause of a considerable valley all around, just inside the 'rim.' The strata dip in varying degrees away from the centre of the Hills, but are in the best exposures nearly horizontal.

The Jurassic is divisible into two parts: a lower marine, corresponding to Knight's Shirley[1]; and an upper fresh or brackish water corresponding to Scott's Como.[2] On the east

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[1] W. C. Knight, 'Jurassic Rocks of Southeastern Wyoming,' Bull. U. S. Geol. Surv., Vol. XI, pp. 377–388.

[2] W. B. Scott, Introduction to Geology, p. 447 (footnote).

side of the Hills, a thick bed of sandstone immediately overlies the Triassic; but this bed is everywhere lacking on the west side of the Hills, the transition being uninterrupted, and seen only in the change from sandy red clay to sandy green clay.

On comparing the sections made on the east side of the Hills,[1] these on the west side, and similar sections made in central and eastern Wyoming,[2] it becomes clear that the Jurassic of the west side corresponds more closely with that in central Wyoming (especially on the Medicine and Como anticlines) than the west side corresponds to the Jurassic on the east side of the Black Hills. However, the upper or freshwater beds of the east and west sides correspond with one another better than the marine layers. Many of the most striking layers of the west side can be detected in the centre of Wyoming almost exactly as they occur in the Hills. To bring this out strongly, in the table where the sections are set side by side, the same series of numbers is used as in the table [3] of sections from central Wyoming, and such layers as are recognized as being equivalent are printed in heavy type.

The Triassic of the west side of the Black Hills is made up of barren red sandy clay. This grades into the green sandy clay of the base of the Shirley, which for some eight to ten feet is also barren. Here, however, *Belemnites densus* begins to appear in great abundance. This clay is then the equivalent of and like in texture to the Belemnites layer further west (No. 2). The upper part of the layer may carry thin beds of limestone as in the Inyan Kara Peak section. This is overlaid by a layer of green clay with large limestone nodules (No. 4), which vary in size from six inches to a couple of feet in diameter. It is in and on just such nodules that *Baptanodon* remains are found in the centre of the State. The layer was everywhere [4] present both on the west and east sides of the Hills. However, no trace of *Baptanodon* was found in any of the exposures; but in the stone-pile of a yard on Miller Creek,

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[1] The east side sections are in manuscript; they were made by G. R. Wieland, and verified by myself.

[2] Loomis, Bull. Amer. Museum. Nat. Hist., Vol. XIV, pp. 189–197.

[3] Last cit., p. 192.

[4] Except in the Salt Creek section, which is an unusual one.

two or three *Baptanodon* vertebræ were discovered, and probably came from this horizon in some of the nearby exposures. In the centre of Wyoming this layer has a purple hue, but is otherwise similar.

A sandy limestone or shell sandstone (No. 5) usually follows, which carries several invertebrate marine forms. At the Belle Fourche station, this layer held *Amaltheus cardiformis*, *Ægoceras tumidus* v. Buch, *Ostrea strigulecula* W., *Tancredia inornata* M. & H., *Pseudomonotis curta* W., *P. orbiculata* W., *Dosinia jurassica* W., *Trigonia* sp., and *Pholadomya* sp. This fauna with some variations is widely distributed at this horizon.[1]

From this horizon to the top of the marine Jurassic there is no uniformity in the character of the beds, usually, as in the Belle Fourche section, the clays alternating rapidly with thin beds of sandstone. The Salt Creek section has soft sandstones alternating with denser ones. The Beaver Creek section has nothing to represent the alternations. In central Wyoming there are several clays and sandstones. There is no uniformity except in the rapidly changing character of the deposits.

The top of the marine beds is a green clay (No. 12) of varying texture. The change to fresh- or brackish-water is a gradual one, so that a distinct boundary is difficult to find, but this bed is the highest in which any trace of marine life was found, and is, therefore, used here as a convenient separating horizon.

The base of the freshwater deposits is a bed of sandstone (No. 13), varying greatly in thickness and in character.

No. 14 is a layer of green clay, the lowest in which any traces of Dinosaurs were found. On the north side of Inyan Kara Peak a few fragments of sauropod limb bones occurred; and near the Sheldon P. O. section a few foot bones were found at this level. At the Belle Fourche station traces of Dinosaurs also occurred. In all cases the bones were uniformly hard, but very scarce.

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[1] At the Sheldon P. O. station there occurred *Camponectes platissiformis* W., *Tancredia warreni* M. & H., *T. bulbosa* M. & H., *Avicula mucronata* W., and *Ostrea strigulecula* M. & H. The Kara Peak section had *Amaltheus cardiformis* M. & H., *Ægoceras tumidus* v. Buch, and *Pseudomonotis curta* W

The Inyan Kara Peak section is remarkable for its thickness. This is most marked in the No. 15 bed of sandstone which is here 75 feet thick. The layer is very generally a fairly heavy one and occurs in all the sections.

Next follow several thin layers of variable character, consisting of clays, sandstones and limestone concretions. There is no constant bed till No. 22 is reached, which is a band of maroon clay filled with tiny concretions. It is present in three of the sections and occupies the same position as a similar band in the centre of Wyoming. It is a very good horizon marker, being so distinctive in texture and conspicuous in color. Just above a very constant layer of limestone nodules (No. 23) occurs.

The layers from 24 to 28 are a series of brilliantly colored clays, red, purple, and green in color, and popularly called the "varigated clays." These clays have occasional beds of limestone nodules. In the variegated beds, especially toward the top, Dinosaur remains are not infrequent, but without exception the bones are in a wretched state of preservation, the iron in the colored beds having eaten into them till great spots are mere powder. In all the sections some traces of Dinosaurs were found at this horizon, but they were especially abundant along the lower reaches of the Inyan Kara Creek. On Inyan Kara Creek in these same beds Mr. Thompson found several specimens of *Unio baileyi* L. and *Valvata leei* L. similar to those found by Logan in the Freezeout Mountains. These variegated clays occur on the east side of the Hills, as well as on the west side, also in the Freezeout Mountains, and in the southeastern part of Wyoming.

The top of the freshwater series is everywhere a bed of olive-green clay of considerable thickness, in which Dinosaur remains are extremely rare, but do occur; and where present, the bones are in a good state of preservation. Fragments were found at the Belle Fourche station and near Inyan Kara Peak. The whole is capped by the heavy bedded Dakota sandstone. The sections are often complicated by this sandstone faulting and slipping part way down the slope of the escarpment. In fact the greatest care is required to find exposures where more or less of the face has not faulted and slipped to some extent. The majority of all the Dinosaur prospects were in clays which were faulted out of place.

Of all the sections the Inyan Kara Peak one is the thickest. This is due in great part to the frequency and extra thickness of the sandstones. The Beaver and Salt Creek sections in the same general neighborhood also have larger quantities of sandstone, which fact I take to mean that in the neighborhood there was some land mass during a part at least of the Jurassic period.

EXPLANATION OF THE PLATES.

Fig. I, Map of the country on the west side of the Black Hills, covered by the prospecting party of the American Museum of Natural History in June, 1901.

Line A–B, Belle Fourche Section.
C–D, Inyan Kara Creek Section.
E–F, Sheldon P. O. Section.
G–H, Inyan Kara Peak Section.
I–J, Salt Creek Section.
K–L, Beaver Creek Section.

The map is modified from Scott's Mineral and Geological Map of the Black Hills.

Fig. II, Belle Fourche Section.

The vertical and longitudinal enlargements are the same in all the sections.

Fig. III, Inyan Kara Creek Section.
Fig. IV, Sheldon P. O. Section.
Fig. V, Inyan Kara Peak Section.
Fig. VI, Salt Creek Section.
Fig. VII, Beaver Creek Section.

		BELLE FOURCHE SECTION.	Ft.	INYAN KARA CREEK SECTION.	Ft.	SHELDON P. O. SECTION.	Ft.
	31	Dakota sandstone	180+	Dakota sandstone	80+	Dakota sandstone	50+
Freshwater Jurassic.	**30**	Olive-green clay	70	Olive-green clay	40	Olive-green clay	30
	29			Light green clay	12		
Variegated Clays	**24** — **28**			Maroon clay with small concretions	10		
		Yellow-green clay with small concretions	12	Green clay with small concretions	5		
				Red clay	5		
						Limestone concretions	1
				Green clay	5	Green clay	10
		Maroon clay	10	Maroon clay	6	Maroon clay	5
		Green clay	6	Green clay	20	Yellow-green clay	9
						Red clay	5
	23	Limestone concretions	1	Limestone concretions	1	Limestone concretions	
		Green clay	6			Green clay	8
	22	Maroon clay with small concretions	6			Limestone concretions	1
	21	Green clay with small concretions	10			Red clay	3
	20			Yellow sandstone	9		
				Dense gray sandstone	8		
	19	Limestone concretions	1				
		Green clay	4			Green clay	12
	18						
	17						
	16	Limestone concretions	1			Limestone concretions	1
		Green clay	6			Green clay	12
	15	Soft yellow sandstone	2	Yellow sandstone	5		
	14	Green clay	7	Limestone concretions	1		
	13	Soft yellow sandstone	2	Yellow sandstone	12	Gray sandstone	2
Marine Jurassic.	12*a*			Limestone concretions	1		
	12	Green clay weathering brown	25	Green clay	8	Yellow-green clay	2
		Limestone concretions	1	Gray sandstone	2		
		Green clay weathering brown	20	Green clay with nodules	6		
	11	Gray sandstone	2	Soft sandstone	10	Soft sandstone	10
	8	Green clay	10				
	7	Gray sandstone	2	Gray sandstone	4		
		Green clay	7	Olive clay	5		
		Gray sandstone	1	Sandstone with shells	2		
		Green clay	4	Olive clay	5		
		Gray sandstone	1	Sandstone with shells	2		
		Green clay	6	Olive clay	5		
		Gray sandstone	1	Gray sandstone	2		
	6	Sandy clay	14				
	5	Shell limestone	3				
	4	Sandy clay	10	Olive clay	1+	Olive-green clay with nodules	35
						Concretions	1
						Olive-green clay with nodules	12+
	2	Green clay with Belemnites densus	20+				
	1*a*						
		Total	271+		191+		159+
	1						

NOTE.—Numbers in heavy type indicate that the layer can be recognized in the centre of Wyoming

		KARA PEAK SECTION	Ft.	SALT CREEK SECTION.	Ft.	BEAVER CREEK SECTION.	Ft.
31		Dakota sandstone	15+			Dakota sandstone	20+
30						Brown-green clay	15
						Olive-green clay	66
29						Green clay with small concretions	15
						Maroon clay with small concretions	6
24 — 28	Variegated Clays	Red clay	3				
		Green clay	3			Green clay	15
		Cream sandstone	8				
		Blue-green clay	6				
		Red clay	1				
23	Freshwater Jurassic	Limestone concretions	1				
		Purple clay	3			Maroon clay with small concretions	12
22		Red clay	2			Green clay	6
21		Cream sandstone	2				
20							
19		Green clay	3				
18		Cream sandstone	2				
17		White sandstone	11				
16		Black clay	2			Limestone concretions	1
		White sandstone	8				
15		Yellow sandstone	75	Dark red sandstone	20		
14		Slate-green clay	50			Olive-green clay	8
13		Gray sandstone	15			Buff sandstone	12
12a	Marine Jurassic						
12		Yellow-green clay	6	Olive-green clay with Belemnites densus	12	Green clay with gypsum	20
				Pink sandstone	8	Gray sandstone	1
		Olive-green clay	6	Buff sandstone	4		
11				Soft pink sandstone	4		
8				Dense buff sandstone	15		
7		Sandstone	1	Soft buff sandstone	8		
		Green clay with nodules	3				
		White sandstone	12	Buff sandstone	8		
6							
5							
4		Green clay with nodules	12				
		Soft gray sandstone	8				
		Green clay with nodules	82			Green clay with nodules	30
2		Belemnites densus bed	2				
		Green clay	20	Olive-green clay	35	Olive clay with Belemnites densus	60
		Belemnites densus bed	10				
		Limestone layer	½				
		Sandy green clay	16			Sandy green clay	10
1a				Gypsum	3		
		Total	373½		117		277
1		Red Triassic sandy clay	50+	Red Triassic sandy clay	90+	Red Triassic sandy clay	40+

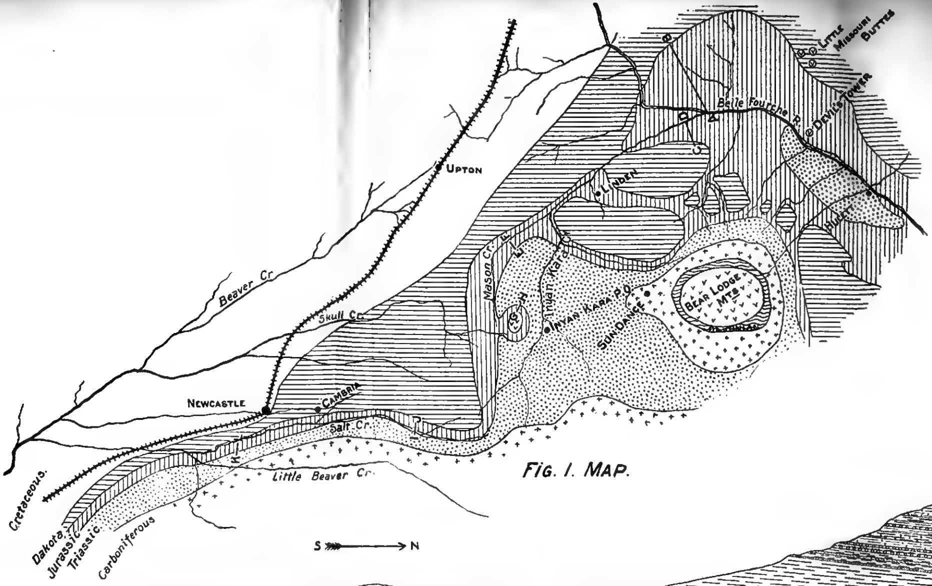


FIG. I. MAP.

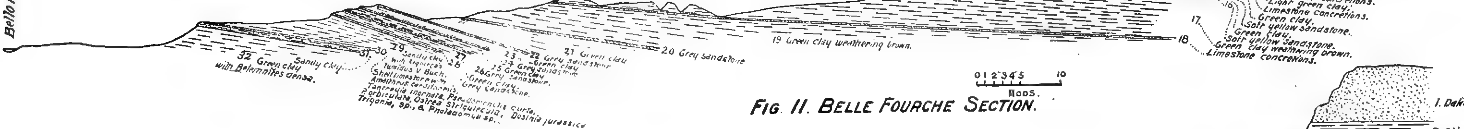


FIG. II. BELLE FOURCHE SECTION.

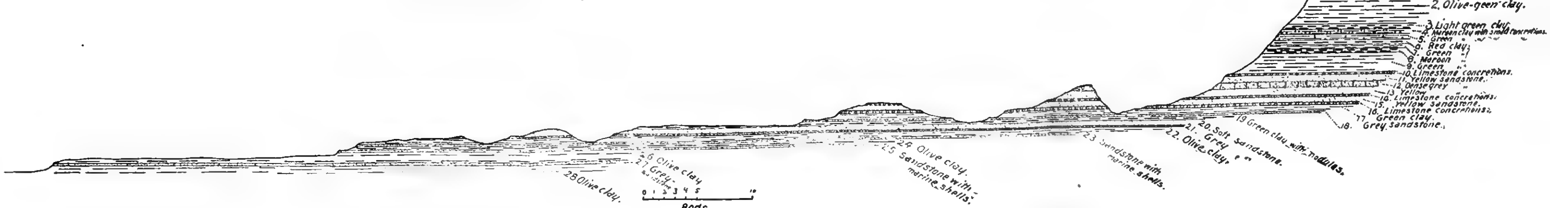
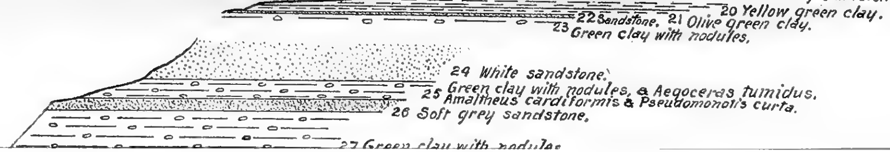


FIG. III. INYAN KARA CREEK SECTION.


20 Yellow green clay.
22 Sandstone.
21 Olive green clay.
23 Green clay with nodules.
24 White sandstone.
25 Green clay with nodules, & Aegoceras tumidus.
Amaltheus cardiformis & Pseudomonotis curta.
26 Soft grey sandstone.
27 Green clay with nodules

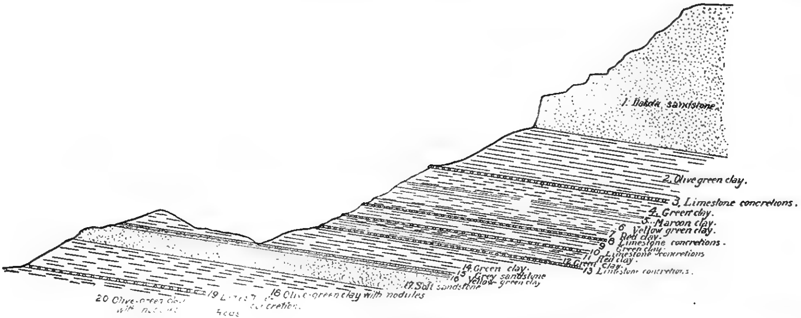


FIG. IV. SHELDON P.O. SECTION.

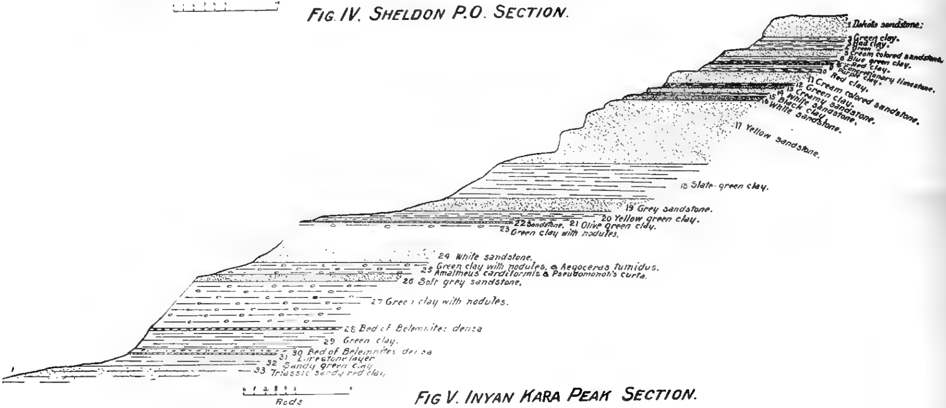


FIG V. INYAN KARA PEAK SECTION.

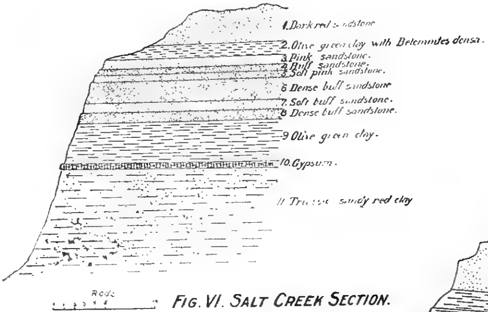


FIG. VI. SALT CREEK SECTION.

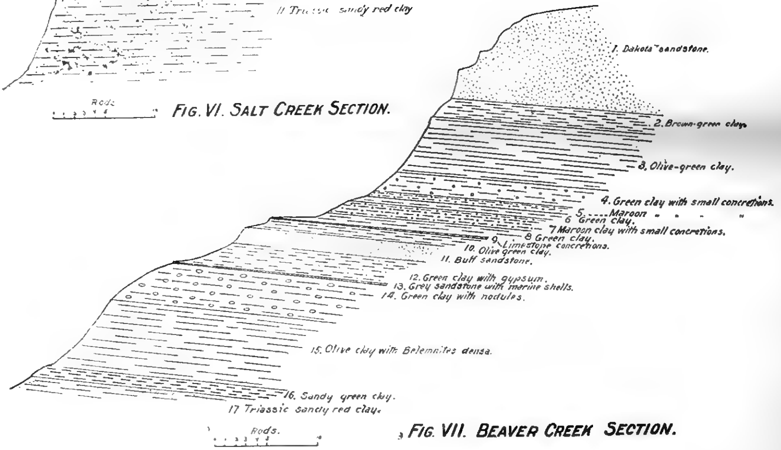


FIG. VII. BEAVER CREEK SECTION.

On Certain Genera and Species of North American Cretaceous Actinopterous Fishes.

By O. P. Hay.

AUTHOR'S EDITION, extracted from BULLETIN

OF THE

American Museum of Natural History,

Vol. XIX, Article I, pp. 1–95.

Plates I–V, and 72 Text Figures.

New York, March 4, 1903.

The Knickerbocker Press, New York

BULLETIN

OF THE

AMERICAN MUSEUM OF NATURAL HISTORY.

VOLUME XIX, 1903.

Article I.—ON CERTAIN GENERA AND SPECIES OF NORTH AMERICAN CRETACEOUS ACTINOPTEROUS FISHES.

By O. P. HAY.

PLATES I–V, AND 72 TEXT FIGURES.

The present paper has resulted from observations made by the author on Cretaceous fishes in the course of his work of identifying, cataloguing, and arranging the Cope Collection of fishes and reptiles, now the property of the American Museum of Natural History. In this collection are most of the types of the fishes which Professor Cope described from the Cretaceous deposits of Kansas, South Dakota, and New Jersey; and there are likewise many other specimens which had not been carefully identified and studied. A comparison of these materials with the types, and of the types with one another, and an estimation of the value of the proposed species in the light of work done by more recent investigators, have resulted in the reduction of a considerable number of nominal species to the position of synonyms. Many of Cope's types have hitherto never been figured and the opportunity offered by the liberality of the Museum authorities has been employed to furnish many drawings and photographic reproductions of interesting specimens. My thanks are especially due to Prof. Henry F. Osborn for the opportunity to prepare and present this

[*January, 1903.*]

paper. Of the drawings, Mr. R. Weber has made numbers 27, 58, 59, 60, 61, 62, and 65. All the others, except 32 and 72, have been prepared by Mrs. L. M. Sterling. The photographs for the plates have been made by Mr. A. E. Anderson, photographer of the Palæontological Department.

PROTOSPHYRÆNIDÆ.

The genus *Protosphyræna* is referred by Dr. A. S. Woodward to the Pachycormidæ; and in this procedure he is followed by Loomis (Palæontogr., XLVI, 1900, p. 221), by Stewart (Univ. Geol. Surv. Kan., VI, 1900, p. 362), and by the present writer (Bibliog. and Cat. Foss. Vert. N. A., 1902, p. 378). A reconsideration of the subject and the study of the materials at hand in this Museum have led me to a different view.

If we refer the genus to this family we must assume that the vertebral column was not at all ossified or only feebly so. That it was composed of well ossified vertebræ cannot yet be proved. However, accompanying the type of *P. dimidiata* there is a single vertebra which belonged close to the skull. It is figured on page 19. This vertebra may be an intrusion from some other fish, but there is nothing in its appearance to suggest this.

So far as the writer can gather from the literature, neither the Isopholidæ, hitherto called Eugnathidæ, nor the Pachycormidæ, possess ossified scapulæ and coracoids. Even the members of the more advanced family Amiidæ, with well developed vertebræ, have scapulæ and coracoids cartilaginous. *Protosphyræna*, on the other hand, has the elements of the shoulder girdle developed as in the modern Isospondyli. While there may be no necessary connection between an ossified shoulder girdle and ossified vertebræ, it seems logical to believe that, when the shoulder girdle is so advanced in its development as it is in *Protosphyræna*, there were probably also well defined vertebræ. It is remarkable that vertebræ have not been certainly collected, but neither has the tail fin been obtained, nor the anal, nor the dorsal fin.

It is proper to add to the above paragraph the statement that in a specimen of *Hypsocormus* from Solenhofen, which the writer has been able to examine, there are evidences of the presence of ossified scapula and coracoid. If this shall prove to be the case, the fact that these elements are ossified in *Protosphyræna* will have no bearing on the question regarding the presence of vertebræ.

While there are many interesting and important characters common to *Hypsocormus* and *Protosphyræna*, there are also many striking differences. I regard the deeply socketed teeth of *Protosphyræna* as furnishing a character of family value. Woodward indeed states that the teeth of *Hypsocormus* are in incomplete sockets, those of the dentary of *H. tenuirostris* (Cat. Foss. Fishes, IV, p. 397) being fused with the bone in sockets which are incomplete on the inner side. The condition of such teeth is certainly very different from that of the teeth of *Protosphyræna*, which are in complete and very deep sockets. It evidently signifies a great departure from the primitive condition in fishes, when teeth become so deeply implanted in the bone and are replaced, not by new teeth developing in the mucous membrane of the mouth, but from germs lodged deep in sockets.

The pectoral fin of *Protosphyræna* is quite different from that of *Hypsocormus*, as may be seen by comparing the description and figures of *P. perniciosa* presented in this paper with the description of the fin given by Dr. Woodward on page 398 of the work cited above. In *Protosphyræna* there is no such intimate fusion of rays and the foremost rays are extremely short.

The condition of the shoulder girdle of *Protosphyræna* would appear to relegate the genus to the Isospondyli. Whether the possession of a splenial and a slight excess of baseosts is sufficient to exclude it from this order may have to be determined hereafter. At any rate, the genus is close to the border line between the Halecomorphi and the Isospondyli.

Protosphyræna nitida (*Cope*).

Erisichthe nitida Cope (E.D.), Proc. Acad. Nat. Sci. Phila. 1872, p. 280; Bull. U. S. Geol. and Geog. Surv. Terrs. I, No. 2, 1874, p. 42;

Vert. Cret. Form. West, 1875, pp. 217, 275, pl. xlviii, figs. 3–8; Bull. U. S. Geol. and Geog. Surv. Terrs. III, 1877, p. 821 (in part).

Protosphyræna nitida NEWTON (E. T.), Quart. Jour. Geol. Soc. XXXIV, 1878, p. 794. — FELIX (J.), Zeitschr. deutsch. geol. Gesellsch. XLII, 1890, p. 278 (in part). — WOODWARD (A. S.), Cat. Foss. Fishes Brit. Mus. III, 1895, p. 409. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 227 (in part only). — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

Pelecopterus chirurgus COPE (E. D.), Vert. Cret. Form. West, 1875, pp. 244E, 273, pl. xlviii, fig. 1; pl. liv, fig. 9.

Protosphyræna chirurgus HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

Erisichthe penetrans COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. III, 1877, p. 822.

Protosphyræna penetrans NEWTON (E. T.), Quart. Jour. Geol. Soc. XXXIV, 1878, p. 795. — FELIX (J.), Zeitschr. deutsch. geol. Gesellsch. XLII, 1890, p. 297, pl. xiv, fig. 1. — CROOK (A. R.), Palæontogr. XXXIX, 1892, p. 109. — WOODWARD (A. S.), Cat. Foss. Fishes Brit. Mus. III, 1895, p. 409. — STEWART (A.), Kan. Univ. Quart. VII, A. 1898, p. 192; Univ. Geol. Surv. Kansas, VI, 1900, p. 369, pl. lxiii, fig. 4. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 227, pl. xix, figs. 1–5.—HAY (O. P.) Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

Protosphyræna obliquidens LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 225, pl. xx, figs. 1–4. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

The type of Professor Cope's *Erisichthe nitida* is now in the American Museum of Natural History. It consists of both premaxillæ, a portion of the left dentary, and the adhering postsplenial, the supposed hyomandibular, and a bone (Vert. Cret. Form. West, pl. xlviii, fig. 7) which is as yet unidentified. Of the same specimen Cope possessed also a fragment of the fin, which lacked the anterior edge and was therefore not susceptible of comparison with other species based on parts of fins. This fragment is now missing. Dr. Loomis (Palæontogr., XLVI, p. 228) has questioned that the fragment of the dentary figured by Cope belongs with the premaxilla; but there is no reason to doubt that all the parts of the type belong to the same individual. As regards the premaxilla it may be remarked that the anterior fang is probably directed more horizontally forward than is natural, a fact due to pressure.

In 1877, Cope, as cited, described from materials collected in Gove County, Kansas, by Mr. Russell Hill, a species which he called *Erisichthe penetrans*. The type, never figured hitherto, is now in the American Museum. Its number is 2105. Views of this type, seen from below and from above, and three cross-sections are here presented (Figs. 1 and 2). The specimen consists of the snout from the front of the orbits to the tip of the rostrum, but no other parts. On the lower side the surface of the bone has been damaged, so that the ornamentation is removed over a considerable area; but where preserved, it is not especially different from that of the upper side. It is somewhat coarser, and for a short distance in front of the vomerine fangs forms areolæ resembling those of the shell of *Trionyx*. The specimen has suffered some crushing, and this affects especially the region from the orbits to the vomerine fangs, but also to some extent nearly the whole length of the rostrum.

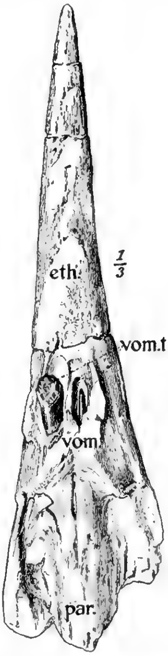


Fig. 1. *Protosphyræna nitida* (Cope). No. 2105. Type of *Erisichthe penetrans* Cope. Rostrum seen from below. × $\frac{1}{3}$. *eth.*, ethmoid; *par.*, parasphenoid; *vom.*, vomer; *vom. t.*, vomerine tooth.

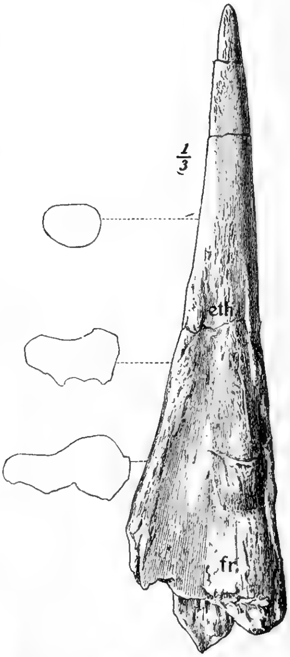


Fig. 2. *Protosphyræna nitida* (Cope). No. 2105. Type of *Erisichthe penetrans* Cope. Seen from above. × $\frac{1}{3}$. With cross-sections. *eth.*, ethmoid; *fr.*, frontal bone.

Cope has given the vertical diameter of the base of the rostrum as 20 mm., but this is not correct. The diameter is

24 mm., and was in life probably somewhat more. The same author has also stated that the superior surface of the skull is swollen above the base of the great vomerine tooth, while no such enlargement marks the position of its young companion. This is readily explained. The downward crushing during fossilization has been resisted by the base of the great fang, while on the other side there has been nothing to resist crushing.

The vomerine fang referred to (Fig. 1, *vom. t.*) has an antero-posterior diameter of 17 mm. and a transverse diameter of 8 mm. The crown is mostly missing. It has been directed strongly forward. In the alveolus of the other side is seen the tip of the fang which was to have come into function on the shedding of the large one now present.

In 1890, Felix, as cited, identified correctly, as it appears, and figured a beak as that of *P. penetrans*.

Various other specimens which were collected for Cope in 1877, by Sternberg and Hill, are regarded as belonging to the same species as *P. penetrans* and serve to throw light on its relations to *P. nitida*. One of these, No. 1871, has been less affected by pressure than any others of the collection. The cross-sections of the rostrum are oval, with the transverse axis the longer, until near the insertions of the vomerine fangs, where the two axes are about equal. The ornamentation of the lower side is coarser than that of the upper, but the pattern is the same. In this beak the left vomerine fang is functional, while the right alveolus is a cavity 9 mm. deep. The distance from the fangs to the tip of the rostrum is 125 mm.; the transverse diameter, 27 mm.; the vertical, 26 mm. Halfway from the fangs to the tip the transverse diameter is 18 mm., the vertical, 15 mm.

No. 2121 of this Museum furnishes a complete beak, with the base of the right tooth; the anterior end of the splenial, freed from the dentary; the tip of the left dentary with three large teeth; some other fragments of the jaws and skull; and three sections of the pectoral fin blade, measuring all together 250 mm. The beak is rather slenderer than the type of *P. penetrans* and is smoother near the base. Sections of the beak are broader than high; but the posterior portion has suffered some distortion. The right vomerine tooth has been functional, but there is hardly a vestige of even the alveolus of the other fang.

Reference must be made here to a species of this genus which has been described by Dr. Loomis (*op. cit.*, p. 225, pl. xx, figs. 1–4) under the name *P. obliquidens*. The beak of this is described as being compressed. The author has figured a portion of the pectoral fin; and this appears to agree in every respect with that of our No. 2121. There is the same front edge, without serrations or undulations; and a band along this edge is represented as being ornamented with fine enamel ridges which run at right angles with the edge. It appears to the present writer that these pectoral fins must be identified as belonging to the same species. Too much importance must not be attributed to the compressed or depressed form of the beak. Many of them have been modified by pressure, and there was probably a good deal of individual variation.

The premaxilla of No. 2121 is missing. The anterior end of the dentary and that of the splenial are well preserved and are figured (Fig. 3). These are attached to the fragment of the fin. Between these bones and the corresponding ones of *P. obliquidens* I find no differences that appear to be important. Dr. Loomis states that his species has three rows of small teeth on the splenial; but in some cases there may be one row on a portion of the splenial and more than one row in another part. The number of rows of these small teeth is probably not a constant character. The small teeth of the dentary are directed forward, as they are in *P.*

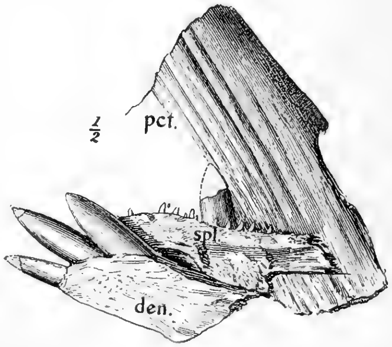


Fig. 3. *Protosphyræna nitida* (Cope). No. 2121. × ½. *den.*, dentary; *pct.*, fragment of pectoral fin; *spl.*, splenial.

obliquidens. The possession of five fangs in the premaxilla, as in *P. obliquidens*, is unusual in *Protosphyræna*, but when we consider that the number of great fang-like teeth in the jaws of *Portheus* varies, we shall not give too great value to this character. In short, it appears to the writer that *P. obliquidens* is identical with *P. penetrans*. Furthermore, it seems impossible to distinguish these two nominal species from Cope's *P. nitida.*

No. 1634 is a part of the Cope Collection, and consists of a considerable part of a crushed skull, with the basal half of the rostrum. The axis of the skull is presented from the vomerine fangs to the basioccipital articulation. A section of the rostrum 52 mm. in front of the vomerine teeth is oval, with the long axis transverse. At the vomerine teeth the section is quadrate, but this is evidently due to lateral pressure. The ornamentation is quite like that of the type of *P. penetrans*, the base of the beak not being so smooth as in No. 2121. Seen from below, it much resembles that of *P. obliquidens.* There is present a part of one of the pectoral fins, presenting about 95 mm. of the edge, and this is identical with that of No. 2121, and, so far as we may judge from the figure, with that of *P. obliquidens.* But the latter has a compressed section; No. 2121, a depressed section. It appears to the writer that the evidence furnished by the fins outweighs that to be derived from the cross-sections of the rostra.

Pelecopterus chirurgus was based on a part of a pectoral fin, with the characteristic front edge broken away. Judging from the part remaining, which comes up close to the edge, and from the angle made by the rays with the edge, there seems little doubt that this fin is identical with *P. obliquidens*, and, therefore, with *P. nitida.* The specimen bears the American Museum of Natural History's number 1894.

Under the name of *Pelecopterus chirurgus* Cope has described (Vert. Cret. Form. West, p. 244E, pl. liv, fig. 9) the articular portion of the shoulder girdle of another specimen. There is no evidence that the latter belongs to the same species as the type of *P. chirurgus;* and the specimen, which is now in the American Museum, No. 1609, cannot be distinguished from the corresponding part of *P. perniciosa*. Indeed, this part is probably much the same in all the species.

Impelled by the evidences furnished by the materials before me, I am compelled to regard Cope's *Erisichthe nitida*, *E. penetrans*, and *Pelecopterus chirurgus*, and Loomis's *P. obliquidens* as belonging to a single species, to which the name *Protosphyræna nitida* must be applied.

Protosphyræna perniciosa (*Cope*).

Plate I, Fig. 1.

Ichthyodectes perniciosus Cope (E. D.), Bull. U. S. Geol. and Geog, Surv. Terrs. I, No. 2, 1874, p. 41; Vert. Cret. Form. West, 1875, p. 275.

Pelecopterus perniciosus Cope (E. D.), Vert. Cret. Form. West, 1875, pp. 244D, 273, pl. xlviii, fig. 2; pl. lii, fig. 2.

Protosphyræna perniciosa Woodward (A. S.), Cat. Foss. Fishes Brit. Mus. III, 1895, p. 414. — ? Loomis (F. B.), Palæontogr. XLVI, 1900, p. 221, text fig. 2. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

This species was established in 1874, as cited, on a fragment of a fin which was afterwards figured on Plate lii of Cope's 'Vertebrata of the Cretaceous Formations of the West.' In this work there were figured also two other fragments of fins which were referred to this species. Of these the one which furnished Fig. 2 of Plate xlviii quite certainly belongs to *P. perniciosa;* the one which is represented by Fig. 13, Plate xliv, appears to belong with those fins which have been referred to *P. tenuis*. It will be observed that the undulations of the edge of this specimen, instead of increasing in height from the base toward the tip, seem to be subsiding.

In the Cope Collection of fishes and reptiles are fragments of several pectoral fins of *P. perniciosa;* but one specimen is especially worthy of description and illustration. This bears the Museum's number 1901. The record accompanying the specimen shows that it was collected by Mr. R. Hill, in 1877, in the Niobrara beds along the South Fork of Solomon River, Kansas. The shoulder girdle accompanies the fin.

The present length of the fin blade (Pl. I, Fig. 1) is 838 mm., but it has doubtless been originally somewhat longer. It is curved saber-like, and the greater part of the front edge is provided with coarse serrations. From the posterior border some rays are probably missing, and a few of those present have been floated away somewhat from the body of the fin. A count of the rays at the base of the fin shows the presence of 45. Even the most posterior of these may be traced to near the anterior border of the fin at the distal end. As in the specimen of *P. tenuis*, described in this paper, there must have been a posterior fringe of soft flexible rays.

The breadth of the base of the fin is about 105 mm. Here the rays midway between the two borders are very slender, the exposed edges of four of them occupying only 5 mm.; but they grow broader toward their distal ends, so that the four referred to occupy a breadth of 22 mm. Near the distal ends of those rays which outcrop in the anterior border of the fin, at the middle of its length, we find signs of a separation of each into two portions, as in *P. tenuis*. In the distal end of the fin the two components are as distinctly separated from each other as they are from the components of contiguous fins. The thickness of the fin at the middle is 9 mm. As in the case of the fin rays of fishes in general, each ray is composed of an upper and a lower half. At the base of the fin these become broader perpendicularly to the surface of the fin, so as to form plates. Finally these diverge, so as to receive between them the baseosts. Near the anterior border of the base there is a large acetabular cavity for the reception of the rounded head of the scapula.

The tooth-like projections on the front of the fin vary in distance apart from 10 to 15 millimeters. Those of the most distal half of the fin protrude beyond their bases as much as 5 mm. and are retrorse; those of the proximal half are shorter and are dentate in form. In the proximal half of the anterior border there is a tooth at the end of each fin ray; in the distal half, a tooth for each of the two subdivisions of the ray. From the tip of each tooth a rounded ridge runs backward on the surface of the fin at right angles with the course of the rays. This appears to be for the purpose of strengthening the tooth. Each ridge soon divides into two diverging smaller ridges and at length disappears. Those of the distal portion of the fin may be traced nearly across the fin.

A considerable part of the shoulder girdle of the fin above described is present (Figs. 4, 5), and it enables me to make some corrections in Cope's account of this part of the anatomy (Vert. Cret. Form. West, p. 244A). This author affirmed that all the basilar bones, which support the fin, articulated with the scapula; and on this character he founded the order Actinochiri.

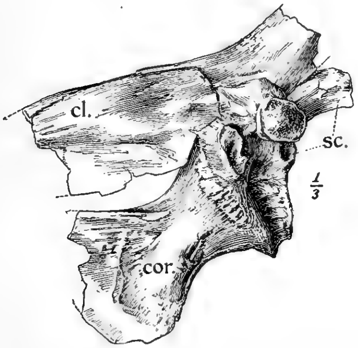


Fig. 4. *Protosphyræna perniciosa* (Cope). No. 1901. $\times \frac{1}{3}$. *cl.*, cleithrum; *cor.*, coracoid; *sc.*, scapula.

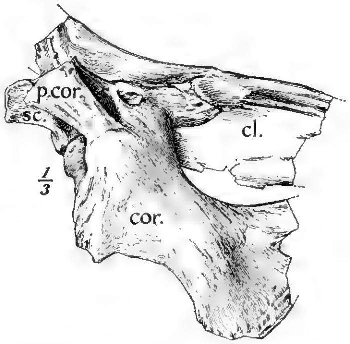


Fig. 5. *Protosphyræna perniciosa* (Cope). No. 1901. $\times \frac{1}{3}$. *cl.*, cleithrum; *cor.*, coracoid; *p. cor.*, precoracoid.

The conclusion reached by Cope is obviously erroneous; for it is certain that the greater portion of the bone which he identified as the scapula is the coracoid; while the bone supposed by him to be the coracoid is the precoracoid. The result of his erroneous determinations was that he had the shoulder girdle turned wrong end up. All this is satisfactorily proved by comparing these bones with the corresponding ones of *Tarpon* or *Salmo*. Unfortunately, most of the sutures in this complex of bones are obsolete, and Cope himself was unable to make them out in his specimens. At the base of the precoracoid of No. 1901 there is a dislocation of the latter which may indicate the position of the suture. In the tarpon the enlarged anterior fin ray and two baseosts articulate with the scapula. In the specimens of *Protosphyræna* there are no satisfactory indications of the suture that once existed between the scapula and coracoid.

The scapula (Figs. 4, 5, *sc.*) is applied to the inner side of the cleithrum, while the precoracoid, *p. cor.*, appears to be applied to the inner side of the scapula. There may, however, be some distortion here. In *Tarpon* the precoracoid is applied to the inside of the cleithrum in front of the scapula, but it also articulates with the latter.

On the united scapula and coracoid are borne the surfaces for articulation with the fin and its supports. Nearest the cleithrum there is a rounded head (Fig. 4), which fits into a cavity at the base of the fin. Beyond this are two surfaces for the paired baseosts which Cope mentions; and still further out is a row of six grooves for the reception of six unpaired baseosts. Between this shoulder girdle and that of *Tarpon* I see no important differences, except in the presence of the paired baseosts. Of these the outer one corresponds, no doubt, to the articulatory surface for the first baseost of *Tarpon*. For the other, situated below the rounded head on the scapula and mesiad of the surfaces for the other baseosts, I find no equivalent in *Tarpon*. Possibly we must credit to *Protosphyræna* the possession of eight baseosts. Of these the first has possibly been crowded out of its place to a position below the rounded head on the scapula, while the second has been crowded to a position above the head.

The disposition of the paired baseosts with reference to the rounded head and the row of unpaired baseosts must limit greatly the movements of the fin. In fishes there is generally a free movement of the fin at right angles to its plane; but it seems that in *Protosphyræna* there could have been only very restricted motion perpendicular to the plane of the fin. The action of the paired baseosts would have had the effect of steadying the motion in the plane. Such motion would have had as its end the employment of the fin as a weapon, with which its possessor could slash an enemy or a victim of its appetite. The position of the paired and the unpaired baseosts may be determined from Cope's figures (Vert. Cret. Form. West, pl. liv, fig. 9), from the figures already cited of the present paper, and from Fig. 6. In the latter figure the front border of the fin is above, and the upper (*bas.*) rests on one of the paired baseosts.

No. 2009 of this Museum furnishes both cleithra of *Protosphyræna perniciosa*, which may be conveniently described here. One of these is represented by Fig. 7. It is possible that a small part of the bone is missing from the upper end of the element. Compared with a specimen of *Tarpon atlanticus*, 5 feet 6 inches long (1.67 m.), the cleithrum is narrower. The portion below the curve is of the same length, but the upper end of that of *Protosphyræna* is about 50 mm. shorter. How much of this deficiency is due to injury cannot be determined. The outside of the cleithrum presents no features worthy of mention; the surface probably has been convex in cross-section. On the inside we see, near the upper border of the lower, or anterior, end, a deep groove which is bounded both above and below by a sharp ridge. On the hinder border of the upper, or posterior, portion there is another groove. This appears to have started at the upper end of the bone and to have run downward as far as the articulation of the fin. It is possible that, as in *Tarpon*, some accessory bone fitted in this groove.

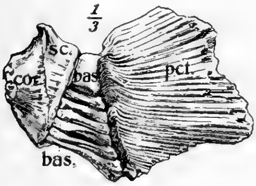
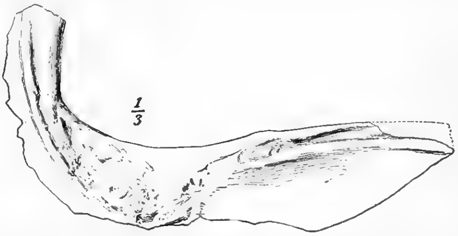


Fig. 6. *Protosphyræna* sp. No. 1646. × ⅓. *bas.*, baseosts; *cor.*, coracoid; *pct.*, pectoral fin; *sc.*, scapula.



No. 7. *Protosphyræna perniciosa* (Cope). No. 2009. × ⅓. Cleithrum seen from inner surface.

It is remarkable that, although this is perhaps the commonest species of *Protosphyræna*, except perhaps *P. nitida*, it is represented by remains of fins and shoulder girdle bones alone. None of these have been found in association with remains of the head. It appears to be possible that *P. tenuis* Loomis and *P. perniciosa* are identical. The fins appear to differ only in the character of the anterior edge, the angle which the rays make with the anterior border being the same in both species. Under *P. tenuis* mention is made of fins whose edges are not repand, but have the summits of the waves sharp. No. 2044 is a specimen which is evidently to be referred to *P. perniciosa*, since it has the serrations well developed on many parts of the edge. And yet, well out toward the distal end these serrations subside and the edge is nearly straight. It seems possible that there was considerable variation in the degree of development of the serrations in different individuals. Only more and better materials will enable us to settle this point.

Protosphyræna tenuis *Loomis.*

PLATE I, FIGS. 2 AND 3.

Pelecopterus perniciosus COPE (E. D.), Vert. Cret. Form. West, 1875, pl. xliv, fig. 13 (erroneous identification).

Protosphyræna tenuis LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 226, pl. xx, figs. 5–7.—HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

Protosphyræna penetrans STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, pp. 370, 402, pl. lxiii, figs. 1–3.

This species is said to be based on three individuals which were collected by Mr. C. H. Sternberg in the Niobrara deposits of Kansas and are now in the Museum at Munich, Germany. The parts figured belong to one individual and consist of a rostrum, premaxilla and maxilla of the left side, and a part of one pectoral fin. This appears to be a well founded species. The rostrum is, relatively to the length of the maxilla, very long and slender. The maxilla enters into the length of the rostrum two times, while in a specimen of *P. nitida* the maxilla is contained in the rostrum only one and a half times. The teeth of the maxilla appear to be smaller than they are in *P. nitida*. The most certain evidence that this species does not belong to *P. nitida* is to be found in the pectoral fin blade. On comparing it with the figure of Dr. Loomis's *P. obliquidens* (= *P. nitida*), figured on the same plate, we find that in the latter the edge of the fin is devoid of any undulations and that the rays make an angle of nearly 10° with the edge; while in *P. tenuis* the edge is wavy, especially near the base, and the rays make an angle of 15° with the edge. I regard these differences as important.

In the American Museum there are several specimens of fins which I refer to *P. tenuis*. One of these, No. 205 (Pl. I, Fig. 2), is 528 mm. long and is accompanied by a portion of the baseosts and a part of the cleithrum. It presents apparently 36 rays, including the shortest one at the base in front. As a result probably of maceration and some disturbance before burial, some of the hindermost rays are separated from one another, except immediately at the base. It is probable that others of the hindermost have been wholly removed. At its base, as now found, the fin is 62 mm. wide. The front edge is gently repand in the basal half; but in the distal half the edge has a uniform curve. The edge is everywhere thin and sharp, and is strengthened by a layer of enamel, as in the other species. This layer is disposed more or less in ridges at right angles to the edge; but these do not have the regularity and fineness which they present in *P. nitida*. As in other species of the genus, the anterior edge of the fin is formed by the ends of the rays which successively outcrop at their distal ends. All the rays, except a few of the first, become broader as they proceed outward. The greatest increase in width is found in the most posterior rays. At the base they are only about 1.5 mm. in diameter, but distally they may be as much as 5 mm. in diameter. At about the 20th ray we find at its distal end evidences of a division into an anterior and a posterior portion. This separation becomes still more distinct in the succeeding rays. In another specimen, No. 215, traces of the cleft condition may be found as far forward as the 12th ray from the front, and is indicated by a narrow furrow, or line of pits.

In the front of the fin in No. 215 are two holes which are made entirely through the rays, and these, with some fractures, must have been produced before the specimen was covered with the matrix. It is easy to imagine that this fish had been seized and destroyed by some *Portheus* or some mosasaur.

The fins of this species resemble those of *P. perniciosa* in the angle which the rays make with the edge of the fin. As in the latter species, the base of the fin is undulated for a few centimeters, but beyond this the character of the edge in the two species is very different. In *P. tenuis* the undulations subside and the edge is continuous; in *P. perniciosa*, the elevations increase in height and soon take the form of hooked teeth.

No. 1620 of this Museum, a part of the Cope Collection, probably belongs to this species. It appears to differ only in having the edge resemble a series of waves whose summits are not rounded but sharp (like Figs. 1, 2, Pl. lxiii, of Stewart's memoir) and in having them continued well out toward the distal end of the fin. Such fins possibly belong to a distinct species. This specimen displays the distal end of the fin apparently to within a few centimeters of the tip (Pl. I, Fig. 3). Behind the rays which are consolidated together are several others which evidently have been only loosely connected and which have been subdivided into very fine filaments. Evidently, too, the hindermost of these loose rays did not reach quite to the tip of the fin. It is quite probable, therefore, that a considerable number of soft flexible rays occupied the hinder border of these remarkable fins. No cross-segmentation of these rays can be observed. As stated under *P. perniciosa*, there is some reason to doubt that *P. tenuis* is distinct from the species just mentioned.

Protosphyræna dimidiata (*Cope*).

Erisichthe nitida Cope (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. III, 1877, p. 822.

Protosphyræna nitida Loomis (F. B.), Palæontogr. XLVI, 1900, p. 227 (in part), pl. xix, figs. 6, 7.

Erisichthe dimidiata Cope (E. D.), Proc. Amer. Assoc. Adv. Sci. XXVI, 1878, p. 300.

Protosphyræna dimidiata Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

This species, the type of which is now in the American Museum of Natural History, having the number 1635, was originally described as belonging to *Erisichthe nitida*. However, within the next year, Prof. Cope came to the conclusion that it represented a distinct species and to this he gave the name *Erisichthe dimidiata* (Proc. Amer. Assoc. Adv. Sci., XXVI, 1878, p. 300). Of this change of opinion and this new name neither Felix, writing in 1890, nor Loomis, writing in 1900, was apprised.

The most obvious characters of the species are those presented by Cope in his original description, the upward curvature of the rostrum and the flattening of the upper surface of its distal half. Felix, having before him a specimen which he regarded as belonging to the same species, denies the presence of the angular ridges on the sides of the rostrum. They are present, nevertheless. The rostrum (Fig. 8) has been broken across just in front of the vomerine fangs and a portion of the upper surface has crumbled away, perhaps for a distance of 25 mm.; but there is little or nothing missing on the lower side. About 22 mm. in front of this break there has been another break and a slight faulting in the bone. From this point there is a gradual upward curve to the tip of the beak. Just in front of the last-mentioned break the vertical diameter is 23 mm., the transverse, 26 mm., the section being oval. Halfway to the tip, the upper surface has become decidedly flat, the vertical diameter being 16 mm., the transverse, 22 mm. Beyond this section the upper surface is somewhat concave, with a sharp ridge bounding the concavity on each side. Near the tip the upper surface again becomes convex. Both the upward curvature of the beak and the concavity of the upper surface appear to be wholly natural.

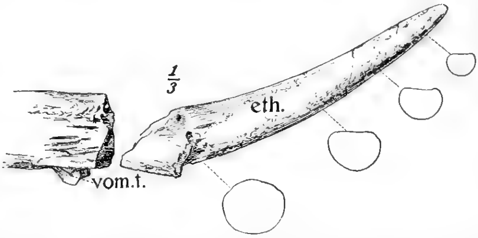


Fig. 8. *Protosphyræna dimidiata* (Cope). No. 1635. × 1/3. Type of *Erisichthe dimidiata* Cope. Rostrum seen from the side, with four cross-sections. *eth.*, ethmoid; *vom. t.*, vomerine teeth.

There appears to be less difference in the sculpture of the upper and lower sides than in the case of *P. nitida*.

The premaxilla (Fig. 9, *pmx.*) possessed four fangs. Its length has been about 75 mm.; the elevation of the hinder end about 43 mm. The maxilla (Fig. 9, *mx.*) is 137 mm. long, with a depth of only 17 mm. where narrowest, then again expanding to near 30 mm. Another bone, probably a jugal, has overlapped the hinder end of the maxilla on the upper side. There is space for about 33 teeth on the maxilla. They are lancet-shaped and are not so strongly inclined forward as they are in *P. nitida.* The same is true of the teeth of the mandible. Outside of the row of cutting teeth is a row of much smaller teeth.

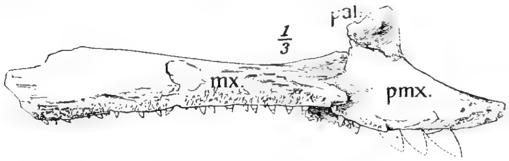


Fig. 9. *Protosphyræna dimidiata* (Cope). No. 1635. × ⅓. Type of *Erisichthe dimidiata* Cope. Upper jaw, side view. *mx.*, maxilla; *pal.*, portion of palatine; *pmx.*, premaxilla.

The lower jaws are represented by 68 mm. of the anterior end of the left mandible and by nearly the whole length of the right. The tip of the latter and a section of about 30 mm. are wanting, as well as most of the lower border of the bone. In the anterior end of the dentary we find the usual three lancet-shaped fangs. These are succeeded by an interval in which the teeth are very small or wanting. Then follows a single row of cutting teeth, of which those in front and those behind are small. The presplenial is occupied, as in the other species, by two strong fangs. Laterad of these and running nearly the full length of the presplenial is a band of small teeth. This consists of three rows where narrowest. A short distance behind the posterior presplenial fang the band of small teeth is interrupted by what may be a suture between the presplenial and the postsplenial. It is not unlikely, however, that it is only a fracture, since the whole jaw has suffered flexure at this point. In specimens of *P. nitida* no suture can be seen; although at this point the band of teeth becomes very narrow and thereafter widens rapidly. Felix was unable to find a suture between the supposed two bones. If they have ever been distinct at any time of the animal's life, they are now probably consolidated. The "predentary" of Felix was evidently the result of erroneous observation.

Lying against the inner surface of the posterior end of the premaxilla (Fig. 10) is a bone whose edge bears a band of three rows of teeth which resemble those of the presplenial, some being two-edged, but most of them conical. This bone, now 30 mm. long, but with its anterior and posterior ends missing, I take to be the palatine. Lying against the median surface of the anterior end of this palatine and extending forward nearly to the anterior end of the premaxilla is another bone which bears a large patch of granular teeth. It is possibly a part of the palatine.

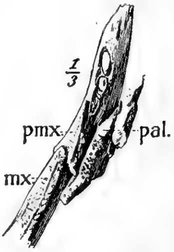


Fig. 10. *Protosphyræna dimidiata* (Cope). No. 1635. $\times \frac{1}{3}$. Type of *Erisichthe dimidiata* Cope. Part of upper jaw from below. *mx.*, anterior end of maxilla; *pal.*, portion of palatine; *pmx.*, premaxilla.

The writer sees little reason to doubt that the specimens referred to *P. nitida* by Dr. Loomis, and figured on Plate xix, Figs. 6, 7, of his paper here frequently quoted, really belong to *P. dimidiata*. There is the same narrow maxilla; but, especially, the dentary teeth are only slightly inclined forward.

Fig. 11. ? *Protosphyræna dimidiata* (Cope). No. 1635. $\times \frac{1}{2}$. Part ? of type of *Erisichthe dimidiata* Cope. Vertebra, view of anterior end.

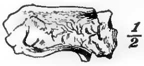


Fig. 12. ? *Protosphyræna dimidiata* (Cope). No. 1635. $\times \frac{1}{2}$. Part ? of type of *Erisichthe dimidiata* Cope. Vertebra, view of lower surface.

Among the remains belonging to the type of *P. dimidiata* there is present a single vertebra, apparently one belonging close to the head. It is possible that this is an intrusion, either at the time of burial or after collection; but the matrix is the same and the bone is similarly fossilized. The vertebra is represented in Figs. 11 and 12. It is 12 mm. long and 19 mm. in the transverse and vertical diameters. The ends (Fig. 11) are deeply cupped. The arches have dropped away, not having been coössified. The lower surface (Fig. 12) is ornamented with a network of low ridges. The vertebra agrees in size with the basioccipital of some skulls of *Protosphyræna.* It is possible that it belongs to either *Pachyrhizodus* or *Anogmius*, but it appears to be different. Cope believed (Proc. Amer. Assoc. Adv. Sci., XXVI, 1878, p. 299) that this genus possessed well developed vertebræ, but whether or not he based his opinion on this particular vertebra is not known. It is very desirable that collectors shall give attention to the finding of such parts of the body of the fishes of this genus as have not yet been described; and such parts include practically all parts behind the shoulder girdle and pectoral fins.

Protosphyræna sequax, sp. nov.

Protosphyræna nitida Felix (J.), Zeitschr. deutsch. geol. Gesellsch. XLII, 1890, p. 278, pl. xii, figs. 1–3; pl. xiii, figs. 1–2b; pl. xiv, figs. 2–7.—Loomis (F. B.), Palæontogr. XLVI, 1900, p. 227 (in part).—Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379 (in part).

Dr. Loomis has already concluded that, on account of the position of the teeth of the dentary bone, Felix's specimen does not belong to the same species as the dentary figured by Cope as part of *P. nitida;* but Loomis's explanation is that Cope's dentary does not belong with the premaxillary, and is, therefore, not a part of *P. nitida*, an idea already suggested by Felix (*op. cit.*). As elsewhere remarked, there is no reason for questioning the unity of Cope's type. The more reasonable explanation is that Felix's specimen does not belong to Cope's species, *P. nitida.* And one of the grounds for this conclusion is found in the fact that the teeth of the maxillæ and those of the dentary, except the three anterior fangs, are, in Felix's specimen, inserted at nearly right angles to the containing bones. Even those of the premaxillæ emerge nearly perpendicular to the border of the latter bone.

Nor can Felix's specimen belong to *P. dimidiata.* The posterior teeth of the maxilla of the type of the latter have a decided slant forward. The median and anterior teeth are nearly perpendicular. All the teeth of the premaxilla appear to have inclined forward. The cutting teeth of the middle of the dentary are only slightly inclined forward, not greatly different from the corresponding ones of the skull described by Felix. The maxilla of the latter is quite different from that of *P. dimidiata* and that of *P. nitida*, as represented by the specimens described under that species. In the type of *P. dimidiata* the maxilla has a length of 137 mm., a width where widest of 17 mm. and where broadest, near the hinder extremity, of 30 mm. The maxilla of Felix's specimen is probably little, if any, longer. The figure gives evidence that little of that of the left side is missing. Its width, where narrowest, is 20 mm.; where widest, at least 32 mm. Of the right maxilla of Felix's specimen perhaps nothing is wanting and it measures only 130 mm. This indicates that the bone was of considerably heavier construction than in *P. dimidiata*. If it be contended that the maxilla of Felix's individual belongs to a larger animal and was both longer and broader, it may be shown that it must have contained a considerably larger number of teeth. On measuring backward from a point 25 mm. behind the anterior end of the maxilla of *P. dimidiata*, there are found 9 teeth or alveoli for them, in 32 mm. In the same distance on the left maxilla of Felix's specimen are 9 or 10 teeth, or spaces for them. This indicates either that the maxilla was no longer or that the teeth were relatively smaller. Indeed, in the portion of the left maxilla represented by Felix, 103 mm. long, there is room for as many of its teeth as are found in the 122 mm. of tooth line of *P. dimidiata*. Furthermore, the rostrum of the specimen described by Felix is very different from that described by Cope, as Felix himself has pointed out.

Protosphyræna sequax differs from the specimens which are here referred to *P. nitida* in most of the respects in which it differs from *P. dimidiata*, viz., in having teeth perpendicular, or nearly so, to the supporting bones and in having a broad heavy maxilla.

It is, of course, impossible to say that the skull here described does not belong to some species which has already received a name based on a fin blade. It may, for example, be the skull of *P. perniciosa*. In such case *P. sequax* will become a synonym.

Protosphyræna ziphioides (*Cope*).

Erisichthe ziphioides (COPE E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. III, 1877, p. 823.

Protosphyræna ziphioides NEWTON (E. T.), Quart. Jour. Geol. Soc. XXXIV, 1878, p. 795. — FELIX (J.), Zeitschr. deutsch. geol. Gesellsch. XLII, 1890, p. 297. — WOODWARD (A. S.), Cat. Foss. Fishes Brit. Mus. 1895, p. 413. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 379.

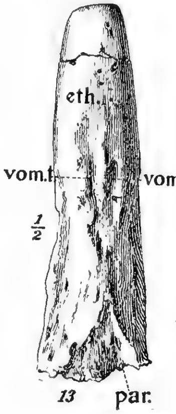
Erisichthe xiphioides LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 222.

This species was described by Cope in 1877, as above cited. The description was quoted by Felix and accompanied with brief remarks. The type specimen is now in the American Museum of Natural History, and has the number 2131. Cope states that the specimen is the muzzle of an old individual which has lost a good deal of its apex by attrition. It is probable that he meant that this attrition had been suffered during the life of the animal. The present writer, however, finds no evidences of any attrition. It appears improbable that the beak could have been worn to any considerable amount without revealing it either in the character of the surface or in some asymmetry. Where the wear must have been suffered, the bone is dense and smooth and the form wholly symmetrical. The specimen appears to have belonged to a species having a short and blunt snout.

The following measurements are given.:

Length of the specimen	102 mm.
Width of the hinder end	30 mm.
Transverse diameter at vomerine alveoli	22 mm.
Vertical " " " "	19 mm.
Transverse " 15 mm. from tip of snout	20 mm.
Vertical " " " " " "	14 mm.

On the under side of the snout (Fig. 13, *vom. t.*) is a pair of longitudinal depressions. These Cope regarded as alveoli for vomerine fangs, from which the teeth had fallen and which had become filled up with bone. His explanation is probably the correct one. At the hinder end of the specimen, on the under side, is a triangular depression. This appears to be produced by the parting of the hinder ends of the vomers, so as to expose the parasphenoid (Fig. 13, *par.*); but the bones are somewhat eroded. The apex of this depression is considerably farther behind the alveoli of the vomerine fangs than in any other described species of the genus, being about 25 mm.; while in the type of *P. penetrans* the interval is only 15 mm.



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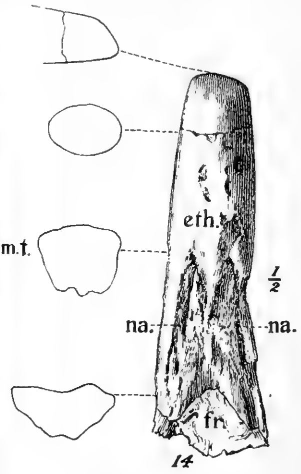

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Fig. 13. *Protosphyræna ziphioides* (Cope). No. 2131. × ½. Type of *Erisichthe ziphioides* Cope, seen from below. *eth.*, ethmoid; *par.*, parasphenoid; *vom. t.*, position of vomerine teeth.

Fig. 14. Same rostrum as Fig. 13, viewed from above, with three cross-sections and a longitudinal section of tip. *eth.*, ethmoid; *fr.*, frontal; *na.*, nasals.

On each side of the basal half of the specimen and extending forward to a line crossing just in front of the vomerine alveoli is a longitudinal excavation. Cope regarded these as probably intended for the reception of the forward prolongations of the premaxillæ. It is more probable that they receive the anterior ends of those bones which Felix has called "ethmoidea lateralia." There is some reason to think that a portion of these bones is yet in these excavations. Possibly if the whole of these lateral ethmoids were present the lower surface of the beak would not be so constricted as it is.

The hinder end of the upper surface is occupied by a triangular smooth depression (Fig. 14, *fr.*). The writer takes this to mark the anterior termination of the frontals, united into one bone. In front of this depression the surface is rough, as if from erosion. On each side of this rough area there is a moderate longitudinal excavation, which appears to be partially filled by the remains of a distinct bone (Fig. 14, *na.*). These two bones appear to have overlapped the anterior ends of the frontals and to have met in the midline. They are probably the nasals.

The supposed nasals on the upper side and the supposed "lateral ethmoids" on the lower side are separated by right and left ridges of bone which evidently form a part of the ethmoid. These are continued forward to the tip of the beak and form the boundary lines which separate the convex lower surface of the beak from the flatter upper surface. As these ridges pass forward they descend on the sides of the beak, until at its tip they meet at the level of the lower surface. The convexity of the upper surface increases as we move toward the tip of the beak and that of the lower surface diminishes, until at length, 15 mm. behind the tip, the upper surface becomes more convex than the lower. In Figure 14 are presented cross-sections of the beak at three points. The outline figure above the sections represents a longitudinal section at the end of the beak.

The specimen was found in the Niobrara deposits of Gove County, Kansas. It seems not unlikely that it represents a distinct genus.

Protosphyræna gladius (*Cope*).

Portheus gladius Cope (E. D.), Proc. Acad. Nat. Sci. Phila. 1873, p. 337; Bull. U. S. Geol. and Geog. Surv. Terrs. I, No. 2, 1874, p. 40.

Pelecopterus gladius Cope (E. D.), Vert. Cret. Form. West, 1875, pp. 244E, 273, pl. xliv, fig. 12; pl. lii. fig. 3.—Loomis (F. B.), Palæontogr. XLVI, 1900, p. 221, text figure 3, tail.

Protosphyræna gladius Hay (O. P.), Bibliog. Cat. Foss. Vert. N. A. 1902, p. 379.

The type of this species is now in the American Museum of Natural History, and bears the number 1849. It measures 728 mm. in length, Prof. Cope's statement making it equal to 31 inches being slightly erroneous. In his description of the specimen Cope says that Prof. Mudge, the collector, reported that the original length was 41 inches. This statement is not at all improbable. The second specimen described by Cope (Vert. Cret. Form. West, p. 244F, pl. xliv, fig. 12) is also in the Museum's collection and is numbered 2064.

The type fin blade has been somewhat distorted by pressure, so that the surface, instead of being flat, as it undoubtedly was originally, is, as Cope says, trough-like. That the surface was flat is shown by other specimens in the collection which were obtained for Cope by Sternberg and Hill. The enamelled edge is sharp, sharper than the edge of the regulation table knife. The edge is not straight, but has the appearance of having been nicked here and there, as is shown by Cope's figure. This author thought that these irregularities had been produced by the rough uses which the fish had made of the fin; but, since the bottoms of the notches are as sharp as the edge elsewhere, it is not probable that there have been any injuries done to the edge.

At the base of the fin the anterior rays have been so thoroughly consolidated that they cannot be counted; but, after making proper allowances, there appear to be about 50 rays entering into the portion of the fin represented by the specimen. The rays, beyond the most anterior ones at the base, grow wider as they are followed toward the distal end; where, one after the other, they emerge at the anterior border, becoming consolidated with those in contact with them. Those which reach the distal half of the fin become divided each into an anterior and a posterior portion, as in the case of *P. perniciosa.*

In the case that the fin was originally about 1040 mm. long, that is about 312 mm. longer than it is now, there must have been about 13 more spines entering into its construction, that is 63 altogether; for the last 312 mm. of the length is now occupied by 26 outcropping ends, and these represent 13 rays at the base. If this estimate is correct, the fin must have been about 200 mm. wide at the base.

For the greater part of its length the fin is 20 mm. thick, measured at a distance of 50 mm. behind the edge. Near the base the thickness is still greater. Other specimens in the collection show that the front border is bevelled off on both sides, as a board may be bevelled off by a carpenter's plane.

At the middle of the length of the fin the component rays make an angle of about 22° with the edge. At the distal end the angle is somewhat smaller.

This fin must have belonged to a large and powerful fish, of which no other parts are known.

Dr. Loomis in his paper on Kansas fishes holds that this fin formed one lobe of the caudal fin of some species of *Protosphyræna;* and in his restoration of *Protosphyræna* he reconstructs the caudal fin from this specimen. This is, however, manifestly an error. In the caudal fin of fishes the right and left halves of the constituent rays diverge slightly at their proximal ends, so as to receive between them the hypural bones. They are also each drawn out to a point. In the pectoral fins the two portions of the ray not only diverge strongly, but each half is broadened so as to form two processes. One of these is directed toward the corresponding surface of the fin, while the other is brought into close contact with the small bones at the distal ends of the baseosts. The fin known as *Protosphyræna gladius* has the same structure as that of the pectoral fin of ordinary fishes and of other species of *Protosphyræna.*

PLETHODIDÆ.

Anogmius *Cope.*

This genus was erected by Prof. Cope in 1871 (Proc. Amer. Philos. Soc., XII, p. 170), the type species being *A. contractus*, and the type specimen consisted of a large number of vertebræ representing a fish believed to be about four feet in length. The vertebræ were in the Agricultural College, at Manhattan, Kansas, and had been collected by Prof. B. F. Mudge. These vertebræ are further described on page 354 of the volume referred to. This description is repeated on page 241 of the same author's 'Vertebrata of the Cretaceous Formations of the West'; but on page 220A, evidently written later, he records his conclusion that the genus in question was really identical with *Pachyrhizodus*. In 1877 (Bull. U. S. Geol. and Geog. Surv. Terrs., III, p. 584) Prof. Cope again restored his genus *Anogmius* to favor, and described the new species *A. aratus*, based on a nearly complete individual. This permitted him to define more fully the characters of the genus. In the same year he described two additional species, *A. favirostris* and *A. evolutus*, collected for him in Kansas, by Sternberg's party.

Dr. A. S. Woodward (Cat. Foss. Fishes, IV, 1901, p. 71) apparently takes the position that Cope, when he described *Anogmius aratus*, intended to employ the generic name in a new sense, and to make *A. aratus* the type of the new genus. Prof. Cope's language may give some justification to this conclusion; but it is evident that he intended to include the original species, since he cites the original description. He had evidently again changed his mind regarding the generic position of the type vertebræ. The vertebræ of the species assigned to *Anogmius* and those of *Pachyrhizodus* resemble one another closely, and Cope's vacillation is not to be wondered at as long as he possessed no other parts for comparison. But in his second description (Proc. Amer. Philos. Soc., XII, p. 354) he mentions characters which appear to separate the two genera. One of these is found in the crowded condition of the vertebræ at the base of the caudal fin of *Anogmius;* the other, in the failure of the upper and lower arches in this region to become coössified with their centra. Figures 15 and 16 of this paper represent the condition of this part of the vertebral column. In *Pachyrhizodus* there is apparently less crowding of the vertebræ, and the arches become coössified with the centra. On this point see Dr. Loomis's figure (*op. cit.*, pl. xxvi, fig. 9). Stewart (Univ. Geol. Surv. Kansas, VI, pl. lxvi) presents a tail of *Anogmius* in which the shortening and crowding are less than in any that I have seen.

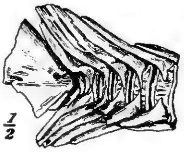


Fig. 15. *Anogmius* sp., No. 1616. × ½. Caudal vertebræ.

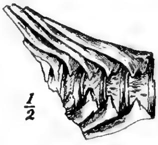


Fig. 16. *Anogmius* sp., No. 1116. × ½. Caudal vertebræ.

Just what Cope's *Anogmius contractus* was we shall probably never know. Prof. E. A. Popenoe, who has charge of the collection of the Agricultural College at Manhattan, Kansas, informs me that he is unable to find any traces of such vertebræ as Cope described. The type being lost, it seems proper to accept Cope's *Anogmius* on the definition given of it. When it becomes necessary to divide the genus as thus defined, it will be time to consider whether or not *Anogmius* is indeterminable.

Recently Dr. Loomis (*op. cit.*, p. 254) has made Cope's *Anogmius* (spelled, however, *Agnomius*) a synonym of *Osmeroides* Agassiz. Mr. Woodward properly, as it seems to me, does not follow this identification. So far as we know, the species of *Anogmius* have an elongated dorsal fin, while *Osmeroides* (*Holcolepis*) has a short dorsal. There exist undoubtedly many other distinctive characters.

Dr. Loomis (*op. cit.*, pp. 229, 235, 252) has described the new genera *Thryptodus*, *Pseudothryptodus*, and *Syntegmodus*. Stewart in his work referred to, p. 391, has expressed the opinion that the first two genera mentioned are synonymous with *Anogmius*. Dr. A. S. Woodward (Cat. Foss. Fishes, IV, pp. 84, 85) regards all three as closely related to *Plethodus*.

There are so many structures common to the genera *Plethodus*, *Anogmius*, *Thryptodus*, *Pseudothryptodus*, and *Syntegmodus*, that it appears evident that they are all closely related, and some of them are quite certainly identical with others. All appear to have an upper grinding plate developed on the parasphenoid and one or more lower plates developed on the median bones in the floor of the mouth. These plates are composed apparently of dense bone, and are often, if not always, furnished with pits, sometimes shallow, sometimes deep. The maxilla forms a considerable part of the boundary of the mouth, the bones about the mouth are similarly sculptured, and, so far as we know, the rear of the skull is similar in all.

Plethodus appears to be characterized by coössification of the premaxillæ and ethmoid and the possession of a lower dental plate composed of a single bone. The upper and lower plates are smooth or furnished with shallow pits.

Anogmius, as represented by *A. aratus* and *A. favirostris*, described on succeeding pages, has the premaxillæ free from the ethmoid, and possibly from each other, and the dental plates are deeply pitted. The lower plate is composed of two and possibly of three median bones.

Syntegmodus is described as having the parasphenoid and some other bones of the mouth covered with a thick mass of osteodentine. This is penetrated by large canals which pass from the surface to the bone on which the supposed osteodentine mass rests. This mass is probably composed of dense bone. On comparing Dr. Loomis's *Syntegmodus*, and the known remains of *A. aratus* and *A. favirostris* and a specimen resembling *Syntegmodus altus*, among one another, it is difficult to see how they may be distinguished generically.

Thryptodus is regarded by Dr. Loomis as having the premaxillæ not free, but probably consolidated with the ethmoid. The parasphenoid has developed a great oval, concave, dental plate, which is furnished with pits; while the median bones of the floor of the mouth support plates which work against the parasphenoidal plate. A study of the type of Cope's *Anogmius aratus*, figures of which are presented in this paper, have convinced me that the relation of the premaxillæ to the ethmoid has been misunderstood by both Prof. Cope and Dr. Loomis, and that *Thryptodus* is identical with the type of *Anogmius aratus*. In this form, as illustrated by the types of *A. aratus* and *Thryptodus*, the premaxillæ appear to be united, while in *A. favirostris* they are possibly, but not certainly, free from each other. If this difference is confirmed by other specimens it may require that two genera shall be recognized; but for the present it seems to the author best to unite all under *Anogmius*. *Pseudothryptodus*, with free premaxillæ, will be included.

Reference has already been made to the differences supposed to exist between the vertebræ of *Pachyrhizodus* and *Anogmius*. However much they may resemble, there is great difference in the structure of the tails of the two genera. There is apparently little difference in the form of the tail fins, both being deeply forked. In *Pachyrhizodus*, as shown by Pl. III, Figs. 1 and 2, the rays constituting each lobe are comparatively few, and these are large, and cross-segmented. In *Anogmius*, on the other hand, the rays (Fig. 17, a fragment of the caudal fin) appear to have been in greater number and to have shown no segmentation, unless this may have appeared toward the distal ends. It will likewise probably prove true that in *Pachyrhizodus* the neural and hæmal arches of the caudal region are always consolidated with the centra, while in *Anogmius* they remain distinct.

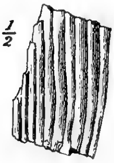


Fig. 17. *Anogmius* sp. No. 2055. × ½. Fragment of caudal fin.

Anogmius favirostris (*Cope*).

Anogmius favirostris Cope (E. D.), Proc. Amer. Philos. Soc. XVII, 1877, p. 178.—Woodward (A. S.), Cat. Foss. Fishes Brit. Mus. IV, 1901, p. 73.—Hay (O. P.), Bibliog. Cat. Foss. Vert. N. A. 1902, p. 393.

Osmeroides favirostris Loomis (F. B.), Palæontogr. XLVI, 1900, p. 256.

This species was based on the skulls of two individuals, one of them accompanied by a number of vertebræ. These specimens are now in the American Museum of Natural History, but they appear to be somewhat less complete than when they were described by Prof. Cope. One of them, No. 2111, which must be regarded as the type, since from it the description was mostly drawn, consists of the rear of the skull and some fragments of its upper surface, the premaxillæ and maxillæ, the anterior portions of both dentaries, the anterior half of the left palatine and the whole of the right, and a considerable part of the parasphenoid. With these skull parts are 11 vertebræ.

The rear of the skull shows that the parietals are broadly joined. Behind these is a narrow area occupied by the supraoccipital and the epiotics, but the exact extent of these cannot be determined. The midline of the rear of the skull is occupied by a valley, deepest and widest between the parietals, where its width is about 10 mm.

Figure 18 presents a view of the front of the head, seen from below. The outer surface of the right dentary is observed; also the tooth-bearing and triturating surfaces of the premaxillæ, the maxillæ, the palatines, the vomer, and the parasphenoid. The premaxillæ are sculptured with grooves superiorly and with pits nearer the tooth line. Here we find a band of 5 or 6 rows of small teeth. The outer rows of teeth become very small and some of them are found standing on the narrow walls surrounding the pits. A similar band is found on each maxilla, and on each of the dentaries. What I regard as the parasphenoid Cope has described as the vomer. It is, however, too elongated; and besides, it seems to correspond with what is certainly the parasphenoid in other specimens of the genus figured in this paper. Moreover, there is a patch of teeth farther forward which is supposed to belong to the vomer. Cope has spoken of this parasphenoid as if it were covered with small teeth. I find traces of teeth around its border and a considerable patch in front; elsewhere, the bone is occupied by pits and is devoid of teeth. Where the teeth are very small, they occupy the summit of the bone surrounding the pits. This bone, as well as the palatines, is thin, only about 2 mm., but this is probably due to pressure. The pits have the appearance of passing deeply down into the mass of the parasphenoid. The surface of the dentine-like layer of the bone presents evidences of wear. The lower surface of the palatines resembles the surface of the parasphenoid. A few small teeth are to be seen around the borders of the bone. The patches of teeth between the maxilla and palatine

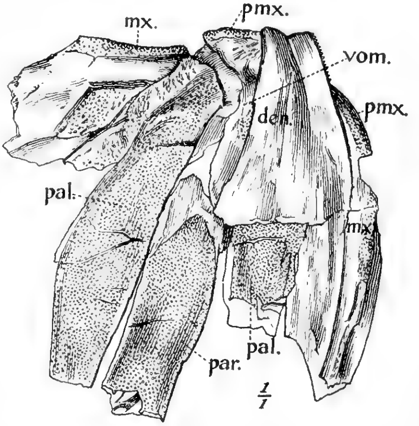


Fig. 18. *Anogmius favirostris* Cope. No. 2111. × ½. Type. *den.*, dentary; *mx.*, maxilla; *pal.*, palatine; *par.*, parasphenoid; *pmx.*, premaxilla; *vom.*, vomer.

in Fig. 18, probably, but not certainly, belong to the palatine.

The hinder end of the parasphenoid is missing; but it is not likely to have been much wider than the part present. The species, therefore, appears to be characterized by a narrow parasphenoid. In one important respect this parasphenoid differs from that of *A. aratus*, figured in this paper. In the latter species the parasphenoid extends forward nearly as far as the palatines do. In *A. favirostris* the parasphenoidal dental plate, at least, falls far short of the anterior end of the palatines. I am not able to see that this is due to displacement.

The vertebræ (Fig. 19) are little constricted, devoid of conspicuous lateral grooves, and provided with fine longitudinal ridges. There appear to be no lateral processes such as are found in some related species.

The paratype of the species, No. 2109, consists of the anterior half of the skull, and is of most interest seen from below (Fig. 20, natural size). The specimen has evidently had pressure applied to the snout, so as to drive it backward against the other bones. The anterior ends of the dentaries overlap. Just behind and

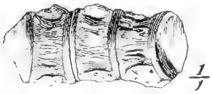


Fig. 19. *Anogmius favirostris* Cope. No. 2111. ×1. Type. Three caudal vertebræ.

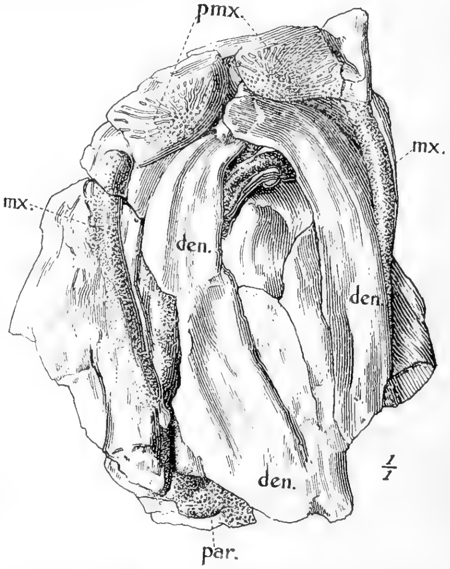
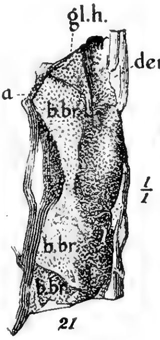


Fig. 20. *Anogmius favirostris* Cope. No. 2109. ×1. Paratype. *den.*, dentary; *mx.*, maxilla; *par.*, parasphenoid; *pmx.*, premaxillæ.

between these overlapping ends are seen the edges of two toothed bones, one in front of the other. Probably the one in front is the vomer, the other possibly a part of the glossohyal.

In front of the symphysis of the dentaries (*den.*) are seen the premaxillæ (*pmx.*) evidently pressed downward and backward. They are ornamented as in the type. As shown in the figure, the maxillæ (*mx.*) join the premaxillæ and form the greater part of the border of the mouth. The lower border is pitted, and some or all of these pits enclosed the bases of teeth. There is also a pitted band on the outer surface of the bone, above the tooth line.

Through a splitting of the specimen a view is afforded of the inside of the mouth. Fig. 21 is a view of the right-hand side of the floor of the mouth seen from above; while Fig. 22 shows the right side of the roof of the mouth turned upside down. If this piece is supposed to be rolled to the left it will fall into its place on Fig. 21, the points marked *a* in the two figures coinciding. Both these figures are of the size of the objects. In Fig. 21 the whole of the surface covered with little rings, which represent pits, except a narrow strip occupying a part of the right-hand side, appears to be made up of one or more dental plates. This is flat along the middle of the figure, but shelves off quite steeply on the right. Near the anterior end is a fold which runs obliquely outward and backward; and there is a similar fold near the hinder end of the dental plate. These folds may be artificial, but they probably represent sutures separating distinct bones. If so, the most anterior one is probably the glossohyal (*gl. h.*); the others



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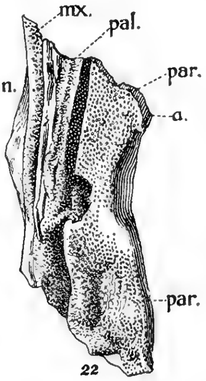

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Fig. 21. *Anogmius favirostris* Cope. No. 2109. × 1. Paratype. Floor of mouth, *a*, point coinciding with *a* of Fig. 22; *b. br.*, basibranchials; *den.*, dentary; *gl. h.*, glossohyal.

Fig. 22. Same as Fig. 21. Roof of mouth, *a*, point coinciding with *a* of Fig. 21; *mx.*, maxilla; *pal.*, palatine; *par.*, parasphenoid.

are median bones behind the glossohyal, baso-branchials (*b. br.*). Certainly, the antero-posterior extent of this mass is too great to belong to any one bone in the floor of the mouth.

Along the right-hand border of Fig. 21 are seen the broken edges of the dentary bone and of at least one, perhaps two bones, between the latter and the tritoral surfaces described above. Probably the hyoid and possibly a branchial arch are thus represented.

Fig. 22 presents, on the left-hand side, the right maxilla; on the right, the tritoral surface of the parasphenoid. Between them there is a toothed and pitted bone (*pal.*) which appears to have been folded longitudinally through pressure. This bone is taken to be the palatine. The parasphenoid, as seen, probably does not represent the whole width of this bone, but posteriorly it was at least 12 mm. wide. The bones, both upper and lower, of this triturating apparatus appear to be masses of dense osseous tissue penetrated by deep pits. On the outer border of the palatine are numerous sharp teeth. No teeth are observable on the border of the maxilla, but doubtless the shallow pits there seen lodged small teeth, as in the type specimen.

In both of the specimens described here there is present a broad thin bone which lies on the snout occupying the region between the anterior ends of the frontals and the premaxillæ. No median suture can be made out. Laterally the borders extend outward as far as the outer ends of the premaxillæ. This bone appears to be separated from the premaxillæ, but the evidence is not satisfactory. The bodies of the premaxillæ are perfectly distinct from each other, but the bone referred to may be their coössified ascending plates. In No. 2111 the bone extends backward about 15 mm. The large area occupied by this bone and its scale-like appearance indicate that it is not the ethmoid.

This species differs from *A. evolutus* in having a much narrower band of teeth on the dentary.

Anogmius aratus (*Cope*).

PLATE II.

Anogmius aratus COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. III, 1877, p. 585.—STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 340.—WOODWARD (A. S.), Cat. Foss. Fishes Brit. Mus. IV, 1901, p. 72.—HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 393.

The following description is based on the type of the species. The matrix containing this fish has apparently formed a large flattened concretion. Of this there are now in the possession of the American Museum four pieces. The largest block presents the head and the anterior half of the fin. Another has been split from the right side and presents the pectoral fin and some ribs and the imprint of some of the opercular bones. A third block shows the body in the region of the anal fin. This piece does not join accurately the largest block, but Cope did not believe that any considerable part was wanting. The fourth block contains the base of the caudal fin and about 10 vertebræ. Between this section and the third there is missing an unknown number of vertebræ, probably about 8. From a specimen of *A. polymicrodus*, studied at the University of Kansas, Dr. A. S. Woodward came to the conclusion that there were altogether about 80 vertebræ, of which nearly 40 were in front of the pelvic fins. This indicates that at least 10 vertebræ are missing in the abdominal region of our specimen and several others from the caudal region. The number of the type of *A. aratus* is 2403. With regard to the dorsal fin Professor Cope's statements are not as positive as the specimen seems to justify. The fin begins just above the hinder border of the operculum. Its first ray is supported by a strong interneural bone (Pl. II, *i. n.*). The succeeding interneurals diminish rapidly in size, so that after the sixth they are slender. Cope says that the fin is "continuous as far as the specimen is preserved in this region, viz., to the fifteenth vertebra behind the scapula." But there are 22 vertebræ preserved on the block and behind these are the imprints of 8 more; and there are impressions of interneurals as far as over the 28th vertebra. There is also the base of a dorsal ray over the 21st vertebra, so that the dorsal fin must have extended to this vertebra, at least. On the succeeding block there are interneurals and fin rays (*i. n.*, *d. r.*). Of the latter several must have had their origin considerably farther forward, possibly on the anterior block. On the hindermost block again there are remains of 4 or 5 rays. If the latter represent a distinct fin the one in front must have ended very abruptly. To the writer it appears quite certain that there was a single dorsal fin and that this extended from near the head to near the root of the tail. This must have resembled considerably the fin of *Coryphæna hippuris* (Jordan and Evermann, Fishes of North and Middle Amer., pl. cxlix, fig. 402).

Unfortunately, throughout most of its length only the bases of the fin rays remain, so that we have little idea regarding the height of the fin. On the second block there are remains of about 9 rays and some of these were at least 75 mm. high.

As stated by Cope some portions of the anal fin are present (*a. r.*). It was certainly short, but its exact length cannot be ascertained. A part of the anterior ray is seen, and about 6 interhæmal supports (*i. h.*) may be counted; but weathering has removed most of the bones.

There are present the distal ends of about 5 rays of one ventral fin (*v. r.*). Their tips have reached the front of the anal. They are cross-segmented.

One pectoral fin (*pct.*) is well preserved. It has lain in the matrix with the distal end directed across the vertebral column and with the convex anterior border directed upward. It is represented, for the sake of convenience, in a different position in the figure, the figure of it being drawn from the block split from the one bearing the body of the fish. The fin is 220 mm. long and seems to have consisted of about 20 rays.

Only the base of the caudal fin is present. The rays are supported by a fan-shaped hypural bone. In front of this are seen the crowded terminal vertebræ. The fin rays appear to have been slenderer and more numerous than in *Pachyrhizodus*. No evidences of cross segmentation appear.

The ribs are long and slender, and they have apparently been connected with the vertebral centra by means of distinct pieces of bone, parapophyses, as in *Tarpon*, *Portheus*, and some other fishes. Intermuscular bones are well developed, those arising just behind the head being especially long and slender.

Some scales are present. One is 18 mm. long and 5 mm. wide. The exposed portion is marked with lines radiating from the centre of growth.

Cope has described the form of the upper surface of the skull. It presents three planes, a median and two lateral. The median is narrow at the supraoccipital, but increases in width to the snout. The lateral planes are widest behind and narrow anteriorly. They slope off at an angle of about 30° with the median plane. The sides of the head are about vertical.

The bones of the upper surface of the skull in front of the orbits have been damaged. A portion of the frontals is gone, but the imprint of these and some splinters of the bones remain. Their anterior border cannot be determined exactly. The anterior extremity of the ethmoid is present and is thick and broad, as seen at the upper end of Fig. 23. Cope regarded this bone as the consolidated premaxillaries and thought that little if any of the ethmoid was exposed. The imprint of the premaxillæ and splinters of these bones still remain on the upper surface of the snout on a portion of the matrix which overlies the ethmoid. Again, a smooth articular surface is found at the proximal end of each of the maxillæ

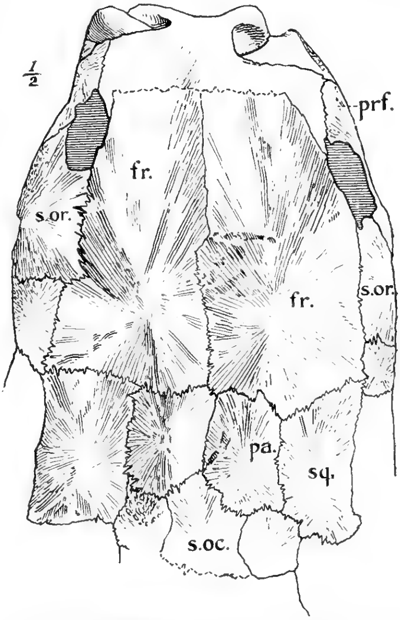

Fig. 23. *Anogmius aratus* Cope. No. 2403. × ½. Type. Head from above. *fr.*, frontal; *pa.*, parietal; *prf.*, prefrontal; *s. oc.*, supraoccipital; *s. or.*, supraorbital; *sq.*, squamosal.

(Pl. II, *mx.*), and these smooth surfaces must have been applied to the premaxillæ, unless the structure of this region was entirely different from that of *A. favirostris.* The premaxillæ have quite certainly been similar to those of Loomis's *Thryptodus zitteli*, and when present have nearly concealed the ethmoid. On the other hand, Loomis is probably mistaken in thinking that the premaxillæ of his species have coalesced with the ethmoid. His specimen and the type of *A. aratus* explain each other, and the explanation is confirmed by the types of *A. favirostris.* Whether or not the premaxillæ of *A. aratus* were coössified, we cannot be sure, No evidences of a median suture appear. Nor is it absolutely certain that the ascending processes of those bones were not united in *A. favirostris.*

The nasal cavities are situated above the level of the eyes and a little in front of them.

The bones of the upper surface of the head (Fig. 23) are in general like those figured by Loomis in his *Thryptodus zitteli*. The supraoccipital (*s. oc.*) does not separate the small and square parietals (*pa.*). Laterad of the last named bones are the large squamosals (*sq.*). The eye has been surrounded by a complete ring of bones. Over the eye are two sculptured supraorbitals (Fig. 23, *s. or.*). Behind the eye is the smooth postorbital (*pt. or.*); while in front is the prefrontal (*prf.*). This bone is sculptured above, but it sends downward in front of the orbit a long smooth process. Another elongated bone, apparently the preorbital, occupies the area between the prefrontal and the maxilla. The number of the bones covering the cheeks cannot be determined. They extend to the preopercular. The preoperculum (*p. op.*) and operculum (*op.*) are as represented in the plate. The other opercular bones were doubtless present, but are not preserved. The posttemporal (*pt.*) and the supracleithrum (*su. cl.*) are present. Of the cleithrum (*cl.*) only fragments remain on the block. An imprint of the coracoid is seen on the matrix below the throat. The articulation of the pectoral fin is high, being just below the vertebral column. If the precoracoid was present, it must have been short.

The articulation of the lower jaw is below the hinder half of the orbit. The articular sends up a strong hook-like process behind the quadrate. The maxilla is curved and does not extend back as far as to the quadrate. Neither the maxilla nor the mandible appears to have differed much from those of *Thryptodus zitteli*. The mouth has been relatively small and quite oblique.

The structure of the greater portion of the dental apparatus was unknown to Cope. He states that teeth are found on the ethmoid bone, his united premaxillæ; but the present writer has been able to find there only a slight roughness. When the fish died, the mouth was left in a gaping position. Recently the matrix has been removed from it to a depth of 98 mm. from the edge of the vomer. This reveals the fact that the mouth is armed with large bony plates which closely resemble those described by Loomis as belonging to *Thryptodus*. From a gelatine mold, plaster casts have been made of the upper surface of the mouth and of the floor. These have given much assistance to the artist in making drawings of the parts. The excavation of the cavity of the mouth did not extend quite to the hinder end of the plates, but must have approached them closely. In the front of the mouth we find a short, broad vomer (Fig. 24, *vom.*) which is covered with villiform teeth. Behind this is found a dental plate (*par.*) at least 82 mm. long and about 30 mm. wide. It has nearly parallel sides, and the lower surface is concave. The concavity is greatest just behind the middle. No doubt, this plate rests on the parasphenoidal bone, as in *A. favirostris*. On each side of this parasphenoidal plate and articulating closely with it is another plate (*pal.*), long, narrow in front, broadening behind, and convex in cross-section. These plates represent the palatine

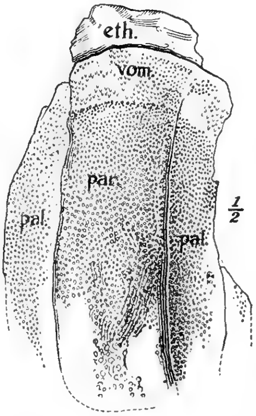

Fig. 24. *Anogmius aratus* Cope. Same specimen as Fig. 23. × ½. Roof of the mouth. *eth.*, ethmoid; *pal.*, palatine; *par.*, parasphenoid; *vom.*, vomer.

bones. The surfaces present the same structure as we have found in the case of the parasphenoid, being furnished with numerous pits. In places, all of these bones present evidences of attrition. Near the hinder end of the palatine is seen a portion of the ectopterygoid.

The floor of the mouth is occupied by two great convex plates which are joined by a transverse suture. The anterior (Fig. 25, *gl. h.*) has the form of the plate figured by Loomis (*op. cit.*, pl. xxi, fig. 4a) as the entoglossal, although it is smaller than the one figured by this writer. The length and breadth are each about 34 mm. It is strongly convex from side to side. The posterior plate (*b. br.*) is still more convex than the anterior, especially behind. The hinder border has not been exposed, so that we do not know its form and whether or not it was followed by a third plate. Both these plates are everywhere pitted, and the posterior one, which has fitted into the concavity of the parasphenoidal plate, is worn smooth over a considerable part of its surface. It is quite certain that these two plates have been developed on the glossohyal and the basi-branchials. Doubtless the structure of these plates is the same as that of the plates described under *A. altus*. Figure 26 illustrates a section across the mouth at about the middle of the basi-branchial plate (Fig. 25, *b. br.*) and some distance in front of the hinder end of the parasphenoidal plate (Fig. 24, *par.*). The line above *b. br.* represents the upper surface of the basi-branchial plate. The upper line shows the vaulted roof of the mouth as formed by the parasphenoidal plate (*par.*) and the right and left palatines (*pal.*).

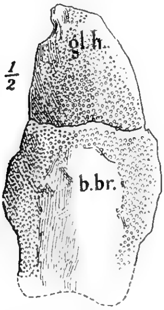

Fig. 25. *Anogmius aratus* Cope. Same specimen as Fig. 23. × ½. Floor of the mouth. *b. br.*, basi-branchial; *gl. h.*, glossohyal.

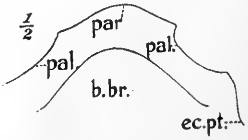

Fig. 26. *Anogmius aratus* Cope. From same specimen as Figs. 23–25. × ½. Diagrammatic section across the cavity of the mouth. *b. br.*, basi-branchial; *ec. pt.*, ectopterygoid; *pal.*, palatine; *par.*, parasphenoid.

It is quite certain that the specimen described by Dr.

Loomis as *Thryptodus zitteli* belongs to the same genus as the one here described, but it is also quite as certain that it represents a different species. It appears to have had a flatter skull and probably a blunter snout. Furthermore, the upper and the lower dental plates were all proportionally shorter and broader than in *A. aratus*.

Anogmius altus (*Loomis*).

Syntegmodus altus Loomis (F. B.), Palæontogr. XLVI, 1900, p. 253, pl. xxii, fig. 9.—Woodward (A. S.), Cat. Foss. Fishes Brit. Mus. IV, 1901, p. 84.—Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 390.

Dr. Loomis's type of this species included the hinder portion of the skull and the parasphenoid. The specimen is figured by him so as to present a lateral view.

No. 2112 of the American Museum of Natural History is a part of the Cope Collection, and was collected by C. H. Sternberg in 1877, probably in Gove County, Kansas. It furnishes about the same parts as does Loomis's specimen; but it is crushed obliquely downward. Figure 27 presents a view from above; Figure 28 from below. The specimen cannot be identified with certainty as *A. altus;* since, as will

Fig. 27. *Anogmius altus ?* (Loomis). No. 2112. × ½. Upper hinder part of skull. *b. oc.*, basioccipital; *ep. o.*, epiotic; *fr.*, frontal; *op. o.*, opisthotic; *pa.*, parietal; *sq.*, squamosal.

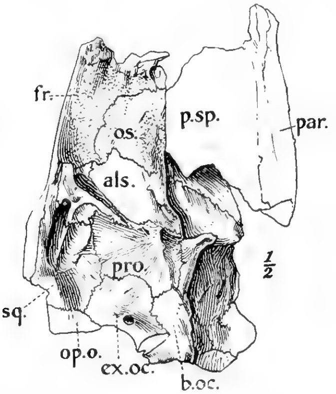

Fig. 28. Same as Fig. 27. × ½. Base of skull. *als.*, alisphenoid; *ex. oc.*, exoccipital; *op. o.*, opisthotic; *o. s.*, orbitosphenoid; *par.*, parasphenoid; *pro.*, proötic; *p. sp.*, presphenoid; *sq.*, squamosal.

be observed, in the type of the species the anterior edge of the presphenoid is but little in front of the middle of the parasphenoidal triturating surface; while in the specimen here described the presphenoid comes much farther forward. These differences may be individual, however.

As will be observed, the supraoccipital lies some 25 mm. to the right of the basioccipital, having been crushed to the right and downward. This shows that the skull must have been elevated at least that many millimeters above the foramen magnum, a conclusion which is confirmed by the skull described by Dr. Loomis. About 20 mm. in front of the hinder extremity of the supraoccipital begins an abrupt depression. It is about 10 mm. wide, and extends well forward on the frontals. From Fig. 28 the position and boundaries of the various bones may be seen. In general, these agree with those shown in the specimen described by Loomis as *Thryptodus zitteli* (*op. cit.*, pl. xxi, fig. 1). On the left the opisthotic, sphenotic, and hinder part of the frontal are in their natural positions and form the border of the skull. On the right the squamosal has been flexed downward at right angles with the surface of the skull. The border of the frontal on the left has probably been bent downward somewhat more than in life.

Figure 28 presents the skull as seen from below, only the outlines of the presphenoid (*p. sp.*) and parasphenoid (*par.*) being drawn. This bone will be described below. The observer must imagine himself as turning it to the left until it stands at right angles with the paper, and has the triturating surface (*par.*) facing him.

In this figure the proötics are drawn as meeting in the midline. This cannot be certainly affirmed; but the appearances are to that effect. There appears to have been a considerable excavation of some sort beneath the projecting edge of the squamosal and outside of the hyomandibular articulation. The alisphenoids are large, agreeing with those of Dr. Loomis's figure of *A. altus*. We come now to the bone called by Dr. Loomis the orbitosphenoid. It appears to agree with the bone so-called by Parker (Philos. Trans. Roy. Soc., CLXIII, 1874, pl. vii.). There is, however, satisfactory evidence of a pair of bones, or more probably of an unpaired bone with right and left wings, which is placed in front of the alisphenoids. This bone, marked *o. s.* in Figure 28, is certainly not the lower surface of the frontal, and there is a plain suture for union with the alisphenoid. The lateral edge of this bone is not so certainly determined, but seems to be where drawn in the figure. The surface for articulation with the large median bone (Figs. 28, 30, *p. sp.*), lies about 10 mm. to the left (right in the figure) of the midline between the frontals. This distortion could not occur if the bone (*p. sp.*) were articulated to the under surface of the frontals. Hence, I hold that the bones *o. s.* are the distinct, or more probably united, orbitosphenoids, while the bone (*p. sp.*) is the presphenoid. The latter would occupy the position of the presphenoidal cartilage shown in Fig. 10 of Pl. v and Fig. 10 of Pl. vii of Parker's paper just quoted. Dr. Loomis's figure of *A. altus* also shows an arch of bone running upward and outward from the upper edge of the bone called by him orbitosphenoid. It is above these bones that the anterior portion of the brain and the olfactory nerve must have lain.

The parasphenoid of this specimen must have had a median process behind, like that represented in Loomis's drawing (Fig. 10, Pl. xxii). At the anterior end of the lower surface of the supposed proötics, in the midline, there is an excavation in which this process must have been lodged. As already stated, the parasphenoidal grinding plate is deeply pitted (Fig. 29). Where a small fracture occurs it is seen that these pits pass down to the bone of the ordinary sort on which the denser mass reposes. Accompanying this plate is another bone which is represented by Fig. 31. This was broken, and the injured end has been ground down to show

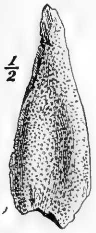

Fig. 29. *Anogmius altus?* (Loomis). Same individual as Figs. 27, 28. × ½. Parasphenoid, palatal surface.

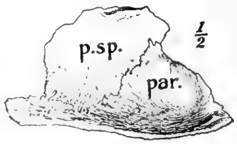

Fig. 30. *Anogmius altus?* (Loomis). Same individual as Figs. 27–29. × ½. Lateral view of parasphenoid and presphenoid.

the structure. Fig. 32 shows a small portion magnified two times. The pits and cavities in the bone are shown by the black. It will be observed that the pits penetrate nearly the whole thickness of the bony mass. Loomis has described the dense mass which forms the bulk of these triturating plates as "dentine" and "osteodentine." I do not discover the peculiar structure of dentine in any of them. The canals which Dr. Loomis calls "Haversian" appear to be the pits which open on the surface. To me the plates appear to be merely a kind of dense bone, similar to that found on the maxilla and premaxilla outside of the mouth cavity; and these bones display not very dissimilar pits. Dr. Woodward has mentioned the presence of dentinal tubules in *Plethodus* (Ann. and Mag. Nat. Hist., Ser. 7, Vol. III, p. 355). Unfortunately he has not furnished figures of these microscopical elements, or given us their dimensions. What is the function of these pits, and how they have been produced, the present writer does not attempt to explain. It would be interesting to know how these bony masses increased in thickness.

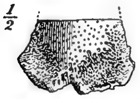

Fig. 31. *Anogmius altus?* (Loomis). Same individual as Figs. 27–30. × ½. Inferior grinding plate.

Fig. 32. *Anogmius altus?* (Loomis). Section through bone of Fig. 31. × 2.

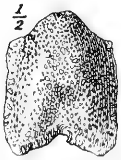

Fig. 33. *Anogmius* sp. No. 994. × ½. Inferior dental plate.

Seen from the lower side this bone is ornamented with fine ridges, which run, for the most part, longitudinally and anastomose, but which, in some parts, run in other and often irregular directions. In cross-section these ridges form narrow perpendicular plates, as appears at the bottom of Fig. 32. They appear to be similar to the fine ridges found by Dr. Woodward in similar situations in *Plethodus*.

The convex surface of this plate fits well the concave surface of the upper plate. Fig. 33 presents a view of the grinding surface of a lower dental plate collected for the author in the region of Butte Creek, Kansas, but which is now the property of the American Museum. It is strongly convex above, concave below. The ends have evidently been suturally joined to other bones; so that it has apparently been the middle one of a series of at least three bones forming a triturating plate. In this bone, as in No. 2112, the pitted surface gives evidences of polishing through use. No evidences of teeth are to be found on the central portions of this plate, but around the borders, especially in front, many small, sand-like teeth are observed. These are clustered on the ridges of dense bone surrounding the pits, as seen in Fig. 34, which represents an enlarged view of the surface of Fig. 32 bounded by the two fractures on the upper left-hand border. The pits are shown in black; the teeth by the small circles. This bone closely resembles the one figured by Stewart (Univ. Geol. Surv. Kansas, VI, 1900, pl. lxvii) as a pharyngeal of *Anogmius polymicrodus*.

Fig. 34. *Anogmius* sp. Enlarged view of part of Fig. 33. × 2.

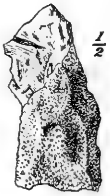

Fig. 35. *Anogmius* sp. No. 1116. × ½. Lower anterior dental plate.

Fig. 36. *Anogmius* sp. No. 1116. × ½. Caudal vertebra.

Fig. 35 represents an upper view of another lower dental plate which evidently belongs to some species of *Anogmius*. The upper surface is in general convex, but the central and hinder part is somewhat concave. On each side of the concavity a ridge runs forward to about the middle of the length. Here it divides, one branch running outward to the border of its side. The other unites with the corresponding ridge of the other side, and the single ridge thus formed continues to the anterior end of the triturating surface. In front of the pitted mass of dense bone there is a thin expansion of ordinary bone. On the right-hand side of the figure this does not appear, but this is because it has been crushed downward and to the left beneath the part seen. It seems most probable that this bone is the glossohyal. It belongs to the same specimen as the piece of tail represented by Fig. 16. Fig. 36 gives a view from above of a caudal vertebra of the same specimen, No. 1116. There are seen the pits for the reception of the neural arches.

There is also presented on each side an outstanding process which is found on some of the vertebræ of some members of the genus. They occupy a position about the middle of the height of the vertebral centrum and near the hinder end.

Anogmius evolutus *Cope.*

Anogmius evolutus Cope (E. D.), Proc. Amer. Philos. Soc. XVII, 1877, p. 179. — Stewart (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 347, pl. lxv, fig. 7; pl. lxvii. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 72. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 393.

Osmeroides evolutus Loomis (F. B.), Palæontogr. XLVI, 1900, p. 257, pl. xxvi, figs. 5, 6.

Beryx multidentatus Stewart (A.), Kansas Univ. Quart. VII, 1898, p. 196.

The type of this species is here figured (Fig. 37). The original description given by Professor Cope seems to be sufficiently clear and accurate. Dr. Loomis has figured a mandible and premaxilla of what appears to be this species. His specimen is different from that described by Cope in having the band of teeth wholly on the inside of the dentary, instead of having it about equally distributed on the inside and the outside of the bone. Fig. 37 shows how much of the band of teeth was on the inside of the jaw in the type of the species; the detached part of the figure represents the teeth on the outer side of the jaw. It is possible that the difference in the two specimens is due to the crushing of one or the other; but of which, it is now impossible to say.

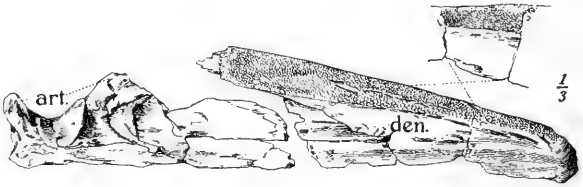

Fig. 37. *Anogmius evolutus* Cope. No. 2101. × $\frac{1}{3}$. Type. Lower jaw, view of inner surface; detached figure, a portion of outer surface. *art.*, articular; *den.*, dentary.

A comparison of the figure of the premaxilla given by Dr.

Loomis shows that this bone must have been quite like that of *A. favirostris*, in both form and sculpture.

Cope's type of *A. evolutus* was, according to Mr. C. H. Sternberg's diary of his expedition of 1877, found near the line between Lane and Gove counties, Kansas. It is now No. 2101 of the American Museum of Natural History.

ELOPIDÆ.

Spaniodon simus *Cope.*

PLATE IV, FIGS. 1 AND 2.

Spaniodon simus COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. IV, 1878, p. 69. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 53. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 391.

Illustrations are herewith presented of the specimens from which Professor Cope drew his description of this species. He has mentioned the possession of three specimens, of which one, said to be nearly entire, served as his type. These specimens are now in this Museum. Fig. 1, Pl. IV, is taken from No. 2508; Fig. 2 of the same plate, from No. 2509. On the block containing the latter specimen are remains of one or more fishes lying behind and above the fish represented on the plate, but it is doubtful whether or not they belong to the latter. In any case the vertebræ are all wanting. Yet it is from this fish that most of the description of the head is derived. Both specimens are labelled by Cope as being his types.

Little criticism can be made on Cope's description. To the writer it appears evident that the lower portion of the body was scaled. The dorsal and anal seem to have had each about two rays fewer than the numbers given in the original description.

The number of vertebræ in this fish is less than in any of the other described species. *S. latus* (Agassiz) is stated by Dr. A. S. Woodward (Cat. Foss. Fishes, IV, p. 53) to have 50 vertebræ, whereas the present species has only 45.

The depth is contained in the length to the end of the vertebral column three and one-half times; the length of the head in the same distance about three and one-third times. Three other species, *S. blöndeli* Pictet, *S. elongatus* Pictet, and *S. latus* (Agassiz) are found in the upper Cretaceous of Sahel Alma, Mt. Lebanon.

On the block bearing No. 2509 are found written in pencil the words "Yankton, Neb." Professor Cope merely stated that the specimens came from Dakota. The formation and locality are therefore as follows: Niobrara Cretaceous, Yankton, South Dakota.

ICHTHYODECTIDÆ.

Saurocephalus *Harlan.*

So far as has yet been shown the only difference between *Saurocephalus* Harlan and *Saurodon* Hays is found in the presence in the former of a row of foramina, one foramen for each tooth, placed some distance from the dental border of the jaws, upper and lower, while in *Saurodon* there is at the base of each tooth a deep notch. In the latter genus the notches are often converted into foramina by the growth of bone across the notch. There can be little doubt that the foramina of *Saurocephalus lanciformis* originated from notches like those of *Saurodon leanus.* Whether or not this difference shall be regarded as sufficient to indicate distinct genera may be a matter of individual judgment. The writer has preferred to retain all the species under *Saurocephalus.*

These openings in the bones of the jaws have been called nutritive foramina, and as such Dr. Woodward speaks of them in the final volume of his work on fossil fishes. There can be little doubt that it is through these foramina that the young teeth enter the sockets. The writer has ground down a small piece of a jaw of this genus and found the very young tooth at the bottom of one of these foramina, lying against the functional tooth. As growth occurs, the root of the tooth pushes itself above the foramen, while the blade grows toward the dental border. It is very improbable that any nutrient vessels enter the sockets through these foramina. From Dr. Loomis's memoir I gather that the view here presented is also that of Dr. Röse.

Saurocephalus phlebotomus *Cope.*

Saurocephalus phlebotomus Cope (E. D.), Proc. Amer. Philos. Soc. XI, 1870, p. 530; U. S. Geol. Surv. Wyoming, etc. 1871, p. 416; Proc. Amer. Philos. Soc. XII, 1871, p. 343. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 386.

Daptinus phlebotomus Cope (E. D.), Proc. Acad. Nat. Sci. Phila. 1873, p. 339; Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 41; Vert. Cret. Form. West, 1875, pp. 213, 275, pl. xlvii, figs. 3, 4, 6; pl. xlix, figs. 1–4. — Newton (E. T.), Quart. Jour. Geol. Soc. XXIV, 1878, p. 440. — Zittel (K. A.), Handbuch Palæont. III, 1890, p. 264.

Saurodon phlebotomus Cope (E. D.), Bull. U. S. Geol. Surv. III, 1877, p. 588. — Stewart (A.), Kansas Univ. Quart. VII, A. 1898, p. 186; Univ. Geol. Surv. Kansas, VI, 1900, p. 312, pl. lvii, figs. 4, 5. — Loomis (F. B.), Palæontogr. XLVI, 1900, p. 248, pl. xxiv, figs. 1–5. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 112.

Daptinus phlebotonum Crook (A. J.), Palæontogr. XXXIX, 1892, p. 123.

The type of this species is in the American Museum and has the number 1906. There are present all of the left maxilla, except the distal end; the alveolar border of the right maxilla; both palatine malleoli; and considerable parts of both dentaries, including the symphysis and surface for articulation of the predentary. All the parts are more or less fragmentary; but it is believed that they furnish a correct idea of the tooth lines, both of the maxillæ and the dentaries. The conclusion is reached that there were not more than 40 teeth in each dentary and about 30 in each maxilla.

The specimen which Stewart has described and figured as *Saurodon phlebotomus* (Univ. Geol. Surv. of Kansas, VI, p. 312, pl. lvii, figs. 4, 5) is quite certainly such. On the other hand, the specimens described and figured by Loomis (Palæontogr., XLVI, p. 248, pl. xxiv, figs. 1–5) are probably not of this species. In these there are 47 teeth in the dentary. Likewise, the premaxilla does not resemble that of one of

Fig. 38. *Saurocephalus phlebotomus* Cope. No. 1907. × ½. Premaxilla, inner view.

the specimens which Cope has (and, so far as I can see, correctly) identified as *S. phlebotomus*. This specimen, No. 1907, is here figured (Fig. 38) and it will be seen that it is much more pointed than is the one figured by Dr. Loomis. The latter is probably *S. xiphirostris* Stew., the premaxilla of which is shown here by Fig. 39.

There seems to be only one objection to Stewart's identification of his specimen, and that is found in the relative lengths of the dentary and maxilla. Cope's specimens indicate that the dentary projected farther in front of the premaxillaries than Stewart's figures would suggest. The tooth line of the dentary of Cope's type must have had a length of 98 mm.; the maxillary tooth line a length of 60 mm. If now we add to the latter 20 mm. for the premaxilla, we have 18 mm. for the distance which the dentary projected beyond the premaxillary. How the discrepancy is to be explained is now uncertain.

Saurocephalus lanciformis *Harlan.*

Saurocephalus lanciformis HARLAN (R.), Jour. Acad. Nat. Sci. Phila. (1), III, 1824, p. 337, pl. xii; Trans. Geol. Soc. Penn. I, 1834, pt. i, p. 83; Med. and Phys. Res. 1835, pp. 286, 289, 366. — ? MORTON (S. G.), Amer. Jour. Sci. XXVIII, 1835, p. 277. — OWEN (R.), Odontog. 1845, p. 130, pl. lv. — GIEBEL (C. G.), Fauna Vorwelt, I, pt. iii, 1848, p. 89. — LEIDY (J.), Proc. Acad. Nat. Sci. Phila. 1856, p. 302; Trans. Amer. Philos. Soc. XI, 1857, p. 87, pl. vi, figs. 8–11. — PICTET (F. J.), Traité Paléont. 1854, ed. 2, p. 93. — ?? SPILLMAN (W.), Hilgard's Rep't on Geol. Miss. 1860, pp. 142, 389. — COPE (E. D.), Proc. Amer. Philos. Soc. XI, 1870, p. 530; U. S. Geol. Surv. Wyom. 1871, p. 415; Vert. Cret. Form. West, 1875, pp. 216, 275. — DAVIES (W.), Geol. Mag. (2), V, 1878, p. 260. — NEWTON (E. T.), Quart. Jour. Geol. Soc. XXXIII, 1878, p. 786. — STEWART (A.), Kansas Univ. Quart. VII, 1898, p. 186. — HAY (O. P.), Amer. Jour. Sci. (4), VII, 1899, p. 299, figs. 1–4. — LOOMIS (F. B.), Palæontogr. XLVI, 1900, p. 251, pl. xxv, figs. 2–5. — STEWART (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 392. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 113. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 386.

Saurodon lanciformis HAYS (I.), Trans. Amer. Philos. Soc. (2), III. 1830, p. 477, pl. xvi, fig. 11.

Saurocephalus arapahovius Cope (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 343; U. S. Geol. Surv. Mont. 1872, pp. 344, 348; Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 41; Vert. Cret. Form. West, 1875, pp. 216, 275, pl. xlix, fig. 5. — Woodward (A. S.), Cat. Foss. Fishes IV, 1901, p. 114. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 385.

Saurocephalus arapalovius Loomis (F. B.), Palæontogr. XLVI, 1900, p. 251 (syn. of *S. lanciformis*).

The type of Cope's *Saurocephalus arapahovius* is in the Cope Collection, now belonging to the American Museum of Natural History, and has the number 2073. It is a fragment of the maxilla. Cope distinguished his species from *S. lanciformis* on the ground that the facets shown by Leidy to exist on the roots of the teeth of the latter were absent in the former. Loomis unites the two species because he regarded the presence of facets to be variable. I have exposed the root of one of the teeth of the type of *S. arapahovius* and find that there are very distinct facets. There appears, therefore, to be no reason for retaining it as a distinct species.

Saurocephalus xiphirostris (*Stewart*).

Saurodon xiphirostris Stewart (A.), Kansas Univ. Quart. VII, 1898, p. 178, pl. xiv; Univ. Geol. Surv. Kansas, VI, 1900, p. 314, pl. lv. — Loomis (F. B.), Palæontogr. XLVI, 1900, p. 247. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 113.

Saurocephalus xiphirostris Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 386.

Saurodon phlebotomus Loomis (F. B.), Palæontogr. XLVI, 1900, p. 248, pl. xxiv, figs. 1–5.

I find difficulty in estimating the value of Stewart's species, *Saurodon broadheadi*, *S. ferox*, and *S. xiphirostris*. There is at least one good species among these; if only one, it must bear the earliest name, *broadheadi*. *S. ferox* appears to differ from *S. broadheadi* in having the maxilla proportionally a little higher. It has also an unusually large number of teeth in the maxilla, 40; an unusually small number, 46, in the dentary; and only 10 in the premaxilla. The number is variable, however; a specimen, No. 1614, referred to *S.*

xiphirostris, having 32 in one maxilla, 35 in the other; 50 teeth in the dentary; and 11 in the premaxilla. Another has 32 and 34 teeth in the maxillæ, 50 in the dentary, and 13 in the premaxilla. However, it is probably better for the present to regard the three species as distinct.

No. 1614 (Figs. 39, 40) was collected in 1877, in Gove County, Kansas, by Mr. R. Hill, for Professor Cope. It consists of both upper jaws complete; the left palatine complete, or nearly so; the greater part of both lower jaws; one quadrate; and the predentary. The number of the teeth has been stated. The predentary has a length of 55 mm., a vertical diameter of 27 mm. at the base, and a transverse diameter of 16 mm. It does not appear to have suffered any crushing. The premaxilla is represented by Figure 39 for comparison with that of *S. phlebotomus*.

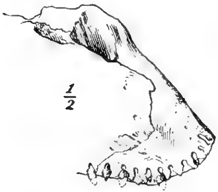

Fig. 39. *Saurocephalus xiphirostris* (Stewart). No. 1614. × ½. Premaxilla, inner view.

The palatine has the form represented in Fig. 40, seen from the outside. The mesial surface is concave in cross-section. On this surface are seen two considerable patches of small teeth, and probably the whole surface was originally furnished with teeth. Attached to the hinder end of the upper border of the maxilla is a supramaxilla.

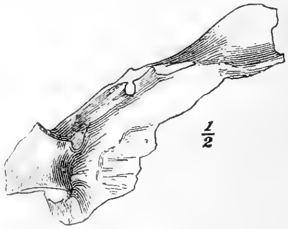

Fig. 40. *Saurocephalus xiphirostris* (Stewart). No. 1614. × ½. Palatine, outer view.

No. 2012 has 35 teeth in the maxilla. The predentary is 66 mm. long and 28 mm. high.

Saurocephalus goodeanus (*Cope*).

Ichthyodectes goodeanus Cope (E. D.), Proc. Amer. Philos. Soc. XVII, 1877, p. 176. — Hay (O. P.), Amer. Jour. Sci. (4), VI, 1898, p. 227; Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 385. — Woodward, (A. S.), Cat. Foss. Fishes, IV. 1901, p. 107.

In the Cope Collection of fossil fishes has been found Cope's type of his *Ichthyodectes goodeanus*. It proves to be a species of *Saurocephalus*, belonging to the section or subgenus *Saurodon*. Its number is 2110. It is difficult to understand how Professor Cope came to refer the species to *Ichthyodectes*, since the forms of the maxillary, premaxillary, and palatine, and the presence of notches at the bases of the teeth plainly indicate its relationship with *Saurocephalus phlebotomus* (Fig. 41).

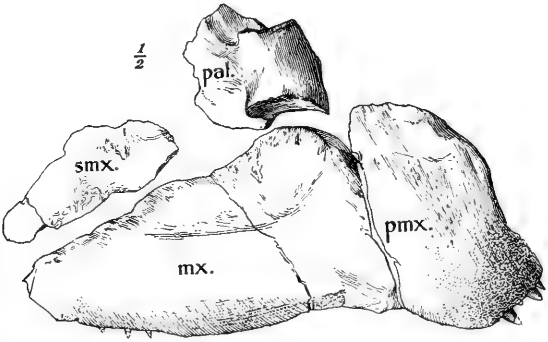

Fig. 41. *Saurocephalus goodeanus* (Cope). No. 2110. × ½. Type. Upper jaw, outer view. *mx.*, maxilla; *pal.*, palatine; *pmx.*, premaxilla; *smx.*, supramaxilla.

Cope's description agrees in almost every respect with the specimen, but in one or two cases there is some apparent lack of agreement, due evidently to a misuse of terms. He states that "the maxillary border is incurved at its anterior extremity," etc. This is exact, if instead of maxillary we read premaxillary. That the latter is meant is indicated by the statements "the middle part of the border being most prominent," and "the anterior border is sigmoidally curved," statements true of the premaxilla, but having little or no significance when applied to the maxilla. The statements as to the number and character of the premaxillary teeth are correct. As Cope says, the maxillary teeth are round in section; but there can be little doubt that if we had the crowns of these teeth they would be found to be two-edged, as are those of the premaxilla. Cope's measurements are correct.

This species differs from all other described species of

Saurocephalus in its heavy structure. The bones are much thicker than those of specimens which I refer to *S. xiphirostris*, as the following measurements indicate.

	S. xiph.	*S. good.*
Thickness of premaxilla 20 mm. above alveolar border............	8 mm.	12 mm.
" " maxilla 10 mm. below condyle..	8 mm.	12 mm.
" " " 10 mm. above alveolar border at middle of length............	5.5 mm.	7.5 mm.

The exact length of the maxilla cannot be determined, but it is quite evident from the way in which the alveolar border is curved upward posteriorly and the small size of the teeth that the bone did not extend much farther backward. Alveoli for 31 teeth are counted; and there are six alveoli in 20 mm. The palatine malleolus, measuring from the articular surface for the maxilla to that for the prefrontal, is high; not low, as we find it in *Ichthyodectes*.

The supramaxilla (Fig. 41, *smx.*) is present. In the drawing this bone is lifted somewhat above its natural position. It is flat on the outside. On the mesial side it is traversed longitudinally by a sharp ridge.

This species was collected by C. H. Sternberg's party during the year 1877, probably in Gove County, Kansas.

The maxilla figured by Stewart as the type of *Saurodon broadheadi* resembles in outline and proportions that of *Saurocephalus goodeanus*, but Dr. S. W. Williston has kindly given me measurements which show that Stewart's species is everywhere much thinner. At 10 mm. below the condyle the thickness is only 7 mm.; at middle of length, 10 mm.; above the lower border, only 4.5 mm.

Ichthyodectes anaides *Cope.*

Ichthyodectes anaides Cope (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 339; 5th Ann. Rep. U. S. Geol. Surv. Mont. etc. 1872, p. 343; Bull. U. S. Geol. and Geog. Surv. Terrs. I, No. 2, 1874, p. 40; Vert. Cret. Form. West, 1875, pp. 206, 274, pl. xliv, figs. 14, 15; pl. xlv, figs. 1–8. — Crook (A. R.), Palæontogr. XXXIX, 1892, pp. 111, 123, pl. xv. — Hay (O. P.), Amer. Jour. Sci. (4), VI, 1898, p. 226, fig. 2; Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 384. — Loomis (F. B.), Palæontogr. XLVI, 1900, p. 244. — Stewart (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 296, pl. xlix, figs. 1–3. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 100.

Portheus arcuatus Cope (E. D.), Vert. Cret. Form. West, 1875, p. 274, pl. xlvii, figs. 7–9.

This is one of the commoner species found in the Niobrara beds of Kansas, and it has been figured by Cope, Crook, Hay, and Stewart. As shown by some of the published figures and by specimens in the American Museum, the mouth has been very oblique. The eyeball is large, as shown by the preserved sclerotic bone.

Crook has figured portions of the shoulder girdle and the first pectoral ray. As in the case of *Portheus*, he has mistaken the upper end of the clavicle for the lower, and consequently the right for the left fin. The first pectoral ray has the same structure as that of *Portheus*, but has evidently been proportionately shorter and more curved distally.

An examination of the original of Cope's figures 7–9, pl. xlvii, 'Vertebrata of the Cretaceous Formations of the West,' has convinced me that they belong to this species and not to *Gillicus arcuatus*. Crook has already surmised this to be true (Palæontogr., XXXIX, p. 112). The skull is shorter and broader and of heavier construction.

After examining skulls of *Portheus*, *Saurocephalus*, and *Gillicus* I am confirmed in my opinion that the parietals are united in the mid-line and lie in front of the supraoccipital. They form the base of the great crest at the back of the head, and extend slightly backward on each side like the horns of a crescent. Posteriorly these horns join the anterior prolongations of the epiotics. I have not been able in any case to discover sutures between the parietals and the epiotics, but doubtless these exist.

No. 2005 of the American Museum was collected in 1877, in Gove County, Kansas, by Russell Hill. It furnishes a complete head, 19 anterior vertebræ, the shoulder girdle, and the first rays of both pectoral fins. Unfortunately, the head is somewhat distorted and crushed, and the greater part of the shoulder girdle hidden. Above each orbit are two supraorbitals, one behind the other and each about 25 mm. wide. There are remains of a supramaxilla, but its limits are not definable. A portion of the palatine behind the malleolus has been exposed in life. Below and behind the eye the bones of the palatopterygoid arch have been wholly hidden by the suborbitals. The boundaries between these latter bones cannot be made out, the bones themselves having probably been very thin. If correctly identified, the supracleithrum is large, about 160 mm. long and 50 mm. or more wide. The preopercular resembles that of *Portheus*. The opercle is large. All the opercular bones are roughened, as if there had been here and there bony nodules. The cleithrum appears to have a backwardly extending flap behind the articulation of the jaw.

The head of this specimen has been shortened by distortion, but must have been, from snout to gill clefts, about 300 mm. long. The length of the whole fish must have been about 5 feet (1.64 m.).

The vertebræ of this species resemble those of *Portheus*. In his description of these (Vert. Cret. Form. West, p. 207) Cope states that the ribs are not articulated directly to the centra, but by means of free elements which were inserted into the lateral grooves. Had I been aware of this fact when writing my observations on the vertebral column of *Portheus* (Zoöl. Bull., II, 1898, pp. 25–54) I might have been saved from the blunder which I there made, that of calling the upper side of the vertebral column the lower. The sections of the column there studied had been crushed so that the ribs of opposite sides had been brought into close contact and so as to resemble neural arches. In *Tarpon*, with which they were being compared, there are also free parapophyses, but posteriorly these diminish and disappear. In *Portheus*, on the contrary, as is now realized, these parapophyses increase in size toward the tail region, and the same is probably true in the cases of other members of the family.

Ichthyodectes multidentatus *Cope.*

Ichthyodectes multidentatus Cope (E. D.), Proc. Amer. Philos. Soc. XII, 1872, pp. 339, 342; 5th Ann. Rep. U. S. Geol. Surv. Montana, etc. 1872, p. 343; Bull. U. S. Geol. and Geog. Surv. Terrs. I, No. 2, 1874, p. 41; Vert. Cret. Form. West, 1875, pp. 212, 275, pl. l, figs. 6, 7. — Crook (A. R.), Palæontogr. XXXIX, 1892, p. 123. — Hay (O. P.), Amer. Jour. Sci. (4), VI, 1898, p. 227; Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 385. — Loomis (F. B.), Palæontogr. XLVI, 1900, pp. 243, 245, text figs. 8, 9; pl. xxiii, fig. 9. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 107.

This species was based on a premaxilla and a fragment of the maxilla, and these parts were figured as cited above. The type now bears No. 2186 of the American Museum of Natural History. Afterward a more complete specimen was secured and described. This is now No. 1743 of this Museum and is represented in Figure 42. The identification of this with the type is doubtless correct. Only a part of a single tooth of the type remains, but this shows the presence of the ridges and furrows which are so distinctly seen in Cope's second specimen (Fig. 42, *t.*).

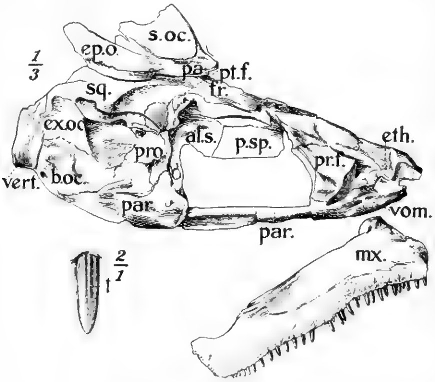

Fig. 42. *Ichthyodectes multidentatus* Cope. No. 1743. Skull $\times \frac{1}{3}$; tooth × 2. *als.*, alisphenoid; *b. oc.*, basioccipital; *ep. o.*, epiotic; *eth.*, ethmoid; *ex. oc.*, exoccipital; *fr.*, frontal: *mx.*, maxilla; *pa.*, parietal; *par.*, parasphenoid; *prf.*, prefrontal; *pro.*, proötic; *p. sp.*, presphenoid; *ptf.*, postfrontal; *s. oc.*, supraoccipital; *sq.*, squamosal; *vert.*, vertebra; *vom.*, vomer.

The skull of this specimen is much crushed and broken, but nevertheless much may be learned from it. In general form it resembles that of *Gillicus arcuatus* (Cope), although the bones are not so thin. As in that species, there is a strong upward flexure of the axis in the basisphenoidal region. The snout is pointed, and there is a high supraoccipital crest. The maxilla has been described by Cope. It bears teeth, or spaces for them, to the number of about 50. Loomis states that there are about 44 teeth. The maxilla which he figures in outline (*op. cit.*, p. 45) is slenderer than the one here figured and of a somewhat different form. Loomis also figures what he regards as the mandible of this species.

In No. 1743 there is a deep excavation in the sides of the skull just below the articulation of the hyomandibular. This is seen also in the skull of *Portheus*, and is probably found in the skulls of all members of the family. The supraoccipital and the epiotic have been broken from the skull and replaced, as shown. Just above the line of fracture is the very distinct suture which passes between this bone and the squamosal. Another suture starts well up on the front of the supraoccipital crest, descends for a short distance, then turns backward. The bone in front of and below it is undoubtedly the unpaired parietal. Cope mistook the epiotic for the parietal. The suture in front of and below the parietal is effaced by the fracture. I have not been able to find a suture separating the parietal from the epiotic, but such no doubt exists. In a former paper (Zoöl. Bull., II, 1898, pp. 25–54) I have announced such to be the position of the single parietal; but its bounding sutures are not often easily seen. One specimen will reveal one suture, another specimen another suture. In a specimen of *Portheus*, No. 2373 of this Museum, both the upper and the lower sutures are distinct. Such a disposition of the parietals doubtless characterizes all members of the family.

The palatine has been provided with a patch of small teeth. The malleolus for union with the maxilla is low, broad, and flat.

The interorbital septum of the species under consideration appears to be occupied by a presphenoid; and above this there were probably orbitosphenoids. The vomer is beset by a patch of teeth.

As has been stated by Cope, the scapula and part of the cleithrum are present. This author states that the width of the cleithrum ("clavicle") below the scapula is 40 mm. This shows that he mistook the upper for the lower end of the cleithrum; for the lower end is missing (Fig. 43). On the inside of the cleithrum there is a precoracoid which ascends from the coracoid three-fifths the distance to the upper end of the cleithrum. This precoracoid, which is like that of *Portheus*, was doubtless regarded by Cope as the coracoid. There are two large convex surfaces for articulation with the fin, the uppermost with the large first ray, the lowermost with the first baseost. On a level with the latter, but more mesiad, are two pits, undoubtedly for the reception of the next two baseosts. The proper interpretation of these parts is made easy by comparison with the shoulder girdle of a tarpon or salmon.

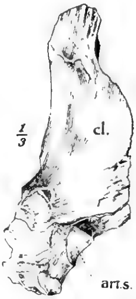

Fig. 43. *Ichthyodectes multidentatus* Cope. No. 1743. × ⅓. *cl.*, cleithrum; *art. s.*, articular surface for fin ray.

Gillicus *Hay.*

The type of this genus is Cope's *Portheus arcuatus*, later called by him *Ichthyodectes arcuatus*. Dr. A. S. Woodward (Cat. Foss. Fishes, IV, 1901, p. 101, pl. viii) has recently described a second species, *Gillicus serridens*, from the Albian epoch, Kent, England, under the name *Ichthyodectes serridens*. It differs in having the anterior mandibular teeth relatively larger. The members of this genus are well characterized by the falcate maxillæ, the reduced dentition, and the thin skull bones.

PACHYRHIZODONTIDÆ.

Pachyrhizodus *Agassiz.*

Cope originally made this genus the type of the family Pachyrhizodontidæ (Proc. Amer. Philos. Soc., XII, 1872, p. 343). Later he placed it in the family Stratodontidæ (Vert. Cret. Form. West, 1875, p. 219). Loomis and Stewart regard the relationships of the genus to be with the Salmonidæ. Dr. A. S. Woodward in his latest volume places the genus in the Elopidæ. To the present writer it seems best to retain it and its related genera in a special family as Cope originally did, until more is known regarding the anatomy.

Pachyrhizodus caninus *Cope.*

Plate III, Figs. 1 and 2.

Pachyrhizodus caninus Cope (E. D.), Proc. Amer. Philos. Soc., XII, 1872, p. 344; Rept. U. S. Geol. Surv. Mont. etc. 1872, p. 348; Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 42; Vert. Cret. Form. West, 1875, pp. 221, 276, pl. l, figs. 1–4. — Crook (A. J.), Palæontogr. XXXIX, 1892, p. 109. — Loomis (F. B.), Palæontogr. XLVI, 1900, p. 262, pl. xxvii, figs. 10–12. — Stewart (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 355, pl. lxx, figs. 2–6.— Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 44. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 387.

Pachyrhizodus latimentum Cope (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 346; Rept. U. S. Geol. Surv. Mont. etc. 1872, p. 348; Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 42; Vert. Cret. Form. West, 1875, pp. 223, 276, pl. l, fig. 5; pl. li, figs. 1–7. — Loomis (F. B.), Palæontogr., XLVI, 1900, p. 263, pl. xxvi, figs. 7, 8. — Stewart (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 357, pl. lxviii; pl. lxx, figs. 9, 10. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 42. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 388.

Pachyrhizodus curvatus Loomis (F. B.), Palæontogr. XLVI, 1900, p. 265, pl. xxv, figs. 6–8. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 44. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 388.

The writer has ventured to unite the two species which Prof. Cope has described under the names *Pachyrhizodus caninus* and *P. latimentum*. The types of these are in this Museum, that of *P. caninus* having the number 1881; that of *P. latimentum* the number 1758. Besides these, there are various jaws and other parts which were collected for Prof. Cope by Messrs. Sternberg and Hill during the year 1877. In attempting to apply to this material the characters assigned by Cope to his two species the writer has become convinced that the differences are due partly to individual variations and partly to distortions during fossilization. The various collections indicate that the bones of this species were soft and spongy, so that they easily suffered compression and distortion. Jaw bones of the opposite sides of the same individual are sometimes so different that one is convinced with difficulty of their identity. The groove which divides the symphyseal surface of the dentary of *P. latimentum* is very distinct in specimens which on account of the small height of the coronoid process would have to be assigned to *P. caninus.* The height of the coronoid process will, with little doubt, be found to vary in all degrees between the measurements given by Cope for his two species.

The mandible of the species (Fig. 44) appears to have had an external vertical surface and an inferior nearly horizontal surface. In some specimens these are separated by a sharp ridge; in others they are with difficulty distinguishable, a condition probably due to distortion during fossilization. Similarly, the maxilla has presented an external nearly flat surface separated by a sharp border from a flat superior surface. This surface, again, meets a flat palatal surface at a sharp internal, or mesial, border. The section of the maxilla is, therefore, nearly triangular. In one specimen, however, the maxilla of one side has the form described, while the other is so distorted that its section is nearly parallelogrammic. These modifications are mentioned in order to show the necessity of guarding against giving too much value to variations in the forms of the bones of this genus.

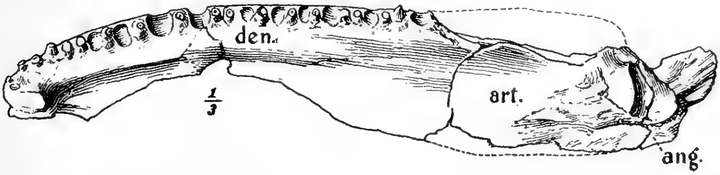

Fig. 44. *Pachyrhizodus caninus* Cope. No. 1662. × ⅓. Mandible. *ang.*, angular; *art.*, articular; *den.*, dentary.

Of the palatines and the pterygoids of this species the writer has been able to learn little. Loomis (*op. cit.*, pl. xxvii, fig. 12) has figured what he regards as a palatine, but it seems to be identical with a left maxilla in this Museum's collection. Besides, one would hardly expect to find a palatine of a length so great that it would reach nearly to the quadrate.

In the National Museum at Washington there is a specimen of this species which I have been permitted to study.

It appears to have been about six feet (1.83 m.) in length. The skull measured about 275 mm. Unfortunately, the right preopercular and some other bones are lying on the top of the skull, so that the relations of the elements were not determined. The preopercle had a length of at least 225 mm.; and at the lower end, a part of which is missing, a width of about 112 mm. A quadrate has a height of 85 mm. There are 53 vertebræ present, but they are considerably disturbed. Of these apparently 27 belong to the caudal region. The neural arches appear to have been slender and not high. The tail is deeply forked. The lower lobe only is present. Its length is about 375 mm., but a ray near the bottom of the fork is only about 90 mm. long. There are about 10 rays in the lobe, not including 5 rudimentary rays on the front edge. The first of the latter is a lunate bone, the others are slenderer and straight or irregularly bent. The terminal vertebræ are not shorter than those farther forward in the caudal peduncle and hence do not display the crowded condition seen in *Anogmius*. There is a fan-shaped hypural. The pectoral fin is long and falcate. The anterior ray measures close to 595 mm. It has a width of 27 mm. at the base and tapers gradually to the tip. It is not divided or segmented. Eleven rays may be counted in this fin, but probably a few are missing. The shortest one observed measures 135 mm. All except the most anterior divide distally into slender filaments. At the base of the fin are seen two or three baseosts. There appear to be no remains of dorsal, ventral, and anal fins. The shoulder girdle of the left side is displayed from the inner surface (Fig. 45). It is

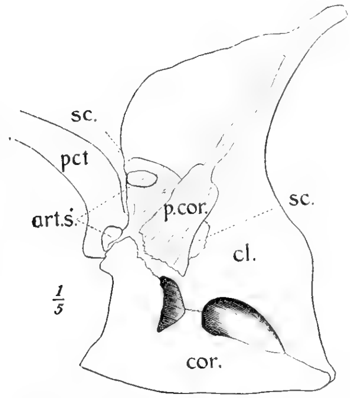

Fig. 45. *Pachyrhizodus caninus* Cope. U. S. Nat. Mus. × ⅕. Shoulder girdle. *art. s.*, articular surfaces for fin; *cl.*, cleithrum; *cor.*, coracoid; *p. cor.*, precoracoid; *pct.*, pectoral fin ray; *sc.*, scapula.

much like that of *Tarpon*, but the precoracoid is larger than in the latter genus. On the other hand, it is smaller than in *Portheus*. In the specimen under consideration it is about 125 mm. long. The shoulder girdle is here illustrated from a rough sketch.

On Plate III, Fig. 1 is shown a view of the tail of this species taken from No. 1900 of the American Museum. The tips of the lobes are broken away so that the original dimensions cannot be known, but the lobes are now respectively about 265 mm. and 335 mm. in length. There is a large terminal fan-shaped bone, which supported the principal rays. On each side there is a triradiate bone, apparently a modified ray, lying on the terminal vertebral bodies. Ryder (Report U. S. Fish. Com. for 1884, pl. vi, fig. 2) has figured a similarly placed bone which he regards as growing out from a displaced epural. In front of the lower lobe of the fin of *Pachyrhizodus* here described is an excavation which probably has been occupied by a lunate bone such as that referred to above as being found in the specimen at Washington. Fig. 2 of Plate III shows a nearly complete lobe. Its length is 435 mm. In these fins the rays are few in number, large, and cross-segmented. The fin resembles considerably that of *Tarpon*. Its number is 1658.

Dr. Loomis has described a species which he calls *P. curvatus*. It is small, the tooth line of the dentary measuring only 50 mm. In this space are alveoli for 38 teeth. The maxilla possessed alveoli for 41 teeth. The species appears to the present writer to be a young individual of *P. caninus*. In the type jaw of *P. caninus* are spaces for 38 or 40 teeth, and in a maxilla I count at least 40 teeth. Professor Cope regarded this fish as probably a ground feeder, but the form of the tail seems to indicate a swift, free-swimming, predaceous animal.

No. 2041 of this Museum consists of 9 caudal vertebræ and apparently 15 rays of an unpaired fin. There can be little, if any, doubt that the fin belongs with the section of the vertebral column, but whether it is the anal or the dorsal cannot be ascertained. The longest rays measure 147 mm.

in length, but the tips are broken off. From the anterior they grow shorter and slenderer to the last. Probably nearly the whole, if not the whole, of the fin is present. The rays divide longitudinally into slender portions but show no signs of segmentation. The nine vertebræ have a length of 185 mm., and the fin has about the same length along its base.

Pachyrhizodus leptopsis *Cope.*

Pachyrhizodus leptopsis Cope (E. D.), Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 42; Vert. Cret. Form. West, 1875, pp. 225, 276, pl. li, figs. 8–8c. — Stewart (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 354, pl. lxx, fig. 1. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 45. — Hay (O. P.), Bibliog. and Cat. Foss Vert. N. A. 1902, p. 388.

Pachyrhizodus lepitopsis Loomis (F. B.), Palæontogr. XLVI, 1900, p. 264.

This species was based on a fragment of a right dentary which presents the symphyseal surface. The specimen bears the Museum's number 1756. The species is characterized by the large size of the bases of the teeth and the narrow symphyseal articulation. The bases on which the teeth rest are large, fully as wide as long, and the empty spaces from which the teeth have fallen are about circular. In *P. caninus* the teeth are crowded, so that the tooth bases, measured across the jaw, are wider than long, and the empty spaces are of greater extent across the jaw than parallel with it.

Oricardinus sheareri *Cope.*

Pachyrhizodus sheareri Cope (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 347; U. S. Geol. Surv. Wyoming, etc. 1872, p. 348; Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 43; Vert. Cret. Form. West, 1875, pp. 225, 276. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 45.

Oricardinus sheareri Cope (E. D.), Proc. Amer. Philos. Soc. XVII, 1877, pp. 177, 178. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 388.

Pachyrhizodus sheari Loomis (F. B.), Palæontogr. XLVI, 1900, p. 264.

The type of this species is supposed to be a portion of the left maxilla. A figure and section of the specimen is herewith presented (Fig. 46). The anterior end of the fragment is directed toward the right. The teeth are pleurodont, as they are in *Pachyrhizodus*. They have been crowded, as in *Pachyrhizodus caninus*, but none of the crowns has been preserved. The roots present at least one difference from the species of *Pachyrhizodus*, so far as I have been able to observe. In the latter, when the tooth separates from the root, which is buried in the bone of the jaw and becomes anchylosed with it, the ring-like edge of the root is very sharp. In *O. sheareri* the remains of the root form a nearly flat ring around the pulp cavity. This, looked at with a lens of high power, shows radiating and concentric lines of dense bone. Nearly all the teeth of the specimen appear to have been shed at the time of its death; very few seem to have been broken off afterward. The Museum number of the type is 1998.

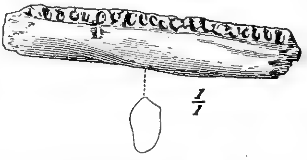

Fig. 46. *Oricardinus sheareri* Cope. No. 1998. × 1. Type. Maxilla and section.

Oricardinus tortus *Cope.*

Oricardinus tortus Cope (E. D.), Proc. Amer. Philos. Soc. XVII, 1877, p. 177. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 46. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 388.

The type of this species is in the American Museum of Natural History and has the catalogue number 2114. The material consists of a part of the left mandible, including the symphysis, and possibly about twenty vertebræ. Figures of the mandible are here presented showing it from the lingual side (Fig. 47) and from the dental border (Fig. 48). In his description, Cope deals much with the internal and external ribs of this mandible, but it is difficult even with the specimen in hand to understand his meaning. The jaw has evidently suffered some distortion and this has resulted in making some of the anterior teeth appear to lie on the outer side of the jaw. The teeth are much like those of *Pachyrhizodus*, but the symphysis is different and the jaw is narrower in front, like that of *Empo*. Nevertheless, the narrowness may be due to crushing, and cannot be relied on. The vertebræ accompanying the jaw may be said to be identical with those of *Empo* in structure, and it is not improbable that they did not belong to the individual that possessed the jaw. Two caudal vertebræ are figured here of natural size (Fig. 49). Until more is known about the species it seems best to retain it in the genus *Oricardinus*, of which it is the type.

Fig. 47. *Oricardinus tortus* Cope. No. 2114. × 1. Type. Dentary. *sym.*, symphysis.

Fig. 48. Same as Fig. 47. Shows tooth line.

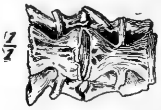

Fig. 49. *? Oricardinus tortus* Cope. No. 2114. × 1. Two caudal vertebræ, lateral view.

ENCHODONTIDÆ.

Enchodus *Agassiz.*

Remains of fishes of this genus are very common in collections made in the Cretaceous of Kansas, and they likewise occur in collections made in New Jersey. Fourteen species have been described from these two States and another, *E. shumardii*, from South Dakota. The greater part of the species have been based on detached teeth. The most conspicuous bone of the skull and the one most likely to be preserved is the greatly swollen palatine, bearing a long fang. This bone was regarded by Cope as the premaxilla, and the pterygoid, which articulates with it behind, was supposed to be the maxilla. The correct interpretation was afforded by Dr. A. S. Woodward (Proc. Geologists' Assoc., X, 1888, p. 315). Dr. Loomis has more recently discussed the anatomy of the genus, but in his restoration of the skull he has not represented the palatine as swollen nor drawn the boundary between it and the ectopterygoid. He also describes the palatine as a mass of osteodentine; but to the present writer this mass, as also that composing the tritoral plates of *Anogmius*, appears to be merely very compact bone.

Dr. Loomis has probably given us the correct explanation of the replacement of the palatine fangs. The new fang is produced in front of the senescent one. Originally the latter had stood on the very anterior extremity of the palatine bone, but after the tooth had become affixed, the bone prolonged itself in front of the base of the tooth and thus provided a surface for the attachment of the next fang in succession. When the new tooth has taken its position, its predecessor, through absorption of its base, is loosened and drops away, leaving a crescentic scar. Sometimes several of these scars may be observed on the palatine. The new tooth probably became firmly fixed before its predecessors fell away; otherwise it would have been easily wrenched from its moorings. It will probably also be found that there is an alternation in the replacement of the fangs. Evidence of this is found in the palatines of No. 2098. The right palatine has a conspicuous process of bone extending forward over the base of the fang. The left palatine has only the slightest trace of such a process.

The large teeth on the anterior end of the pterygoid are replaced also by the development of others in front of them; and the scars resulting from the falling away of the old teeth may be seen. On the other hand, the great fang on the anterior end of the dentary is replaced by the growth of another behind it, and the scars of former teeth lie in front of the functional fang. Prof. Cope's figure (Vert. Cret. Form. West, pl. liv, fig. 3) shows the end of the right dentary from without. The functional fang is broken off some distance above its base. In front of it is an elevation of bone on which stood the replaced fang. In the specimen, the surface of the scar looks as if the old fang had only recently been broken off. Cope's figure 3*a* is unsatisfactory. Other specimens of *Enchodus* confirm the conclusion that the new fang of the dentary is produced behind the old one. Thus, while the fang of the palatine is moving forward, that of the dentary is moving backward; but it is probable that growth of other parts makes compensations, so that the two fangs are always closely opposed to each other. Cope (*op. cit.*, p. 301) has described the mode of succession of the teeth of the dentary.

Enchodus ferox *Leidy.*

Enchodus ferox Leidy (J.), Proc. Acad. Nat. Sci. Phila. 1855, p. 397. — Emmons (E.), Man. Geol. 2nd ed. 1860, p. 214, fig. 1824. — Cope (E. D.), Vert. Cret. Form. West, 1875, p. 277. — Loomis (F. B.), Palæontogr. XLVI, 1900, p. 277. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 204. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 389.

Enchodus pressidens Cope (E. D.), Proc. Amer. Philos.-Soc. XI, 1869, p. 241; Vert. Cret. Form. West, 1875, p. 277. — Loomis (F. B.), Palæontogr. XLVI, 1900, p. 277. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 205. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 389.

"*Sphyræna*" Morton (S. G.), Synop. Org. Rem. Cret. U. S. 1834, p. 32, pl. xii, fig. 1.

In the Cope Collection are two palatines belonging to the genus *Enchodus*, both of which are labelled in Cope's handwriting. One of these, No. 2251, is labelled "*Enchodus ferox*"; the other, No. 2250, "*Enchodus pressidens*, not typical." Fig. 50 represents the specimen of *E. ferox*. A study of these has led to the conclusion that the two species, *E. ferox* and *E. pressidens*, are identical. The characters which are relied on to distinguish *E. pressidens* are the crescentic section of the base of the palatine fang, the triangular section of the middle of the tooth, the grooves bounding the cutting edges, and the projection of the base of the tooth beyond the anterior margin of the palatine.

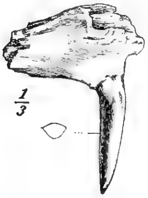

Fig. 50. *Enchodus ferox* Leidy. No. 2250. × ⅓. Palatine and fang, with section.

As to the crescentic base, this results from the pressure of the hinder side of the new tooth against the base of the old tooth, and there is some reason for believing that the concavity of the posterior side of the new tooth diminishes somewhat after the old tooth has fallen out. At any rate, such an explanation is suggested by a difference found in the form of the bases of the two fangs of a specimen of *E. petrosus*. As regards the cross-section at the middle of the tooth, I find no considerable difference. The specimen labelled "*E. pressidens*" agrees with the description of that species, but the "*E. ferox*" also has the inner face considerably more convex than the outer, and the sections of these faces may be regarded as forming two sides of a triangle, with the separating angle rounded off. The grooves bounding the cutting edges of "*E. pressidens*" are hardly apparent, while there are indications of them in the specimen called *E. ferox*. Doubtless there were individual variations in this character.

If Loomis's explanation of the manner of replacement of the palatine fangs is correct, as it quite certainly is, we can see why in some cases the palatine bone projects beyond the base of the fang, while in other cases the fang projects beyond the bone. After the new tooth has taken its position in front of the old tooth and at the very extremity of the palatine bone, the latter proceeds to extend itself forward in order to provide a seat for the base of the next tooth in succession. Thus we sometimes get a palatine bone in one stage, sometimes in another. In the "*ferox*" specimen the palatine had extended considerably in front of the fang; in the "*pressidens*" specimen the fang had only recently taken its place.

The specimen called *E. pressidens* is a little more than one-half the size of that called *E. ferox*, the tooth being 32 mm. long, that of *E. ferox* 51 mm. The palatine bone of the "*pressidens*" is also relatively slenderer than the other; but all these differences are probably due to difference in age of the animals.

E. ferox appears to differ from *E. petrosus* in three respects. The inner face of the palatine fang is smooth, while in *E. petrosus* it is coarsely striated. In *E. ferox* the cutting edges of the palatine fang are minutely serrated; in *E. petrosus* they are smooth. In both species there is, on the outside of the palatine, a broad shallow groove which runs from the lower hinder portion of the bone upward and forward. In *E. ferox* this groove meets the upper edge of the bone over the base of the fang; in *E. petrosus*, well behind its base. The drawings of *E. ferox* furnished by both Morton and Emmons of this species represent the teeth only and are very unsatisfactory. I find no reason for questioning the correctness of Cope's identification of the tooth here figured as *E. ferox*. *E. ferox* and *E. pressidens* Cope were both described from the Cretaceous of New Jersey.

Enchodus petrosus *Cope*.

Enchodus petrosus Cope (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. I, No. 2, 1874, p. 44; Vert. Cret. Form. West, 1875, pp. 239, 278, pl. liv, figs. 4–7. — ? Loomis (F. B.), Palæontogr. XLVI, 1900, p. 278, pl. xxvii, figs. 13–15. — Stewart (A.), Univ. Geol. Surv. Kansas, VI, 1900, pl. lxx, fig. 11. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 205. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 389.

Tetheodus pephredo Cope (E. D.), Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 43; Vert. Cret. Form. West, 1875, pp. 237, 277, pl. liv, figs. 1–3. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 205. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 389.

Tetheodus pephero Loomis (F. B.), Palæontogr. XLVI, 1900, p. 278 (syn. of *Enchodus petrosus*).

The present writer agrees with Dr. Loomis in referring Cope's *Tetheodus pephredo* to *Enchodus petrosus*. The type of this supposed species is in this Museum and has the number 1605. Cope's description and figures are for the most part correct.

Prof. Cope states that in *Tetheodus pephredo* there is no surface for the attachment of a tooth and no scar or other trace of the former existence of one. However, a close examination of one of the palatine masses shows that there are traces, faint but undeniable, of at least four fangs which at different times have occupied the lower border of the bone. Moreover, where we would expect to find a functional fang, the surface is somewhat rough; while on the oral border of the bone there is a ragged area which looks as if some of the bone had been broken away. All this makes it appear probable that in some conflict both fangs had been torn away at their bases, and that sufficient time had not elapsed for the scars to be wholly healed. In front of and above the base of the supposed former fang, on the anterior extremity of the palatine, there is a process of bone which may be regarded as an outgrowth preparatory to the attachment of a new fang. It is rather thin from side to side, only about one half as thick as would be required for the fang, but it is possible that its thickness might become greater in due time. Whether or not a new fang could be produced and effect an attachment without the support and protection of a fang already in place seems to be doubtful. It seems likely that every victim by its strugglings would destroy any incipient connections that had been formed.

Fig. 51 represents a damaged dentary bone of this species, with two teeth nearly complete. The most anterior of these is shown two-thirds of the natural size, in order to display the rather strongly developed ridges on the posterior half of the tooth. On the lingual face of the tooth these ridges are found well forward, but here they are rather short. Toward the hinder border of this face they rise well toward the tip of the tooth. About three millimeters above the base of the tooth the ridges cease suddenly, and the portion of the surface below them is provided with very fine striations. The anterior fang is broken away, but its outlines are restored from another specimen. The number is 2062.

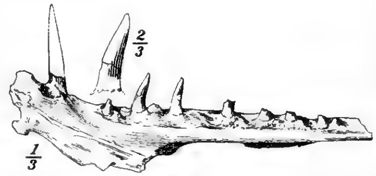

Fig. 51. *Enchodus petrosus* Cope. No. 2062. Dentary, × 1/3; one tooth, × 2/3.

The surfaces by means of which the palatine bone comes into contact with the bone which acted as its suspensory, doubtless the prefrontal, deserve description. These articulatory surfaces are found at the hinder end of the palatine, and those of Cope's type are shown in Fig. 62; those of *E. sævus* in Fig. 61. In the former we have two processes, one below and directed upward and outward. The posterior face of this is smooth and forms one of the articulatory surfaces.

Another process is considerably in front of the one just described, and is directed upward. Its posterior face is flat and smooth. The inner face of the lower and hindermost process looks upward and inward, and is slightly convex and smooth. It connects the two articulatory surfaces which are directed backward and form a third surface. A thin perpendicular plate of bone has extended backward from the inner border of the anterior articular surface near the base of the posterior process, but it is now broken away. It is seen in the figure of the corresponding parts of *E. sævus*. It appears evident that the posterior process in *E. petrosus* has been distorted, so that its upper surface is directed more outwards than in life. For the same reason, it is now lower than originally. This is indicated by another specimen. Through these smooth articulatory surfaces the palatine must have had a very free movement on the prefrontal.

Portions of the palatine fangs of an *Enchodus* from the Fox Hills Group of New Mexico are not distinguishable from those of *E. petrosus*. (Cope, Amer. Naturalist, XXI, 1887, p. 566.)

Enchodus dolichus *Cope*.

Enchodus dolichus Cope (E. D.), Vert. Cret. Form. West, 1875, pp. 239, 278, 300, pl. liv, figs. 8, 8a; Proc. Amer. Philos. Soc. XXIII, 1885, p. 3. — Loomis (F. B.), Palæontogr. XLVI, 1900, p. 279, pl. xxvii, figs. 16, 17. — Stewart (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 377, pl. lxx, fig. 12. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 204. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 389.

Of this species the type, a fragment of the palatopterygoid, is in the Museum and bears the number 1820. There are likewise considerable portions of three skulls, including those described by Cope on page 300 of his 'Vertebrata of the Cretaceous Formations of the West.' One of these skulls, Cope's "No. 1," No. 1837 of this Museum, is represented by Fig. 52. It displays both palatines, the right much out of its natural position, the left pushed backward about 25 mm. Its great fang is crossed by the anterior end of the ectopterygoid. The long teeth of the latter bone are well shown.

The anterior end of the mandible is broken away. Above the palatine is the right premaxilla with about 23 teeth and spaces for others. Between the upper and the lower thirds of the figure lie the occipital bones and the frontals. The left articular runs forward beneath the left palatine. The right quadrate is displaced so that its articular surface (above *qu.*) looks upward.

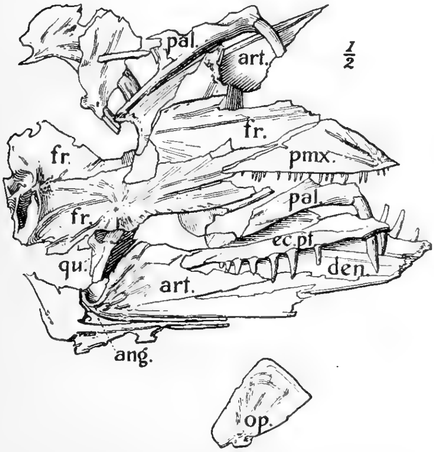

Fig. 52. *Enchodus dolichus* Cope. No. 1837. × ½. Disturbed skull. *ang.*, angular; *art.*, articular; *den.*, dentary; *ec.pt.* ectopterygoid; *fr.*, frontal; *op.*, opercular; *pal.*, palatine; *pmx.*, premaxilla; *qu.*, quadrate.

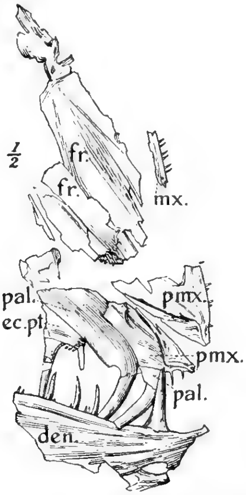

Fig. 53. *Enchodus dolichus* Cope. No. 1685. × ½. *den.*, dentary; *ec.pt.*, ectopterygoid; *fr.*, frontal; *mx.*, maxilla; *pal.*, palatine; *pmx.*, premaxilla.

Figure 53 represents No. 1865 of this Museum. This displays both palatines and their fangs; the anterior end of the ectopterygoid and two teeth; the lower jaw, with its fang and teeth of two sizes; both premaxillæ, with their small teeth; and the anterior end of the frontal. Alongside of the frontal is a fragment of a toothed bone which lies on a line with the dental border of the premaxilla. It is probably a portion of the maxilla.

The palatine fang was missing in the type. No. 1837 shows, as Cope has already stated, that the palatine fangs are finely striated on the outer surface. On the hinder portion of the inner face of the left palatine and of two mandibular teeth we find a moderately coarse striation. Cope's specimen "No. 2," which is No. 1890 of this Museum, presents both palatines, one with the fang complete. The ornamentation is as in No. 1837. The same is true of the fang of No. 1865, except that the striation, both on the inner and the outer face, is somewhat coarser. The striation of the hinder part of the inner face of No. 2385 is decidedly coarser than that of any of the other specimens. All these teeth show that *E. dolichus* differs from *E. petrosus* in having the outer face with practically the same convexity as the inner. The latter seems also to have attained a considerably larger size. We must, however, keep in mind that there are likely to be small specimens of *E. petrosus*.

Enchodus tetræcus *Cope.*

Enchodus tetræcus Cope (E. D.), Vert. Cret. Form. West, 1875, p. 278. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 205. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 389.

Enchodus tetracus Loomis (F. B.), Palæontogr. XLVI, 1900, p. 277. — Stewart (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 375.

This species is said to have been based on various teeth from the Greensand of Delaware and New Jersey. One whole tooth, which is labelled as the type, is in the Museum and has been given the number 2248. There is another with the distal end missing. Cope's description is sufficient, but it is thought to be proper to present here a drawing of the type (Fig. 54). Figure 55 represents the paratype, an imperfect tooth designated as No. 2249. The sharply defined striations of the very convex inner face distinguish this species from *E. ferox*. The teeth are apparently slenderer than those of *E. petrosus*, and the shallow

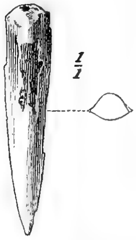

Fig. 54. *Enchodus tetræcus* Cope. No. 2248. × 1. Type. Palatine fang and cross-section.

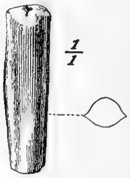

Fig. 55. *Enchodus tetræcus* Cope. No. 2249. × 1. Paratype. Palatine fang and cross-section.

grooves running along the inner face, one close to and parallel with each cutting edge, are somewhat more distinct; but these characters are hardly satisfactory. On account of the little that is known about *E. tetræcus* and on account of the different geographical distribution, the two species may best be regarded for the present as distinct.

Enchodus gladiolus *Cope.*

Cimolichthys gladiolus Cope (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 353.

Phasganodus ? gladiolus Cope (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. I, No. 2, 1872, p. 43; Vert. Cret. Form. West, 1875, pp. 235, 277.

Enchodus gladiolus Cope (E. D.), Vert. Cret. Form. West, 1875, p. 301, pl. xlii, fig. 7. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 204. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 389.

The type of this species was a single detached tooth, and this has not yet come to light in the examination of the Cope collection. Cope states (Vert. Cret. Form. West, p. 301) that he had a better specimen; but while he figured the type tooth, he did not figure or describe the better example. In the collection there is found a specimen which bears the label in Cope's handwriting "*Enchodus ?gladiolus*," the interrogation doubtless belonging, according to Cope's usage, with the specific name. To these remains have been given the number 1818. The specimen presents the left palatine, with its great tooth complete; the left ectopterygoid, with several teeth; and the tip of the left dentary with its fang. As shown in Fig 56, the ectopterygoid has been turned so that the teeth point in a direction opposite to that of the palatine teeth. On another block and apparently belonging to the same individual is shown the upper surface of the hinder half of the skull. The palatine fangs differ from those of *E. dolichus* in

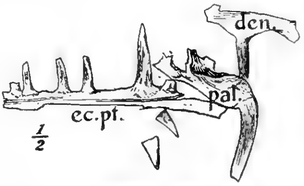

Fig. 56. *Enchodus gladiolus* Cope. No. 1818. × ½. Jaws. *den.*, dentary; *ec.pt.*, ectopterygoid; *pal.*, palatine.

having nearly the whole of both the inner and the outer face coarsely striated. The ridges and intervening furrows are easily seen with the unaided eye, while in the case of *E. dolichus* this requires a close observation. The striation subsides close to the anterior very thin edge. As in *E. dolichus*, the two faces are equally convex. The pterygoid and the mandibular teeth are similarly marked by coarse ridges and grooves.

It is possible that this specimen is only an example of *E. dolichus* with unusually coarse grooving of the teeth; but I think that it is distinct.

Fig. 57 represents the upper surface of the skull. The more anterior portions of the frontals have left their impression on the matrix but are not represented in the drawing. From each epiotic region a grooved ridge runs forward to the prefrontal region. From this ridge, at the centre of growth of the frontal bone, a less prominent ridge runs outward and backward to the middle of the squamosal. The epiotics are prominent and are connected by a sharp ridge, behind which the occiput drops off steeply. The parietals are apparently separated by the small supraoccipital. The parietals seem to form a narrow band along the ridge connecting the epiotics. The sutures are very indistinct.

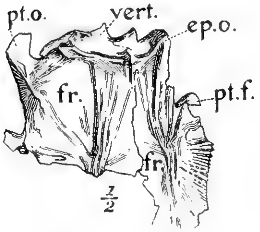

Fig. 57. *Enchodus gladiolus* Cope. No. 1818. × ½. Hinder part of skull. *ep.o.*, epiotic; *fr.*, frontal; *pt.f.*, postfrontal; *pt.o.*, pterotic.

Enchodus sævus, sp. nov.

This species, which appears to be distinctly different from any hitherto described, was collected near Elkader, Logan County, Kansas, by Dr. W. D. Matthew, in 1897. The collector regarded the beds as belonging to the Pierre formation; but Dr. Williston, who is familiar with the locality, informs me that the deposits belong to the Niobrara. The species has been a large one, as is indicated by the following measurements:

Length of the lower jaw from the chin to the articular condyle	223 mm.
Height of the jaw at the coronoid process	67 mm.
Breadth of the skull at the postorbitals	111 mm.
Length of the palatine and prefrontal to the front of the fang	72 mm.

Unfortunately the whole surface of the specimen has been covered and in some places injured by a deposit of crystals of gypsum, so that it is difficult to determine some structures. Other structures and the general forms of the bones are distinct enough. The number of the specimen is 198.

The distinguishing character of this species is found in the great palatine fang. In other American species of the genus where the palatine fang is known the latter is compressed laterally. In the present species the compression is nearly antero-posterior. The species is nearest to *E. petrosus*, with which it was at first identified.

The right palatine bone (Fig. 58) is in excellent condition, barring the deposit of gypsum on its surface. It has suffered little or no distortion or compression. No part of the ectopterygoid adheres to it. The figure represents the inner side of the tooth and shows the position of the inner, or posterior, cutting edge. The greater part of the fang is preserved. The left palatine is distorted and has lost all but the base of the fang.

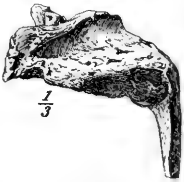

Fig. 58. *Enchodus sævus* Hay. No. 198. × 1/3. Type. Right palatine bone and fang.

In *E. petrosus* a sharp cutting edge begins at the base of the fang in front and runs downward to the tip (Fig. 59). This is very distinct from the first, and it pursues its course near the anterior midline of the tooth, separating an outer from an inner face. The section shown in Fig. 59, *b*, ought to have been taken somewhat higher up on the tooth, in which case the inner face (on the left) would have been somewhat more convex, but it would still have differed much from Fig. 60, *a*. In *E. sævus* (Fig. 60) there is a faint trace of a corresponding edge and it may once have been stronger, but it lies much nearer the inner side of the tooth. Another cutting edge starts at the outer side of the base of the tooth; but, instead of soon getting near the middle of the hinder surface of the tooth, as it does in *E. petrosus*, it forms the outer border of the tooth when this is looked at directly from behind or front. These two edges divide the surface of the distal end of the tooth into two nearly equal faces, of which one, somewhat smaller, is nearly anterior, but is directed somewhat outward, while the larger and somewhat more convex one is directed backward and inward. About the middle of the length of the tooth, where the section (Fig. 60, *a*) is taken, the inner face is far larger and more convex. The palatine bone, from which Fig. 60 is taken, was only slightly larger than that from which Fig. 59 was obtained.

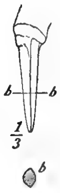

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Fig. 59. *Enchodus petrosus* Cope. No. 2062. × ⅓. Left palatine fang from in front. The line, *bb*, marks position of section *b*.

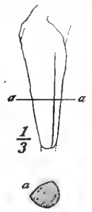

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Fig. 60. *Enchodus sævus* Hay. No. 198. × ⅓. Type. Right palatine fang from in front. The line *aa* marks position of the cross-section *a*.

The palatine bone has about the size of that of *E. ferox*, figured in this paper, and the fang has probably had about the same length. If we measure the greatest diameter of this fang of *E. ferox* at a point 10 mm. below its base we find it to be 10 mm., and this diameter is the antero-posterior, while the transverse diameter is not quite 8 *mm.* At the same height the diameter of *E. sævus* is 10 mm. in the transverse axis of the cross-section, and 9 mm. in the antero-posterior. The same proportions and directions of the axes are found in *E. petrosus* as in *E. ferox*.

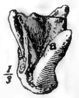

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Fig. 61. *Enchodus sævus* Hay. No. 198. × ⅓. Type. Posterior end of right palatine bone. *a*, articular process.

62

Fig. 62. *Enchodus petrosus* Cope. No. 1608. × ⅓. Type. Posterior end of left palatine bone.

The posterior end of the palatine (Fig. 61) appears to differ somewhat from that of *E. petrosus* (Fig. 62). It presents the same smooth articular surfaces as are observed in the latter species, but, as will be observed in the figures, the lower process, *a*, of the bone in *E. sævus*, is much thinner and higher than in *E. petrosus*. This difference may not be specific but due in some part to accidents of fossilization. Fig. 61 represents the bone of the right side; Fig. 62, that of the left side.

Fig. 63 represents the lower jaw seen from the outside. It is everywhere ornamented with radiating ridges and grooves. In front are three deep notches, as in many species of the genus. Fig. 64 shows the lower jaw from the lingual side, together with the ectopterygoid and quadrate. The two last-mentioned bones are somewhat displaced. Attention is called to the great raptorial tooth on the anterior end of the ectopterygoid. It is about 30 mm. long. The upper border of the ectopterygoid is excavated in front and received the lower border of the palatine.

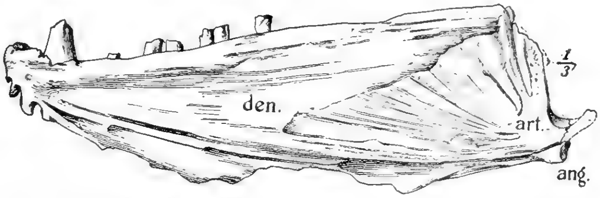


Fig. 63. *Enchodus sævus* Hay. No. 198. × ⅓. Type. Lower jaw, outer view. *ang.*, angular; *art.*, articular; *den.*, dentary.

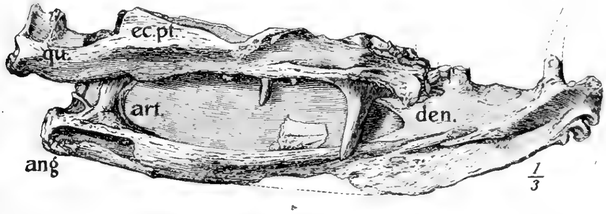


Fig. 64. *Enchodus sævus* Hay. No. 198. × ⅓. Type. Lower jaw, quadrate, and ectopterygoid; inner view. *ang.*, angular; *art.*, articular; *den.*, dentary; *ec. pt.*, ectopterygoid; *qu.*, quadrate.

One preoperculum is present (Fig. 65). It appears to me to belong to the left side. It is very narrow above, but broadens somewhat below. The exterior surface is convex transversely and has ridges and grooves running lengthwise. A conical process from its front border fits into a groove in the hinder border of the quadrate. On the inner face of the preoperculum there is a deep channel running nearly the full length and opening forward. What I regard as the left interoperculum is shown in Fig. 65, *i. op.* A portion of its hinder border has been broken away. It is a rather heavy bone and is ornamented with radiating ridges and grooves. The anterior border has been furnished with a row of about eight sharp processes. It seems to have been overlapped by the hinder border of the lower end of the preoperculum.

The upper surface of the head is present, except the snout; but it is too much overlain with gypsum to permit accurate description. It resembles the skull of *E. faujasi* Agassiz, which is figured by Dr. A. S. Woodward (Cat. Foss. Fishes, IV, pl. xi, fig. 6). A deep and broad excavation runs along the middle of the head from the supraoccipital.

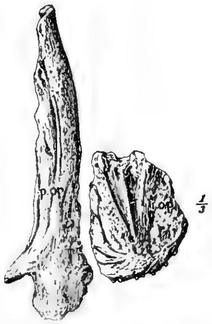


Fig. 65. *Enchodus sævus* Hay. No. 198. × ⅓. Type. *i. op.*, interoperculum; *p. op.*, preoperculum.

Stratodus oxypogon *Cope.*

Stratodus oxypogon Cope (E. D.), Proc. Amer. Philos. Soc. XVII, 1877, p. 180. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p, 189. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 387.

The type of this species bears the number 2113. It consists of the distal portion of the right dentary (Fig. 66, *den.*), a portion of what Prof. Cope regarded as a maxilla (Fig. 66, *mx.*) a piece of a palatine (Fig. 67), and eight vertebræ. Cope has given sufficient description; but no figures have hitherto been furnished of the specimens. The dentary and maxilla are here shown as seen from the outer side, and the fragment of palatine is represented from the toothed surface. Most of the teeth are pressed against the surface in such a way as to

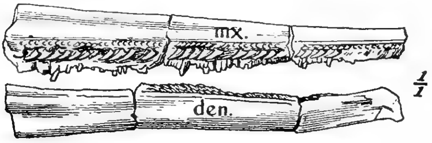


Fig. 66. *Stratodus oxypogon* Cope. No. 2113. × 1. Type. Jaws, outer view. *den.*, dentary; *mx.*, maxilla.

Fig. 67. *Stratodus oxypogon* Cope. No. 2113. × 1. Type. Fragment of palatine, showing teeth.

suggest that they were hinged; as Cope also inferred from the form of the alveolar fossæ. This author has described the tips of the teeth as being simple; but in the case of some of them I find the peculiar spade-shaped apices which Cope has described in the case of *S. apicalis*. Fig. 68 shows two of the caudal vertebræ. They are much like those of *Empo*, but lack the longitudinal ribs of that genus. Under the lens, however, a fine longitudinal striation is seen on the sides of the centra. Dr. Woodward has placed this genus in the Dercetidæ, but notwithstanding the union of the parietals in the midline, it appears to the writer to belong to the Enchodontidæ.

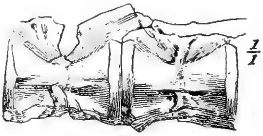


Fig. 68. *Stratodus oxypogon* Cope. No. 2113. × 1. Type. Two caudal vertebræ, side view.

Empo *Cope*

This genus was erected by Cope in 1872 (Proc. Amer. Philos. Soc., XII, p. 347). The type species is *E. nepaholica*, later emended by Cope to *nepæolica*. The species belonging to this genus have been referred by Loomis (Palæontogr., XLVI, 1900, p. 267) to *Cimolichthys;* and Dr. A. S. Woodward has more recently (Cat. Foss. Fishes, IV, p. 221) adopted the same course. That the two genera are not identical the present writer will not affirm; but the type species of *Cimolichthys*, *C. levesiensis*, is, as Dr. Woodward has said, not satisfactorily definable, many parts of the skull not being known. Likewise, we are in ignorance regarding various structures of *Empo*. It is therefore not at all improbable that differences of generic importance may yet be discovered in these types. It is as well to be conservative in suppressing genera as in establishing them. For these reasons the writer prefers to retain *Empo*.

Empo nepaholica *Cope.*

PL. I. FIG. 4.

Empo nepaholica COPE (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 347; Rep't U. S. Geol. Surv. Mont. etc. 5th Ann. Rep't, 1872, p. 345. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 387.

Empo nepæolica Cope (E. D.), Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 46; Vert. Cret. Form. West, 1875, pp. 230, 279, pl. xlix, fig. 9; pl. l, fig. 8; pl. lii, fig. 1; pl. liii, figs. 3–5. — Stewart (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 332, pl. lix, figs. 1–9; pl. lxi, figs. 2–5.

Cimolichthys nepæolica Loomis (F. B.), Palæontogr. XLVI, 1900, p. 271, pl. xxvii, figs. 1–3. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 225, text figs. 8, 9.

Cimolichthys semianceps Cope (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 351; Rep't U. S. Geol. Surv. Mont. etc. 1872, p. 326. — Loomis (F. B.), Palæontogr. XLVI, 1900, p. 273, pl. xxvii. figs. 4–6. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 228.

Empo semianceps Cope (E. D.), Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 46; Vert. Cret. Form. West, 1875, pp. 233, 279, pl. liii, figs. 1, 2, 6–9. — Stewart (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 338, pl. lxi, figs. 6–9. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 387.

Cimolichthys sulcatus Cope (E. D.), Proc. Amer. Philos. Soc. XII, 1872, p. 351.

Empo sulcata Cope (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. I, No. 2, 1874, p. 46.

Empo contracta Cope (E. D.), Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 46; Vert. Cret. Form. West, 1875, pp. 232, 279, pl. liii, figs. 14–17. — Stewart (A.), Univ. Geol. Surv. Kansas, VI, 1900, p. 339. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 387.

Cimolichthys contracta Loomis (F. B.), Palæontogr. XLVI, 1900, p. 273, pl. xxvii, figs. 8, 9. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 228.

Empo merrillii Cope (E. D.), Bull. U. S. Geol. and Geog. Surv. I, No. 2, 1874, p. 46; Vert. Cret. Form. West, 1875, pp. 232, 279, pl. liii, figs. 10–13. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 387.

Cimolichthys merrillii Loomis (F. B.), Palæontogr. XLVI, 1900, p. 272, pl. xxvii, fig. 7. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 228.

The type specimen of *Empo nepaholica* is a fragment of the hinder end of the palatine, which bears the bases of two large teeth and parts of smaller teeth, or bases thereof. It is figured by Cope as cited in the synonomy. The specimen is in the American Museum, and has the number 1904. Afterwards Cope identified as belonging to the same species much more satisfactory materials. One lot of these, No. 1736 of this Museum, was figured on plate lii, fig. 1, of his large work of 1875. Another, No. 1735, furnished figures 3–5 of plate liii of the same work. From these more complete materials many additional characters of the species were determined. In the paper in which *E. nepaholica* was described, Cope proposed also the new species *Cimolichthys sulcatus*, which he afterwards made a synonym of *E. nepaholica*. The type of this, No. 1882, is the left dentary, showing thirteen large teeth. The distal end of this dentary afterwards furnished figure 8 of plate l of the monograph of 1875.

The type of *Cimolichthys semianceps* consists of vertebræ, a palatine, portions of the dentaries with teeth, and some other parts. The vomer mentioned by Cope has not been recognized. The number of this type is 1989. In the monograph just mentioned Cope figured other specimens which he had identified as belonging to this species. One of these, now No. 1740, furnished figures 1 and 1*a* of plate liii; another, No. 1741, furnished figure 2 of the same plate; while No. 1742 was represented by figures 6–9.

Empo merrillii was based on fragments now included under the number 1737. There are present nearly the whole left palatine, of which figure 11 of plate liii of Cope's monograph represents the anterior end; a considerable part of the right palatine, one fragment of which is shown by figure 12; a flat bone, represented by figure 10, and which is probably the entopterygoid; and the vomer, represented by figure 13.

Empo contracta is likewise founded on fragments of jaws. There are present the right palatine, except its anterior extremity; the anterior extremity of the left palatine; the vomer; and the anterior portion of the left dentary. Most of these parts are represented on plate liii of Cope's work. The Museum number of this lot is 1738.

It may be said that the figures which Cope has published represent the originals adequately, and that nothing would be gained by refiguring them. If the figures are in some cases unsatisfactory the fault lies in the materials.

What is the value of these species? *E. contracta* is said to be characterized by the flatness of the "maxillary bone," by which is meant the palatine; but in the types the palatine of *E. merrillii* is still flatter, especially at the anterior end. To what extent the flatness of this bone in both species is due to its original form and to what extent to distortion during fossilization is hard to determine. There was probably considerable individual variation among these fishes. As regards the sizes of the teeth in different parts of the palatine, the writer has found, in looking through the collection of this Museum, so much variation that he regards the distinctions specified by Cope as of little or no value. Considerable differences are often to be observed on the opposite sides of the head. Cope also found characters in the "tongue-shaped pharyngeal bone," which is really the vomer; but after diligent comparison on the part of the present writer the attempt to find specific characters in this part was abandoned.

Prof. Cope has given extended and accurate descriptions of *E. nepaholica* and *E. semianceps;* but when we seek for the characters by which they may be distinguished from each other, they are found to be rare and elusive. The character which is most definitely stated is found in the structure of the mandibular teeth. In *E. nepaholica* these are said to possess no cutting edge on the posterior face. Unfortunately the crowns of the teeth are nearly always broken off, so that it is impossible to apply this test. The types themselves cannot, at least now, be distinguished in this respect. In another specimen I find a mandibular tooth with a posterior edge, but there is no other indication that it is not *E. nepaholica*. Both species possess such two-edged teeth on the palatines. On the lower jaw of a very large specimen in the Museum I find that the teeth are two-edged; and observation makes it certain that if such teeth belong only to *E. semianceps* this was not a smaller species than *E. nepaholica*. Stewart says that the mandibular teeth of specimens which he identified as *E. nepaholica* seemed to have both anterior and posterior cutting edges.

Having made an earnest effort to apply to the specimens in this Museum the characters presented by Cope as belonging to his species and such other characters as could be found, the writer has been compelled to abandon the attempt to retain the species founded by Cope and has found it necessary to reduce them all to the one having priority of description, *E. nepaholica.*

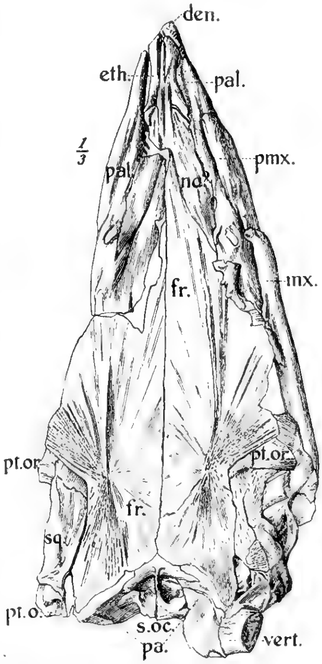


Fig. 69. *Empo nepaholica* Cope. No. 2522. × ⅓. Upper view of skull. *den.*, dentary; *eth.*, ethmoid; *fr.*, frontal; *mx.*, maxilla; *pa.*, parietal; *pal.*, palatine; *pmx.*, premaxilla; *pt.o.*, pterotic; *pt.or.*, postorbital; *s. oc.*, supraoccipital; *sq.*, squamosal; *vert.*, vertebra.

Dr. Loomis has furnished an excellent figure of the skull of this species, seen from the side, and other figures of the rear of the skull. A view of a well preserved skull is presented here (Fig. 69). The number of the specimen is 2522. The squamosal region of the left side has been damaged somewhat, and the drawing of this part is completed from another skull, No. 1888. On the right side a vertebra and some other elements are lodged against the skull behind the postorbital region. As both Loomis and Woodward have indicated, the very large frontals (Fig. 69, *fr.*) extend close to the hinder end of the skull. However, there is a narrow band of bone showing behind each frontal on the upper surface and extending from the supraoccipital outward to the epiotic process. These bands are doubtless the parietals. No suture is to be observed between the parietal and the epiotic, but it may have been present. The supraoccipital meets the frontals, thus separating the parietals. It sends on each side outward and backward a process which passes behind the inner end of the parietal. There is a deep fossa intervening between the epiotic and pterotic processes. There appear to be good reasons for drawing as we have, the lateral boundaries of the frontals; but the suture between the squamosal, *sq.*, and the postorbital, *pt. or.*, cannot be determined. The frontals extend far forward, so that they occupy by far the greatest portion of the upper surface of the skull. In the median line in front is the ethmoid, *eth.* The exact limits of this have not been determined. Posteriorly it expands and it appears to divide, sending a branch, *na?*, backward close to the mesial border of each premaxilla; but it is more probable that these lateral branches are distinct bones, the nasals. The premaxilla, *pmx.*, is a thin, elongated, sculptured bone, having small teeth along the lower border, except in front. It is applied closely to the palatine. Its teeth appear to have been directed forward. This is shown in Figure 70, *pmx.*, and the same appearance is presented by so many specimens that this position of the teeth appears to be the normal one.

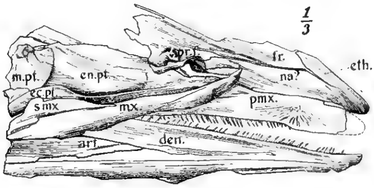


Fig. 70. *Empo nepaholica* Cope. No. 1776. × ⅓. Part of skull, lateral view. *art.*, articular; *den.*, dentary; *ec. pt.*, ectopterygoid; *en. pt.*, entopterygoid; *eth.*, ethmoid; *fr.*, frontal; *m. pt.*, metapterygoid; *mx.*, maxilla; *na ?*, nasal? : *pa.*, parietal; *pmx.*, premaxilla; *pt. o.*, postorbital; *smx.*, supramaxilla.

The maxilla, Figs. 69, 70, *mx.*, is a long, compressed, toothless bone which forms the posterior border of the mouth. Its anterior end overlaps for a long distance the premaxilla, its extremity in both the specimens figured here rising above the upper border of the premaxilla. The same position is shown in the skull figured by Loomis. Figure 71, No. 1969, shows the skull seen from below. The parasphenoid is very broad in front. It has possessed no teeth. The articular surface for the hyomandibular is short. The vomer does not appear in this specimen. It is the bone which Cope called and figured with doubt a pharyngeal. Stewart calls it the ethmoid. It is possibly consolidated with the ethmoid, but certainly both bones are represented. It possesses a varying number, one to four, of rows of teeth. Various specimens indicate that other bones within the mouth were furnished with small teeth, but which they are has not been accurately determined. It appears likely that the ectopterygoid had minute teeth on its surface and some larger ones near one border.

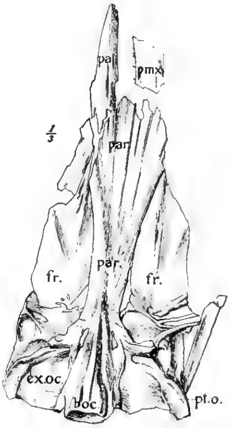


Fig. 71. *Empo nepaholica* Cope. No. 1969. × ⅓. Skull from below. *b. oc.*, basioccipital; *ex. oc.*, exoccipital; *fr.*, frontal: *pa.*, parietal: *pmx.*, premaxilla; *pt. o.*, pterotic.

I have had the opportunity of studying No. 4186 of the U. S. National Museum. In this the cleithrum has its external face presented. The first ray of the pectoral is segmented transversely, and was not a spine. Its anterior border is furnished with square notches and teeth, as is seen in Cope's work, pl. lii, fig. 1. On lifting the cleithrum from its bed the base of the fin is seen more distinctly. Besides the first ray about seven others are present. The precoracoid is present and is somewhat larger than in a salmon which has a jaw two-thirds as long as that of the fish here described. A portion of the coracoid is present and perhaps some of the scapula. The presence of the precoracoid fixes the position of the fish among the Isospondyli.

In No. 4719 of the U. S. National Museum there is a series of 25 vertebræ, together with ribs and the supports of the pelvic fins. Of these, apparently 10 belong to the caudal region, possibly only 9. Many ribs are present and several of them in their natural relation with the vertebræ. They are strongly developed, broad, and with much broadened heads. They resemble those of the common carp. They have been attached to distinct parapophyses. In some cases the latter have been freed by maceration and disturbance, and falling out have left long and deep cavities along the sides of the vertebræ. The hæmal arches of the tail region are apparently consolidated with their corresponding vertebral centra.

The supports of the pelvic fins are preserved and a portion of one fin (Fig. 72). It seems probable that the fin supports have not been removed from their natural position. If so the base of the fin is placed between the 5th and 6th vertebræ in front of the first caudal. The fin itself is overlaid with fragments of ribs, so that the number of its rays cannot be accurately determined, but there were at least eight of them, the most anterior one being apparently rudimentary.

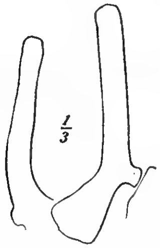


Fig. 72. *Empo nepaholica* Cope. No. 4719. U. S. Nat. Mus. × 1/3. Supports of ventral fins.

At the upper ends of the 4th and 5th caudal vertebræ are two bones which resemble interneurals with enlarged upper ends. They may represent the supports of the dorsal fin. They are rather weak and may be the more posterior ones of the series. In the region of the three or four most anterior hæmal arches are slender bones which may have been the supports of the anal fin.

No. 2032 of the American Museum of Natural History furnishes most of the tail fin (Pl. I, Fig. 4). The principal rays are large and coarsely segmented, but distally the rays divide into extremely fine filaments. The lobes of this fin were probably about 175 mm. in length.

The following fishes, as well as *Spaniodon simus*, described on page 47 were, as we learn from Prof. Cope (Bull. U. S. Geol. and Geog. Surv. Terrs., IV, 1878, p. 66), collected by Dr. F. V. Hayden in the "Niobrara Cretaceous of Dakota." No more accurate information has been afforded us regarding the locality where these specimens were found; but on several of the blocks of soft limestone, on which these fishes are preserved, some person has written in lead pencil the words "Yankton, Neb." From this label we may be quite sure that the specimens were found in the region of Yankton, South Dakota. We know likewise that the Niobrara deposits are abundantly developed in that region.

These fishes are of great interest from the fact that they belong to genera found in Upper Cretaceous deposits at Mount Lebanon, in Syria, or to genera very closely related to those of the latter region. It is greatly to be desired that further search shall be made in the country about Yankton for more satisfactory specimens of those described by Cope, and for other species which may be yet unknown. That fishes are abundant in the soft limestone whence Dr. Hayden obtained his specimens, is shown by Plate V, which reveals three types on one side of a block, while a fourth type is found on the other side, besides a part of a large undescribed fish.

The figures of the species furnished on the plates are of the natural size and may be of some value in identifying other specimens, but they are difficult subjects to illustrate.

DERCETIDÆ.

Triænaspis *Cope.*

This genus was established by Cope in the 'Bulletin of the U. S. Geological and Geographical Survey of the Territories,' Volume IV, 1878, page 67. The type is *T. virgulatus* Cope. Dr. A. Smith Woodward unites the genus with *Leptotrachelus*, but the present writer is inclined, for the present, to regard it as distinct on account of the backward position of the ventral fins and the relatively short head. The type of the genus *Leptotrachelus*, *L. armatus*, possesses a dorsal fin of apparently about 12 rays, with the ventrals beneath the front of this dorsal. In *Triænaspis* the dorsal is still shorter, not having beyond 10 rays, and the ventrals are placed a distance behind the origin of the dorsal equal to one-third of the distance from the head to the dorsal.

Triænaspis virgulatus *Cope.*

PLATE V, FIG. 1.

Triænaspis virgulatus COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. IV, 1878, p. 67. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 397.

Leptotrachelus virgulatus WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 187.

Of this species Professor Cope possessed, so far as can be determined, only the specimen here figured (Pl. V, Fig. 1) and a fragment of another. The present number of the type is 2516. The describer concluded that the anal fin was absent in the species, but the present writer finds no warrant in the specimens for making any statements regarding this fin. The length of the head, including the opercular apparatus, is contained in the distance from the end of the operculum to the beginning of the dorsal fin something over one and one-half times. The head has not been prolonged into a beak such as we find in the species of *Leptotrachelus*.

Leptotrachelus longipinnis *Cope.*

PLATE IV, FIG. 3, and **PLATE V**, FIG. 4.

Leptotrachelus longipinnis COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. IV, 1878, p. 68. — WILLISTON (S. W.), Kansas Univ. Quart., VIII, 1899, p. 115; Univ. Geol. Surv. Kansas, VI, 1900, p. 382. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 187. —HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 397.

Of this species Cope possessed two specimens. Of these his "No. 1" bears the Museum's catalogue number 2521 (Pl. V, Fig. 4) while his "No. 2" has the number 2520 (Pl. IV, Fig. 3). The former displays indistinctly the head, with its long beak, the neck consisting of much elongated vertebræ, the rays of the dorsal fin, and the ventral fins. Under a lens traces of the pectoral fin may be found close to the head. The other specimen shows more distinctly the dorsal and ventral fins, and some ribs, triradiate scales, and longitudinally directed hair-like bones in front of the dorsal. In No. 2521 a considerable part of the bones of the beak have been flaked away, leaving only their impression on the matrix. The letters *sn* indicate approximately the end of this beak. Pl. V, Fig. 4 shows the vertebræ of the neck forming a curve at the left of the head. Above and at the left of this curve is a blotch formed by the rays of another fish.

Besides the American species, six others may be recognized, as follows: *L. armatus* Marck and *L. sagittatus* Marck, from the Upper Cretaceous of Westphalia, *L. triqueter* Pictet, *L. gracilis* Davis, *L. hakelensis* Pictet and Humbert, all from the

Upper Cretaceous of Mount Lebanon, and *L. elongatus* (Agassiz), from the Senonian and Turonian of England.

It seems not unlikely that of the species of *Leptotrachelus* those having a long dorsal fin, *L. triqueter*, *L. longipinnis*, and *L. gracilis*, will have to be separated as a distinct genus, while *L. armatus* and *L. hakelensis* will be retained in *Leptotrachelus*.

MYCTOPHIDÆ.

Myctophidæ Jorlan and Evermann, Fishes of North and Middle America, 1896, p. 550.

Scopelidæ of most authors.

Leptosomus *Marck.*

To this genus the present writer assigns the species from the Niobrara of South Dakota, which Cope placed in the genus *Sardinius*. The latter genus has the scales pectinated, the pectoral fins with about 18 rays, the anal with about 20 rays, and about 45 vertebræ. The American species agree with *Leptosomus* in having, so far as can be determined, cycloid scales, narrow pectorals, a short anal, and about 30 vertebræ. Cope regarded *Leptosomus* as a synonym of *Sardinius*, but Woodward properly separates it. The author last named recognizes four species of this genus, *L. guestphalicus* Marck and *L. elongatus* Marck, both from the Upper Cretaceous of Westphalia, and *L. macrourus* Pictet and Humbert, and *L. minimus* (Agassiz), both from the Upper Cretaceous of Mount Lebanon.

Leptosomus nasutulus (*Cope*).

Plate IV, Figs. 4 and 5.

Sardinius nasutulus Cope (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. IV, 1878, p. 70. — Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 248. — Hay (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 391.

Of this species there are in this Museum three specimens as follows: The type No. 2512 (Pl. IV, Fig. 4), No. 2513 (Pl. IV, Fig. 5), and No. 2523.

Most of Cope's measurements are taken from the type, but the distance from the snout to the base of the ventral fins is taken from No. 2513. This was necessary because in the type the ventrals have been washed forward to beneath the lower jaw, as may be seen from the figure.

On the block containing No. 2523 are scratched in pencil the words "Yankton, Neb." The other specimens are without doubt from the same locality.

Leptosomus lineatus (*Cope*).

PLATE IV. FIG. 6 AND PLATE V. FIG. 2.

Sardinius lineatus COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. IV., 1878, p. 71. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 248. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 391.

This species was based on two specimens, No. 2538 (Pl. IV, Fig. 6) and No. 2511 (Pl. V, Fig. 2). The former specimen displays the body as far back as the rear of the dorsal fin; the latter specimen shows the hinder half far enough forward to show the tips of the ventral fins; but neither specimen shows both the dorsal and the ventrals. Hence, the exact relation of these fins to each other can not be determined.

The block on which No. 2538 is preserved, and which also bears *Spaniodon simus*, is marked "Yankton, Neb."

Leptosomus percrassus (*Cope*).

PLATE V, FIG. 3.

Sardinius percrassus COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. IV, 1878, p. 72. — WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 248. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 391.

This species is represented by a single specimen, No. 2510 (Pl. V, Fig. 3). It differs from the other species in having a much deeper body. Although there is no record either on the block bearing this species, or in Professor Cope's description, there can be do doubt that it came from the same locality and deposit as the other species here recorded from South Dakota.

Sardinius? imbellis *sp. nov.*

PLATE IV, FIG. 9.

The block of soft limestone which bears the type of Cope's *Sardinius nasutulus* presents also parts of two other small fishes which appear to be undescribed. One of these, No. 2550, lacks the head and the whole of the body above the vertebral column, except a portion of the upper lobe of the caudal fin. The other specimen, No. 2549, presents the body from the front of the dorsal fin to the extremity of the caudal. Perhaps it would be wise to refrain from describing these specimens, as Cope refrained. Nevertheless, they appear to differ from any species yet described and to furnish characters which will make it possible to recognize other specimens when they shall be found. So far as can be determined from the remains at hand, the species belongs to the Myctophidæ, and it stands nearer to *Sardinius cordieri* than to any other related form. From *Sardinius* it appears to differ in having fewer vertebræ, fewer rays in most of the fins, in the position of the dorsal, and in the character of the scales. It appears safer, however, to await the finding of additional and better materials before proposing a new generic name. The longitudinally divided specimen, No. 2550 (Pl. IV, Fig. 9), is taken as the type.

From the caudal fin to the insertion of the pectoral 36 vertebræ are counted. The whole number probably has been about 40. Of these, 15 appear to have belonged to the caudal region. The ribs are slender. The pectoral fin is broad and consists of 15 rays; but it is rather short and lacks somewhat of reaching the ventrals. The latter fins are pressed down, the one on the other, so that the exact number of rays cannot be determined. Six may be counted. These fins are placed nearer to the pectorals than to the anal. The dorsal is missing in the type. The anal has a long basis and consists of 15 or 16 rays. The caudal is deeply forked. No evidences appear of any pectination of the scales. The body has been rather deep.

The second specimen presents an anal fin of 16 rays. In front of it is the dorsal, which appears to be supported by 12 interneurals. The front of the dorsal begins above the tenth vertebra in front of the origin of the anal. Three or four neural arches and two or three hæmal arches at the base of the caudal are expanded somewhat. Besides the slender neural arches and ribs, there are numerous fine intermuscular bones. No part of the ventrals appears in this specimen. Assuming both fishes to belong to the same species, it is evident that the dorsal fin is placed in the interval between the ventral and the anal fins. The whole length of the type has been close to 65 mm.

Niobrara Cretaceous, region of Yankton, South Dakota.

Rhinellus *Agassiz.*

Dr. A. .S. Woodward has properly, as it appears to the writer, reduced Cope's genus *Ichthyotringa* to a synonym of *Rhinellus* Agassiz. The scales along the lateral line of the American species also may have been somewhat thickened, and the dorsal fin has about the same number of rays as in *R. furcatus*, the type of the genus.

Rhinellus tenuirostris (*Cope*).

PLATE IV, FIGS. 7 AND 8.

Ichthyotringa tenuirostris COPE (E. D.), Bull. U. S. Geol. and Geog. Surv. Terrs. IV, 1878, p. 69. — HAY (O. P.), Bibliog. and Cat. Foss. Vert. N. A. 1902, p. 297.

Rhinellus tenuirostris WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 269.

This species is based on two specimens, No. 2514, the type (Pl. IV, Fig. 7), and No. 2515 (Pl. IV, Fig. 8). The former shows the head, with its long beak, and the body above the vertebral column as far backward as the rear of the dorsal fin. The latter, a small fish, displays the anterior portion of the body from below. Both pectoral and both ventral fins are presented.

The block on which this specimen is found is marked "Yankton, Neb." Of the other valid species of this genus *R. furcatus* Agassiz is found in the Upper Cretaceous of Mount Lebanon and Westphalia; *R. ferox* Davis and *R. damoni* Davis, in the Upper Cretaceous of Mount Lebanon.

Explanation of the abbreviations employed in the figures and on the plates to indicate the names of the bones and other structures.

a. f. = anal fin,
als. = alisphenoid,
ang. = angular,
a. r. = anal fin rays,
art. = articular,
art. s. = articular surface,
bas. = baseosts,
b. br. = basibranchial,
b. oc. = basioccipital,
cl. = cleithrum,
cor. = coracoid,
den. = dentary,
d. f. = dorsal fin,
d. r. = dorsal fin rays,
ec. pt. = ectopterygoid,
en. pt. = entopterygoid,
ep. o. = epiotic,
eth. = ethmoid,
ex. oc. = exoccipital,
fr. = frontal,
gl. h. = glossohyal,
i. h. = interhæmals,
i. n. = interneurals
i. op. = interoperculum,
m. pt. = metapterygoid,
mx. = maxilla,
na. = nasal,
op. = operculum,
op. o. = opisthotic,
os. = orbitosphenoid,
pa. = parietal,
pal. = palatine,
par. = parasphenoid,
p. cor. = precoracoid,
pct. = pectoral fin,
p. f. = pectoral fin,
pmx. = premaxilla,
p. op. = preoperculum,
pr. f. = prefrontal,
pro. = proötic,
p. sp. = presphenoid,
pt. f. = postfrontal,
pt. o. = pterotic,
pt. or. = postorbital,
sc. = scapula,
smx. = supramaxilla,
sn. = tip of snout,
s. oc. = supraoccipital,
s. op. = suboperculum,
s. or. = suborbital,
sq. = squamosal,
su. cl. = supracleithrum,
vert. = vertebra,
v. f. = ventral fin,
vom. = vomer,
vom. t. = vomerine tooth,
v. r. = ventral fin rays.

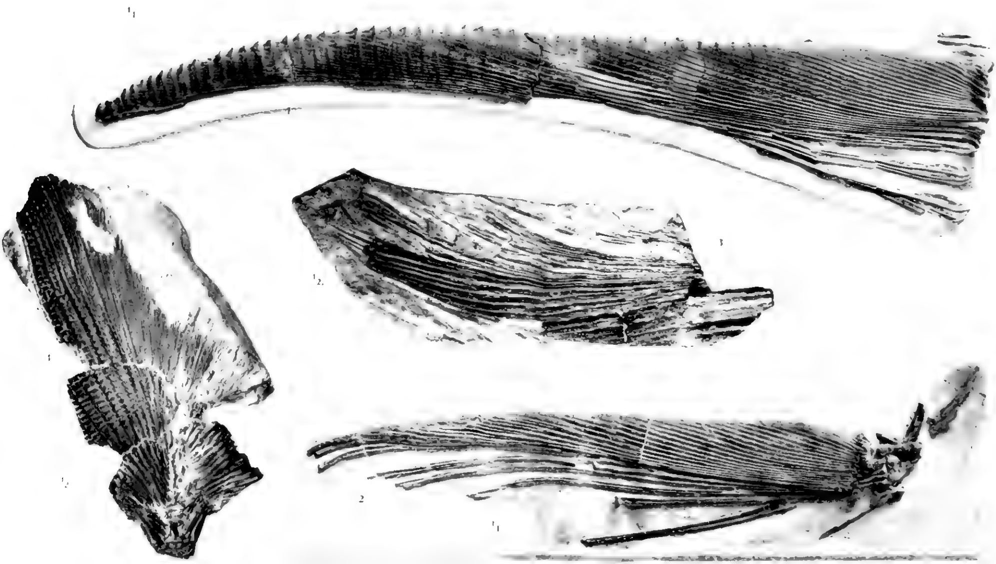
EXPLANATION OF PLATE I.

Fig. 1.—*Protosphyræna perniciosa* (Cope). Page 9. Pectoral fin. × ¼. No. 1901.

Fig. 2.—*Protosphyræna tenuis* Loomis. Page 15. Pectoral fin. × ¼. No. 205.

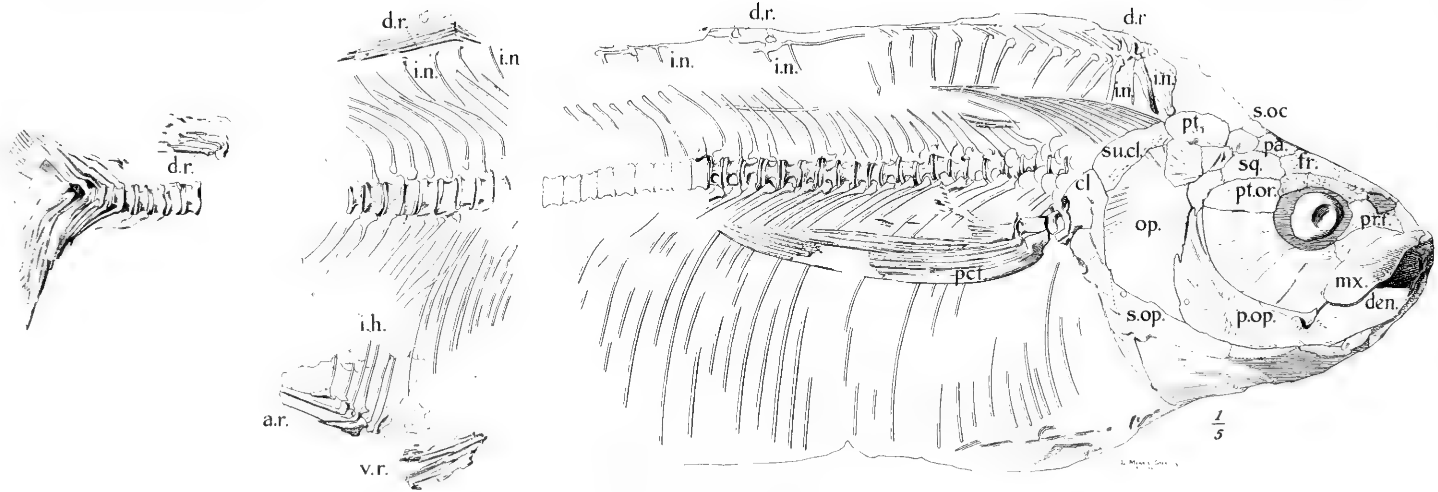
Fig. 3.—*Protosphyræna tenuis* Loomis. Page 16. Distal end of pectoral fin. × ½. No. 1620.

Fig. 4.—*Empo nepaholica* Cope. Page 88. Part of caudal fin. × ½. No. 2032.



Protosphyræna and Empo.

C. L. Wright, Sc. & Imp. New York



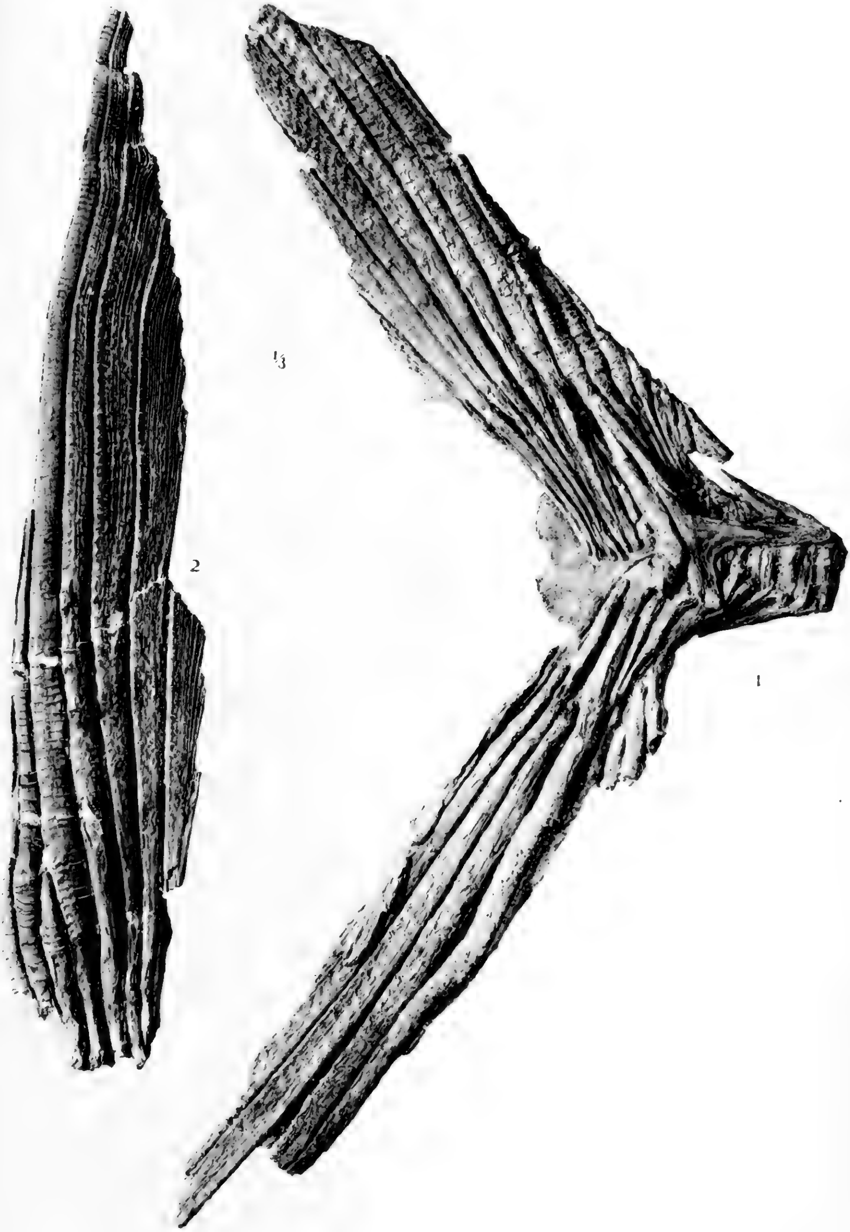
Anogmius aratus Cope.

Anogmius aratus Cope. No. 2403. × ⅕. Type. *a. r.*, rays of anal fin; *cl.*, cleithrum; *d. r.*, rays of dorsal fin; *den.*, dentary; *fr.*, frontal; *i. h.*, interhæmal bones; *i. n.*, interneural bones; *mx.*, maxilla; *op.*, opercular; *pa.*, parietal; *pct.*, pectoral fin; *p op.*, preoperculum; *pr. f.*, prefrontal; *pt.*, post-temporal; *pt. or.*, postorbital; *s. oc.*, supraoccipital; *s. op.*, suboperculum; *sq.*, squamosal; *su. cl.*, supracleithrum; *v. r.*, rays of ventral fin.

PACHYRHIZODUS.

EXPLANATION OF PLATE III.

Pachyrhizodus caninus Cope. Page 63.
Fig. 1.—Caudal fin and vertebræ. × 1/3. No. 1900.
Fig. 2.—One lobe of caudal fin. × 1/3. No. 1658.



Pachyrhizodus.

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EXPLANATION OF PLATE IV.

Fig. 1.—*Spaniodon simus* Cope. Page 47. Nearly complete fish. Type. × 1/1. No. 2508. *a. f.*, anal fin; *d. f.*, dorsal fin; *p. f.*, pectoral fin; *v. f.*, ventral fin.

Fig. 2.—*Spaniodon simus* Cope. Page 47. Anterior half of fish. Paratype. × 1/1. No. 2509. *den.*, dentary; *p. f.*, pectoral fin; *pmx.*, premaxilla.

Fig. 3.—*Leptotrachelus longipinnis* Cope. Page 90. Part of trunk. Cotype. × 1/1. No. 2520. *d. f.*, dorsal fin; *v. f.*, ventral fin.

Fig. 4.—*Leptosomus nasutulus* (Cope). Page 91. Nearly complete fish. Type. × 1/1. No. 2512. *a. f.*, anal fin; *d. f.*, dorsal fin; *v. f.*, ventral fin (displaced).

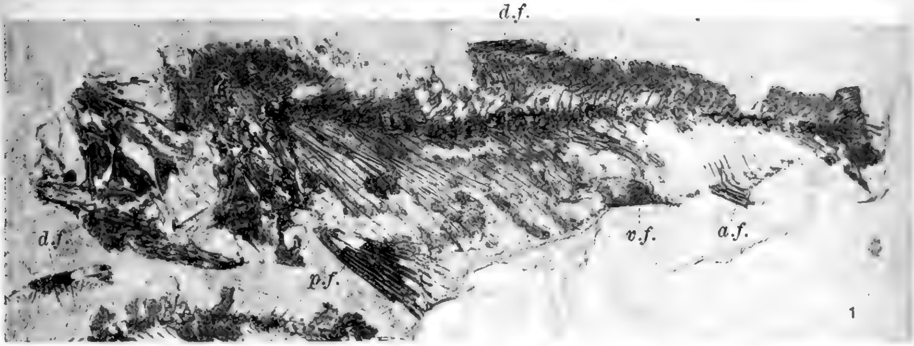
Fig. 5.—*Leptosomus nasutulus* (Cope). Page 91. Nearly complete fish. × 1/1. No. 2513. *d. f.*, dorsal fin; *p. f.*, pectoral fin; *v. f.*, ventral fin.

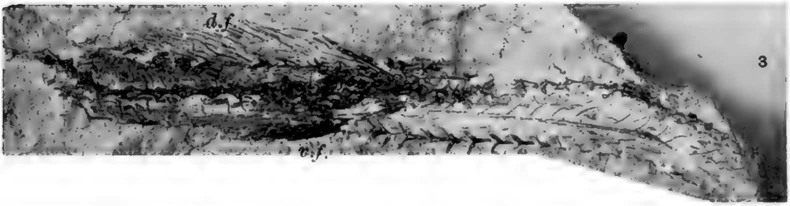
Fig. 6.—*Leptosomus lineatus* (Cope). Page 92. Fish with tail missing. Cotype. × 1/1. No. 2538. *d. f.*, dorsal fin; *v. f.*, ventral fin.

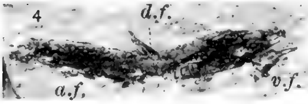
Fig. 7.—*Rhinellus tenuirostris* Cope. Page 94. Head and part of trunk. Cotype. × 1/1. No. 2514. *d. f.*, dorsal fin.

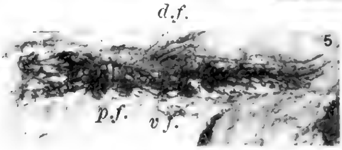
Fig. 8.—*Rhinellus tenuirostris* Cope. Page 94. Head and part of trunk. Cotype. × 1/1. No. 2515. *p. f.*, pectoral fin; *v. f.*, ventral fin.

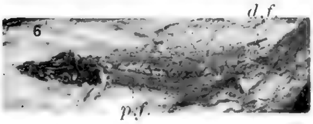
Fig. 9.—*Sardinius ? imbellis* Hay. Page 93. Lower half of fish. Type. × 1/1. No. 2550. *a. f.*, anal fin; *p. f.*, pectoral fin; *v. f.*, ventral fin.

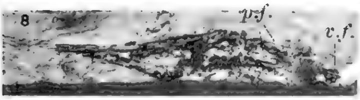


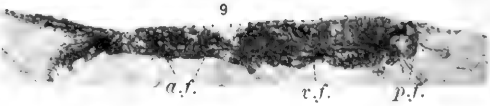












CRETACEOUS FISHES.

EXPLANATION OF PLATE V.

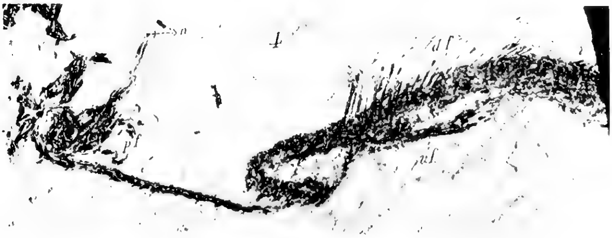
Fig. 1.—*Triænaspis virgulatus* Cope. Page 89. Head and part of trunk. Type. $\times \frac{1}{1}$. No, 2516. *d. f.*, dorsal fin; *p. f.*, pectoral fin; *v. f.*, ventral fin.

Fig. 2.—*Leptosomus lineatus* (Cope). Page 92. Hinder half of fish. Cotype. $\times \frac{1}{1}$. No. 2511. *a. f.*, anal fin; *v. f.*, ventral fin.

Fig. 3.—*Leptosomus percrassus* (Cope). Page 92. Complete fish. Type. $\times \frac{1}{1}$. No. 2510. *a. f.*, anal fin; *d. f.*, dorsal fin; *p. f.*, pectoral fin; *v. f.*, ventral fin.

Fig. 4.—*Leptotrachelus longipinnis* Cope. Page 90. Head, neck, and part of trunk. Cotype. $\times \frac{1}{1}$. No. 2551. *d. f.*, dorsal fin; *p. f.* pectoral fin; *sn.*, snout; *v. f.*, ventral fin.

Lying against the bend in the neck are some remains of another fish.



CRETACEOUS FISHES

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The Fauna of the Titanotherium Beds at Pipestone Springs, Montana.

By W. D. Matthew.

AUTHOR'S EDITION, extracted from BULLETIN
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Article VI. — THE FAUNA OF THE TITANOTHERIUM BEDS AT PIPESTONE SPRINGS, MONTANA.

By W. D. Matthew.

The American Museum Expedition of 1902 in western Montana had for object to make a further search in the Tertiary deposits of that region, where Mr. Earl Douglas has recently discovered many new and interesting fossil mammals. In the White River formation near Pipestone Springs, Mr. Douglas had found a very interesting micro-fauna, and our collections at the same locality, which Professor Osborn has kindly turned over to me for study and description, enable us considerably to extend the list. I am indebted to Mr. Douglas for the opportunity to examine the type specimens of his various species, as well as for the information concerning localities, etc., contained in the stratigraphic part of his very excellent memoir recently published on the White River of Montana.

The majority of the species are small or minute forms, not found in the Titanotherium Beds of South Dakota or Colorado, where the scanty fauna is almost entirely of large animals, — Titanotheres, Elotheres, and Rhinoceroses. A few small species have been described from Swift Current Creek, Canada, based on very fragmentary materials. The Pipestone Springs fauna is therefore of much interest, as it illustrates the direct precursors of the numerous small species of the Oreodon Beds. In the species from the three successive stages of the White River we have the most favorable opportunities for study of the details of evolutionary progress in a given race that are presented among fossil vertebrata; for the materials are abundant and complete, the succession is unquestionable, and the character of the beds, and hence the local conditions of deposition, very uniform, so that we get the same facies of the three faunas. It is doubtful how far, if at all, the Eocene deposits of the Rocky Mountain divide and foothills contain the same facies of their respective faunas as do the Oligocene deposits of the plains. They contain an important aquatic contingent, fish, crocodiles, and water-turtles being comparatively abundant. In the White River fauna all these are absent, except in the sandstone lenses,[1] while a large element of it is apparently adapted to open grassy plains; this is not found in the Eocene faunas. But in the three zones of the White River a great part of their respective faunas appears to be in direct and exact genetic succession. We can therefore measure the amount and direction of change during the Oligocene epoch in many series.

The amount of evolution as thus measured appears small, but its direction somewhat constant. The species of the Titanotherium Beds are all distinct from their successors in the Oreodon Beds, but the difference is uniformly small. Between the Oreodon and Leptauchenia faunas the difference is often greater but less uniform, so far as present data go. Some genera run through the three horizons (*e. g.*, *Cynodictis*, *Palæolagus*, *Mesohippus*, *Cænopus*, *Leptomeryx*). Others have been found only in the two lower zones or in the two upper zones, while many are as yet known from one horizon only.

Stratigraphy. — Mr. Douglas refers all the Tertiary at this locality to one stage, correlating it with the Titanotherium Beds of South Dakota. We find, however, a lithologic distinction between the higher beds exposed north of the railroad, which resemble the Oreodon Beds of South Dakota, Colorado, and elsewhere, and the lower beds exposed south of the railroad, which resemble rather the Titanotherium Beds of some parts of South Dakota. Likewise on Thompson's Creek, not far from the Pipestone locality, we were able to distinguish between the Oreodon Beds exposed near the head of a small northerly branch of the creek, and the Titanotherium Beds exposed on the main western branch. At

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[1] Mr. Douglas has recently discovered fish remains in strata which he refers to the White River *epoch*, so-called, in the Madison valley in Montana. But these strata are quite different in character from the beds in which White River mammals are found, apparently lacustrine or fluviatile in origin, and a very thorough search on his part failed to reveal any mammals in them except a skull of the beaver *Steneofiber*. I do not understand that he considers them as of the same formation or origin as the mammal beds, but merely as of equal age. The discovery of fish in them, therefore, does not at all invalidate the fluviatile-eolian hypothesis of origin of the White River formation maintained by Hatcher and myself. The same explanation probably applies to other reported occurrences of fish in the White River.

both localities the lithologic distinctions are confirmed by the fossils found.

The Titanotherium Beds are soft, easily weathering, banded clays, often sandy, crumbling to the usual weathered-clay surface, varying in color from dark reddish brown through buff to an almost greenish white. Cross-bedding is seen in the sandier layers. They are not unlike the Titanotherium Beds in South Dakota, but run to deeper and more contrasted coloring. At Pipestone Springs they dip quite steeply toward the north, lying up against the ancient crystalline rocks on the south side of the creek. We found in them the following fauna:

Marsupialia.

Peratherium titanelix, sp. nov.	Allied to *Peratheria* of Middle Eocene and Oligocene.

Insectivora.

Apternodus mediævus, g. et sp. nov.	Allied to ? *Centracodon* of Middle Eocene.
Micropternodus borealis, " "	Allied to ? *Centetodon* of Middle Eocene.
Ictops acutidens *Douglas*	More primitive than any Middle Oligocene Leptictid.
" thomsoni, sp. nov.	

Creodonta.

Pseudopterodon minutus (*Douglas*)	Intermediate between the Oligocene *Hyænodon* and Middle Eocene *Sinopa*.
? Hyænodon sp.	

Carnivora Fissipedia.

Bunælurus infelix, sp nov.	
Cynodictis paterculus, sp. nov.	Somewhat more primitive than Middle Oligocene species.

Rodentia.

Ischyromys veterior, sp. nov.	Somewhat more primitive than Middle Oligocene species.
Cylindrodon fontis *Douglas*.	
Sciurus vetustus, sp. nov.	
Gymnoptychus minor (*Douglas*).	
" minimus, sp. nov.	

Palæolagus temnodon *Douglas.*	More primitive than Middle Oligocene species.
" brachyodon, sp. nov.	

Perissodactyla.

Mesohippus westoni *Cope.*	More primitive than Middle Oligocene species.
Hyracodon sp.	
? Cænopus sp.	
Titanotherium sp.	

Artiodactyla.

Stibarus montanus sp. nov.	
Bathygenys alpha *Douglas.*	
Limnenetes sp. div.	
Leptomeryx mammifer *Cope.*	
" ? esulcatus *Cope.*	
Leptotragulus profectus sp. nov.	Advanced species of an Eocene genus.

Lizards and Tortoises, sp. div.

Two species are reported by Mr. Douglas of which we obtained no further evidence: *Sciurus jeffersoni* Douglas, ? *Agriochœrus maximus* Douglas.

The Oreodon Beds are buff clays, somewhat harder than the Titanotherium Beds, finer, not sandy, more calcareous, and not unlike the Oreodon Beds of Dakota and Colorado. They were very barren so far as we could discover, and the only determinable fossils found at Pipestone Springs were: *Palæolagus haydeni*, *Eumys elegans*, *Mesohippus bairdii*, ? *Poëbrotherium.*

These are all characteristic species of the Oreodon Beds in South Dakota, Colorado, etc.

The fauna from the Titanotherium Beds is a quite remarkable one. Not a single species is identical with those of the Oreodon horizon; all are either new, or have been described by Douglas from the same locality, or by Cope from the same horizon at Swift Current Creek. The majority of the species, however, belong to genera of the Oreodon Beds, and these, though fairly distinct, are not widely divergent from their successors. We find that the Pipestone Beds are much nearer to the Oreodon horizon than to the upper Uinta or Diplacodon Beds. Fourteen genera are in common with the later horizon, while there is but one Uinta genus (*Leptotragulus*) and that represented by a rather divergent species. This contrast is partly explained by the fact that the known White River fauna is a very large one, while that from the Uinta is comparatively small; partly also by considerations of geographical distribution of the Oligocene mammals and by different conditions of deposition in the Uinta and White River beds. But, making allowance for all these, there seems still to be a considerable gap between the Diplacodon and Titanotherium faunas, while the latter is much closer to the Oreodon fauna. It shows some marked differences, however:

(1) There are two new insectivore genera of the primitive section (Zalambdodonta) of the order, which has hitherto been practically unknown in a fossil state, unless the Eocene species reported by Professor Marsh shall prove to belong to it.

(2) All the rodents are sciuromorphs[1] or lagomorphs. Myomorpha, more abundant than sciuromorpha in the Oreodon Beds, have not yet appeared. They are unknown in the Eocene, except *Protoptychus*, a form of doubtful affinities.

(3) The only Creodont from the Oreodon Beds is the highly specialized *Hyænodon*. At Pipestone Creek we have a more primitive type, intermediate between *Hyænodon* and *Sinopa*. At Swift Current Creek occurs *Hemipsalodon* (?=*Pterodon*), also less specialized than *Hyænodon*. (*Hyænodon* itself occurs also in the Titanotherium Beds.)

(4) *Oreodon* is not found, and two or three more primitive genera (*Bathygenys*, *Limnenetes*, ? *Agriochœrus*) take its place.

(5) *Hypertragulus*, common in the Middle and Upper Oligocene, is not found, while *Leptomeryx* of the Lower and Middle Oligocene is abundant and large.

(6) In place of *Poëbrotherium*, the camel of the Oreodon Beds, is found a brachyodont form, apparently the Eocene genus *Leptotragulus*.

From the above facts we would infer that the Pipestone Beds are at the base of the Oligocene, but above the Eocene, accepting Osborn's correlation of the White River formation

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[1] If *Gymnoptychus* be considered a sciuromorph, as it was by Professor Cope and is by Dr. Hay.

with the Oligocene, and of the Uinta with the Upper Eocene. They are probably of approximately the same age as the White River beds of Swift Current Creek, Canada, with which they have three species in common, probably a fourth ("*Palæolagus turgidus*" from Swift Current Creek probably is *P. brachyodon*),— a fair proportion out of so limited a fauna.

Descriptions of Species.

MARSUPIALIA.

Peratherium titanelix, spec. nov.

Type, No. 9603, a lower law with p_3 and m_{2-4} and alveoli of the remaining teeth except incisors.

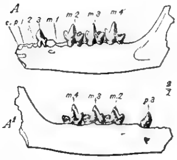

Fig. 1. *Peratherium titanelix.* Type specimen, twice natural size. *A*, outer, *A*¹, inner view of teeth.

This species is about the size of *P. huntii* of the Oreodon Beds, and resembles it in the rather short premolar region, the premolars and canine small, close together without any diastemata.

The molars are similar to those of typical *Peratheria* from the Phosphorites, but the premolars are very distinct, crowded, and reduced anteroposteriorly, the cusps recurved instead of symmetrical as in *Peratheria* from the Phosphorites, and in *P. fugax* of Cope. The anterior part of the jaw is rather short and deep and the canine directed more upward than in *P. fugax.*

Measurements.

Length p_1–m_4	7.3 mm.
Length m_{2-4}	4.2
Depth jaw under m_2	1.9

INSECTIVORA.

Apternodus mediævus, gen. et spec. nov.

Type, No. 9601, posterior half of a lower jaw with two complete molars and the root of another.

Molars composed of high trigonid and minute basal talonid. Protoconid high, sharp, and triangular, paraconid and metaconid subordinate. Dentition probably $i_?\ c_1\ p_3\ m_3$.

Talonid a small sharp cusp on m_3; on m_2 it is a minute postero-internal basal cusplet. The third molar a little smaller than the second; both are two-rooted, the anterior root wider transversely.

The cusps are all high, sharp, trigonal in cross-section, the whole tooth subtriangular with transverse and longitudinal diameters about equal and vertical diameter considerably exceeding either. The heel is much smaller than in Centetidæ, the protoconid higher and larger in proportion than in any other Insectivore or Chiropter.

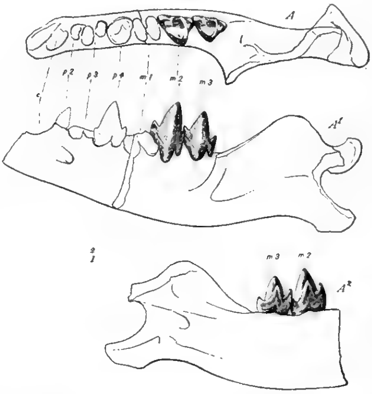

Fig. 2. *Apternodus mediævus.* Type, No. 9601, twice natural size, the outlines of front of jaw from No. 9607. *A*, crown; *A*^{1}, external, *A*^{2}, internal view.

No. 9608, a lower jaw without teeth, broken off in front at about the same point as the types, but with the condyle complete, appears to belong to the same species. The condyle is widely expanded transversely, on a level with the bases of the molars. The angle in the type specimen is extended into a rather long and stout flattened process with a sharp medial ridge on the internal side. The coronoid is broken off in both specimens, but was evidently high, stout, placed mostly external to the toothrow, and directed upwards instead of backwards.

No. 9607, the anterior part of a lower jaw, with one premolar preserved and the roots of other teeth, is provisionally referred to this species. The premolar is either the third or fourth; it is stout, two-rooted, composed of a round-conical protocone and small postero-internal basal cusp. The anterior root is wider than the posterior. The premolar in front of this was apparently similar but smaller, and was preceded by a small one-rooted premolar, and this by a larger tooth, probably a canine. Behind the premolar are roots of two teeth, one of which was probably m_1, the other certainly a molar, judging from comparison of the corresponding parts of the jaw in the three specimens.

The dentition is then probably c_1 p_3 m_3, but may be c_1 p_4 m_3. The weight of the anterior part of the jaw and doubtful indications of a large alveolus lead to the suspicion that one or more of the incisors was enlarged.

No. 9612, part of a lower jaw with the roots of the last two molars, is also referred here.

This remarkable little jaw is quite unlike any described species of Insectivore or Chiropter, except, perhaps, Marsh's *Centracodon*. So far as anything can be determined from his brief description, the last molar of *Centracodon* is like the second molar of *Apternodus*. *Centracodon* has four premolars. Although the short, deep jaw would appear to ally it rather with the Chiroptera, yet as the tooth without talonid is quite unknown in this order, while it does characterize a section of the Insectivora, I leave it provisionally in the latter group, without attempting to assign it to any especial family. Its nearest relatives are most probably the little Eocene Insectivora from the Bridger Basin, described by Professor Marsh in 1872. With the probable exception of these Eocene types and of a single South American species, no fossil Insectivores of the Zalambdodont division have hitherto been described, although according to the Tritubercular theory this, as the more primitive section, should have been more abundant in ancient times.

Measurements.

M_{2-3}	3.9 mm.
M_2 longit.	2.0
" transv.	2.0
" height.	3.7
M_3 longit.	2.0
" transv.	1.8
" height.	2.9
Depth of jaw.	3.5

Micropternodus borealis, gen. et spec. nov.

Type, No. 9602, a lower jaw with p_3-m_3 and alveoli of the anterior teeth.

Dentition $\overline{3.1.3.3}$. Molars somewhat like those of *Centetes* in composition, with high trigonid and small, low talonid. Trigonid very wide transversely with pr^d considerably overtopping pa^d and me^d. Talonid with sharp posterior margin and low median ridge. Molars and especially premolars, short, high, and recurved; p_4 sub-molariform, with small anterior and internal trigonid cusps and strong basal heel. P_3 much smaller and simpler, with small heel and no other accessory cusps. P_2 is small and one-rooted, canine small, incisors small, subequal. No diastemata except a slight one behind p_2. Jaw rather deep in front. Second molar slightly larger than the first, third much smaller.

Like the preceding genus, this must be placed among the Zalambdodonta, with no very near relatives among living species, although it is not so strikingly different from modern types. Its nearest allies are also quite probably some of the very inadequately described Insectivora from the Bridger Basin, but neither it nor *Apternodus* can be considered as possibly congeneric with any of the Bridger species, if Marsh's descriptions are correct.

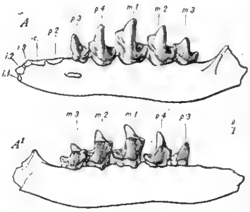

Fig. 3. *Micropternodus borealis.* Type specimen, twice natural size. *A*, outer, *A*¹, inner view of teeth.

Measurements.

Lower jaw, m_3 to incisive alveoli	12.4 mm.
Lower teeth p_3–m_3	8.4
Lower molars m_{1-3}	6.4
Lower molar, m_1 longitudinal, at base	1.8
" " " transverse	1.9
" " " height of crown	2.7

Ictops acutidens *Douglas*.

A fragmentary skull and jaws, with some limb-bones of one individual, and the upper and lower molars of another, confirm and extend the characters of this species as indicated by Douglas.

The distinctions from previously described species are:

Dimensions fifteen per cent. less than any of the Leptictidæ from the Oreodon Beds. First upper premolar one-rooted, two-rooted in *I. dakotensis* and *bullatus* and in *Leptictis haydeni*. Supra-temporal crests widely separated anteriorly and convergent posteriorly, instead of close together and parallel as in all the later species. Upper molars and p^4 more constricted between the inner and outer cusps than in any described Leptictid; cusps somewhat higher and last molar less reduced than in any later species.

No. 9604, a fragmentary skull and jaw, with humerus, radius, two phalanges, and a caudal vertebra, exhibits most of the permanent dentition well preserved.

Upper jaw. — Incisors not known. Canine of moderate size, compressed, somewhat ridged externally, with no indication of the incipient heel seen in *Palæictops*. P^1 one-rooted, smaller than canine. P^2 two-rooted, compressed, with small posterior basal cusp or heel. P^3 three-rooted, with strong, well-separated *de*, higher but less separated *tr*, and minute antero-external basal cusp; the protocone much overtopping the other cusps. P^4 molariform, but *tr* not yet as high as *pr*, *de* equalling *pr* in height, small *hy*, and strong protostyle. First and second molars with *pa* and *me* of equal size, *hy* better developed than in p^4, a small protostyle on m^1. M^3 with reduced *me* and rudimentary *hy*. All molars and p^4 wide transversely, with some constriction between inner and outer cusps. M^3 smaller than m^1 and m^2, but not so much reduced as in the later species.

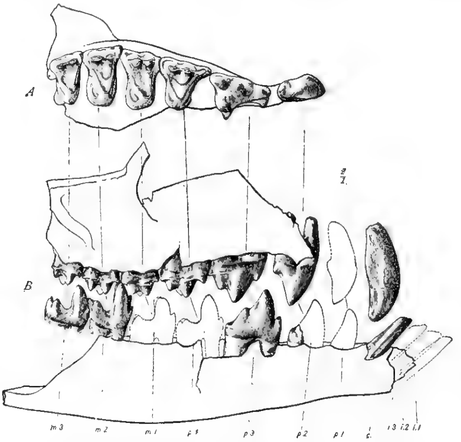

Fig. 4. *Ictops acutidens.* Teeth, twice natural size. *A*, crown view of upper teeth; *B*, external view of upper and lower teeth. No. 9604, the lower molars from No. 9605.

Lower jaw. — Dental series continuous without diastemata. Three small incisors. Canine small, incisiform, somewhat larger than incisors. P_1 one-rooted, p_2 two-rooted, p_3 two-rooted, compressed, with anterior and posterior cusps and small heel. The lower molars are not preserved in this specimen. In No. 9605 m_2 and m_3 are preserved; the trigonid is high, composed of two equal well-separated cusps, talonid much lower, bearing three posterior cusps, external, internal, and postero-median respectively, well separated from the trigonid but not from each other. M_3 is a little longer than m_2 but much narrower, especially the talonid, in which the hypoconulid is situated more behind the hypo- and entoconid instead of nearly between them.

The skull is wider between the eyes than those from the Oreodon Beds, the postorbital constriction less pronounced. The temporal crests begin on the posterior third of the frontal bones, eleven millimeters apart, and converge rapidly on the posterior half of the parietals.

The humerus is disproportionately smaller and more curved than in *I. dakotensis*, the deltoid crest is not so wide nor does it extend so far down. The radius is likewise strongly curved, its distal end bearing two ill-separated subquadrate facets for scaphoid and lunar, the scaphoid facet the wider of the two. Two rather long and slender phalanges are preserved, one somewhat compressed laterally. The caudal vertebra associated is from the middle part of the series and indicates a large, long tail.

This species is in some, but not in all respects intermediate between *Palæictops* and the Leptictidæ of the Oreodon Beds. The last molar is more reduced than in *P. bicuspis*, less than in any later Leptictid. The first premolar is one-rooted, as in *P. bicuspis*, while in the later species it is two-rooted. On the other hand, the molars are more compressed and more constricted medially, and the size is smaller than in either the Wind River species or those from the Oreodon Beds; and the temporal crests are further apart than in the later species, while in the earlier one they are united into a sagittal crest.

Ictops thomsoni, spec. nov.

Fig. 5. *Ictops thomsoni.* Crown view of upper molars, × $\frac{2}{1}$. Type specimen.

Two upper jaws, Type, No. 9606, Cotype, No. 9606*a*, indicate a species closely allied to *Ictops acutidens*, but distinguished by smaller size, more compressed teeth, and other characters of less importance. The metacone on all the molars is decidedly smaller than the paracone; in *I. acutidens* they are nearly, and in other Leptictidæ quite, equal in size on m^{1-2}. The protocone on $p^{4}-m^{3}$ is more compressed antero-posteriorly, and the constriction between it and the outer cusps is more marked than in *I. acutidens.* The hypocone is smaller on m^1 and m^2, absent on m^3 and p^4. The trittocone of p^4 is smaller than in *I. acutidens.*

All these distinctions are exaggerations of the differences between *I. acutidens* and the Leptictidæ of the Oreodon Beds, but none of them ally it to *Palæictops*, in which the molars and premolars (except p^1) are fully as complicated as in the species of the Oreodon horizon.

The species is named in honor of Mr. Albert Thomson of the American Museum Expedition of 1902, who discovered the type specimens of this as well as those of four other new species described in this article.

Comparative Measurements.

	I. thomsoni Type.	I. acutidens Nos. 9604 and 9605.	I. dakotensis Type.[1]	I. bullatus Type.	Mesodectes. No. 9316.	Leptictis Type.[1]
Upper molar-premolar series		20.8		23.5		24.
" true molars and fourth premolar	9.3	10.4		11.7	11.7	12.
" m^1 longitudinal	2.7	2.6	3.3	3.4	3.4	3.
" " transverse	3.9	4.0	4.0	5.3	4.9	4.7
" m^3 longitudinal	1.5	2.1		1.6	1.9	2.4
" " transverse	3.6	3.5		3.2	3.9	4.9
Lower molar-premolar series		E. 20.0				
" true molars		E. 10.1				
" m$_2$ longitudinal		2.7				
" " transverse		2.1				
" " height		3.7				

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[1] Measurements from Leidy's figure.

CREODONTA.

? **Pseudopterodon minutus** (*Douglas*).

Hyænodon minutus Douglas.

No. 9623, the upper jaw of a small Creodont of the family Hyænodontidæ is referred provisionally to Schlosser's genus, and may be identified specifically with the lower molar on which Mr. Douglas based his species "*Hyænodon*" *minutus.* This upper jaw, however, cannot be referred to *Hyænodon*, as the first molar shows a sharp antero-internal angle and small antero-internal cusp. It is not very close to Schlosser's type, and if, as Scott believes, *Pseudopterodon* is founded on milk teeth of *Hyænodon*, then our species represents an undescribed genus, which may well stand ancestral to *Hyænodon*, being directly intermediate between that genus and *Sinopa*.

Fig. 6. *Pseudopterodon minutus.* Crown view of upper teeth, natural size. No. 9623.

The animal was a little smaller than *Cynohyænodon cayluxi* Filhol. P^3 is two-rooted, slightly compressed, set a little transversely in the jaw, moderately high, with small anterior basal cusp and heel. P^4 is three-rooted, the internal root well separated, median, supporting a strong internal buttress to the protocone and a basal cingulum, but no defined cusp. The antero-external cusp is of moderate size, the postero-external developed into a short cutting blade. M^1 is three-rooted, the inner root anterior and well separated, bearing a wide buttress ridge and a small internal cusp, which is worn off in the specimen. Only the front part of the tooth is preserved. M^2 was larger than m^1 and similar to it, judging from the character and position of the two anterior alveoli which indicate it on the specimen.

? *Hyænodont*, indet.

An upper premolar of singular character which I am unable to refer to any described species of Carnivore or Creodont. It has two roots, the posterior one broadened inwardly so as to support a median internal buttress to the protocone. The protocone is very high, its height exceeding the antero-posterior length of the tooth; somewhat compressed posteriorly, with a well-distinguished posterior cusp and small posterior cingular cusp. Cingulum obsolete except at anterior and posterior ends of tooth. Appears to be the third or, perhaps, second upper premolar of some Hyænodont, but not of *Hyænodon* or *Pterodon*.

CARNIVORA (FISSIPEDIA).

Cynodictis paterculus, spec. nov.

Two lower jaws and parts of others, Nos. 9616, 9619, represent this species. Of these I take No. 9616 as type. Compared with a quite large series of specimens, including the types of *C. gregarius* and *C. lippincottianus*, these specimens show certain constant differences, chiefly in the construction of m_2. This tooth is proportionately larger and longer, the heel larger and wider, and the proto- and metaconids are raised above the paraconid, instead of being nearly on a level with it, as they usually are in *C. gregarius*. The shear of m_1 is somewhat more transverse, and m_3 is a little less reduced. The size is that of *C. gregarius*.

The above characters are slight distinctions indeed, but their constancy in the very considerable series of specimens compared makes them valid specifically. In *Procynodictis vulpiceps* of the Uinta, the shear is more transverse, but m_2 is smaller and its heel more reduced than in *C. gregarius*.

Measurements.

	Type, No. 9616	Cotype, No. 9618
P_1-m_3		35 mm.
M_1-m_3	18 mm.	17
M_1 longit	9.5	9.
" transverse	4.5	4.2
" height of pr_d	7.	
M_2 longit	5.5	5.2
" transv	3.5	3.3
M_3 longit	3.	..
" transv	2.5	..

Bunælurus infelix, spec. nov.

No. 9620, part of a lower jaw with p_4-m_1 and the stump of m_2, represent this species, which is with difficulty distinguishable from *B. lagophagus*. The protocone of m_1 is more rounded, the shear a little more transverse than in Cope's species. The fourth premolar appears to be stockier and longer than in the type of *B. lagophagus*, but it is not fully formed in the jaw in that specimen, so the comparison is questionable; the protocone is stout and round, with a small postero-external cusp, and external basal cingulum rising to a small heel behind. The second molar is a minute crownless stump.

Measurements.

P_4–m_2	10.2 mm.
P_4 longit.	4.1
" transv.	1.9
M_1 longit.	5.9
" transv.	2.3
Depth of jaw beneath m_1	6.

A larger Musteline is indicated by part of a jaw, No. 9621, with p_4 and the roots of the front teeth in it. It is about the size of *Cynodictis paterculus*, but the premolars are higher, shorter; the heel smaller, anterior basal cusp absent; and other details join to show that it is a Musteline.

RODENTIA.

ISCHYROMYIDÆ.

Ischyromys veterior, spec. nov.

The anterior part of a skull and some forty jaws or parts of jaws, upper and lower, represent this species. It is considerably smaller than a series of specimens from South Dakota, which agree well with Leidy's types of *I. typus*, and the teeth are narrower throughout with higher cusps. It is much closer to the variety or separate species from Colorado, *I. cristatus* (Cope, 1872), which Cope has referred to *I. typus* and described and figured in 'Tertiary Vertebrata.' From this species I find a constant distinction in the last molar, which in the Montana jaws has always a narrow heel with the last crest imperfect internally, while in all the Colorado specimens the heel is as wide as the rest of the tooth, and the third (last) crest perfectly developed.

In the upper teeth a corresponding difference is to be seen in the last molar, and also the valley between the anterior and posterior inner cusps is well marked on all the teeth, distinct nearly to the base of the enamel, while in the specimens from Colorado and from South Dakota it is obsolete on p^4 and on the molars does not extend so far down.

? CASTORIDÆ.

Cylindrodon fontis *Douglas.*

We have eight lower jaws and an upper jaw of this species, some of which exhibit the tooth pattern, and enable us to refer this curious little rodent provisionally to the Beavers. The two lower jaws on which the species was based were of comparatively old individuals, and the pattern had disappeared, so that it was not possible for Mr. Douglas to determine its relationship.

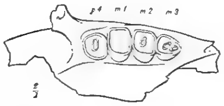

Fig. 7. *Cylindrodon fontis.* Upper jaw, twice natural size. No. 9639.

The dentition is $I\frac{1}{1}$ $c\frac{0}{0}$ $p\frac{1}{1}$ $m\frac{3}{3}$ — four cheek teeth in each jaw, as in Castoridæ, instead of five above and four below as in Sciuridæ and Ischyromyidæ. The pattern resembles that of *Steneofiber* more than any other related form, consisting in the lower molars of a deep and persistent external enamel inflection, and three fossettes corresponding in position to the internal enamel inflections of *Steneofiber* and *Castor*. Of these fossettes the median is the most persistent; the median and posterior are at first internal enamel inflections, the posterior inflection becoming a closed fossette at a very early stage of wear, while the anterior fossette is closed from the first.

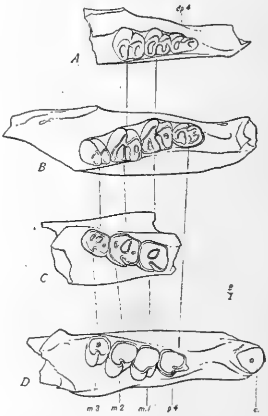

Fig. 8. *Cylindrodon fontis.* Crown views of lower teeth, showing the pattern at successive stages in their wear. All twice natural size. Nos. 9644, 9638, 9640, 9642.

It would appear from the history of those teeth that the enamel inflections did not originate on the sides of the tooth and become gradually deeper and more complicated as the tooth became more hypsodont, the fossettes being a secondary modification; but that the inflections and fossettes have both originated from the valleys and lateral notches of a brachyodont molar, such as that of *Ischyromys*. Either of these is easily derivable from a primitive tritubercular molar such as those of the Tillodonta, but not easily from such teeth as are displayed by *Paramys* and its allies, in which, as in the squirrels, the teeth appear to be specialized and degenerate rather than primitive.

The *upper jaw* of *Cylindrodon* (No. 9639) is that of an old individual, with but little indication of the pattern left on the teeth. From what there is present it appears that the pattern exhibited a strong median external inflection and anterior and posterior fossettes, and a trace remains on p^4 of an internal inflection. The pattern was probably like that of *Ischyromys*, in having the external inflection of greater persistence and depth than the internal. In other Castoridæ this condition is reversed. The upper molars decrease in size from before backward and are of rounded peg-like outline, fossettes on all but m^1. The incisor originates just above the roots of p^4 and m^1, and is stout, not grooved, with a moderate diastema between it and the grinding teeth. The antorbital foramen is small and the palate in front of it is narrow.

The depth of the jaw of *Cylindrodon* in its anterior portion is a very marked character. *Ischyromys* comes nearest to it in this respect.

SCIURIDÆ.

Sciurus (Prosciurus) vetustus, subg. et spec. nov.

Represented by an upper jaw, No. 9626, with complete unworn dentition.

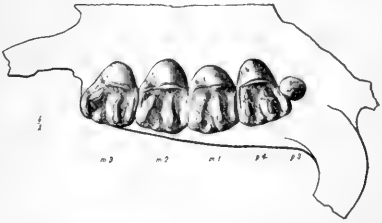

Fig. 9. *Sciurus vetustus.* Crown view of upper teeth, four times natural size. Type.

The species is smaller than *S. relictus* of the Oreodon Beds, and at least a third smaller than *S. jeffersoni* Douglas of the Pipestone Creek Beds, or *S. wortmani* of the John Day formation. It is larger than *S. ballovianus* of the John Day, the first molar (the only upper tooth preserved in the type of *S. ballovianus*) is considerably wider transversely, its anterior cingulum much less developed, its *mesostyle* or median external cusp (between the anterior and posterior transverse ridges) more prominent. In none of the other species is the upper dentition known, so that an exact comparison is not possible.

Compared with modern Sciuridæ this species shows some interesting points of difference. It is nearest to *Sciurus*, but differs in several points of importance:

1. The cross crests on the molars are less complete, and are partly broken up into separate cusps.
2. The third premolar is a much larger tooth and has a small accessory posterior cusp.
3. The heel of m^3 bears a short transverse crest and a strong posterior marginal ridge. In *Sciurus* the posterior part of m^3 is a slightly concave flat basin.
4. The base of the zygoma is anterior to p^3.

From *Tamias* and the other modern Sciuridæ it also differs in the retention of the mesostyle, in addition to most or all of the above-mentioned points. The ridges are not so high as in *Cynomys* and *Arctomys*, and their patterns differ in various other details. I have little doubt that with more perfect material it will be necessary to place this and all the other Oligocene *Sciuri* in a separate genus, nearest to *Sciurus*, but retaining the above primitive features in the dentition, and others of more importance in the skull. But with our present knowledge the distinction in the last molar is the only one which we can predicate of all the Oligocene species in common, and this is only of subgeneric importance at best. The last lower molar in *S. relictus*, *ballovianus*, and *wortmani* exhibits a correspondingly ridged and unreduced heel to the ridged and unreduced heel of the last upper molar in *S. vetustus*.

Upper dentition, p^3–m^3	7.7 mm.
" molars m^1–m^3	5.5
P^3 transverse	0.9
" longitudinal	0.8
P^4 transverse	2.3
" longitudinal	2.0
M^1 transverse	2.5
" longitudinal	1.8

M^2 transverse	2.5 mm.
" longitudinal	1.8
M^3 transverse	2.3
" longitudinal	2.0
Width of palate, including molars	9.6

? HETEROMYIDÆ.

Gymnoptychus minor (*Douglas*).

Eumys minor Douglas, Trans. Am. Phil. Soc. 1901, 16.

The position of *Gymnoptychus* and *Heliscomys* has been variously given by different authors; they are, in fact, rather remote relatives of any modern type, and combine characters of Sciuridæ, Geomyidæ, and Heteromyidæ with others peculiar to themselves or shared by the Ischyromyidæ. The dental pattern strongly suggests that of *Ischyromys*, but the resemblance may be superficial; by simplification and hypsodonty it might be converted into a Heteromyid pattern. I place the genus in this family on Scott's authority.

The present species is intermediate in size between *G. minutus* and *G. liolophus*, but nearer to the latter. The type of *G. liolophus* retains the milk dentition; a specimen of *G. minor* of corresponding age shows a smaller and shorter d_4 and somewhat narrower and smaller m_1.

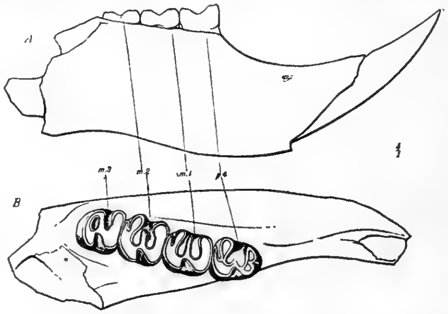

Fig. 10. *Gymnoptychus minor.* Lower jaws, four times natural size. *A*, external view, No. 9632; *B*, crown view of teeth, No. 9630.

Seven lower jaws are referred to this species.

Measurements.

	Type (Douglas).	No. 9630.
Lower dentition p_4–m_3		5.5 mm.
" molars m_1–m_3		4.0
P_4 transverse	1.3 mm.	1.3
" longitudinal	1.5	1.4
M_1 transverse	1.7	1.7
" longitudinal	1.5	1.4
Diastema behind incisor		4.3

Gymnoptychus minimus, spec. nov.

A smaller species than *G. minutus* Cope. Fourth lower premolar larger in proportion to the rest of the dentition, its anterior and posterior halves of equal width; while in *G. minutus* the anterior half of p_4 is much narrower than the rest of the tooth. The first and second molars are narrower than in *G. minutus*, and the whole molar series is thus much more uniform in width.

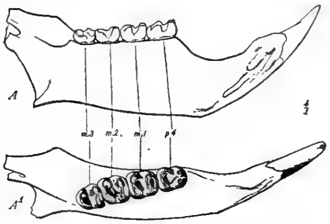

Fig. 11. *Gymnoptychus minimus.* Type specimen, four times natural size. *A*, internal, *A*^{1}, crown view.

Only one specimen of this tiny rodent was found by our party.

Measurements.

Length of dentition, tip of incisor to m_3	8.4 mm.
" " molar-premolar series, p_4–m_3	3.5
" " true molars, m_1–m_3	2.6

LEPORIDÆ.

Palæolagus temnodon *Douglas.*

This species is nearly related to *P. haydeni* of the Oreodon Beds. We have for comparison a series of about seventy-five jaws, upper or lower, but nothing more complete. Mr. Douglas distinguished the species by the presence of an antero-external groove on p^2.[1] On comparison of our series with several hundreds of jaws of *P. haydeni* in the American Museum collections, we are able to add a number of other changes less obvious on a single individual, owing to the great variation that age brings about in the characters of the teeth.

The size appears to be nearly constant, approximating that of the smaller specimen described by Mr. Douglas, which, as the first measured specimen, is the type of the species. The molars, and especially the premolars, are less hypsodont than

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[1] Mr. Douglas says p^3, but this must be a slip of the pen.

in *P. haydeni.* The internal enamel inflection on the upper teeth is less deeply impressed and less persistent; it has disappeared on all the older individuals, as it does in *P. turgidus*, but at an earlier age; in *P. haydeni* only a few of the very oldest animals have lost this inflection. The last upper molar is larger than in *P. haydeni.* In the lower jaw p_3 has a less persistent external enamel inflection, so that in old individuals it becomes one-lobed, a character seen also in very old individuals of *P. turgidus*, but which I have not seen in any example of *P. haydeni.*

Measurements.

Upper molar-premolar series	12.	mm.
Lower " "	11.	
Post-canine diastema in lower jaw	8.	

Palæolagus brachyodon, spec. nov.

Palæolagus ? turgidus, P.? triplex, DOUGLAS, Trans. Am. Phil. Soc. 1901, Vol. XX, p. 6. Not of Cope, except:

Palæolagus turgidus COPE, Geol. Sur. Canada. Contrib. to Can. Palæont. Vol. III (quarto), p. 5, pl. xiv, fig. 9. Not of previous publications.

This species is of the size of *P. turgidus*, and probably the specimens referred by Mr. Douglas to that species and to *P. triplex* really belong here. It is more brachyodont than *turgidus*, and much more so than any other species of *Palæolagus*. P^2 is smaller and more conical, m^3 appears to have been larger, the internal enamel inflection less persistent. In the lower jaw p_3 is shorter, more conical, and the inflection disappears a little earlier than in *P. turgidus.*

Twelve specimens of more or less complete upper or lower jaws represent this species in our collection.

Measurements.

Molar-premolar series, upper jaw (m^3 estimated)	16.	mm.
" " " lower jaw	15.	
P^2, longitudinal	1.5	
" transverse	2.5	

It appears probable that this species and *P. temnodon* stand in direct or almost direct genetic relationship to *P. turgidus* and *P. haydeni* respectively. The occurrence of the species of *Palæolagus* is:

Oligocene	John Day		*Lepus ennisianus*	
	White River	Leptauchenia Beds	*P. agapetillus*	*P. intermedius*
		Oreodon Beds	*P. haydeni*	*P. turgidus*
		Titanotherium Beds	*P. temnodon*	*P. brachyodon*

The evolution in *Palæolagus* ran in parallel lines in the different species, some being more progressive in one character, some in another, but none exhibiting either wide divergence or retrogression. The characters in which progress is observed, as I have remarked in a previous paper,[1] are:

1. Superposition of the *Lepus* tooth-pattern over the older and simpler one inherited by *Palæolagus*. This pattern, showing at the crown in the older species, bites continually deeper into the tooth until it entirely replaces the older pattern during the whole life of the animal.
2. Increase in length of teeth, molarization of anterior premolars, and some reduction in size of m$\frac{3}{3}$.
3. Bending down of facial portion of skull on cranial portion. This is associated with lengthening of neck and legs.
4. Increase in brain-capacity, in supra-orbital processes, etc.
5. Increase in size.

It will be observed that in the first and second characters, our two species from the Titanotherium Beds are in all respects more primitive than those of the Oreodon Beds. The difference in size is trifling if any, the third and fourth characters cannot be observed in our specimens.

PERISSODACTYLA.

EQUIDÆ.

Mesohippus westoni *Cope.*

Parts of upper and lower jaws, fore and hind feet, and many fragmentary jaws and teeth represent one or more species certainly distinct from *M. bairdii*, which does not occur

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[1] Bull. A. M. N. H., XVI, 1902, p. 306.

in these beds. It is provisionally referred to Cope's species, known hitherto by an upper and two lower teeth from Swift Current Creek, Canada. These specimens will be described by Professor Osborn in a later paper.

HYRACODONTIDÆ.

Hyracodon sp.

Two lower jaws and an upper molar belong to a species of *Hyracodon.* I do not observe any important distinctions from *H. nebrascensis* in the parts preserved; but in the absence of the diagnostic teeth (upper premolars) make no specific reference.

ARTIODACTYLA.

LEPTOCHŒRIDÆ.

Stibarus montanus, spec. nov.

No. 9668, a lower jaw containing the second, third, and fourth premolars, and the first molar, enables us to place the hitherto problematic genus *Stibarus* in the Leptochœridæ.

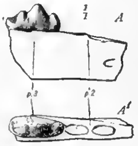

Fig. 12. *Stibarus obtusilobus* Cope, type specimen, natural size, from the Oreodon Beds of Northeastern Colorado. *A*, external, A^1, crown view.

Generic distinctions. — Molars like those of *Leptochœrus.* Premolars much like those of *Leptomeryx,* but with lower and more rounded cusps.

Specific distinction. — Third premolar with no posterior cingular cusp. The second premolar is long and laterally compressed, with three rounded cusps in line, the anterior the smallest, the median the highest. The third premolar has a similar form and composition, but the median and posterior cusps are somewhat larger, and there is a cingulum around the posterior end of the tooth. The fourth premolar is wider but not much over half as long as the third, it has a main cusp, protoconid, an anterior cusp connected by a ridge with it, a postero-internal and postero-external cusp, all worn off in the specimen and none marginal, and a

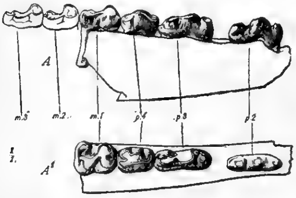

Fig. 13. *Stibarus montanus,* part of lower jaw, type specimen, natural size. *A*, external, A^1, crown view of teeth.

posterior cingulum. The first molar has four chief cusps, the external ones somewhat crescentic, the postero-internal smaller than the others, and a posterior cingulum with small hypoconid. P_2 with diastemata behind and in front of it.

No. 9670 shows the second and third molars of similar composition to the first except that the hypoconulid in m_3 is equal to the other cusps and posterior to them.

This species appears to be closely related to *S. obtusilobus* Cope, but the posterior cingular cusp (heel-cusp) is lacking, and p_2 has small diastemata before and behind it, while there are none in *S. obtusilobus*. In size and other characters it is identical as far as the type of Cope's species permits comparison.

Stibarus has been conjectured to be allied to the camels; its actual position has, I think, never been suspected. It is, in a way, a link between the Leptochœridæ and *Leptomeryx*, and makes it more certain that the former is truly an artiodactyl family. "*Leptochœrus*" *quadricuspis* Hatcher is probably a species of *Stibarus*.

Measurements.

Length p_2–m_1	27.3 mm.		
" p_2	7.	width	2.1 mm.
" p_3	7.6	"	2.7
" p_4	4.9	"	3.7
" m_1	5.0	"	4.2
Depth of jaw below p_2			7.
" " " m_1			10.

OREODONTIDÆ.

Bathygenys alpha *Douglas.*

We have three specimens referable to this genus and species: parts of two upper jaws and one lower jaw. I identify these with Mr. Douglas's species in spite of wide distinctions in the drawing of the teeth of his cotype specimen. These, if correctly drawn, could hardly be *Oreodon* teeth; they are fully as narrow and trenchant as those of *Leptomeryx*. As, however, he compares the teeth to those of *Merycochœrus*, which are short and wide and crowded, I assume that the error is in the drawing, especially as the other drawings of the type and cotype agree well with the description and with our specimens.

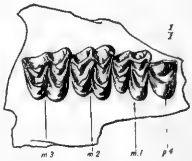

Fig. 14. *Bathygenys alpha.* Upper teeth, crown view, natural size.

The best upper jaw shows the molars and fourth premolar. The premolar is simpler than that of *Oreodon*, lacking internal cingulum and antero-external accessory ridge, and consisting of external and internal crescent, the former with slightly concave external surface, the latter with a short postero-internal cingulum. The molars are composed of four crescents, no trace of the paraconule remaining on m^2 or m^3; m^1 is a little worn, so that it is uncertain whether or not a minute *pl.* existed. The anterior halves of m^1 and m^2 are wider transversely than the posterior, the protoselene projecting further inward on the palate than does the hyposelene. The posterior half of m^3 is nearly as wide as the anterior half, as in *Agriochœrus* and the Uinta Oreodonts, instead of reduced in width as in *Oreodon* and the other Oreodontidæ. The exterior surface of the inner crescents is slightly concave, as in *Agriochœrus*, instead of strongly concave as in the later Oreodonts, or convex as in *Protoreodon.* The exterior surface of the outer crescents is nearly flat.

The fourth lower premolar is oreodont in type, but differs from *Oreodon* and resembles *Promerycochœrus*, *Merycochœrus*, and *Merychyus*, in that the entoconid is a ridge extending down and back from the deuteroconid, instead of a separate cusp or distinct ridge. In *Protoreodon* the entoconid is rudimentary. This tooth is a little narrower anteriorly than p_4 in *Oreodon*, wider than in *Protoreodon*, *Merychyus*, or *Promerycochœrus.* The molars are proportioned nearly like those of *Oreodon*, but are more brachyodont. They are shorter, higher, and with more crescentic cusps than those of *Protoreodon.*

Bathygenys is in most respects between *Oreodon* and *Protoreodon*, but considerably nearer to the former. Some characters point toward a nearer relationship with the Merycochœrid group of Oreodonts than with *Oreodon* itself.

More complete material is needed before its place can be definitely determined.

Measurements.

Upper molars, m_{1-3}	1.7 mm.		
" premolar p^4, longitudinal	4.	transverse	5.2 mm.
Lower teeth, p_4–m_2	16.		
Upper molar m^1 longitudinal	5.3	"	6.8
" " m^2 "	5.8	"	7.3
" " m^3 "	6.2	"	7.

? **Limnenetes** sp.

A number of lower jaws and parts of jaws may be provisionally referred to this genus, although the characters of the teeth are nearer to those of *Bathygenys* than to *Oreodon;* while Mr. Douglas describes the teeth of *Limnenetes* as so like those of *Oreodon* as not to need a separate description. The premolars are narrower than those of *Oreodon*, the entoconid ridge not separated from the deuteroconid on p_4, and the structure of p_3 is intermediate between that of *O. culbertsoni* and *Merychyus elegans*, but more brachyodont than either. The lower molars are intermediate between those of *Protoreodon*, with conical internal cusps, and those of *Oreodon* with fully crescentic internal cusps. Heel of m_3 narrow, as in *Protoreodon.*

There is more than one species, and may be more than one genus, among these specimens, and it is inadvisable to attempt to place them very definitely at present.

HYPERTRAGULIDÆ.

Leptomeryx ? **esulcatus** *Cope.*

The type of Cope's species is an upper molar, probably m^1, from the Titanotherium Beds of Swift Current Creek, Canada.

We have a large number of parts of lower jaws and separate upper teeth, which belong to one or more species of *Leptomeryx* a little larger than *L. evansi*, but variable in size. These are referred provisionally to *L. esulcatus*, because it is within the limits of size, comes from the same geological horizon, and agrees well enough with other first molars in our series. The character by which Cope separated it from *L. evansi*, the absence of defining furrows to the rib of the external crescents, is exhibited only on first molars, and not on all of these; but two other characters of more importance are seen in our material, viz.:

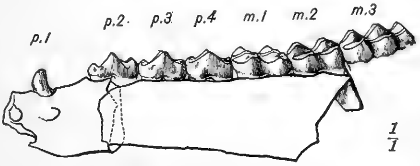

Fig. 15. *Leptomeryx esulcatus.* Lower jaw, natural size, external view, composite, Nos. 9696, 9706, 9702.

1. The median internal cusp, a strong cusp in m^3 of *L. evansi*, and a smaller one on m^2 and m^1, is quite small on m^3, and absent, or nearly so, on m^2 and m^1.

2. In the third lower premolar the protoconid has two posterior ridges, of which the internal one connects with the heel, and the external one does not; while in *L. evansi* and other species from the Oreodon and Leptauchenia Beds, the external ridge connects with the heel, and the internal one does not.

In the lower jaw I have observed no entirely constant distinctions, except in p_3. The first premolar is small, and is separated from p_2 by a diastema of about the same length as that of *L. evansi;* the size of the jaws averages larger than those of *L. evansi* from South Dakota, and all are larger than *L. evansi* of Colorado. The height of crowns and proportion of the teeth are about the same, and the premolar pattern, allowing for individual variation, is identical, except as above noted.

I have no doubt that better material will furnish more satisfactory distinctions, but, except for the characters noted above, I am unable to find any in the teeth.

Measurements.

Lower premolars p_{2-4}	19 mm.
Lower molars m_{1-3}	24
Upper molar, m^3, antero-posterior	8.
" " " transverse	8.5

Leptomeryx mammifer *Cope.*

A much larger species than the preceding, size about that of *Poëbrotherium eximium.* Distinguished from *L. evansi* by the pattern of p_3, which is like that of *L. esulcatus*, but with the external ridge of the protoconid more clearly separate from the heel, and the postero-internal more clearly joined to it. The first lower incisor is large, second and third small, canine nearly as large as first incisor (larger than in *L. evansi*).

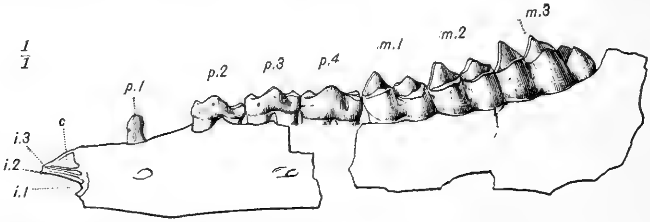

Fig. 16. *Leptomeryx mammifer.* Lower jaw, natural size, external view. No. 9684, p_3 and p_4 supplied from No. 9686.

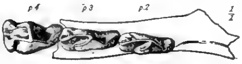

Fig. 17. *Leptomeryx mammifer.* Crown view of lower premolars, natural size. No. 9687; p_4 from No. 9689.

First premolar equally spaced between c and p_2; remaining premolars close set. Molars an enlarged copy of those of *L. evansi.* Parts of the feet of *Leptomeryces* of appropriate size were found at the locality; they show no important distinctions either in fore or hind foot, from *L. evansi.* The upper molars have a smaller median internal cusp than those of *L. evansi.* The size is nearly a third larger, lineally.

Lower premolars, p_{2-4}	24	mm.
" first premolar, p_1	2	
Space between c and p	17	
Lower molars, m_{1-3}	32	
Complete lower dentition, estimated	78	
Upper molar, longitudinal	9	
" " transverse	11	

CAMELIDÆ.

Leptotragulus profectus, spec. nov.

Parts of several lower jaws represent a species of Camelid nearly as large as *Poëbrotherium wilsoni*, but with brachyodont molars like *Leptotragulus*. No. 9681 (type) shows p_2–m_1; No. 9682 (cotype) p_{2-3} and the root of m_1; No. 9683 a number of lower molars and milk molars. Nearly all these teeth are unworn or very little worn.

The species is of about the same size as *Leptomeryx mammifer*, but is distinguished by the camelid pattern of the premolars. The molars are very difficult to separate from those of *L. mammifer;* they are a little wider and shorter-crowned, with the crescents placed less obliquely, and m_3 has but a vestigial postero-internal cusp. The fourth premolar has no deuterocone, but two strong posterior crests from protocone to heel sub-parallel, enclosing a narrow lenticular fossa. The third premolar is similar, but more compressed; the second has but one complete posterior ridge. Their pattern differs from that of *Poëbrotherium* chiefly in the completeness of the inner posterior ridge, which in *Poëbrotherium* does not reach the heel on p_3 and p_4, and is entirely absent in p_1.

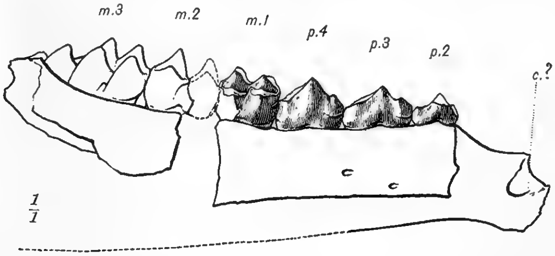

Fig. 18. *Leptotragulus profectus.* Type specimen, external view, natural size; second and third molars supplied from another individual.

The cotype shows a moderate diastema, considerably shorter than that of *L. proavus*, separating p_2 from the alveolus of a strong caniniform tooth.

The heel of the last molar in referred specimens is like that of *Leptomeryx* or *Leptotragulus*, with postero-external crescent and small antero-internal cusp. In *Poëbrotherium* is a posterior crest, not crescentic, and a small antero-internal cusp.

The species is about a fifth larger than *L. proavus*, with which its premolar pattern corresponds quite closely, according to Scott's description. The molars are a little wider and a little more hypsodont, and the diastema both relatively and absolutely less. It is throughout very suggestive of *Poëbrotherium*, much more so than either *Protylopus* or *Leptotragulus proavus*, in the details and conformation of the molar and premolar cusps. It shows much less resemblance to *Hypertragulus*. Unfortunately no upper teeth can with entire certainty be referred to our species. Those which are doubtfully referred have the *Leptomeryx-Poëbrotherium* pattern, with strong mesostyle and a rib on the external face of the anterior external crescent, but none on the posterior; they are less extended transversely than those of *Leptomeryx*, much more than those of *Poëbrotherium*. The upper molars of *Hypertragulus* are very easily distinguished by the entire absence of mesostyle and equal development of the external ribs on anterior and posterior crescents. No upper teeth of this pattern were found in the Pipestone beds. The upper molars of *Leptotragulus proavus* are not known.

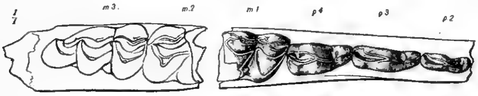

Fig. 19. *Leptotragulus profectus*. Type specimen, crown view of teeth, natural size; molars 2 and 3 supplied from another individual.

From the above facts I am inclined to believe that *Leptotragulus* — this species at least — is more nearly related to *Poëbrotherium* than Professor Scott has supposed, and that it has not much to do with *Hypertragulus*. It is probable in either case that the caniniform tooth is the first premolar. The species is really far nearer to *Poëbrotherium* than is *Protylopus petersoni;* how much of the resemblance is due to parallelism remains to be determined.

Mr. Gidley discovered last summer in the Oreodon Beds of South Dakota, a brachyodont camel, which may be a direct descendant of this species.

Measurements.

Lower premolars, p_2–p_4	25 mm.
Diastema in front of p_2	10
Last lower molar	15
Lower molars, m_{1-3} (from three specimens)	30

A Fossil Hedgehog from the American Oligocene.

By W. D. Matthew.

AUTHOR'S EDITION, extracted from BULLETIN

OF THE

American Museum of Natural History,

Vol. XIX, Article VII, pp. 227–229.

New York, May 9, 1903.

The Knickerbocker Press, New York

Article VII.—A FOSSIL HEDGEHOG FROM THE AMERICAN OLIGOCENE.

By W. D. Matthew.

The Hedgehog family (Erinaceidæ) has hitherto been found only in the Old World (Europe, Asia, and Africa). It includes three living and five extinct genera, ranging from Lower Oligocene to recent. It has been divided into two subfamilies, one including the modern hedgehogs (*Erinaceus*) and one extinct genus (*Palæoërinaceus*), the other with two modern genera, *Gymnura* and *Hylomys*,— small rat-like East Indian insectivores,— and four extinct genera, *Necrogymnurus*, *Galerix*, *Lanthanotherium*, and *Tetracus*. The subfamilies are distinguished as follows:

Erinaceinæ. — Dentition $\frac{3.1.3.3}{2.1.2.3}$. Palate imperfectly ossified. Pelvis wide. Fur with spines.

Gymnurinæ. — Dentition $\frac{3.1.4.3}{3.1.4.3}$. Palate completely ossified. Pelvis very narrow. Fur without spines.

A related but more primitive family, the Leptictidæ, is found in the American Eocene and Oligocene. The dentition is unreduced (except that there are only two upper incisors), the molars subtriangular and extended transversely, while in Erinaceidæ they are subquadrate and not extended transversely. The Leptictidæ might, however, without serious straining of relationships, be included as a primitive subfamily of Erinaceidæ, with which they agree well enough in skeleton and in most skull characters. There are four described genera, *Palæictops* from the Middle Eocene, *Leptictis*, *Ictops*, and *Mesodectes*, from the Lower Oligocene of the Western United States.

A true Hedgehog, of the Erinaceine subfamily, is represented by the front half of a skull from the Upper Oreodon Beds of South Dakota, found by Dr. F. B. Loomis of the American Museum Expedition of 1902. The dentition is that of *Erinaceus*, but the teeth are less specialized, and in several respects resemble those of the Leptictidæ. The reduced premolars and short facial portion of the skull exclude it from the Gymnurinæ, but the teeth resemble quite nearly those of *Necrogymnurus*,[1] and the palate does not show the defective ossification of *Erinaceus*. The last molar is small and tritubercular as in *Hylomys*, *Necrogymnurus*, and *Galerix*. In *Gymnura* it is large and extended longitudinally; in *Erinaceus* small and reduced to a transverse blade. The teeth are more extended transversely than those of *Erinaceus*, and retain considerable indications of the tritubercular form of molar from which they no doubt originated. Their pattern, however, is definitely Erinaceid, with two equal outer and two equal inner cusps, a smaller separate median cusp (metaconule), and an antero-median ridge from the antero-internal cusp (protocone) to the antero-external cingulum.

This hedgehog forms a connecting link between the Erinaceine and Gymnurine subfamilies, and to some extent between Erinaceidæ and Leptictidæ. It seems impossible to place it in any of the described genera, and it is therefore named:

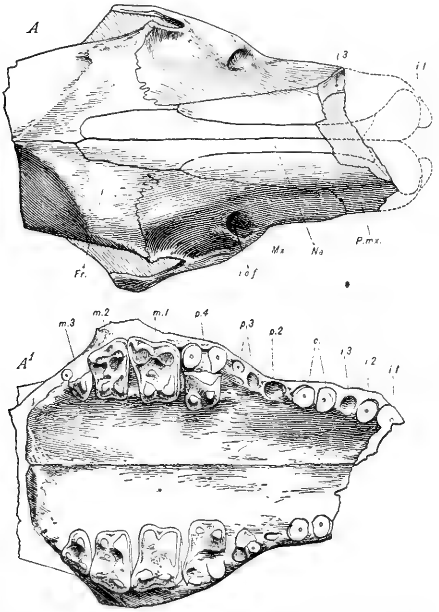

Fig. 1. *Proterix loomisi.* Type specimen, twice natural size. *A*, anterior part of skull from above; *A*^{1}, palate from below.

Proterix loomisi, gen. et sp. nov.

Dentition $\underline{3 \cdot 1 \cdot 3 \cdot 3 \cdot}$ I^1 enlarged. C^1 large, two-rooted. P^2 small, one-rooted. P^3 small, three-rooted with well developed deuterocone. P^4 large, molariform, with small hypocone.

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[1] Relying on Dr. Leche's very careful figures and descriptions.

M^1 and m^2 wider than long, quadrate with two external and two internal cusps of about equal size and a small separate postero-intermediate cusp (metaconule), the antero-internal cusp (protocone) with a ridge running out towards the antero-external margin. M^3 trihedral, small, not extended transversely, paraconid and metaconid equal and well separated, no hypocone. Palate completely ossified, its posterior margin as in *Erinaceus*. Skull bones arranged much as in *Erinaceus*, a well defined sagittal crest; premaxillæ not reaching frontal bones.

Measurements.

Maxillary dentition, c–m^3 inclusive	18.4 mm.
Transverse width of palate including molars	17.6
Depth of skull, junction of postorbital crests to palate	16.8
Length of three true molars (antero-posterior)	7.9
Antero-posterior diameter of m^1	3.4
Transverse " " "	4.8
Antero-posterior " " m^2	2.9
Transverse " " "	3.9
Antero-posterior " " m^3	2.0
Transverse " " "	2.8

RANGE OF THE ERINACEIDÆ AND LEPTICTIDÆ.

	Europe.	Asia.	Africa.	North America.
Modern.	Erinaceus.	Erinaceus. Gymnura. Hylomys.	Erinaceus.	
Pleistocene.	Erinaceus.			
Pliocene.	Erinaceus.			
Miocene.	Erinaceus. Galerix. Lanthanotherium.			
Oligocene.	Palæoërinaceus. Tetracus. Necrogymnurus.			Proterix. { Leptictis, Mesodectes. Ictops.
Eocene.				Anisacodon ? Passalacodon. Palæictops.

Adaptive Significance of the Shortening of the Elephant's Skull.

By W. K. Gregory.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XIX, Article IX, pp. 387–394.
New York, July 8, 1903.

The Knickerbocker Press, New York

Article IX. — ADAPTIVE SIGNIFICANCE OF THE SHORTENING OF THE ELEPHANT'S SKULL.

By W. K. Gregory.

Plate XXIII and 4 Text Figures.

The following observations were made in connection with Professor Osborn's forthcoming memoir on American fossil Proboscidea, for which were also prepared the figures here used by his kind permission.

Weithofer[1] regards the changes in the elephant's skull observable during individual growth as well as in phylogeny, such as the compression and vertical heightening and deepening of the skull, the wide separation of the inner and outer tabulæ of the bones, and the cancellous condition of the diploë, the forward shifting of the orbits from a point above the anterior grinders, etc., as primarily correlated with the prodigious development of the tusks — weapons and crow-bars whose effectiveness increased with and reciprocally hastened the phyletic advance in body dimensions. Now the earliest known proboscideans (*Mœritherium*) possessed upper as well as lower incisor tusks, and there are other grounds also for inferring that the ancestors of *Dinotherium* probably possessed upper incisor tusks of small size, even smaller than in the primitive *Mastodon* (*Trilophodon*) *euhypodon;* the presence of these may have initiated the shortening of the head, but the final compression of the skull in *Dinotherium* progressed notwithstanding the reduction and entire disappearance of upper tusks, and this, together with the underlying similarity of its skull to that of *Mastodon* and of *Elephas*, shows that some other factor must also be represented in the extraordinary end results of the process of fore-and-aft compression.

This factor seems to be the development of the proboscis. This unique organ probably owes its existence partly to the shortening reach of the head and neck which took place

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[1] Die Fossilen Proboscidier des Arnothales in Toskana. 4to, Wien, 1890.

simultaneously with increasing stature and longer limbs, partly to the necessity of reaching outside the lengthening tusks, partly to the intrinsic advantages of a prehensile organ of such manifold possibilities. On the one hand, we may suppose, the enlargement of the trunk intensified the changes due to the shifting and enlargement of the tusks, and on the other hand inaugurated many of the peculiar conditions described below.

The backward shifting of the weighty tusks and trunk, compensating their adverse leverage, lessened the antero-posterior space available for the grinding series, while the work put upon the individual grinders increased with larger bodies and longer lives. This may explain in part why the simple grinders of *Dinotherium*, with their two, or at most three, low, widely separated ridges, were constrained to evolve into the wonderfully specialized and effective grinders of the Mammoth, with ridges in great number, exceedingly high, and closely appressed, and in which there is a so-called horizontal succession in use, the unworn teeth being pushed into place from behind. The weighty, rapidly heightening molars, together with their immense, backward and upwardly growing alveolar pouch, might thus be regarded as a third factor in the evolution and individual growth history of the skull. It is plain, however, that this factor was a minor one and that the characteristic features of the skull were attained, in great part, before the teeth had become so highly specialized; for the typical *Mastodon americanus*, with its great size, and great tusk-and-trunk development, shows nearly the same degree of backward and downward extension of the posterior nares and hard palate as in *Elephas*, yet retains comparatively primitive low-crowned grinders, and the considerable space between the posterior border of the last molar and the posterior lateral limits of the hard palate in this genus was not nearly so much utilized for storing incoming grinders as it is in *Elephas*.

Principally then, to the enlargement and backward shifting of the trunk and tusks and the consequent fore-and-aft compression of the whole skull, combined with the progressively widening separation of the inner and outer surfaces of the bones for the sake of lightness and large area for the head muscles, we may ascribe the following morphological conditions, which attain the extreme of specialization in the skull of the Mammoth. In the inferior view of the skull the hard palate, contrary to what obtains in most Ungulates, is tilted somewhat upward; the palatines become reduced antero-posteriorly and shoved backward so as to diverge widely posteriorly; the posterior nares, probably *pari passu* with the anterior nares, have been pushed very far back[1]; the enormous vertical pterygoid wing of the alisphenoid wraps itself around and functionally replaces the hinder end of the encroaching molar-tooth pouch; the foramen ovale of the alisphenoid, which in the most primitive Ungulates is anterior to the foramen lacerum medius, has been shifted obliquely backward and outward, and becomes confluent with it externally (Fig. 1)[2]; the presphenoid, basisphenoid, basioccipital thicken in the median plane and at diminishing rates, the lower tabulæ of these bones growing downward to a less and less extent as we pass backward, so that in the adult the inferior surface of the basis cranii points sharply downward, and forms, with the plane of the back of the occiput, an angle greater than 90°; the tympanic bullæ, relatively large and inflated in the young, flatten down and become closely appressed to the skull, pointing obliquely downward, forward, and inward, with the wider end toward the transversely expanded occipital region (Fig. 1, *Ty.*). In brief, the progressive brachycephaly of the skull has apparently involved not so much a fore-and-aft shortening of the individual elements as a readjustment and modification of them, and secondly an expansion in the transverse vertical planes.

The shortening and deepening of the temporal fossæ, and perhaps to some extent the above-mentioned expansion of

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[1] Among the Glyptodonts a similar backward and downward growth of the palate and posterior nares seems to be correlated chiefly with the shortening of the skull, as the anterior nares remain terminal.

[2] This change must have taken place at a very early date in the history of the Proboscidea, as it is already established in the primitive *Mastodon* (*Trilophodon*) *productus* and also, if Kaup's figures are here rightly interpreted, in *Dinotherium*.

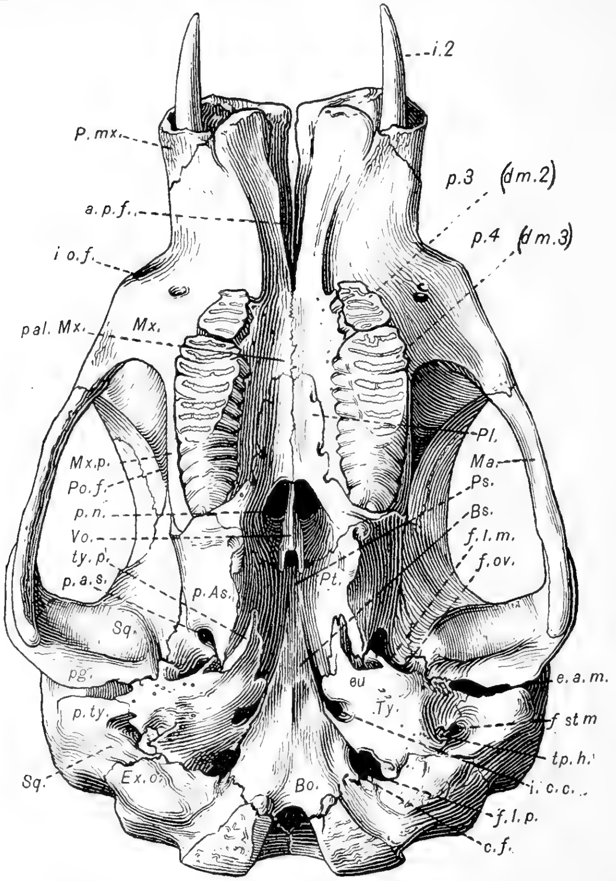


Fig. 1. Inferior view of the skull of a young Asiatic elephant. About ⅕ nat. size. From a forthcoming memoir by Professor Osborn.

BONES.

P. mx.—Premaxillary.
Mx.—Maxillary.
Mx. p.—Maxillary pouch for molars.
Ma.—Malar.
Po. f.—Postorbital ridge of frontal.
pal. Mx.—Palatine ledge of maxillary.
Pl.—Palatine.
Vo.—Vomer.
Ps.—Presphenoid.
Bs.—Basisphenoid.

Bo.—Basioccipital.
p. As.—Pterygoid wing of alisphenoid.
Pt.—Pterygoid.
Sq.—Squamosal.
Ex. o.—Exoccipital.
pg.—Postglenoid ledge of squamosal.
p. ty.—Posttympanic ledge of squamosal, which with *pg.* forms a secondary external auditory meatus.
Ty.—Tympanic bulla.

FORAMINA, ETC.

ty. p.—Anterior process of tympanic.
tp. h.—Tympanohyal.
eu.—Eustachian opening of tympanic.
a. p. f.—Anterior palatine foramina (canals).
i. o. f.—Infraorbital foramen.
p. n.—Posterior nares.
p. a. s.—Alisphenoid canal.

f. l. m.—Foramen lacerum medius.
f. ov.—Foramen ovale (confluent with *f. l. m.*)
i. c. c.—Canal for internal carotid artery.
f. st. m.—Stylomastoid foramen.
f. l. p.—Foramen lacerum posterius.
c. f.—Notch, a vestige of condylar foramen (?) (confluent with *f. l. p.*).

TEETH.

i.^{2}.—Tusk.
p^3 (*dm*2).—Third premolar (or second deciduous molar of authors).
p^4 (*dm* 3).—Fourth premolar (or third deciduous molar of authors).

the grinders and their alveolar pouch, have had a marked effect on the relations of the bones and foramina of the sphenoidal region: the obliquely placed external portion of the orbito sphenoid (Fig. 2); has been squeezed into a long,

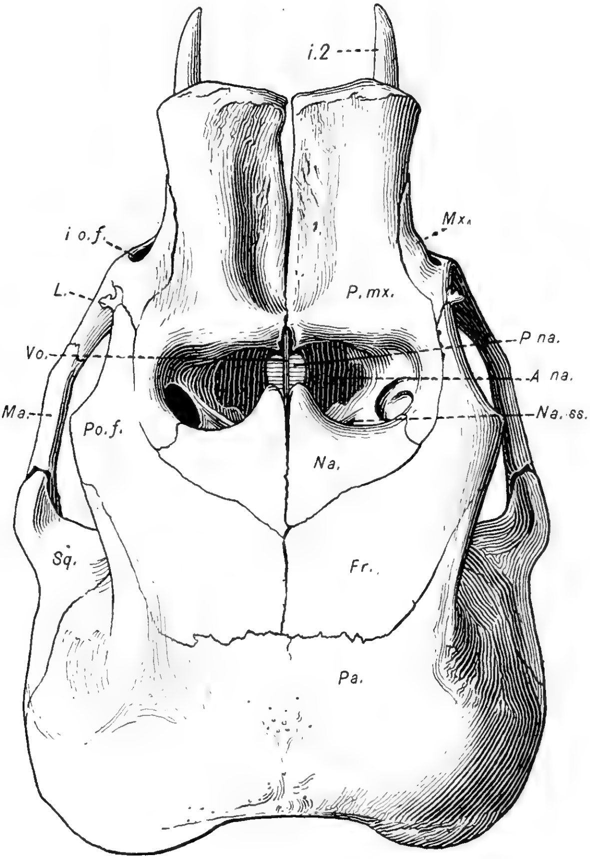


Fig. 2. Superior view of the same skull. From Osborn. Abbreviations as above; also *La.*—Lachrymal. *A. na.*—Anterior nares. *Na. s.*—Narial sinus.

thin process; internally (Pl. XXIII) the anterior edges of the basisphenoid are directed outward and backward; both internally and externally the optic foramen, foramen lacerum anterius, and foramen rotundum, in the order named, are obliquely arranged on descending levels from within outward and from in front backward, the whole region having been thickened by the separation of the inner and outer tabulæ of all the bones, and also sharing in the upward-and-backward tilting of the nasal region and in the general fore-and-aft squeezing of the skull, the end result being that the foramina have been pulled out into long tunnels running obliquely for-

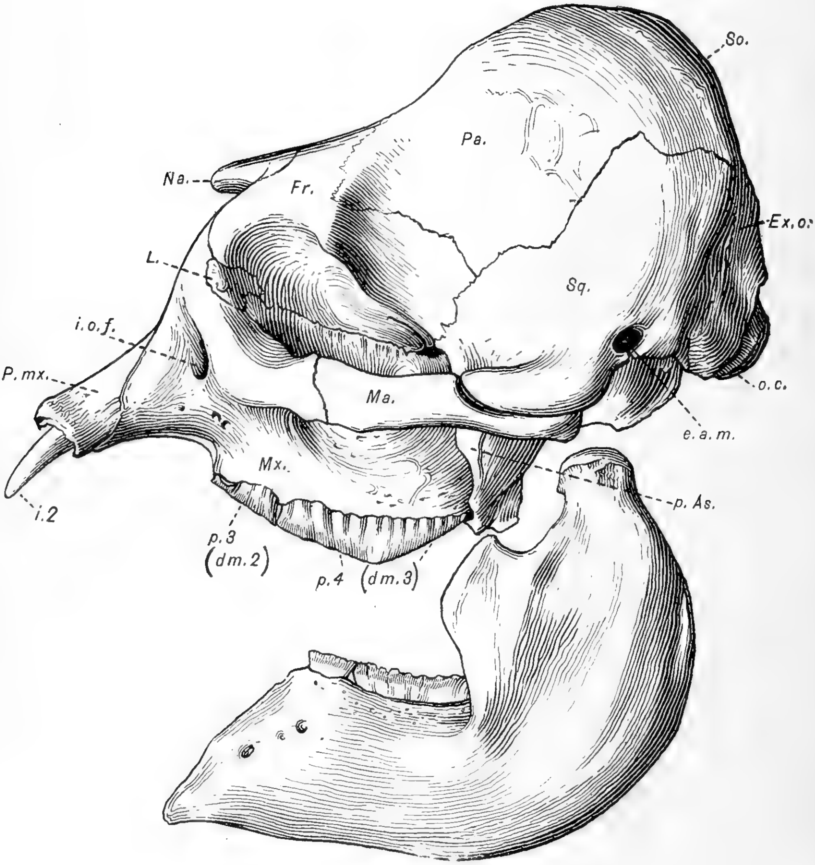


Fig. 3. Side view. From Osborn.

ward, outward, and downward; especially internally the fore-and-aft extent of the alisphenoid proper is brief.

Internally the skull has shortened up, one might almost say in bellows fashion, with the optic foramen on each side at the apex of the internal transverse folding (Pl. XXIII), the ridge of the "lesser wing" of the human sphenoid. As the skull has also expanded transversely, the general effect of the internal view of the skull is thus that of compression around the center (represented by the basisphenoid) and increasing expansion toward the periphery — somewhat recalling the conditions of the domelike human skull. Between the frontal and temporo-sphenoidal fossæ, which form a large trefoil as seen from above, there is on each side, running obliquely outward, forward, and upward, a prominent triangular buttress, the transverse ridge mentioned above, to the formation of which the orbitosphenoid, frontal, and parietal contribute. On each

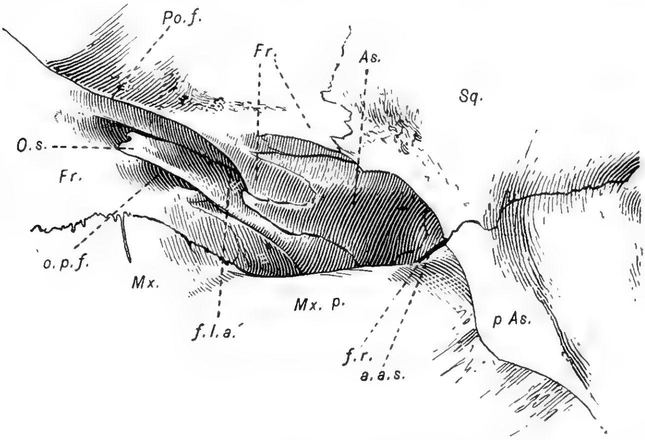


Fig. 4. Orbito-sphenoidal region, left side. From Osborn. The view is obliquely from the side and from below the malar bone (compare Fig. 3).

BONES.

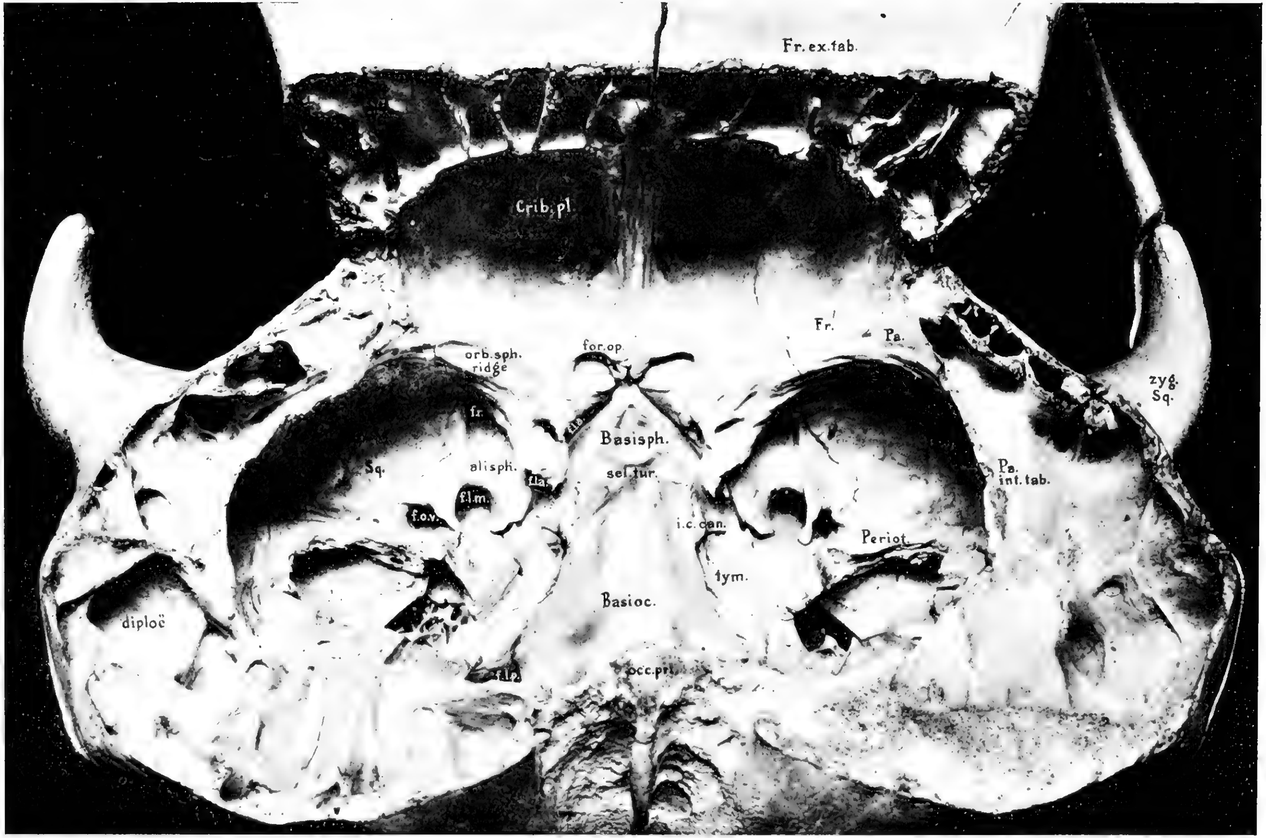
Po. f.—Post-orbital ridge of frontal.
Fr.—Frontal.
O. s.—External process of orbitosphenoid.
As.—Alisphenoid.
Sq.—Squamosal.
p. As.—Pterygoid wing of alisphenoid.
Mx. p.—Maxillary pouch for molars.

FORAMINA, ETC.

op. f.—Foramen opticum.
f. l. a.—Foramen lacerum anterius.
f. r. and *a. a. s.*—Arcade leading to foramen rotundum and anterior opening of the alisphenoid canal.

side, at a point opposite the malars, where the skull is most constricted laterally, these buttresses branch off externally into symmetrically opposed arches in different planes, which pass forward, backward, downward, or upward. The wedge-shaped basisphenoid, situated between the inner ends of the buttresses, is the veritable keystone of this converging system.

The skull as a whole is thus highly adapted to resist the severe strains put upon it. The occiput, both in ontogeny and phylogeny, flattens out and rotates backward, spreading both vertically and laterally, until at last it forms, as it were, a great, functionally solid bed-plate, receiving the thrusts of the opposite inverted arches into which the skull has been resolved. Each pair of these symmetrically disposed arches, which also connect with the system culminating in the basisphenoid, reacts, of course, against some component of the force transmitted either to or from the tusks, trunk, and grinders, or when the forehead is used in pushing. The innumerable toughly constructed air cells of the diploë give immense strength, lightness and especially resiliency. This desideratum may also be the reason for the very loose articulation of the malar with the zygomatic process of the squamosal, which would also permit the facial portion of the skull to bend back slightly, under pressure, toward the cranial portion.



INTERIOR VIEW OF SKULL OF YOUNG ASIATIC ELEPHANT.

On a Collection of Upper Cretaceous Fishes from Mount Lebanon, Syria, with Descriptions of Four New Genera and Nineteen New Species.

By O. P. Hay.

AUTHOR'S EDITION, extracted from BULLETIN
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Article X. — ON A COLLECTION OF UPPER CRETACEOUS FISHES FROM MOUNT LEBANON, SYRIA, WITH DESCRIPTIONS OF FOUR NEW GENERA AND NINETEEN NEW SPECIES.[1]

PLATES XXIV–XXXVII.

BY O. P. HAY.

In accordance with an arrangement entered into between Professor H. F. Osborn, Curator of the Department of Vertebrate Palæontology, and Professor R. P. Whitfield, Curator of the Department of Geology, the writer has studied the collection of fishes which was made in 1901 by Professor Alfred Ely Day in the Cretaceous deposits of Mount Lebanon, Syria. This collection consists of several hundred specimens of fishes, besides a considerable number of crustaceans and a few mollusks. The result of the examination of the fishes has been the discovery of a considerable number of undescribed species and various additions to our knowledge of the structure of species already described. A large part of the collection and nearly all of the new species come from a village called Hajula. This may be regarded as really a new locality, since I have been able to find it mentioned only once in Dr. A. S. Woodward's Catalogue of the Fossil Fishes in the British Museum. From a letter written by Professor Day to Professor Whitfield we learn that Hajula and Hakel are each about twelve miles nearly northeast of the seacoast town of Jebeil, the ancient Biblus. Hajula is situated six miles south of Hakel; and between the two villages there are two westwardly projecting spurs of Mount Lebanon and an intervening valley. Professor Day estimates the elevation of these villages to be

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[1] The collection of fossil fishes, of which the new forms hereinafter described form a part, was made by members of the staff of instructors of the Syrian Protestant College at Beirut, Syria, during the year 1901, and donated to the American Museum of Natural History by the Rev. D. Stuart Dodge. They now form a part of the Museum's exhibit in the Geological Hall as part of its chronological series, under the head of the Cretaceous formation, in the foreign series of fossil forms.

As Dr. O. P. Hay has recently been engaged in preparing a catalogue of the fossil fishes of the Museum collection and is familiar with the forms found at the Syrian localities, it has been considered advisable to place this collection in his hands for identification. While doing this he has found several interesting species not hitherto known to science. These are described and illustrated in the following pages as a contribution to the work of this department.— R. P. WHITFIELD, *Curator of the Department.*

between 2500 and 3000 feet. In both places there are clear evidences of faulting by which the fish-bearing strata have been let down into the midst of older strata. Those at Hakel have been let down to the level of the hippurite limestone of Lebanon, being above the Trigonia sandstone. Professor Day thinks that the Hajula beds are an extension of those at Hakel. This study of the fishes appears to show that the horizon of the beds at Hajula is some what higher than that of the beds at Hakel. Professor Day says that one notable difference is found in the great abundance of crustaceans at Hajula.

According to Professor Day, the fish-bearing strata at Hakel are exposed over a space of half an acre or more on the side of a valley, which slopes about 30° to the northeast, the dip of the strata corresponding nearly with the slope. The outcrop at Hajula is similar, but more broken up and irregular. At both localities the slabs of rock which lie on the surface are more easily and perfectly split than are those which are dug up from some depth.

Professor Day was not permitted to work at Sahel Alma.

Much credit is due to the Rev. D. Stuart Dodge, at whose suggestion and expense this collection was made, and to Professor Day, who has displayed great industry and good judgment in gathering the materials.

At the close of this paper the writer will add a few words on the age of the strata.

In the following pages most of the specimens are recorded under two numbers, of which the second is enclosed within parentheses. The first number is the one given to the specimen in the Department of Geology, while the number in parentheses is the one which it bears in the general catalogue of fishes. This catalogue belongs to the Department of Vertebrate Palæontology.

Figure 2, Plate XXVI; figures 3 and 4, Plate XXXVI; and figures 4–6, Plate XXXVII, have been reproduced from photographs made by Mr. A. E. Anderson. Figures 3 and 4, Plate XXVI, are from drawings made by Mrs. L. M. Sterling. All the other figures are from photographs made by Mr. Rudolph Weber.

Class ELASMOBRANCHII.

LAMNIDÆ.

Otodus sulcatus *Geinitz.*

PLATE XXVI, FIGURES 3 AND 4.

Otodus sulcatus GEINITZ (H. B.), Char. Schicht. u. Petrefakt. sächs.-böhm. Kreidegeb., Nachtr., 1843, p. 5, pl. iv, fig. 2.

Lamna sulcata WOODWARD (A. S.), Cat. Foss. Fishes, 1, 1889, p. 398. (Synonomy and literature.)

In the collection there is a single tooth of a shark, and this I refer to the above species. The number of the tooth is 4508 (3867).

The height of the crown has been about 15 mm., but the apex is broken off. The crown has resembled that of a specimen figured by Geinitz in 1875 (Palæontogr., XX, pt. 1, pl. lxv, fig. 4*d*). At the base of the crown, in front, the width is 6.25 mm. At the base, the anterior face is somewhat concave, but it soon becomes slightly convex. There are a few short grooves at the base of the crown in front. The cutting edges are very sharp. The posterior face is very convex, and there are present numerous sharp costæ of various lengths. The lateral denticles are relatively large, close to 5 mm. high, and are costate both in front and behind, although the anterior costæ are feeble.

The root is relatively large, and its branches make a very acute angle with each other. The outer borders descend from the lateral denticles so as to be nearly parallel with each other. In this respect the root resembles that of Sauvage's *Odontaspis rochebrunei* (Bull. Soc. géol. France [3], VIII, p. 437, pl. xiii, fig. 3). The tooth from Hakel differs from the one just referred to in having a less slender crown and more prominent lateral denticles. The length of one branch of the root is 10 mm.; of the other, 12 mm.

Collected at Hakel.

PRISTIDÆ.

Sclerorhynchus *Woodward.*

PLATE XXIV, FIGURE 1.

WOODWARD (A. S.), Cat. Foss. Fishes, I, 1889, p. 76.

In the collection there is found the greater portion of the trunk of a sawfish, No. 4502 (3686). To what species this may belong cannot now be determined. The shagreen granules of this trunk are small, and are furnished with two or three longitudinal ridges and intervening furrows. In two of the species of this genus here described, *S. sentus* and *S. hiram*, no shagreen is satisfactorily observable behind the rostrum, while in *S. solomonis* the shagreen appears to be wholly smooth. Hence, while it is improbable that the trunk belongs to the latter-mentioned species, it cannot be connected with either of the others. The shagreen of the trunk resembles that of *Pristis perrotteti.*

The structure of the species of *Sclerorhynchus* here described, especially the evidence that the gill-slits opened on the lower side of the head, shows that the genus is to be referred to the Pristidæ.

To whatever species this trunk may belong, it gives us a clear idea of the form of the body of the Upper Cretaceous sawfishes. And this form is remarkably like that of *Pristis.* As is to be observed from the figure (Pl. XXIV, Fig. 1), the body is long and slender. The portion at hand begins apparently near the base of the pectoral fin and ceases about the root of the caudal fin. The length of the part is 280 mm. It is not certain that any portion of the pectoral fin is seen. The depth of the body anteriorly is 47 mm. Both the dorsal fins and one ventral are presented. All are triangular in form and approximately of the same length. The base of the first dorsal is 36 mm.; the height, 21 mm. The apparent height of the ventral fin is 14 mm. At the base of each fin are seen impressions of the cartilaginous supports of the fin. At the base of the first dorsal there are at least 16 rays; at the base of the second dorsal, a somewhat greater number; at the base of the anal, at least a dozen.

The vertebræ have been well calcified. In front of the first dorsal there are present 24 vertebræ; from the front of the first dorsal to the front of the second dorsal, 34; behind the latter, 20. The diameter of those beneath the first dorsal fin is 5 mm.

In the abdomen of the specimen just described, is seen the skull and most of the vertebral column of a bony fish, probably *Eurypholis boissieri* (Pl. XXIV, Fig. 1).

It is interesting to observe how closely the sawfishes of the Upper Cretaceous resemble those of our own day in most of their characters, and yet how primitive is the condition of their rostral teeth. We cannot doubt that our modern species of *Pristis* have descended from forms closely like those found at Mount Lebanon.

No species known to belong to *Pristis* has, I believe, yet been found in Cretaceous strata. In my work, 'Bibliography and Catalogue of the Fossil Vertebrata of North America,' page 316, I have credited *Pristis curvidens* Leidy to the Cretaceous of New Jersey; but on examining the matter more closely, I have concluded that the deposits from which Leidy's specimens were derived belong really to the Eocene.

Sclerorhynchus solomonis, sp. nov.

PLATE XXV.

The specimen on which this species is based, No. 4503 (3706), consists of the rostrum complete or nearly so, the head somewhat damaged, and a faint impression of one pectoral fin. It is the upper surface of the head which is directed toward the observer. The plate will impart a sufficiently clear idea of the form and proportions of the parts.

Dr. A. S. Woodward has described and figured the type of the genus *Sclerorhynchus*, *S. atavus* (Cat. Foss. Fishes, I, 1889, p. 76, pl. iii, fig. 1). The only part which this author had at his command was a portion of the rostrum, with the teeth along its borders. That the present species is distinct from *S. atavus* is evident from various considerations.

The tip of the rostrum is slightly damaged, so that there is some doubt regarding a small patch of scales seen there. Measuring from the mouth to this patch of scales, which appear to form the tip, the distance is 150 mm. The borders of the rostrum have been straight or slightly convex. At 50 mm. in front of the mouth the width of the rostrum is 50 mm.; at a distance of 100 mm. the width equals 35 mm. Beyond this the rostrum appears to have narrowed somewhat more rapidly. A glance at the rostrum described by Dr. Woodward shows that it was of a different form, the lateral borders being concave. In *S. solomonis*, at a point 45 mm. in advance of the mouth, the head begins to expand rapidly, so that at a line slightly in front of the mouth the width is 100 mm. In *S. atavus* the width in a corresponding position could not have been more than 75 mm.

The preservation of the rostrum is due to its being composed of a mosaic of minute hexagonal calcifications, such as we find in the same cartilages of *Pristis*. If there was a shagreen overlying these cartilages, it does not now show itself. A stellate shagreen is present along the sides of the head as far forward as where these join the rostrum. Over the base of the fin rays the shagreen scales are polygonal, convex, smooth, and enameled.

The rostral teeth of this species are quite different from those of *S. atavus*, in size at least. The longest of those represented in Dr. Woodward's figure are 7 mm. long, and there are about 4 of them in a distance of 10 mm. In *S. solomonis* there are no teeth more than 3 mm. long, and there are 8 of them in 10 mm. These teeth have a stellate base, as in *S. atavus*, and they appear to have been directed somewhat backward. For some distance beyond the base, for one third or one half of its length, the tooth is terete; then the diameter is suddenly increased, forming a sort of shoulder. The remainder of the tooth is gently curved backward, slightly flattened, and brought to an edge on the convex border. It is apparently only the distal portion of the tooth which is enameled. Toward the extremity of the rostrum the teeth are somewhat smaller. Posteriorly, the teeth become very small and are hardly to be distinguished from some of the shagreen scales on the border. Some of these scales are also stellate.

There are some indications of gill arches and of the base of the pectoral fin, but they are not distinct enough for description. On the right side is seen the outline of the mouth, and a few small teeth appear.

This specimen was collected at Hajula.

Named in honor of Solomon, king, philosopher, poet, and naturalist. "And he spake of trees from the cedar that is in Lebanon even unto the hyssop that springeth out of the wall; he spake also of beasts and of fowl and of creeping things and of fishes."

Sclerorhynchus hiram, sp. nov.

PLATE XXVI, FIGURE 1.

The type of this species consists of the head, with probably most of the rostrum, the pectoral fins, and the anterior portion of the vertebral column. Its number is 4501 (3705), and it was collected at Hajula.

The extremity of the rostrum is missing. The portion present extends 103 mm. in front of the mouth. The form of the rostrum corresponds quite accurately to that of *S. atavus*. From the latter species *S. hiram* is to be distinguished principally by the size and structure of the teeth of the rostrum. Those of *S. atavus* reach a length, according to Dr. Woodward's figure (Cat. Foss. Fishes, I, 1889, pl. iii, fig. 1), of 7 mm.; and there are not more than 4 of them in a length of 10 mm. In *S. hiram* they are not more than 3 mm. long, and about 8 of them are found in a distance of 10 mm.

In *S. atavus* each rostral tooth is said to comprise "a high, round base, crimped, and having a somewhat stellate appearance when viewed from beneath; upon this is fixed a backwardly directed crown, compressed to an anterior and posterior edge." In *S. hiram* each enameled crown is fixed on a high, round base, but this base is not crimped, but perfectly smooth, and no evidences have been observed of any stellate appearance. Each crown is curved, but, in addition to this, the crown as a whole is directed backward so as to make an angle of 45° with the axis of the pedicel produced. As in *S. atavus*, the crown is flattened to anterior and posterior edges. As in *S. atavus*, again, the teeth appear to graduate posteriorly into the dermal scales; but this occurs at a greater distance in front of the mouth than in the species from Sahel Alma.

At 50 mm. in front of the mouth the rostrum is 46 mm. wide; at a distance of 100 mm., 35 mm. wide; at the mouth, 75 mm. wide. The rostral cartilages have been well developed and have left their impress on the matrix. These and all the other cartilages present a mosaic of hexagonal calcifications. From the point where these cartilages begin to narrow, in front of the mouth, a band of stellate shagreen runs backward along the sides of the head. In a few other places the shagreen appears to have been circular in form and smooth. The mouth resembles that of the living species of *Pristis*, and it has a width of 50 mm. The teeth are small, and some of them appear to have been furnished with one or more sharp ridges, one of which was doubtless the cutting edge.

The position of the gill arches is seen in the figure. On the outer borders of each are seen the rays which supported the gill septa. There can be no doubt that the gill slits opened out on the lower side of the body, and that hence the genus belongs to the Pristidæ.

This species is dedicated to Hiram, king of Tyre, the friend of Solomon, who furnished for the latter cedar-trees and fir-trees from the forests of Lebanon.

Sclerorhynchus sentus, sp. nov.

Plate XXVII, Figure 1.

The only portion of this fish that is known is a part of the rostrum. This fragment, numbered 4504 (3864), has a total length of 153 mm. The distal end of this rostrum is missing. The proximal end of the specimen is supposed to have come close to the mouth. From the distal end, where the width is 29 mm., the specimen expands gradually until, at a distance of 80 mm. from the distal end, the width has become 45 mm.

From this point backward the width again diminishes until at the proximal end the width is about 35 mm. It might be supposed that immediately behind the widest part of the rostral cartilages the shagreened skin would part from the cartilages and pass outward and backward to the sides of the head. There is, however, no indication of such expansion of the head, and a few teeth are found at a little distance behind this broadest part of the rostrum.

The rostral teeth resemble most those of *S. solomonis*, but they are still smaller, not exceeding 2.5 mm. in length, and numbering 10 in 10 mm. The base does not appear to be distinctly stellate. From *S. hiram* the teeth differ in that the enameled blade does not form any considerable angle with the pedicel.

The form of the rostrum is quite different from that of *S. solomonis*, in that it does not contract so rapidly toward the distal end, and it has evidently been longer in proportion to its width. The rostrum has been composed of small, hexagonal, smooth calcifications. Most of these are now removed from the fossil, only their imprints remaining. A peculiar feature, one not found in either *S. hiram* or *S. solomonis*, is the presence of two rows of denticles throughout about the anterior two-thirds of the fragment, one row on each side of the midline. These denticles appear to have had a height of about a millimeter. Only their bases are seen, the remainder being buried in the matrix. The bases are stellate on their hinder borders, but not in front. The denticles are placed about 3 mm. apart. Whether they were on the upper or the lower side of the rostrum I am unable to determine. These doubtless belonged to the shagreen, and they appear to be all of the dermal structures, except the teeth, that now remain.

It will, perhaps, be profitable to note certain differences in the forms of the rostra of the three species described in this paper. In *S. hiram* the rostral cartilages have a width, where widest, of 44 mm., and the mouth is placed 55 mm. behind this. In *S. solomonis* the greatest width is 55 mm., and the mouth is only 40 mm. behind this widest portion. In *S. sentus* the rostrum has a maximum width of 45 mm., and the mouth must have been at least 75 mm. behind this. As will be observed from the figures, the rostrum of *S. solomonis* tapers toward the distal end more rapidly than that of either of the two other species.

Locality, Hajula.

RHINOBATIDÆ.

Rhinobatus eretes, sp. nov.

Plate XXIV, Figure 2.

The type and only known specimen of this species was collected at Hajula. It has the number 4500 (3715). As may be seen from the figure, Pl. xxiv, Fig. 2, the specimen is quite incomplete, neither the extremity of rostrum nor the tail being present. The species has probably resembled *R. tenuirostris* Davis in having had a much-prolonged snout, but this is uncertain. There appear, however, to be characters which are sufficient to distinguish the present form from the Sahel Alma species just mentioned.

In general, the type has about the same size as the type of *R. tenuirostris.* The distance from the pectoral arch to the mouth is the same in the two; the distance between the inner borders of the hinder lobes of the pectoral fins is a little greater in *R. eretes.* The differences noted between the two species are the following:

The concavity of the sides of the head opposite the gill arches is considerably greater in *R. eretes* than in *R. tenuirostris.* In the latter the pectoral fin extends forward to a point somewhat in front of the mouth; in *R. eretes* it lacks about 25 mm. of reaching a point opposite the mouth. In the type of *R. tenuirostris* the pectoral measures, fore and aft, 180 mm.; in *R. eretes* they measure 103 mm. It is thus seen that the latter species has a much shorter fin in proportion to the size of the animal.

It is evident that the ventral fins are also relatively smaller than in *R. tenuirostris.* In the latter the length of this fin along the body is 75 mm.; in *R. eretes* the hinder extremity of this fin is broken away, but the whole length could not have been more than 60 mm. The anterior border of the ventral of *R. eretes* is about 30 mm. and the breadth 20 mm., as compared with 50 mm. and 25 mm. respectively in *R. tenuirostris*.

We cannot be certain what was the form of the apex of the pectoral fin of the species here described, since, after taking into account the remnants of the right and the left fins, there yet remains about 30 mm. of the border unrepresented, and this includes the apex.

The mouth of *R. tenuirostris* appears to have been smaller than that of *R. eretes*, the former being said to measure about 33 mm. from side to side, while the latter measures 40 mm. In the mouth of *R. eretes* there are seen several rows of teeth. They each measure a millimeter in length parallel with the jaw, and each has a thin cutting edge, in the middle of which is a conical point.

The vertebræ have a diameter of about 7 mm. Davis states that those of *R. tenuirostris* have a diameter of 0.1 inch, but this is obviously an error. The length of those of *R. eretes* is 2.6 mm.; and, according to this, there would be about 15 of them between the pectoral and the pelvic girdles. Davis states that those of *R. tenuirostris* have a length of .15 inch, and that there are 14 of them between the two girdles.

Over the greater portion of the body of the specimen here described the shagreen has been removed. There is, however, a band of stellate scales along the margin of the rostrum; and further toward the midline, apparently on the upper side of the rostrum, there are three or four rows of similar scales. Along the greater part of the border of the front lobe of the pectoral fin the shagreen has become smooth, and each scale nearly circular in form. Probably this represents the general character of the shagreen.

RAJIDÆ.

Raja whitfieldi, sp. nov.

PLATE XXVIII.

This new species is represented in the collection by three specimens, No. 4505*a* (3707), No. 4505*b* (3708), and No.

4505*c* (3709), all from Hajula. Of these the first-named is taken as the type, inasmuch as it presents a greater portion of the body than either of the others does. Even in this, the tail is missing and a part of the right side is gone.

The disk is broad and rounded. The snout is slightly drawn out, but its tip is rounded. The greatest width across the pectorals is 156 mm. The distance from the snout to the hinder border of the pectoral girdle equals 82 mm.; from the snout to the pelvic girdle, 117 mm. There appear to be 15 vertebræ between the pectoral and pelvic girdles.

The disk is everywhere covered with a very fine shagreen, and no asperities are anywhere visible. On the upper surface of the snout there are a few enlarged scales, each nearly 2 mm. across. On the upper surface, on each side of the midline and over the pectoral girdle, is a patch of scales, some of which are about .5 mm. in diameter.

On each side of the head, where the scales have been broken away so as to expose the mouth, may be seen a few small teeth. The impressions of the gill arches are faintly seen; likewise those of the eyes and the nasal cavities.

The other specimens add little or nothing to our knowledge of the species.

Three other species of *Raja* have been described from Mount Lebanon. *Raja expansa* (Davis), from Hakel, has a very broad disk, and the pectoral fins are acute at their outer angles. This species was regarded by Davis as belonging to *Rhinobatus* (Trans. Roy. Dublin Soc., (2), III, 1887, p. 486, pl. xviii). *Raja primarmata* A. S. Woodward (Cat. Foss. Fishes, I, 1889, p. 85, pl. iv, figs. 1–3), from Sahel Alma, also has the outer angles of the pectorals acute. *Raja minor* Davis (*op. cit.*, p. 493, pl. xxi, fig. 2), from Sahel Alma, is either a very small species or the young of a species otherwise unknown. The pectorals are rounded. There is little or no shagreen on the disk. The disk is very broad.

This species is named in honor of Professor R. P. Whitfield, Curator of the Department of Geology of this Museum, who is the author of many important memoirs on palæontology, among them one entitled 'Observations on some

Cretaceous Fossils from the Beyrut District, Syria, in the Collection of the American Museum of Natural History, with Descriptions of some New Species' (Bull. Amer. Mus. Nat. Hist., III, 1891, pp. 381–441, pls. iv*a*–x).

Class PISCES.

BELONORHYNCHIDÆ?

Stenoprotome, gen. nov.

The writer finds it difficult to determine with any certainty either the relationships or the characters of this genus. The following characters are given provisionally:

Body furnished with large tuberculated bony scutes. Vertebral centra not developed. Head elongated, the snout slender, obtuse at the apex. Teeth of moderate size, conical. Opercular? bone furnished with a long, curved spine. Type, *Stenoprotome hamata* sp. nov. Derivation of name, στενός, narrow, and προτομή, the face.

Stenoprotome hamata, sp. nov.

PLATE XXVI, FIGURE 2; PLATE XXVII, FIGURE 2.

The specimen which forms the basis of the following description was obtained at Hakel, and the number is 4509 (3863). The head is the part most satisfactorily preserved, and figures are here presented of both the counterparts. The most striking feature of the fish is the possession of two long, curved spines, one on each side of the head. Each of these ends in a sharp point; and just proximad of the point is a sharp barb. The distal end of the spine resembles closely the point of a fishhook. The writer has not been able to determine conclusively what bone supports this spine. On looking at *Coccodus* it is suggested to one that the spine is homologous with the lateral spine of that genus, but further consideration makes it evident that the present form has no relationships with the pycnodonts; and the close attachment of the spine to the side of the head and its evident great extension forward indicates that it is rather the opercular bone.

The length of the head, from the apex of the snout to a line joining the hinder borders of the lateral spines, is 35 mm. The apex of the snout is rounded and only 3.5 mm. wide. The skull lies with the upper surface toward the viewer. The bones are so closely united that their limits cannot be distinguished. The surface is almost everywhere covered with tubercles, sometimes scattered, but usually arranged in rows more or less regular. A few of those on the upper surface of the snout form short spines.

Along the borders of the snout, for about 20 mm., there are seen, at intervals of two or three millimeters, what appear to be teeth, but which are possibly only enlarged marginal tubercles. Between the larger ones are others of smaller size. Some medium-sized ones are found at the apex of the snout. At a considerable distance behind the head is seen a stout bone bearing four or five teeth larger than those of the rostrum, the largest about 1.5 mm. in length. This bone seems to the writer to be a portion of the lower jaw, which has been displaced.

As may be seen from Pl. XXVI, Fig. 2, *orb.*, there are, between the bases of the spines, two rings of bone. These appear to be the sclerotic rings and to indicate the position of the eyes; but, incomprehensibly enough, these have been overlain by some bones of the upper surface of the skull. The appearances of the fossil are not consistent with the supposition that the lower surface of the head is presented. There is probably some distortion here.

Behind the bases of the spines the fossil contracts for about 10 mm. Whether this region belongs to the skull or not is not easily decided. There appear to be five bones here, an elongated median one, extending the full length of the area, and two others on each side. Of the latter, the hindermost sends an arm forward along the outside of the more anterior one. These bones can be distinguished on the specimens only by close inspection.

Behind the area mentioned, at *a*, Pl. XXVII, Fig. 2, there is a bony mass whose surface is covered with ridges which converge to a point at one side. These ridges may represent either the sculpture of a bony scute or a number of rays of a dorsal fin. On one side of this, *b*, is a bony scute whose axis runs obliquely to the axis of the head; while at *c* there is another scute whose greater axis is transverse to that of the head. Still farther away, at *d*, is found the supposed lower jaw. Around this are some remains apparently of fin rays. Finally, at *e*, is seen a very large bony plate, 33 mm. long and 21 mm. wide. One end is narrowed and rounded off. Near this plate also there are seen scattered fin rays. All the plates are tuberculated.

Nowhere are there any certain evidences of vertebral centra or ribs. There seem to be some evidences of neural or hæmal arches.

PYCNODONTIDÆ.

Coccodus lindstrœmi *Davis.*

PLATE XXIX, FIGURE 1.

Coccodus lindstrœmi DAVIS (J. W.), Jour. Geol. Soc., XLVI, 1890, p. 565, pl. xxii.—WOODWARD (A. S.), Cat. Foss. Fishes, III, 1895, p. 268.

Of this not well-known species there are in the collection three specimens. One of these, No. 4517*a* (3698), with its counterpart, presents the head. The second, No. 4517*b* (3699), much damaged, shows a part of the head, with the occipital spine, and a portion of the abdominal region. The third, No. 4517*c* (3793), also presents the head and a complete occipital spine. The first-mentioned specimen is here figured (Pl. XXIX, Fig. 1). On the hinder border of the spine there are 14 denticles. The region below the orbit has been covered with bony plates, whose surface was ornamented with more numerous and smaller tubercles than the other portions of the head. Behind the occipital spine is seen a series of fin rays, 10 in number. They are slender, and present distinct evidences of segmentation, but none of longitudinal division. They extend downward beneath the bony covering of the region and toward the neural spines, or between them. No. 4517*c* (3793) shows the presence of the same rays, and here they seem to be longitudinally divided. They appear to form a feeble anterior dorsal fin.

Through a fracturing of the snout some of the teeth, apparently those of the splenial bone, are exposed. The rows cannot be counted, but the teeth themselves are very much smaller than those of *Coccodus armatus*. At the tip of the lower jaw is seen a small, conical, pointed tooth.

The specimens are from Hakel.

Coccodus insignis, sp. nov.

PLATE XXIX, FIGURES 2–5.

Of this species there are in the collection several specimens, all from Hajula. The following six are especially to be mentioned: Nos. 4516*a* (3666), 4516*b* (3700), 4516*c* (3701), 4516*d* (3702), 4516*e* (3703), and 4516*f* (3794). Of these, No. No. 4516*b* (3700) and No. 4516*d* (3702) are to be regarded as the types. The former consists of a somewhat damaged fish which has been flattened from above downward, and may be taken as showing the form of the fish when seen from above. Only the tip of the tail fin is missing. The total length is 80 mm. On each side is seen a broad, hooked spine, a part of the shoulder girdle. The head is pointed in front, and it and the anterior body region expand backward to the ends of the spines mentioned, so as to be wedge-shaped. These lateral spines appear to be much broader than the corresponding ones of *C. armatus*, as figured by Davis (Trans. Roy. Dublin Soc., III, pl. xxx, fig. 1) and Woodward (Cat. Foss. Fishes, III, p. 267). The anterior, or outer, border of each is finely denticulated. The upper and lower surfaces are ornamented with fine ridges, which start from the base and converge to the point. Anteriorly these ridges become tuberculated. In front and behind, the base of each spine passes into anterior and posterior processes of the pectoral arch. Lying in the curve of the hinder border of the pectoral spine and on the matrix from which a portion of the spine has been removed are seen abundant remains of pectoral fin rays; but these have been much disturbed. The rays of the dorsal are so much disturbed that their number cannot be determined; but they are not numerous. Somewhat in front of a perpendicular from the origin of the dorsal fin are seen the ventral fins and their supports. The latter are 6 mm. long and rather slender. So far as can be determined, there are only 5 fin rays in each, and the outermost of these is short and claw-like. The divided rays are also segmented. The anal fin is disturbed, and the caudal is missing. Another specimen, No. 4516*f* (3794) (Pl. XXIX, Fig. 2 *v. f.*), appears to have an additional divided ray in the ventral fin.

In No. 4516*b* (3700) two or three rows of teeth can be seen. Nothing more can be said of them than that they resemble those of *C. armatus*. There are indications given by the neural and hæmal arches that there were 15 or more vertebral segments.

The block bearing this specimen has been broken along the length of the fish in such a manner as to expose the occipital spine, which was buried in the matrix. This is represented by Fig. 3 on Pl. XXIX. It is readily seen to be different from that of either *C. lindstrœmi* or *C. armatus*, being broad anteroposteriorly and relatively short. The posterior edge is finely denticulated; the anterior edge is nearly smooth. The lateral surfaces are ornamented with fine ridges, which rise from the base and either terminate in the borders or ascend to the apex. Just behind this spine there is another process of bone which may be either another spine or a ridge passing across the rear of the skull. Its hinder border overhangs the anterior vertebræ.

The co-type, No. 4516*d* (3702) (Pl. XXIX, Fig. 4), is a small fish having a length of 97 mm. from the snout to the end of the caudal fin. The specimen is especially interesting because it presents the shoulder girdle from below. It is difficult to determine what sutures exist in this region. The lower ends of the right and left halves of the girdle join in the midline, and here the bones are 8 mm. wide, fore and aft. The suture between them is very distinct for a part of the distance across the bridge, but it then becomes indistinct. Whether or not these bones are separated by suture from the bases of the lateral spines I have been unable to determine with any certainty; but they are possibly distinct bones.

Dorsal and anal fins are present, but their rays are disturbed.

What are probably vomerine teeth are presented. There are three rows on one side of the midline and one row on the other, and there were not less than 5 rows. Those of one of the rows farther from the midline are compressed laterally and each forms a longitudinal cutting edge. The other teeth have a part of their triturating surface mammillated and the borders finely crenulated.

No. 4516*e* (3703) is a fish which has been spread out either by crushing or by inflation by gases during decomposition. The space occupied by the notochord is enlarged so that the bases of the neural arches and those of the ribs are from 6 to 11 mm. apart. This specimen shows that both the neural arches and the hæmal arches had their proximal ends expanded against the notochord. The expansions of the neural arches join and form a continuous covering for the upper side of the notochord. The ends of the hæmal arches probably did not come into contact with each other or with the neural arches.

Beneath the dorsal rays I count 10 interneural supports. There appear to have been 8 anal rays. There are traces of both pectoral and ventral fins. In one gill chamber are seen the impressions of four series of gill filaments.

No. 4516*a* (3666) shows the fish as seen from the side, and thus gives us an idea of the elevation of the head and body. The total length is 120 mm. The height of the body at the pectoral spine is 30 mm. Only a faint impression of the occipital spine remains. The rays of the dorsal fin cannot be counted. The lower rays of the caudal are the longest and the fin ends rather bluntly. The anal appears to comprise 8 rays. The ventrals are distinctly displayed. There is a continuous line of bones along the upper side of the notochordal region, the bases of the neural arches. Eleven neural arches are counted from the middle of the back to the base of the caudal fin. Vomerine and splenial teeth are seen, but the number of rows cannot be determined.

No. 4516*c* (3701) lacks the hinder portion of the body (Pl. XXIX, Fig. 5). The fish presents the body as seen from above, but damaged somewhat, the roof of the skull being gone, as well as the occipital spine. The head is 40 mm. long, from the snout to a transverse septum formed apparently by the shoulder girdle. Splenial teeth are present, three rows on each splenial. Six teeth are found in each row, and there were probably three or four more. The ones in front are small. The inferior transverse portion of the shoulder girdle is seen, on the left side, passing across beneath remains of probably gill arches. Faint indications of pectoral fin rays are seen on one side.

No. 4516*f* (3794) appears to deserve description and illustration (Pl. XXIX, Fig. 2). The inferior surface of the body lies toward the viewer, and the apex of the occipital spine has been found by excavating on the opposite side of the block. From the base of one pectoral spine to the other, a bar of bone crosses the body. It presents a fractured edge toward the abdominal surface, and has, in all probability, been a ridge, or plate, of bone which extended upward from the inferior transverse portion of the shoulder girdle.

Behind the right (left in the figure) pectoral spine are seen the neural arches with their conjoined expanded proximal ends. Each arch is seen to have a wing-like expansion in front of the spine. Crossing the upper ends of the hindermost spines are seen some interneural supports of the rays of the dorsal fin. Immediately behind the bar of bone, passing from one pectoral spine to the other, are seen some confused ribs. Then come the supports of the ventral fins and the fins themselves, and immediately behind and above these, the expanded ends of the hæmal arches. Behind each pectoral spine are seen the remains of pectoral fin rays. Twelve of these may be counted behind the right spine. The proximal ends of these rays are to be seen on the matrix mesiad of the base of the spine. This proves that the pectoral fins were inserted above the spines.

In front of the transverse bar of bone mentioned above is seen the parasphenoid. In front it appears to receive between two prongs the hinder end of the vomer. On the latter there appear to have been four rows of teeth, but many of these teeth are broken away.

The counterpart of specimen No. 4516*c* (3701) presents the parasphenoid bone. Posteriorly this seems to join a basisphenoid. On the lower surface of the latter, in the midline, there is a short, pointed, downwardly directed process.

All the specimens were collected at Hajula.

ELOPIDÆ.

Holcolepis attenuatus (*Davis*).

Clupea attenuata Davis (J. W.) Trans., Roy. Dublin Soc. (2), III, 1887, p. 580, pl. xxxiii, fig. 4.

Osmeroides attenuatus Woodward (A. S.), Ann. and Mag. Nat. Hist. (7) II, 1898, p. 409; Cat. Foss. Fishes, IV, 1901, p. 19.

No. 4526 (3781), from Hakel, is a specimen which the writer is unable to distinguish from Davis's *Clupea attenuata*, a species hitherto known only from Sahel Alma. In the present specimen the total length is 95 mm.; to the base of the caudal fin, 77 mm. The head, including the opercular apparatus, is about 23 mm., but the extremity of the snout is missing. The depth is only 15 mm. There are a few more than 50 vertebræ, of which not more than 20 belong to the caudal region. There are 20 interneurals supporting the dorsal fin. Davis reports the presence of only 10 rays in the dorsal, but this is doubtless an error. This fin, in our specimen, is equally distant from the occiput and the base of the caudal fin. The ventrals are inserted below the front of the dorsal. The anal is disturbed, but there are 7 supporting interhæmals present. It is entirely behind the dorsal. The bones of the head are smooth. Nothing can be determined regarding the size or the form of the scales.

There are various reasons for not identifying this specimen as *H. sardinioides* (Pictet). It is entirely too slender to be *H. lewisi* (Davis). The dorsal and ventral fins of the latter are farther backward, and there are said to be 35 vertebræ in the abdominal region behind the operculum.

Dr. A. S. Woodward has called our attention to the fact that the name *Holcolepis* antedates *Osmeroides* as a name for the species of this genus (Cat. Foss. Fishes, IV, p. 11).

ICHTHYODECTIDÆ.

Eubiodectes, gen. nov.

Teeth in sockets? Vertebræ with lateral grooves; the centra pierced by the notochord. Some of the anterior pectoral rays expanded distally, and longitudinally divided. Anal fin elongated, falcate in front. Type, *Chirocentrites libanicus* Pictet and Humbert. Derivation of name, εὐβιος, *well-living;* and δήκτης, *a biter.*

Eubiodectes libanicus, (Pict. and Humb.).

Plate XXX, Figure 1.

Chirocentrites libanicus Pictet and Humbert, Nouv. Rech. Poiss. Foss. Mt. Liban, 1866, p. 88, pl. xiii.—Davis (J. W.), Trans. Roy. Dublin Soc. (2), III, 1887, p. 585.

Ichthyodectes libanicus Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 105.

This species has been referred by Dr. Woodward to the genus *Ichthyodectes.* However, a comparison with *I. anaides*, the type of *Ichthyodectes*, will convince one that the Syrian species belongs elsewhere. In *I. anaides* the anterior pectoral ray is very stout, but it does not expand distally; and I know of no evidence that its distal end was split into fine filaments. It formed rather a sort of spine, like that of *Portheus.* The succeeding rays were considerably smaller than the anterior one and were distally divided, as is usually the case with such rays. In *I. anaides* the notochord seems not to have passed continuously through the centrum of the vertebra; but in the Syrian species under consideration there was free communication between the concave ends of the centrum. In this Syrian species the anal fin is very long; we have no proof that it was so in the American species of *Ichthyodectes.* For these reasons I place the *Chirocentrites libanicus* of Pictet and Humbert in a distinct genus. I have not seen the teeth, nor have I found any statement that they are lodged in sockets. If they are not in sockets, this will furnish another character to distinguish the species from *Ichthyodectes*.

In the collection there are several portions of this fish, but no complete specimen. None of these furnish the teeth. One example, No. 4506*a* (3681), shows the fish from apparently just behind the pectoral girdle to the base of the caudal fin. This length is 400 mm. In this distance there are about 54 vertebræ, but these have been disturbed anteriorly. The depth at the origin of the anal fin is 120 mm. The anal fin begins 186 mm. in front of the base of the caudal. There are apparently about 8 strong rays in front; behind these the rays are weak and, in the fossil, form an obscure fringe along the body. There are altogether 34 interhæmal fin supports. The whole length of the anal base is 137 mm.

So far as indicated by the specimen, the dorsal fin begins 110 mm. in front of the base of the caudal fin and opposite the beginning of the hinder third of the anal. Only 10 rays can be counted, but there may have been others posteriorly. Large interneurals are present in front of the fin, but there seem to have been no rays attached to them. The neural and hæmal spines are long, slender, and sigmoid in form. The vertebræ both of the abdominal and caudal regions are somewhat higher than long, about 7 mm. long and 9 mm. high. The side of the centrum is excavated by a pair of rather deep pits or grooves. Where the centra happen to be split longitudinally they show that the notochordal perforation is a millimeter or more in diameter.

About 95 mm. in front of the dorsal fin, and therefore not far behind the head, there is, on the back, a rounded mass of bone. This seems to be connected with the distal ends of some rather stout interneurals. This mass is about 27 mm. long, 10 mm. high, and 5 mm. thick from side to side.

Most of the scales are removed from the fossil. They appear to have been about 15 mm. high, and their exposed portion about 8 mm. fore and aft.

Another specimen, from Hajula, No. 4506*b* (3646), confirms the above description, except that it does not include the region of the bony mass behind the head. There are apparently 13 dorsal rays. A considerable portion of the body is covered with scales. No. 4506*c* (3799), from Hakel, exposes on the matrix an impression of the caudal fin. It has been deeply forked. The larger rays have been obliquely segmented; the median ones split up into smaller filaments.

No. 4506*d* (3866) is part of a fish which had a depth of at least 125 mm. It presents the ventral fins; but no other fins are present to afford us a means of locating the position of the ventrals. These fins appear to have been about 30 mm. long.

No. 4506*e* (3823), from Hakel, is about as large as No. 4506*a* (3681). It seems to present some traces of the ventrals at a point 75 mm. in front of the anal fin. There are also some faint indications of the bony mass on the back, to which reference has been made above.

No. 3899, of the Cope Collection, is probably from Hakel. The specimen resembles much the one figured by Pictet and Humbert, but not so much of the body is present. One pectoral fin is well exposed, mostly as an impression on the matrix (Pl. xxx, Fig. 1). The longest ray, the most anterior, has a length of 65 mm., and its distal end is slightly more than 7 mm. wide. The next ray, somewhat shorter, is 9 mm. wide distally. The other rays are successively shorter and narrower. All the rays, for a great part of their distal portions, are longitudinally divided. There appear to be somewhat more than 10 rays. No teeth are seen in this specimen.

CTENOTHRISSIDÆ.

Ctenothrissa signifer, sp. nov.

PLATE XXXI, FIGURES 1 AND 2.

Two fishes which were collected at Hajula belong evidently to an undescribed species of *Ctenothrissa*. The number of the type is 4521*a* (3651). With its counterpart, it furnished all parts of the animal. A second specimen is numbered 4521*b* (3813).

The total length of the type is 80 mm.; to the base of the caudal fin, 55 mm. The body is deeper than it is in *C. vexillifer* (Pictet), the greatest depth, 30 mm., being contained in the length to the base of the caudal somewhat less than two times; and in the distance from the pectoral arch to the base of the caudal, one and one fourth times. The length of the head, 21 mm., is less than the greatest depth of the body.

The height of the dorsal fin is fully 30 mm., and when depressed its distal end would reach beyond the base of the caudal fin. It contains 20 rays, including the anterior undivided ones. The anal fin has a height of 13 mm., but the rays are broken and zigzagged, so that it is evident that originally the fin was still higher. There are present in it 13 or 14 rays.

The body is slightly turned, so that both ventral fins come into view. These sweep backward along the lower border of the body and cross all the anal fin-rays. The pectoral fins are only dimly seen.

The maxilla is provided with short conical teeth. This bone and the supramaxilla resemble those of *C. radians*, as figured by Dr. A. S. Woodward (Cat. Foss. Fishes, IV, pl. x, figs. 2, 3). The cheeks and the opercular bones are covered with scales.

No. 4521*b* (3813) shows only the posterior half of the body. The dorsal fin is depressed and overlaps the base of the caudal fin. The anal rays pass somewhat behind the last caudal vertebra. Some of the rays of the ventrals extend beyond the origin of the anal.

This species differs from *C. vexillifer* in having a shorter and deeper body, much higher dorsal and anal fins, and longer ventral fins.

No. 4522 (3802) is a small fish from Hakel which I identify as *C. vexillifer*. The length to the base of the caudal is 35 mm. and the depth is 14 mm. The fish is therefore considerably slenderer than the specimens of *C. signifer*. The pectoral fin in this Hakel specimen also is long, as in those from Hajula; but the dorsal is not more elevated than usual.

DERCETIDÆ.

Leptotrachelus serpentinus, sp. nov.

PLATE XXXII, FIGURE 1.

This species is represented in the collection by two specimens, No. 4511*a* (3683), which was collected at Hajula, and No. 4511*b* (3739), which was obtained at Hakel. The first mentioned specimen is regarded as the type. It lacks a large part of the caudal region and the whole of the head, except a part of the opercular apparatus. The length of the specimen in its present condition is 260 mm., and the total length in life could hardly have been less than 300 mm., and was probably more. The distance from the opercular region to the ventral fins is 134 mm. The diameter (probably the horizontal) at the ventral fins is contained in the distance from the operculum to these fins thirteen times. In *L. triqueter* the diameter at the ventral fins, as shown by Pictet and Humbert's figure (Nouv. Rech., pl. xiv, fig. 1), is contained in the part of the body in front of the ventral fins about seven times. We have in both of these cases apparently the breadth of the body and not its height. *L. serpentinus*, therefore, appears to have been a much slenderer fish than *L. triqueter*. This slenderness is shown also by the bodies of the vertebræ, which are more than three times as long as the diameters of their articular ends. In *L. triqueter* the bodies are said to be twice as long as deep.

There are 31 vertebræ between the operculum and the ventral fins, about the same number as in *L. triqueter*. The vertebral centra are much constricted. Each vertebra of the abdominal region sends out on each side two long processes, which diverge from the middle of the centrum. The broader one is directed outward and forward. Near its end there is articulated to it the head of a long, slender rib. The posterior and narrower process is directed outward and backward. Its distal end approaches very closely the rib-bearing process of the next vertebra behind. In the region of the ventral fins these processes are nearly 5 mm. long. These lateral processes are found on about 12 of the vertebræ behind the ventral fins. The posterior process appears to be the one first reduced, but both soon disappear. From the figures and descriptions of *L. triqueter* we must conclude that there is only a single process on each side of each centrum.

There are present about 6 or 7 rays of one pectoral fin, and these are about 15 mm. long. A broad bone having a posteriorly directed process lies just behind the operculum. This may belong to the pectoral arch. The dorsal fin is missing, unless it is represented by two or three rays which lie above the ventral fins.

One of the ventral fins is present and appears to contain 6 rays. Its supporting bone is 7 mm. long and 2.5 mm. wide posteriorly, and is pointed in front. No remains of the anal fin are seen.

As may be seen from the figure, on the upper side and behind the ventral fin, there is a row of triradiate dermal scutes running along one side of the body. A similar row is found on the other side, but the bone is broken away and only the imprints of the scutes are left on the matrix. These scutes continue for some distance in front of the ventral fins. They appear to have a longer anterior branch than do those of *L. triqueter*. There are also numerous fine intermuscular bones throughout the length of the fish.

The condition of the vertebræ and dermal scutes occupying some distance behind the head is not easy to determine, on account of the presence there of the bodies of three small fishes. It is possible that these had been swallowed, but their presence there is more probably accidental.

The specimen collected at Hakel is a fragment 98 mm. long. It is from the portion of the body behind the ventral fins. It presents no new features.

From *Leptotrachelus gracilis* Davis (Trans. Roy. Dublin Soc., III, 1887, p. 623, pl. xxxviii, fig. 3), this species differs in having a much less slender anterior abdominal region and probably a longer post-pelvic region. Davis's species likewise had quite different lateral vertebral processes.

Collected at Hajula and Hakel.

ENCHODONTIDÆ.

Enchodus marchesettii ? (*Kramberger*).

PLATE XXX, FIGURES 2 AND 3.

Eurygnathus marchesettii KRAMBERGER (D. G.), Djela Jugoslav. Akad., XVI, 1895, p. 34, pl. vii, fig. 2.

In the collection are two specimens of an *Enchodus* which seems to be distinct from *E. longidens;* and, since there are no species of fishes known to be common to Sahel Alma, where the latter species is found, and Hakel, where *E. marchesetti* was found, it appears to be best for the present to retain the two species as distinct. It is proper to state that I have had no specimens of *E. longidens* for direct comparison, and I have not been able to see Kramberger's description and figure of his species. The present identification is therefore wholly provisional.

The two specimens are numbered respectively 4507*a* (3779) and 4507*b* (3859). The former (Pl. xxx, Fig. 2) presents the head, except a portion of the lower jaw, and the body to the rear of the anal fin, except a portion of the back. No. 4507*b* (3859) consists of the body and tail from the beginning of the dorsal fin. The two specimens have been almost identical in size, and they supplement each other quite completely.

The head of No. 4507*a* (3779) is 55 mm. long to the hinder border of the operculum. The lower jaw has been broken away just below the tooth-line, leaving the teeth, but rendering it impossible to determine the depth of the jaw. The teeth have been slender, some of them quite long; and they are furnished with a few sharp grooves, especially distally. The premaxilla has been of moderate size, and furnished with a long, now missing, fang. The skull and opercular bones appear to have been ornamented as in *E. longidens.*

In front of the dorsal fin are three dermal scutes. These are of an elongated oval form, with pointed ends. The anterior and largest is 8 mm. long and a little more than 3 mm. wide. From the centre of each, ridges radiate to the circumference. Below each scute there is seen a plate of bone which appears to be an expansion of an interneural bone. This has probably formed a support for the scute. The first interneural support of the dorsal fin is similarly expanded. Along the position of the lateral line is seen a succession of small thin scutes, each not more than 2 mm. long. These are to be observed as far backward as the rear of the dorsal fin, where they lie close to the upper border of the vertebræ. It is probable that they continue to the base of the caudal. I have observed no traces of the hooked dermal scutes that are described as occurring at the base of the tail of some species.

The pectoral fin has had a length of at least 25 mm., and it must have had somewhat more than 15 rays. The ventrals arise about 30 mm. behind the pectorals and slightly behind the origin of the dorsal fin. Its rays are somewhat damaged in both specimens, but they were at least 17 mm. long. The number of dorsal fin rays cannot be accurately determined, since some are wanting in both specimens; but there were probably 16, as in *E. longidens.* The anal fin was supported by 19 rays, so that the fin does not appear to have differed from that of *E. longidens.* The caudal fin is deeply forked, and some of the external rays are rather strongly developed.

In the specimen showing the head there are 24 vertebræ in front of the origin of the dorsal fin, and 15 behind this point; therefore 39 altogether, possibly 40. Dr. A. S. Woodward, in his description of *Enchodus longidens* (Cat. Foss. Fishes, IV, p. 199), states that there are 24 vertebræ in the caudal region of the latter species. In our specimens from Hakel, the twenty-fourth vertebra from the base of the caudal fin will be on a line joining the base of the ventral fins with the anterior portion of the dorsal. Not more than 19 or 20 vertebræ can be fairly assigned to the caudal region. This may furnish us with one difference between *E. longidens* and *E. marchesettii.* Another will probably be found in the different forms of the dorsal scutes, those of *E. longidens* being broadly oval, those of our Hakel specimens elongated oval.

Besides the specimens described above, there are in the collection three others which probably belong to the same species. One of these, No. 4527*a* (3735), is from Hakel; the others, No. 4527*b* (3840) and No. 4527*c* (3832), are from Hajula. The first-mentioned presents the head and the body to behind the ventral fins; the two others, only the heads. In the first, the lower jaw has a width of 11 mm. and a length of 45 mm. The teeth behind the anterior fangs appear to be compressed to edges and to be striated and grooved. The fangs are slender. No dorsal scutes are present. In No. 4527*c* (3832), the jaw is 12 mm. wide and apparently 55 mm. long. The teeth, upper and lower, are mostly damaged, but they are rather coarsely striated; and many of them, even the large fangs, are furnished with edges.

No. 4527*b* (3840) and its counterpart furnish the head of a large individual. The length of the head to the hinder border of the operculum is 120 mm. The length of the lower jaw is 80 mm.; its depth is 21 mm. The head has been crushed from above. Both tumid palatines are shown, each with a long slender fang. The fang is nearly smooth on the outer side, but coarsely striated on the inner side. Whether cutting edges are present is not certain. The lower fang is likewise striated on the inner surface. This belongs possibly to a different species, but this cannot now be demonstrated.

Specimens from both Hakel and Hajula.

MYCTOPHIDÆ.

Osmeroides *Agassiz.*

Osmeroides AGASSIZ (L.), Poiss. Foss., V, pt. ii, 1844, p. 103.—PICTET (F. J.), Poiss. Foss. Mt. Liban, 1850, p. 27.

Sardinioides MARCK (W. v.), Zeitschr. deutsch. geol. Gesellsch., X, 1858, p. 245.—WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 236; Foss. Fishes English Chalk, 1902, p. 32.

Dermoptychius MARCK (W. v.), Palæontogr., XV, 1868, p. 287.

The employment of the name *Sardinioides* for this genus is an evident violation of the law of priority; a law recognized by all naturalists, but obeyed with reluctance by many when their prepossessions are attacked; and the only means now provided for deciding between rival systematic names. The type of the genus is *O. monasteri* Agassiz.

The species which are satisfactorily determined as belonging to the genus are the following: *Osmeroides monasteri* Agassiz, *O. crassicaudus* (Marck), *O. megapterus* Pictet, *O. pusillus* (A. S. Woodward), *O. woodwardi*, nom. nov. (= *Sardinioides attenuatus* A. S. Woodward), *O. macrophthalmus* (Marck), and the two new species below described, *O. pontivagus* and *O. ornatus*.

Three other species of doubtful value, according to Dr. A. S. Woodward, have been described by von der Marck, *O. macropterygius*, *O. minutus*, and *O. tenuicaudus*.

Osmeroides pontivagus, sp. nov.

PLATE XXXIII, FIGURES 1–4.

This species is represented by at least 15 individuals. The size is small, and the fish is closely related to *O. pusillus*, which has been described as *Sardinioides pusillus* by Dr. A. S. Woodward from Sahel Alma (Cat. Foss. Fishes, IV, p. 240, pl. xvi, figs. 2, 3). *O. pontivagus* differs from the latter in several important respects. Dr. Woodward states that in *O. pusillus* the serrations of the scales are deep and conspicuous. In *O. pontivagus*, on the contrary, they are very obscure, and it is only in favorable situations on the matrix, and with the aid of a good lens, that they can be seen at all. There are also more rays in the dorsal fin than there are in the species from Sahel Alma, 12 or 13, instead of 10 or 11. There are quite certainly 9 rays in the anal fin. The ventrals are inserted somewhat behind the origin of the dorsal fin, and they show the presence of 7 rays. Several specimens present at least 13 rays in the pectoral.

The mouth of this species is large, the articulation of the lower jaw being placed well behind the orbit. No. 4524*b* (3846) has the mouth widely opened and shows the slender and toothed premaxilla as forming the whole of the upper border of the mouth (Pl. XXXIII, Fig. 1). There is a patch of teeth on the palatopterygoid arch. The maxilla is expanded at the distal end. There were probably 8 branchiostegal rays on each side. There are about 30 vertebræ, not more.

No. 4524*a* (3845) (Pl. XXXIII, Fig. 2), is taken as the type of this species. It has a length of 60 mm.; to the base of the caudal, of 47 mm. The head is 16 mm. long, and the depth is 20 mm.

Among the specimens which I am compelled to refer to this species there is much variation in the depth of the body. On Pl. XXXIII, Figs. 1, 2, are represented two specimens which have very deep bodies. Fig. 3 of the same plate shows another specimen, No. 4524*c* (3855), whose body has less depth. In this, the depth of the body, 15 mm., equals the length of the head. The distance from the snout to the base of the caudal fin is 50 mm. No structural differences are to be seen. Still slenderer specimens occur, as No. 4524*e* (3852), which is 37 mm. long from the snout to the base of the caudal fin, while the depth is only 10 mm. Between the extremes there are all gradations in relative depth.

In some of the slenderer specimens there is a tendency toward a deepening of the fins. In No. 4524*f* (3841) (Pl. XXXIII, Fig. 4), about 50 mm. long to the base of the caudal and 15 mm. deep, the rays of the dorsal fin extend backward two thirds of the distance from the fin to the base of the caudal. The anal is rather deep, while the pectoral rays fully reach the base of the ventrals, and the rays of the latter lack but little of attaining the front of the anal. In No. 4524*g* (3842) from Hakel, the dorsal and anal fin-rays extend backward to the base of the caudal.

In some, but not all, of the slender individuals, the scales appear to be quite thick; but this condition may be due to some peculiarity of preservation.

The slender specimens described here resemble somewhat *O. woodwardi* (= *Sardinioides attenuatus*), described by Dr. A. S. Woodward, from Hakel (Cat. Foss. Fishes, IV, p. 241, pl. xii, fig. 5). However, the latter is a more elongated fish, having the length of the head contained in the distance between the pectoral arch and the base of the caudal fin three times. It also has the scales conspicuously serrated, and only 10 or 11 rays in the dorsal fin.

All of the specimens, except two, are from Hajula.

Osmeroides ornatus, sp. nov.

PLATE XXXIII, FIGURE 5.

No. 4518 (3870), from Hakel, appears to belong to an undescribed species of *Osmeroides.* Only a single specimen has been found in the collection. The total length is 48 mm.; to the base of the caudal 36 mm. The length of the head, including the opercular apparatus, equals 14 mm. The greatest depth is 12.5 mm. It will be seen, therefore, that the depth is less than the length of the head, and is contained in the distance from the pectoral arch to the base of the caudal fin less than twice. There are 25 vertebræ behind the operculum; hence not more than 30 altogether. There are 11 or 12 in the caudal region. The dorsal fin arises 7.5 mm. behind the occiput. The number of its rays is uncertain, but there are probably not more than 10. The ventrals are inserted below the anterior half of the dorsal. The rays of the anal cannot be counted, but the fin is short. The caudal is deeply forked. The pectoral fins are delicate and inserted well above the ventral border.

The scales are thick and deeply serrated, as may be seen on the matrix, and even in some places where the scales overlie one another. The operculum is conspicuously ornamented with coarse ridges and rows of tubercles, which radiate from the articulation of the bone with the hyomandibular. There seem to be similar ridges on the other opercular bones and apparently on the cheeks.

The mouth appears to have been relatively small, the articulation of the lower jaw being advanced to a perpendicular line from the front of the orbit. The lower jaw is only 5 mm. long. The orbit is rather large.

This species differs from *O. megapterus,* a Sahel Alma species, in having fewer vertebræ, 30 or fewer instead of 40. From *O. woodwardi* Hay (= *S. attenuatus* A. S. Woodward), from Hakel, it differs in being less elongated and in having coarsely serrated scales. It appears to resemble most *O. pusillus*, described as *Sardinioides pusillus* by Dr. Woodward, from Sahel Alma, but the latter is a more robust species, with evidently a larger mouth. Nothing in the description indicates that its opercular bones are ornamented like those of *O. ornatus*.

Collected at Hakel.

Acrognathus *Agassiz.*

Acrognathus Agassiz (L.), Poiss. Foss., V, pt. ii, 1844, p. 108.—Woodward (A. S.), Cat. Foss. Fishes, IV, 1901, p. 243; Foss. Fishes English Chalk, 1902, p. 36.

The type of this genus is *A. boops* Agassiz. The type specimen of this species is practically the only known example. It is refigured in Dr. Woodward's publication of 1902, cited above. Unfortunately this author has not figured his *A. libanicus*, from the Cretaceous of Sahel Alma. The following species is believed to be congeneric with the one described from Sahel Alma, but it is doubtful if either belongs to the genus *Acrognathus*.

Acrognathus dodgei, sp. nov.

Plate XXXIV, Figure 3.

The type of this species is No. 4520*a* (3673). It has a total length of 88 mm.; to the base of the caudal fin 68 mm. The head and the opercular region together measure 20 mm. The depth is 21 mm. The rays of the dorsal fin are somewhat confused, but there appear to be 12 interneural supports. The pectoral fin is wanting in the specimen. The ventrals are slightly in front of the origin of the dorsal, but this is probably due to slight displacement. The rays are stout. The anal is somewhat damaged, but it was evidently short. The vertebræ number 32 or 33. The scales are thick.

The premaxilla is furnished with small teeth. The mandible is high posteriorly. Its length is 10 mm. The articulation is brought forward to beneath the eye.

At the base of the caudal fin, both above and below, are about half a dozen reduced rays, and these are preceded by a very short, but stout, modified ray, which appears to have been pointed at both ends. It resembles a similar ray seen in the same situation in *Microcœlia dayi*.

Another example, No. 4520*b* (3696), shows the ventrals placed slightly farther backward than in the type. The pectoral fin has 10 rays. Other specimens, referred to the same species, present the pectoral fin as placed considerably above the ventral border.

It is probable that normally the ventral fins of this species are inserted opposite the middle of the dorsal fin.

This species differs from *A. boops* Agassiz and *A. libanicus* A. S. Woodward in having a shorter head and a smaller orbit. All the specimens, about 10 in number, are from Hajula, except No. 4520*c* (3836), No. 4520*d* (3767), No. 4520*e* (3730), which are from Hakel.

Named in honor of Rev. D. Stuart Dodge, the donor of the collection here described.

Nematonotus longispinus (*Davis*).

PLATE XXXIV, FIGURE 2; PLATE XXXV.

Pseudoberyx longispina DAVIS (J. W.), Trans. Roy. Dublin Soc. (2), III, 1887, p. 511, pl. xxv, fig. 2.

Nematonotus bottæ (in part) WOODWARD (A. S.), Cat. Foss. Fishes, IV, 1901, p. 250.

Among the fishes collected by Professor Day at Hajula there is a considerable number which appear to me to be different from *Nematonotus bottæ*, and which I have no means of distinguishing from the species described by Davis, as above cited. The latter has been identified by Dr. A. S. Woodward as *N. bottæ;* and his procedure may prove to be correct. If so, the form here described will require a new specific name.

These Hajula specimens differ from *N. bottæ* especially in the great length of one of the anterior dorsal fin-rays. It also appears to attain a much greater size than does the species from Hakel. Six specimens are especially to be mentioned, as follows: Nos. 4510*a–f* (3655, 3663, 3664, 3678, 3679, 3723).

No. 4510*a* (3655) has a total length of 95 mm. The pectorals and ventrals appear to be larger than they are in specimens of *N. bottæ*. The pectoral seems to have had 13 rays. Of these the third is the largest, its breadth being 1 mm, and it is broken off at a distance of 16 mm. from its base. The ventral fin appears to have comprised 8 rays. These are broken off at a distance of 10 mm. from the base, but they have evidently extended much farther. The dorsal probably possessed 12 rays; there are 12 interneurals. Of the rays, the third is greatly elongated, extending nearly to the tip of the caudal fin. In the anal there are 8 or 9 rays. The caudal is deeply forked. There appear to be 28 vertebræ. The scales are large. I count 4 above the lateral line.

No. 4510*b* (3663) has the caudal region and the caudal fin wanting. The total length must have been close to 170 mm. The head is 39 mm., the depth of the body, 47 mm. The elongated dorsal ray is only 50 mm. long, but had doubtless in life been longer. The pectoral rays are 24 mm. long, but may originally have been longer. The stomach and intestines are represented by their phosphatic contents, the former having formed an S-like loop.

No. 4510*c* (3664) lacks the body in front of the dorsal fin and most of the remainder of the body below the vertebral column. This individual has had a total length of about 200 mm., a giant when compared with the described specimens of *N. bottæ*. From the fork of the caudal fin to the front of the dorsal is 107 mm. The third dorsal ray has no remarkable length, but it appears to have had the extremity broken off.

No. 4510*d* (3678) (Pl. XXXIV, Fig. 2), lacks most of the caudal fin. The specimen measures 70 mm. to the base of the caudal. The third dorsal ray has a length of 56 mm., and would extend nearly to the extremity of the caudal fin. The head is 24 mm. long; the body 37 mm. deep. The longest pectoral ray is nearly as long as the head.

No. 4510*e* (3679) is a nearly complete fish, but it has suffered some weathering. The total length is 102 mm.; to the base of the caudal fin 76 mm. The longest dorsal fin-ray equals 62 mm. No. 4510*f* (3723) (Pl. XXXV), has a total length of 170 mm. The elongated dorsal ray runs to the edge of the block bearing the fish; the part remaining measures 77 mm., and would have overlapped somewhat the caudal rays.

Other specimens of the genus found at Hajula are referred to *N. bottæ*. Some of these are quite certainly such, but others may belong to *N. longispinus;* being either quite young individuals, or having had the elongated dorsal ray broken off. If the form here called *N. longispinus* is really *N. bottæ*, it appears strange that more individuals have not been found at Hakel, Davis's specimen being the only one found there possessing a greatly elongated dorsal.

Microcœlia dayi, sp. nov.

PLATE XXXI, FIGURE 3; PLATE XXXIV, FIGURE 1.

There is in the collection a considerable number of specimens of what must be regarded as a distinct species of the genus *Microcœlia*. Of these, No. 4525*a* (3692) is taken as the type (Pl. XXXIV, Fig. 1). The total length of this is 98 mm.; to the base of the caudal fin 75 mm. All portions of the body are represented, although in places the scales are flaked off, leaving only their imprint on the fine matrix. The length of the head, including the opercular apparatus equals 23 mm. The depth of the body, greatest between the pectoral and the ventral fins, is 28 mm.; but other specimens seem to indicate that this is not natural. From the shoulder girdle to the base of the caudal fin is 53 mm. There are 42 vertebræ behind the pectoral arch, of which 24 belong to the caudal region. Altogether there are 49 vertebræ. Each vertebral centrum is strengthened by about 5 longitudinal ridges on each side. The jaws are tightly closed, so that the teeth cannot be observed. The gape is evidently large and considerably oblique, the length of the lower jaw being 15 mm. The orbit is large; the diameter of the eye, as shown by the sclerotic bones, is 7 mm. There are 25 or 26 rays in the dorsal fin, including 5 short, undivided ones in front. I count 22 supporting interneurals. In the anal fin there appear to be

18 or 19 rays, but there are 20 interhæmals present. The middle of the back, from the occiput to the dorsal fin, is occupied by a line of crimpings, such as have been mentioned by Dr. A. S. Woodward in the case of *M. libanicus*. These have the appearance of narrow folds or ridges, which are directed upward and backward, each ending in a point. What the relation of these crimpings is to the median row of scales has not been determined.

The pectoral fins are missing from this specimen. The ventrals are inserted somewhat in front of the origin of the dorsal, but they may have been moved slightly forward through distortion.

Another specimen, No. 4525*b* (3677), is a slenderer fish than the type, but this elongation may not be wholly natural. The head has a length of 19 mm., while the depth is only 16 mm. The length of the head is contained in the total length of the fish 4 times, as in the type. The fin rays agree closely with those of the type. The ventrals are placed beneath the origin of the dorsal. Fifteen rays are counted in the pectorals and 13 in the ventrals. In front of the interneural bones which support the dorsal fin rays there are at least 12 others which have no rays. These have the upper ends expanded and turned somewhat forward. These are seen also in the type of the species. Both specimens show also an enlarged, free, and spine-like ray in the midline above and below and just in front of the first caudal rays. It was wholly, or almost wholly, buried in the flesh. There are on each side at least 9 branchiostegal rays.

No. 4525*c* (3798) is a third specimen of this species. It is nearly complete, and it has a length of 84 mm.; to the base of the caudal of 65 mm. The head is 21 mm. long; the depth is 19 mm. There are 49 vertebræ. The origin of the ventrals is beneath that of the dorsal fin. There are apparently 26 rays in the dorsal, and these are supported by 23 interneurals. The anal fin is supported by 20 interhæmals. The crimped scales in front of the dorsal are seen.

No. 4525*d* (3803) has a length of 110 mm. No. 4525*e* (3816) shows unusually well the crimpings in front of the dorsal (Pl. XXXI, Fig. 3, *cr. sc.*). These appear to consist of squarish masses whose broad sides are applied to the similar masses in front and behind, while the narrower sides look outward and upward. There seem to be about three or four of such masses for each median scale.

All the specimens are from Hajula. The species is named in honor of Professor Alfred Ely Day, of the Protestant Syrian College at Beirut, who made the collection which is described in this paper.

Rhinellus delicatus, sp. nov.

The type of this species is a small and probably young fish. Its number is 4530 (3661). The total length is only 32 mm.; from the snout to the base of the caudal fin is 26 mm. It is also quite slender, the greatest depth being only 2.5 mm. The head is injured, so that little except the upper and lower jaws remains. The whole head seems to have been 7 mm. long. The jaws are slender and are 4 mm. long, but it is not certain that the extremities are not broken off. No teeth are to be seen. Pectoral, ventral, dorsal, anal, and caudal fins are all present. The pectorals have a length of 4 mm. The ventrals are inserted 4.8 mm. behind the base of the pectorals. The number of the rays cannot be determined. The origin of the dorsal fin is about 2 mm. behind that of the ventrals. The rays are delicate, and those that can be counted are 8 in number, but these probably do not represent the whole number originally present. The anal fin is placed halfway between the dorsal and the caudal fins. The number of its rays cannot be determined. The caudal fin is deeply forked.

There appear to be 43 vertebræ. These, especially the more anterior ones, are somewhat longer than deep. No ribs are seen. Scales are present, but their boundaries are indistinguishable.

This fish differs from others of the genus in having the origin of the dorsal fin much nearer the occiput than to the base of the caudal fin.

This species comes to us from Hajula.

GONORHYNCHIDÆ.

Charitosomus hakelensis (*Davis*).

Spaniodon hakelensis DAVIS (J. W.), Trans. Roy. Dublin Soc., III, 1887, p. 591, pl. xxxiv, fig. 4.

Charitosomus hakelensis WOODWARD (A. S.), Ann. and Mag. Nat. Hist. (7), II, 1898, p. 412; Cat. Foss. Fishes, IV, 1901, p. 274.

Some specimens of this species appear to have the ventral fins situated immediately below the origin of the dorsal. No. 4523*a* (3746) is from Hakel. It is much elongated and very slender, but this form may be due to distortion. The anterior portion of the head is missing. The ventrals are placed just below the origin of the dorsal. No. 4523*b* (3817) has apparently 44 vertebræ, and the ventrals are situated slightly behind the front of the dorsal.

In the Cope collection there is a small lot of fishes from Mount Lebanon. There is no record of the locality, but all the species are those found at Hakel. Among these are two specimens of this species. No. 3895 is a nearly complete fish, only the anal fin and a portion of the caudal being gone. The length to the base of the caudal is 82 mm. The elements of the snout are injured, so that not much information regarding them is to be obtained. Dr. A. S. Woodward's conclusions regarding the small size of the mouth are confirmed. No teeth are observed. In this specimen also the ventral fins are below the front of the dorsal. There are 44 vertebræ. Where the scales are present they form an incrustation whose elements cannot be distinguished. Where they are flaked away from the matrix but little impression is left. There are, however, faint lines which seem to indicate that the scales were of an elongated diamond-shaped form, ending behind in a sharp point. Nothing is seen to suggest the spiny scales of *Gonorhynchus*.

The other specimen, No. 3894, is without the head and the caudal fin. The length from the pectoral arch to the base of the caudal has been more than 100 mm. The ventral fins are placed below the middle of the dorsal. Each ventral fin has plainly 8 rays. There are at least 11 rays in the pectoral fin. Where the incrustation of scales remains there is seen a number of very distinct narrow, longitudinal, whitish lines along the body. These probably indicate rows of scales. I count about 10 of these lines below the vertebral column, and apparently 5 or 6 above it. Possibly this species was longitudinally striped. No additional information regarding the scales is to be obtained.

ANGUILLIDÆ.

Urenchelys *A. S. Woodward.*

Urenchelys WOODWARD (A. S.), Ann. Mag. Nat. Hist. (7), V, 1900, p. 322; Cat. Foss. Fishes, IV, 1901, p. 337; Foss. Fishes English Chalk, 1902, p. 30.

Urenchelys germanus, sp. nov.

PLATE XXXVI, FIGURE 1; PLATE XXXVII, FIGURE 7.

There are several specimens of eels from Hajula which are referred to this supposed new species. None of these are complete fishes, more or less of the caudal region being missing in all of them. No. 4515*a* (3654) is regarded as the type (Pl. XXXVI, Fig. 1). Of this individual, perhaps about 25 mm. of the extremity of the tail is gone. The remainder of the animal is well preserved. Anteriorly the head and trunk are viewed from above; from just in front of the anal fin backward the fish lies on its side. This species is closely related to *U. avus*, described by Dr. A. S. Woodward from the Upper Cretaceous of Sahel Alma (Cat. Foss. Fishes, IV, p. 337, pl. xviii, figs. 1, 2), and there are few characters by means of which it may be distinguished. However, it appears that the part of the trunk which lies in front of the anal fin has a greater number of vertebræ, and it is longer in proportion to the length of the head than in *U. avus*. The latter is stated to have about 35 vertebræ in front of the anal, whereas *U. germanus* possesses over 40. This portion of the trunk is also about 5 mm. longer than that of *U. avus* relatively to the length of the head.

For these reasons I regard the Hajula specimens as forming a distinct species.

There is in none of the individuals any trace whatever of the ventral fins, although the fishes must have been enclosed in the matrix without any disturbance of their parts. This is indicated by a brown stain on the matrix, which shows that the outline of the body is unbroken in the region where the ventrals would have been located. It is further evident that they are not specimens of *Anguillavus quadripinnis*, since the head of the latter is longer and more pointed; furthermore, in the specimens referred to *Urenchelys* there are no indications of plates in the region of the lateral line.

The head of the type of *U. germanus* has a length of 24 mm.; the portion of the trunk between the head and the anal fin measures 46 mm., and the part of the caudal region remaining equals 74 mm. Between the occiput and the anal fin I count 43 vertebræ. The neural arches of this region are broken away. Slender ribs project on each side. Behind the origin of the anal fin are 47 vertebræ, making 90 in all. In case the caudal region was more than twice as long as the portion of the trunk in front of the anal, as is the case with *U. avus*, there must have been considerably more than 100 vertebræ in the vertebral column.

The upper surface of the skull closely resembles that of *Anguilla*. Vomer, ethmoid, united frontals, the parietals, and probably the supraoccipital and epiotics can be located, although the sutures cannot always be seen. The opercular apparatus is well developed, showing apparently all the elements found in *Anguilla*, and possessing the peculiarities of the latter genus. The lower jaw is two thirds the length of the cranium. The palatopterygoid bar seems to have the structure seen in *Anguillavus*. Many teeth are seen on both the maxilla and dentary.

Both pectoral fins are well displayed, and each had at least 18 rays. As already stated, there are no evidences of ventral fins. The dorsal fin is seen to come as far forward as the 13th vertebra from the occiput. Just behind the head there are 8 vertebræ in 10 mm.; in the anterior portion of the caudal region there are only 6 in this space. From this and other specimens it is seen that the notochord passed uninterruptedly through the vertebral centra. The neural spines of the caudal region are moderately stout and are smaller at their bases than in the middle of their length. The hæmal spines are slender and tapering, and have long, delicate flesh-bones attached to them.

No. 4515*b* (3762) appears to have only 40 or 41 vertebræ in front of the anal fin. In No. 4515*c* (3695) we have what seem to be the most anterior rays of the dorsal fin, and these are placed over the 12th vertebra behind the occiput. Another specimen confirms this view.

No. 4515*d* (3790), from Hakel, probably belongs to this species, since it is too large to belong to *U. hakelensis*. This presents the vertebral column seen from above. In the case of some of the vertebræ the neural arches have slipped to one side of their centra, so that the upper surfaces of the latter are exposed. The right and left portions of each arch are distinct, never having been co-ossified (Pl. XXXVII, Fig. 7).

No. 4515*e* (3860) presents the head and the trunk to a short distance behind the origin of the anal fin. Here also there are 43 vertebræ in front of the anal. The head is flattened from above, and its hinder portion is broken away. Numerous short blunt teeth are seen on the dentary and the maxilla. There are also traces of vomerine teeth. Eleven branchiostegal rays are counted on one side. They extend far backward and the distal ends of some are curved upward. Both pectoral fins are displayed, and each seems to have possessed at least 20 rays. There are no traces of ventral fins, although the conditions seem favorable for their preservation had they existed.

ANGUILLAVIDÆ, fam. nov.

Apodes with well-developed cleithrum, pectoral arch, pectoral and ventral fins, and a distinct caudal fin. Dorsal and anal fins extended. Palatopterygoid arch developed. Scales rudimentary or absent; in some cases a row of enlarged plates on each side, probably on the lateral lines. Ribs present. One genus, *Anguillavus*.

Anguillavus, gen. nov.

The characters of this genus are included in those of the family. The type of the genus is *Anguillavus quadripinnis.*

Anguillavus quadripinnis, sp. nov.

PLATE XXXVI, FIGURES 2 AND 3.

Of this species there is recognized in the collection only a single specimen, No. 4512 (3796), collected at Hajula. This specimen lacks the whole of the caudal region. It is lying on the block with the dorsal surface directed upward. The following dimensions are noted: Length of the head to the occiput, 25 mm.; to the posterior border of the opercular apparatus, 33 mm. Length from the snout to the thirty-eighth vertebra, 90 mm.; height of the body, 14 mm.

The suspensory apparatus of the jaws is extended laterally. Hyomandibular and quadrate are present, and from the distal end of the latter the mandible runs forward and projects somewhat beyond the snout, as in *Anguilla.* Parallel with the premaxillæ on each side are the maxillæ. Starting from the quadrate there runs forward on the left side a very distinct palatopterygoid arch. The pterygoid portion terminates 7 mm. behind the snout. For a great part of its length this portion has a width of only one millimeter, and the width is occupied by two distinct bones. Of these, the inner is regarded as the entopterygoid, the outer, as the ectopterygoid. The anterior ends of these bones lie on the upper surface of the parasphenoid, as do also the corresponding bones of the other side; but this position is probably due to some shifting during decomposition. Immediately in front of these pterygoids there is, on each side, a small, scale-like bone which may be the prefrontal. Outside of these, underlapping the anterior ends of the pterygoids, and extending forward toward the snout, are two delicate bones, one on each side, and these I regard as the palatines. The appearance of these bones indicates that they were already much reduced. There are almost certainly no teeth on the arch thus constituted. A bone resembling a supramaxilla lies above the maxilla.

Behind and mesiad of the palatopterygoid arch are seen the anterior ends of the stout hyoids. Slender branchiostegals appear to be attached to these near their anterior ends. Some of the upper branchiostegals are widened out at their posterior ends and curled upward, but not so conspicuously so as in *Anguilla*. The opercular bones appear to have resembled those of *Anguilla*, but mostly only impressions of these on the matrix remain.

The bones of the roof of the skull have been considerably injured, so that the exact limits of the elements cannot be determined.

Fragments of the cleithrum are present. The pectoral fins are well preserved, and the rays, apparently 16 in number, had a length of nearly 9 mm. The number of the baseosts cannot be determined. There are distinct evidences of the scapula and the coracoid.

Both ventral fins are present, attached to their supporting bones (Pl. XXXVI, Figs, 2, 3, *v. f.*). The latter are only slightly more than 2 mm. long. The extremities of the fin rays are broken off. There appear to have been about 8 rays in each fin. These fins are placed 65 mm. behind the occiput, and were doubtless only a short distance in front of the anal fin. Owing to the position of the fish, the dorsal fin is not displayed.

There are 31 vertebræ preserved, the last of which lies over the ventral fins. The centra are constricted, and 5.5 of them occupy the space of 10 mm. The ribs are slender and rather long, some of them 5.5 mm.

There are evidences of the presence of two rows of bony plates, one on each side of the body. These probably occupy the position of the lateral line. On the right side these are shown as impressions on the matrix, and, beginning just behind the cleithrum, continue as far as the specimen is preserved. On the left side, they may be followed throughout the greater part of the abdominal region, and in several places are represented by thin bony scales. These plates, or scales, are relatively large, six of them being found in 10 mm. No other scales or plates are seen on the body.

Collected at Hajula.

Anguillavus bathshebæ, sp. nov.

PLATE XXXVII, FIGURE 1.

The type of this species is No. 4513*a* (3704), while No. 4513*b* (3685) is regarded as the paratype. The type is from Hakel, the paratype is from Hajula. No. 4513*c* (3868) is a second specimen from Hajula.

The type is a nearly complete fish, wanting only the tip of the snout and the extremities of the rays of the caudal fin (Pl. XXXVII, Fig. 1). The paratype presents the hinder half or more of the body. The total length of the type is 168 mm. Two millimeters may be added for the missing portion of the snout. The whole head would then measure, to the occiput, 12 mm.; to the cleithrum, 19 mm. The dorsal fin has evidently had its origin 13 mm. behind the occiput, since there the first rays are seen, and in front of these a stain on the matrix plainly reveals the outline of the body. The dorsal fin continues backward to near the caudal fin, but is plainly distinct from the latter. The caudal is fan-shaped, rounded at the extremity, and is supported by 5 or 6 hypural bones. These characters are confirmed by the paratype. The anal begins 59 mm. behind the occiput and continues to near the caudal fin. The ventral fins have their origin 50 mm. behind the occiput. In the type only one of these fins is preserved, and an injury to the matrix has removed both the supports of these fins. Another flaking away of the rock occurs just behind the ventral; but these rays cannot belong to a detached portion of the anal, since they have the structure of ventral rays, and not that of anal rays. Moreover, the course of the hinder portion of the intestine is shown by its fossilized contents, and this passes above the rays in question. In the paratype both ventrals are in their normal position and attached to their supports. Each of these fins is about 5 mm. long and is composed of 8 rays.

There are apparently 44 vertebræ in front of the origin of the anal fin and 57 behind its origin. The neural arches are long and low, and each is overlapped in front by the preceding arch. The centra are long, constricted in the middle of the length, and they are permitted the notochord to pass continuously through them. In the abdominal region there appear to be no neural spines. These are first seen as low and rather broad plates just over the origin of the anal fin. They soon become considerably higher and quite slender, but expanding somewhat toward their distal ends. The hæmal arches are well developed, the spines of many of the anterior ones being expanded at their distal extremities. Only the merest traces of a few ribs are seen in the specimens.

The rays of the dorsal and anal fins are slender, and there are, on an average, two and one third interneurals and interhæmals for each vertebra.

The cleithrum is preserved in its natural position. It is sigmoid in form, and is pointed at both the upper and the lower end. The substance of the pectoral fins is wanting, but there is present what appears to be the imprint of one on the matrix.

So far as preserved, the head resembles that of *Anguilla*. The hinder portion of the lower jaw is present, articulated to the quadrate. It is not certain that any part of the palatopterygoid arch is seen. A strongly developed hyoid arch is present, and to each side are attached at least 15 branchiostegal rays. These are long and slender, some of the uppermost ones being broadened at their hinder ends and turned upward. The opercular bone is probably represented by a flake of bone.

Both the specimens appear to have been enveloped in a fine matrix without any part having been disturbed. The lower outline of the body is distinctly marked by a brown stain. This stain and minute patches of similar stain on the sides of the abdominal region may indicate the existence of scales, but of these there is no other evidence. There are no traces of enlarged scales along the sides of the body, such as are found in *A. quadripinnis*.

This eel resembles rather closely Davis's *Urenchelys hakelensis*, and at first it was regarded as such. A closer study has, however, made it certain that the two are distinct species. In *U. hakelensis* the dorsal fin probably came forward to the occiput. According to the published figures of *U. hakelensis*, the vertebral centra are higher than long. This is confirmed by the examination of three small specimens in this collection. In *A. bathshebæ*, on the contrary, the centra are longer than high, longer, in fact, than the height of the centrum and the neural arch taken together. The figures of *U. hakelensis* show that the portion of the body in front of the anal fin measures 38 mm., the portion behind this fin to the base of the caudal, 53 mm. In *A. bathshebæ* the two portions of the body are practically equal. Of course, the presence of ventral fins in *A. bathshebæ* and their absence in *U. hakelensis* constitutes the most important difference between the two species; but the other differential characters given may enable us to distinguish specimens when the region of the ventral fins is injured or absent.

Named in honor of Bathsheba, who attained the distinction of being a wife of one great king and poet and the mother of another great king and poet.

ENCHELIIDÆ, fam. nov.

Apodes destitute of cleithrum, of all paired fins, and, so far as known, of all median fins. Opercular apparatus greatly reduced. Vertebral centra apparently diplospondylous. No scales.

Enchelion, gen. nov.

Characters included in those of the family. Type *E. montium.* Derivation, εγχέλειον, a little eel.

Enchelion montium, sp. nov.

PLATE XXXVII, FIGURES 2–6.

The types of this species are No. 4514*a* (3765) and No. 4514*b* (3766). These specimens are both from Hakel.

No. 4514*a* (3765) (Pl. XXXVII, Fig. 2) presents a vertebral column extending from the extremity of the tail forward to an unknown distance behind the head. The length of the part of the column present is 143 mm. No. 4514*b* (3766) (Pl. XXXVII, Figs. 3, 4) presents the head and 45 mm. of the vertebral column. It has belonged to a somewhat smaller specimen than the other. The striking feature of the vertebral axis of this form is that all the vertebræ, from the head to the tail, have been represented each by two rings or "bodies," apparently just such a condition as we find in the middle of the caudal region of *Amia* among living fishes and in that of *Eurycormus* of the Jurassic. That this condition exists in the species before us is shown by the fact that throughout the series only alternate vertebral centra possess neural spines, while in the caudal region only those centra bear hæmal spines which have neural spines.

In view of my results in the study of the vertebral column of *Amia* (Field Columbian Mus. Pubs., Zoöl. Ser., I, p. 37, 1895), I hold that a vertebral ring possessing a neural arch and one without such an arch together constitute the equivalent of such a vertebra as we find in ordinary fishes; and that the archless ring belongs, not with the ring situated immediately in front of it, but with the one just behind it. In the species before us the rings, or "bodies," which have no neural spines appear to possess neural arches, and thus seem to differ from the corresponding elements in *Amia*. However, in the tail of *Amia* the rings which have no neural arches have their upper halves formed from ossifications which develop on the upper surface of the notochord and on each side of the myelon; and there appears to be no reason why these ossifications should not sometimes grow upward and form an arch over the myelon. Such an arch would not, however, be the equivalent of the arch which develops the spine, since this arch is formed, in *Amia* at least, by a pair of bones distinct from the centrum on which it rests.

For reasons detailed in the paper referred to, I shall call the 'centrum' which is devoid of either neural spine or hæmal arch an epihypocentrum; that provided with either or both arches, a pleurohæmacentrum. The former corresponds with what Dr. Zittel and others call the hypocentrum; the latter with what is called a pleurocentrum.

In the species before us I find 17 vertebral rings in a length of 10 mm. in the larger specimen, and 23 in the same length of the smaller one. The pleurohæmacentra are usually somewhat shorter than their companion rings. Both have their neural arches low and extending backward so as to overlap the arch just behind it. The epihypocentra present a short backwardly directed spine and a shorter process which extends forward somewhat over the arch in front. The pleurohæmacentra possess neither process. Both kinds of centra send downward a rather broad, short process, that of the epihypocentrum being apparently somewhat longer. No ribs are found articulating with any of these processes. Both the pleurohæmacentra and the epihypocentra are constricted about the middle. I have not been able to determine whether or not they permitted the passage of the notochord.

When we come to examine the caudal region we find the pleurohæmacentra not especially different from those of the abdominal region (Pl. XXXVII, Fig. 6). The inferior processes are, however, somewhat smaller. On the other hand, the epihypocentra are furnished with well-developed hæmal arches. These can be seen to continue to near the tip of the tail. Altogether there are close to 275 vertebral rings preserved in the larger specimen. Of these about 170 belong to the caudal portion of the body. This would indicate that in the tail there are 85 complete vertebræ.

No traces are seen anywhere of either fin rays or of interneural or interhæmal bones. All were probably absent. The extremity of the tail is shown only by a faint impression on the matrix, and there are no traces of a caudal fin. Likewise, there are no indications anywhere of scales.

The head of this species appears to be remarkably small. Its length in the smaller specimen, measured to the occiput, is only 4.5 mm.; but, including the branchiostegal rays, 9.5 mm. Its height is 1.5 mm. The snout appears to have been conical. In the jaws are small teeth in more than a single row. The branchiostegal rays are slender, much longer than the skull, and the hinder ends are somewhat curved upward. No opercular bones or pectoral arch is present.

BERYCIDÆ.

Pycnosterinx levispinosus, sp. nov.

PLATE XXXVI, FIGURE 4.

This small species was found at Hajula. The number of the type and only specimen is 4528 (3671).

This has been a very short-bodied, elevated, and compressed fish. It is possible that distortion has somewhat diminished its length, but of this there is no evidence. The length from the snout to the base of the caudal fin is 29 mm., while the greatest depth is 30 mm. The length of the head to the border of the operculum is 12.5 mm. The body has been covered with scales of moderate size. Whether or not these were ctenoid is yet uncertain. There is some indication that they were feebly ctenoid. The scales have also covered the bases of the dorsal and anal fins.

The dorsal fin has been composed of 7 or 8 spines and apparently 16 soft rays. Seven spines are present, but it seems probable that the most anterior one has been eroded away. The spines are stout and entirely smooth. The tip of the hindermost has apparently been segmented, but its size makes it proper to count it with the spines. Through erosion of portions of the bone it is seen that the spines and the supporting interneurals have been hollow, their lumen being now filled with calcite. It is also revealed that the notochord passed continuously through the vertebral centra.

The anal fin has had 3 or 4 spines and 10 to 12 soft rays. It seems probable that the most anterior one has been weathered away. These spines are stout and smooth.

The caudal fin has been forked. The pectoral fin is present in its natural position, but the rays have been damaged. The ventrals arise below the pectoral. The spine has been stout, and long enough to reach to the first soft rays of the anal fin. It is now represented mostly by its imprint in the matrix.

From the other species of the genus found at Mount Lebanon, except *P. dubius*, this species differs in the greater number of dorsal spines and smaller number of soft rays.

From *P. dubius* it differs in having fewer soft rays in the dorsal and anal fins, and in having these smooth, instead of ribbed.

The possibility that this fish is specifically identical with the one here described as *Aipichtys formosus* has not escaped the attention of the writer. Were the dorsal spines present in the latter species, this question could be settled more satisfactorily. It is regarded as belonging to *Aipichtys* rather than to *Pycnosterinx*, because the scales are smooth-edged, and there appear to be thickened scales along the border of the abdomen. Aside from the generic differences, *Pycnosterinx levispinosus* has almost certainly been a deeper-bodied fish. If we measure the distance from the anterior anal spine to the anterior soft rays of the dorsal in the two fishes, we find that in *P. levispinosus* this measurement is equal to the distance from the base of the caudal fin to the snout; while in the case of *Aipichtys formosus* the dimension will be equal only to the distance from the caudal base to the front of the opercular apparatus. Again, the ventral spine of *P. levispinosus* extends backward to the first soft ray of the anal fin, while in *A. formosus* it reaches only to the first spine. Lastly, there do not seem to have been any thickened scales on the abdomen of *P. levispinosus*.

CARANGIDÆ.

Aipichtys formosus, sp. nov.

Plate XXXII, Figures 2 and 3.

Of this supposed new species there is in the collection only a single specimen, No. 4519 (3831). This is incomplete, the head and the anterior portion of the body being broken away from about the articulation of the lower jaw to the middle of the dorsal fin. As a consequence, various characters are undetermined, and we cannot be wholly certain regarding the generic position of the fish.

No dorsal spines remain in the specimen. Of the articulated rays there are 13 present; possibly, but not certainly, all that were possessed by the fish. The anal fin comprises

4 short stout, spines and 12 articulated rays. The longest anal spine is only 7 mm. long, and all the spines are entirely smooth. The ray which I recognize as the first articulated one is very stout and resembles one of the spines, but it is divided and articulated at the distal end.

The base of the left pectoral fin is present. The pelvic fin has its origin directly below the pectoral. The first ray is long and thick, the length being 13 mm. and the extremity reaching the anal fin. There are at least 5, and possibly 6 or 7, articulated rays; but the number cannot be definitely determined. The caudal fin is forked, but the extremities of the rays are not exposed. Seven branchiostegal rays are counted. There are 14 caudal vertebræ.

The scales are thin, and their hinder borders have a perfectly smooth edge. They are rather large, there being about 8 longitudinal rows above the vertebral column and 12 below it. The greatest height of the body equals 38 mm.; the distance from the pectoral arch to the base of the caudal is about 28 mm.

This fish has been assigned provisionally to the genus *Aipichtys*, but it possibly belongs to *Acrogaster*, of the Berycidæ. Nothing is known regarding the structure of the head, and the number of the pelvic soft rays is uncertain. The rather large scales suggest *Acrogaster;* while, on the other hand, there appears to be a series of thickened scales along the lower edge of the abdomen, as in *Aipichtys*.

From all the described species of *Aipichtys* this differs in having a smaller number of anal rays.

From *Acrogaster heckelii* this fish differs in having a greater number of anal spines and a smaller number of articulated rays.

Collected at Hajula.

List of the Fishes found at the Three Fish-bearing Localities of Mount Lebanon.

Sahel Alma.	Hakel.	Hajula.
HEXANCHIDÆ.		
Heptranchias? gracilis.		
SCYLLIIDÆ.		
Scylliorhinus elongatus.		
Scylliorhinus curtirostris.		
Scylliorhinus tumidens.		
Mesiteia sahel-almæ.		
LAMNIDÆ.		
Scapanorhynchus lewisii.		
Scapanorhynchus elongatus.		
Otodus latus.	Otodus sulcatus.	
SQUALIDÆ.		
Squalus latidens		
S. ? primævus.		
SQUATINIDÆ.		
Squatina crassidens.		
PRISTIDÆ.		
Sclerorhynchus atavus.		Sclerorhynchus solomonis.
		Sclerorhynchus hiram.
		" sentus.
RHINOBATIDÆ.		
Rhinobatus tenuirostris.	Rhinobatus maronita.	Rhinobatus eretes.
Rhinobatus intermedius.		
Rhinobatus latus.		
RAJIDÆ.		
Raja primarmata.		
" minor.	Raja expansa.	Raja whitfieldi.
DASYATIDÆ.		
	Cyclobatis oligodactylus.	Cyclobatis oligodactylus.
	Cyclobatis major.	

Sahel Alma.	Hakel.	Hajula.
	BELONORHYNCHIDÆ?	
	Stenoprotome hamata.	
	PYCNODONTIDÆ.	
	Coccodus armatus. “ lindstrœmi. Xenopholis carinatus. Palæobalistum gœdeli.	Coccodus insignis.
	MACROSEMIIDÆ.	
	Petalopteryx syriacus. “ dorsalis.	
	OLIGOPLEURIDÆ.	
	Spathiurus dorsalis.	
	ELOPIDÆ.	
Holcolepis gracilis. “ attenuatus. Spaniodon blondeli. “ elongatus. “ latus. Thrissopteroides tenuiceps. Thrissopteroides pulcher. Istieus lebanonensis.	Holcolepis attenuatus? “ sardinioides. “ lewisi.	Holcolepis lewisi.
	ICHTHYODECTIDÆ.	
	Eubiodectes libanicus.	Eubiodectes libanicus.
	CTENOTHRISSIDÆ.	
	Ctenothrissa vexillifer. “ ovalis.	Ctenothrissa signifer.
	CLUPEIDÆ.	
Histiothrissa crassipinna.	Pseudoberyx syriacus. “ bottæ. “ grandis. Scombroclupea macrophthalma. Scombroclupea gaudryi. Diplomystus brevissimus. Diplomystus birdi.	Pseudoberyx syriacus. Scombroclupea macrophthalma. Scombroclupea gaudryi. Diplomystus brevissimus.

Sahel Alma	Hakel	Hajula
	HALOSAURIDÆ	
Enchelurus syriacus.		
	NOTACANTHIDÆ.	
Pronotacanthus sahelalmæ.		
	DERCETIDÆ.	
Leptotrachelus triqueter.	Leptotrachelus serpentinus.	Leptotrachelus serpentinus.
Leptotrachelus gracilis.	Leptotrachelus hakelensis.	
	ENCHODONTIDÆ.	
Enchodus longidens.		
" major.	Enchodus marchesettii.	Enchodus marchesettii?
Pantopholis dorsalis.	Eurypholis boissieri.	Eurypholis boissieri.
	Halec microlepis.	Halec microlepis.
	Prionolepis cataphractus.	Prionolepis cataphractus.
	Prionolepis laniatus.	
	MYCTOPHIDÆ.	
Osmeroides megapterus.	Osmeroides woodwardi.	
Osmeroides pusillus.	Osmeroides pontivagus.	Osmeroides pontivagus.
	Osmeroides ornatus.	
Acrognathus libanicus.	Acrognathus dodgei.	Acrognathus dodgei.
Leptosomus macrurus.	Leptosomus minimus.	Leptosomus minimus.
	Nematonotus bottæ.	Nematonotus bottæ.
	" longispinus.	" longispinus.
Opistopteryx gracilis.	Microcœlia libanica.	Microcœlia dayi.
Rhinellus furcatus.		Rhinellus delicatus.
" ferox.		
" damoni.		
	GONORHYNCHIDÆ.	
Charitosomus major.	Charitosomus hakelensis.	
" lineolatus.		
	CHIROTHRICIDÆ.	
Chirothrix libanicus.	Telepholis? tenuis.	
" lewisi.	Exocœtoides minor.	Exocœtoides minor.
	ANGUILLIDÆ.	
Urenchelys avus.	Urenchelys hakelensis.	Urenchelys germanus.

Sahel Alma.	Hakel.	Hajula.
	ANGUILLAVIDÆ.	
	Anguillavus bathshebæ.	Anguillavus quadripinnis.
		Anguillavus bathshebæ.
	ENCHELIIDÆ.	
	Enchelion montium.	
	BERYCIDÆ.	
Acrogaster heckeli.		
" davisi.		
Pycnosterinx russeggeri.		Pycnosterinx levispinosus.
Pycnosterinx discoides.		
" gracilis.		
" dubius.		
" elongatus.		
" latus.		
Hoplopteryx syriacus.	Hoplopteryx lewisi.	Hoplopteryx lewisi.
" stachei.		
" oblongus.		
Dinopteryx spinosus.		
	STROMATEIDÆ.	
Orosoma sahel-almæ.		
" intermedium.		
" pulchellum.		
	CARANGIDÆ.	
	Aipichtys velifer.	Aipichtys formosus.
	" minor.	" minor.

An examination of the lists given above shows that the beds at Sahel Alma contain an assemblage of species which is quite different from that found at either of the other localities; furthermore, that the fauna of Hajula closely resembles that of Hakel. From Sahel Alma there have been collected 62 species; from Hakel, 50 species; and from Hajula, 34 species. Of those obtained at Sahel Alma it is not certain that a single species has been collected at either of the other localities. It is possible that *Holcolepis attenuatus*, of Sahel Alma, occurs also at Hakel, and that *Enchodus longidens* is common to all three localities; but this is not yet proved. On the other hand, out of the 34 species found at Hajula, 20 are common to this place and Hakel. This indicates that the fish-bearing beds of these two localities are on nearly the same geological level. In case the deposits are not synchronous, can we reach any conclusion regarding their relative ages?

We observe that the Hajula fauna is related to that of Sahel Alma by the presence of three genera which are not found at Hakel, viz., *Sclerorhynchus*, *Rhinellus*, and *Pycnosterinx*. Furthermore, that pycnodonts, especially abundant during the Jurassic, are well represented at Hakel, but by only a single species at Hajula; that, of *Pseudoberyx*, there are three species at Hakel, and only one, so far as we know, at Hajula. While too great reliance must not be placed on these observations, they appear to indicate that the beds at Hakel are the lowest; that these are followed at no great distance by those at Hajula; and that those at Sahel Alma are considerably above the latter. That the latter beds are higher in the series than those at Hakel has been the conclusion of most geologists. This is further confirmed by the occurrence of Macrosemiidæ, one oligopleurid, and many pycnodonts at Hakel; while at Sahel Alma there are few or none of these, but many Berycidæ, altogether 12 species. The large number of sharks found at Sahel Alma, mostly belonging to living genera, may be regarded as indicating a more recent time than that during which the beds of the other localities were deposited.

Explanation of the Abbreviations employed on the Plates.

a. f.	anal fin.
ant. pr.	anterior transverse process (*Leptotrachelus*).
br.	branchiostegals.
br. ar.	branchial arches.
c. f.	caudal fin.
cl.	cleithrum.
cran.	cranium.
cr. sc.	crimped scales (*Microcœlia*).
den.	dentary.
derm. sc.	dermal scutes.
d. f.	dorsal fin.
d. r.	dorsal fin ray.
d. sc.	dorsal scutes.
ep. hy.	epihypocentrum.
h. a.	hæmal arch.
hy.	hyoid.
hym.	hyomandibular.
int.	intestine.
i. op.	interoperculum.
lat. sc.	lateral scutes.
mes. pt.	mesopterygoid.
met. pt.	metapterygoid.
mo.	mouth.

mx.	maxilla.
na. cp.	nasal capsule.
nar.	nares.
n. sp.	neural spines.
oc.	occiput.
op.	operculum.
orb.	orbit.
par.	parasphenoid.
pelv. gird.	pelvic girdle.
pl. h.	pleurohæmocentrum.
p. op.	preoperculum.
post. pr.	posterior transverse process.
pro. p.	propterygium.
p. sp.	pectoral spine.
pt.	pterygoid.
qu.	quadrate.
rost.	rostrum.
rost. t.	rostral teeth.
shag.	shagreen.
s. op.	suboperculum.
spl. t.	splenial teeth.
v. a.	neural arches.
v. c.	vertebral centra.
v. f.	ventral fin.
v. f. s.	ventral fin support.

EXPLANATION OF PLATE XXIV.

FIG. 1.—*Sclerorhynchus* sp. undet. Page 398. Trunk from near pectoral fin to near root of caudal fin. ×$\frac{2}{3}$. No. 4502 (3686). *d. f'*, anterior dorsal fin; *d. f.''*, posterior dorsal fin; *v. f.*, ventral fin. Anteriorly is seen the skeleton of a swallowed fish.

FIG. 2.—*Rhinobatus eretes* Hay. Page 404. Part of head and part of trunk. Type. ×$\frac{2}{3}$. No. 4500 (3715). *br. ar.*, branchial arches; *mes. p.*, mesopterygium; *met. p.*, metapterygium; *p. f.*, pectoral fin; *pelv. gird.*, pelvic girdle; *pro. p.*, propterygium; *shag.*, shagreen; *v. f.*, ventral fin; *vert.*, vertebræ.

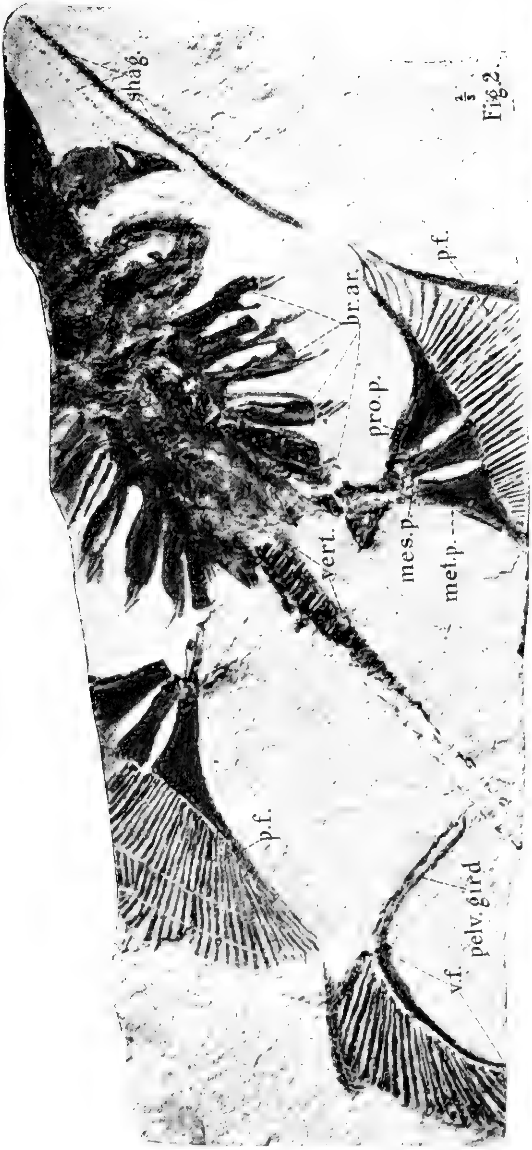


Fig. 2. $\frac{2}{3}$

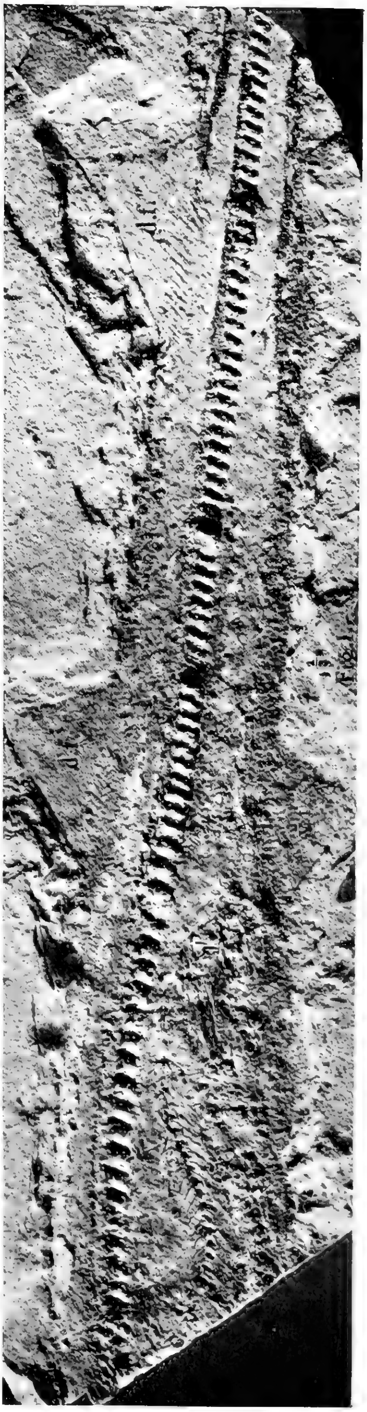
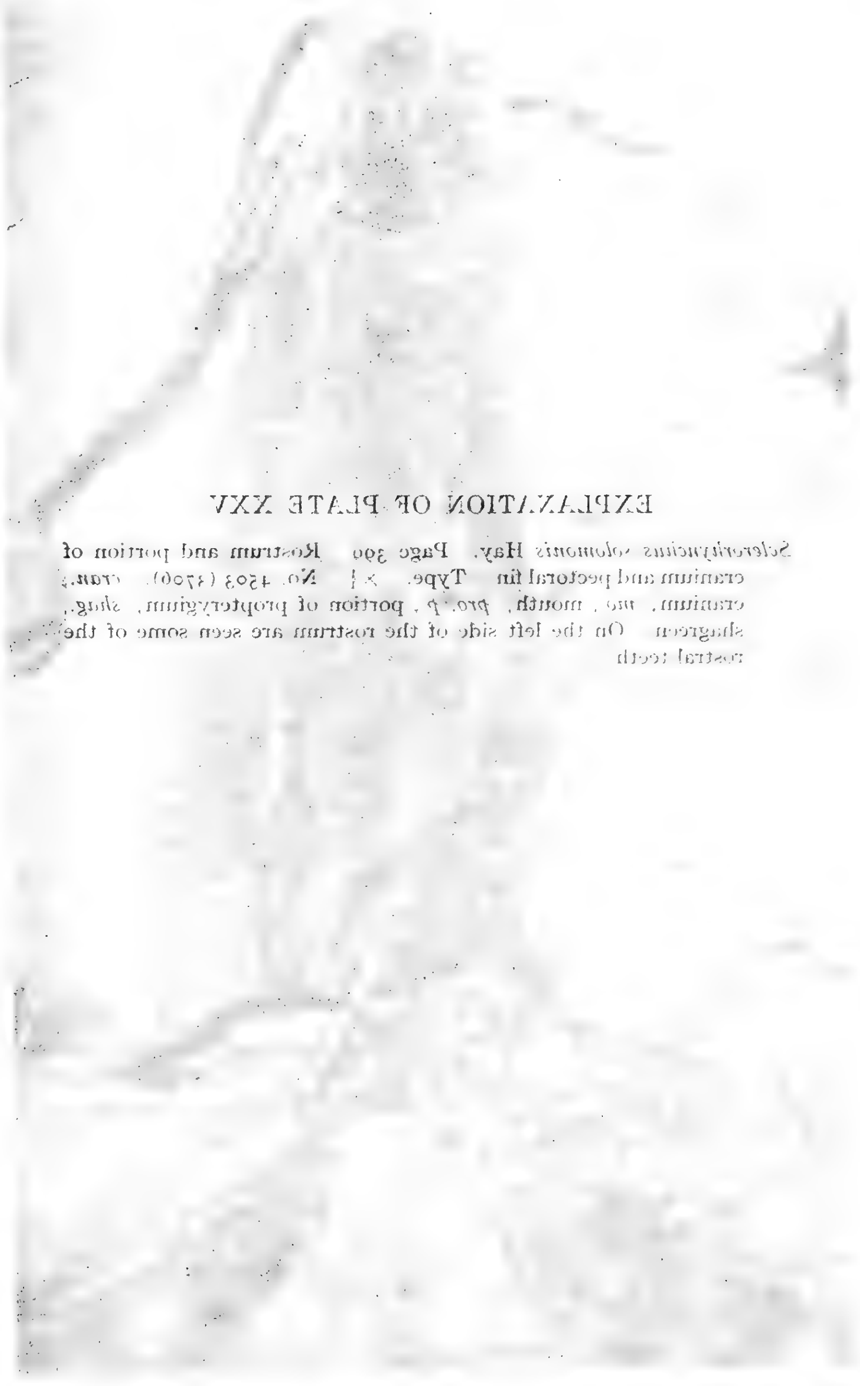


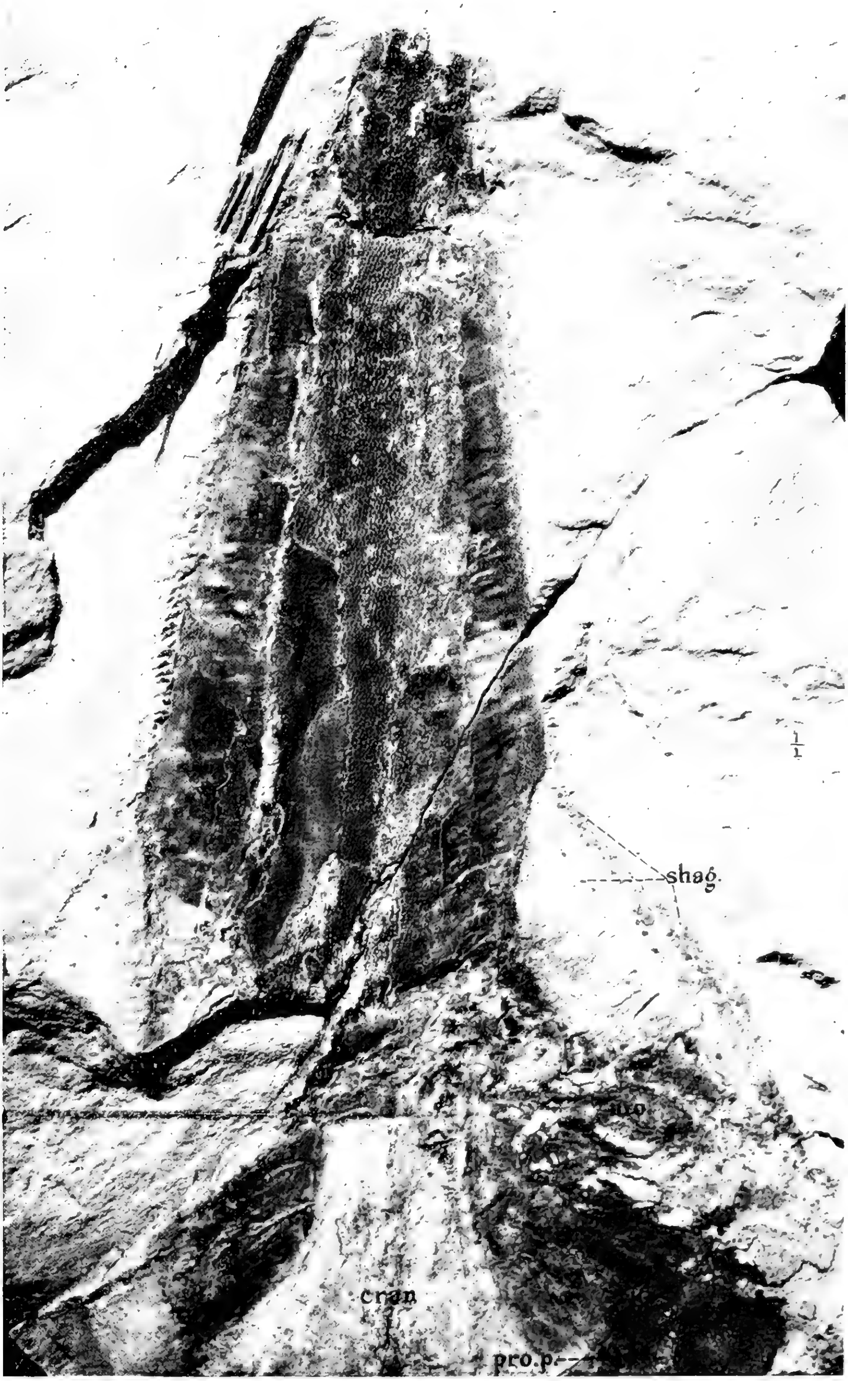
Fig. 1. $\frac{1}{3}$

MOUNT LEBANON CRETACEOUS FISHES



EXPLANATION OF PLATE XXV.

Sclerorhynchus solomonis Hay. Page 399. Rostrum and portion of cranium and pectoral fin. Type. ×$\frac{1}{1}$. No. 4503 (3706). *cran.*, cranium; *mo.*, mouth; *pro. p.*, portion of propterygium; *shag.*, shagreen. On the left side of the rostrum are seen some of the rostral teeth.



MOUNT LEBANON CRETACEOUS FISHES

EXPLANATION OF PLATE XXVI.

FIG. 1.—*Sclerorhynchus hiram* Hay. Page 401. Head, part of rostrum, and pectoral fins. Type. $\times\frac{3}{4}$. No. 4501 (3705). *br. ar.*, branchial arches; *mo.*, mouth; *mes. p.*, mesopterygium; *met. p.*, metapterygium; *nar.*, nares; *p. f.*, pectoral fin; *pro. p.*, propterygium; *rost.*, rostrum; *rost. t.*, rostral teeth; *shag.*, shagreen.

FIG. 2.—*Stenoprotome hamata* Hay. Page 407. Head and part of trunk. Type. $\times\frac{1}{1}$. No. 4509 (3863).

FIG. 3.—*Otodus sulcatus* Geinitz. Page 397. Tooth wanting the tip. Front view. $\times\frac{1}{1}$. No. 4508 (3867).

FIG. 4.—Side view of same tooth.

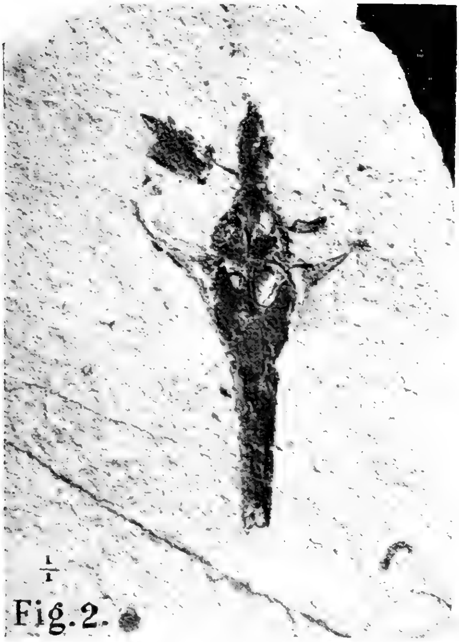


Fig. 2.

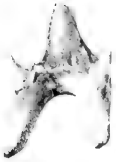
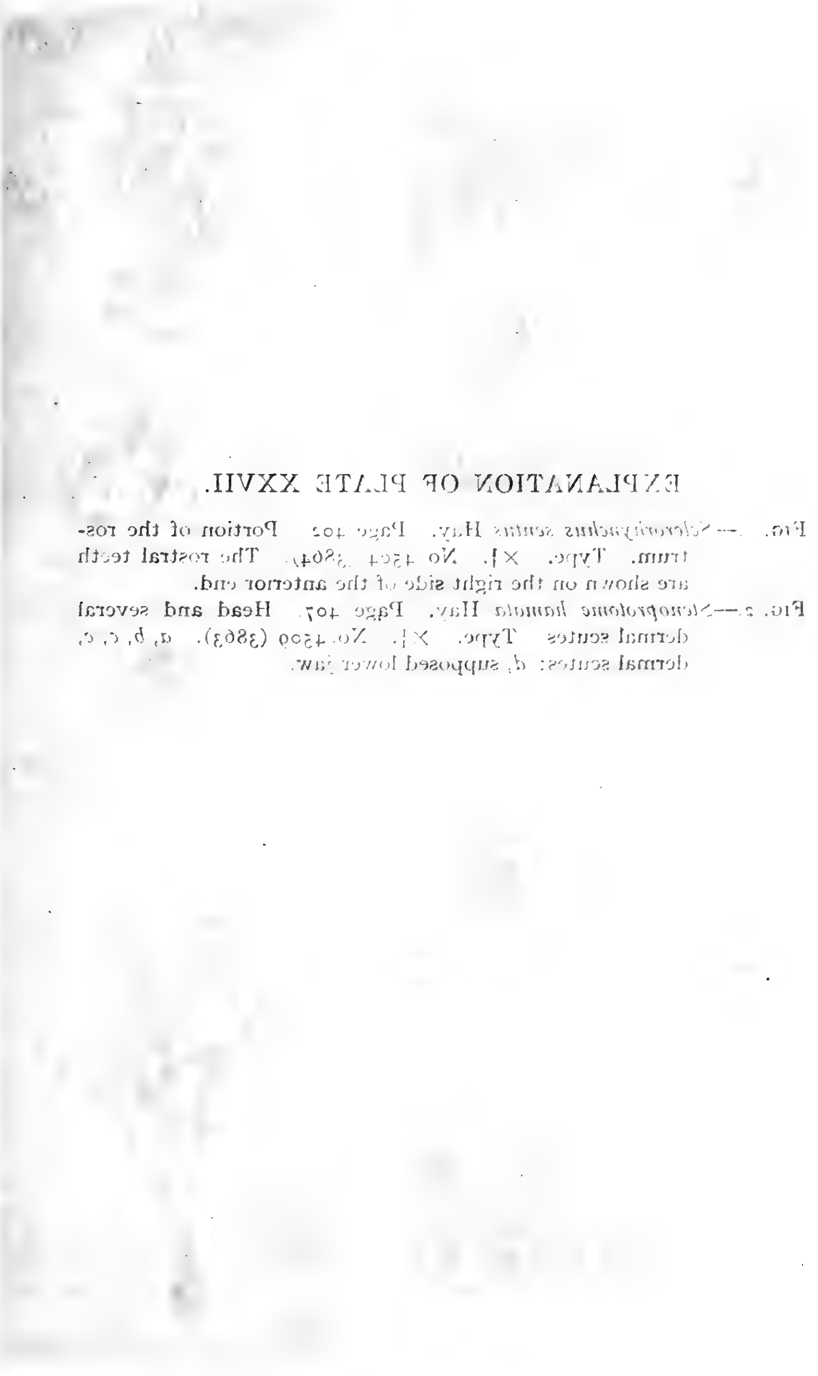


Fig. 3.

Fig. 4.

Fig. 1.

MOUNT LEBANON CRETACEOUS FISHES



EXPLANATION OF PLATE XXVII.

Fig. 1.—*Sclerorhynchus sentus* Hay. Page 402. Portion of the rostrum. Type. ×$\frac{1}{1}$. No. 4504 (3864). The rostral teeth are shown on the right side of the anterior end.

Fig. 2.—*Stenoprotome hamata* Hay. Page 407. Head and several dermal scutes. Type. ×$\frac{1}{1}$. No. 4509 (3863). *a*, *b*, *c*, *e*, dermal scutes; *d*, supposed lower jaw.

Fig. 2.

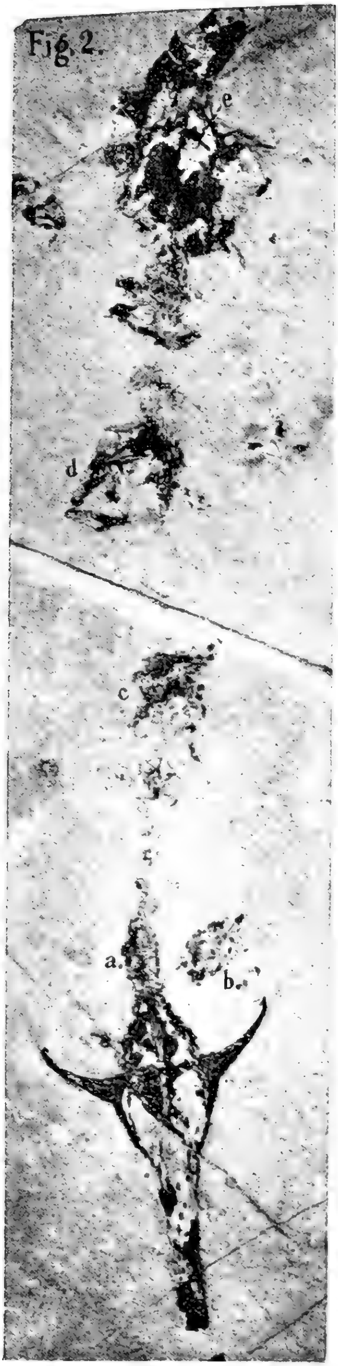


Fig. 1.

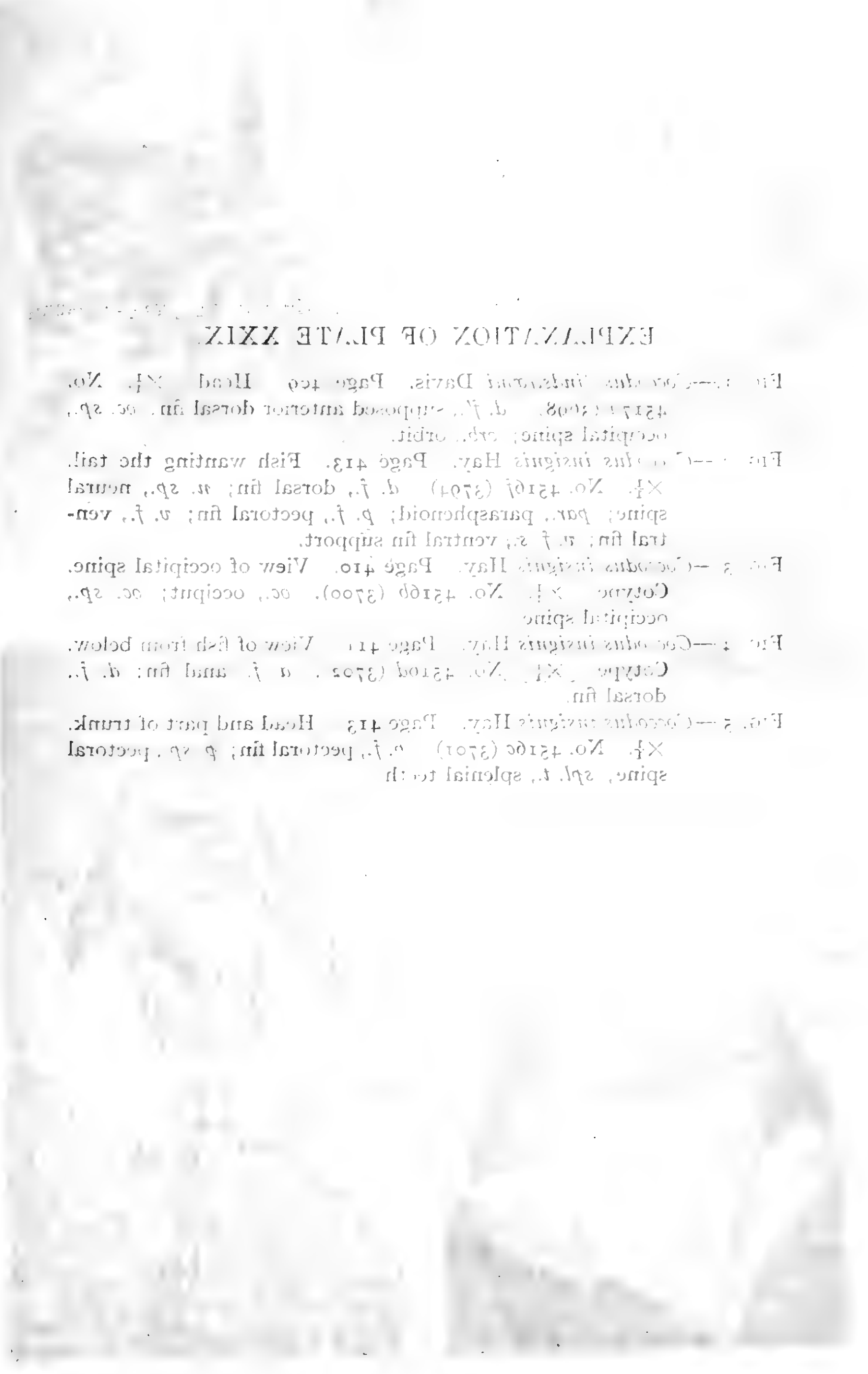
Mount Lebanon Cretaceous Fishes

Mount Lebanon Cretaceous Fishes

EXPLANATION OF PLATE XXVIII.

Raja whitfieldi Hay. Page 405. Head and trunk. Type. $\times \frac{1}{1}$. No. 4505*b* (3708). *mo.*, mouth; *na. cp.*, nasal capsule; *p. f.*, pectoral fin; *rost.*, rostrum; *v. f.*, ventral fin; *vert.*, vertebræ.

MOUNT LEBANON CRETACEOUS FISHES



Mount Lebanon C

EXPLANATION OF PLATE XXIX.

FIG. 1.—*Coccodus lindstrœmi* Davis. Page 409. Head. $\times\frac{1}{1}$. No. 4517*a* (3698). *d. f'.*, supposed anterior dorsal fin; *oc. sp.*, occipital spine; *orb.*, orbit.

FIG. 2.—*Coccodus insignis* Hay. Page 413. Fish wanting the tail. $\times\frac{1}{1}$. No. 4516*f* (3794). *d. f.*, dorsal fin; *n. sp.*, neural spine; *par.*, parasphenoid; *p. f.*, pectoral fin; *v. f.*, ventral fin; *v. f. s.*, ventral fin support.

FIG. 3.—*Coccodus insignis* Hay. Page 410. View of occipital spine. Cotype. $\times\frac{1}{1}$. No. 4516*b* (3700). *oc.*, occiput; *oc. sp.*, occipital spine.

FIG. 4.—*Coccodus insignis* Hay. Page 411. View of fish from below. Cotype. $\times\frac{1}{1}$. No. 4516*d* (3702). *a. f.*, anal fin; *d. f.*, dorsal fin.

FIG. 5.—*Coccodus insignis* Hay. Page 413. Head and part of trunk. $\times\frac{1}{1}$. No. 4516*c* (3701). *p. f.*, pectoral fin; *p. sp.*, pectoral spine; *spl. t.*, splenial teeth.

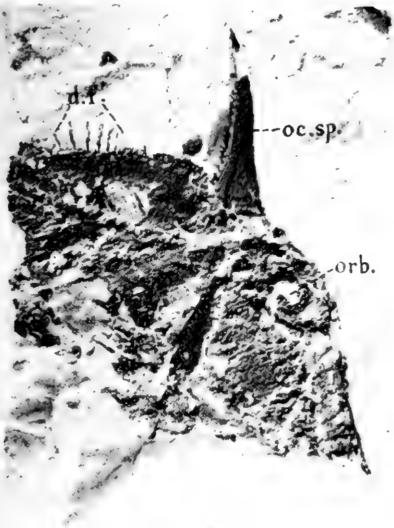


Fig.1.

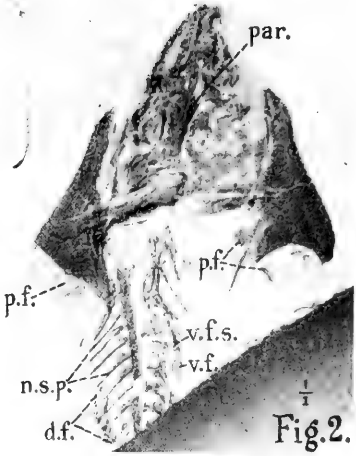


Fig.2.

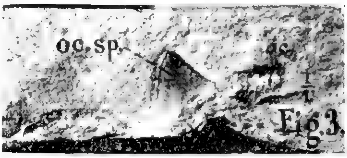


Fig.3.

Fig.4.

Fig. 5.

MOUNT LEBANON CRETACEOUS FISHES

EXPLANATION OF PLATE XXX.

FIG. 1.—*Eubiodectes libanicus* (Pict. and Humb.). Page 417. Pectoral fin. $\times\frac{1}{1}$. No. 3899, Dept. Vert. Pal.

FIG. 2.—*Enchodus marchesettii ?* (Kramb.). Page 421. Head and trunk. $\times\frac{1}{1}$. No. 4507*a* (3779). *a. f.*, anal fin; *d. f.*, dorsal fin; *d. sc.*, dorsal scutes; *lat. sc.*, lateral scutes; *p. f.*, pectoral fin; *v. f.*, ventral fin.

FIG. 3.—*Enchodus marchesettii ?* (Kramb.). Page 421. Trunk and tail. $\times\frac{1}{1}$. No. 4507*b* (3859). *a. f.*, anal fin; *v. f.*, ventral fin.

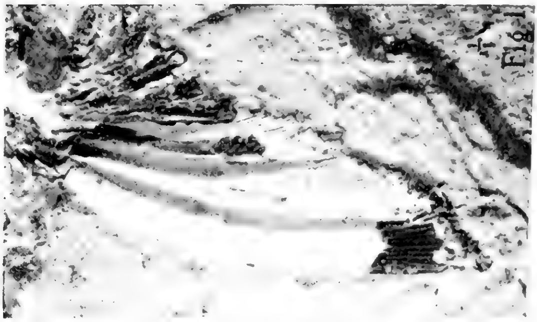


Fig. 1 $\frac{1}{1}$

Fig. 2. $\frac{1}{1}$

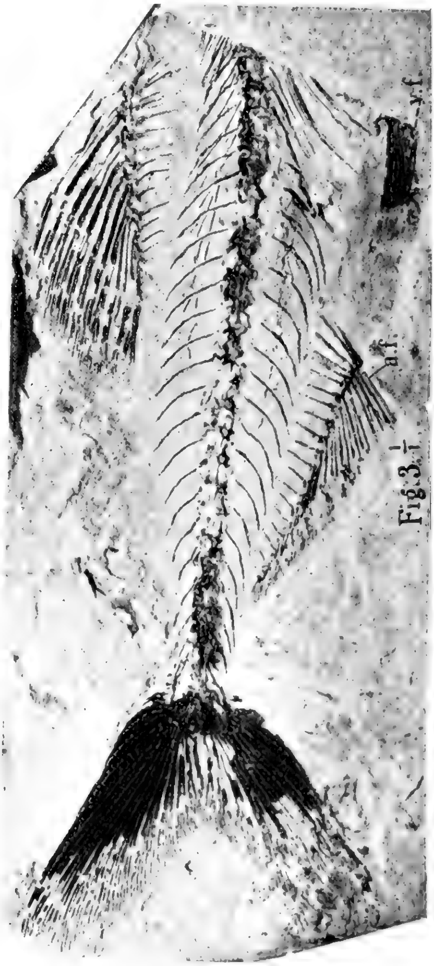


Fig. 3. $\frac{1}{1}$

MOUNT LEBANON CRETACEOUS FISHES

EXPLANATION OF PLATE XXXI.

FIG. 1.—*Ctenothrissa signifer* Hay. Page 417. Complete fish. Type. $\times\frac{1}{1}$. No. 4521*a* (3651). *a. f.*, anal fin; *br.*, branchiostegals; *den.*, dentary; *op.*, operculum; *v. f.*, ventral fins.

FIG. 2.—Counterpart of same fish as above. *p. f.*, pectoral fin; *mx.*, maxilla.

FIG. 3.—*Microcœlia dayi* Hay. Page 431. Head and part of trunk. Type. $\times\frac{1}{1}$. No. 4525*e* (3816). *a. f.*, anal fin; *cr. sc.* crimped scales; *den.*, dentary; *d. f.*, dorsal fin; *int.*, intestine; *op.*, operculum; *p. f.*, pectoral fin; *v. f.*, ventral fin.

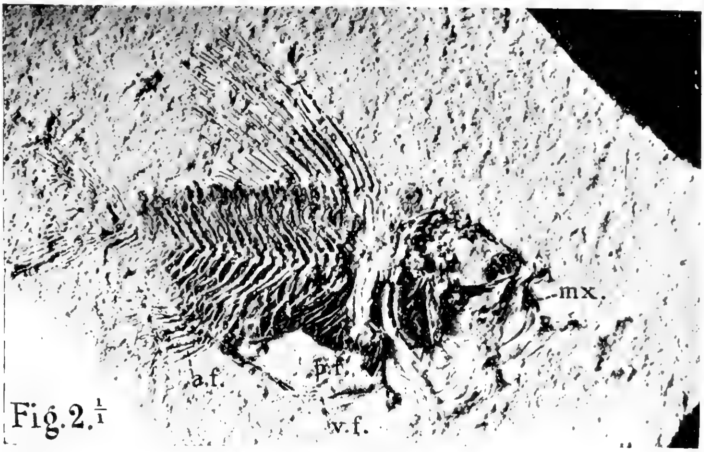


Fig. 2. 1/1

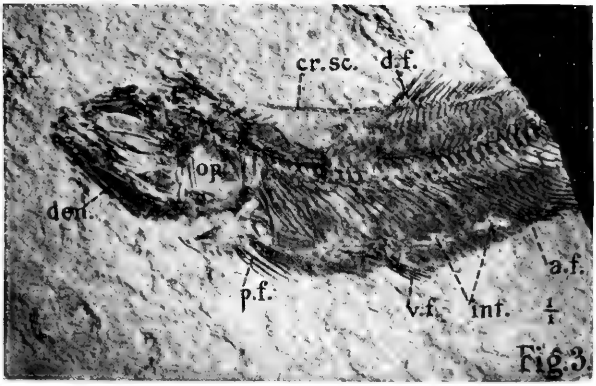
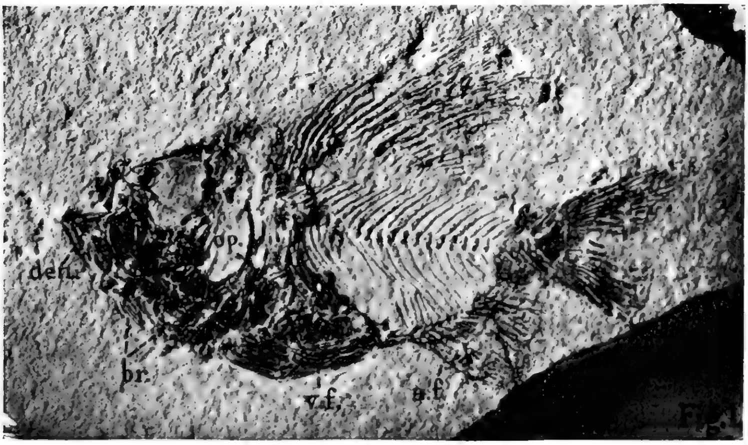


Fig. 3.

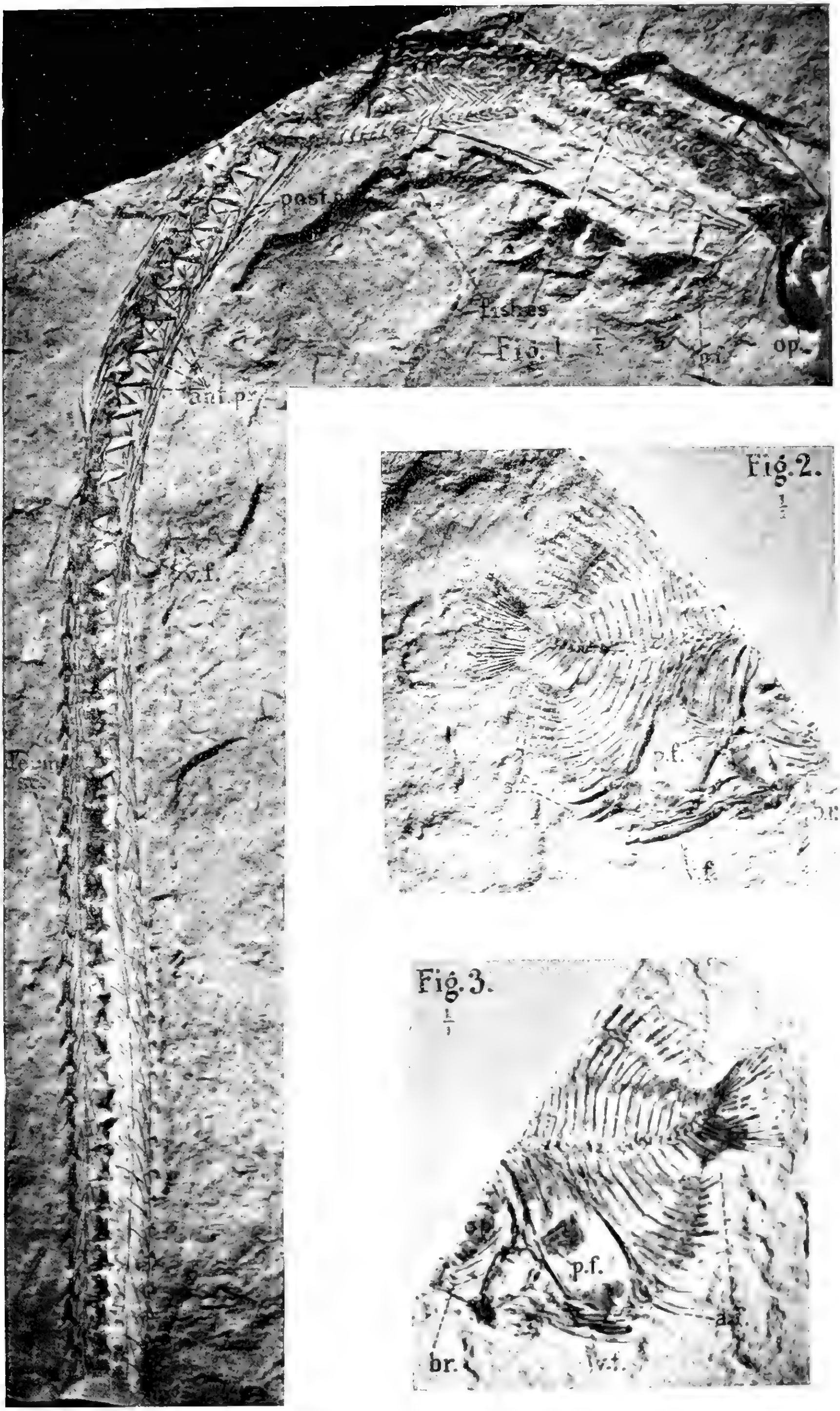


MOUNT LEBANON CRETACEOUS FISHES

EXPLANATION OF PLATE XXXII.

FIG. 1.—*Leptotrachelus serpentinus* Hay. Page 419. Trunk. Type. ×$\frac{1}{1}$. No. 4511*a* (3683). *ant. pr.*, anterior transverse processes of vertebræ; *derm. sc.*, dermal scutes; *op.*, operculum; *p. f.*, pectoral fin; *post. pr.*, posterior processes of vertebræ; *v. f.*, ventral fin.

FIGS. 2 and 3.—*Aipichtys formosus* Hay. Page 445. Fish and its counterpart, without head. Type. ×$\frac{1}{1}$. No. 4519 (3831). *a. f.*, anal fin; *br.*, branchiostegals; *op.*, operculum; *p. f.*, pectoral fin; *v. f.*, ventral fin.



Mount Lebanon Cretaceous Fishes

Lebanon Cretaceous Fishes

EXPLANATION OF PLATE XXXIII.

FIG. 1.—*Osmeroides pontivagus* Hay. Page 424. Complete fish. ×$\frac{1}{1}$. No. 4524*b* (3846). *a. f.*, anal fin; *br.*, branchiostegals; *den.*, dentary; *d. f.*, dorsal fin; *hy.*, hyoid; *mx.*, maxilla; *p. f.*, pectoral fin; *pmx.*, premaxilla; *v. f.*, ventral fin.

FIG. 2.—*Osmeroides pontivagus* Hay. Page 425. Complete fish. Type. ×$\frac{1}{1}$. No. 4524*a* (3845). *a. f.*, anal fin; *den.*, dentary; *d. f.*, dorsal fin; *p. f.*, pectoral fin; *v. f.*, ventral fin.

FIG. 3.—*Osmeroides pontivagus* Hay. Page 425. Complete fish. ×$\frac{1}{1}$. No. 4524*c* (3855). *a. f.*, anal fin; *den.*, dentary; *d. f.*, dorsal fin; *p. f.*, pectoral fin; *v. f.*, ventral fin.

FIG. 4.—*Osmeroides pontivagus* Hay. Page 425. Complete fish. ×$\frac{1}{1}$. No. 4524*f* (3841). *a. f.*, anal fin; *br.*, branchiostegals; *den.*, dentary; *d. f.*, dorsal fin; *p. f.*, pectoral fin; *v. f.*, ventral fin.

FIG. 5.—*Osmeroides ornatus* Hay. Page 426. Type. ×$\frac{1}{1}$. No. 4518 (3870). *a. f.*, anal fin; *d. f.*, dorsal fin; *v. f.*, ventral fin.

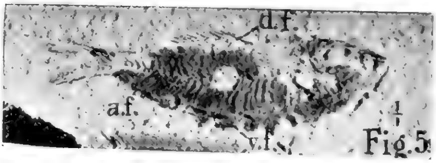


Fig. 5

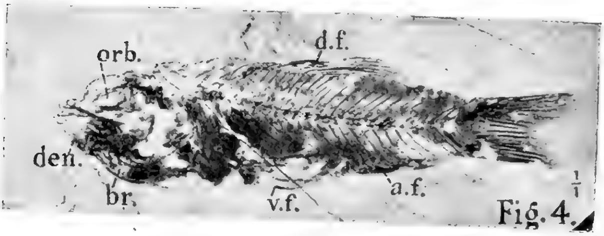


Fig. 4.

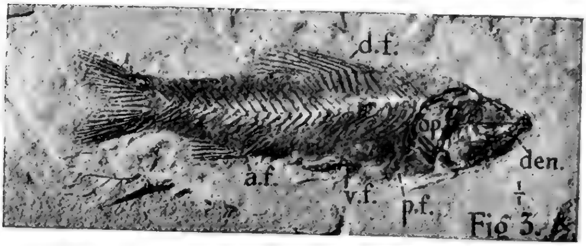


Fig 3.

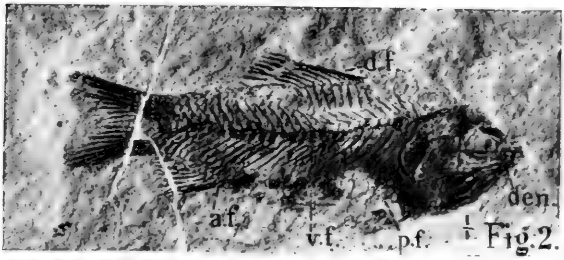


Fig. 2.

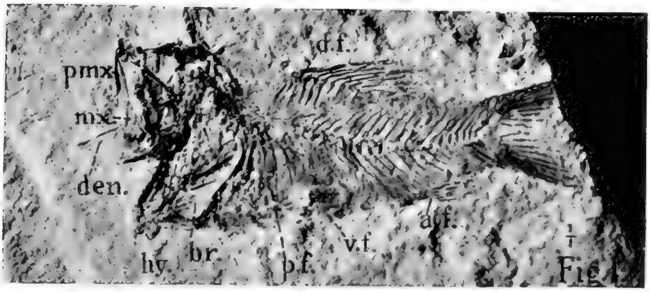


Fig.

MOUNT LEBANON CRETACEOUS FISHES

EXPLANATION OF PLATE XXXIV.

FIG. 1.—*Microcœlia dayi* Hay. Page 430. Complete fish. Type. ×1/1. No. 4525*a* (3692). *a. f.*, anal fin; *den.*, dentary; *d. f.*, dorsal fin; *p. f.*, pectoral fin; *v. f.*, ventral fin.

FIG. 2.—*Nematonotus longispinus* (Davis). Page 429. Fish wanting tail. ×1/1. No. 4510*d* (3678). *a. f.*, anal fin; *den.*, dentary; *d. f.*, dorsal fin; *orb.*, orbit; *p. f.*, pectoral fin; *v. f.*, ventral fin.

FIG. 3.—*Acrognathus dodgei* Hay. Page 427. Complete fish. Type. ×1/1. No. 4520*a* (3673). *a. f.*, anal fin; *br.*, branchiostegals; *den.*, dentary; *d. f.*, dorsal fin; *mx.*, maxilla; *orb.*, orbit; *pmx.*, premaxilla; *v. f.*, ventral fin.

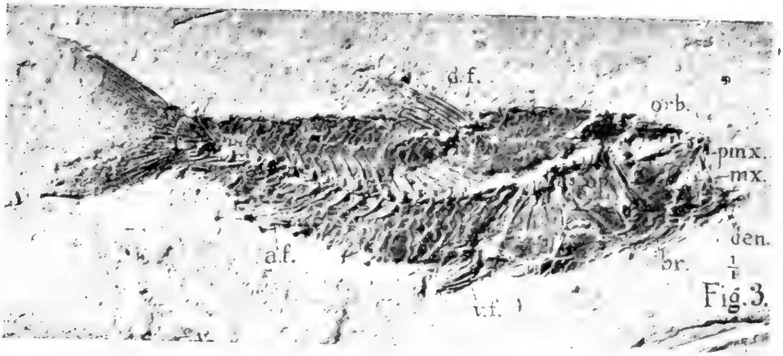


Fig. 3.

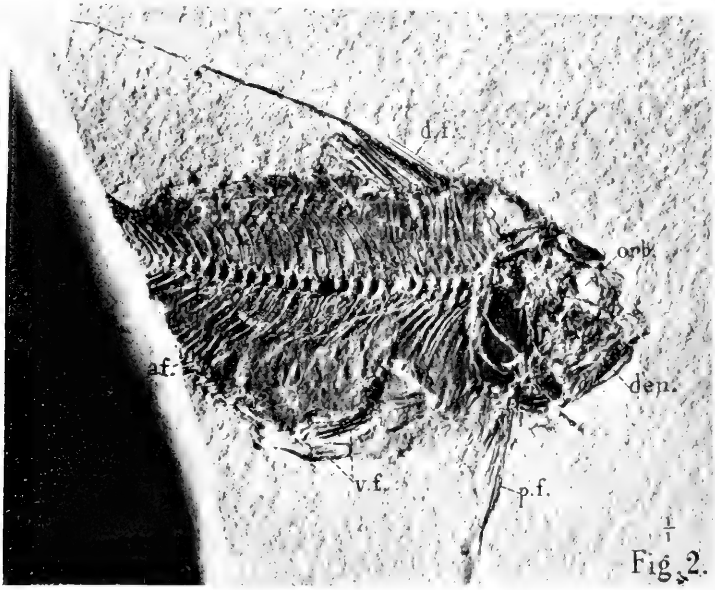


Fig. 2.

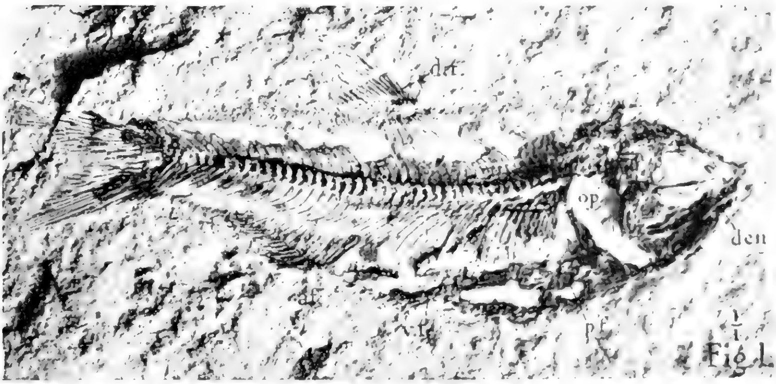
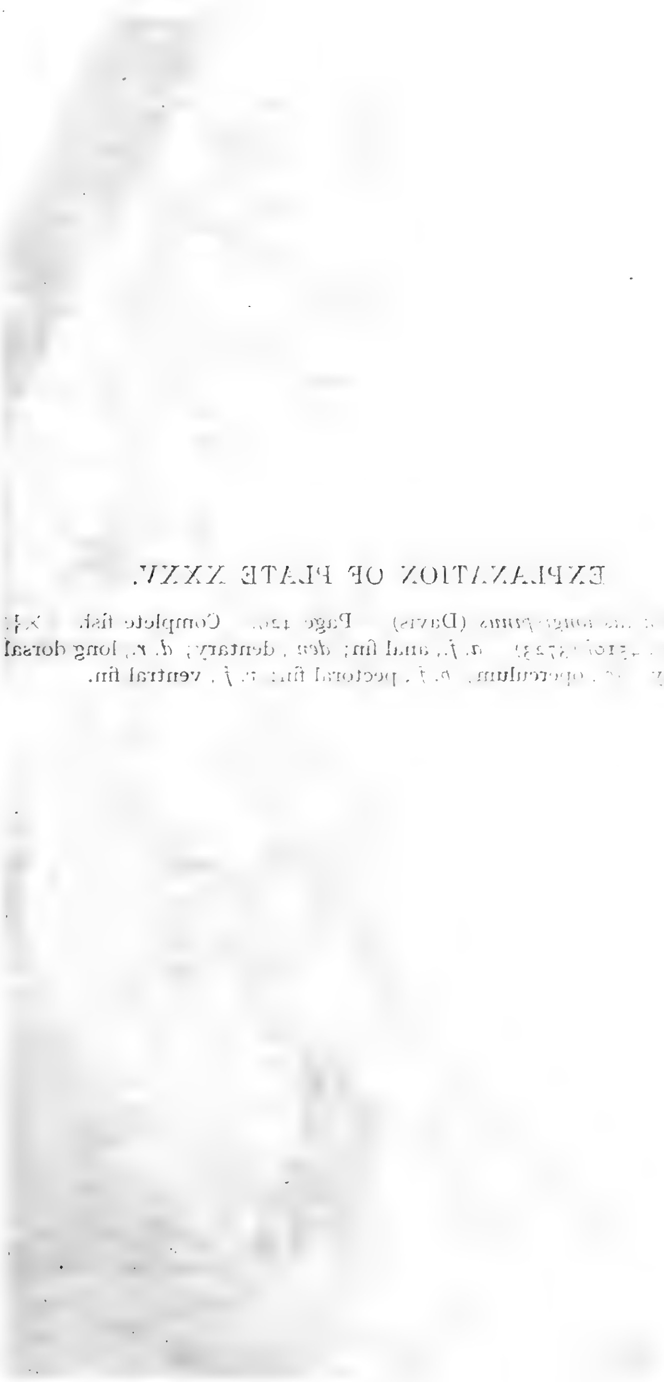


Fig. 1.

MOUNT LEBANON CRETACEOUS FISHES



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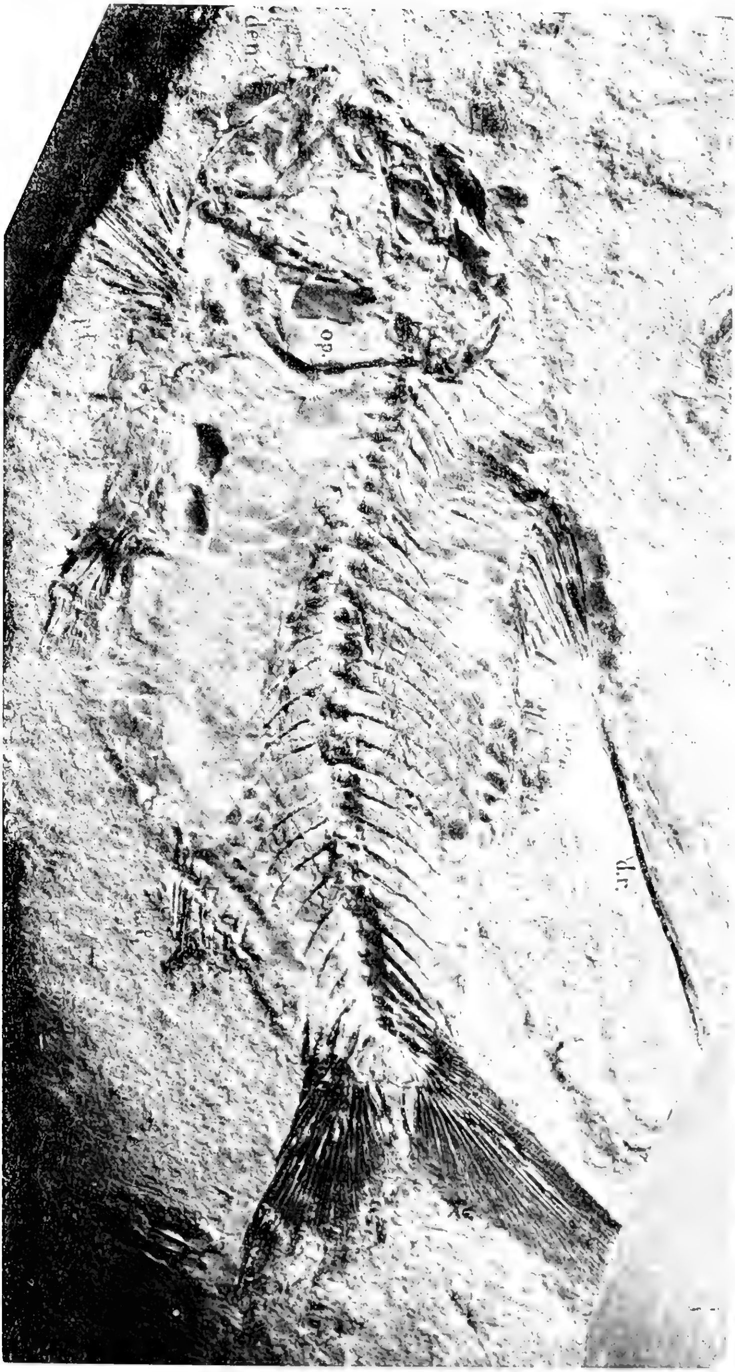
EXPLANATION OF PLATE XXXV.

Nematonotus longispinus (Davis). Page 429. Complete fish. $\times \frac{1}{1}$. No. 4510*f* (3723). *a. f.*, anal fin; *den.*, dentary; *d. r.*, long dorsal ray; *op.*, operculum; *p. f.*, pectoral fin; *v. f.*, ventral fin.



Mount Lebanon Cretaceous Fishes

EXPLANATION OF PLATE XXXVI.

FIG. 1.—*Urenchelys germanus* Hay. Page 434. Nearly complete fish. Type. ×$\frac{1}{1}$. No. 4515*a* (3654). *a. f.*, origin of anal fin; *cl.*, cleithrum; *den.*, dentary; *d. f.*, origin of dorsal fin; *hy.*, hyoid; *hym.*, hyomandibular; *i. op.*, interoperculum; *mx.*, maxilla; *op.*, operculum; *pal.*, palatine; *p. f.*, pectoral fin; *p. op.*, preoperculum; *pt.*, pterygoid; *qu.*, quadrate; *s. op.*, suboperculum.

FIG. 2.—*Anguillavus quadripinnis* Hay. Page 437. Anterior half of fish. Type. ×$\frac{1}{1}$. No. 4512 (3796). *br.*, branchiostegals; *den.*, dentary; *hy.*, hyoid; *int.*, intestine; *lat. sc.*, lateral scutes; *mx.*, maxilla; *op.*, operculum; *p. f.*, pectoral fin; *pt.*, pterygoid; *qu.*, quadrate; *v. f.*, ventral fins.

FIG. 3.—Ventral fin of the same specimen as Fig. 2. Page 437. Enlarged 7 diameters. *v. f.*, ventral fins; *v. f. s.*, ventral fin supports.

FIG. 4.—*Pycnosterinx levispinosus* Hay. Page 444. Complete fish. Type. ×$\frac{1}{1}$. No. 4528 (3671).

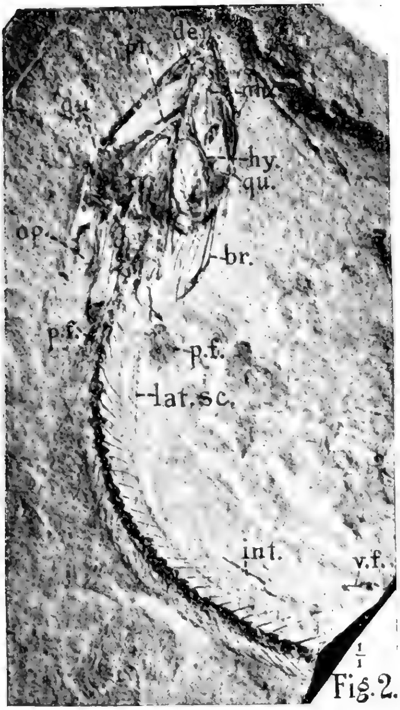


Fig. 2.


Fig. 4.

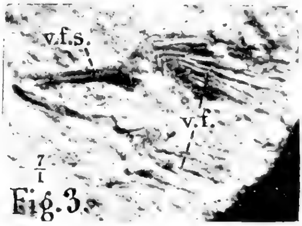


Fig. 3.

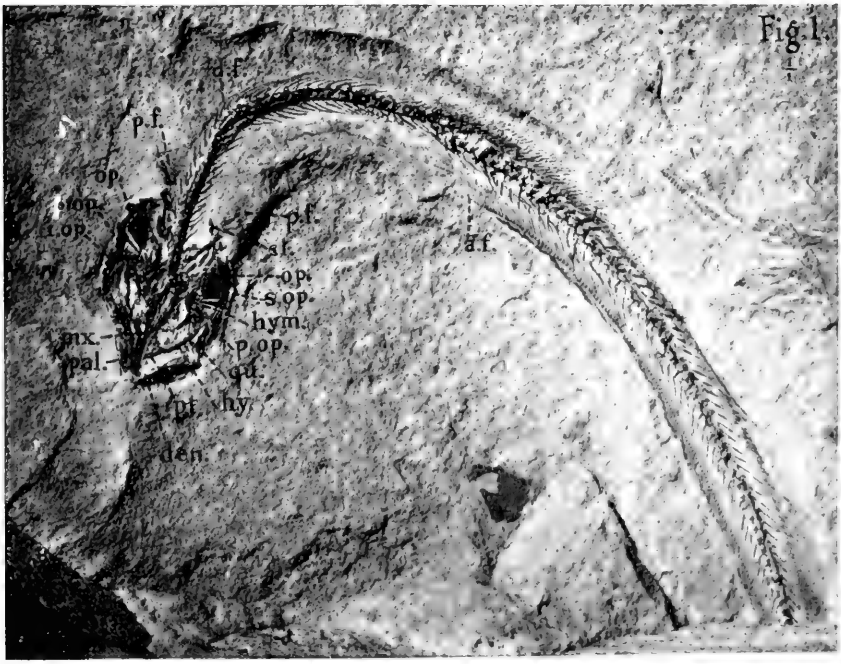


Fig. 1.

Mount Lebanon Cretaceous Fishes

EXPLANATION OF PLATE XXXVII.

FIG. 1.—*Anguillavus bathshebæ* Hay. Page 439. Complete fish. Type ×1/1. No. 4513*a* (3704). *a. f.*, anal fin, origin and end of; *br.*, branchiostegals; *c. f.*, caudal fin; *cl.*, cleithrum; *den.*, dentary; *d. f.*, dorsal fin, origin of; *hy.*, hyoid; *int.*, intestine; *p. f.*, pectoral fin; *v. f.*, ventral fin.

FIG. 2.—*Enchelion montium* Hay. Page 441. Fish wanting head. Cotype. ×1/1. No. 4514*a* (3765).

FIG. 3.—*Enchelion montium* Hay. Page 442. Head and anterior part of trunk. ×1/1. No. 4514*b* (3766).

FIG. 4.—Part of same specimen as Fig. 3. Page 442. Enlarged 4 diameters. *br.*, branchiostegals; *den.*, dentary.

FIG. 5.—Part of same specimen as Figs. 3 and 4. Page 442. Enlarged 4 diameters, showing alternation of epihypocentra and pleuro-hæmacentra.

FIG. 6.—Part of same individual as Fig. 2. Page 443. Vertebræ 88 mm. behind anterior end, enlarged 9 diameters. *ep. hy.*, epihypocentra; *ha.*, hæmal arches; *n. sp.*, neural spines; *pl. h.*, pleuro-hæmacentra.

FIG. 7.—*Urenchelys germanus* Hay. Page 436. Portion of vertebral column. ×3. No. 4515*d* (3790). *v. c.*, vertebral centra; *v. a.*, displaced neural arches.

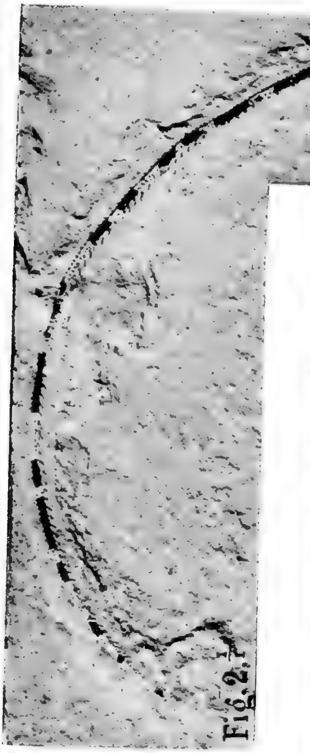


Fig. 2. 1/1


Fig. 7. 4/1


Fig. 4. 4/1

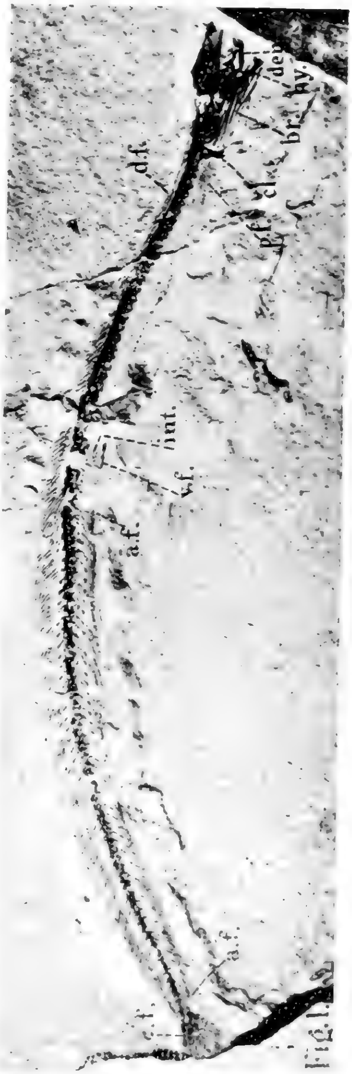


Fig. 1. 2/1

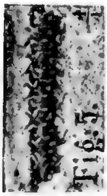


Fig. 5. 4/1


Fig. 6. 9/1

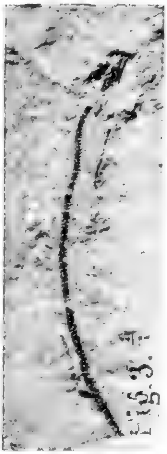


Fig. 3. 4/1

MOUNT LEBANON CRETACEOUS FISHES

A New Species of Fossil Edentate from the Santa Cruz Formation of Patagonia.

By Barnum Brown.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XIX, Article XI, pp. 453–457.
New York, July 8, 1903.

The Knickerbocker Press, New York

Article XI. — A NEW SPECIES OF FOSSIL EDENTATE FROM THE SANTA CRUZ FORMATION OF PATAGONIA.

By Barnum Brown.

In the autumn of 1898 the American Museum of Natural History made arrangements with the Princeton University Museum for the writer to accompany the third expedition to Patagonia, under the leadership of Mr. J. B. Hatcher. The expenses of this trip were largely defrayed by Professor Henry Fairfield Osborn.

A large collection, comprising nine nearly complete skeletons and nearly a hundred skulls with skeletal material, was secured by the writer from exposures on the Rio Gallegos, on the seashore south of Rio Coy, and from the bluffs along the coast south of Rio Santa Cruz. This material represents most of the families that lived in such great numbers during the Santa Cruz period, and contains several new species.

By previous arrangement with Professor Scott and Mr. Hatcher, the portion of this material belonging to species already known will be described in the Princeton memoirs, while the new species will be described in the American Museum Bulletin.

Eucinepeltus complicatus, nov. sp.

This species is founded on an adult skull with cephalic shield, No. 9248 of the collection of the American Museum of Natural History. The type was found in the talus of cliffs on Rio Gallegos, near Mr. Felton's residence.

Comparison with the type of the genus, *Eucinepeltus petesatus*, has been possible through the kindness of Professor W. B. Scott, the advance sheets of whose memoir I have examined.

It differs from the type of the genus in the following characters:

	Eucinepeltus petesatus.	*Eucinepeltus complicatus.*
Pattern of teeth:	1st to 3rd non-lobate.	1st to 3rd-lobate.
Cephalic shield:	9 plates, not all pitted.	11 plates, all pitted.

The cephalic shield is composed of eleven plates in four rows, arranged in the following order from the anterior to the posterior end: 2 in the first, 3 in the second, 4 in the third, and 2 in the fourth rows. Each plate has a central pit which is of pronounced character in the two median plates of the third row. These pits have a circular shape, with raised margin, very rugose sides, and a small cone at the bottom of the pit.

The sutural borders present a prominent ridge, very rugose, with deep paired holes on either side of ridge, excepting the sutures separating the four posterior median plates which are well defined, but do not show raised edge or holes.

The outline of the shield is not as circular as in *E. petesatus*, and the border is more distinctly emarginated at the junction of the first and the second rows. The plates in the first row, also the median plates of the second row, in the present species are smaller than in *E. petesatus*, while the four posterior median plates are relatively larger.

The teeth differ from those of *E. petesatus*, especially in the anterior part of the jaw. The first molar is rather large, of elliptical contour, though the grinding surface is broken away, set obliquely to the dental series so that the anterior teeth of the two rows approach each other more closely than any of the following teeth. M^2 is larger, less elliptical, and obscurely trilobate, only one internal groove being prominent, with faint indication of posterior internal and external grooves. M^3 is much larger and more distinctly trilobate internally. M^4 is distinctly trilobate, the lobes separated by deep sulci; the anterior lobe in each tooth showing a groove on the anterior face near the external border. M^{5-8} are of the same pattern as M^4.

Most of the sutures are obliterated, so that little can be said of the cranial bones or of their proportions. The cranium is broad and depressed. The forehead is flattened and very wide, ending in a distinct postorbital process. The rostrum is very broad at the base, narrowing rapidly to the narial opening. The muzzle is heart-shaped. The zygomatic arch extends out widely from the skull and is very deep, with

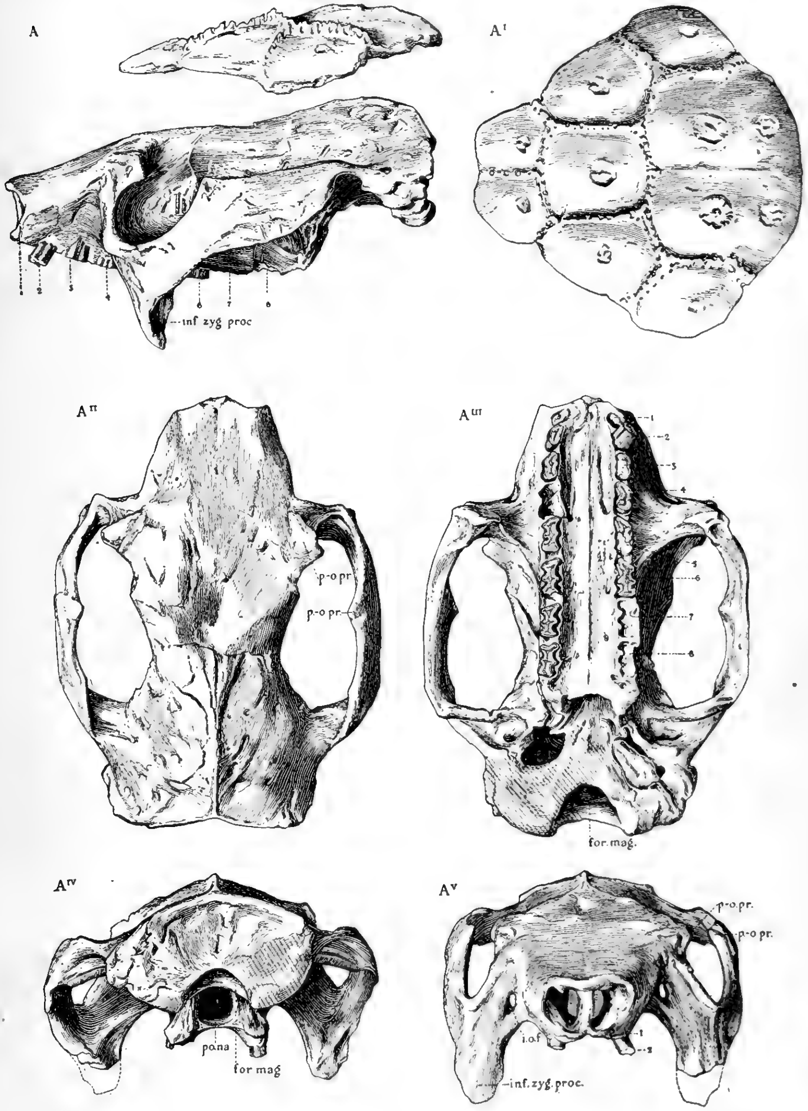


Fig. 1. *Eucinepeltus complicatus.* Type skull and casque. (No. 9248.) × ⅓.

prominent postorbital process. The descending process is triangular at the base. The parietals are very rugose, pitted with large foramina, gently convex transversely and longitudinally. The sagittal crest is prominent. The lambdoidal crest extends out over the occipital plane in a heavy ridge, curving in to join the sagittal crest. The occiput is about half as high as wide; deeply incised for foramen magnum. The bony palate is perforated by numerous large foramina,

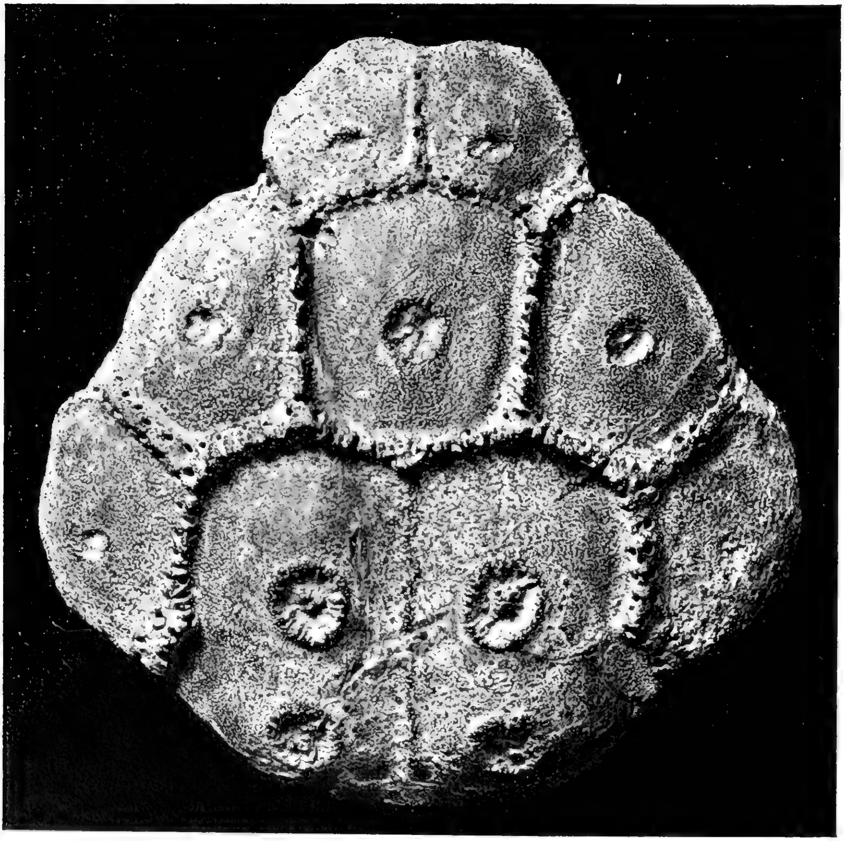


Fig. 2. *Eucinepeltus complicatus.* Type casque. (No. 9248.) × $\frac{3}{4}$.

with a large foramen opposite the posterior of M^4. This foramen leads into a deep canal, extending forward nearly to the premaxillary. The palate is straighter than in *Propalæohoplophorus australis*, and forms with the superior line of the skull a more acute angle than in the last named genus.

Measurements.

Cephalic shield: length in median line	130 mm.
" " greatest width	133

Teeth.

M^1	Length	8 mm.	width	4 mm.
M^2	"	9	"	5
M^3	"	12	"	6.6
M^4	"	13	"	7
M^5	"	15	"	7
M^6	"	15	"	7.8
M^7	"	14.4	"	7.8
M^8	"	14	"	7.8

Upper dental series, length	109 mm.
Skull, extreme length	176
" length of median basal line	156
" " occ. condyle to anterior end of premaxillary	175
Cranium, length to anterior rim of orbit	125
" width behind zygomatic arches	102
Skull, maximum width over zygomatic arches	135
Occiput, height vertically	48
" width	89
Zygoma, extreme length inside	77
" maximum vertical diameter	28
" length of descending process	45
" breadth " "	20.5
Palate, length in median line	117
" width at M^1	14
" " at M^8	25
Rostrum, length	43
" width at base	63
" " at anterior end	41
Cranium, width at postorbital constriction	49
Face, length	53
Forehead, width across postorbital process	91

Ornitholestes Hermanni, A New Compsognathoid Dinosaur from the Upper Jurassic.

By Henry Fairfield Osborn.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,

Vol. XIX, Article XII, pp. 459-464.

New York, July 23, 1903.

The Knickerbocker Press, New York

Article XII.—ORNITHOLESTES HERMANNI, A NEW COMPSOGNATHOID DINOSAUR FROM THE UPPER JURASSIC.

By Henry Fairfield Osborn.

The type skeleton (Amer. Mus. Coll. No. 619) of this remarkable animal was discovered at Bone Cabin Quarry, near Medicine Bow, Wyoming, by the American Museum Expedition of 1900. It was removed and transported to the Museum with the greatest care, and worked out, restored, and mounted under the direction of the head preparator, Mr. Adam Hermann, in recognition of whose many services to vertebrate palæontology the species is named.

The material embraces: the skull; 45 vertebræ, including 3 cervicals, 11 dorsals, a complete sacrum, 27 caudals; the complete pelvic girdle; representative portions of both fore and hind limbs,—all belonging to one individual; our knowledge of the manus is chiefly derived from another specimen (Amer. Mus. Coll. No. 587).

Principal Characters.

The entire length of the skull and vertebral column as restored is 2.22 m. (7 ft. 3½ in.); the height at the pelvis is .56 m. (22 in.).

The vertebral formula, except in the sacrum, is still undetermined.

The most distinctive feature is the narrowing of the manus and the great elongation (.172 m.) of the metapodials and phalanges of the second digit, suggesting the rapid grasping power of agile and delicate prey. This feature, combined with the prehensile character of the somewhat enlarged anterior teeth, the extreme lightness of the skeleton, the cursorial structure of the hind limbs, the balancing power of the tail, suggest the hypothesis that the animal may have been adapted to the pursuit of the Jurassic birds; in allusion to this supposed habit the genus may be named *Ornitholestes*, or 'bird robber,' as suggested by Dr. Theodore Gill.

A possible objection to this hypothesis is that the teeth, while distinctively prehensile, are not so serrate or trenchant as in *Cœlurus*. They are, however, quite as sharp as in the varanoid and other lizards which are known to capture and feed upon small birds.

The premaxillary contains 4 teeth, the most anterior of which is the largest tooth in the upper jaw. The maxillary retains 10 teeth, of which the fifth is the largest. In the dentary are 12 teeth. In both jaws the teeth occupy a rather short space, a little more than one third the entire length of the skull, and gradually decrease in size posteriorly. The premaxillary teeth are slightly worn on the posterior surface. There are two antorbital openings, a smaller within the maxillary, and a larger bounded posteriorly by the coalesced lachrymal and jugal. The orbits are very large, bounded posteriorly by the united postorbito-frontal, which connects by a slender bar with the squamosal. The depression of the quadrate extends the latero-temporal fenestra vertically. The jaw is relatively long and slender, with sessile coronoid process; the sutures have not been determined. The cervicals are gently opisthocœlous, the dorsals are amphicœlous, the posterior face being slightly more concave than the anterior; the caudals are gently amphicœlous. The neural arch only of the supposed fifth cervical is preserved. The supposed tenth and eleventh cervicals are moderately elongate, slightly opisthocœlous, with separate attachments for the capitulum on the anterior portion of the centrum, and for the tuberculum on the broad diapophysial expansion of the neural arch; the zygapophyses are large and the neurocentral suture is faintly indicated. In the supposed second dorsal or thirteenth presacral the capitulum is still borne on the centrum; behind the capitulum is a pit (paracœle), a feature also observed in the supposed fifth dorsal; the diapophysis is narrow; the head of the rib gradually rises to the junction between the centrum and neural arch, as in other dinosaurs. The four sacrals are firmly coalesced. The sacral ribs are still suturally distinct and attached chiefly at the sides of the centra, although the third sacral rib partially overlaps the

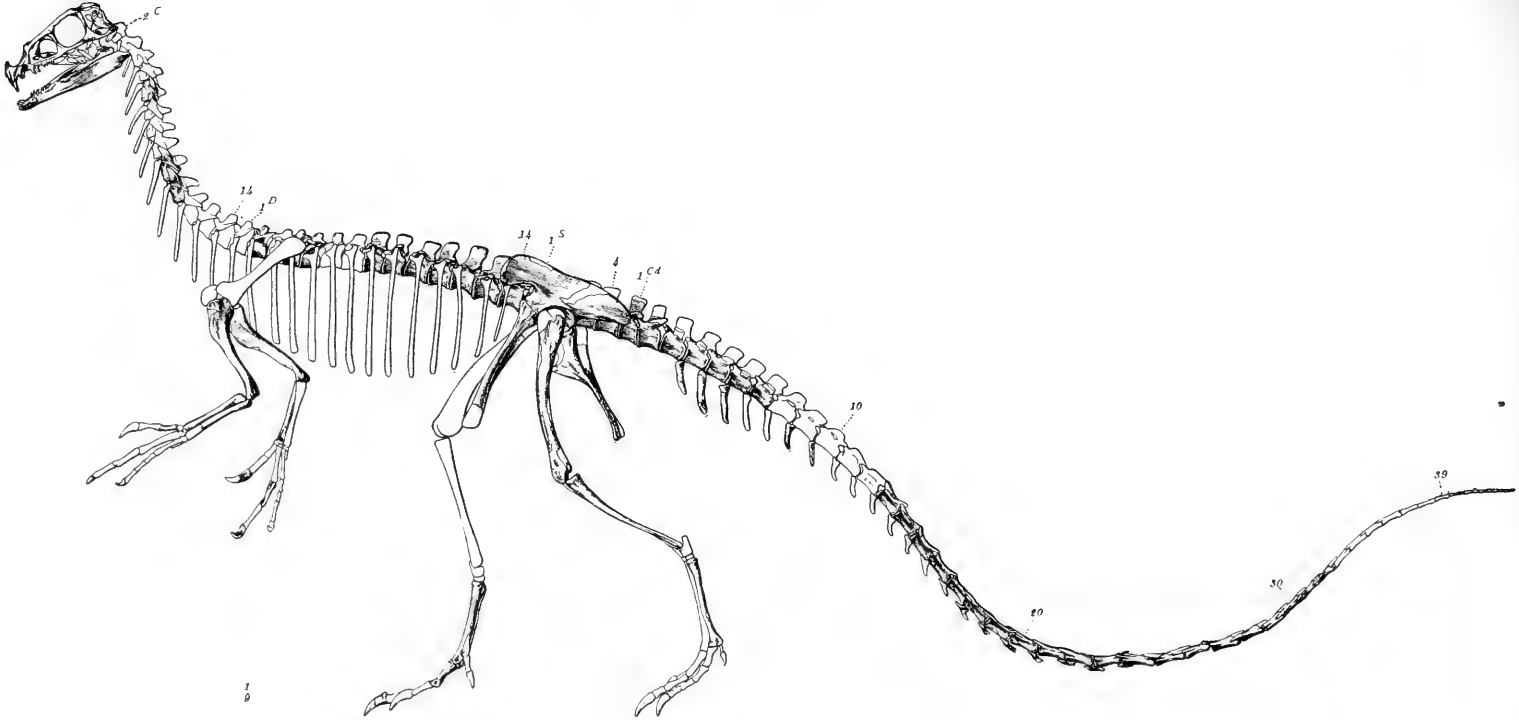


Fig. 1.—*Ornitholestes hermanni.* Type. Am. Mus. No, 619. × $\frac{1}{9}$. The unshaded areas indicate the portions restored.

posterior portion of the second centrum. The forked chevrons apparently begin at the posterior side of the third caudal, the chevrons being intervertebral; the hæmapophysial canal is apparently closed in the first chevron. The firmly coalesced caudal ribs of the anterior caudals are broad and backwardly directed. With the supposed thirteenth caudal there begins a gradual elongation of the zygapophyses, which reaches a great development between the sixteenth and twenty-fourth, the prezygapophyses being greatly elongated and partly encircling the somewhat smaller postzygapophyses of the preceding vertebræ. At the same time the chevrons become depressed, bifurcate in front, with a deep posterior keel.

Fig. 2.—*Ornitholestes hermanni.* Amer. Mus. No. 587. Palmar view of left manus. × ½.

The pelvic girdle is distinguished by the deep symphysial union of the pubes, the considerably more slender ischia, which are in contact distally and proximally exhibit two hooked processes; the ilium has a very broad pubic and narrow ischial peduncle, the pre- and post-acetabular portions of the depressed crest are subequal. A very distinctive feature of the postacetabular crest is the hollowing out and inferior expansion into a broad concave plate.

In the fore limb there was some question as to the determination of the ulna and radius. The humerus is longer than these elements, measuring .127 m. The few phalanges preserved enable us to associate with this animal a relatively complete manus belonging to another individual, in which the striking elongation of the second digit, the comparative slenderness of the third and the atrophy of the fourth can be clearly made out. The palmar view of the manus somewhat suggests that of the two-toed sloth. The terminal phalanges are elongate, recurved, and laterally compressed, with a distinct lateral claw-groove. The somewhat crushed femur (.207 m.) is much longer than the humerus and somewhat longer than the tibia (.159 m.). The pes has the typical tridactyl arrangement, the phalanges being more rounded and less decidedly curved than those of the manus; the median metatarsal measures .117 m.

Fig. 3.—*Ornitholestes hermanni.* Amer. Mus. No. 587. × ½. Left manus.

GENERIC AND SPECIFIC CHARACTERS.

Skull with two antorbital openings; four premaxillary and ten maxillary teeth, non-serrate; twelve dentary teeth. Four coalesced sacrals. Mid- and posterior-caudal vertebræ with greatly elongate zygapophyses; manus narrow with greatly elongate digits, second digit of manus enlarged, fourth digit vestigial, fifth digit wanting.

AFFINITIES.

The affinities of the animal are evidently with the light-limbed, slender-jawed group of Theropoda, for which the subordinal name Compsognatha Huxley will probably be found applicable, as distinguished from the large Megalosauria. The exceptional rod-like elongation of the pre- and postzygapophyses in the mid- and posterior caudals strongly suggests affinity to *Ornithomimus* of the Upper Cretaceous. *Ornitholestes*, however, is a much less specialized form, lacking the peculiar compression of metatarsal III which characterizes the Cretaceous genus. It is distinguished from the contemporary *Cœlurus* by the non-serration of the teeth, by the relatively short cervical vertebræ, by the less extreme hollowness of all the vertebræ. From the contemporary *Hallopus* it is distinguished by the less elongate character of the metatarsals. Comparison with smaller foreign Wealden dinosaurs also serves to show its distinctness. The sacrum differs from that of *Aristosuchus* in the possession of four primary sacral ribs. The elongation of the second digit of the manus resembles that in *Archæopteryx*, but was evidently for a different purpose.

A New Three-Toed Horse.

By J. W. Gidley.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XIX, Article XIII, pp. 465–476.
New York, July 24, 1903.

The Knickerbocker Press, New York

Article XIII.—A NEW THREE-TOED HORSE.

By J. W. Gidley.

The Expedition of 1902, sent out by Prof. Henry F. Osborn to explore the Miocene exposures in South Dakota, had the good fortune to obtain, besides other material, a complete skeleton of a large three-toed horse (Amer. Mus. Coll. No. 9815), associated with incomplete skeletons of five other individuals, undoubtedly of the same species.

This splendid specimen, which represents an undescribed genus and species, was discovered by Mr. H. F. Wells, a member of the party, in the upper Miocene deposits on Little White River, near Rosebud Agency, South Dakota.

The characters presented, especially in the teeth, if interpreted according to former authors, would undoubtedly place the present species in the genus *Hipparion*. However, as indicated by a careful study of this new material, and of the abundant material of other Miocene horses in the American Museum collection, together with a comparison with specimens and descriptions of the European forms, it seems probable that the genus *Hipparion* is limited in distribution entirely to the Old World, and that the American species formerly referred to this genus should be placed in a group distinct from *Hipparion*.

Before describing the new skeleton, therefore, the writer wishes to point out the chief characters which distinguish the Old World from the New World forms.

The characters common to both groups are as follows: (1) Column of protocone of the upper molariform teeth entirely surrounded by cement; (2) the lower molars of the milk dentition possess a median external basal tubercle; (3) each foot possesses three complete toes, the lateral ones being much reduced.

The characters which especially distinguish the true *Hipparion* are: (1) Protocone cylindric or subcylindric throughout the greater part of its length. (2) Enamel borders of the fossettes of the upper molariform teeth very elaborately folded. (3) The middle portion of the external walls of the meta- and paracones is flat or slightly convex. (4) The external median tubercle in the lower milk molars is relatively high and circular in cross-section.

The American group differs from *Hipparion* in the following characters: (1) The protocone is relatively larger and elliptical in cross-section, or with the outer wall flat to concave. (2) The enamel foldings are in general comparatively simple. (3) The external walls of the meta- and paracones are concave. (4) The external median tubercle of the lower milk molars is elliptical in cross-section and less prominent than in *Hipparion*. (5) The limbs and feet, so far as known, indicate a comparatively more slender construction of the long bones and especially longer proportions of the metapodials. There is also apparently a relatively greater reduction of the lateral digits in the American genus.

These characters, as stated above, have the more significance from the fact that nearly all the American species are Miocene, while those of the Old World are of Pliocene age. It will be seen that in the development of the protocone and the ectoloph in the upper teeth, and the proportions of the feet and limbs, the American species, though coming from an older formation, are more progressive than the Pliocene species of Europe; while in some other respects, especially the complicated foldings of enamel in the upper teeth, the Old World species are more progressive. The reasons for separating these two groups are further strengthened by the fact that there are apparently no species common to both hemispheres.

From the foregoing it seems apparent that a new term is necessary for the American species hitherto referred to *Hipparion*, and they may be distinguished by the name **Neohipparion.**

The following description is based on the complete skeleton above referred to and is named in honor of Mr. William C. Whitney, whose generosity made possible the expedition which secured this very valuable acquisition to the present knowledge of American fossil horses.

Neohipparion whitneyi, gen. et sp. nov.

Generic characters. — Protocone free, except at base, as in *Hipparion.* Protocone comparatively large and much expanded anteroposteriorly. Enamel foldings simple. The median external basal column present in the lower milk molars as in *Hipparion,* but much shorter and more expanded anteroposteriorly. Lateral digits much reduced.

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

Although the collected material representing the Miocene horses of America is very abundant, it is, for the most part, so fragmentary and the different parts of the skeleton so uncertainly associated that most of the species are known only from the teeth. Hence the present specimen, though not in the line of ancestry of any of the living horses, may serve as a standard for comparison of equal value with *Mesohippus bairdii,* so fully described by Scott,[1] and may be described in detail as follows:

I. THE DENTITION.

Dental formula I.$\frac{3}{3}$, C.$\frac{1}{1}$, P.$\frac{4}{3}$, M.$\frac{3}{3}$. In proportion to the other parts of the skeleton the teeth are very large compared with those of *Equus caballus.* The molars and premolars of both jaws are heavily cemented.

The Upper Jaw. — The tooth-crowns, though strongly hypsodont, are of moderate length. Incisors much shorter than in *Equus.* P^1 is placed well back, extending but little forward of the anterior lobe of p^2 to which it is closely appressed on the inner side. This position brings it in opposition with the anterior lobe of p_2 of the lower jaw.

The external styles of the molars and premolars are as

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[1] Journal of Morphology, Vol. V. 1891, pp. 301–342.

strongly developed as in *Equus caballus* and here is no trace of the external median ribs of the meta- and paracones. These last two characters are apparently common to all the species of *Neohipparion* and may be of generic importance.

Though the teeth in the present specimen are worn just to the stage when they present the most complicated pattern of enamel folding, they are very simple in this respect.

The Lower Jaw. — The incisors, like those of the upper jaw, are only moderately long-crowned, and are all fully cupped. The external pair is smaller than the others. The first premolar (p_1) is entirely wanting. The molars and premolars show an advanced stage of progression in the greatly flattened external walls of the para- and hypoconids. The antero-external enamel fold of the protoconid, except in p_2, is strongly developed. The lower border of the jaw is very much curved.

The Milk Dentition. — There is no trace of p^1 in the milk series of one of the specimens, but another associated specimen possesses this tooth reduced to a mere vestige. In the upper molars the protocones are strongly developed and free as in the adult. They are elongated in cross-section, though not to the degree shown in the permanent series. The lower molars possess a little tubercle arising from the cingulum between the para- and hypoconids. This conule is much shorter than in the *Hipparion* of Europe, but broader antero-posteriorly, being elliptical in cross-section. The outer walls of the para- and hypoconules are flattened, but in less degree than in the permanent series.

II. The Skull.

There are many primitive characters observable in the skull, the most prominent of which are the vertical thickness, general shortness, and consequently the relatively large space occupied by the molar-premolar series. The orbit is placed well forward, its anterior border being above the posterior half of p^2. The anterior projection of the masseter ridge extends forward to the middle of m^1. The position of the infraorbital foramen is between p^3 and p^4. The facial pit is broad and its borders are not clearly defined. The anterior palatal foramina are small and do not extend back of the canines. The anterior border of the posterior narial notch is opposite the middle of m^2. The vomer overlaps the anterior end of the basisphenoid.

Measurements of Teeth.

	Anteroposterior.	Transverse.
Diameters of p^1	9.5 mm.	7 mm.
“ “ p^2	29.5 “	23.5 “
“ “ p^3	25 “	25 “
“ “ p^4	25 “	25.5 “
“ “ m^1	22 “	23 “
“ “ m^2	24 “	23 “
“ “ m^3		

Total length of series	152 mm.
Width across external incisors	55 “
Anteroposterior diameter of protocone, p^2	8 mm.
“ “ “ “ p^3	9.5 “
“ “ “ “ p^4	10.5 “
“ “ “ “ m^1	9 “
“ “ “ “ m^2	9.5 “
“ “ “ “ m^3	10.5 “

	Anteroposterior.	Transverse.
Diameters of p_2	24 mm.	11.5 mm.
“ “ p_3	25 “	13 “
“ “ p_4	25 “	12 “
“ “ m_1	24 “	10 “
“ “ m_2	25.5 “	9.5 “
“ “ m_3	22 “	75 “

Milk dentition (Upper)

	Anteroposterior.	Transverse.
Diameters of dp^2	31.5 mm.	21.5 mm.
“ “ dp^3	26 “	21 “
“ “ dp^4	29 “	20 “

Skull Measurements.

Total length of skull	378 mm.
“ “ “ palate	205 “
Width of palate between first molars	44 “
“ “ “ at narrowest point	29 “
Length of diastema between canine and external incisor	20 “
“ “ “ “ external incisor and p^1	67.5 “
Greatest width of posterior nares	28 “
Width of skull	128 “
“ “ condyles	54 “

III. The Vertebral Column.

The vertebral column of the type specimen was found completely articulated, even to the tip of the tail, hence the formula can be given without a possibility of error. It is as follows: Cervicals, 7; dorsals, 18; lumbars, 6; sacrals, 6; caudals, 17 + (?) 1.

The *cervicals* are long and slender and are horse-like in general appearance. They resemble much more those of *Equus* than those of *Mesohippus*, but show some intermediate characters.

The *atlas* differs from *Equus* in the following characters: The exterior pair of anterior foramina observed in the atlas of the horse are not bridged over in *Neohipparion*, but are represented by open notches at the anterior borders of the transverse processes. The median ventral tubercle, for the attachment of the longus colli muscle, is very strongly developed.

The *axis* is comparatively longer and of less vertical thickness than in either *Mesohippus* or *Equus*. Compared with *Equus* the odontoid process is not so deeply spout-like, and is proportionately narrower. The anterior vertebral foramina are comparatively large, opening directly into the side of the neural canal, and are not directed forward as in *Equus*. In *Mesohippus* the foramen seems not to be inclosed, but is open anteriorly. The spine is divided posteriorly into two diverging ridges which, extending backward and downward, merge into the posterior zygapophyses on either side. In *Mesohippus* the spine is not divided posteriorly, but extends backward, ending in a strong high tubercle.

The *3rd*, *4th*, and *5th* cervicals, except for their greater comparative length and more delicately formed processes, differ but little from those of the modern horse.

The ventral surface of the *6th* cervical is flat, turning downward laterally into the wing-like transverse processes, which are more strongly developed than in *Equus*. There is only a trace of the median keel, so well developed in both *Mesohippus* and *Equus*.

The spine of the *7th* cervical is comparatively higher than in *Equus*, but more reduced than in *Mesohippus*.

The spines of the anterior *dorsals* are long and slope backward at a greater angle than in *Equus*.

The spines of the *lumbar* vertebræ are comparatively high and narrow. The transverse processes of the third lumbar from the sacrum are comparatively long and do not articulate with those of the second lumbar from the sacrum.

The *ribs* are remarkably like those of the zebra in form, except the more posterior ones, which are proportionately longer and have a greater curvature.

The *sternum*, which is well preserved in the type specimen, is very characteristic. It is composed of six bony segments, as is usual in the horse, but the ventral keel, so highly developed in the living horses, is entirely wanting, except in the two anterior segments, and it is only weakly developed in these. The ventral surfaces of the third, fourth, and fifth sections are flat and are widest transversely. The xiphisternum is the largest of the series. The anterior portion of the ventral surface is broad, concave, becoming narrower posteriorly where the edges turn upward, making the posterior third of the ventral surface convex.

The *cartilaginous ribs* are composed mainly of spongy bone as in the horse, hence are preserved in the type specimen.

IV. The Fore Limb.

The *scapula* is distinguished from *Equus* by: (1) relatively narrow prespinous fossa; (2) the narrowness of the neck; (3) the prominent vertical ridge or thickening of the subscapular area beneath the postscapular border.

The *humerus* is widely distinguished from that of *Equus* by: (1) the depth and narrowness at the proximal and distal extremities; (2) the shallowness of the bicipital groove; (3) the absence of the groove in the lesser tuberosity; (4) the sharp definition of the grooves and convexities of the ulno-radial trochlea.

The *radius* is proportionately long and slender and, except for modifications of the shaft, is much like that of *Equus*. The shaft of the radius, in its median portion, is concave behind, forming a sharp angle with the posterior border of the inner face.

The shaft of the *ulna* is continuous, but very much reduced, and firmly coalesced with the radius.

The *carpus* as a whole is more rounded in contour, and the transverse diameter is proportionately less than in *Equus*. The articulation of the scaphoid and magnum is peculiar. On the distal face of the scaphoid the facets for the articulation of the trapezoid and magnum are in form and position practically the same as in *Equus*, except that the magnum facet extends further backward and curving downward ends in a conical tooth-like process, which in the flexed position of the carpus fits into a corresponding depression in the magnum. In *Equus* the scaphoid and magnum do not touch each other when the foot is fully flexed.

The convex portions of the radial facets of the scaphoid and lunar occupy a relatively larger part of their proximal surfaces than in *Equus*. The cuneiform is proportionately smaller than in either *Mesohippus* or *Equus*. The pisiform is short, thin, and broad, resembling that of *Equus* in proportions. The trapezium is very small and rudimentary, and articulates principally with the trapezoid, though there are two other small facets which indicate that the trapezium articulates slightly with the scaphoid proximally and with the rudimentary metacarpal I distally. The unciform is relatively high and narrow, and projects below the distal face of the magnum.

The *metacarpus* consists of one principal and two much reduced lateral members, metacarpals III, II, and IV, and two rudimentary bones representing metacarpals I and V. These rudimentary metacarpals are about equal in size and are reduced to mere nodules of bone, which articulate principally with the second and fourth metacarpals respectively. Metacarpals II and IV are nearly as much reduced in size as the splint bones in *Equus*. Their proximal ends and the greater part of their shafts are placed well behind metacarpal

III. Their shafts taper to very slender proportions, but expand again distally, forming articular ends which support small lateral toes. Compared with *Mesohippus* and *Equus*, metacarpal III is very long and slender. The distal end is keeled entirely around, but is not so strongly developed on the distal surface as in *Equus*. The lateral toes are much shorter than the median toe, their extreme points reaching only to about four fifths the length of the first phalanx of the latter. The terminal phalanx of the median toe, compared with that of *Equus*, is proportionately longer and more compressed laterally in front. The palmar surface is heart-shaped in outline, with the apex deeply cleft. The proximal end is moderately high. The articular facet is placed at about the same angle as in *Equus*. Two processes extend outward and backward, one on either side of the articular face. These processes are thin, with rounded edges, and each is perforated by an arterial foramen.

V. The Hind Limb.

The *femur* is slender and the shaft is relatively long. The second and third trochanters are placed relatively nearer the proximal end of the shaft than in either *Mesohippus* or *Equus*. The groove for the ligamentum patellæ is comparatively longer and narrower than in *Equus*. The *tibia* exceeds the femur in length, but in other respects is like that of *Equus*. The *fibula* is as much reduced as in *Equus*. The remnant of the distal end is entirely fused with the distal end of the tibia.

The *tarsus* is relatively deeper anteroposteriorly than in *Equus*, but is essentially the same in other proportions. The shallow, irregular pits are beginning to form on the broad, flat facets of the astragalus, navicular, cuneiforms, and the proximal end of metatarsal III, but are, for the most part, only indicated by slight depressions and roughened patches on the bone surface. In *Equus* these pits are deeper and their boundaries are well defined, though varying greatly in size and form in different individuals.

The *metatarsals* are very long and slender, metatarsal III equaling the femur in length. The lateral digits are reduced in about the same proportion as those of the fore-foot. The phalanges are much like those of the fore-foot, except that the terminal phalanx of the third digit is somewhat smaller and comparatively narrower than that of the fore-foot.

VI. Pelvis.

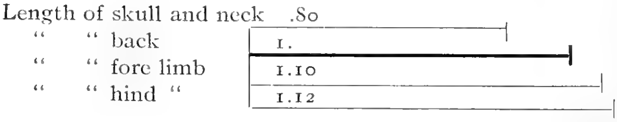
The *pelvis* shows a marked stage of advancement. It differs in no essential way from that of *Equus*, the proportions throughout being about the same as in *Equus caballus*.

As the comparisons in the foregoing description have been mainly with *Mesohippus bairdii* and *Equus caballus*, it may prove instructive to give here a comparative table of measurements taken from skeletons representing the three genera, and tables showing comparative proportions. In the latter the Virginia deer is included.

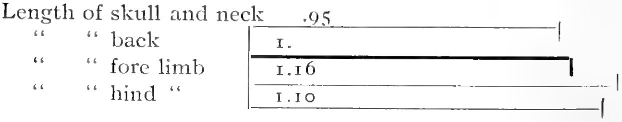
COMPARATIVE SKELETAL PROPORTIONS.

DORSO-LUMBAR SERIES TAKEN AS STANDARD.

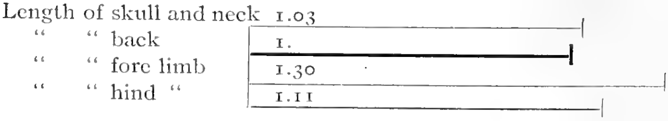
Mesohippus bairdii.



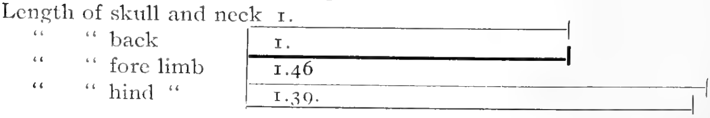
Neohipparion whitneyi.



Equus caballus.



Virginia Deer.



COMPARATIVE PROPORTIONS OF LIMBS.

Mesohippus bairdii.

Length of fore limb	Fore 1. limb.
“ “ humerus	.23
“ “ radius	.24
“ “ metacarpal III	.16

Neohipparion whitneyi.

Length of fore limb	1.
“ “ humerus	.19
“ “ radius	.24
“ “ metacarpal III	.21

Equus caballus.

Length of fore limb	1.
“ “ humerus	.21
“ “ radius	.22
“ “ metacarpal III	.16

Virginia Deer.

Length of fore limb	1.
“ “ humerus	.19
“ “ radius	.23
“ “ metacarpals	.22

Mesohippus bairdii.

Length of hind limb	Hind 1. limb.
“ “ femur	.34
“ “ tibia	.34
“ “ metatarsal III	.17

Neohipparion whitneyi.

Length of hind limb	1.
“ “ femur	.27
“ “ tibia	.31
“ “ metatarsal III	.27

Equus caballus.

Length of hind limb	1.
“ “ femur	.31
“ “ tibia	.28
“ “ metatarsal III	.21

Virginia Deer.

Length of hind limb	1.
“ “ femur	.27
“ “ tibia	.31
“ “ metatarsals	.26

COMPARATIVE SKELETAL MEASUREMENTS.

	Mesohippus bairdii.	*Neohipparion whitneyi.*	*Equus caballus.*
	mm.	mm.	mm.
Skeleton: Total length, premaxillaries to ischia	......	......	......
“ height, spine of 3d dorsal	460	......	1600
“ breadth across ilia	135	290	620
Axial Skeleton: Skull, incisors to occipital condyles	175	378	638
“ transverse, zygomatic arches	80	130	205
Vertebral column, 30 presacral vertebræ	645	1280[1]	1961
7 cervicals, total	195	446	686
midcervical centrum	30	80	135
18 dorsals, total	280	605[2]	911
4th dorsal, centrum	20	32	50
“ “ height of spine	53	135	250
7 lumbars, total	170	240[3]	364
2d lumbar centrum	23	40	58
6 sacrals, total	100	170	230[5]
caudals, total	?	325	650
Ribs, 5th, length, outer measurement	175	285	400
“ 8th, “ “ “	190	365[4]	638
“ 13th “ “ “	135	350	655
“ 17th “ “ “	......	252	490
Appendicular Skeleton: Hind limb, total length	506	950	1416
Femur, total length	170	255	435
“ circumference of shaft	55	100	215
Tibia, total length	170	290	400
“ circumference of shaft	50	90	180
Pes, os calcis to Dig. III, Ph. 3	190	460	660
“ transverse, tarsals	20	30	82
“ anteroposterior, tarsals	22	34	70
Metatarsal III, total length	98	255	300
“ “ circumference of shaft	32	70	132
Fore limb, total length	498	1010	1660
Scapula, length	130	250	450
“ greatest width	80	128	250
Humerus, total length	115	190	350
“ circumference of shaft	47	85	190
Radius, total length	122	245	375
“ circumference of shaft	38	80	165
Ulna, total length	157	300	490
Manus, lunar to Dig. III, Ph. 3	130	355	513
“ transverse, carpals	19	40	88
“ anteroposterior, carpals	15	30	55
Metacarpal III, total length	80	215	263

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[1] Thirty-one presacral vertebræ.

[2] Eighteen dorsals.

[3] Six lumbars.

[4] Seventh rib.

[5] Five sacrals.

On Two Species of Platygonus from the Pliocene of Texas.

By J. W. Gidley.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XIX, Article XIV, pp. 477–481.

New York, July 24, 1903.

The Knickerbocker Press, New York

Article XIV. — ON TWO SPECIES OF PLATYGONUS FROM THE PLIOCENE OF TEXAS.

By J. W. Gidley.

Among the very interesting fossils obtained by the American Museum expedition of 1901 from the Blanco beds, are two specimens of peccaries. Both are referable to the genus *Platygonus*, but represent two distinct species. One is probably referable to *P. bicalcaratus* Cope, but the other is clearly distinct from any described species. Both specimens consist of upper teeth unassociated with those of the lower series.

Platygonus bicalaratus *Cope.*[1]

This species was founded on a posterior portion of a molar, m_3 of the lower series. Unfortunately there were no characteristic portions of the upper teeth associated with the type, hence the upper dentition of *P. bicalcaratus* is not known. As shown by Cope's figures, the crests of the lower teeth are very high, and the conids forming them are subequal. These characters, together with the agreement of size, have led the writer to refer provisionally the present specimen

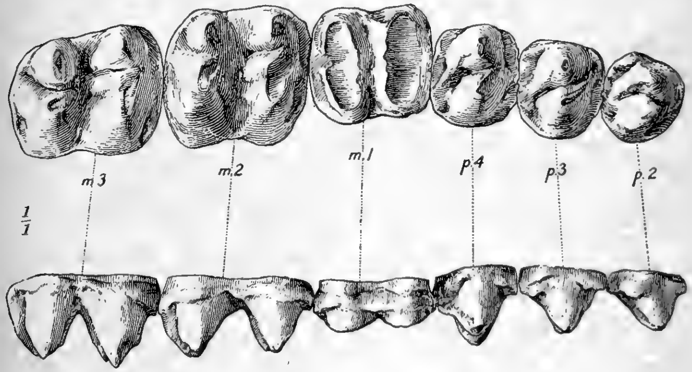

Fig. 1.—*Platygonus bicalcaratus ?* Cope. Right upper molar series. Amer. Mus. No. 10701. × 1/1.

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[1] Geol. Surv. Texas, 4th Ann. Rep., 1892 (1893), pp. 68–70, Pl. XIII, fig. 5.

(No. 10701 Coll. Am. Museum, Fig. 1) to Cope's species, *P. bicalcaratus*, from the same beds. Although the teeth present the generic characters of *Platygonus* they differ strikingly from any species hitherto described in which the upper teeth are known.

The chief distinguishing characters are as follows: (1) The posterior and anterior crests of the molars are high and completely divided by the cross valley. (2) The cones forming the crests are comparatively wide apart at their summits; thus when they become a little worn the upper molars of this species present very much the appearance of the lower molars of the tapir. (3) The posterior heel in m³ is entirely wanting.

Measurements.

		Anteroposterior.		Transverse.	
Diameters,	p²	11	mm.	12	mm.
"	p³	12	"	13	"
"	p⁴	12	"	14	"
"	m¹	16.5	"	15	"
"	m²	19.5	"	17.5	"
"	m³	20	"	16	"

Platygonus texanus, sp. nov.

The second species, hitherto undescribed, is represented by the type, a palate (No. 10702, Am. Mus. Coll., Figs. 2 and 5),

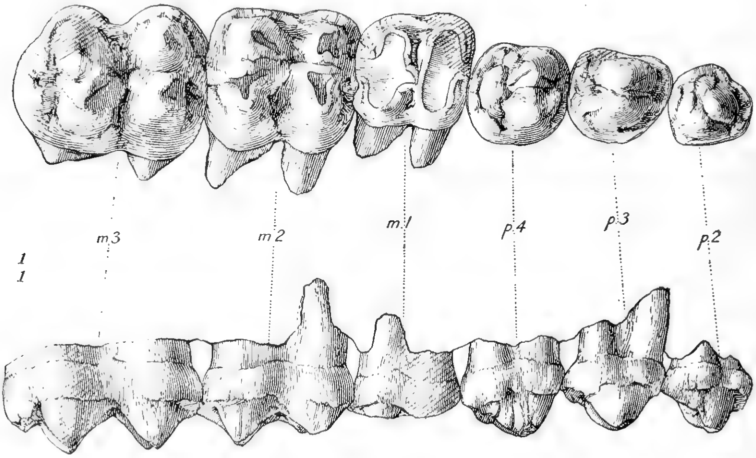

Fig. 2.—*Platygonus texanus.* Type. Amer. Mus. No. 10702. × 1/1.

containing the complete upper molar-premolar series, parts of the alveoli of the canines and incisors, and a portion of the upper anterior part of the skull.

Though coming from a later horizon,[1] the somewhat primitive quadritubercular character of the molars suggests in this species a close relationship to *P. rex* Marsh.[2] However, comparing it with a cast of Marsh's type, which the writer has at hand, the following differences are very clearly shown: (1) The four principal cusps of the molars are proportionally shorter. (2) The cusps are subequal in the anterior and posterior pairs, and are comparatively wide apart at their summits. In *P. rex* the cusps of the outer side of the molars are perceptibly higher than those of the inner side. (3) The posterior heel of m^3 is much more strongly developed. It is very weakly represented in *P. rex*. (4) The size of the molars indicates a species larger than *P. rex*.

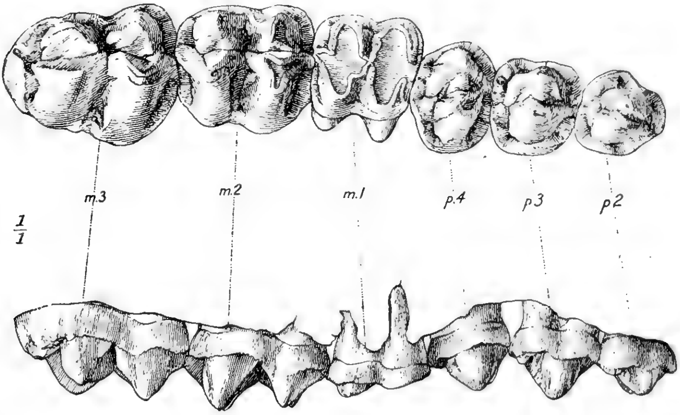

Fig. 3.—*Platygonus vetus.* Leidy. Amer. Mus. No. 2724. × 1/1.

Compared with *P. vetus* Leidy (Figs. 3 and 4) the chief distinctions are as follows: (1) The cones of both the molars and premolars are proportionally lower and, in the molars, more

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[1] The type locality of *Platygonus rex* Marsh is eastern Oregon. Marsh gives the horizon as Pliocene, but it is almost certainly Upper Miocene.

[2] Am. Jour. Sci. (3) xlviii, 1894, p. 273.

simple. (2) The molars are proportionally wider transversely, especially at the summits of the cones. (3) The posterior heel of m³ is wider transversely, and is more distinctly separated by a cross valley from the posterior crest of the tooth. (4) The canine is proportionally much thicker anteroposteriorly than in *P. vetus*, as indicated by the alveolus. (5) The backward extension of the palatines is much greater than in any species in which this character is known, the anterior border of the palatal notch being situated nearly three times farther back of the posterior molars than in *P. rex.*

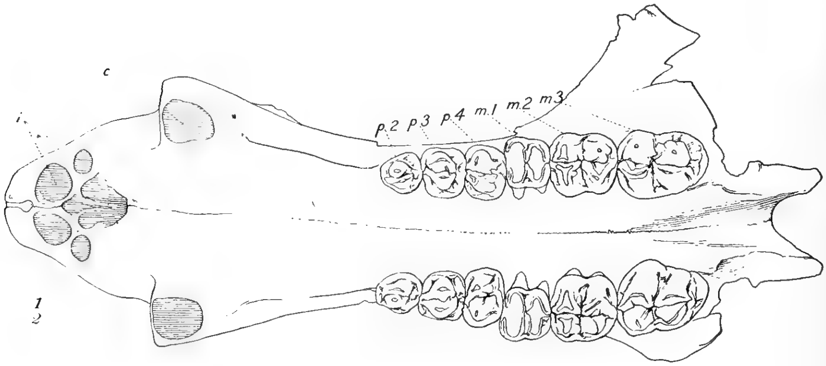

Fig. 4. –*Platygonus vetus* Leidy. Amer. Mus. No. 2724. × ½.

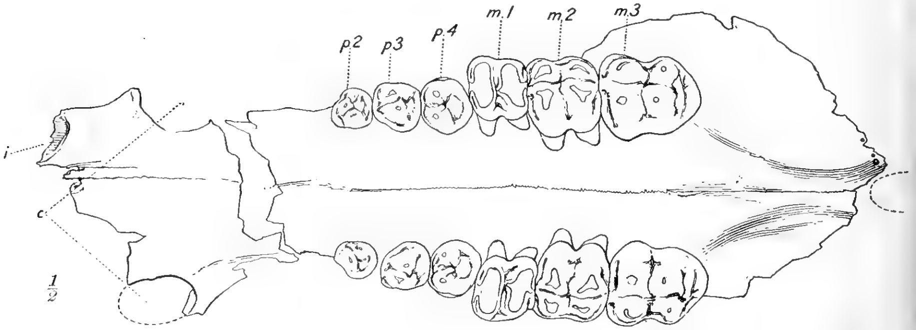

Fig. 5.—*Platygonus texanus.* Type. Amer. Mus. No. 10702. × ½.

Measurements of Type.

	Anteroposterior.	Transverse.
Diameters, p²	11.5 mm.	10.5 mm.
" p³	13.5 "	12 "
" p⁴	14 "	14 "
" m¹	17.5 "	15.5 "
" m²	20 "	20 "
" m³	25.5 "	21.5 "
Total length of series		101 mm.
Position of palatal notch back of posterior molars		48 mm.

Measurements of two upper molars of Platygonus rex *Marsh.*

	Anteroposterior.	Transverse.
Diameters, m²	19 mm.	16 mm.
" m³	21 "	18 "

(These measurements are taken from Marsh's figures and confirmed by the measurements of the cast.)

Glyptotherium texanum, A New Glyptodont, from the Lower Pleistocene of Texas.

By Henry Fairfield Osborn.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XIX, Article XVII, pp. 491–494.
New York, August 17, 1903.

The Knickerbocker Press, New York

Article XVII.— GLYPTOTHERIUM TEXANUM, A NEW GLYPTODONT, FROM THE LOWER PLEISTOCENE OF TEXAS.

By Henry Fairfield Osborn.

Plate XLIII.

The existence of Glyptodonts in the United States was made known by Cope [1] in 1888 in his description of *Glyptodon petaliferus*, based on a single carapace scute or plate from the Lower Pleistocene Equus Beds of Texas; and by Leidy [2] in 1889 in his *Glyptodon septentrionalis*, based on carapace and caudal scutes from Florida; Leidy also described [3] and figured from Florida plates of the G. *petaliferus* type. The American Museum Expedition sent out by the writer, with the aid of the William C. Whitney Fund, under the leadership of Mr. J. W. Gidley, was fortunate in securing the nearly complete carapace, pelvis, sacrum, caudals, and complete tail armature of an individual in fine preservation. It proves to represent a new genus and species, combining characters of several of the South American forms of the Pleistocene and Miocene periods. The specimen was skillfully brought in by Mr. Gidley and prepared and mounted under the direction of Mr. Adam Hermann. The writer is especially indebted to Prof. W. B. Scott for pointing out several of the features in which *Glyptotherium* differs from the known South American genera. Also to Mr. W. K. Gregory for the preparation of the manuscript for the press.

The specific distinctions given below are derived by comparison of (1) the specimens referred by Leidy to *G. petaliferus* and of (2) Cope's description, which runs as follows: ". . . with the circumferential areas of the rosette but little smaller than the central one. The former are regularly pentagonal,

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[1] Amer. Naturalist, Vol. XXII, 1888, p. 345.

[2] Proc. Acad. Nat. Sci. Phila., 1889, p. 97; and 'Description of Vertebrate Remains from the Peace Creek of Florida,' Trans. Wagner Free Inst. of Phila., Vol. II, 1889, p. 24.

[3] *Ibid.*, pl. iv, fig. 9; pl. vi, fig. 1.

the latter regularly hexagonal, and they are separated by well-defined grooves." Cope's type specimen is not available for comparison; it may prove that Cope's description and Leidy's reference are both misleading.

Glyptotherium texanum, gen. et sp. nov.

The *carapace* measures 1450 mm. (4 ft. 9 in.) along the dorsal curvature anteroposteriorly, and 1920 mm. (6 ft. 4 in.) from side to side; the tail armature is 620 mm. (about 2 ft. 1 in.) long, having a circumference proximally of 705 mm. The larger plates in the dorsal region measure 60 mm. in the longest diameter, which is oblique to the axial line of the carapace. The marginal plates may be estimated at 84, or 42 as counted on the more perfectly preserved left side. Eight of the posterolateral marginal plates are pointed or projecting; all the others have an even, gently convex, border. The central plates are quadrate in the lower portion of the shield, irregularly pentagonal and hexagonal in the upper, all being characterized by a large central circular area surrounded by from 7 to 12 smaller peripheral areas, all separated by grooves. From 35 to 36 transverse rows of these plates may be counted along the top of the carapace, and 34 at the side, practically the same number as in *Glyptodon clavipes* Owen.[1] The six anterolateral rows are firmly united, but the seventh to fifteenth are separated by deep grooves and admitted of some freedom of motion; these plates overlapped, the borders being bevelled. A similar freedom is observed in *Panocthus*.

The *tail armature* is composed of eighteen circles of plates, of which the anterior fifteen are arranged in paired rings and the posterior three are coalesced into a single triple piece or terminal cone. There are thus eight of the movable rings, of which the seven anterior are composed of two rows of simple flattened plates, and the eighth of a single row of elongate

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[1] *Cf.* Lydekker, R., Contributions to a Knowledge of the Fossil Vertebrata of Argentina, Pt. II., pll. i–v. Paleontologia Argentina, III. La Plata, 1894.

plates with three pieces intercalated anteriorly. Behind these eight distinct rings is the terminal cone, composed of three rings of plates; of this coössified portion the anterior ring contains eight pieces with two anterolateral pieces; the mid-ring is composed of six pieces, and the terminal ring is irregularly composed of four pieces. Thus the tail comprises eight complete rings and a terminal cone, the same number as in *Glyptodon clavipes* as described by Lydekker. The rings gradually increase in length from 60 mm. anteroposterior measurement, and decrease in diameter from 230 to 183 mm. The terminal cone is laterally compressed, measuring 75 mm. transversely and 132 anteroposteriorly. The posterior borders of the ring plates are gently scalloped, not pointed as in *Glyptodon clavipes*.

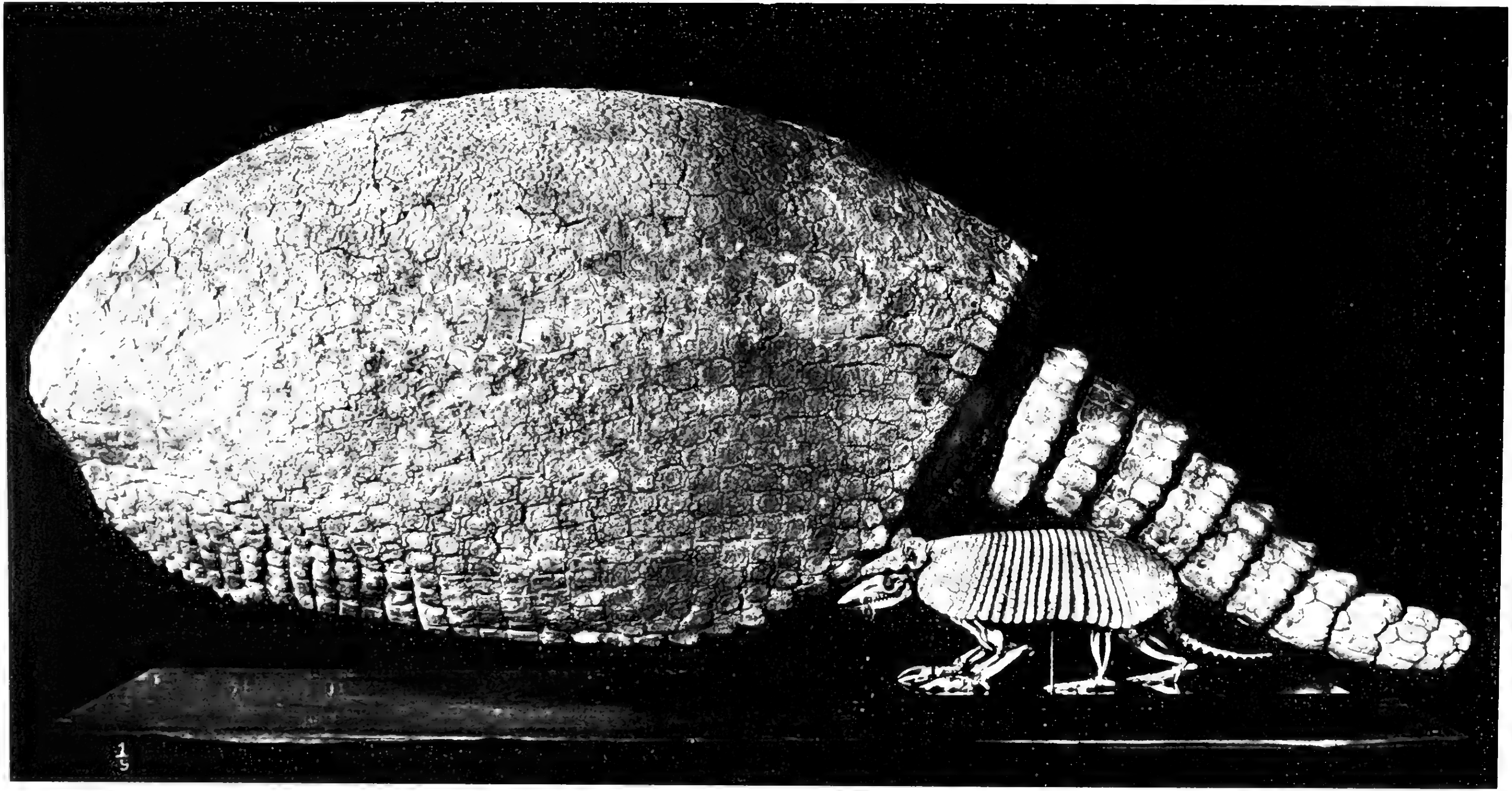
Within the carapace and caudal rings were found one *sacrocaudal* and thirteen free *caudal vertebræ*, with an imperfectly developed fourteenth, and seven chevrons—all perfectly preserved. Of these vertebræ the posterior ten, as appears from measurement and from the deflected transverse processes, were fitted within the tail-sheath, there being thus a vertebra for each ring, while the anterior three articulated with the peculiar sacrocaudal vertebræ, in which the greatly elongated transverse processes or ribs extend outward to coössify with the posterior plates of the ischia. The first free caudal has a transverse diameter of 302 mm., and distinct lateral articulations as facets for the posterior borders of the last sacrocaudal and of the ischium; the neural laminæ are elevated, the pre- and postzygapophyses are elevated and vertically placed; the neural spine is low; caudals 2 and 3 were also well within the carapace, with transversely extended spines; in caudals 4–11 the transverse processes are deflected, downwardly and forwardly directed; the neural arches, zygapophyses, and spines diminish in distinctness. Caudals 12–13 lack all processes. A single *chevron* of the narrow type, similar to the most anterior chevron in *G. clavipes*, was found with the specimen; it measures 130 mm. vertically. Six stout chevrons with shallow, obtusely forked inferior processes, anteroposteriorly expanded distally, are placed beneath caudals 5–11. These chevrons have an entirely different form from the deep, narrow chevrons in *G. clavipes*.

Both ossa innominata, as well as the entire dorso- and caudo-sacral complex, are preserved.

GENERIC AND SPECIFIC CHARACTERS.

The hexagonal osseous plates of the carapace of this species resemble those figured by Leidy (*op. cit.*, pl. iv, fig. 9; pl. vi, fig. 1) as *G. petaliferus*, but differ specifically in: (1) the relatively large size of the central area; (2) the smaller size and irregular form of the peripheral areas; (3) the shallowness of the circular and radiating grooves.

As regards generic distinction, this animal is very primitive and simple in its tail structure, which strongly suggests that of *Propalæohoplophorus* and other Santa Cruz (Miocene) types, but it appears to show some degeneration in the sculpturing of the carapace plates, in which the central and marginal areas are not so sharply defined as in *G. petaliferus*, *Panocthus*, and other types. The imbricating lateral plates suggest those of *Panocthus*. The shallow caudal chevrons are rather like those of *Sclerocalyptus* (*Hoplophorus*) than the deep chevrons of *Glyptodon*. The general shape of the carapace is also rather like that of the *Sclerocalyptus* type than that of *Glyptodon*.



Glyptotherium texanum, Type.

With *Tatusia novemcincta* 1/5

A New Genus of Ground Sloth from the Pleistocene of Nebraska.

By Barnum Brown.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XIX, Article XXII, pp. 569-583.

New York, October 28, 1903.

The Knickerbocker Press, New York

Article XXII. — A NEW GENUS OF GROUND SLOTH FROM THE PLEISTOCENE OF NEBRASKA.

By Barnum Brown.

Plates L and LI.

Paramylodon, gen. nov.

This genus is founded on a nearly perfect skull and lower jaw in the American Museum collections (No. 2780), with associated skeletal material including five cervical vertebræ, tibia, fibula, calcaneum, astragalus, lunar, middle digit of manus, and ribs, found by the Expedition of 1897 near Hay Spring, Nebraska. Professor Henry F. Osborn has placed this material in the writer's hands for description.

The following characters distinguish it from allied genera:

Skull elongate; muzzle inflated; dentition $\frac{4}{4}$; first upper molar the largest of the series; last lower molar trilobate; first lower molar without opposing tooth.

Paramylodon seems to have been less specialized than *Mylodon*, retaining features of the older, more primitive sloths. From the long nasals it seems improbable that it had a proboscis, while the greatly inflated muzzle, and the large movable premaxillæ, indicate a large prehensile lip. The reduction of the twelfth nerve [1] shows a less specialized tongue than in *Mylodon*. The rounded condyles, with the greater part of the articular area on the ventral surface, and the aspect of the foramen magnum, opening obliquely to the long axis of the skull instead of backward, show that the head was carried more at right angles to the vertebral column than in *Mylodon*. The long calcaneum with posterior end resting flat on the ground, and the astragalar facet looking forward, indicate a primitive foot more flexible at the ankle than in the contemporaneous *Mylodon*.

The sum of these characters points to a difference in feeding habits and indicates that *Paramylodon* was a grazer.

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[1] As indicated by the small condylar foramen in the skull.

SYNOPSIS OF ALLIED GENERA.

	Mylodon.[1]	*Grypotherium.*	*Paramylodon.*
Number of teeth in skull....	5	4	4
Number of teeth in lower jaw	4	4	4
Character of last molar of lower jaw..............	bilobed	bilobed	trilobed.
Character of first molar of lower jaw...............	elliptical, opposes $m^{\underline{2}}$	cylindrical, opposes $m^{\underline{1}}$	elliptical, long, not opposing any tooth.
Character of muzzle.........	slightly contracted, rugose.	contracted, with osseous interseptum.	inflated, thin and smooth.

GENERIC CHRONOLOGY.

1840. *Glossotherium* OWEN, Foss. Mam. Voy. Beagle, p. 57. No species named. Type, the back of a skull from S. America.

1840. *Mylodon* OWEN, *ibid.*, p. 86. Type, *M. harlani*, based on a jaw found in Kentucky, which had been previously referred by Harlan to his *Megalonyx laqueatus.* Referred species, *M. darwini*, based on jaws, etc., from S. America.

1842. *Mylodon robustus* OWEN. Skull and skeleton. *Glossotherium* here made a synonym of *Mylodon.*

1855. *Lestodon* GERVAIS. Type, *L. armatus*, which (*fide* Lydekker) is not generically distinct from *Mylodon.*

1879. *Grypotherium* REINHARDT. Founded on skulls of *Mylodon darwini.*

1880. *Pseudolestodon* GERVAIS and AMEGHINO. Type, *Mylodon gracilis* = *Lestodon myloides.*

1887. LYDEKKER, in his Catalogue of the Fossil Mammalia in the British Museum, correctly states that *M. harlani* is the type of the genus, and divides *Mylodon* into two groups: one represented by *M. darwini*, the other including *M. harlani*, along with *M. robustus*, *M. littsomi*, *M. armatus*, and *M. gracilis.* In the first, "the first tooth in each jaw is extremely minute and wears horizontally." His reason for placing *M. harlani* with the second group is, perhaps, that a jaw shorter in front than the length of the dentition is indicated in that species, as is the case in *M. robustus*, etc., while in *M. darwini* the predentary portion of the jaw is much elongated.

1899. *Neomylodon* AMEGHINO. Type, *N. listai.*

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[1] *M. robustus.*

1900. ROTH and SMITH WOODWARD identify *Neomylodon* with *Grypotherium*, which they hold to be generically distinct from *M. robustus*, etc. (presumably from Lydekker's second group as a whole, and therefore by inference from the typical *Mylodon*).

1900. AMEGHINO objects to the use of *Grypotherium* on the ground that it was founded on the type species of *Mylodon*, which he erroneously supposes to be *M. darwini*.

The type of *M. harlani* should be in the Columbia University Museum, but has been lost or mislaid. A cast of it, in the Museum of Williams College, has been loaned to the writer through the kindness of Professor Cleland. Comparison of this cast with a series of skulls of the subsequently described genera and species shows that *M. harlani* is not congeneric with *G. darwini* and is nearest, on the whole, to *M. robustus* This classic species, therefore, is properly referred to *Mylodon* and the characters of the genus may be derived from it. *Grypotherium* appears to be a valid genus, but its name may, perhaps, be antedated by *Glossotherium*. *Lestodon* is a valid genus; *Pseudolestodon* is not separable from *Mylodon*.

Paramylodon nebrascensis, sp. nov.

SKULL.

Basal View. — The upper *dentition* comprises eight teeth set in two diverging rows at such an angle that the space separating the two anterior is twice that separating the two posterior teeth.

The *first molar* is the largest and simplest of the series, having the form of an elongated ellipse, with the longer diameter twice that of the shorter. It is greatly curved antero-posteriorly, the convex surface in front; the sides are straight. The longest diameter of the tooth is parallel to the dental series, and the outer side forms a line with the posterior teeth. The crown is worn deepest in the middle.

The *second molar* is bilobed; the anterior lobe stands at right angles and the posterior lobe oblique to the series. The tooth is triangular, with the angles rounded. The anterior side is gently convex; the inner side is marked by a deep sulcus, a little in front of the middle; the outer face is marked by a corresponding sulcus opposite but not quite so deep. These sulci, on opposite sides, form the constriction that divides the tooth into two lobes. Its greatest length is oblique to the line of the series.

The *third molar* is bilobed but somewhat modified from the preceding. The anterior side is gently convex with a faint indication of a groove in the middle. The inner side is shortest with a deep sulcus near its middle, while the outer side is longest with a less defined sulcus. The outer anterior angle is convex, as in the preceding tooth, but much broader. The greatest diameter is oblique to the series.

The *fourth molar* is shaped like the figure 8; the anterior lobe is larger and slightly oblique to the dental series. The anterior side is convex; the outer and the inner sides are nearly parallel, and near the middle of each is a sulcus that forms the constriction dividing the tooth into two lobes; the posterior side is convex but not as wide as the anterior side. The greatest diameter is parallel to the series. The plane of the alveolar outlet slopes from without, inwards and downwards; the space separating the alveoli of the first two is about twice that separating the succeeding teeth.

The maxillary part of the *palate* is of a triangular form with the base turned forward; gently convex from the palatines forward to a line connecting the anterior borders of the first molars, from which point it bends downward to the end of the maxillaries. The surface is pitted with several rows of small deep foramina parallel to the alveoli, and the anterior palatine foramina are situated on either side of the median premaxillary notch, passing forward, in two shallow grooves on each side, to small notches on the inner anterior border. The median maxillary suture presents a raised ridge, on either side of which is a shallow groove extending from the antepenultimate molar back to the palatines. The anterior border of the *maxillaries* presents two rounded thickened surfaces, separated by a deep median notch, for the articulation of the *premaxillaries*, which must have been large and movable, indicating a large prehensile lip. Directly in front of the first molar, marking the boundary of the premaxillary surface, is a small deep notch, back of which there is a small expanded area marking the widest part of the maxillaries.

The *palatine* is concave and smoother than the maxillary surface; the median sutural line is not prominent. Anteriorly the palatines join the maxillaries in an irregular suture, anterior to the alveoli of the last molars; laterally it unites with the maxillaries just internal to the alveoli. The posterior palatine foramina, situated on the outer side near the origin of the descending pterygoid processes, are the only openings in the palatines. Posteriorly they expand to unite with the orbitosphenoids and are separated by a wide entering notch.

The *pterygoids* will be described from the outer aspect. Internally they are convex, with a rugose posterior border forming the lateral boundaries of the large posterior narial opening.

The *sphenoidal bones* are not suturally defined from one another: that part forming the roof of the nasal depression between the pterygoids is broadly arched from side to side, and wider than in *Mylodon;* the surface is smooth with two longitudinal channels parallel to the base of the pterygoids. Posteriorly the narial opening is bounded by two rough subelliptical tuberosities.

The *basioccipital* is a broad concave plate, the posterior edge of which is deeply incised, forming the lower boundary of the foramen magnum; the palate is pierced by a small vascular foramen immediately in front of the condyles. The anterior condylar foramina are large, but not more than half the diameter of those in *M. robustus.* External to the condylar foramen the basioccipital continues in a strong rough tuberosity forming the posterior inner boundary of the articular depression for the stylohyal, and also the posterior boundary of the jugular foramen. The sides of the basisphenoid descend rapidly in front of the jugular foramen, ending in the large tuberosities before mentioned as bounding the posterior narial opening.

The *condyles* are rounder and shorter than in *Mylodon,* without the encroaching ridge which bounds the articular surface in that genus. The convex surface of each condyle is inclined a little outwards; the inner edges bounding the foramen magnum converge from the upper to the lower boundary. The condyles stand away from the skull more than in *Mylodon*, and the greater articular area is on the lower surface. The foramen magnum looks downwards as well as backwards.

The *tympanic* is lost, leaving exposed the petrous bone wedged in between the sphenoid, exoccipital, and squamosotemporal bones. The inner portion is a subcompressed, conical protuberance uniting with the basisphenoid in a straight line, forming the outer and posterior margin of the carotid canal. In *Mylodon* the basisphenoid is distinctly emarginated for its reception. On the outside and posterior to the conical process the petroso-temporal sends down a rugged process forming the anterior boundary of the jugular foramen and the depressions for the stylohyal. In front it bounds the posterior part of the tympanic cavity. The bony canal of the Eustachian tube expands where it communicates with the narial aperture, separating the pterygoids from the sphenoid protuberances.

Side View.— As in *Mylodon* the side view of the skull presents the form of an elongated parallelogram. The occipital plane inclines forward as it rises to the upper surface of the skull. The top of the cranium presents a nearly straight line slightly depressed at the posterior end of the nasals. The muzzle ends in a slightly curved line; nasals and maxillaries about the same length above, with protruding palate. Ventrally the basicranial outline is interrupted by the greatly expanded pterygoid.

The *supraoccipital* element forms nearly the whole of the posterior region of the skull, joining the parietals in a transverse lambdoidal suture, which forms the crest but does not encroach upon the coronal surface of the skull. From the condyles the broad *occipital plate* rises upward and forward, first at an angle of about 75° to two-thirds its height, and then forward to the lambdoidal suture at an angle of 60°. It is divided into two equal areas by a prominent occipital crest.

On each side of this crest there is a shorter parallel ridge extending from above to about the middle of the skull. Immediately above the left condyle there is a small foramen. A deep groove separates the condyle from the occipital plate.

Wedged in between the occipital and temporal regions is the prominent *mastoid*, about half as wide as it is long, bounded above by a continuation of the suture that separates the exoccipital from the supraoccipital. The outer margin is raised into a prominent ridge forming the lower posterior boundary of the temporal fossa. Immediately inside this ridge there is a deep channel running upward, ending in the mastoid foramen. The entire posterior surface of the mastoid, between the raised outer border and the exoccipitals, is a depressed rugose area. The inner part of the lower end of the mastoid is a cup-like depression for the articulation of the stylohyal, which is not nearly so deep or so extensive as in *Mylodon*.

The *temporal fossa* is uniformly smooth with an extensive depression just above the mastoid, and a large protuberance above this area, as in *Mylodon*.

The *zygomatic process* of the temporal is a stout trihedral bone, the upper edge of which is nearly straight; the external surface is nearly flat and gently convex. The under surface is broad and flat for the articulation of the lower jaw, without any distinct glenoid cavity, thus allowing a great forward and backward movement of the jaw. The anterior end of the zygoma terminates in an obtuse point.

The *malar* undoubtedly articulated loosely with the maxillary and the zygoma, but unfortunately is missing on both sides.

The most prominent bone of the skull is the *pterygoid*, which extends downward and outward in a broad plate ending in a very wide convex border, more prominent than in any allied genus. Posteriorly it descends from the sphenoid at an angle of twenty degrees, forming the gently rounded distal end, then sweeps upward, in a quarter arc of a circle. The external surface is rugose with a prominent ridge parallel to the zygoma dividing it into two depressions. In the posterior part of the upper one is the large foramen ovale, which opens forward and upward in a small canal at the upper border of the pterygoid, partly defined by the overhanging projection of the temporal. The posterior upper border is marked by deep channels and ridges.

The *frontal* is the largest bone of the skull, forming the middle half of the upper surface of the cranium, articulating in front with the nasal, maxillary, and lachrymal, below with the lachrymal, maxillary, and orbitosphenoid, and behind with the parietal and squamosal. Externally it presents a smooth surface of irregular curves expanded in front at the postorbital process, extending downward and inward to unite with the maxillary below the lachrymal, with a deep overhanging fold exterior to the optic foramen, as in *Glyptodon*. Above the optic foramen it descends outward slightly to unite with the orbitosphenoid.

The *orbitosphenoid* is not suturally defined but represents a depressed area, bounded on the outside by an overhanging wall of the frontal containing the optic foramen and foramen rotundum separated by a thin wall of bone.

The *lachrymal* presents an irregular outline, the superior border of which rises anteriorly above the malar in a rugose surface, in the centre of which is the lachrymal foramen. The posterior portion is much thinner and extends back in a truncated point to a line connecting the postorbital process of the frontal and the posterior margin of the last molar. Below the lachrymal foramen there is a deep rounded pit, with a raised cone in the center, for articulation with the malar.

That part of the *maxillary* presented in side view is of a quadrate form, convex on the outer surface, and extends nearly to the anterior end of the nasals, with which it forms a vertical cross-section. Posteriorly it unites with the orbitosphenoid at the beginning of the canal that leads into the optic foramen; above, with the lachrymal, frontal, and nasals. The malar process is a stout projection set obliquely to the maxillary, forming the anterior buttress of the malar and enclosing the infraorbital foramen. Across the middle of the maxillary, beginning above the infraorbital foramen in a curved line from the lachrymal foramen to the middle of the muzzle, there is a line of foramina of decreasing size.

Top View. — The length of the skull from the condyles to the upper anterior border of the maxillary is about the same as in the type of *M. robustus*. In the mastoid region it is slightly narrower, while across the anterior end of the zygoma at its widest point, behind the postorbital process and at the muzzle, it is much narrower. The upper surface is uniformly smooth; gently convex transversely; nearly flat in the parietal region, and slightly depressed from the postorbital process forward, but much less than in *Mylodon*. The face is much narrower than in *M. robustus* and the nasals are more highly arched; in the type, the nasals are crushed down into the narial opening. At the anterior end the nasals are slightly deflected, terminating in an outer rounded edge, the median halves presenting wide notches with two central, extended points and articular upper faces, to which were probably attached an incipient osseous interseptum. No well defined ridge separates the top of the skull from the temporal fossa, this surface merging into the sloping sides of the skull without any marked separation. The posterior boundary is formed by the thickened deltoid ridge, behind which are seen the sloping occipital region and the condyles.

LOWER JAW.

Dentition. — The *first molar* is smallest in diameter and simplest of the series: it is ellipsoid in cross-section and tapers to a point, the internal and posterior borders of which are worn down, leaving a crescentic anterior border. This tooth projects far above the crowns of the succeeding teeth (canine-like) and has no opposing tooth in the upper jaw.

The *second molar* presents an irregular trapezoidal outline with rounded angles, the posterior one most produced. The external side is convex, while the internal side is strongly concave, the concavity marked by a deep sulcus in the middle. The anterior and the posterior sides are concave, the latter more strongly pronounced. The sulci of the internal and the posterior sides tend to divide the tooth into two lobes. The posterior lobe is worn obliquely. The greatest length is oblique to the dental series.

The crown of the *third molar* is broken off, but the root gives the shape and dimensions of this tooth accurately. The external side is slightly convex, nearly straight. The internal side is slightly concave with indication of a groove in the middle. The anterior and the posterior sides are concave, with a faint groove in the middle of each. The greatest length is oblique to the dental series.

The *fourth molar* is the largest and most complicated of the series. It is composed of three lobes: a large anterior lobe, oblique to the dental series; a posterior lobe, more than half the size of the anterior lobe, transverse to the series, and a much smaller, less defined middle lobe, connecting the two and parallel to the series. The anterior lobe is convex on the internal and the external sides, concave on the anterior side, with a faint double groove in the middle, and concave on the posterior border, drawn out to form the connecting middle lobe, which unites with it on the internal half of the posterior border. The external and the internal sides of the posterior lobe are convex, and the posterior side is convex, with a slight median groove; the anterior side is convex, uniting with the middle lobe on the outer half. The middle lobe is well defined on the outer face by two deep sulci, and less marked on the internal side by two broad shallower sulci. The anterior and posterior borders are drawn out to form the connecting isthmuses, the latter being twice the width of the former. The posterior and half of the middle lobes of this tooth opposed the last molar of the upper series, and the crown is nearly flat. The anterior lobe opposed the second molar of the upper series, and the crown is worn in a crescentic surface.

Ramus, etc. — The *ramus* of the lower jaw is long and robust but contracts rapidly to the symphysial region. It is thick and massive in the dental portion and expanded in a thin vertical plate posteriorly. The external surface is concave — rounded both vertically and horizontally. The internal surface may be divided into three regions: the anterior, which, from the second molar to the symphysis, is convex vertically and concave horizontally; the middle, from the second to the last molars, which is nearly flat; and the posterior, back of the last molar, which is deeply concave. The lower border is rounded and thickened below the dental series, thinning out anteriorly and posteriorly. The upper or alveolar border is wide and rugose, and on the outside of the jaw there is a shallow depression extending the entire length below the alveoli.

The anterior expanded end presents an obliquely sloping *symphysis*, nearly half as wide as deep, extending anteriorly in a deep rounded border. From a front view this anterior border has the outline of a keel-like projection extending forward in the middle of the jaw. Below this keel is a rounded mammilloid process, much less prominent than in *Mylodon*. The portion of the jaw in front of the first molar is longer than in *M. robustus* and the width of the expanded portion is much less. The dental region is not nearly so deep as in *Mylodon*.

The posterior part of the jaw is expanded into a thin deep plate, divided into the *coronoid*, *condyloid*, *and angular processes*. The point of the *angular process* is broken off; the lower margin is convex and the inner side presents a deep concavity bounded below anteriorly by the inferior inflected border of the process and a ridge that extends forward and upward to near the alveolus of the last molar; below, posteriorly, the inner border is roughened by processes; above, it is bounded by the rounded border of the dental canal. The outer surface of the angle is convex and rugose.

The *coronoid* process is broken at the point but seems to have been nearly straight, slightly convex on the anterior border.

The *condyle* is long and narrow, set obliquely to the vertical plane of the coronoid. The greater part of the condyle overhangs the supporting plate of bone, only about one fourth extending on the outer side of the ramus. It rises from a triangular base, the outer angle of which begins below the notch separating the coronoid from the condyle, and passes backward and upward in a sharp ridge, forming the outer articular border of the condyle. The articular surface is slightly rounded.

The *dental canal* begins in a deep elliptical depression at a point below the origin of the condyle and passes forward to the entry of the large dental foramen. It continues forward in two divisions: the smaller and shorter, opening on the outer side of the jaw, opposite the posterior border of the last molar; the larger, passing forward and dividing into three branch canals that open on the outer side of the jaw where it bends forward to form the symphysis. These foramina are about 10 mm. apart, and the middle one is the largest. The smaller ones are about one fourth the diameter of the larger one. Near the depression that gives rise to the dental canal is a narrow deep channel that passes downward and forward under the upper part of the ridge bounding the concavity of the angle where it divides and comes to the surface in two foramina 20 mm. apart.

Tibia.

The tibia is a short, massive bone with a flattened shaft. The proximal end is greatly expanded laterally and in width is about three fourths of the entire length of the tibia. In general appearance and proportions it agrees with the type of *M. robustus* with the following exceptions. The external condylar facet is distinctly pyriform. In *M. robustus* it is circular. The fibular facet is elliptical and slightly concave; oblique to the condylar surface and sloping from without inward and downward. Anteriorly it nearly meets the superior surface. Posteriorly they are separated by a convex facet for the articulation of a sesamoid. The distal articular surface is divided as in *M. robustus*, but the external semi-elliptical compartment is convex, while in *M. robustus* it is flat. The external malleolus is not as prominent as in *M. robustus*.

Fibula.

The fibula is a subprismatic bone enlarged at both ends. The outer surface of the shaft is convex; the inner surface flattened, slightly convex and rugose, the posterior border thin and rounded. The upper end of the inner surface is excavated with a rugose border. The proximal end is truncated obliquely, presenting two facets: the outer and smaller for the articulation of a sesamoid; the inner (a very long surface convex in its narrowest dimension) for articulation with the tibia. About one half of the proximal end of the fibula on the outer side presents a rugose border and excavated surface for the attachment of the peroneus longus. The tibial facet is prolonged backward in a hook-like process. The distal end is expanded in an irregular quadrilateral form on the inner surface and a convex, very rugose, pitted obtuse point. The inner surface presents a deeply excavated concavity and two articular facets; the lower part of the concavity is occupied by the flat, oblique, tibial facet, which continues uninterruptedly into the vertical plane of the astragalar facet. The posterior distal third of the malleolus is rugose. In *M. robustus* the tibial and astragalar facets are separated by a transverse concavity.

ASTRAGALUS.

The astragalus, aside from being much larger than that of *M. robustus*, agrees with it in form and proportion with the following exceptions: The navicular facet is deeply excavated in the middle, with convex edges continuing uninterruptedly into the cuboidal facet. In *M. robustus* it is flat on its upper half and convex on the lower. The calcaneal facet is elongate and triangular to a greater extent than in *M. robustus*, with scarcely a perceptible constriction in the middle.

CALCANEUM.

The base of the calcaneum forms a nearly straight plane, concave on its posterior triangular surface, and of greater length proportionally than in *M. robustus*, with a broadly expanded posterior end. The astragalar facet occupies a more anterior position than in *M. robustus*, while the large tendinous grooves on the outer side of the bone are similar, but the tuberosities marking their boundaries are more prominent. In other respects it agrees with *M. robustus*.

LUNAR.

The transverse surface of the radial facet is convex in this form and the posterior extension of the same surface is broadly expanded, while in *M. robustus* it is nearly flat transversely and contracted on the posterior surface.

DIGITS OF MANUS.

The three phalanges of the middle digit are preserved, and differ considerably from those of *M. robustus*. The claw process of the *ungual phalanx* is somewhat deeper than wide, of an ellipsoid outline. The under surface is not separated from the sides by sharp ridges toward the distal end, as in *Mylodon*, and it is only toward the base that these ridges are shown. The *middle phalanx* resembles that of *Mylodon*, though the proximal facet is much deeper. The *proximal phalanx* is very much shorter than in *M. robustus;* the outer surface is twice the width of the inner surface and is expanded on the lower outer side. The proximal articular facet presents a deep concave channel for the articulation of the trochlea of the metacarpal; on the inner side of this channel, continuous with its inner edge, is a narrow, concave articular surface. The outer surface of the trochlear depression presents a sharp ridge. On the ventral surface there is a sesamoid facet on each side of the trochlear depression, the outer being the larger. The distal articular facet is a wide shallow channel, concave from side to side and convex vertically. Below the distal articular surface there is a rugose depression one fourth the height of the articular surface.

MEASUREMENTS.

Skull.

	mm.
Length of m^1	29
Width " "	15
Length " m^2	26
Width " "	23
Length " m^3	23
Width " "	25
Length " m^4	30
Width " "	17

	mm.
Length of dental series	133
“ “ skull from condyles to end of maxillary	470
Depth of occiput in vertical line to condyles	136
Width across muzzle at widest part	128
Width at narrowest part back of postorbital process	89
Width of condyles	128

Mandible.

Length of m^1	20
Width “ “	14
Length “ m^2	24
Width “ “	22
Length “ m^3	31
Width “ “	17
Length “ m^4	56.4
Width “ “	24.4
Length of dental series, alveolar measurement	180
Length of jaw from condyle to extreme point	371.3
Length of symphysis	120
Width of anterior end	445

Tibia.

Length	275
Proximal end across widest part	178
Distal “ “ “ “	150

Fibula.

Length	280
Width of proximal end	105
Width of distal end	70

Astragalus.

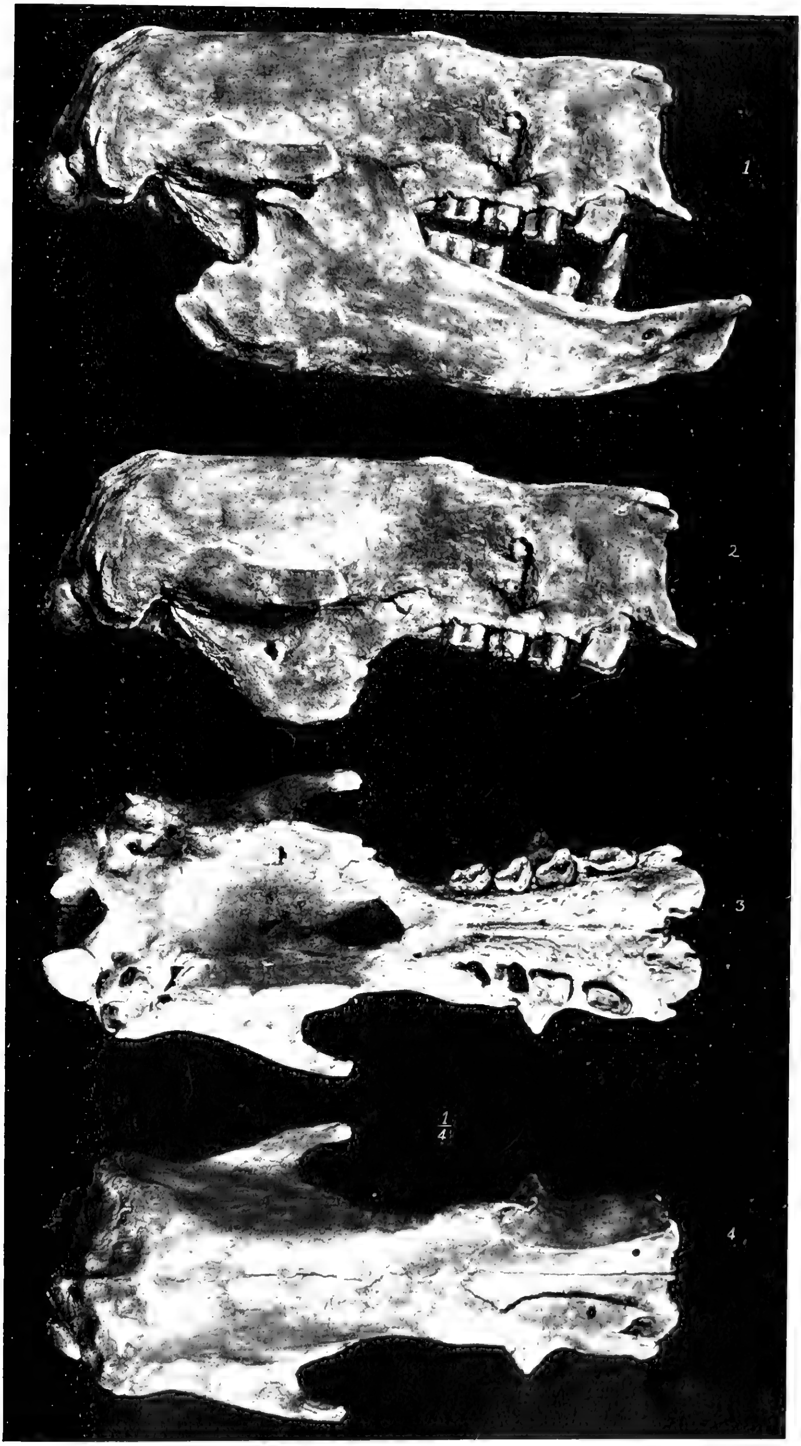
Greatest breadth	150
“ height	127

Calcaneum

Length	240
Width across base	130
Height at posterior articulation of astragalus	123

Third Digit of Manus.

Ungual phalanx, length	180
Second “ “	63
“ “ width	47
Proximal “ length	33
“ “ width across middle	46



PARAMYLODON NEBRASCENSIS

Type skull. × 1/4

The Fresh-Water Tertiary of Northwestern Texas. American Museum Expeditions of 1899–1901.

By J. W. Gidley.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
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Vol. XIX, Article XXVI, pp. 617–635.
New York, November 21, 1903.

The Knickerbocker Press, New York

Upper Mulberry Cañon.

Showing typical Miocene Scarp.

Article XXVI. — THE FRESH-WATER TERTIARY OF NORTHWESTERN TEXAS. AMERICAN MUSEUM EXPEDITIONS OF 1899–1901.

By J. W. Gidley.

Plates LII–LVIII.

In the spring of 1899 Professor Henry F. Osborn sent an expedition, under the leadership of the writer, to the Llano Estacado or Staked Plains in northwestern Texas, for the purpose of exploring the Miocene, Pliocene, and Pleistocene beds previously reported from that region by Professor E. D. Cope and Mr. W. F. Cummins, of the Texas Geological Survey. This expedition met with such success that a second and third expedition were sent to this region in the successive summers of 1900 and 1901. The results of the work of the three years are comprised in this report.

The following brief itinerary of the three expeditions seems necessary to a clearer understanding of the region explored and the relations of the different localities visited.

Expedition of 1899.

Clarendon, the county-seat of Donley County, a little town on the Fort Worth and Denver City Railway, was the chief base of outfitting and supplies, and the initial starting-point of the three expeditions.

The writer, with Mr. Alban Stewart as assistant and Mr. Alfred Brown as cook and teamster, left Clarendon July 1, 1899. Going north about ten miles the first camp was established on Barton Creek, where a thorough exploration of the surrounding country was made.

As reported by Cope and Cummins, the beds occupying the tops of the divides in this vicinity are true Miocene and, though of not great vertical thickness nor extensively exposed, are very rich in fossil remains. Several good fossils were found at this locality, the most important being a partial skeleton, in a splendid state of preservation, of *Mastodon* *productus* (No. 10582, American Museum Collection) including the skull and lower jaws.

Leaving this locality the party returned to Clarendon, then going west about twenty-five miles to the head of Mulberry Cañon turned southeast about three miles and established a camp at the top of the bluffs a little to the west of the mouth of the cañon. It was at this locality that Cope and Cummins reported a new geological horizon which Cummins called the 'Goodnight Beds' and which Cope considered the same as the Paloduro beds, placing them, in time, between the Loup Fork (Miocene) and Blanco beds which are true Pliocene.

The party remained several days in this locality and the writer explored both sides of the cañon for its entire length, failing to find any evidences of a break in the stratigraphic continuity of the deposits on opposite sides of the cañon, as reported by Cummins.

From Mulberry Cañon the party traveled southeast, crossing the South Fork of Red River near the mouth of Mulberry Creek, continuing south to a point nearly due east of Silverton, the county-seat of Swisher County, turned west and ascended the steep and rugged escarpment to the top of the Staked Plains. Continuing west, passing the head of Rock Creek, a third camp was established at the head of Tule Cañon.

The deposits here and extending east to and beyond Rock Creek on the south side of the cañon, and for some distance along the north side of the cañon as well, are of Pleistocene formation. At the head of Tule Cañon was found a specimen of *Elephas imperator* (No. 10598, American Museum Collection), consisting of a complete fore limb, part of the fore foot, the lower jaw and upper teeth, besides a few vertebræ and ribs.

Returning to the head of Rock Creek, seven miles to the east of the Tule Cañon camp, the party established a fourth camp. At this locality was made the splendid find of fossil horse skeletons (*Equus scotti*) already described by the writer.[1]

This practically ended the season's work, the party returning to Clarendon by the way of Canyon City at the head of

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[1] Bull. Am. Mus. Nat Hist., Vol. XIII, pp. 114–116; Vol XIV, pp 134–137.

Paloduro Cañon, then to Amarillo and back along the line of the railroad.

EXPEDITION OF 1900.

The writer was accompanied on the second expedition by Mr. Hans W. Zinsser, of Columbia University, who proved both a valuable assistant and agreeable companion.

A little preliminary work was done this year at the old locality north of Clarendon, but the main object of this expedition was to explore the eastern escarpment of the Staked Plains south from Silverton, and especially to examine the Blanco beds at Mount Blanco. Accordingly the party, leaving Clarendon July 26, 1900, started southwest, taking nearly the route followed the previous year as far as the main divide between Mulberry Creek and South Fork of Red River, then crossing the South Fork of Red River, several miles west of the crossing point of the previous year, ascended the steep escarpment to the top of the Staked Plains at a point nearly north of Silverton. Going east about fifteen miles to the point at which the party ascended the previous year, we turned south along the top of the escarpment, examining the bluffs for a distance of forty or fifty miles, then taking a southwest course across the Plains went direct to Mount Blanco.

The exposures at Mount Blanco are true Pliocene, and, though of small extent, are very rich in fossil remains. The specimens of most importance found at this locality were a nearly complete skull and lower jaws of *Dibelodon mirificus* (No. 10622, American Museum Collection), and, the following year, a partial skeleton of a Glyptodont consisting of a nearly complete carapace, tail pieces, pelvis, sacrum, lumbar and caudal vertebræ. This specimen has since been described by Professor Henry F. Osborn,[1] under the name *Glyptotherium texanum*, gen. et sp. nov.

On finishing the work at this place the party went directly north to the head of Rock Creek, where a second excavation was made in the bank or quarry, from which the horse skele-

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[1] Bull. Am. Mus. Nat. Hist., Vol. XIX, 1903, pp. 491–494.

tons were taken the previous year, resulting in the finding of additional material of *Equus scotti* (Nos. 10628, 10629 and 10630, American Museum Collection).

Finishing up the season's work here the party again returned to Clarendon, practically by the same route followed the previous year.

EXPEDITION OF 1901.

The third expedition to the Staked Plains was made possible by the kind generosity of Mr. William C. Whitney, who donated a sum to the American Museum to be used, under the direction of Professor Henry F. Osborn, for the collecting and placing on exhibition of fossil horse material to illustrate the evolution of the horse in America. The object, therefore, of this last expedition was to make a more extended exploration of the Miocene and Pliocene exposures with the hope of obtaining some new material of the three-toed horses of these periods.

Accompanied by Mr. William Kendal as assistant and Mr. James Morton as cook and teamster, the writer left Clarendon July 1, going first to the old locality between Barton Creek and Salt Fork of Red River. Wishing to extend the explorations further to the north and east the party continued on north about five miles to the head of Petrified Cañon, camping there a few days, then turning east traveled down Whitefish Creek about twenty-five miles to Skillet Creek, making another camp at this place. At the head of Petrified Cañon were found the skulls and parts of skeletons of twelve three-toed horses. Unfortunately, however, the bones were badly crushed and broken and covered with a hard limestone concretion which is very difficult to remove without injury to the fossil.

On the divide east of Skillet Creek the writer obtained three important specimens, a skull and lower jaws of a Mastodon (No. 10673, American Museum Collection) of the *M. productus* type, both fore feet complete of a second individual (No. 10672, American Museum Collection) of the same species, and a skull with a few skeleton bones of the big dog *Dinocyon* *gidleyi* (No. 10671, American Museum Collection) subsequently described by Dr. W. D. Matthew.[1]

The creeks have cut deeply into the underlying strata of the Triassic in this locality, and erosion has entirely obliterated the Miocene deposits from many of the divides.

The deposits that remain in this vicinity differ greatly in character from the exposures along Barton Creek and to the west. They represent much more the appearance of the underlying red beds of the Triassic, from which the materials composing them are apparently derived.

Finishing the work at this locality the party made a second visit to the Blanco beds at Mount Blanco. Except for a few days of fruitless search in the vicinity of the mouth of Tule Cañon, the remainder of the time was occupied in a second careful examination of the deposits at this place and in exploring Blanco Cañon to its mouth. The most important specimens found on this second trip to Mount Blanco were the *Glyptodon* specimen referred to above and a new species of *Platygonus*, since described by the writer[2] (*Platygonus texanus*, No. 10702, American Museum Collection).

Returning to Clarendon, practically by the route taken the year before in going from Clarendon to Mount Blanco, the three years' work in northwestern Texas was at an end.

GEOLOGICAL NOTES.

Professor W. F. Cummins, in the very complete and interesting reports of his explorations in northwestern Texas,[3] has so fully, and, for the most part, accurately described the general geological character and stratigraphy of the Staked Plains, that an attempt at any such extensive and detailed description here would be an unnecessary repetition of much of Cummins's work. Cope[4] has given detailed descriptions of the fossils, taken from various localities, apparently verifying Cummins's determination of the various beds. It is, therefore, the inten-

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[1] Bull. Am. Mus. Nat. Hist., Vol. XVI, 1902, pp. 129–136.

[2] Bull. Am. Mus. Nat. Hist., Vol. XIX, 1903, p. 478.

[3] Geol. Surv. Texas, 3rd Ann. Rep., 1891 (1892), pp. 129–200; 4th Ann. Rep. 1892 (1893), pp. 179–238.

[4] Geol. Surv. Texas, 4th Ann. Rep., 1892 (1893), pp. 11–87. Proc. Acad. Nat. Sci. Phila., Vol. XLV, 1894, pp. 63–68.

tion of the writer to discuss, in some detail, only the more important localities with the purpose of correcting some obvious errors made by Cummins, both in the distribution and correlation of these beds, and to present briefly some of the writer's observations and conclusions which are at variance with those of both Cope and Cummins. These conclusions are briefly as follows:

(1) The fossil-bearing formations are fluviatile, not lacustrine, in origin.

(2) The Blanco has a limited distribution.

(3) The Goodnight (Paloduro) Beds are not a valid division.

(4) The principal deposits forming the Staked Plains are of the Miocene epoch but older than the Loup Fork stage.

(5) The fossil-bearing beds in the locality north of Clarendon and at Mulberry Cañon correspond in age with the Loup Fork formation, as shown by the fossils.

PLEISTOCENE.

Rock Creek Beds.[1] = *Sheridan (Equus) Beds.*

The Sheridan or Equus division of the Pleistocene beds, as reported by Cummins, are extensively exposed, especially along the south side of Tule Cañon and at the head and on both sides of Rock Creek, a small tributary emptying into Tule Cañon from the south.

Cummins's section of Tule Cañon, taken near the head, is as follows:

6.	Fine white sand	25 feet
5.	Coarse sand, with pebbles	20 "
4.	Bluish clay	15 "
3.	Coarse sand	30 "
2.	Reddish clay	60 "
1.	Triassic sandstone	20 "

The upper four strata of this section (Nos. 3–6) belong to the Pleistocene age. But the section is representative of these beds only in a general way. Other sections taken at different

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[1] Local name proposed by the writer.

PLEISTOCENE EXPOSURES, AT HEAD OF ROCK CREEK, SWISHER CO., TEXAS.

In the middle foreground is seen the quarry from which were taken six partial skeletons of *Equus scotti*.

points show great variations in details of character and in the relative thickness of the different strata. No. 1 belongs to the Triassic, which apparently underlies the whole of the Staked Plains. No. 2 of the section, designated by Cummins as "Reddish clay," is probably of Miocene age, as will be shown later. Unfortunately no characteristic fossil remains have been found in this stratum to fix definitely its geological position. However, it is older than the Sheridan beds, as are also the strata which bound them on the north and south. The Sheridan beds are unconformable with those of this older formation and apparently mark the course of an ancient stream which, after scooping out a channel or narrow valley in the older formation, refilled it again in Pleistocene times.

Fig. 1, page 625, is a diagrammatic cross-section across Tule Cañon near its head.

There is nothing in the character of the deposits to indicate beds of lake formation. On the contrary, the distribution of the beds, which are nowhere very wide but extend several miles east to the edge of the Plains, indicates, rather, an alluvial origin. The sharp cross-bedding of sand, gravel, and clay, which the writer observed at certain points in the formation, and the peculiar distribution of the coarser gravels, all indicate the depositions of a river or smaller stream rather than those of a lake. A further indication of an alluvial derivation of these beds is that the fauna represented consists wholly of land forms, and some of the bones show weather checking. The wind, carrying large quantities of fine sand and dust from the surrounding plains, may also have played a very important part in forming these deposits.

Following is a list of species from the beds at Tule Cañon, as given by Cope[1]:

TESTUDINATA.

Testudo hexagonata Cope,
" *laticaudata* Cope.

EDENTATA.

Mylodon ? sodalis Cope.

PROBOSCIDIA.

Elephas primigenius Blum.[2]

DIPLARTHRA.

Equus excelsus Leidy,
" *semiplicatus* Cope,
" *tau* Owen,
" *major* Dekay,[3]
Holomeniscus sulcatus Cope,
" *macrocephalus* Cope.

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[1] Rep. Geol. Surv. Texas, 1892 (1893), p. 87.
[2] *Elephas primigenius*, probably *E. imperator.*
[3] *Equus maior = E. complicatus.*

The following additional species were taken from these beds by the American Museum party:

Elephas imperator,	*Platygonus* sp. ind.
Equus scotti,	Large carnivore, gen. et sp. ind.

PLIOCENE.

Blanco Beds.

The Blanco beds have been correctly referred to the Pliocene age, as is shown by the peculiar fauna they contain; Cummins has, however, given them a much wider distribution than is evident from a close study of the formations in that region. He says of these beds[1]: "This formation constitutes the eastern scarp of the Staked Plains from the Double Mountain Fork of the Brazos River on the south to Paloduro Canyon on the north."

Cope also reported exposures of these beds northeast of Miami, Roberts County, Texas, more than one hundred and fifty miles to the north of Mount Blanco. His identification was founded on some fossil horse teeth which he referred to *Equus cumminsii* Cope. This species, as has been shown by the writer in a former paper,[2] is not referable to the genus *Equus*, and is indistinguishable at present from some species of the Loup Fork *Protohippus*, hence the correctness of Cope's identification of Blanco beds at Miami is, at least, doubtful.

Cummins was probably led to error by including in his section of the Blanco beds strata properly belonging to beds of an older age.

Cummins's sections of the Blanco beds, taken at two different localities, are as follows[3]:

At Mount Blanco.

12.	Soil	8 feet
11.	Hard limestone	2 "
10.	Sandstone	3 "
9.	Stalactitic limestone	4 "
8.	Calcareous sandstone	4 "
7.	White sandy clay	30 "
6.	White diatomaceous earth	4 "
5.	Packsand	20 "

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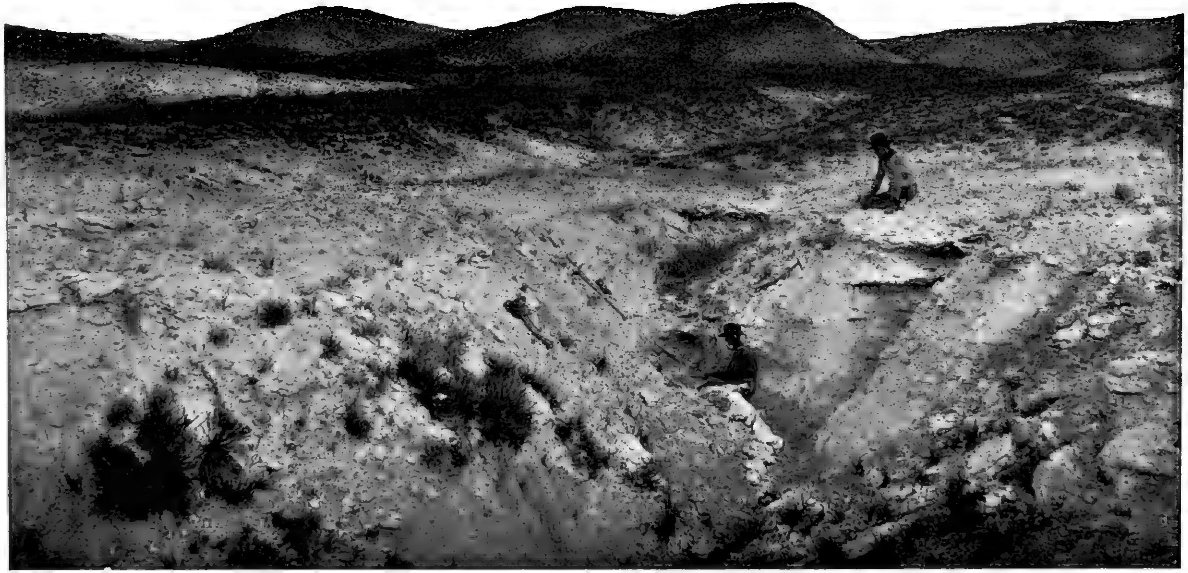
[1] Geol. Surv. Texas, 4th Ann. Rep., 1892 (1893), p. 201.
[2] Bull. Am. Mus. Nat. Hist., Vol. XIV, pp. 126, 127.
[3] Geol. Surv. Texas, 4th Ann. Rep., 1892 (1893), pp. 200, 201.



Blanco Beds.

One half-mile southwest of Mount Blanco.

4.	White diatomaceous earth	8 feet
3.	Green sandy clay	30 “
2.	Red clay	2 “
1.	Reddish clay	30 “

Three miles north of the old town of Docum, in Dickens County:

5.	White sandy clay	6 feet
4.	White diatomaceous earth	3 “
3.	Purple clay	3 “
2.	White diatomaceous earth	4 “
1.	Reddish sandy clay	150 “

These sections are valuable only in giving the approximate thickness and general character of the deposits. No. 1, of both sections, is wrongly included in the Blanco series, as are also Nos. 9, 10 and 11 of the section taken near Mount Blanco. These strata belong probably to the Miocene age and are apparently continuous with the beds they so much resemble at Tule Cañon and other portions of the Staked Plains.

A complete section of this older formation is represented by Cummins's section taken "one fourth of a mile northwest of H. C. Smith's ranch and one mile north of Mount Blanco":

3.	Limestone	2 feet
2.	Stalactitic limestone	10 “
1.	Red clay (same as No. 1 of previous section)[1]	30 “

The diagrammatic section, Fig. 2, page 626, taken by the writer across Blanco Cañon and through the Blanco beds, shows both of Cummins's sections taken near Mount Blanco and illustrates their relations to each other.

It is thus seen that the Blanco beds, at Mount Blanco, like the Rock Creek beds, apparently occupy a comparatively narrow valley or basin formed for their deposition by ancient erosion of the older beds. Like the Rock Creek beds also they extend a long distance in one direction, being traceable southeastward for fifteen or twenty miles to the edge of the Plains. Though the deposits differ in character from those of the Rock Creek beds and the fauna indicates an earlier age, here, as at Tule Canoñ, there is a total absence of any proof of a lake origin for these beds and many evidences of river or stream deposition.

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[1] Cummins refers to the section taken near Mount Blanco and given above.

SHERIDAN BEDS

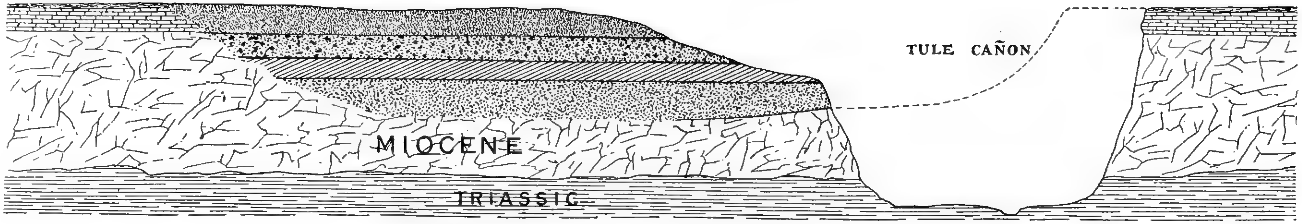

Fig. 1. Diagrammatic section across Tule Cañon, near its head, showing position of Rock Creek (Sheridan) beds and underlying strata. Vertical scale about 1 in. to 150 ft.; horizontal scale about 3 in. to 1 mile.

BLANCO BEDS

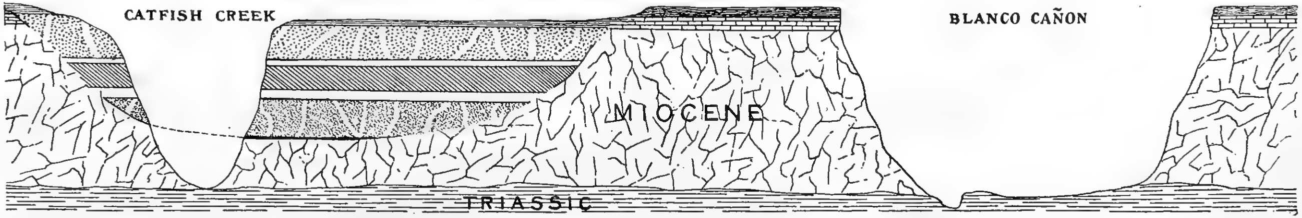

Fig. 2. Diagrammatic section across Blanco Cañon at Mount Blanco, showing position of Blanco beds and underlying strata. Vertical scale about 1 in. to 150 ft.; horizontal scale about 3 in. to 1 mile.

The occasional beds of diatomaceous earth are easily accounted for by supposing that there were in this ancient valley occasional ponds filled with clear water, enduring for various periods of time, partially or totally isolated from the stream that ran through the valley, such as exist at the present time in the West, especially in the Sand-hills country of northern Nebraska and southern South Dakota. The diatomaceous deposits are for the most part quite impure and contain great quantities of remains of rushes and pond grasses, indicating that these ponds were never of any great depth and probably occasionally received an overflow from the stream in times of freshet.

Following is the list of species, as reported and determined by Cope from the Blanco beds[1] and also as reported and determined by the American Museum Expeditions:

Cope.

TESTUDINATA.

Testudo turgida Cope,
" *pertenuis* Cope.

AVES.

Creccoides osbornii Schuf.

EDENTATA.

Megalonyx leptostoma Cope.

CARNIVORA.

Canimartes cumminsii Cope,
Borophagus diversidens Cope,
Felis hillanus Cope.

PROBOSCIDIA.

Tetrabelodon shepardii Leidy,
Dibelodon humboldtii Cuvier,
" *tropicus* Cope,
" *præcursor* Cope.

DIPLARTHRA.

Equus simplicidens Cope,[2]
" *cumminsii* Cope,[2]
" *minutus* Cope,[2]
Platygonus bicalcaratus Cope,
Pliauchœnia spatula Cope.
Total number of species, 16.

American Museum.

TESTUDINATA.

Testudo campester.

EDENTATA.

Glyptotherium texanum,
Megalonyx sp.,
Mylodon sp.

CARNIVORA.

Amphicyon (?Borophagus).

PROBOSCIDIA.

Dibelodon mirificus,
" *tropicus.*

PERISSODACTYLA.

Neohipparion sp.,
Pliohippus simplicidens.

ARTIODACTYLA.

Platygonus bicalcaratus,
" *texanus,*
Pliauchœnia spatula,
" sp.

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[1] Rep. Geol. Surv. Texas, 1893, p. 73.

[2] *Equus simplicidens* = *Pliohippus simplicidens*; *Equus cumminsii* = *Protohippus* sp.?, and *Equus minutus* = *Protohippus* sp.? See Bull. Am. Mus. Nat. Hist., Vol. XIV, pp. 123–128 and p. 140.

MIOCENE.

(?) *Goodnight (Paloduro) Beds.*

In 1893 Cummins proposed a new horizon, the Goodnight beds, placing it, in time, between the Loup Fork and Blanco divisions. In thus placing these beds he says: "I do this on both stratigraphic and palæontologic grounds. In making a stratigraphic section of the country, I found that the Goodnight fossil beds were above the conglomerate bed of the Loup Fork section made at Clarendon, the Clarendon beds being near the base of the Tertiary and below the conglomerate, while the beds at Goodnight were nearly at the top of the plains."

Following are Cummins's sections taken at the typical locality on opposite sides of Mulberry Cañon near its mouth:

North Side.

1.	White sandy clay, concretionary	60 feet
2.	Sandy clay	40 "
3.	Reddish sandy clay	25 "
4.	Conglomerate, cross-bedded	20 "
5.	Red clay, to the base	80 "
		225 feet

South Side, about one mile from the preceding section.

1.	Concretionary yellow limestone	4 feet
2.	Yellowish clay, with small concretions	12 "
3.	Concretionary limestone	3 "
4.	Yellowish sandy clay	40 "
5.	Hard stalactite limestone, breaking into conchoidal fracture	3 "
6.	Yellowish sandy clay, with small concretions, less concretionary at base	80 "
7.	Bright red clay	40 "
8.	Soft dark red sandstone	20 "
9.	Soft limestone	4 "
10.	Red clay, with white spots	20 "
		226 feet

A careful study of this region has compelled the writer to disagree with Mr. Cummins both as to the correctness of his

MULBERRY CAÑON.

Showing horizontal position and continuity of strata on opposite sides of the Cañon.

observations and in his interpretation of the strata in this locality. The writer could find no warrant for making any separation of the beds at Mulberry Cañon, either on stratigraphic or palæontologic grounds.

Briefly, Cummins's stratigraphic grounds for separating the Goodnight beds from the Loup Fork division are as follows: (1) That the Loup Fork beds in the vicinity of Clarendon were overlaid by the heavy cross-bedded conglomerate layer which underlies the upper series of strata at Mulberry Cañon. (2) That there is a marked difference in his two sections taken on opposite sides of Mulberry Cañon. He says of these sections: "It will be apparent upon examination of these two sections that there is a marked difference between them. The heavy bed of conglomerate on the north side of the canyon, No. 4 of the section, does not occur on the south side, nor was there any gravel on that side to show that the conglomerate bed had ever been there."

This statement is incorrect, for the writer found an abundance of gravel on both sides of the cañon and had no trouble in tracing the conglomerate layer (No. 4 of Cummins's section) across to the south side of the cañon where it is exposed in two localities, showing a maximum thickness of at least fifteen feet. This bed of conglomerate and sand is nowhere of great width, hence it does not appear in every section on either side of the cañon. The writer also found this coarse conglomerate bed appearing again in the Clarendon locality, resting directly on the eroded surface of the Triassic and *underlaying* the Miocene beds, but not overlaying them, as reported by Cummins. There are scattered patches of loose gravel partially covering the Miocene deposits in the vicinity, but it is superficially distributed and nowhere can be said to be in its original bed of deposition. It was probably this frequent occurrence of loose gravel which led Cummins to believe that the conglomerate bed had overlaid the Miocene in this locality.

Cummins's two sections taken at Mulberry Cañon are misleading, for no two sections, even though taken on the same side of the cañon, agree in detail. There is, therefore, no such real difference in the two sides of the cañon as these sections apparently show. The main divisions of either section are traceable around the head of the cañon and are continuous with corresponding strata of similar character on the opposite side.

From the foregoing facts it seems evident that Cummins's separation of the Goodnight beds on stratigraphic grounds is scarcely admissible.

Cummins's palæontologic grounds for the separation of these beds is based on Cope's determination of the small collection of fragmentary fossils taken from the vicinity of Mulberry Cañon on the south side.

Cope's determination of these fossils is as follows[1]:

Aphelops sp.,
Protohippus lenticularis Cope,
Protohippus sp.,
" *? perditis* Leidy,
Hippidium interpolatum Cope,
" *? spectans* Cope,
Equus eurystylus Cope,
" *? simplicidens* Cope.

In referring to this list Cope[2] stated that two of these genera are characteristic of the Loup Fork beds, but are not known to extend higher; that *Equus*, on the contrary, had never been found in the Loup Fork formation; and that *Hippidium* was of uncertain horizon. Of the species Cope said "the three which are identifiable are new to science."

As shown by the writer in a former paper[3] *E. simplicidens* Cope and *E. eurystylus* Cope can not be referred to the genus *Equus*, but on the contrary are distinctly Miocene in character and only referable to Miocene genera. *Hippidium* is probably an exclusively South American genus, and the species referred to it by Cope are probably referable to the genus *Protohippus*. The three species from the Mulberry Cañon locality which Cope considered identifiable are as follows: *Protohippus lenticularis* Cope, *Hippidium interpolatum* Cope, and *Equus eurystylus* Cope.

The first of these species is, perhaps, authentic, but it is referable to the genus *Neohipparion*[4] and not to *Protohippus*.

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[1] Geol. Surv. Texas. 4th Ann. Rep., 1892 (1893), p. 45.

[2] Geol. Surv. Texas, 4th Ann. Rep., 1899 (1892), p. 45.

[3] Bull. Am. Mus. Nat. Hist., Vol XIV, 1901, pp. 123–126.

[4] The genus *Hipparion* was founded on an European type, though many American species have since been referred to it. The writer, however, has separated generically the American group from the Old World *Hipparion*, giving to the American group the name *Neohipparion*. (Bull. Am. Mus. Nat. Hist., Vol. XIX, p. 467)

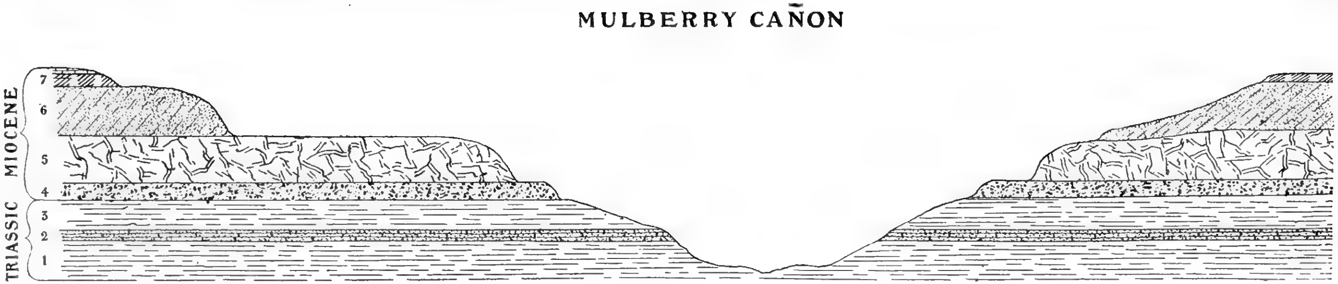

Fig. 3. Diagrammatic section across Mulberry Cañon near its mouth, showing position of Panhandle (Lower or Middle Miocene) beds and the underlying strata. Vertical scale about 1 in. to 250 ft.; horizontal scale about 2 in. to 1 mile.

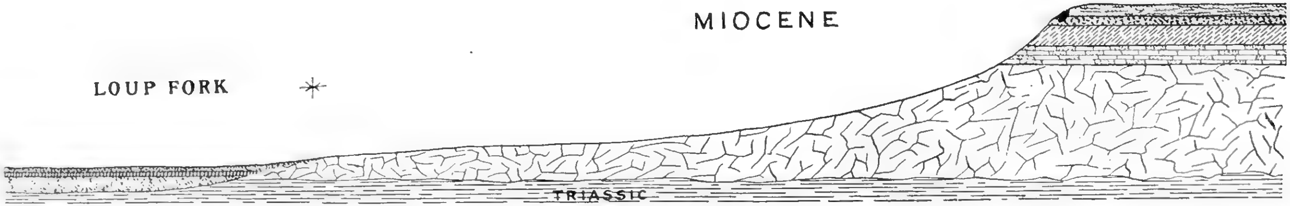

Fig. 4. Diagrammatic section of the Clarendon locality, showing position of Clarendon (Loup Fork) beds and Panhandle (Middle or Lower Miocene) beds, extending west to the top of the Staked Plains. Vertical scale about 1 in. to 300 ft.; horizontal scale about 1 in. to 1 mile.

The species does not indicate a later phase than the Upper Miocene, for the writer found, in the Clarendon locality, several specimens, including a skull with complete dentition, which are indistinguishable from *Protohippus lenticularis* Cope. The second species, as already mentioned, is indistinguishable from some species of *Protohippus*. The third species of this group, *Hipparion eurystylus* Cope, was founded on lower teeth and is not distinguishable from specimens found in the Clarendon locality. It is quite possible that Cope's type of this species represents the lower dentition of *Neohipparion lenticularis*, with which it corresponds in size.

Thus it will be seen that the palæontological evidence at hand not only fails to prove a new horizon for the so-called Goodnight beds, but, on the contrary, seems to prove conclusively that they are identical in age with the beds in the vicinity of Clarendon, which Cope recognized as Loup Fork (Upper Miocene) deposits.

There is little doubt, then, that there is no break at Mulberry Cañon, either in strata or fauna. Hence the Goodnight beds, as a new horizon, should be abandoned.

Upper Miocene.

Clarendon Beds.[1] *"Loup Fork" Stage.*

The deposits at the locality north of Clarendon belong undoubtedly to the Miocene epoch. The fauna indicates a close relationship with the Loup Fork formation.

This locality is east of the Staked Plains proper, but connected with them through long, low divides. The fossil-bearing strata do not, however, follow these divides back to the Plains, and is it impossible to say, owing to so much of the country in that direction being covered by recent deposits which are now more or less grass-covered, whether they extended any great distance to the westward or not. The

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[1] Local name proposed by the writer. The name Loup Fork was first proposed as a formation name, and its subsequent extended use has given rise to so much confusion that it seems better not to employ it in the sense of a time division, but to limit its use to the formation occurring in the Loup River, Niobrara, and White River valleys for which it was originally used. The Clarendon beds are of approximately the same age as the Loup Fork beds, as judged by the known fauna, but cannot be regarded as a part of the same terrane, and they differ considerably in structure and composition.

HEAD OF PETRIFIED CAÑON.

Showing excavation in Clarendon Beds from which were taken several skulls and partial skeletons of three-toed horses.

exposures, however, show an extensive distribution to the northeast.

Here again, as at Tule Cañon and Mount Blanco, the peculiar formation of the deposits indicates, though in a somewhat different manner, an alluvial origin. Though distributed over a wider area in every direction there are running through these beds several narrow channels of sandy clay. The main body of the beds consists for the most part of cross-bedded sands and sandstones intermixing more or less and cross-bedding with the clays. These channels all take a direction nearly east and west, or approximately the same as that of the streams draining the country at the present time. Some of them are traceable for long distances. It is in these peculiar beds of sandy clays that all the fossils of this region occur.

Cummins's section of the Clarendon locality is as follows:

1. Whitish sandy clay	20 feet
2. Sandy clay, with many rounded siliceous pebbles of different sizes	20 "
3. Yellowish sand	40 "
4. Indurated white sand	40 "
5. Yellow sandy clay, with the sand more or less predominating in places. In places the sand is hardened, while in others the clay is more or less concretionary	250 "
6. Alternating beds of bluish clay and white sand (Loup Fork)	30 "
	400 feet

Cummins has here placed the Loup Fork formation at the very bottom of this section of 400 feet of deposits. A careful study of this region, however, does not warrant such a disposition of this stratum. In reality this stratum (No. 6) belongs properly at the top of the above section, and the explanation is simple. Nowhere is bed No. 6 overlaid by any of the upper strata of the section; hence to obtain this section Cummins probably included the beds west to the top of the plains, and because No. 6 was at a lower level concluded that it ran under the beds to the west. This, however, is erroneous. The writer found several places where this fossil-bearing stratum lies unconformably on the eroded surface of beds resembling the lower portion of the beds to the west which Cummins identified as probably Goodnight beds. It seems certain, therefore, that the beds to the west are older than the fossil-bearing strata under discussion. This apparent inconsistency in level is due to the heavy erosion of the older beds before the Upper Miocene deposits were laid down.

The following species have been reported from the Clarendon locality:

REPORTED AND IDENTIFIED BY COPE.

Aphelops fossiger Cope,
Protohippus perditis Leidy,
" *parvulus* Marsh,
" *fossulatus* Cope (sp. nov.),
Protohippus mirabilis Leidy[1],
" *placidus* Leidy,
Hippotherium[2] *affine* Leidy,
" *occidentale* Leidy,
Procamelus robustus Leidy,
" *gracilis* Leidy,
" *leptognathus* Cope (sp. nov.),
Blastomeryx gemmifer Cope,
Tetrabelodon serridens ? Cope.

OBTAINED AND IDENTIFIED BY THE AMERICAN MUSEUM EXPEDITIONS.

Mastodon productus,
" sp.
Dinocyon gidleyi,
" *mæandrinus*,
Machærodus sp.,
Teleoceras sp.,
Hipparion[3] *lenticularis*,
" *occidentalis*,
" sp.,
Protohippus perditis ?
" sp.,
Pliohippus ? sp. nov.
Procamelus sp.,
Pliauchænia sp.

MIDDLE OR LOWER MIOCENE.

Panhandle Beds.[4]

As to the age of these older beds it is difficult to say, owing to the present lack of palæontologic evidence, just where they should be placed. It is probable, however, that they are Lower or Middle Miocene.

Some lower teeth of *Merycochœrus* and a lower tooth of *Procamelus* taken from these beds by the writer prove them to be not older than the Lower Miocene.

Though differing somewhat in detail in the different localities, these older beds in the vicinity of Clarendon, at Mulberry Cañon, at Mount Blanco, and at Tule Cañon and Rock

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[1] *Protohippus mirabilis = Merychippus mirabilis.*

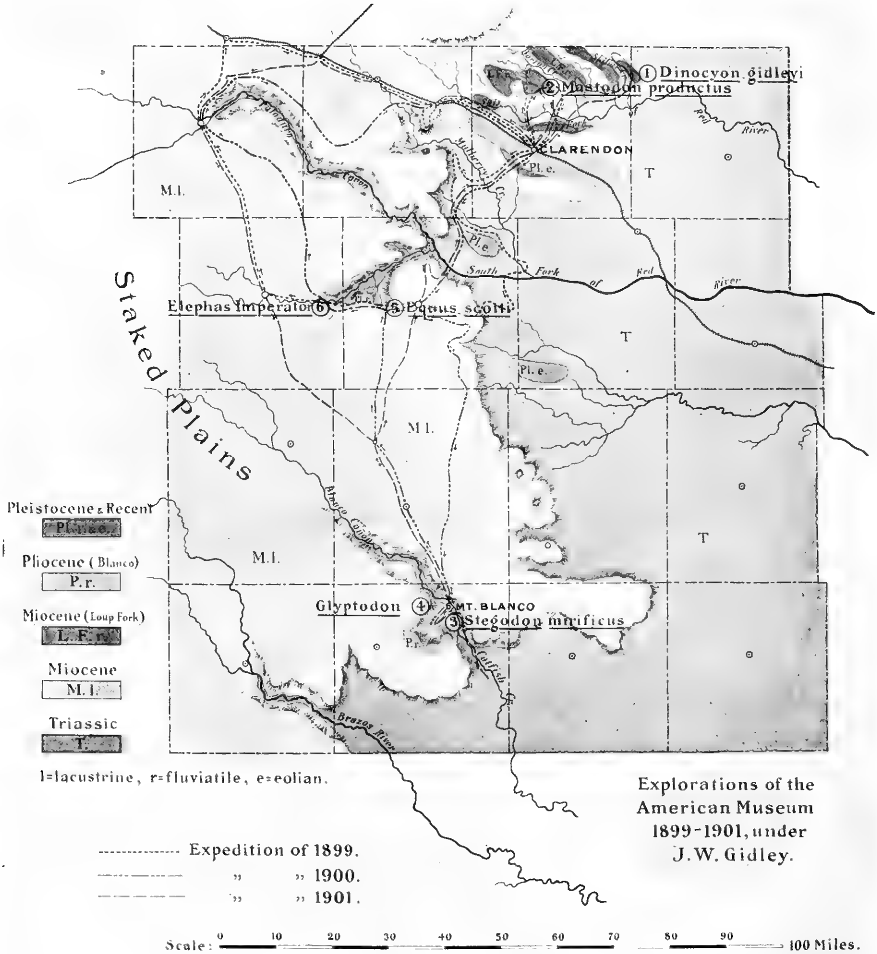
[2] *Hippotherium = Neohipparion.*

[3] *Hipparion = Neohipparion*

[4] *Local name proposed by the writer.*

MAP OF TEXAS.

Showing area of Explorations.



Explorations of the American Museum 1899-1901, under J.W. Gidley.

Pleistocene = Rock Creek Beds.
Pliocene = Blanco Beds.
Miocene (Loup Fork) = Clarendon Beds.
Miocene = Panhandle Beds.

Creek are evidently of the same age. They closely resemble each other in a general way, and the formations are traceable from one locality to another around the irregular escarpment of the Plains. Numerous wells dotting the Staked Plains show everywhere the existence of these beds. They are of nearly uniform thickness, and form practically the whole area of the Staked Plains.

SUMMARY.

Following is a summary of the conclusions reached by the writer from this study of the formations of northwestern Texas:

(1) There has been no great disturbance or change of level in the region of the Staked Plains since the close of the Triassic, hence the strata of the Triassic which underlie this whole region are for the most part nearly horizontal, and the country at the beginning of the Miocene was comparatively level.

(2) The Panhandle (Lower or Middle Miocene) beds were comparatively evenly distributed over the vast area now occupied by the Staked Plains and in addition extended westward to the Rocky Mountains in New Mexico, and spread out to the eastward over a much greater territory than they now occupy. These deposits seem to be, at least partially, lacustrine in origin.

(3) All the formations of the Staked Plains that are of more recent date than the Lower or Middle Miocene are represented by comparatively small areas, and are fluviatile, or æolian and fluviatile, in origin. These later depositions are represented by the Clarendon beds in the vicinity of Clarendon, the Blanco Beds at Mount Blanco, and the Rock Creek beds at Tule Cañon and Rock Creek.

Skull of Triceratops Serratus.

By Richard Swann Lull, Ph.D.

AUTHOR'S EDITION, extracted from BULLETIN

OF THE

American Museum of Natural History,

Vol. XIX, Article XXX, pp. 685–695.

New York, December 24, 1903.

The Knickerbocker Press, New York

Article XXX. — SKULL OF TRICERATOPS SERRATUS.

By Richard Swann Lull, Ph.D.

Plate LIX.

The American Museum Expedition of 1902, under Mr. Barnum Brown and the writer, which was sent by Professor Osborn into the Laramie formation of Montana had the good fortune to secure, among other material, a fine specimen of *Triceratops serratus* Marsh. The exact locality in which the specimen was found was in the wall of Hell Creek Cañon, some twenty-five miles from the Missouri River, and one hundred and thirty-five miles northwest of Miles City, Montana. The unconsolidated sand matrix has been entirely removed from the skull, thus affording an exceptional opportunity for the study especially of the remarkably preserved palate.

Through the courtesy of Professor Charles E. Beecher the writer was permitted to study the type skulls of *Triceratops prorsus* and of *T. serratus* which are preserved in the Peabody Museum at Yale University. This confirmed the opinion already formed that the American Museum specimen is referable to the latter species. The agreement between the specimens is close, the main points of difference being the inferior size of the type specimen, which is evidently that of a younger animal, and that the median ridge of the parietal crest or frill is not so prominent in the American Museum specimen; nor are the bony projections along the ridge quite so conspicuous as in the type; but in general proportions, the form and arch of the frill, the shape of the orbit and other points mentioned by Marsh in his specific definition the resemblance is very close.

Triceratops serratus *Marsh.*

Marsh, O. C., 1890, Amer. Jour. Sci. (3) XXXIX, p. 81.

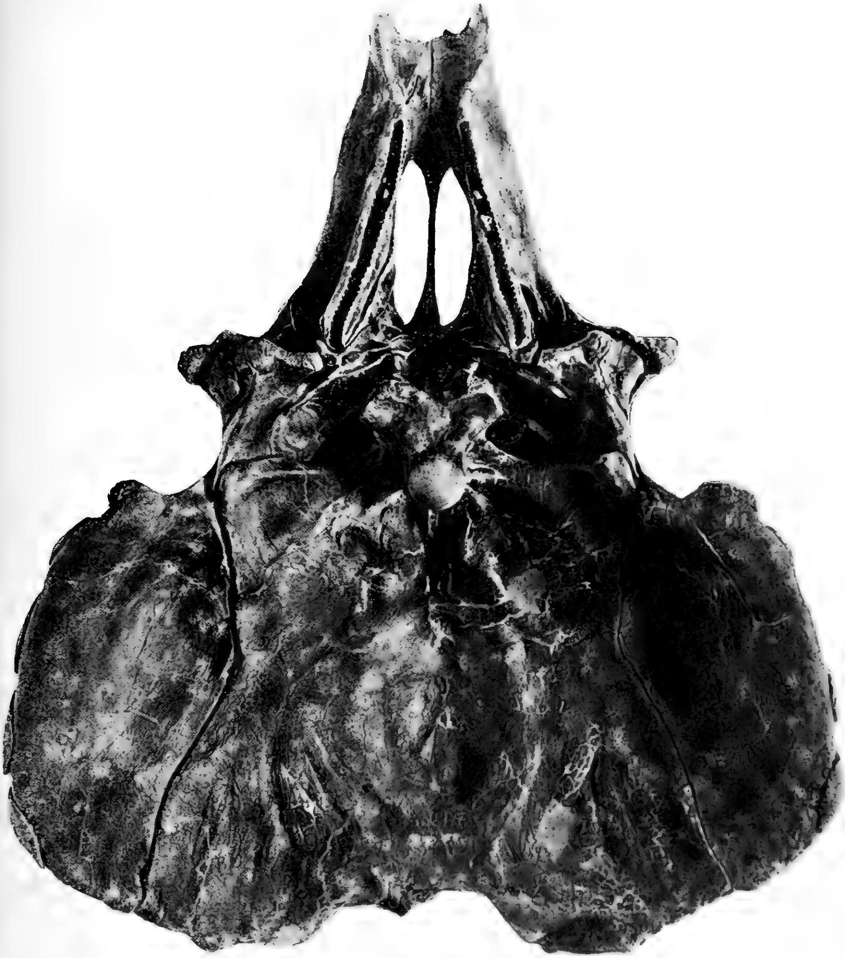
Marsh, O. C., 1890, Amer. Jour. Sci. (3) XXXIX, p. 425, pl. v, fig. 2; pl. vi, figs. 1–6.

Marsh, O. C., 1896, Sixteenth Annual Report U. S. Geol. Survey, p. 208; pl. lx, fig. 3; pl. lxi, figs. 7, 9, 10.

Materials. — The skull lacks only the distal portions of the postfrontal horn cores, the nasals and their horn core, and a portion of the premaxillary bones. The rostral bone was found displaced but a short distance to the rear on the right side of the muzzle, while on the other side lay the left mandible in perfect condition. The coössified right angular and articular, together with portions of both splenials, were found beneath the skull. One badly preserved humerus, half of another, a radius, five metacarpals, three phalanges, a fibula, and fragments of a scapula complete the list. The specimen is No. 970 of the American Museum fossil reptilian collection.

THE SKULL.

The condition of the sutures, the fact that the rostral bone had not ankylosed with the premaxillaries, and that the so-called epoccipital bones, the lozenge-shaped ossicles around the margin of the frill, were not sufficiently coössified with the latter to prevent the loss of some of them, give evidence that in spite of the enormous size of the animal it had not yet reached maturity. The maxillary teeth have dropped out of position with one exception, a tooth which lay deep in the alveolar channel of the right side. Other teeth, found loose in the matrix, were clearly of the upper series and are shown in position in the photograph (Plate LIX). The *rostral bone* is highly rugose, due to the impressions of blood-vessels over its surface showing it to have been closely sheathed in horn. The forward border is a full, gentle curve, while the inferior margin is straight and nearly horizontal when the bone is in position, as in most Testudinata. This, together with the form of the predentary bone, which curves upward towards the tip, would seem to indicate a cutting beak very turtle-like in aspect, as one would be led to expect from somewhat similar feeding habits, rather than the trenchant, downwardly curved, raptorial beak usually given to the restored *Triceratops*. The fact that in *Chelydra*, where the upper beak is hooked, the bone which supports it is of similar form, may be taken as corroborative evidence.



TRICERATOPS SERRATUS *Marsh.*

Palatal aspect of skull, with frill. × $\frac{1}{15}$. (Extreme length about 6 ft. 4 ins.).

Palatal Aspect.

The *premaxillaries* are only in part preserved. The *maxillaries* are heavy bones uniting anteriorly in the median line, in front of the narial fenestræ, by a pronounced dentate suture. Anteriorly the premaxillaries overlap them above and posteriorly they bifurcate, one limb, the dorso-lateral, running obliquely outward and backward to join the jugal, while the postero-ventral limb unites posteriorly with the pterygoids. The maxillaries thus form the anterior and about two thirds of the lateral walls of the large narial fenestræ. In the palatal face lies the alveolar channel, sculptured transversely into a number of shallow grooves, incomplete sockets in which the teeth were formed, forty in the right channel and forty-two in the left. The dental channel, is 482.8 mm. in length with an average width of 30 mm., which is somewhat less than its original measurement, owing to crushing. Other measurements may be found in the table on page 694. As in the mandible, a row of dental foramina runs along the inner face of the maxilla, one foramen being opposite each alveolar groove, through which passed the blood-vessels needful for the rapid forming of teeth in the dental magazine. The external face of the bone also bears two such foramina.

The *vomer*, or 'prevomer' as determined by Broom,[1] is a slender rod-like bone bridging fore and aft the space of the narial fenestra. Anteriorly it is dilated into a flattened rhombic expansion articulating by a squamous suture with the united maxillary bones. Passing backward there appears a median ventral keel giving the bone in its narrowest part, about the middle, a triangular section. Further to the rear the lateral edges bend downward to the level of the median keel and then rise again to their former level, where they give rise to thin plate-like expansions which are embraced at their posterior end by the pterygoid bones. Dorsally viewed the vomer is seen to become trough-like, the depression being about the width of the shaft of the bone and running the

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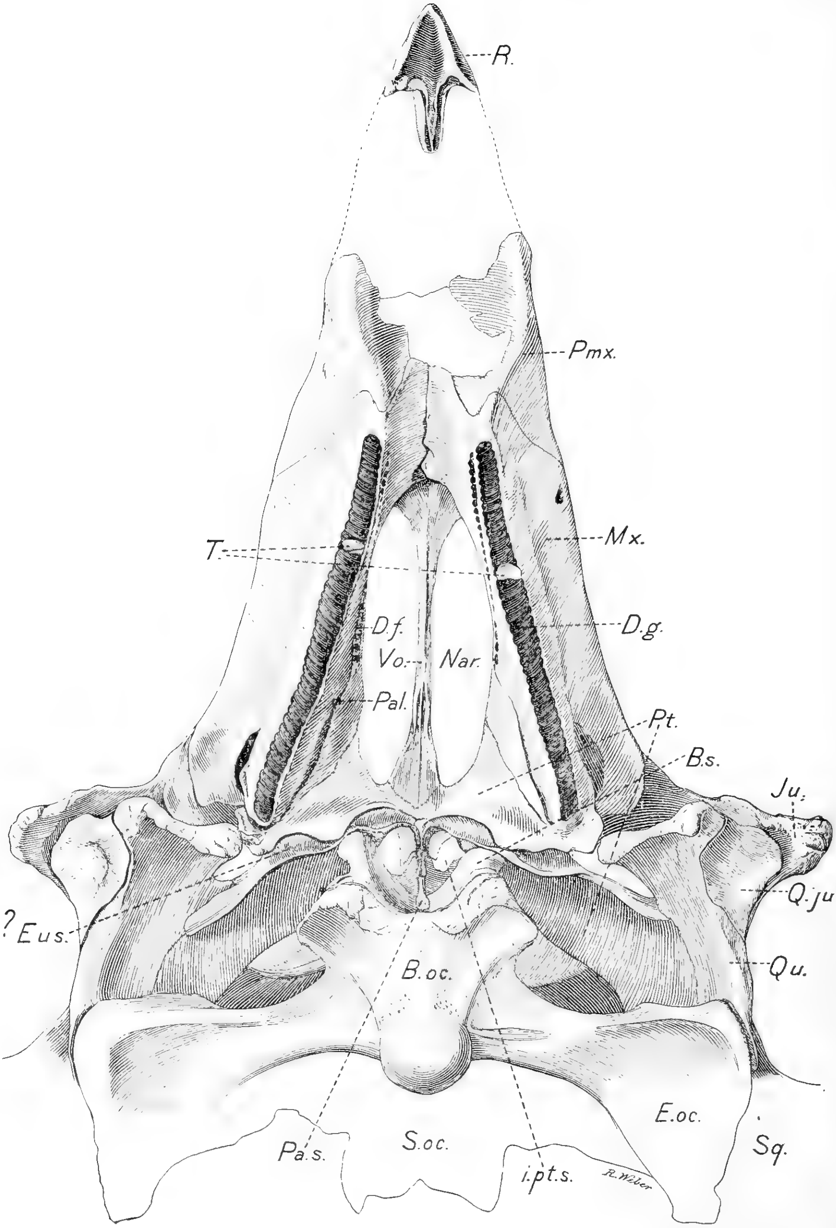
[1] Broom, R., Proc. Linn. Soc. N. S. W., 1902, pt. 4, pp. 545–560.



Triceratops serratus Marsh. Palatal aspect of skull. × 1/9. *R*, rostral bone, *Nar.*, narial vacuity, *i.pt.s.*, interpterygoid space, *D.g.*, dental groove, ? *Eus.*, Eustachian groove (?).

length of the expanded posterior portion. There is no trace of paired elements in the vomer.

The *palatines* bound laterally the posterior part of the narial fenestræ, and are somewhat triangular in shape, with the base of the triangle meeting the maxillaries in a squamous articulation somewhat overlapping the dental foramina. Posteriorly they are bounded by the pterygoids, and the anterior portion runs upward over the jaw until it ends in a large vacuity on the dorsal side. This vacuity is further bounded anteriorly and externally by the maxillary, and posteriorly by the pterygoid, and it lies above a point one third of the distance from the posterior end of the dental channel.

The *pterygoids* are large and irregular with peculiar channels, probably the eustachian canals, running obliquely from the articulation with the posterior end of the maxillaries to the median line; these channels are formed by thin, overarching ridges of bone which in their mid-length almost meet. The pterygoids form the postero-lateral margins of the narial fenestræ in the rear of the palatine bones and embrace the hinder end of the vomer. Anteriorly they are bounded by the palatine and maxillary bones and possibly by the ectopterygoids, though the last-mentioned cannot be located in this specimen[1]; the ectopterygoids are not suturally separated from the pterygoids themselves. Posteriorly the pterygoids are met by the basisphenoid and in the median line they nearly embrace the parasphenoid, or 'vomer' of Broom. Laterally they are broad and thin plate-like expansions which pass outward and backward to meet opposing processes of the quadrate, though the precise limit of the pterygo-quadrate suture is not everywhere distinct.

The *quadrates* are well developed and firmly fixed in place by the pterygoids within and the quadratojugals without. They also pass backward and upward, forming, with the quadratojugals, the lower boundary of the infratemporal fossa. Posteriorly they join the squamosals, which are widely expanded to form the lateral elements of the frill. The

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[1] Marsh, O. C., Amer. Jour. Sci. (3), XLI, p. 171.

quadrate is flattened on its ventral aspect and somewhat cylindrically concave on its dorsal surface. The head is elongated transversely to a length of 147 mm., the facet which articulates with the lower jaw being somewhat saddle-shaped. The posterior end of the quadrate is embraced between the exoccipital and the squamosal bones. The *quadratojugals* are comparatively small bones lying between the quadrates and the jugals. Dorsally they extend in thin, plate-like expansions between the aforesaid bones, and in their posterior portions form part of the infratemporal arcade, almost, if not quite, meeting the forwardly extending process of the squamosals. In their ventral portion where the distance widens between the quadrates and the jugals the quadratojugals dilate into a thick, wedge-shaped mass to fill the gap. The greatest thickness is 89 mm.

The *occipital region* of the skull is rendered very massive to support the great weight of the head, the sutures between the various elements being closed. The occipital condyle is almost spherical, and has a diameter of 115 mm. It looks almost directly backward and but little downward. Anteriorly it merges into a heavy basioccipital and laterally into the exoccipitals, the limits of these three elements in the condyle itself not being discernible.

The *basioccipital* diverges into two stout limbs with heavy, rugose extremities, in front of which appear the pulley-like basisphenoid bones, the parasphenoid ('vomer') arising between the limbs.

The *exoccipitals* run out laterally to join the quadrates and squamosals, overlapping the former and firmly articulating with the latter to afford a strong brace across the entire base of the frill. They thin away posteriorly and are, together with the supraoccipital, overlain by the largely developed parietals which form the median element of the frill.

The ventral aspect of the *frill* or crest is well shown in Plate LIX, and is without vacuities of any sort, although just behind the exoccipital bones the parietals are excessively thin. Vascular impressions occur on the posterior half of the parietal bones on either side, but there is no evidence of a wide free margin sheathed with horn as in the frill of *Triceratops prorsus*.[1]

The squamoso-parietal suture is a squamous one for a short distance backward, the squamosal overlapping; but at the point where the suture bends outward it becomes a plain harmonic suture having but little strength, as is evidenced by the fact that in the specimen under consideration the squamosal bone had slipped dorsally past the parietal on the right side, while on the left the bones were flush with each other. In the type specimen of *Triceratops serratus* in the Yale University Museum both sutures, that on the left as well as on the right, have slipped. The frill thus seems to have afforded leverage to assist in moving and supporting the huge head with its weighty armament and also to have protected the neck against the assaults of enemies, but it seems hardly probable in the present species that the dorsal part could have withstood crushing blows without injury to the frill. The hinder margins of the parietals have decomposed somewhat and the marginal ossicles are here wanting, though most of them are present on the squamosals.

Dorsal Aspect.

The anterior part of the skull has been weathered off, as it formed the outcrop of the specimen, and much of the bone has been disrupted by grass roots even where it had not yet been exposed by erosion.

The *postfrontals*, with the exception of the horn cores, are entire and the underlying sinus is readily explored through the large postfrontal fontanelle (the parietal or pineal foramen of authors). This sinus is continuous with those of the horn cores and in turn with the space within the skull behind the orbits, but not with the brain case. It is more or less wedge-shaped, tapering dorso-ventrally as one goes forward, the anterior limit being just in front of the orbit. The flat roof is formed by the overlying postfrontal and frontal bones, while the sinus is laterally constricted into three chambers. The anterior chamber has a rather flat floor and is separated from

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[1] Marsh, O. C. 1896. Dinosaurs of North America, pl. lx, fig. 4.

the median chamber by vertical pillar-like bones, one on either side, which serve also to support the antero-internal portions of the horn cores. The floor of the second or largest chamber is deeply excavated, and it is this chamber which communicates with the horn-core sinuses by openings in the lateral walls. The posterior chamber, lying just beneath the fontanelle, is small and round. and in the specimen in question has a small pencil-like bone running obliquely from the left lateral wall to the floor, after the manner of a flying buttress. There is no indication of a pineal foramen opening into the brain case which lies directly beneath the above sinus; hence the Ceratopsia agree with other Dinosauria in this respect. The postfrontal fontanelle closes in old animals, as in the type skull of *Triceratops prorsus*, which is that of a fully adult though comparatively small animal, and is thus analogous to that in the skull of the human infant.

The loss of the frontals and nasals from our specimen renders possible the study of the interior of the skull, the bones of which are admirably preserved, and while the entire skull gives an appearance of massiveness, the individual bones are comparatively thin, but so constructed as to brace in the most admirable manner the portions of the skull subject to strains and impact, especially beneath the horns.

The *frill* viewed from above presents much the same relative expanse of bone as is shown in the ventral aspect except that the squamosals now extend forward and upward to the base of the horn cores. Anteriorly they are bounded by the jugals, the infratemporal vacuities, and the quadrates. On one squamosal, and to a less extent on the other, a ridge for muscular attachment extends diagonally upward and backward across the posterior portion of the bone. The parietals have the same extent as in the ventral view except that here they overlie the occipital bones and articulate with the postfrontals at about the posterior limit of the horn cores. The supratemporal vacuities open forward beneath the postfrontals and above the parietals into the main sinuses of the skull. Large blood-vessels had their exit through these vacuities, their branches being deeply impressed into the surface of the parietals and to a less extent into the squamosals, thus implying a compactly fitting integument. The base, especially of the right horn core, is well preserved. It is extremely hollow, but with a shelf-like circular projection of bone running around the inner wall just above the level of the postfrontal bones without, and doubtless to aid in resisting the thrust of the latter bones when lateral pressure was brought to bear upon the horns. Around the outside base of the horn is a horizontal ridge which may have supported the base of the horny sheath. The *orbits* are nearly circular and are surrounded by a thickened ridge of bone, especially in front. The downward and outward crushing of the left horn core has partially closed the left orbit, adding to the sinister expression of the skull.

THE LOWER JAW.

The left *mandible*, which is admirably preserved, consists of dentary, surangular, and coronoid, with a full magazine of thirty-nine vertical rows of teeth. On the inner face is a row of thirty-eight dental foramina, and the meckelian groove on the inferior face is wide and deep, but was covered by the thin, plate-like splenial which, though lying detached in the quarry, presents a perfect contact when placed in position. Cope[1] claims that in *Hadrosaurus* it is the splenial which contains the magazine of teeth. Whether or not this be true of *Hadrosaurus* it is certainly not true of *Triceratops*, in which the magazine is contained in the dentary in the normal manner. The teeth arise in alternate series in the successive vertical rows, only one series being in full use at one time, though those of the secondary series, arising between the teeth of the primary series, show partial wear, while in the posterior part of the jaw individual teeth of the primary set are already succeeded by tertiary teeth. The vertical worn faces of the teeth present the surface known to mathematicians as an hyperbolic paraboloid or warped surface; the whole mechanism reminding one of a slightly twisted saw with alternating higher and lower teeth. Marsh notes the fact that in the Ceratopsia the teeth are double-rooted, a feature almost unique among reptiles. This

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[1] Cope, E. D., Amer. Naturalist, July, 1883, p. 775.

seems to have been brought about by the mechanical necessity of a base widened transversely to meet a lateral strain in the shearing process of mastication and the subsequent constriction of this base into an inner and outer pillar due to the crowding of the crowns of adjacent teeth set at a lower level. There could have been no lateral movement in mastication, but a chopping motion, possibly with a slight orthal movement combined with it. The food gathered by the cutting beak was probably chopped into short pieces by the teeth, being kept in the mouth by the muscular wall of the cheeks. It is doubtful whether the gape of the mouth had a posterior extent further than the anterior end of the tooth series, as otherwise the portions of food chopped off, falling outside of the lower teeth, could not have been retained in the mouth.

The alveolar grooves are equally developed in the inner surface of both inner and outer walls of the dental channel and not in the inner surface of the outer wall only as in *Trachodon* (*Hadrosaurus*) as shown by Lambe.[1] This is due to the fact that in *Triceratops* the crowns of the teeth do not form so flat a tassellated pavement when viewed from within; their position in the jaw being more nearly vertical than in *Trachodon*.

Measurements.

Length of skull (estimated)	2160 mm.
Width across frill	1578
Maxillary bones, length	672
" " length of dental channel	482.8
" " average width dental channel	30
Premaxillary bones, width at posterior end	177
Vomer, length	410
" width at anterior end	70
" width of shaft	15
Palatine bones, length	293
Occipital condyle, diameter	115
Foramen magnum, width	47
" " height	39
Basioccipital bone, width	280
Exoccipitals, distance from tip to tip	790

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[1] Lambe, L. M., 1903, Ottawa Naturalist, Vol. XVII, pp. 136, 137; Osborn, H. F., and Lambe, L. M., 1902, Contributions to Canadian Palæontology, III, Part II, p. 73.

Exoccipitals, greatest fore and aft width	260 mm.
" least " " " "	147.5
Parietal bones, ventral aspect, length	808
" " " " least width	742.5
" " " " greatest "	115.4
Squamosal bones, ventral aspect, length	820
" " " " width	355
Postfrontal fontanelle, height	97
" " width	130
Infratemporal vacuity, length	130
" " height	52
Right horn core, longitudinal diameter at base	235
" " " transverse " " "	215
" orbit, length	170
" " height	115
Lower jaw, length of dentary	672.5
" " greatest depth to summit of teeth	183
" " height of coronoid	287.5
" " length of dental channel	324

The Skull of Creosaurus.

By Henry Fairfield Osborn.

AUTHOR'S EDITION, extracted from BULLETIN
OF THE
American Museum of Natural History,
Vol. XIX, Article XXXI, pp. 697–701.
New York, December 24, 1903.

The Knickerbocker Press, New York

Article XXXI. — THE SKULL OF CREOSAURUS.

By Henry Fairfield Osborn.

The skull of the Jurassic Carnivorous Dinosaur *Creosaurus* is represented by two specimens, from the Bone Cabin Quarry, in the American Museum Collection, Nos. 600 and 666, which supplement each other admirably and give a very complete knowledge of all except the palatal region. The side and back view of No. 600 is presented in figures 1 and 2.

The chief features are: (1) the presence of three preorbital fenestræ, (2) the great elongation of the facial region, (3) the abbreviation of the temporal region, (4) the wide extension of the parietals on the occiput, (5) the deep depression of the quadrate and its rounded articular connection superiorly with the squamosal.

Proportions. — The skull is relatively high and narrow, the chief measurements being as follows:

	No. 600.	No. 666.
Length, occipital condyles to premaxillæ......	810 mm.	885 mm.
Depth, parietal crest to distal extremity of quadrate..............................	415	430
Width of occiput across parietals.............	...	230
Vertical measurement of quadrate............	205	235

Openings. — The openings are placed as follows: (1) the paired narial openings, of elongate oval form, at the sides of the snout, bounded by the premaxillæ, nasals, and maxillæ; (2) the greatly abbreviated supratemporal fenestra; (3) the deeply extended latero-temporal fenestra (the post-temporal fenestra is entirely closed, and there is no pineal opening); (4) there is a slit-like foramen between the quadrate and quadratojugal; (5) the orbital openings are deeply vertical; (6) the preorbital fenestra, *f′*, is by far the largest vacuity in the skull, and is bounded by the maxillaries, prefrontals, and jugals; (7) a much smaller second preorbital fenestra, *f″*, is bounded entirely by the maxillaries; (8) the third preorbital fenestra, *f‴*, lies between the premaxillaries and maxillaries, and is very small.

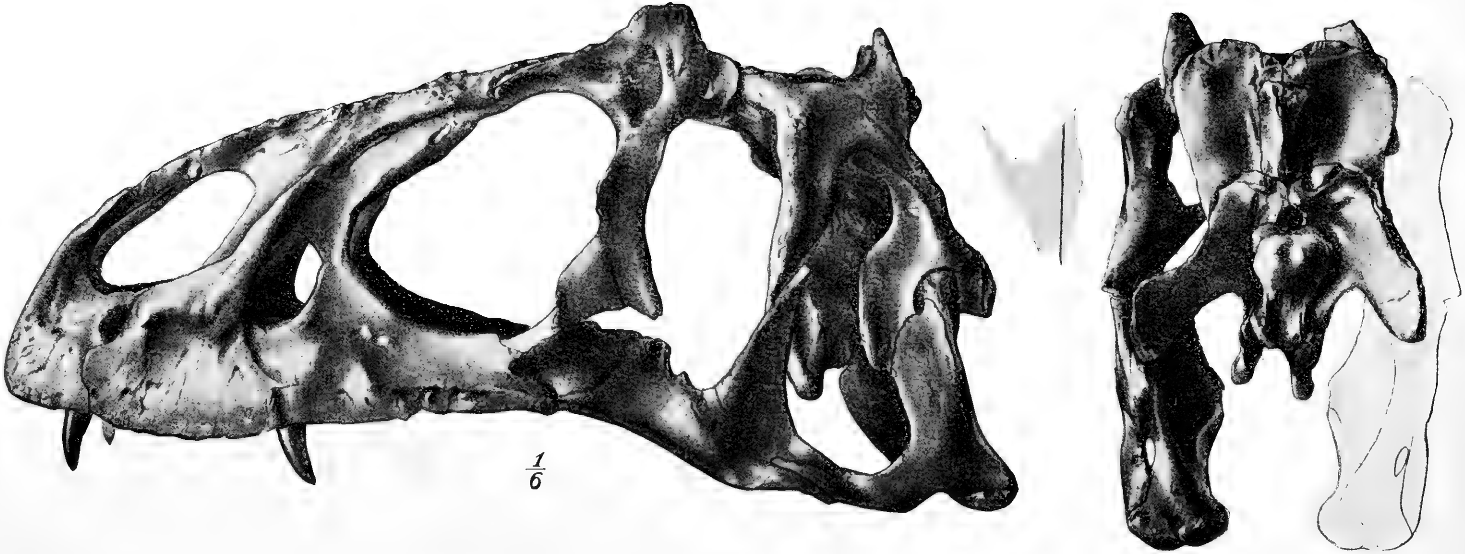

Fig. 1. Skull of *Creosaurus atrox* Marsh. × $\frac{1}{6}$.

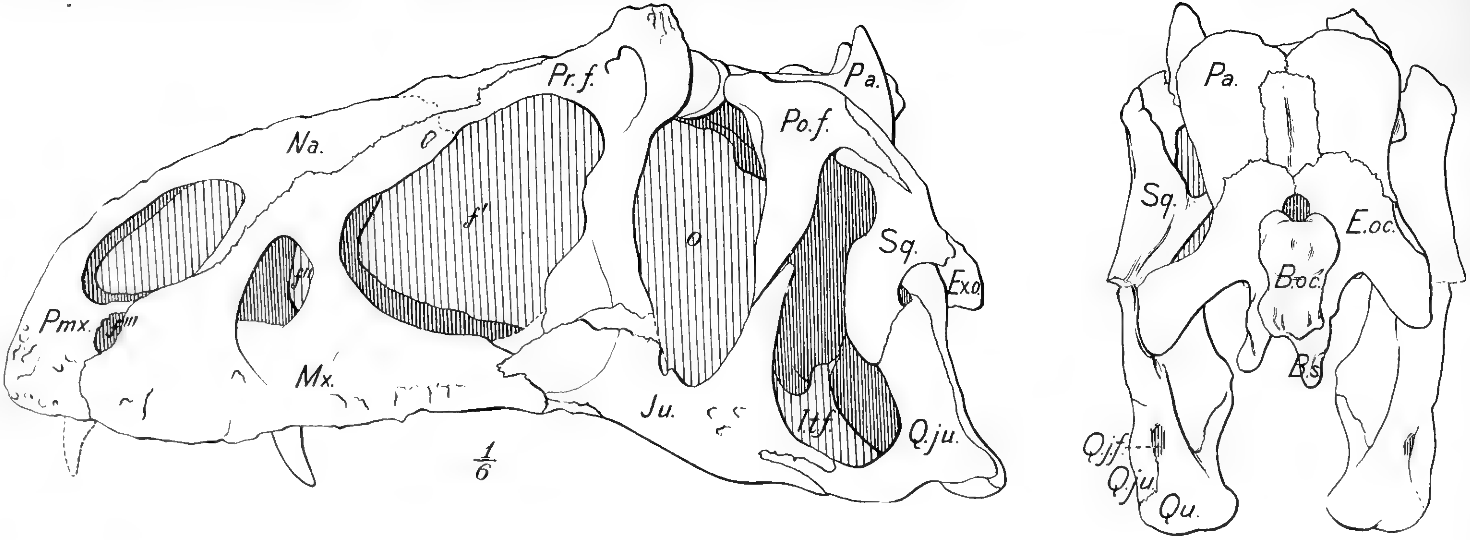

Fig. 2. Key to Fig. 1.

o, orbit.
f′, first preorbital fenestra.
f″, second preorbital fenestra.
f‴, third preorbital fenestra.
l.t.f., laterotemporal fenestra.
Q.j.f., quadratojugal foramen.

The *premaxillaries* retain the alveoli of five teeth, and resemble the type premaxilla of *Creosaurus atrox*, a genus which, however, has not yet been clearly separated from *Allosaurus*.[1] The *maxillaries* contain the alveoli for from 16 to 18 teeth. Length, 460 mm. The *nasals* are remarkably elongate, 470 mm. (No. 666), and gradually increase in breadth posteriorly; in No. 666 they are continuous back to the frontals; in No. 600 there is a fracture or suture above the preorbital fenestra which is not observed in No. 666, and, therefore, is apparently accidental. The *frontals* are extremely short, 140 mm. in No. 666, extending back to a point midway between the supratemporal fossæ. The superior portion of the parietals is also abbreviate, but laterally and posteriorly they form two large transversely extended vertical plates constituting the crest or superior and lateral portions of the occiput. The narrow *supraoccipitals* apparently extend partly between the parietal crest above; below they are in contact with the conjoined exoccipitals. The *exoccipitals* unite in the median line above the foramen magnum and extend outward in two broad winglike plates with which the paroccipitals are coalesced. The *basioccipital* alone enters into the prominently convex condyle.

The lateral portions of the occipital region are formed by the posterior plates of the *squamosals*, which fill the bordering angle between the parietals and paroccipitals; in side view the squamosals are indented by a spur of the postorbito-frontals, and send a descending process for articulation with the ascending process of the quadratojugals. The *quadrates* are vertically extended with a singly convex head above for a jointed articulation with the squamosals, and a doubly convex transversely extended distal extremity for union with the articulars. The *quadratojugals* are placed on the outer sides of the quadrates, and are shorter elements than the jugals. The *jugals* are triradiate bones articulating with the quadratojugals, postorbito-frontals, and prefronto-lachrymals, respectively. The elements bounding the orbits anteriorly, uniting with the jugals and maxillaries below and with the nasals and

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[1] This matter has been carefully discussed by S. W. Williston: 'The Dinosaurian Genus Creosaurus, Marsh.' Amer. Journ. Sci., Vol. XI, 1901, p. 111.

frontals above, are considered to represent a complex composed of the *prefrontals* and *lachrymals;* they are surmounted by a stout tuberous process which is deeply excavated on the antero-external surface; this process may have supported something in the nature of a low dermal horn.

Below the condyles the basioccipitals descend abruptly downward and backward; on each side of this downward projection are the apparently inferior plates of the exoccipitals. From these inferior plates two still more depressed wings extend downward, which probably represent antero-inferior processes of the basisphenoids for articulation with the pterygoids.

Lower jaw. — In the *lower jaw* the articulars, angulars, and dentaries are clearly determinable. The suture between the coronoid and angular is faintly determinable posteriorly, the coronoid being depressed. The convex element extending along the inner side of the dentary but firmly coalesced with it may represent a presplenial; if this is truly the presplenial it appears to extend as far forward as the symphysis. There are apparently sixteen alveoli for the laterally compressed lower teeth in the dentary.

A fuller description of these skulls will appear in a forthcoming memoir.

AMERICAN MUSEUM OF NATURAL HISTORY,
NEW YORK CITY, U. S. A.

SUPPLEMENTS TO THE AMERICAN MUSEUM JOURNAL.

The following Guide Leaflets to the Hall of Fossil Vertebrates will be prepared under the direction of Professor HENRY FAIRFIELD OSBORN, Curator of the Department of Vertebrate Palæontology:

I. The Hall of Fossil Vertebrates. Introduction and General Guide. (Published January, 1902.)

II. Evolution among Fossil Mammals as illustrated by the AMERICAN MUSEUM Collections.

Section 1. The Horse.
2. The Camel.
3. The Titanothere.
4. The Rhinoceros.
5. The Elephant.

III. Extinct Carnivora.

IV. The Dinosaurs or Giant Reptiles.

Section 1. Sauropoda.

V. Marine Reptiles.

Section 1. Mosasaurs.
2. Ichthyosaurs.
3. Plesiosaurs.

VI. The Fossil Fields of the West, their Topography and Geology, with a brief account of the Field Expeditions sent out by the AMERICAN MUSEUM OF NATURAL HISTORY.

February, 1902.

AMERICAN MUSEUM OF NATURAL HISTORY,
DEPARTMENT OF VERTEBRATE PALÆONTOLOGY.

PROVISIONAL GUIDE
TO THE
Hall of Fossil Vertebrates.

(NO. 402, FOURTH FLOOR, EAST WING.)

EDITION OF 1900–1901.

The collections in this hall are not yet complete nor permanently arranged.
We cannot therefore issue a guide-book at present.

The arrangement of the specimens is intended to show the history or evolution of different races of animals, chiefly in North America. All the specimens of one race or kind of animal are placed together, the most ancient first, the most recent last.

All the skeletons in this hall are those of extinct animals. The *Mastodon* and *Great Irish Deer* are half-petrified bone dug out of peat bogs. All the others are petrified (*i. e.*, have been buried so long that they are converted from bone into stone), and have been chiseled out of the solid rock. The *Megatherium* is a plaster cast.

Some of the skeletons are partly restored in plaster, indicated by a red cross (restored bones) or red lines (outlines of restored parts of bones). Bones supplied from other specimens are marked with the catalogue number of the specimen, or indicated by a red circle if uncatalogued.

The most ancient of the extinct animals shown here are the Dinosaurs or great land Reptiles, Mosasaurs or great marine Lizards, and other creatures of the *Age of Reptiles.* These are millions of years old. Some of the Dinosaurs are the largest known land animals, longer than the width of this hall, and standing on all fours with the back reaching nearly as high as the ceiling.

The rest of the specimens are *mammals* (animals which suckle their young, including most four-footed beasts). Most of them are hundreds of thousands of years old, ranging from perhaps three million years down; these lived long before man had appeared on the earth. A few, including the Mastodon, Mammoth, Megatherium, Irish Elk, One-toed Horse and others, are of the latest geological age (the "Pleistocene"), and, while tens of thousands of years old, were contemporaries of primitive man.

Many of the extinct animals are allied to animals still living, and are called by the common names of their modern relatives. Thus we have extinct Horses, Rhinoceroses, Tapirs, Camels, etc. Other races have died out completely and are not related to any living animals. *For these there is no common name*, and we have to coin a name from their (Latin or Greek) scientific name, calling them "Titanotheres," "Dinosaurs," etc.

The best example of Evolution is the race of extinct ancestors of the Horse, shown in the right hand far corner of the hall. Next best is the series of Camel ancestors, on the left hand side near the far end, and the series of ancestors of Titanotheres and ancestors of Rhinoceroses, skulls and skeletons ranged along the right hand (south) side of the hall beginning at the entrance. All these series are arranged according to age, the most ancient (oldest or first stage of evolution, found in the lowest rock-strata) first, the most recent (final stage of evolution, found in the uppermost rock-strata) last.

On the left side of the hall are arranged the Amblypods, ancient hoofed animals long ago extinct, unlike any living animal, although suggesting elephants, rhinoceroses, hippopotami and bears, in different parts of the body. Next there are the Condylarths, the most ancient of hoofed mammals, then the Creodonta and Carnivora (flesh-eating mammals), the Insectivora (insect-eaters), Rodents (gnawers), and other small and primitive mammals. Then come the Elephants and the various kinds of cloven-hoofed animals, allied to modern pigs, deer, sheep and cattle.

The **Dinosaurs or Giant Reptiles** are temporarily placed at the end of the hall and in the two high cases to the left of the centre aisle. Small models of restorations of three kinds of Dinosaur will be found in an A-case near the end of the hall left of the centre aisle.

The **Mosasaurs or Great Marine Lizards** are represented by the skeleton on the wall of the corridor by the staircase. This corridor will ultimately be filled with great marine reptiles.

The **Water-color Restorations** by Charles Knight, mainly based on complete skeletons exhibited in this hall, show the *probable appearance* of the different extinct animals, according to our best judgment, as indicated by the characters of the skeleton, appearance of their nearest surviving relatives, and the habits of life for which the animals seem to have been fitted.

The **Window Transparencies** are enlarged from photographs of the regions where the fossils occur, and generally show the localities where unusually fine specimens in this hall were found.

The **Pillar Cards** and general **Labels** in the cases give detailed information about each group of fossils.

The **Synoptic Case** in the centre of the middle aisle illustrates the method by which the fossils are collected and conveyed to the Museum.

The **Charts** at each side of the entrance show the order in which the rock strata lie, one over another, and the kinds of fossils found in each stratum.

WHAT THE EVOLUTION SERIES PROVE.

Each series of specimens is arranged according to the age of the strata in which they are found. This age is known by the order in which the strata lie one over another. In all ordinary circumstances the underlying stratum must have been deposited first, the overlying one afterwards. In each stratum is found most abundantly a particular species of a race of animals and all the fossil specimens of that race ever found in that stratum are like the said species within quite narrow limits. Arranging the characteristic species from each stratum in order of the age of the strata, we find that they show a regular uniform change from the most ancient to the most recent. At no point in a given series can we draw a line and say: This is, and that is not, a horse—or a camel—or a rhinoceros. The visitor, therefore, can demonstrate for himself the Evolution of the race of Horses, or Camels or Rhinoceroses, within certain limits. (Of the evolution of Man we have not satisfactory illustration from fossils.)

It should be observed that the evolution of a race consists mainly in the adaptation of the structure of the animals to particular surroundings and habits of life. There is also a universal progress in intelligence, the older animals having relatively smaller brains.

AMERICAN MUSEUM OF NATURAL HISTORY

The Evolution of the Horse

BY

William D. Matthew, Ph.D.

Associate Curator of Vertebrate Palæontology

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Guide Leaflet No. 9

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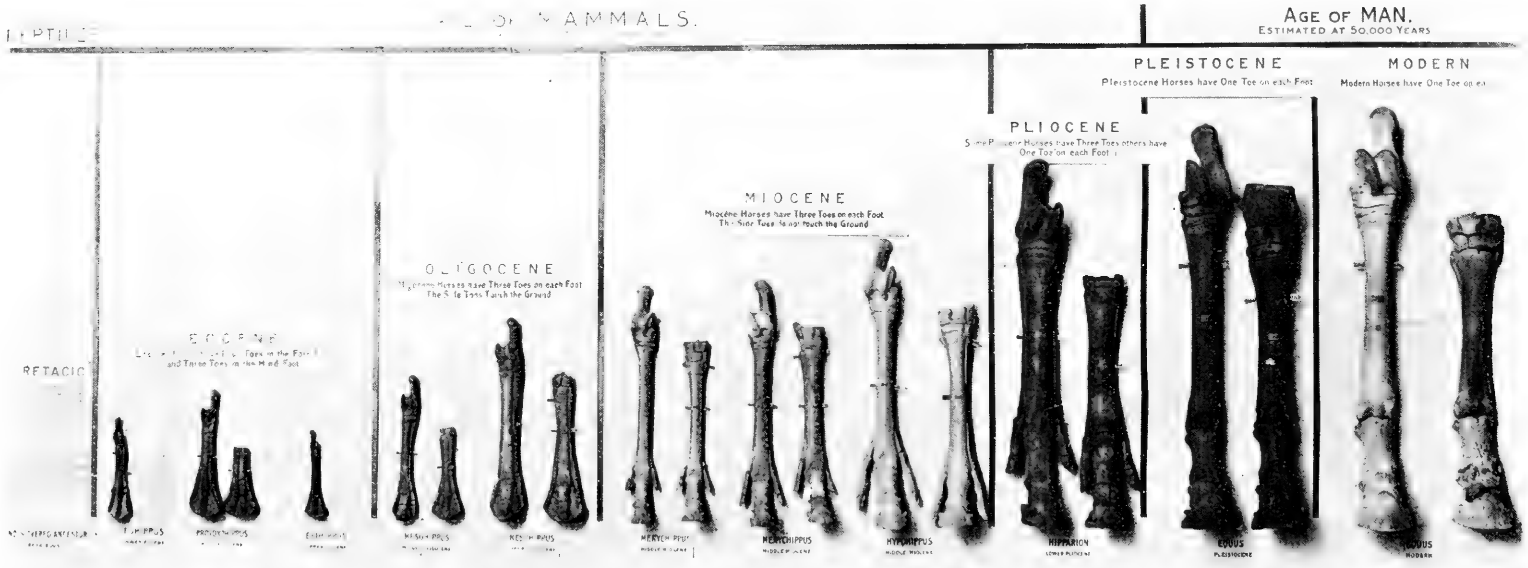

EVOLUTION OF THE HORSE. FEET
Series on exhibition in the American Museum

ILLUSTRATIONS OF EVOLUTION AMONG FOSSIL MAMMALS.

A.— THE HORSE.

By W. D. MATTHEW, Ph.D.,
Associate Curator, Department of Vertebrate Palæontology.

As a domestic animal the Horse is to be found almost everywhere that man can live. He is spread all over the world — from torrid to arctic climates, in all the continents, in remote oceanic islands — he is completely cosmopolitan. But as a wild animal the Horse is at present limited to the Old World, and is found there only in the open arid or desert plains of Central Asia and Africa. There are two species in Asia, the Asiatic Wild Ass (*Equus hemionus*), and the little known Przewalsky's Horse (*E. przewalskii*), while in Africa there are the African Wild Ass (*E. asinus*) and the several species of Zebra (*E. zebra*, *E. burchelli*, *E. quagga*). In the Americas and Australia there are no true wild horses, the mustangs and broncos of the Western Plains and South America being *feral* (domesticated animals run wild) and descended from the horses brought over from Europe by the early white settlers. When the Spaniards first explored the New World they found no horses on either continent. The Indians were quite unfamiliar with them and at first regarded the strange animal which the newcomers rode with wonder and terror, like that of the ancient Romans when Pyrrhus and his Greeks brought elephants—"the huge earth-shaking beast"[1]—to fight against them.

The Horse is distinguished from all other animals now living by the fact that he has but one toe on each foot. Comparison with other animals shows that this toe is the third or middle digit of the foot. The hoof corresponds to the nail of a man or the claw of a dog or cat, and is broadened out to afford a firm, strong support on which the whole weight of the animal rests. Behind the "cannon-bone" of the foot are two slender little

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[1] Macaulay —"The Battle of Lake Regillus."

bones, one on each side, called *splint-bones*. These represent the second and fourth digits of other animals, but they do not show on the surface, and there is nothing like a separate toe. So that the horse may be said to be an animal that walks on its middle finger-nail, all the other fingers having disappeared.

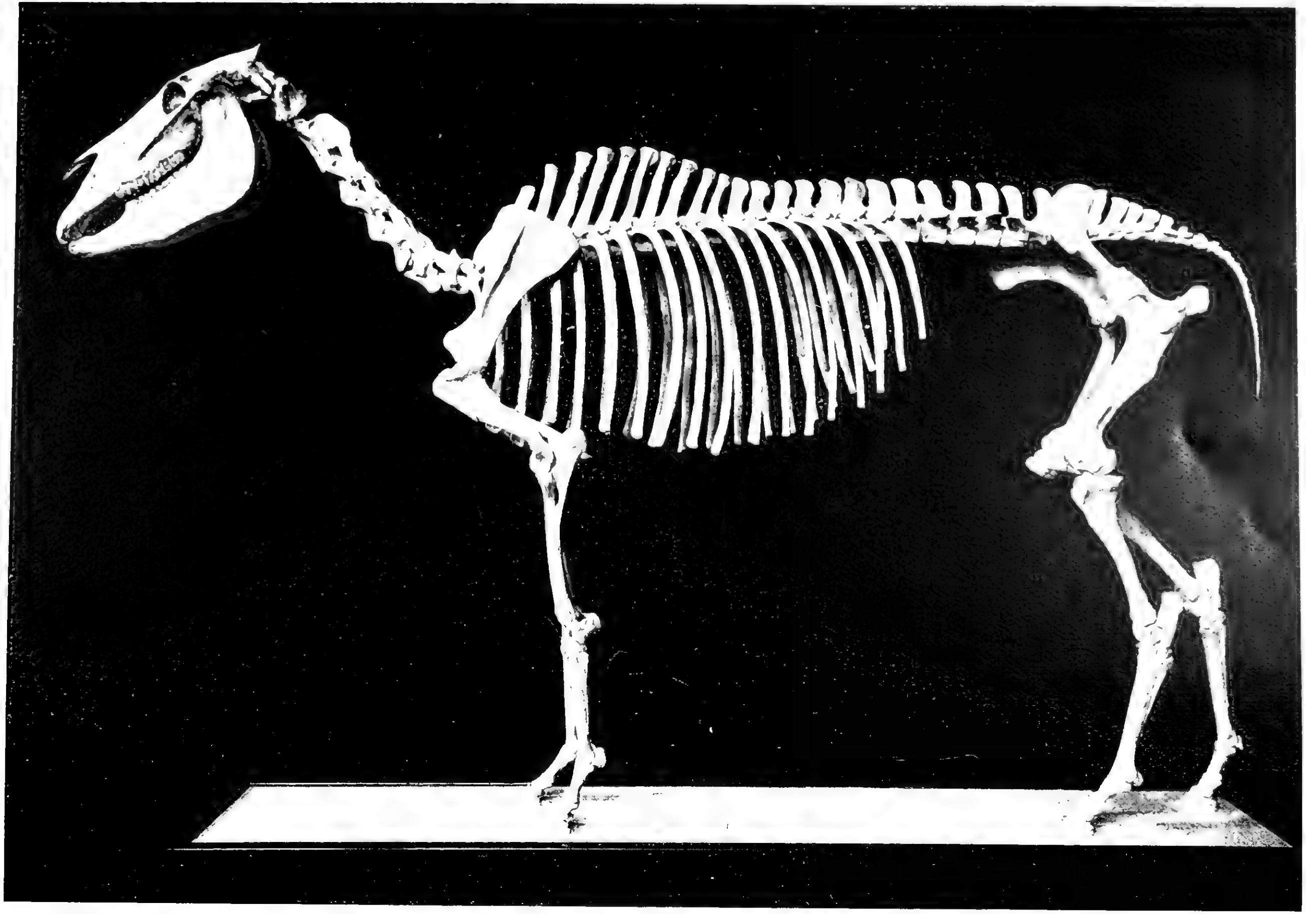
The teeth of the horse are almost equally peculiar. The molars are long, square prisms which grow up from the gums as fast as they wear off on the crowns. Their grinding surface exhibits a peculiar and complicated pattern of edges of hard enamel between which are softer spaces composed of dentine and of a material called "cement," much like the dentine in quality but formed in a different way. The dentine is formed on the inside surfaces of the enamel while the tooth is still within the jaw-bone; the cement is deposited on the outside surfaces of the enamel after the tooth has broken through the jaw-bone and before it appears above the gums.

Various other peculiarities distinguish the Horse from most other animals; some of these are shared by other hoofed animals. The two long bones of the fore-arm (*radius* and *ulna*) are separate in the greater number of animals, but in the Horse, and in many other hoofed animals they are consolidated into a single bone. The same consolidation is seen in the bones of the lower leg (*tibia* and *fibula*). The lengthening of the foot and stepping on the end of the toe raises the heel in the Horse, as in many other animals, to a considerable height above the ground, where it forms the hock joint, bending backward, as the knee bends forward. In these as in various other ways the legs of the horse are especially fitted for swift running over hard and level ground, just as its teeth are for grinding the wiry grasses which grow on the open plain.

The Zebra and the Ass have the same peculiar structure of teeth and feet as the Domestic Horse, and differ only in the color of the skin, proportions of various parts of the body etc.

Fossil Horses of the Age of Man.

The Age of Man, or Quaternary Period, is the last and by far the shortest of the great divisions of geological time. It includes the Great Ice Age or Glacial epoch (Pleistocene), when heavy



SKELETON OF "EQUUS SCOTTI," FROM THE LOWER PLEISTOCENE OF TEXAS

Mounted in the American Museum

continental glaciers covered the northern parts of Europe and North America, and the Recent Epoch, of more moderate climate during which civilization has arisen.

In the early part of the Quaternary Period, wild species of Horse were to be found on every continent except Australia. Remains of these true native horses have been found buried in strata of this age in all parts of the United States, in Alaska, in Mexico, in Ecuador, Brazil and Argentina, as well as in Europe, Asia and Africa. All these horses were much like the living species and most of them are included in the genus *Equus*. A complete skeleton of one of them (*Equus scotti*) found by the American Museum expedition of 1899 in Northern Texas, is mounted in the large wall-case. The difference between it and the Domestic Horse (see framed diagram of modern horse skeleton) is chiefly in proportions, the skull shorter with deeper jaws, the legs rather short and feet small in proportion to the body. In these characters this fossil horse resembles an overgrown zebra rather than a domestic horse. We know nothing of its coloring. It may have been striped, and in this case would have been very zebra-like; but there are some reasons for believing that it was not prominently striped. The bones are petrified, brittle and heavy, the animal matter of the bone having entirely disappeared and having been partly replaced by mineral matter. They are not much changed in color, however, and are so perfectly preserved that they look almost like recent bone.

All the remains of these native horses which have been found in America have been petrified more or less completely; this means that they have been buried for many thousands of years, for petrifaction is an exceedingly slow process.[1] It serves as an easy method of distinguishing them from bones of the Domestic Horse, found buried in the earth. These cannot in any case have been buried for more than four or five centuries, and have not had time to petrify.

Remains of these fossil horses from various parts of the United States are shown in the counter-case. One very rich

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[1] The so-called petrifaction which occurs in some hot springs, coating objects dipped into them with a white, stony coat of lime is not true petrifaction. In true petrifaction the substance of the bone is replaced particle by particle with mineral matter.

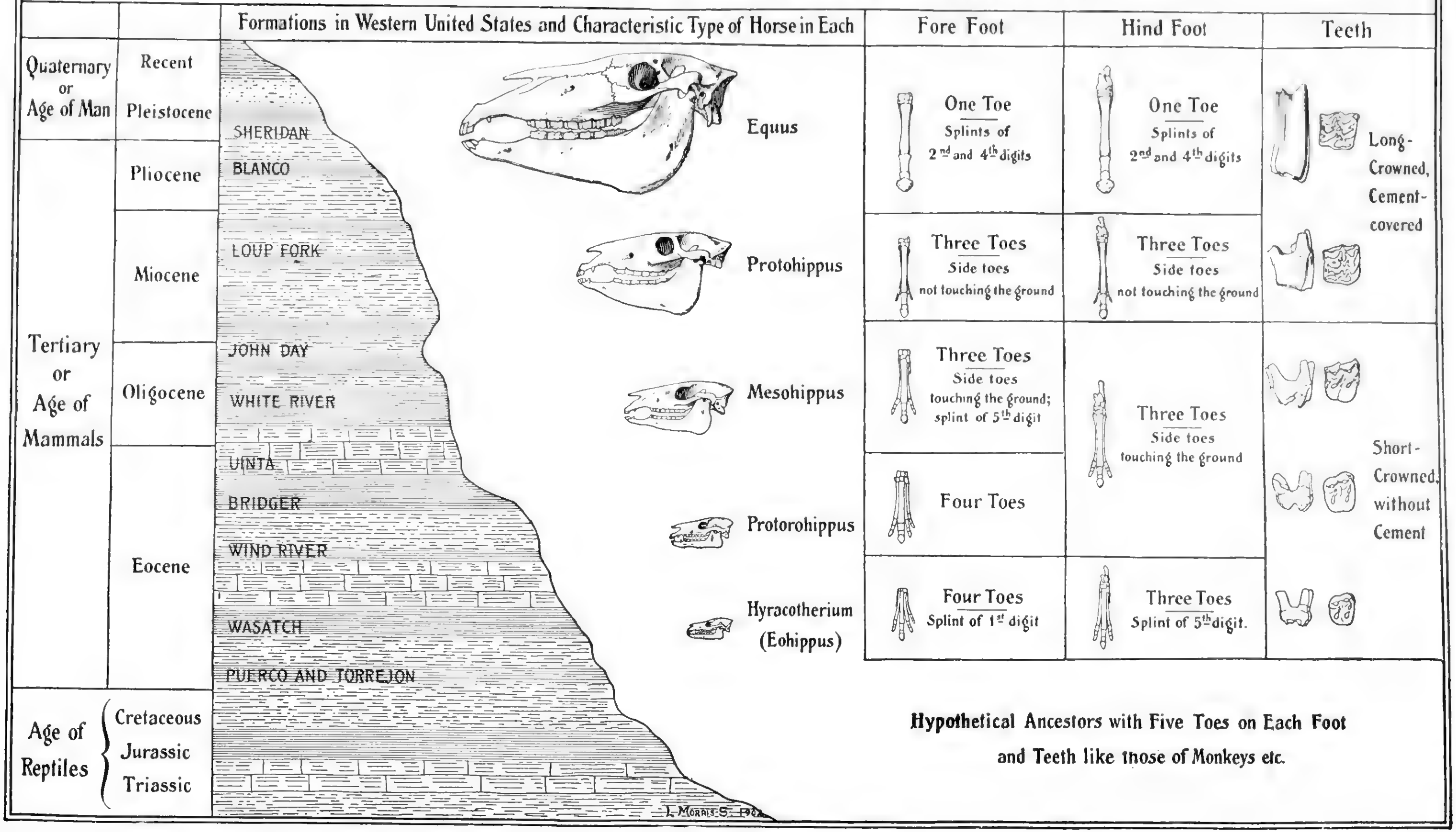
locality is on the Niobrara river in Nebraska, another in central Oregon. Many separate teeth and bones have been found in the phosphate mines near Charlestown, S. C.; other specimens have come from central Florida, from southern Texas, Arizona, Kansas, Louisiana and even from Alaska. They are, in fact, so often found in deposits of rivers and lakes of the latest geological epoch (the Pleistocene) that the formation in the western United States has received the name of Equus Beds.

In South America, in strata of the Pleistocene Epoch, there occurs, besides several extinct species of the genus *Equus*, the *Hippidium*, a peculiar kind of Horse characterized by very short legs and feet, and some peculiarities about the muzzle and the grinding teeth. The legs were hardly as long as those of a cow, while the head was as large as that of a racehorse or other small breed of the Domestic Horse.

All these horses became extinct, both in North and South America. Why, we do not know. It may have been that they were unable to stand the cold of the winters, probably longer continued and much more severe during the Ice Age than now. It is very probable that man — the early tribes of prehistoric hunters — played a large part in extinguishing the race. The competition with the bison and the antelope, which had recently migrated to America — may have made it more difficult than formerly for the American Horse to get a living. Or, finally, some unknown disease or prolonged season of drought may have exterminated the race. Whatever the cause, the Horse had disappeared from the New World when the white man invaded it (unless a few individuals still lingered on the remote plains of South America), and in his place the bison had come and spread over the prairies of the North.

In Central Asia, two wild races persist to the present day; others were domesticated by man in the earliest times, and their use in Chaldæa and Egypt for draught and riding is depicted in the ancient mural paintings. In Africa the larger species became extinct in prehistoric times, as in America, but the smaller zebras still survive in the southern part of the continent (one species, the Quagga, abundant fifty years ago, is now probably extinct), and the African Wild Ass is found in the fauna of the northern

THE EVOLUTION OF THE HORSE.



part. The Wild Horse of prehistoric Europe, a small race, short-legged and shaggy-haired, was domesticated by man, a fact that is known from the rude drawings scratched on bone or ivory by men of the Neolithic or Polished Stone Age. But the Domestic Horse now in use is derived chiefly from the Asiatic race, although it is probable that in some breeds there is a considerable strain of this shaggy, short-legged European race, and it is possible also that African races may have been domesticated and to some extent mixed with the Asiatic species. The domesticated Ass is a descendant of the African species.

The Evolution of the Horse.

The history of the evolution of the Horse through the Tertiary period or Age of Mammals affords the best known illustration in existence of the doctrine of evolution by means of natural selection and the adaptation of a race of animals to its environment. The ancestry of this family has been traced back to nearly the beginning of the Tertiary without a single important break. During this long period of time, estimated at nearly three millions of years, these animals passed through important changes in all parts of the body, but especially in the teeth and feet, adapting them more and more perfectly to their particular environment, namely the open plains of a great plateau region with their scanty stunted herbage, which is the natural habitat of the Horse.

In the series of ancestors of the Horse we can trace every step in the evolution of those marked peculiarities of teeth and feet which distinguish the modern Horse from an ancestor which so little suggests a horse that, when its remains were first found forty years ago, the animal was named by the great palæontologist Richard Owen, the *Hyracotherium* or "Coney-like Beast." Its relation to the Horse was not at that time suspected by Professor Owen, and was recognized by scientific men only when several of the intermediate stages between it and its modern descendant had been discovered. On the other hand this first ancestor of the Horse line is very difficult to distinguish from the contemporary ancestors of tapirs and rhinoceroses, and indicates how all the modern quadrupeds have diverged from a single type, each becoming adapted to the needs of its especial mode of life.

The earliest known ancestors of the Horse were small animals not larger than the domestic cat, with four complete toes on each forefoot and three on each hindfoot. There is reason to believe that the still more ancient ancestors of this and all other mammals had five toes on each foot. In the forefoot of the earliest known stage we find a splint-bone or small, slender rudiment representing the missing first digit or thumb, which no longer appears on the surface of the foot, while in the hindfoot there is a similar rudiment representing the outer or fifth digit, but no trace is left of the innermost or first digit. The proportions of the skull, the short neck and arched back and the limbs of moderate length, were very little horse-like; recalling, on the contrary, some modern carnivorous animals, especially the civets (*Viverridæ*). The teeth were short-crowned and covered with low rounded knobs of enamel, suggesting those of monkeys and of pigs or other omnivorous animals, but not at all like the long-crowned complicated grinders of the Horse.

Commencing with the *Hyracotherium*, twelve stages have been recognized from as many successive formations, showing the gradual evolution of the race into its modern form, and each stage is characteristic of its particular geological horizon. Some of the stages have been found in several parts of the world, but by far the most complete and best known series comes from the Tertiary Badlands of the Western States. Besides the main line of descent which led into the modern horses, asses and zebras, there were several collateral branches which have left no descendants. Of some stages all parts of the skeleton have been found; of others only the jaws, or jaws and feet, are known. We can mention only the more important stages.

1 and 2.[1] **Hyracotherium** and **Eohippus.** LOWER EOCENE. The *Hyracotherium* is the most primitive stage known, but only the skull has been found, so that it has not been determined exactly what the feet were like. The teeth display six rounded knobs or cusps on the upper molars and four on the lower ones,

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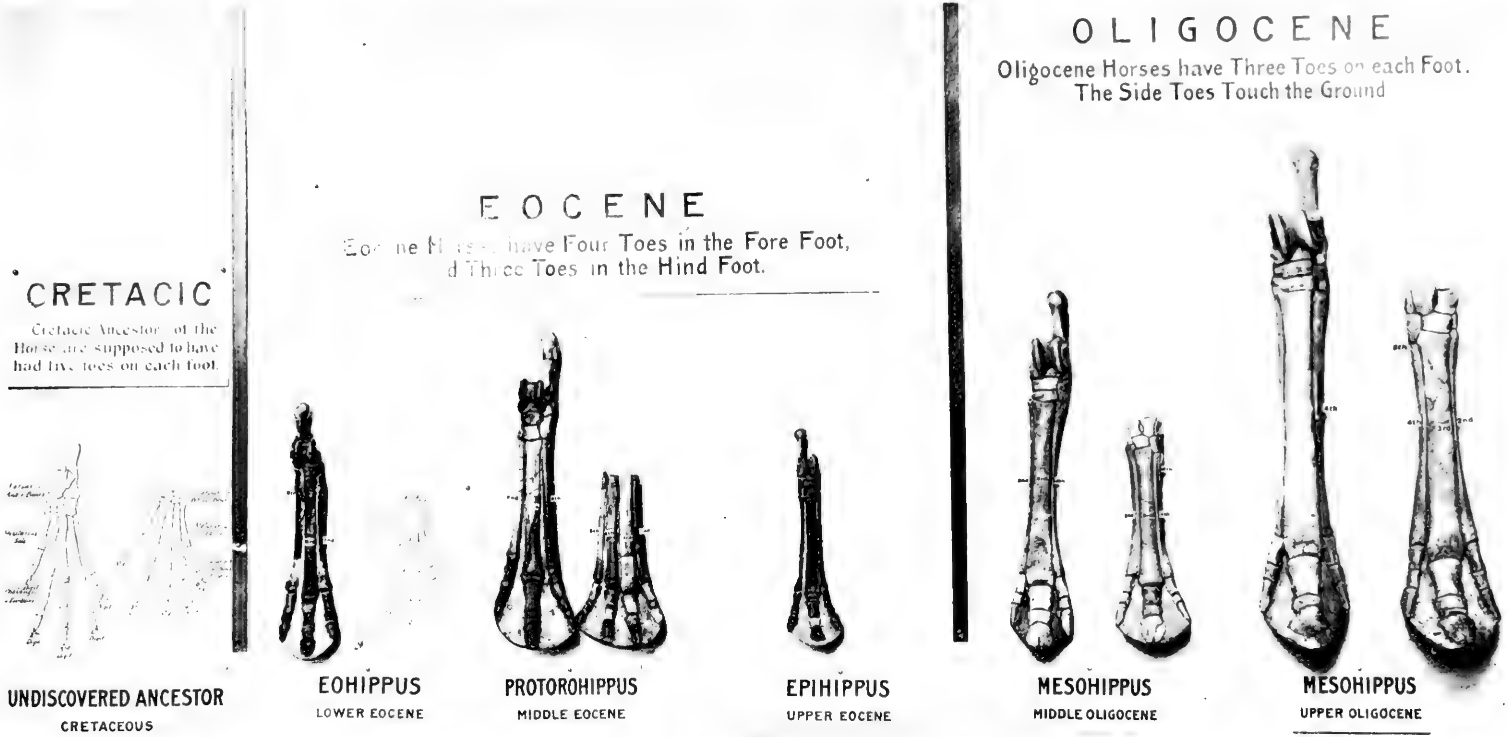
[1] These numbers refer to the stages in the direct line of descent of the modern Horse; see frontispiece.



EARLY STAGES IN THE EVOLUTION OF THE FEET
From the series on exhibition in the American Museum

and these are just beginning to show signs of fusing into cross-crests. The premolar teeth have only one main cusp, except the third and fourth premolars (next the molars) in each jaw, which have two and three, respectively. The only specimens which have been found were in the London Clay or Lower Eocene of England and are preserved in the British Museum.

The *Eohippus* is much better known. It comes from the Lower Eocene of Wyoming and New Mexico, and is very like the *Hyracotherium* except that the molar teeth have the cusps more clearly fusing into cross-crests, and the last premolar is beginning to look like one of the true molars. The forefoot of this animal has four complete toes and the splint of a fifth. The hindfoot has three complete toes and the splint of another. A specimen of the hindfoot is shown in the series in the A-case and many incomplete specimens, skulls, jaws etc., of several species in the counter-case.

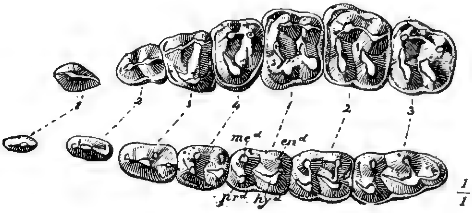


FIG. 1.—UPPER AND LOWER TEETH OF "EOHIPPUS," FROM THE LOWER EOCENE OF WYOMING. NATURAL SIZE

3 and 4. **Protorohippus** and **Orohippus.** MIDDLE EOCENE. In these animals the splint of the first digit in the forefoot and the splint of the fifth digit of the hindfoot have disappeared, but there are still four complete toes in the fore- and three in the hindfoot. The crests on the molars are a little clearer and the last premolar has become almost like the molars, while the next to the last premolar is beginning to become so. A skeleton of *Protorohippus* is mounted in the wall-case. It shows an animal of the size of a small dog, and proportioned much like the breed known as the *whippet*, of which a skeleton has been placed near by for comparison with the *Protorohippus* skeleton. The *Protorohippus* was found by Dr. J. L. Wortman in 1880 in the Wind

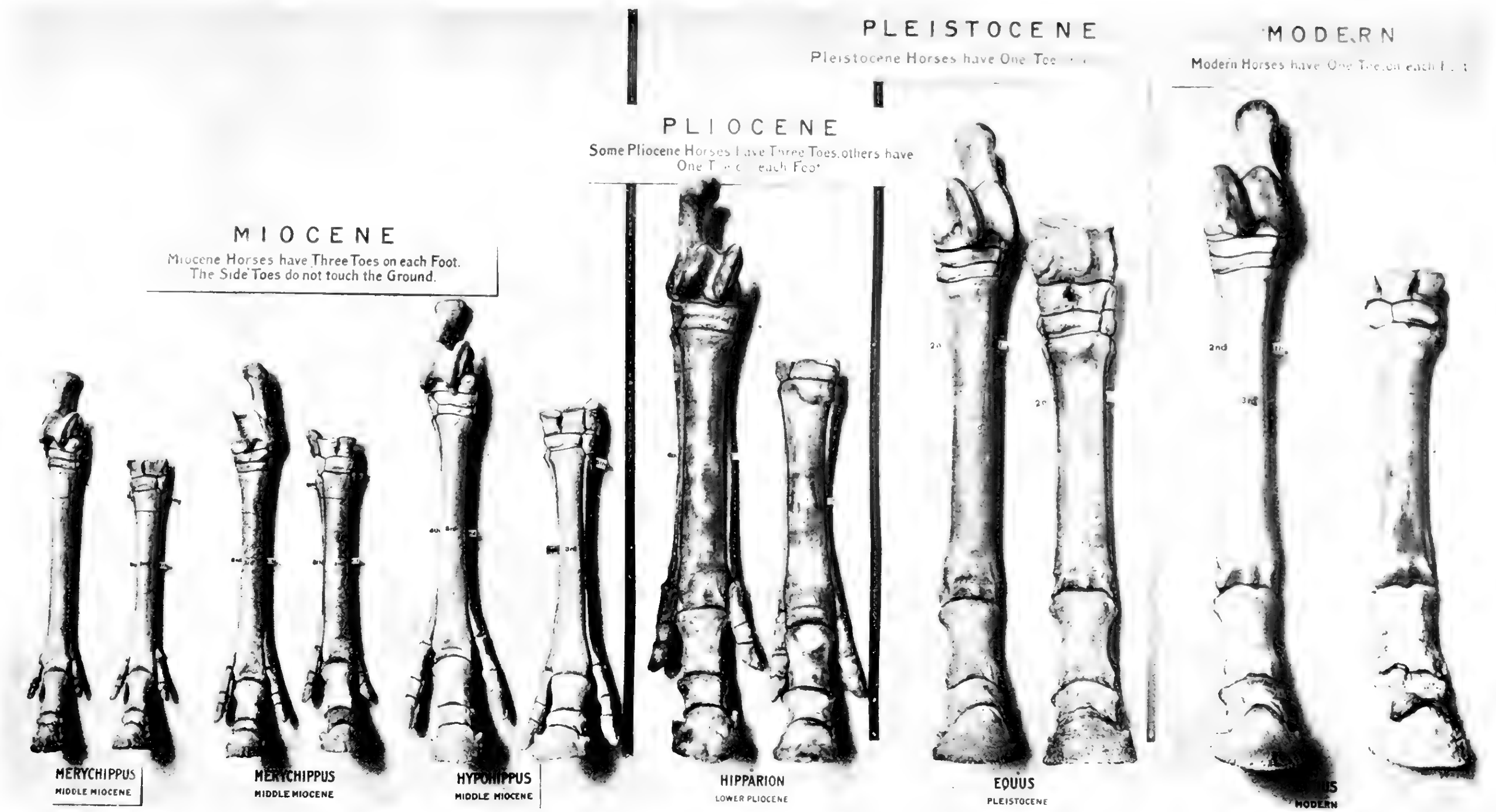
River Badlands of Wyoming, and was described by Professor Cope and others under the name of the "Four-Toed Horse."

Of *Orohippus* we have only parts of jaws and teeth. A specimen of the forefoot is exhibited in the Museum of Yale University.

5. **Epihippus.** UPPER EOCENE. Of this stage of the evolution of the Horse only incomplete specimens have been found. The molar teeth have the once round cusps almost completely converted into crescents and crests, while another tooth of the premolar series has become like the molars. The toes are still four in the forefoot and three in the hindfoot, but the central toe in each foot is becoming much larger than the side toes, a feature which may be seen in the hindfoot shown in the series in the case. (This species happens to be somewhat smaller than those found in the Middle Eocene stage, but no doubt there were others of larger size living at the same time.)

Palæotherium and *Paloplotherium* of the Upper Eocene of Europe form a side branch of the Horse line. They were very abundant in Europe, but have not been found in the New World. On each foot they had three toes of nearly equal size, and the teeth show a rather peculiar pattern. One of these animals was thought by Professor Huxley to be a direct ancestor of the Horse, but it now is considered to be merely a collateral relative. Some species of *Palæotherium* were of large size, equal to a tapir. They were first described in the year 1804 by the celebrated Baron Cuvier from remains found in the gypsum quarries of Montmartre, Paris. A large series of skulls, jaws, foot-bones etc., from the Upper Eocene of France, is exhibited in one of the counter-cases.

6 and 7. **Mesohippus.** OLIGOCENE (*White River Formation*). In this stage there are three toes on each foot, a splint representing the fifth digit of the forefoot of the Eocene ancestors. The middle toe is now much larger than the side toes, which bear very little of the weight of the animal. Three of the premolars have now become entirely like the molar teeth, the crests on the crown are completely formed, and the outside crest in the upper molars has taken the shape of two crescents. In the Middle Oligocene is found *Mesohippus bairdi* about the size of a coyote,



LATER STAGES IN THE EVOLUTION OF THE FEET
From the series on exhibition in the American Museum

while in the Upper Oligocene occurs *Mesohippus intermedius* as large as a sheep. Of both these animals all parts of the skeleton are known, and a good series of skulls, feet, jaws, palates etc. is exhibited in the counter-case, besides the specimens shown in the series of feet and in the series of skulls.

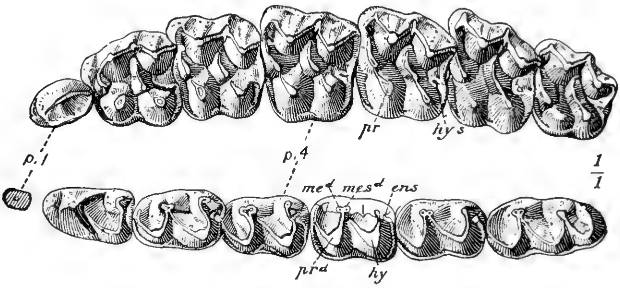


FIG. 2.—UPPER AND LOWER TEETH OF "MESOHIPPUS BAIRDI," FROM THE MIDDLE OLIGOCENE OF SOUTH DAKOTA. NATURAL SIZE

8. **Anchitherium.** Lower Miocene. This stage has been found both in Europe and in America. It is much like its predecessor, but is larger and has the crests of the teeth somewhat higher and more complete. It probably is not in the direct line of descent of the horses, but is on a side branch. A palate, jaws, teeth and foot-bones are exhibited here.

9. **Parahippus** and **Hypohippus.** Middle Miocene. In *Parahippus* the tooth-crests are much higher, and the transverse ridges on the upper molars are beginning to change shape so as to become a second pair of crescents inside the outer pair. *Hypohippus* is off the direct line of descent; its teeth are like those of *Anchitherium*, by which name it has been generally called, but the animal was much larger, equalling a Shetland pony in size. A complete skeleton of the *Hypohippus* is shown in wall-case 15, and illustrates very well the general characters of the Three-Toed Horses, although it is not in the direct line. This specimen was found near Pawnee Buttes, Colorado, in 1901 by Barnum Brown, of the Whitney expedition. Other incomplete specimens of *Hypohippus*, *Parahippus* and *Merychippus* are shown in the counter-case, and casts of the feet and skull in the evolution series in A-Case 49. It may be observed that in the forefoot of

Hypohippus small rudiments still remain representing the first and fifth digits, but there is no splint of the fifth, as in *Mesohippus*. The second and fourth digits still touch the ground, though lightly.

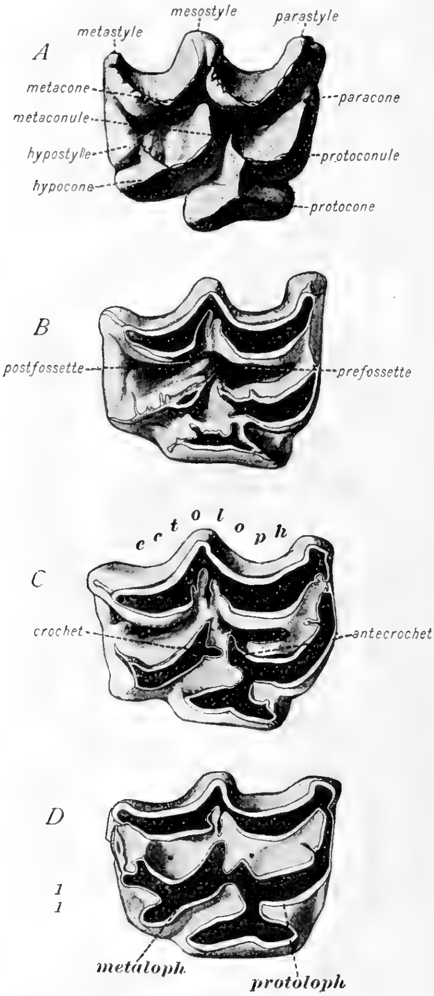
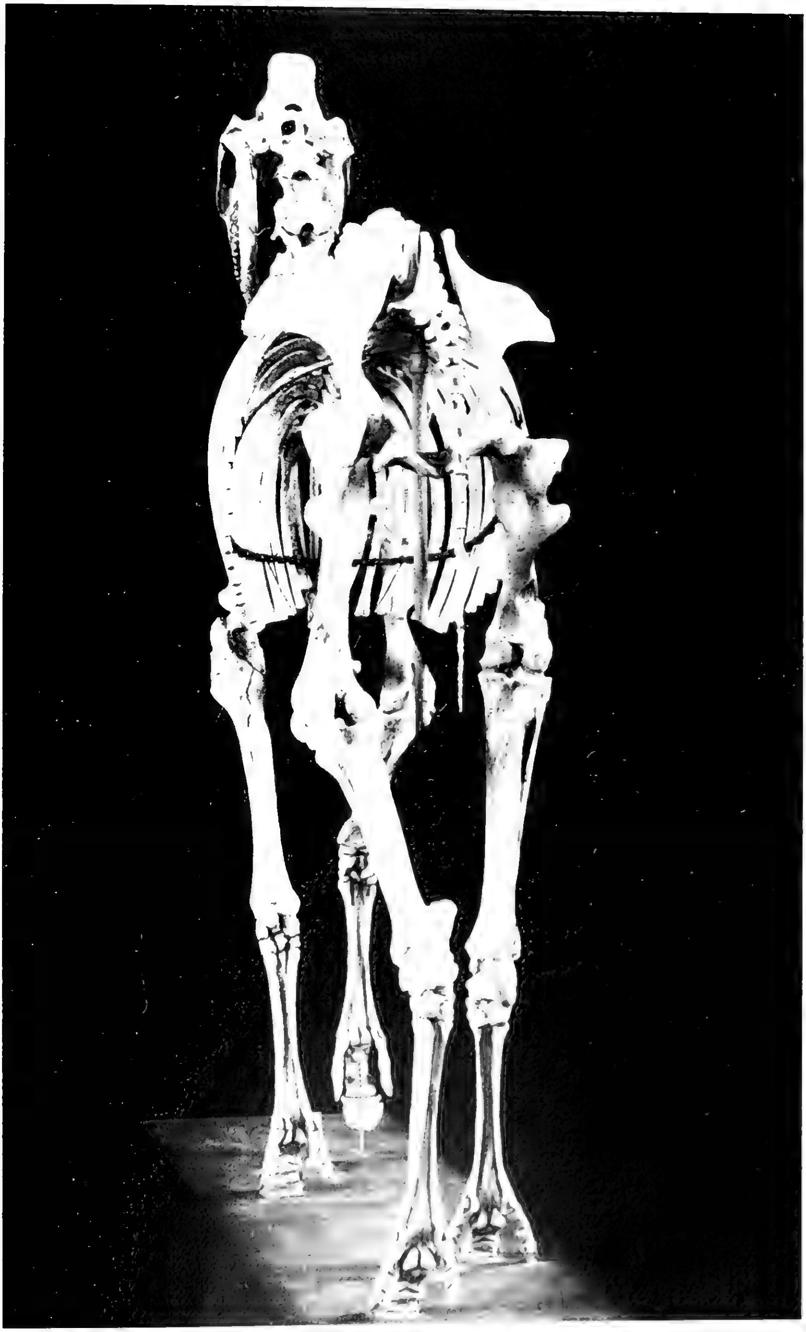


FIG. 3.—UPPER MOLAR OF MODERN HORSE, SHOWING EARLY STAGES OF WEAR OF THE TOOTH. CROWN VIEW. NATURAL SIZE

The feet of *Parahippus* were much like those of *Hypohippus*, but the side toes were smaller.

10 and 11. **Protohippus** and **Pliohippus.** MIDDLE and



THREE-TOED HORSE "HYPOHIPPUS," FROM THE MIDDLE MIOCENE OF COLORADO

Rear view of skeleton, showing small stile toes

UPPER MIOCENE. In this stage the crowns of the upper molars have become much longer, the two pairs of crescents on the upper molars are complete, with two half-separated cusps within the inner pair. And the valleys between the crests have become filled with cement, so that with the wear of the teeth the edges of hard enamel are backed inside by dentine and outside by cement. In this way the surface of the tooth has a series of enamel ridges always projecting a little above the grinding surface, because the softer material on each side wears down into hollows, yet never breaking off, because they are braced so thoroughly on each side. This is a very efficient instrument for grinding hard grasses. In *Protohippus* and *Pliohippus*, especially in the former, the crowns of the teeth are by no means as long as in the modern horses; they must therefore wear more slowly or wear out at an earlier age.

The feet in these two genera have but one toe touching the ground. The side toes (second and fourth digits) are complete, but much more slender than in the earlier stages and are apparently useless, as they cannot reach the ground. In some species of *Pliohippus* they have almost disappeared. The forefoot of *Protohippus* still retains tiny nodules of bone at the back of the "wrist" (sometimes improperly called in the Horse the "knee-joint"), which are the remains of the first and fifth digits.

Hipparion. PLIOCENE. This genus, probably also a side branch of the genealogical tree of the horse family, is much like *Protohippus*, but larger and with more complication about the tooth pattern. It is common in the European Pliocene beds and has been found in America also. The feet are still three-toed, the side toes as large as those of the older *Protohippus*.

12. **Equus.** PLEISTOCENE and RECENT. In this stage, that of the modern Horse, the side toes have entirely disappeared and are represented by splints on the fore- and hind-foot. No trace remains on the forefoot of the little nodules which in *Protohippus* represented the first and fifth digits. The crowns of the teeth are much longer than in the last stage, and of the two half-separated inner columns on the upper molars, one has disappeared, the other has increased in size and changed in form. The skull has lengthened and the animal is much larger.

Hippidium. PLEISTOCENE. SOUTH AMERICA. The feet are like those of *Equus*, except that they were short and stout. The teeth are like those of *Pliohippus*, from which it is supposed to be descended. The skull is large and long with very long slender nasal bones. Casts of the skull and limbs presented by the Museo Nacional of Buenos Ayres, Argentine Republic, are exhibited here.

MEANING OF THE CHANGE IN FEET AND TEETH.

Along with the disappearance of the side toes in the evolution of the Horse there is a considerable increase in the proportionate length of the limbs, and especially of the lower part of the leg and foot. The surfaces of the joints, at first more or less of the ball-and-socket kind, which allows free motion of the limb in all directions, become keeled and grooved like a pulley-wheel, permitting free motion forward and backward, but limiting the motion in all other directions and increasing considerably the strength of the joint. By this means the foot is made more efficient for locomotion over a smooth regular surface, but less so for traveling over very rough ground, and it becomes of little use for striking or grasping or the varied purposes for which the feet of polydactyl animals are used.

The increased length in the lower leg and foot increases the length of the stride without decreasing its quickness. The heavy muscles of the leg are chiefly in the upper part, and to increase the length of the lower part changes the centre of gravity of the limb very little. Consequently the leg swings to and fro from the socket nearly as fast as before, since in an ordinary step the action of the leg is like that of a pendulum and the speed of the swing is regulated by the distance of the centre of gravity from the point of attachment, as that of a pendulum is by the height of the bob. To increase the length of lower leg and foot therefore gives the animal greater speed; but it puts an increased strain on the ankles and toe-joints, and these must be strengthened correspondingly by converting them from ball-and-socket joints to "ginglymoid" or pulley joints. Additional strength, likewise at the expense of flexibility, is obtained by the consolidation of the two bones of the fore-arm (*ulna* and

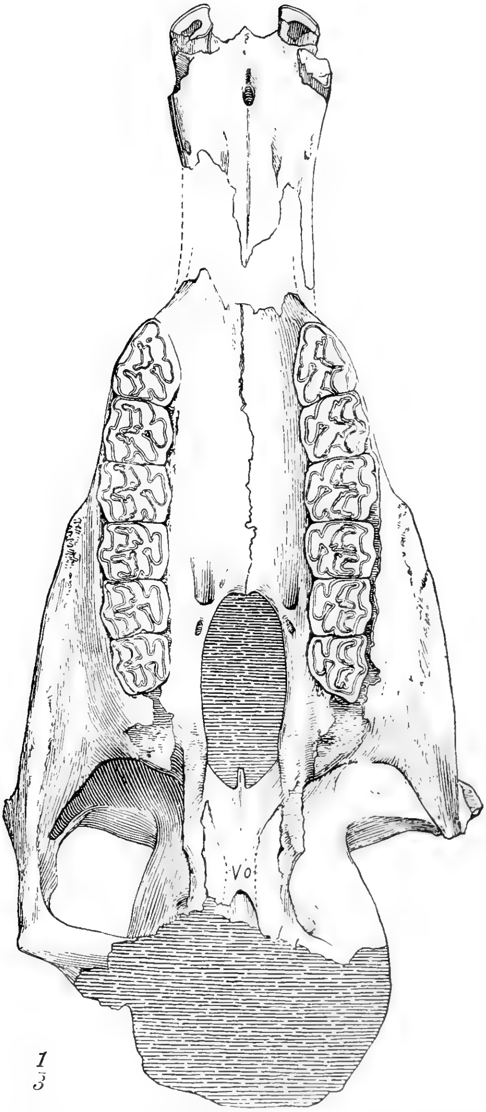


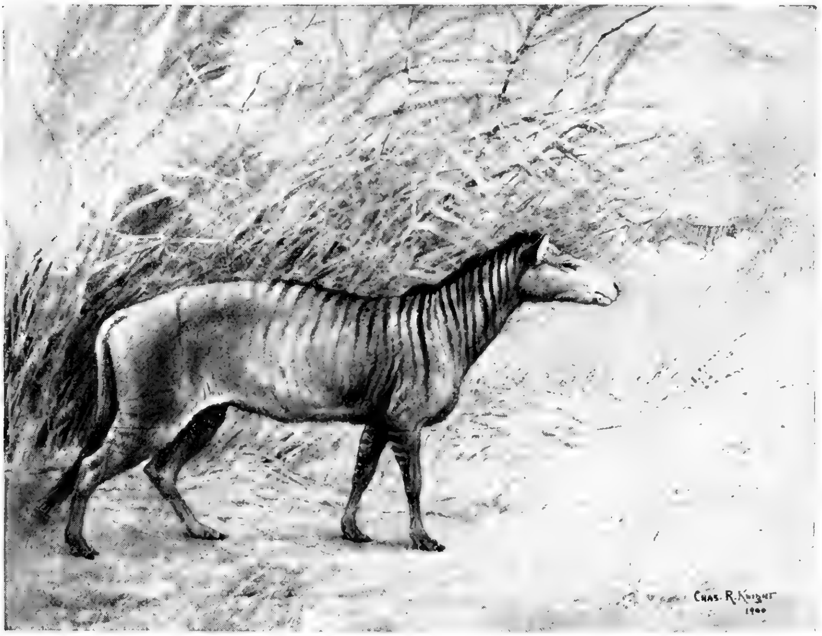
FIG. 4.—PALATE AND UPPER TEETH OF "EQUUS INTERMEDIUS," FROM THE LOWER PLEISTOCENE OF TEXAS. ONE-THIRD NATURAL SIZE

radius) and of the leg (*tibia* and *fibula*) into one, the shaft of the smaller bone practically disappearing, while its ends become fused solidly to its larger neighbor.

The increase in length of limb renders it necessary for the grazing animal that the head and neck should increase in length in order to enable the mouth to reach the ground. An example of these changes is the modern Horse, in which we find the neck and head much elongated when compared with the little *Hyracotherium* and this elongation has taken place *pari passu* with the elongation of the legs. The reduction and disappearance of the side toes and the concentration of the step on the single central toe serve likewise to increase the speed over smooth ground. The soft yielding surface of the polydactyl foot is able to accommodate itself to a rough irregular surface, but on smooth ground the yielding step entails a certain loss of speed. A somewhat similar case is seen in the pneumatic tire of a bicycle; a "soft" tire accommodates itself to a rough road and makes easier riding, but a "hard" tire is faster, especially on a smooth road. Similarly, the hard, firm step from the single toe allows of more speed over a smooth surface, although it compels the animal to pick its way slowly and with care on rough, irregular ground.

The change in the character of the teeth from "brachydont" or short-crowned to "hypsodont" or long-crowned enables the animal to subsist on the hard, comparatively innutritious grasses of the dry plains, which require much more thorough mastication before they can be of any use as food than do the softer green foods of the swamps and forests.

All these changes in the evolution of the Horse are adaptations to a life in a region of the level, smooth and open grassy plains which are now its natural habitat. At first the race was better fitted for a forest life, but it has become more and more completely adapted to live and compete with its enemies or rivals under the conditions which prevail in the high dry plains of the interior of the great continents. The great increase in size, which has occurred in almost all races of animals whose evolution we can trace, is dependent on abundance of food. A large animal, as may be shown on ordinary principles of mechanics, requires more food in proportion to its size than does a small one, in order to keep up a proper amount of activity. On the other hand a large animal is better able than a small one to defend itself against its enemies and rivals. Consequently, as long as food is abundant, the larger animals have the advantage over their smaller brethren, and by the laws of natural selection the race tends to become continually larger until a limit is reached, when sufficient food becomes difficult to obtain, the animal being compelled to devote nearly all its time to getting enough to eat.



RESTORATION OF THE FOUR-TOED HORSE

Oldest known Ancestor of the Modern Horse; only 16 inches high

Photo from original watercolor by C. R. Knight, based on mounted skeleton in American Museum

Cause of the Evolution.

The evolution of the Horse, adapting it to live on the dry plains, probably went hand in hand with the evolution of the plains themselves. At the commencement of the Age of Mammals the western part of the North American continent was by no means as high above sea-level as now. Great parts of it had but recently emerged and the Gulf of Mexico still stretched far up the valley of the Mississippi. The climate at that time was probably very moist, warm and tropical, as is shown by the tropical forest trees, found fossil even as far as Greenland. Such a climate, with the low elevation of the land, would favor the growth of dense forests all over the country, and to such conditions of life the animals of the beginning of the mammalian period must have been adapted. During the Tertiary the continent was steadily rising above the ocean-level, and at the same time other influences were at work to make the climate continually colder and drier. The coming on of a cold, dry climate restricted and thinned the forests and caused the appearance and extension of open, grassy plains. The ancient forest inhabitants were forced either to retreat and disappear with the forests, or to adapt themselves to the new conditions of life. The ancestors of the Horse, following the latter course, changed with the changing conditions, and the race became finally as we see it to-day, one of the most highly specialized of animals in its adaptation to its peculiar environment. At the end of the Age of Mammals the continents stood at a higher elevation than at present, and there was a broad land connection between Asia and North America, as well as those now existing. At this time the Horse became cosmopolitan, and inhabited the plains of all the great continents, excepting Australia.

It is a question whether the direct ancestry of the modern Horse is to be searched for in Western America or in the little known interior plains of Eastern Asia. It is also unknown why the various species which inhabited North and South America and Europe during the early part of the Age of Man should have become extinct, while those of Asia (Horse and Wild Ass) and of Africa (Wild Ass and Zebra) still survive. Man, since his appearance, has played an important part in the extermination of the larger animals; but there is nothing to show how far he is responsible for the disappearance of the native American species of horse.

PARALLEL EVOLUTION IN OTHER RACES.

It is interesting to observe that while the evolution of the Horse was progressing during the Tertiary period in North America another group of hoofed animals, the *Litopterna*, now extinct, in South America evolved a race adapted to the broad plains of Argentina and Patagonia and singularly like the Horse in many ways (see exhibit in A-case in centre of hall). These animals likewise lost the lateral toes one after another, and concentrated the step on the central toe; they also changed the form of the joint-surfaces from ball-and-socket to pulley-wheel joints; they also lengthened the limbs and the neck; and they also lengthened the teeth, and complicated their pattern. Unlike the true Horse, they did not form cement on the tooth, so that it was by no means so efficient a grinder. This group of animals native to South America became totally extinct, and were succeeded by the horses, immigrants from North America, which in their turn became extinct before the appearance of civilized man.

Many of the contemporaries of the Horse in the northern hemisphere were likewise lengthening the limbs, lightening and strengthening the feet, elongating the tooth-crowns to adapt themselves to the changing conditions around them, but none paralleled the Horse Evolution quite so closely as did the pseudo-horses of South America. But the camels in America, the deer, antelope, sheep and cattle in the Old World progressed on much the same lines of evolution, although their adaptation was not to just the same conditions of life.

AMERICAN MUSEUM OF NATURAL HISTORY

The Collection of Fossil Vertebrates

BY

W. D. Matthew, Ph.D.

Associate Curator of Vertebrate Palæontology

SUPPLEMENT TO AMERICAN MUSEUM JOURNAL
VOL. III, No. 5, OCTOBER, 1903

Guide Leaflet No. 12

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The Collection of Fossil Vertebrates

A Guide Leaflet to the Exhibition Halls
of
Vertebrate Palæontology
in the
American Museum of Natural History

By
W. D. MATTHEW, Ph.D.
Associate Curator, Department of Vertebrate Palæontology

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VOL. III, NO. 5, OCTOBER, 1903

Guide Leaflet No. 12

PREFATORY NOTE

THE COLLECTION of fossil vertebrates belonging to the American Museum of Natural History comprises the extensive material collected by the late Professor E. D. Cope chiefly between 1870 and 1890 and the much larger collections made by the expeditions which have been sent out by the Museum every year, beginning with 1891. Most of the Museum expeditions have worked in the western States.

From the beginning of the department in 1891 the collection and exhibition of these fossils have been under the direction of Professor Henry Fairfield Osborn, the curator. From 1891 to 1898, inclusive, the exploring parties in the field were under the immediate supervision of Dr. J. L. Wortman. Since that time Messrs. Matthew, Granger, Brown and Gidley have been in charge of the field work.

The funds necessary for sending out the expeditions and for the purchase of the Cope Collection have been furnished chiefly by President Jesup and Messrs. Osborn, Whitney and Constable. The exhibit illustrating the evolution of the Horse is mostly the gift of Mr. William C. Whitney.

EDITOR.

HALL OF FOSSIL MAMMALS

THE COLLECTION OF FOSSIL VERTEBRATES.

By W. D. Matthew, Ph.D.,

Associate Curator, Department of Vertebrate Palæontology.

TABLE OF CONTENTS.

INTRODUCTION.

When we dig beneath the present surface of the ground we sometimes find remains of ancient cities, dwellings, bones of men and animals, buried many centuries ago under accumulations of débris, deposits of river mud or drifted sand. From these have been gleaned many facts concerning the early history of mankind of which there is no written chronicle. From the study of these facts the science of Archæology has arisen, the science which deals with the early history of mankind, with the evolution of civilization.

What Fossils Are.

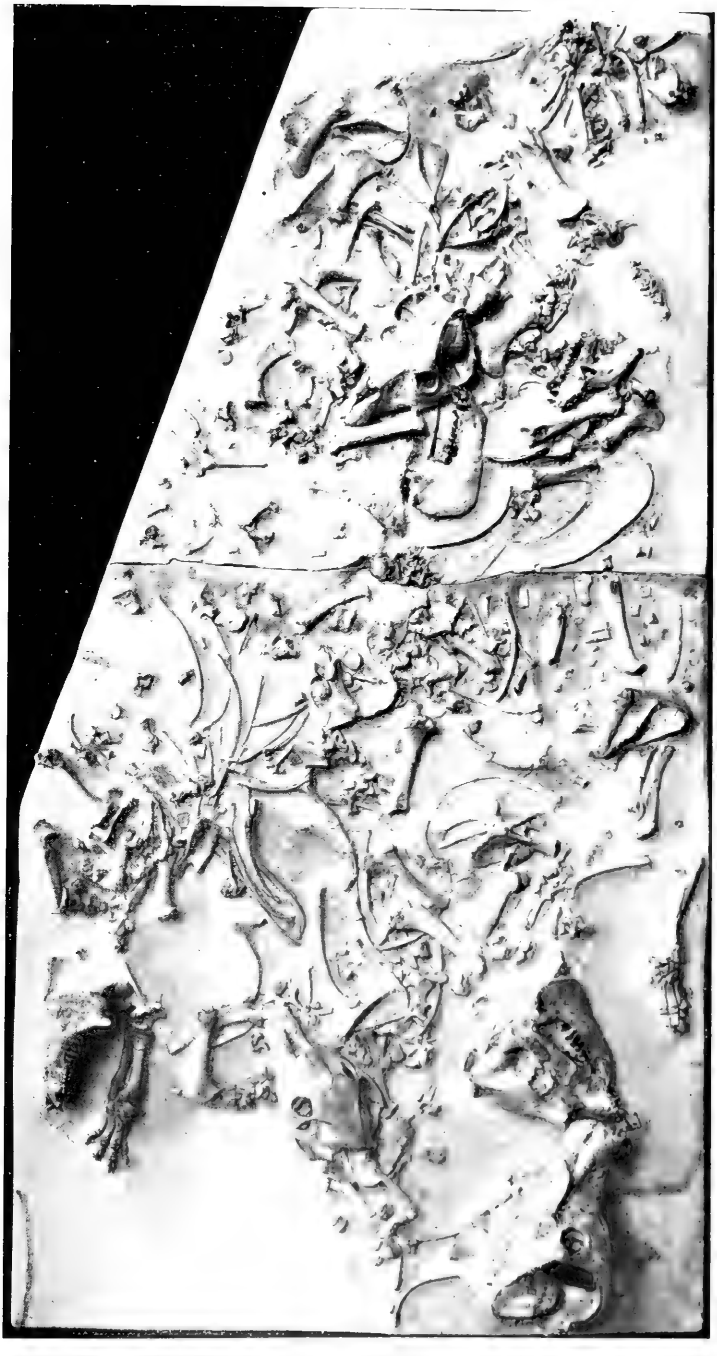
Most of the lower animals of which the archæologist finds traces are like those now living, although a few have become extinct. But in those more ancient deposits which are now consolidated into clays, sandstones etc., indications of man are not found, and the remains of lower animals which they contain are unlike any now living—the more unlike as the rock is more ancient. These remains are called *fossils.* They consist only of the hard parts of animals (bones, shells, spines etc.). The soft parts are never preserved, and only very rarely is some trace of skin or hair, horns or hoofs, to be distinguished. As in the course of ages the mud or sand in which they are buried changes to rock, so little by little the fossils have been changed by heat, pressure and especially by the slow infiltration of mineralized waters into brittle, stony material, while retaining their outward form and usually their peculiar structure. But mud and clay, in changing into rock, settle down and contract considerably, and the fossils are flattened out correspondingly, sometimes to such a degree, in the case of a rock which has once been a soft, oozy mud, that they suggest rather a picture or a bas-relief than the original form of the animal. The fossil skeletons of marine reptiles and fishes on the walls of the corridor hall and in the case opposite the elevator have been flattened out in this manner, especially the Ichthyosaur skeletons.

Science of Palæontology.

From fossils we can interpret the history of the world of life during the long ages before man appeared. The science which deals with the ancient history and evolution of the animal kingdom is Palæontology (*παλᾶιος*, ancient, *ὄντα*, living beings, -*λογία*, science). It tells us of a long period of time before Man appeared, probably millions of years, during which Mammals of great size and unfamiliar form were the dominant animals—of a yet longer era before that, during which huge Reptiles were rulers of earth, sea and air—and of other still more ancient periods during which Amphibians, Fish and Invertebrate Animals held sway in turn. Vertebrate Palæontology deals only with the higher classes of fossil animals, the Vertebrata, or those that have backbones (fish, amphibians, reptiles, birds and mammals).

Geological Time.

Earth-history or geological time has been divided into many parts according to the evidence furnished by the rocks and the fossils contained therein. The principal subdivisions are shown in the accompanying table:



FOSSIL SKELETONS IN THE ROCK

This slab of soft chalky clay contains five skeletons of an extinct animal. One is an old male, the other four are young

GEOLOGICAL ERAS, PERIODS AND AGES.

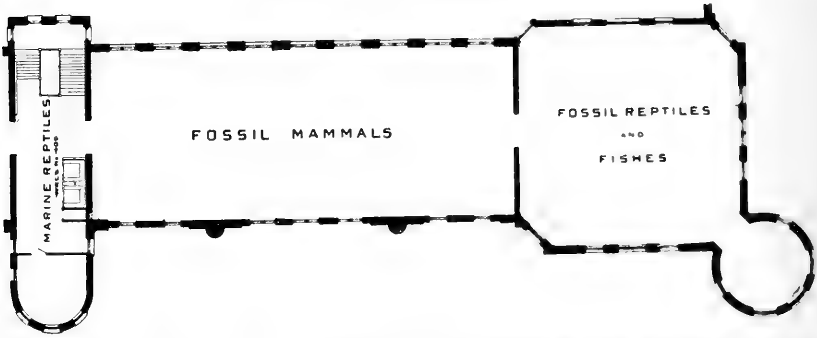
Eras.	Periods.	Ages.
Cenozoic	Quaternary	Age of Man, 50,000 years
	Tertiary	Age of Mammals, 3,000,000 years
Mesozoic	Cretaceous	Age of Reptiles, 7,000,000 years
	Jurassic	
	Triassic	
Palæozoic	Permian	Age of Amphibians and Coal Plants, 5,000,000 years
	Carboniferous	
	Devonian	Age of Fishes, 2,000,000 years
	Silurian	Age of Invertebrates, 10,000,000 years
	Cambrian	
Eozoic	Algonkian	(No fossils)
	Archæan	

The estimates in years of the geological periods given in this table, which is arranged in descending order from the most recent to the most ancient time, must be understood to be merely very rough approximations. There is no known method of finding any exact equivalent in years of any geological period, although the relative length of each to each is much more nearly known. The estimates given herewith are based on the careful study of the subject made by C. D. Walcott, Director of the U. S. Geological Survey. In concluding his discussion Dr. Walcott stated his belief that the duration of geological time (the entire period included in this table) might be measured by tens of millions of years, but not by single millions or by hundreds of millions.

How Fossil Skeletons are Mounted.

To give the visitor a clear idea of these extinct animals, the skeletons usually have been removed entirely from the rock in which they were found and have been mounted as much as possible like skeletons of modern animals. To mount a petrified skeleton in this manner is a very difficult matter, for such skeletons are rarely perfect, and the bone is always very brittle and more or less shattered and crushed out of shape. In the mounted skeleton the missing parts have been restored in tinted plaster, modeled from other individuals or from nearly related animals in which these parts are known. The outlines of the restored parts of bones are marked off with red lines, while entire bones modeled in plaster are marked with a red cross, or with a red circle if supplied from other individuals. All the skeletons are original specimens except the *Megatherium* at the far end of the hall; and all are of extinct animals except a few which are placed with the others for comparison. With each fossil skeleton will be found, besides a descriptive label, a small model and a water-color restoration of the animal, showing its probable appearance during life and indicating its supposed habitat. The transparencies in the windows show the localities where the fossils are found, chiefly in the Bad-lands of the western States.

General Arrangement.



General Arrangement of Collections.

The collections are arranged to illustrate the geological history and evolution of the different groups of Vertebrata, especially those of North America. They fill two large halls and a corridor.

East Wing. Hall No. 406. Fossil Mammals.

East Wing. Hall No. 407. Fossil Reptiles, Amphibians and Fishes.

In addition

East Corridor, No. 405 (in which are the elevator and stairways), contains fossil Marine Reptiles and Fishes of the Age of Reptiles.

SKELETON OF THE GREAT MARINE LIZARD IN THE EAST CORRIDOR

THE EAST CORRIDOR. No. 405.

The Preservation of Fossils in the Rocks.

On stepping from the elevator the visitor sees before him a case filled with skulls and skeletons of the marine reptiles and fishes which inhabited the great inland sea that once spread over the center of the North American continent, from Canada to Mexico. The reptiles were of kinds now long extinct, *Plesiosaurs* with long snaky neck, short bulky body with long flippers and stubby tail, and *Mosasaurs* with short neck and longer tail. Some of the fishes were ancestors, collateral or direct, of certain modern fishes, others belonged to groups now extinct. These animals lived and died, their carcasses sank to the bottom of the sea, and were buried in whatever sediment was being deposited there—soft white ooze in the open sea, dark gray or black mud nearer the shores. In the course of ages this ooze or mud settled gradually and consolidated into chalk or shale. Afterwards as the continent rose above the waters and assumed more nearly its present dimensions, the rivers flowing over the broad plains excavated

HUNTING FOR FOSSILS IN THE BAD-LANDS

Members of the American Museum Expedition of 1894 in the Uinta Basin, Utah broad shallow valleys in the chalk and shale. In the dry climate of the present day the sides of these valleys often are bare rock, carved by wind and the infrequent storm-bursts of rain into the fantastic maze of cliffs and winding cañons known as "bad-lands." Here and there, projecting from an outstanding ledge or trailing in fragments down some crumbling slope, a fossil bone may be seen by the trained eye of the collector as he searches along the rock exposures; and quarrying in around the bone he is sometimes rewarded by a skull, sometimes by a string of vertebræ, occasionally by a whole skeleton, buried in the rock except for such parts of it as have been weathered out and washed away.

The Finding and Collecting of Fossils.

To excavate the fossil without damaging the brittle bones, buried as they are in a weak and shattered mass of heavy shale or chalk, is a slow and delicate operation, requiring special methods and considerable care and skill. Then the specimen must be packed, and sent in to the Museum, where the rock is removed and the specimen is prepared for exhibition. When the bones are as much crushed and distorted as those represented in the photograph (page 10) the matrix is removed from one side only, and the specimen is thus placed on exhibition.

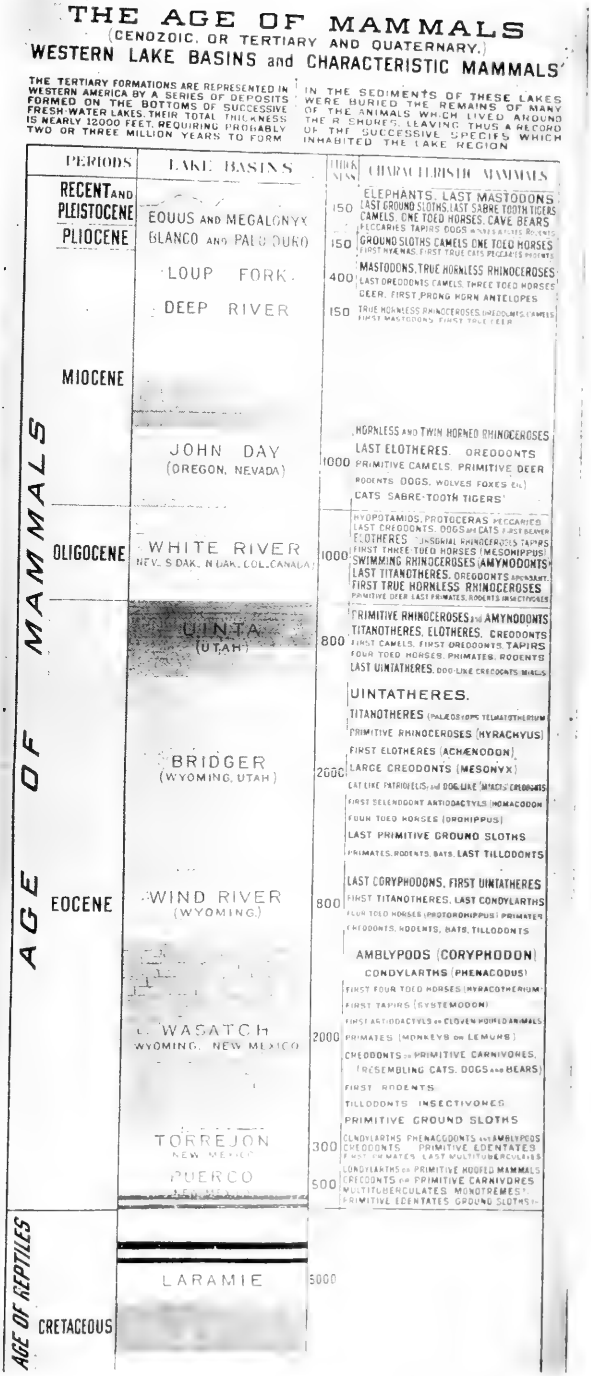
Important Specimens in Corridor.

Temporarily placed in the bottom of the case is a large Plesiosaur skeleton, only partly removed from the rock. This specimen unfortunately lacks the skull. Beside the lower stairway is a Mosasaur skeleton, the finest specimen of its kind ever found, and above it is a large fish skeleton which was found in the same strata in western Kansas. Beside the upper stairway are three skeletons of Ichthyosaurs, another long extinct group of marine reptiles, of fish-like appearance, paralleling the modern Whales among mammals.

EAST WING. HALL NO. 406. FOSSIL MAMMALS.

Arrangement of the Fossil Mammals.

The ancestors of our modern quadrupeds are to be found in the East Wing, No. 406, together with many extinct races more or less nearly related to them. All the fossil specimens of each group of mammals are placed together in one alcove, where they have been arranged according to their geological age. Thus all the fossil Horses, direct



THE AGE OF MAMMALS
(CENOZOIC, OR TERTIARY AND QUATERNARY.)
WESTERN LAKE BASINS and CHARACTERISTIC MAMMALS

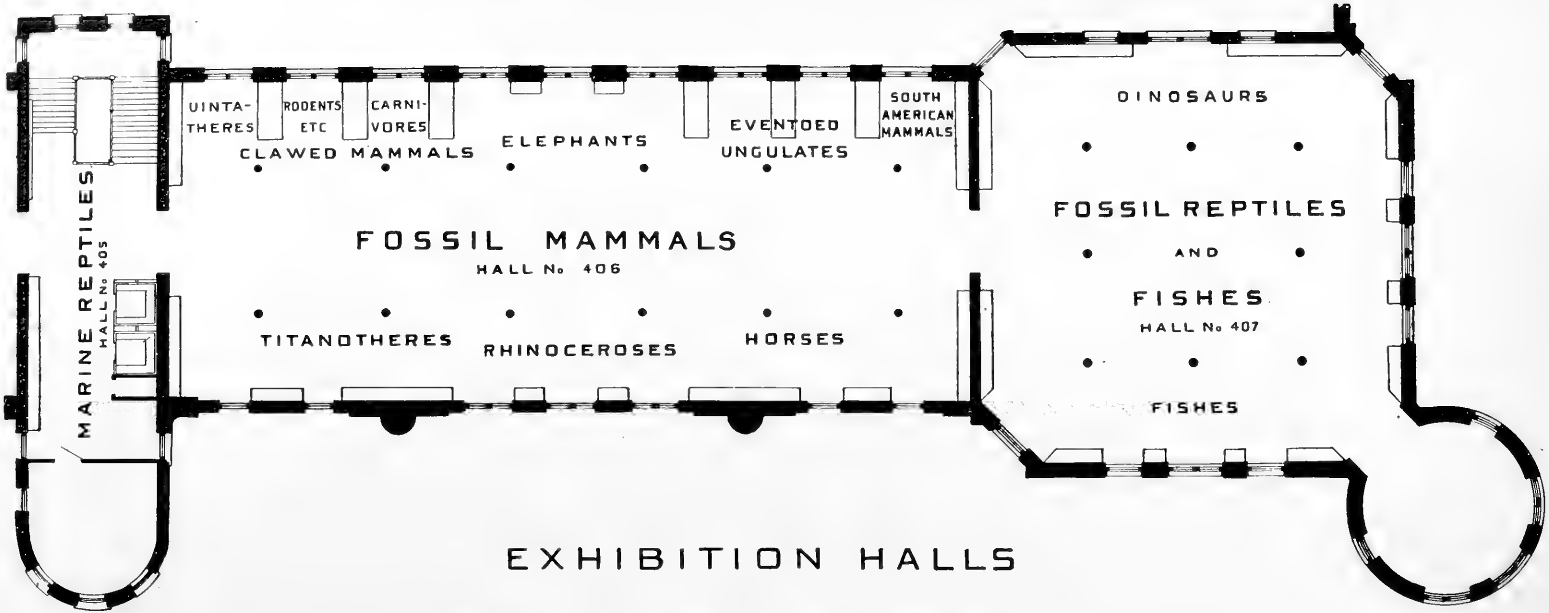
THE TERTIARY FORMATIONS ARE REPRESENTED IN WESTERN AMERICA BY A SERIES OF DEPOSITS FORMED ON THE BOTTOMS OF SUCCESSIVE FRESH-WATER LAKES. THEIR TOTAL THICKNESS IS NEARLY 12000 FEET, REQUIRING PROBABLY TWO OR THREE MILLION YEARS TO FORM

IN THE SEDIMENTS OF THESE LAKES WERE BURIED THE REMAINS OF MANY OF THE ANIMALS WHICH LIVED AROUND THEIR SHORES, LEAVING THUS A RECORD OF THE SUCCESSIVE SPECIES WHICH INHABITED THE LAKE REGION

	PERIODS	LAKE BASINS	THICKNESS	CHARACTERISTIC MAMMALS
AGE OF MAMMALS	RECENT AND PLEISTOCENE	EQUUS AND MEGALONYX	150	ELEPHANTS, LAST MASTODONS LAST GROUND SLOTHS, LAST SABRE TOOTH TIGERS CAMELS, ONE TOED HORSES, CAVE BEARS PECCARIES TAPIRS DOGS WOLVES AND FOXES RODENTS
	PLIOCENE	BLANCO AND PALO DURO	150	GROUND SLOTHS CAMELS ONE TOED HORSES FIRST HYÆNAS, FIRST TRUE CATS PECCARIES RODENTS
	MIOCENE	LOUP FORK	400	MASTODONS, TRUE HORNLESS RHINOCEROSES LAST OREODONTS CAMELS, THREE TOED HORSES DEER, FIRST PRONG HORN ANTELOPES
		DEEP RIVER	150	TRUE HORNLESS RHINOCEROSES, OREODONTS, CAMELS FIRST MASTODONS, FIRST TRUE DEER
		JOHN DAY (OREGON, NEVADA)	1000	HORNLESS AND TWIN HORNED RHINOCEROSES LAST ELOTHERES. OREODONTS PRIMITIVE CAMELS, PRIMITIVE DEER RODENTS DOGS, WOLVES FOXES ETC.) CATS SABRE-TOOTH TIGERS
	OLIGOCENE	WHITE RIVER (NEV., S. DAK., N. DAK., COL., CANADA)	1000	HYOPOTAMIDS, PROTOCERAS PECCARIES LAST CREODONTS, DOGS AND CATS FIRST BEAVER ELOTHERES CURSORIAL RHINOCEROSES TAPIRS FIRST THREE-TOED HORSES (MESOHIPPUS) SWIMMING RHINOCEROSES (AMYNODONTS) LAST TITANOTHERES, OREODONTS ABUNDANT. FIRST TRUE HORNLESS RHINOCEROSES PRIMITIVE DEER LAST PRIMATES, RODENTS INSECTIVORES
	EOCENE	UINTA (UTAH)	800	PRIMITIVE RHINOCEROSES and AMYNODONTS TITANOTHERES, ELOTHERES. CREODONTS FIRST CAMELS, FIRST OREODONTS, TAPIRS FOUR TOED HORSES, PRIMATES, RODENTS LAST UINTATHERES, DOG-LIKE CREODONTS MIACIS
		BRIDGER (WYOMING, UTAH)	2000	UINTATHERES. TITANOTHERES (PALÆOSYOPS TELMATOTHERIUM PRIMITIVE RHINOCEROSES (HYRACHYUS) FIRST ELOTHERES (ACHÆNODON) LARGE CREODONTS (MESONYX) CAT LIKE PATRIOFELIS, and DOG LIKE 'MIACIS' CREODONTS FIRST SELENODONT ANTIODACTYLS (HOMACODON FOUR TOED HORSES (OROHIPPUS) LAST PRIMITIVE GROUND SLOTHS PRIMATES, RODENTS, BATS, LAST TILLODONTS
		WIND RIVER (WYOMING.)	800	LAST CORYPHODONS, FIRST UINTATHERES FIRST TITANOTHERES, LAST CONDYLARTHS FOUR TOED HORSES (PROTOROHIPPUS) PRIMATES CREODONTS, RODENTS, BATS, TILLODONTS
		WASATCH WYOMING, NEW MEXICO	2000	AMBLYPODS (CORYPHODON) CONDYLARTHS (PHENACODUS) FIRST FOUR TOED HORSES (HYRACOTHERIUM FIRST TAPIRS (SYSTEMODON) FIRST ARTIODACTYLS OR CLOVEN HOOFED ANIMALS PRIMATES (MONKEYS OR LEMURS) CREODONTS OR PRIMITIVE CARNIVORES, (RESEMBLING CATS, DOGS AND BEARS) FIRST RODENTS TILLODONTS INSECTIVORES PRIMITIVE GROUND SLOTHS
		TORREJON NEW MEXICO	300	CONDYLARTHS PHENACODONTS AND AMBLYPODS CREODONTS PRIMITIVE EDENTATES FIRST PRIMATES LAST MULTITUBERCULATES
		PUERCO NEW MEXICO	500	CONDYLARTHS OR PRIMITIVE HOOFED MAMMALS CREODONTS OR PRIMITIVE CARNIVORES MULTITUBERCULATES MONOTREMES? PRIMITIVE EDENTATES GROUND SLOTHS?-
AGE OF REPTILES	CRETACEOUS	LARAMIE	5000	

DIVISIONS OF THE AGE OF MAMMALS

Characteristic fossil mammals, and the geological formations in which they are found



EXHIBITION HALLS

DEPARTMENT OF VERTEBRATE PALAEONTOLOGY

or collateral ancestors of the modern Horses, Asses and Zebras, are in one alcove, arranged in series from the most ancient to the most recent. The most ancient and structurally primitive groups of mammals come first, the most modern and familiar types come last.

	South (Right) Side.	North (Left) Side.	
Perissodactyls or Odd-Toed Hoofed Mammals	TITANOTHERES	AMBLYPODS	Primitive Hoofed Mammals
	Chalicotheres	CONDYLARTHS	
		Monkeys, Bats, Rodents, Insectivores and other Small Primitive Mammals	
		Marsupials	
		CREODONTS	Carnivorous Mammals
		CARNIVORES	
		Seals, Dolphins, Whales, Sirenians etc.	Marine Mammals
	Tapirs Lophiodonts	MASTODONS and ELEPHANTS	Proboscideans
	RHINOCEROSES	ELOTHERES	Artiodactyls or Even-Toed Hoofed Mammals
		Anthracotheres	
		Pigs and Peccaries	
		OREODONTS	
		CAMELS	
	Palæotheres	DEER etc.	
	HORSES	Litopterna	Fossil Mammals Peculiar to South America.
		Toxodontia	
		Typotheria	
		EDENTATA	

SOUTH (RIGHT) SIDE.

The south side of the hall is entirely devoted to the Perissodactyls or Odd-Toed Hoofed Mammals in which the number of toes (in the hind foot and generally in the forefoot) is either 1, 3 or 5, while in the other main division of hoofed animals, the Artiodactyls, it is either 2 or 4; or more exactly, the axis of symmetry of the foot passes through the central toe in Perissodactyls, while in Artiodactyls it passes between two toes.

South Alcove 1. Titanotheres

The Titanotheres come first in the series of Perissodactyla, large animals which suggest rhinoceroses in general proportions, but have a differently shaped head and peculiar teeth. These began as hornless animals of moderate size (Cases 1 and 17) and increased in size and developed large bony horns (Cases 3, 5 and 19) before they became extinct. The Titanotheres occupy the first of the three main alcoves into which the south side of the hall is divided.

The second alcove is devoted to the RHINOCEROSES, which were very common beasts in North America as well as in the Old World during the Tertiary period. They also began in the Eocene as small hornless animals (*Hyrachyus*, Case 7), but diverged in the Oligocene into cursorial, aquatic and true (terrestrial) Rhinoceroses of which the two former soon became extinct. True Rhinoceroses also became extinct in America by the Pliocene epoch, while in the Old World several of them have survived to the present day.

RESTORATION OF TITANOTHERIUM, AN EXTINCT HOOFED MAMMAL OF WESTERN AMERICA

The picture shows a bull, a cow and a calf

From the original water-color, based on mounted skeleton and skulls in American Museum of Natural History

South Alcove 2. Rhinoceroses.

Third Alcove. HORSES.[1] This fine exhibit is due chiefly to

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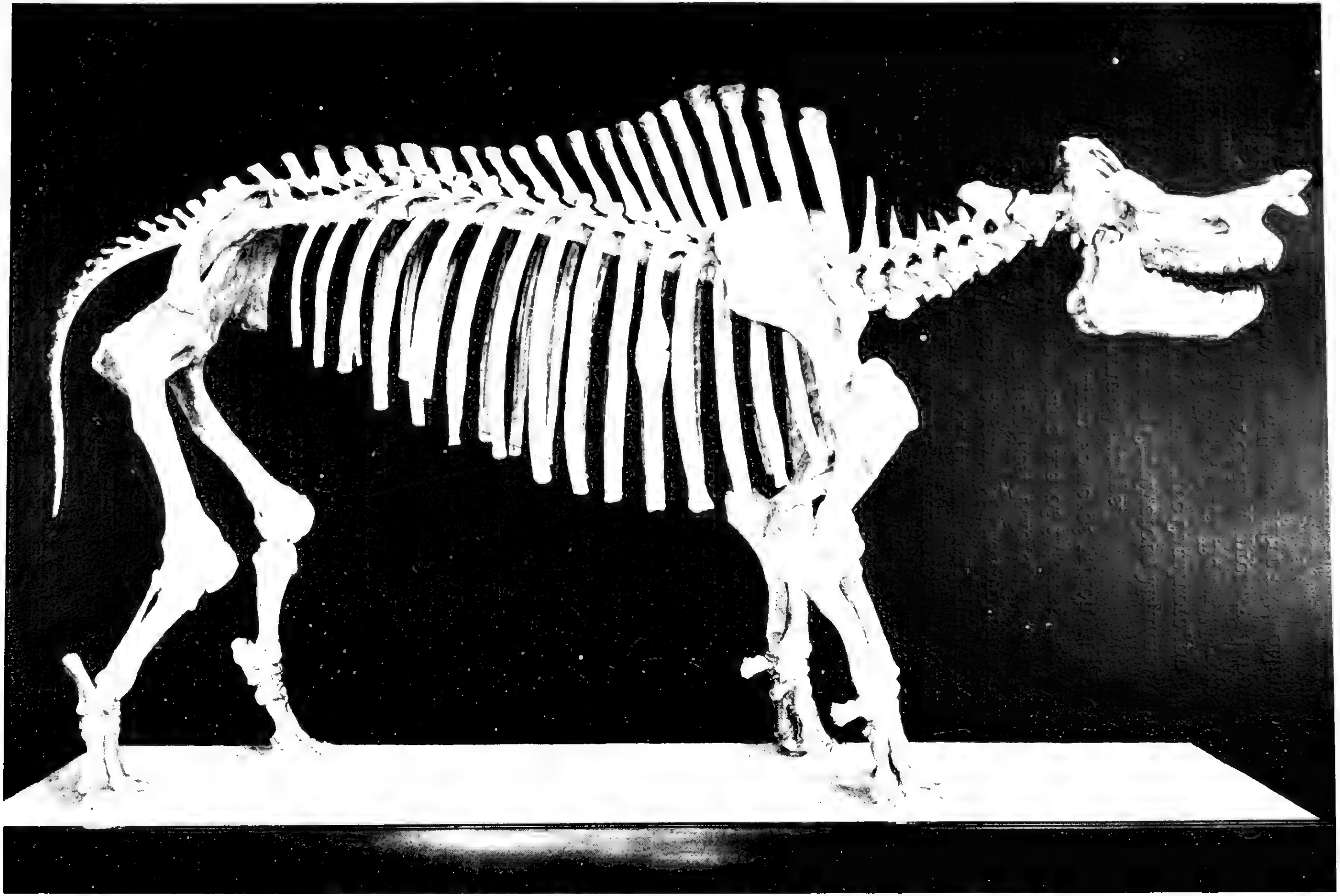
[1] For more detailed information regarding the evolution of the Horse, see Guide Leaflet No. 7, "The Evolution of the Horse." Published January, 1903.



MOUNTED SKELETON OF THE TITANOTHERE, FROM THE BIG BAD-LANDS OF SOUTH DAKOTA the liberality of Mr. Wm. C. Whitney. The Evolution of the Horse is illustrated by a series of feet and skulls, and of complete skeletons, from the little Four-Toed Horse of the Lower Eocene to the different varieties of the modern animal. The construction of the modern Horse, structure of the bones, the way in which the teeth grow, characters of the different races of domestic Horse and of the different wild species are shown in the end case (Case 15).

South Alcove 3. Horses.

NORTH (LEFT) SIDE.

North Alcove 1. Amblypods, etc.

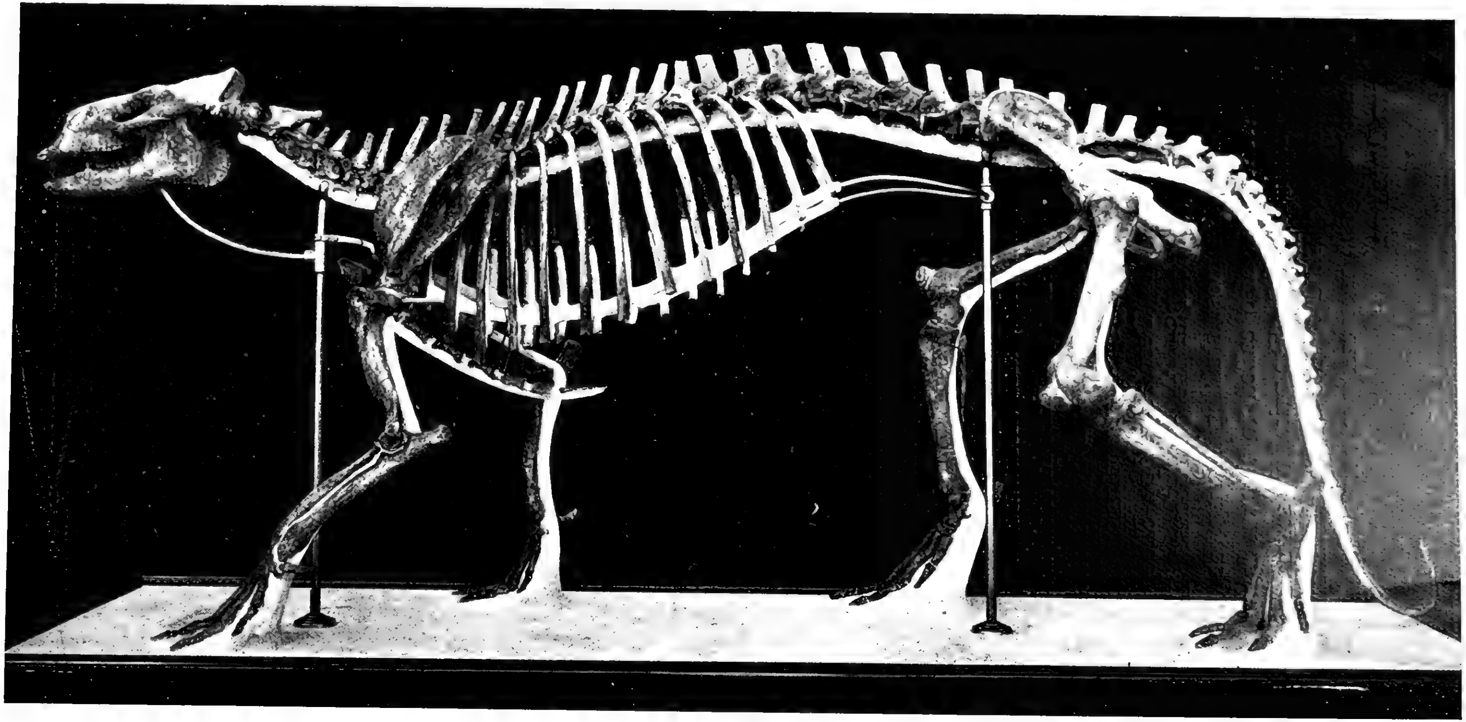
First come the AMBLYPODS and CONDYLARTHS. These groups of Primitive Hoofed Mammals are first found in the lowest Eocene strata, at the very beginning of the Age of Mammals and they became extinct before the end of the Eocene epoch. Like so many other races the Amblypods begin with small hornless animals (*Pantolambda*) and finally develop into huge elephantine beasts (*Uintatherium*) with six horns on the skull, and great sabre-like tusks. The Condylarths were more slender types, fitted for running. The best known among them is *Phenacodus*, which is considered to represent very nearly the prototype of the hoofed mammals, although it was not the direct ancestor of the later groups.

North Alcove 2. Small Mammals.

The second alcove is devoted to Rodents, Insectivores, Bats, Marsupials and other groups of small mammals, among which are the ancestors of the Monkeys and Lemurs and collateral ancestors of Man. Most of these remains are small and incomplete. Here are also some very fragmentary remains of ancient and primitive mammals which represent all that we know of the evolution of the mammalia during the Age of Reptiles, before the Age of Mammals began. These teeth and jaws are of interest because they are the oldest of mammals, from some of which are probably descended all the later mammal groups.

North Alcove 3. Carnivora.

In the third alcove are the Carnivorous Mammals, on one side the CREODONTS or Primitive Carnivora, on the other the True CARNIVORA (Dogs, Cats, Bears, Martens etc.), represented by a number of finely preserved mounted skeletons, and a large series of skulls, together with other specimens.



MOUNTED SKELETON OF PHENACODUS IN NORTH ALCOVE 2
This animal, although not a direct ancestor, represents the prototype of the hoofed mammals

Most remarkable among extinct carnivora are the Sabre Tooth Tigers, in which the upper canine teeth are enlarged into long, curving, flattened, serrate fangs, most terrible weapons, effective no doubt against the thick hides of the primitive pachyderms.

North Alcove 4. Marine Mammals.

The fourth alcove is very narrow. In it are placed a few remains of fossil marine mammals: Seals, Cetaceans and Sirenians. These groups are very imperfectly known as fossils.

North Alcove 5. Proboscidea.

The fossil ELEPHANTS and Mastodons are in the next broad alcove, about the middle of the hall. The evolution of these animals is shown by a series of skulls. The Mastodon skeleton and the skull and fore-limb of the Imperial Mammoth from Texas, and tusk of the Siberian (Hairy) Mammoth are noteworthy specimens.

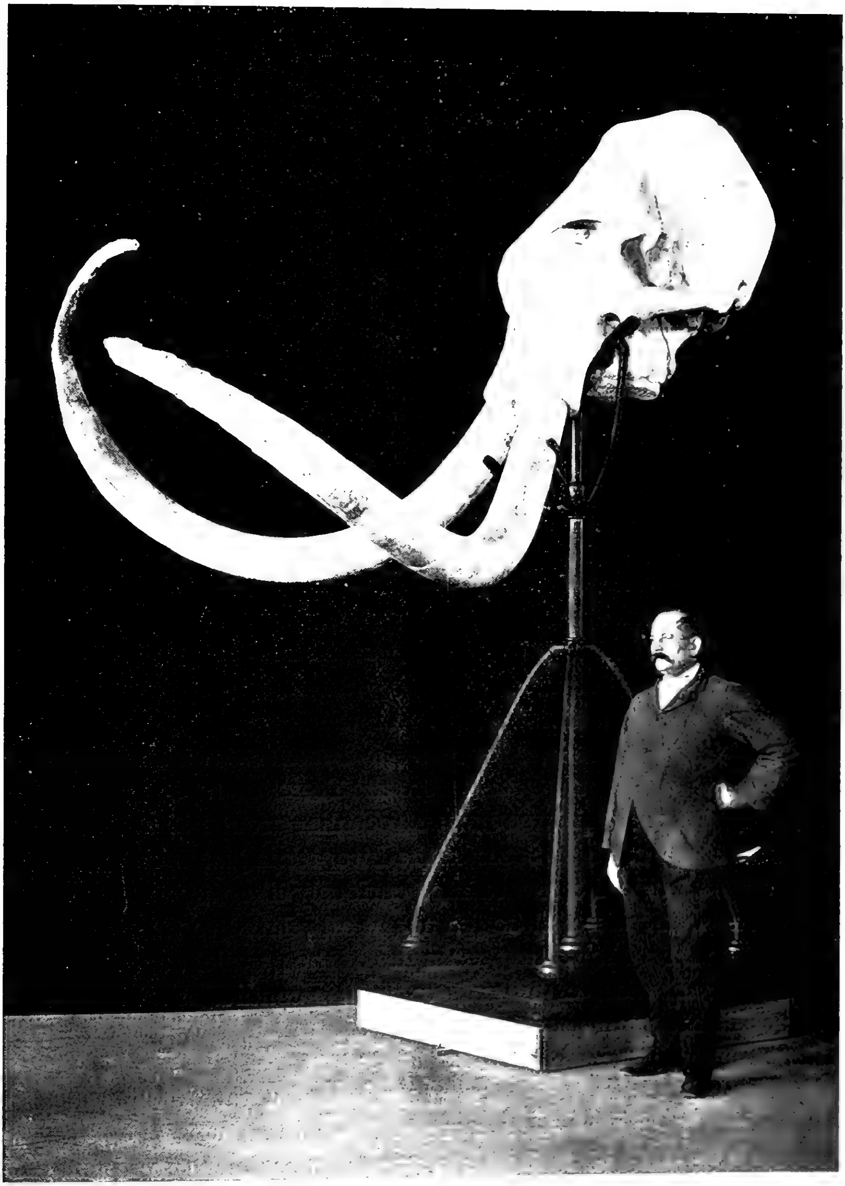
North Alcove 6. Elotheres.

North Alcove 7. Pigs, Peccaries, Oreodonts, Camels.

Beyond the Elephants are the ARTIODACTYLS or Cloven-Hoofed Mammals. They divide into two groups, typified by the Pigs and the Ruminants, the latter including the greater part of modern hoofed mammals, but by no means proportionally common as fossils. First among the fossil artiodactyls are the Elotheres, an extinct race of large animals distantly related to Pigs and Hippopotami. Next are the fossil Peccaries; then the Oreodonts, pig-like animals with the teeth of ruminants, very abundant in America during the middle and later Tertiary, but extinct before the Pliocene epoch. Then come the Camels, which although now found only in Asia and South America, originated in North America, and afterwards migrated to these other continents and became extinct in their native land. The evolution of these animals is shown by a series of stages only less complete than the stages in the evolution of the Horse.

North Alcove 8. Deer, Antelope etc.

The higher ruminants (Deer, Antelope, Sheep and Cattle) are rather poorly represented in the collections. The Great Irish Deer is the most striking among the extinct species; attention is also called to the mounted skeletons of *Protoceras*, a deer-like primitive ruminant of the Oligocene epoch, and of *Merycodus*, a graceful little animal of the Miocene epoch intermediate between the Deer and the Prong-horn Antelope.



SKULL AND TUSKS OF THE IMPERIAL MAMMOTH

From a photograph of the specimen on exhibition in the American Museum of Natural History

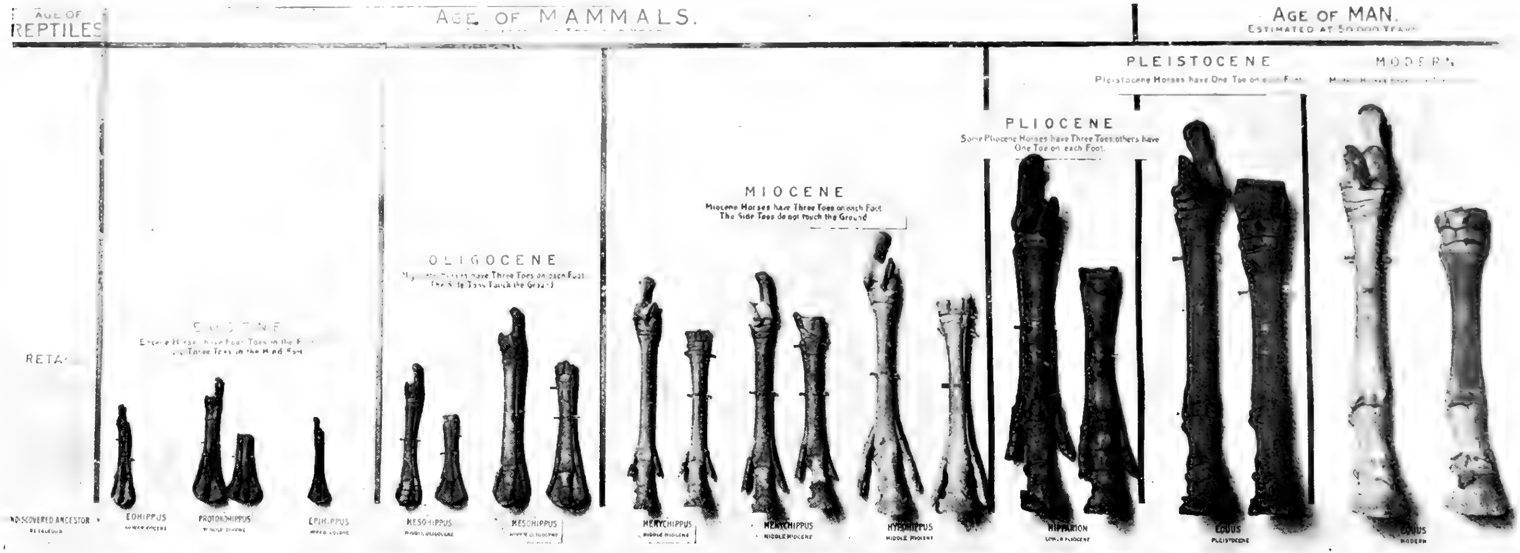
North Alcove 9. South American Fossil Mammals.

The northeast corner of the hall is devoted to a number of peculiar groups of South American Fossil Mammals, almost all extinct. During the Age of Mammals the two great northern continental areas were joined together from time to time, so that there has been an occasional interchange of animals and plants among them, the races developed in one continent spreading to the other. The animals of North America therefore, although mostly of species distinct from those of Europe and Asia, are more or less nearly related to them. But during most of the Age of Mammals South America was an island continent, as Australia is still; and its extinct animals are as peculiar and as different from those of the rest of the world as are the living animals of Australia different from those of other continents. It is by no means certain where these animals originally came from, but there is much evidence to show that both South America and Australia were peopled from an Antarctic continent, now sunk beneath the ocean or buried in the ice fields of the more frigid climate of modern times.

Of these peculiar South American groups the most extraordinary are the Edentates, including the Sloths, Armadillos and Anteaters which still survive, and the huge Megatheria or Ground-Sloths and Glyptodonts or Tortoise-Armadillos which have become extinct. Others were the Toxodonts, Typotheres, Astrapotheres and Litopterna, peculiar groups of hoofed animals all now extinct. Some of the Litopterna lost their side toes and evolved into a one-toed race curiously like the horses of the northern hemisphere, although not at all related to them; this is one of the most interesting examples of the parallel adaptation of two different races of animals to similar conditions of life; the horses in the plains and prairies of the north, the litopterna in the pampas of the southern continent.

Instances of Evolution.

The best example of the evolution of a race of animals is shown in the southeastern corner of the hall. Here is exhibited the *Ancestry of the Horse*, the specimens from successive geological strata showing how the modern Horse has descended from diminutive ancestors with four toes on each forefoot and three on each hind foot, and with teeth and other



EVOLUTION OF THE HORSE. FEET

parts of the skeleton different from those of their modern representatives.

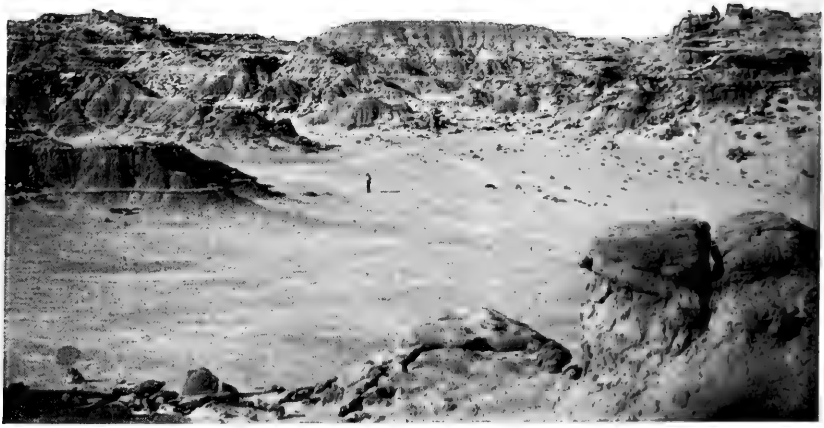
Almost equally complete, although less familiar, is the series illustrating the *Ancestry of the Camel*, which may be found on the north side of the hall near the east end. These animals, like the Horses, evolved from small and primitive ancestors to large and highly specialized descendants, and then became extinct in their former home, the broad and arid plains of western America, before the advent of civilized man, but survived to modern times in other parts of the world (Asia, Africa and South America). Less complete series are the skulls and skeletons illustrating the ancestors of Titanotheres and the ancestors of Rhinoceroses. These are ranged along the south side of the hall beginning at the entrance.

All these series have been placed according to geological age. The most ancient specimens, found in the lowest rock-strata, and hence representing the earliest stage of evolution, are placed first in the series. The most recent ones, found in the uppermost rock-strata, and representing the final stage of evolution of the race, are placed last. Arranging the species of a race from each stratum in the order of the age of the strata, we find that they show a regularly progressive change from the most ancient to the most recent. At no point in a given series can we draw a line and say: This is and that is not, a Horse—or a Camel—or a Rhinoceros. The visitor, therefore, can demonstrate for himself the evolution of the race of Horses or Camels or Rhinoceroses, within certain limits. Of the evolution of Man we have no satisfactory illustration from fossils.

It should be observed that the evolution of a race consists mainly in the adaptation of the structure of the animals to particular surroundings and habits of life. There is also a universal progress in intelligence, the more ancient animals having relatively smaller brains than their successors.

Water-color Restorations.

The water-color restorations by Charles R. Knight, done under the immediate supervision of Professor Osborn, mainly based on complete skeletons exhibited in this hall, show the *probable appearance* of the different extinct animals, according to our best judgment, as indicated by the characters of the skeleton, appearance of their nearest surviving relatives and the habits of life for which the animals seem to have been fitted. The general proportions of the animal, the outlines and form of head and body, and, to a great extent, the expression of the features are usually accurately known from the fossil skeleton. The nature of the skin is sometimes but not often certainly known, and the coloring is always conjectural, the palæontologist and the artist having been guided by the coloring of living relatives and the supposed habits of the animal.



SCENE IN THE BAD-LANDS OF THE UINTA BASIN—TERTIARY FOSSIL FIELD OF NORTHEASTERN UTAH

Window Transparencies.

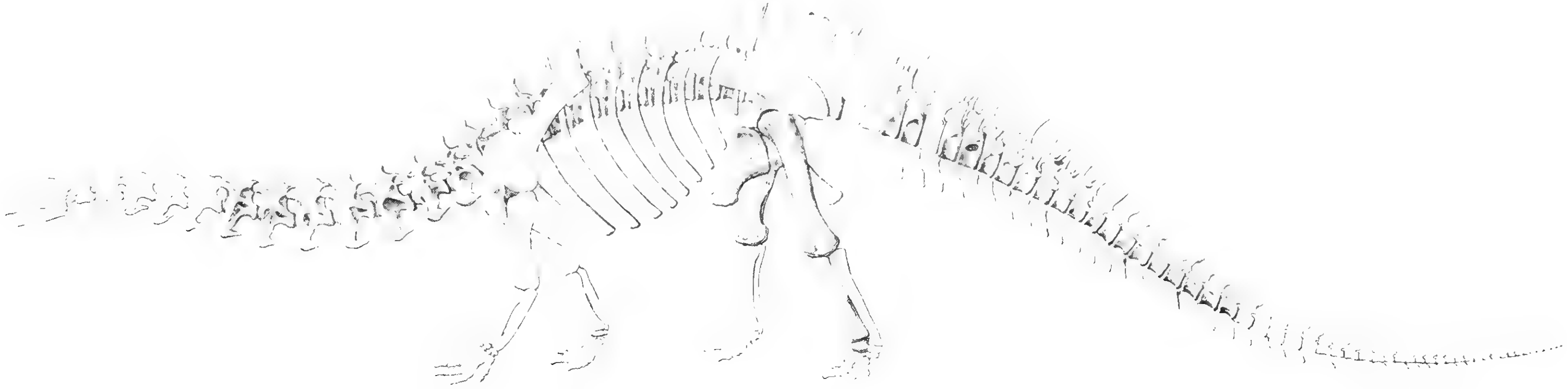
The window transparencies are enlargements from photographs of the regions where the fossils occur, and generally show the localities where unusually fine specimens in this hall were found. The expeditions sent out yearly to the fossil fields carry with them photographic outfits, and several hundred characteristic views have been taken, from which these have been selected. The pillar cards and general labels in the cases give detailed information about each group of fossils. One of the cases in the center of the middle aisle illustrates the method by which the fossils are collected and conveyed to the Museum. The charts at each side of the entrance show the order in which the rock-strata lie, one over another, and the kinds of fossils found in each stratum.

EAST WING. HALL NO. 407. FOSSIL REPTILES, ETC.

This hall forms an introduction to an earlier world, the Age of Reptiles. These fossils are of strange and unfamiliar outlines, quite unlike ordinary quadrupeds; they represent an era, long since passed away, when reptiles were the "lords of creation." Chief among them were the Dinosaurs, great land and amphibious reptiles to which the greater part of this hall is devoted. They occupy the north, east and west sides and the center.

Amphibious Dinosaurs.

The AMPHIBIOUS DINOSAURS, on the west and north sides and in the center of the hall, were the largest of land animals, some of them sixty to seventy feet in length, and of enormous bulk. They were quadrupedal beasts, with long necks and long tails, and comparatively long and very massive limbs. The head was very small in proportion to the size of the animal, and the brain inferior to that of modern reptiles. They were cold-blooded, slow-moving, unintelligent creatures, vast storehouses of flesh which lived and grew to huge size with but little occasion for very active exertion amidst the rich vegetation of the moist and tropical climate of the reptilian era. Several incomplete skeletons of Amphibious Dinosaurs are exhibited, besides limbs and other separate parts. The Brontosaurus skeletons in Case 1 (on the right-hand or south side of the entrance) and in the center of the hall are among the largest. The thigh bone in this animal was nearly six feet long and weighs in its petrified state 500 to 600 pounds. The *Diplodocus* (Case 2 on the left-hand or north side of the entrance) was less robust but almost as long. This specimen lacks the fore part of the skeleton and most of the limbs, but the tail is very perfectly



SKELETON OF BRONTOSAURUS

RESTORATION OF THE SKELETON OF AN AMPHIBIOUS DINOSAUR OF THE AGE OF REPTILES. THE SKELETON WAS 65 FEET LONG

TAKING UP FOSSIL DINOSAUR BONES AT "BONE CABIN" QUARRY, WYOMING

Parts of several skeletons appear in the photograph preserved. In Case 4 are limbs and other parts of several species of Amphibious Dinosaurs.

Beaked Dinosaurs, Stegosaurus, Triceratops and Hadrosaurus.

The Beaked Dinosaurs (Predentata) northeast corner of the hall, had a horny beak or bill at the front of the jaw, and teeth at the back of it. They were most extraordinary and bizarre animals, huge in size, although not so large as the Amphibious Dinosaurs. *Stegosaurus* had a series of great bony plates projecting from the back, and stout bony spines on the tail. *Triceratops* had an enormous skull with three great horns projecting forward, and a strong bony frill projecting backward around the neck. Both these were quadrupedal animals with massive limbs and elephantine feet. *Hadrosaurus* was a bipedal dinosaur with long hind limbs and three-toed bird-like feet, but with hoofs instead of claws. Its beak was broad and flattened, as in the spoon-bill duck or Ornithorhynchus of Australia.

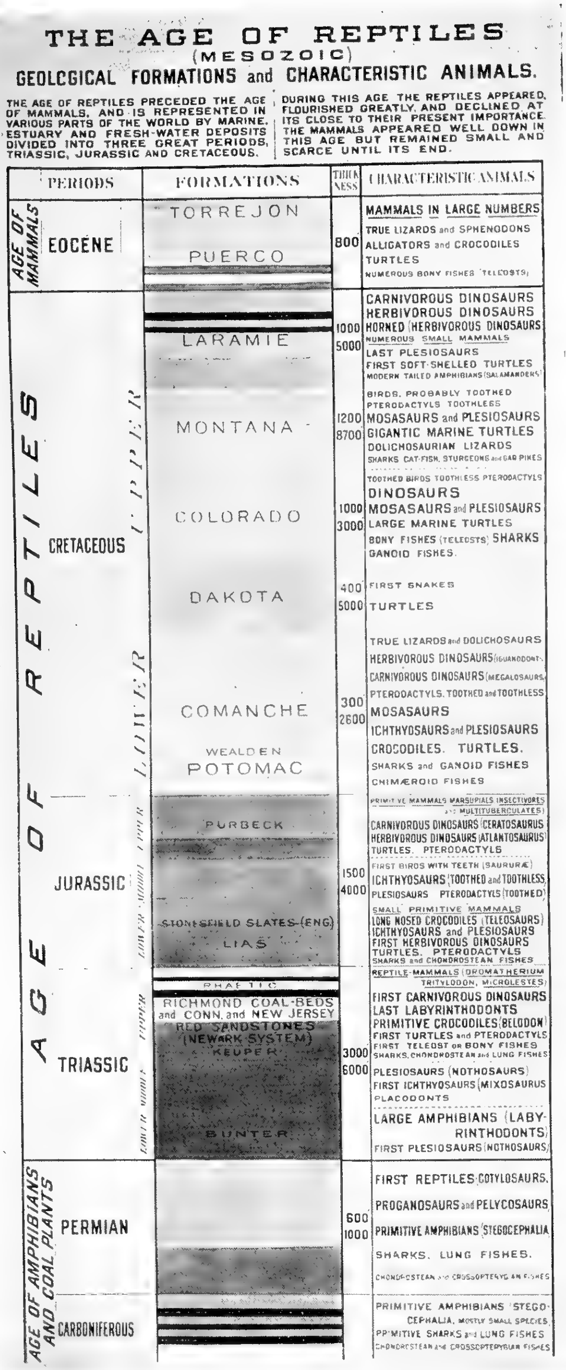
Carnivorous Dinosaurs.

The Carnivorous Dinosaurs are exhibited on the east side of the hall (opposite the entrance). They were bipeds with bird-like feet, sharp claws and large heads with sharp-pointed teeth. Some of these, the Megalosaurs, were of gigantic size, much larger than any modern carnivore. *Allosaurus* was as large as an elephant, while other Megalosaurs were even larger. Other Carnivorous Dinosaurs, such as *Ornitholestes*, were small and of slender proportions; these probably lived on the small animals of that period—toothed birds, pterodactyls, small reptiles of various kinds—while the large herbivorous dinosaurians were more probably the chief prey of the Megalosaur.

All the Dinosaurs had become extinct by the end of the Age of Reptiles. Their place was taken by the more intelligent and adaptable mammals, the evolution of which into the different kinds of modern quadrupeds has been seen in the Hall of Fossil Mammals.

Other Reptiles—Crocodiles, Turtles, Pterodactyls etc.

On the south side of the Fossil Reptile Hall are fossil remains of four other groups of reptiles, the Crocodiles, Turtles, Lizards and Snakes, which, more fortunate than the dinosaurs, have survived to the present day, though in much diminished numbers and importance.



THE AGE OF REPTILES
(MESOZOIC)
GEOLCGICAL FORMATIONS and CHARACTERISTIC ANIMALS.

THE AGE OF REPTILES PRECEDED THE AGE OF MAMMALS, AND IS REPRESENTED IN VARIOUS PARTS OF THE WORLD BY MARINE, ESTUARY AND FRESH-WATER DEPOSITS DIVIDED INTO THREE GREAT PERIODS, TRIASSIC, JURASSIC AND CRETACEOUS.

DURING THIS AGE THE REPTILES APPEARED, FLOURISHED GREATLY, AND DECLINED AT ITS CLOSE TO THEIR PRESENT IMPORTANCE. THE MAMMALS APPEARED WELL DOWN IN THIS AGE BUT REMAINED SMALL AND SCARCE UNTIL ITS END.

	PERIODS		FORMATIONS	THICKNESS	CHARACTERISTIC ANIMALS
AGE OF MAMMALS	EOCÉNE		TORREJON PUERCO	800	MAMMALS IN LARGE NUMBERS TRUE LIZARDS and SPHENODONS ALLIGATORS and CROCODILES TURTLES NUMEROUS BONY FISHES (TELEOSTS)
AGE OF REPTILES	CRETACEOUS	UPPER	LARAMIE	1000 5000	CARNIVOROUS DINOSAURS HERBIVOROUS DINOSAURS HORNED (HERBIVOROUS DINOSAURS) NUMEROUS SMALL MAMMALS LAST PLESIOSAURS FIRST SOFT-SHELLED TURTLES MODERN TAILED AMPHIBIANS (SALAMANDERS)
			MONTANA	1200 8700	BIRDS, PROBABLY TOOTHED PTERODACTYLS TOOTHLESS MOSASAURS and PLESIOSAURS GIGANTIC MARINE TURTLES DOLICHOSAURIAN LIZARDS SHARKS CAT-FISH, STURGEONS and GAR PIKES
			COLORADO	1000 3000	TOOTHED BIRDS TOOTHLESS PTERODACTYLS DINOSAURS MOSASAURS and PLESIOSAURS LARGE MARINE TURTLES BONY FISHES (TELEOSTS) SHARKS GANOID FISHES.
			DAKOTA	400 5000	FIRST SNAKES TURTLES
		LOWER	COMANCHE WEALDEN POTOMAC	300 2600	TRUE LIZARDS and DOLICHOSAURS HERBIVOROUS DINOSAURS (IGUANODONTS) CARNIVOROUS DINOSAURS (MEGALOSAURS) PTERODACTYLS, TOOTHED and TOOTHLESS MOSASAURS ICHTHYOSAURS and PLESIOSAURS CROCODILES. TURTLES. SHARKS and GANOID FISHES CHIMÆROID FISHES
	JURASSIC	UPPER MIDDLE LOWER	PURBECK STONESFIELD SLATES (ENG) LIAS	1500 4000	PRIMITIVE MAMMALS (MARSUPIALS, INSECTIVORES and MULTITUBERCULATES) CARNIVOROUS DINOSAURS (CERATOSAURUS) HERBIVOROUS DINOSAURS (ATLANTOSAURUS) TURTLES. PTERODACTYLS FIRST BIRDS WITH TEETH (SAURURÆ) ICHTHYOSAURS (TOOTHED and TOOTHLESS) PLESIOSAURS PTERODACTYLS (TOOTHED) SMALL PRIMITIVE MAMMALS LONG NOSED CROCODILES (TELEOSAURS) ICHTHYOSAURS and PLESIOSAURS FIRST HERBIVOROUS DINOSAURS TURTLES. PTERODACTYLS SHARKS and CHONDROSTEAN FISHES
	TRIASSIC	UPPER MIDDLE LOWER	RHAETIC RICHMOND COAL-BEDS and CONN. and NEW JERSEY RED SANDSTONES (NEWARK SYSTEM) KEUPER BUNTER	3000 6000	REPTILE-MAMMALS (DROMATHERIUM TRITYLODON, MICROLESTES) FIRST CARNIVOROUS DINOSAURS LAST LABYRINTHODONTS PRIMITIVE CROCODILES (BELODON) FIRST TURTLES and PTERODACTYLS FIRST TELEOST OR BONY FISHES SHARKS, CHONDROSTEAN and LUNG FISHES PLESIOSAURS (NOTHOSAURS) FIRST ICHTHYOSAURS (MIXOSAURUS) PLACODONTS LARGE AMPHIBIANS (LABYRINTHODONTS) FIRST PLESIOSAURS (NOTHOSAURS)
AGE OF AMPHIBIANS AND COAL PLANTS	PERMIAN			600 1000	FIRST REPTILES (COTYLOSAURS.) PROGANOSAURS and PELYCOSAURS PRIMITIVE AMPHIBIANS (STEGOCEPHALIA) SHARKS. LUNG FISHES. CHONDROSTEAN and CROSSOPTERYGIAN FISHES
	CARBONIFEROUS				PRIMITIVE AMPHIBIANS (STEGOCEPHALIA, MOSTLY SMALL SPECIES PRIMITIVE SHARKS and LUNG FISHES CHONDROSTEAN and CROSSOPTERYGIAN FISHES

DIVISIONS OF THE AGE OF REPTILES

Characteristic fossil reptiles, amphibians and fishes, and the formations in which they are found

Crocodiles in their palmier days were of world-wide distribution and comprised marine as well as fresh-water types. Turtles are among the commonest of fossils in the Bad-lands and some of them of very large size. Lizards and snakes, the only common reptiles of modern times, are very rare and fragmentary as fossils, and little is known about them.

Besides these surviving groups, several extinct groups of reptiles are shown on the south side of the hall. The BELODONTS, of the dawn of the Reptilian Era, were partly intermediate between Dinosaurs and Crocodiles. The still older PELYCOSAURS were remarkable for an enormous rigid bony fin on the back; among the contemporary THERIODONTS there existed perhaps the remote ancestors of the Mammals. The PTERODACTYLS or Flying Reptiles were the most extraordinary of reptiles, tailless, with batlike wings, supported on the enormously lengthened little finger, and with a spread in the largest species of twenty feet from tip to tip. The RHYNCHOCEPHALIANS are an interesting group of very primitive reptiles, of which a single species, the Tuatara, still survives in New Zealand.

FOSSIL AMPHIBIANS.

Armored Amphibians (Stegocephalia).

The Age of Reptiles was preceded by an Age of Amphibians, when the dominant animals were allied to modern Frogs, Toads and Salamanders, but had the skulls covered by a solid bony roof and the bodies by more or less scaly armor. These Armored Amphibians have been called Stegocephalia (στέγη, ϰεφαλή = deck-head) or Labyrinthodonts (λαβύρινθος, ὀδούς = labyrinth-tooth, from the complicated fluting or infolding of the enamel on the teeth). Some of them, like *Eryops*, were large animals with heads eighteen inches long and a foot wide; others resembled colossal tadpoles; but the majority of them were quite small animals, either proportioned like salamanders or else long and eel-like with minute limbs or none at all.

These fossil Amphibians are the most ancient of fourfooted animals, and are not far removed from the central type from which all the higher vertebrates are believed to be descended. They are exhibited near the middle of the south side of the Hall of Fossil Reptiles.

FOSSIL FISHES.

Some of the finest specimens of fossil fishes in the collection are exhibited in the corridor hall. Others are placed in the southwest corner of the Fossil Reptile Hall. These range from the exceedingly ancient and archaic types, such as the huge Dinichthys of the Age of Fishes, older even than the fossil Amphibians, to more modern and familiar types such as the fossil Perch and Herring of the Green River Tertiary formation.

AMERICAN MUSEUM OF NATURAL HISTORY.
DEPARTMENT OF VERTEBRATE PALÆONTOLOGY.

Revised List
OF
Casts, Models, and Photographs
OF
Fossil Vertebrates.

NEW YORK:
Published by the Museum.
1904.

SUPPLEMENT TO BULLETIN AMERICAN MUSEUM OF NATURAL HISTORY, VOL. XX, 1904.

The Knickerbocker Press, New York

AMERICAN MUSEUM OF NATURAL HISTORY.

DEPARTMENT OF VERTEBRATE PALÆONTOLOGY.

REVISED LIST[1] OF CASTS, MODELS, PHOTOGRAPHS, AND RESTORATIONS OF FOSSIL VERTEBRATES.

This Department of the American Museum of Natural History was established in May, 1891, as the Department of Mammalian Palæontology, and was extended to include Vertebrate Palæontology in 1896. The object of the Trustees is to procure a representative collection of the American Fossil Vertebrates from the successive geological horizons of the West for purposes of exhibition, research and publication. The collections are being made readily accessible to students, and placed upon exhibition as rapidly as they are prepared. Such duplicate original specimens as are available for purposes of exchange are offered to other museums.

In order to publish as widely as possible the discoveries of scientific and popular interest and to place the knowledge of them within reach of those unable to visit this Museum, a series of plaster casts of specimens and models, and of photographs of skeletons and restorations has been prepared for sale to, or exchange with, other museums, colleges and high schools.

1. *Plaster Casts of Specimens.* — These are from sharp gelatine moulds, of plaster mixed with gum-arabic, strengthened by embedded rods or wires, carefully finished and accurately colored by a skilled artist, so as to be as nearly as possible fac-similes of the original specimens. The price is based on the actual cost of making, and includes coloring and packing, but not transportation charges. The packing

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[1] Revised to January, 1904.

is done in the department, as carefully as possible, but the more delicate casts and models cannot be absolutely guaranteed against breakage.

2. *Models of Extinct Animals.* — These are plaster casts of reduced models (from 1 to 3 feet in length) made by the animal painter and sculptor, Mr. Charles Knight, under direction of Professor Osborn. The casts are made in the same manner as those of specimens and colored under Mr. Knight's personal supervision.

3. *Photographs of Mounted Skeletons of Extinct Animals.* — These are bromide enlargements, 18 x 22 inches, mounted on card, with descriptive labels, from photographs by Mr. Anderson of mounted skeletons in this Museum. These enlargements are not available for purposes of exchange and are sold at $4.00 each.

4. *Photographs of Restorations of Extinct Animals.* — These are bromide enlargements, 18 x 22 inches, on card, with descriptive labels, from photographs of the series of water-color restorations by Charles Knight. These restorations are drawn from the models above mentioned, and in almost every case based upon a careful study of the complete mounted skeleton, made by Mr. Knight under direction of Professor Osborn, and with advice and assistance of other specialists in Vertebrate Palæontology. The bromides are sold at $4.00 each and are not available for exchange.

The models and photographs are copyrighted and are sold upon the express understanding that they are not to be copied or adapted for publication.

Orders should be addressed to the CURATOR.

Payments, either by draft or by postal money-order, should be made to the order of *Treasurer of the American Museum of Natural History.*

HENRY FAIRFIELD OSBORN,
Curator.

W. D. MATTHEW }
O. P. HAY } *Associate Curators.*
BASHFORD DEAN }

I. — CASTS OF ORIGINAL FOSSILS AND TYPES.

Casts Nos. 1 and 2. Coryphodon testis (*Cope*).

Fore and Hind Feet.

Am. Mus. No. 258.

This large species of *Coryphodon* was the first described from this country, and is second only to *C. anax* in size. The specimens consist of the left fore and hind feet of the same animal. The casts consist of the 52 podial elements colored and mounted in the natural position upon plaster blocks imitating the matrix. Each piece is complete and can be studied separately.

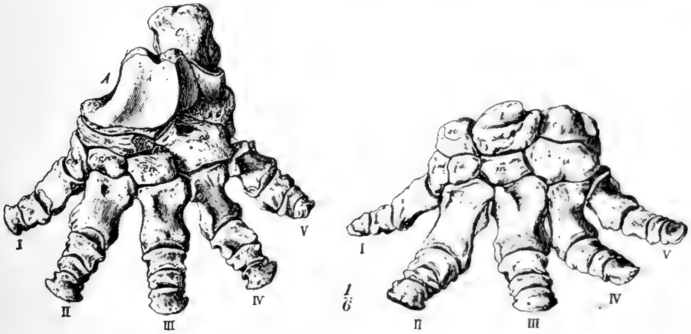

Fig. 1. *Coryphodon testis.* No. 258. Fore and hind feet. One-sixth natural size. Lower Eocene. Wyoming.

Price, $20.

Coryphodon radians COPE, OSBORN & WORTMAN, Fossil Mammals of the Wahsatch and Wind River Beds, Bull. Am. Mus. Nat. Hist., 1892, Vol. IV, p. 119; OSBORN, A Mounted Skeleton of *Coryphodon radians*, ibid. Vol. X, pp. 81–91.

Coryphodon testis (COPE) OSBORN, Evolution of the Amblypoda, Bull. Am. Mus. Nat. Hist., 1898, Vol. X, pp. 189–205.

No. 3. Palæosyops major *Leidy.*

Fore Foot.

Am. Mus. No. 1544.

Cast from the foot of the complete skeleton mounted in the American Museum. This is the characteristic Titanothere of the Middle Eocene Period (Bridger and Washakie). The foot bones are not cast separately.

The especial interest of the Titanothere fore foot is that it is essentially paraxonic (Artiodactyl) although belonging to a member of the Perissodactyla, with a typically Perissodactyl (mesaxonic) pes. Several other Artiodactyl characters are found in this family, supporting Cope's contention that the Perissodactyla and Artiodactyla should be united in a single order (Diplarthra).

Price, $5.

Nos. 4 and 5. Diplacodon emarginatus *Hatcher.*

Front of Skull and Lower Jaw.

Cast, by courtesy of the Princeton University Museum, from the type specimen described by Hatcher.

It shows the intermediate stage in the development of the horns between the ancestral Titanotheres of the Middle Eocene, hornless or with very rudimentary horns (*Palæosyops* and *Telmatotherium*), and the horned species (*Titanotherium*) of the Oligocene. The greatest diameter of the horns is antero-posterior, and both the nasals and frontals enter to some degree into the base. *Diplacodon* is found in the Upper or True Uinta Beds of the Upper Eocene.

Price, $15.

HATCHER, On a New Species of *Diplacodon*, Am. Nat., 1895, p. 1084, pl. xxxviii.

No. 6. Dromatherium sylvestre *Emmons.*

Type Lower Jaw.

Cast, by courtesy of the Geological Museum of Williams College, from the original.

This classic specimen is the better preserved of the two jaws found by Prof. Ebenezer Emmons in 1854 in the Triassic Coal Beds of Egypt, North Carolina. It is distinguished from the jaw of a reptile by apparently consisting of a single bone, while the teeth begin to show two fangs and multiple cusps prophetic of the mammal type, the Protodonta of Osborn.

Price, $3.

EMMONS, American Geology, Part VI, p. 93.
OSBORN, Proc. Acad. Nat. Sci. Phila., 1886, p. 359.

No. 7. Micronodon tenuirostris *Osborn.*

Type Lower Jaw.

Cast, by courtesy of the Philadelphia Academy of Natural Sciences, from the original there preserved.

This specimen, referred by Emmons to *Dromatherium sylvestre*, was shown by Osborn in 1886 to present important differences, and made the type of a new genus and species. The specimen is so small that the cast is not very perfect in detail.

Price, $3.

No. 8. Periptychus rhabdodon (*Cope*).

Brain Cast.

Am. Mus. No. 3665.

Periptychus, the most abundant quadruped of the Basal Eocene Torrejon Formation, presents a very small brain resembling that of a rabbit.

Price, $1.

No. 9. Pantolambda bathmodon *Cope.*

Brain Cast.

Am. Mus. No. 3957.

The brain of *Pantolambda* was very similar to that of its contemporary *Periptychus*, and gives us the early Amblypod type, ancestral to that of *Coryphodon* and *Uintatherium.*

Price, $1.

10. Giraffe-Camel. Alticamelus altus (*Marsh*).

Hind Limb.

Am Mus. No. 9109.

Upper Miocene (Loup Fork) of Colorado, Am. Mus. Expedition, 1898.

Cast from the hind limb of the specimen in the American Museum Collection. This animal, although a true Camel, simulated the Giraffe in the extreme elongation of the neck and legs, and equalled it in size, the hind limb being over seven feet long. It is a most instructive example of parallelism, as well in its points of difference from the Giraffe as in the resemblances.

Price, $12.

MATTHEW, Mem. Am. Mus. Nat. Hist., Vol. I, Pt. vii, 1901, p. 429, pl. xxxix.

11. **Dissacus saurognathus** *Wortman.*

Lower Jaw.

Am. Mus. No. 2454. Type specimen.

Dissacus was the largest and one of the most characteristic Creodonts of the Torrejon horizon of the Basal Eocene. It is believed to have been the direct ancestor of the great *Mesonyx* of the Middle and Upper Eocene. This very perfect lower jaw, sixteen inches long, is the best specimen of the large species.

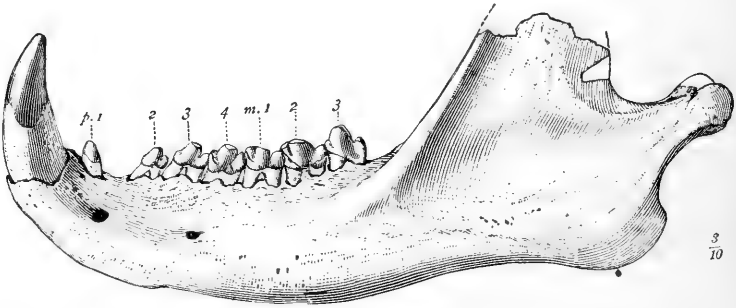

Fig. 2. *Dissacus saurognathus.* Lower jaw. Basal Eocene (Torrejon or Upper Puerco) New Mexico. Three tenths natural size.

Price, $8.

MATTHEW, Bull. Am. Mus. Nat. Hist., 1897, p. 286, fig. 9.

12. Polymastodon taöensis *Cope.*

Lower Jaws.

Am. Mus. No. 968.

A pair of complete rami of the lower jaw. The Multituberculates, a characteristic group of Mesozoic time, reached their culmination in the Puerco or lower horizon of the Basal Eocene, in this species, about the size of a Beaver. The true position of this group of pseudo-rodents is uncertain; they are generally considered, though on very insufficient evidence, to be related to the modern Monotremata.

Price, $6.

Osborn & Earle, Bull. Am. Mus. Nat. Hist., 1895, p. 13, fig. 1*c.*

13. Polymastodon attenuatus *Cope.*

Upper Teeth.

Am. Mus. No. 970.

The incisors of one side and premolars and molars of both sides, set in plaster.

Price, $3.

Osborn & Earle, Bull. Am. Mus. Nat. Hist., 1895, p. 13, fig. 1*b.*

14. Palæonictis occidentalis *Osborn & Wortman*

Lower Jaws and Front of Skull.

Am. Mus. No. 110. Type specimen.

From the Suessonian (Wasatch) of Wyoming.

This rare and fine specimen, found by Wortman in 1891, supplies another proof of the homotaxy of the Wasatch with the Suessonian of Europe, where the genus is represented by the less perfect specimens preserved in the Paris Museum.

Price, $12.

Osborn & Wortman, Bull. Am. Mus. Nat. Hist., 1892, p. 104, pl. iv.

15. Carnivorous Dinosaur, Allosaurus.

Hind Limb Complete.

Am. Mus. No. 290.

Upper Jurassic (Atlantosaurus or Como beds) of Wyoming, Expedition of 1898.

The limb is seven feet two inches high, as mounted in the natural position, and is almost absolutely complete, the distal parts of the fourth digit being perfect, the proximal splint only wanting. Each bone is cast separately—twenty-four pieces in all.

Fig. 3. *Allosaurus* hind limb, from Upper Jurassic of Bone Cabin Quarry, Wyoming.

Price, $40.

OSBORN, Bull. Am. Mus. Nat. Hist., 1899, p. 161, figs. 1–4*a*.

16. Patriofelis ferox (*Marsh*).

Fore and Hind Feet.

Am. Mus. No. 1507.

Original from the Bridger or Middle Eocene of Wyoming, Expedition of 1893.

Typical Creodont or Primitive Carnivore foot. Taken from the mounted skeleton in the American Museum Collection.

Displays the broad, spreading foot with blunt, hoof-like claws and very limited play on the joints, common to most of the larger Creodonts. The hind foot is nine inches long.

Price, $10.

OSBORN, *Patriofelis* and *Oxyæna* Re-studied as Terrestrial Creodonts, Bull. Am. Mus. Nat. Hist., XIII, 1900, pp. 269–279.

WORTMAN, Osteology of *Patriofelis*, Bull. Am. Mus. Nat. Hist., VI, 1894, pp. 129–164.

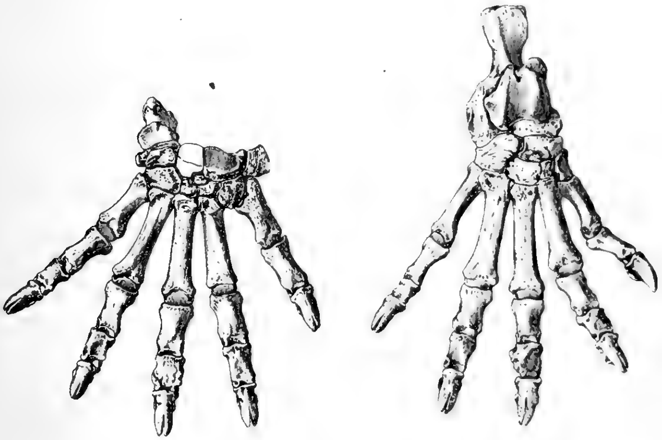

Fig. 4. *Patriofelis ferox* (Marsh). Fore and hind feet. One-fourth natural size.

17–20. Type Specimens of Eocene Tapiroids.

	Price.
17. *Desmatotherium guyoti*, upper jaws, type	*$1.00*
18. *Dilophodon minusculus*, lower jaw, type	*1.00*
19. *Isectolophus latidens*, jaw fragments, types	*1.50*
20. *Isectolophus annectens*, jaw fragments, types	*1.50*

Four little-known Tapiroid mammals from the Bridger and Uinta Eocene of Wyoming. The originals are in the Princeton Museum.

SCOTT, *Desmatotherium* and *Dilophodon*, Contributions from the Museum of Princeton College, 1883, p. 51, pl. viii.

SCOTT & OSBORN, The Mammalia of the Uinta Formation, Trans. Amer. Philos. Soc., 1889, pp. 519, etc.

21. Heptodon calciculus *Cope.*

Palate and Complete Lower Jaws.

Amer. Mus. No. 294.

Primitive Lophiodont from the Wind River Eocene of Wyoming. Probably ancestral to the *Colodons* of the American Oligocene.

Price, $7.

Osborn & Wortman, Fossil Mammals of the Wasatch and Wind River Groups, Collection of 1891, Bull. Amer. Mus. Nat. Hist., IV, 1892, p. 127.

22. Colodon dakotensis *Osborn & Wortman.*

Upper Jaws.

Am. Mus. No. 1212.

White River Oligocene, S. Dakota.

Price, $3.

23. Colodon occidentalis (*Leidy*).

Lower Jaws and Fore Foot.

Am. Mus. No. 658.

White River Oligocene, S. Dakota.

This rare Lophiodont is known only by fragmentary specimens. The group is intermediate between Tapirs and Horses in some respects, between Tapirs and Rhinoceroses in others. It left no descendants.

Price, $5.

Osborn & Wortman, Perissodactyls of the Lower Miocene White River Beds, Bull. Amer. Mus. Nat. Hist., VII, 1895, p. 362, fig. 7.

Wortman & Earle, Ancestors of the Tapir from the Lower Miocene of Dakota, Bull. Amer. Mus. Nat. Hist., V, 1893, p. 174, figs. 6 and 7.

24. Systemodon primævus *Wortman.*

Palate and Lower Jaw.

Am. Mus. Nos. 144 and 131.

Suessonian (Wasatch Beds) Wyoming.

Systemodon is the starting point, as far as known, of the Tapir line, and strikingly resembles in most respects the contemporary ancestors of the Horse (*Hyracotherium*, etc.).

Price, $4.

OSBORN & WORTMAN, Fossil Mammals of the Wasatch and Wind River Beds, Collection of 1891, Bull. Amer. Mus. Nat. Hist., IV, 1892, p. 125, fig. 17.

WORTMAN, Species of Hyracotherium, etc., Bull. Amer. Mus. Nat. Hist., VIII, 1896, p. 87, fig. 3.

25. Protapirus validus *Hatcher.*

Skull.

Type specimen (Original in Princeton Museum).

Protoceras Beds, White River Formation (Oligocene), S. Dakota.

Price, $7.

HATCHER, Recent and Fossil Tapirs, Amer. Jour. Sci., I, 1896, p. 162, pl. ii.

26. Protapirus obliquidens *Wortman & Earle.*

Lower Jaws and Fore Foot.

Am. Mus. Nos. 661 and 662.

Protoceras Beds, White River Formation (Oligocene), S. Dakota.

Protapirus is intermediate between the modern Tapirs and their primitive Eocene ancestors (*Systemodon* and *Isectolophus*).

Price, $6.

WORTMAN & EARLE, Ancestors of the Tapir from the Lower Miocene of Dakota, Bull. Amer. Mus. Nat. Hist., V, 1893, p. 165, figs. 2, 3, 4.

27. Oreodon culbertsoni *Leidy.*

Fore and Hind Foot.

Am. Mus. No. 1287. Cast from the mounted skeleton in the American Museum.

Oreodon Beds, White River Formation (Oligocene), S. Dakota.

Shows a very primitive Artiodactyl foot, the fore foot still retaining a rudimentary thumb, and the lateral digits being less reduced than in any of the more recent Artiodactyls.

Price, $6.

Scott, W. B., Beiträge zur Kenntniss der Oreodontidæ, Morph. Jahrb., 1890, pp. 328, 334, pl. xvi, figs. 27, 28.

28. Hyænodon horridus *Leidy.*

Fore and Hind Foot.

Am. Mus. No. 1375. Cast from the mounted skeleton in the American Museum.

Oreodon Beds, White River Formation (Oligocene), S. Dakota.

Hyænodon was the latest and most specialized of the Creodonts or Primitive Carnivores, and the feet are adapted for running, although not so well as in the modern swift-footed Carnivora.

Price, $7.

Scott, W. B., The Osteology of *Hyænodon*, Journ. Acad. Nat. Sci. Phila., Vol. IX.

29. Series of Fossil Horse Feet.

Illustrating the Evolution of the Horse.

The Horses afford the best illustration of the evolution of a race of animals during geological time, commencing in the Lower Eocene as small fox-like animals with several toes on each foot, and ending with the modern Horses, Asses, and Zebras. At least ten intermediate stages are known in the direct line of descent, besides several stages of collateral branches, leading into types which have left no modern descendants. Those of which casts are now ready are:

Stage *b.*—*Hyracotherium craspedotum.* Fore and hind feet. Middle Eocene (Wind River), Wyoming. Four toes and a rudiment of a fifth (1st digit) on the fore foot, three toes on the hind foot. Size of a fox. *Price, $4.*

Stage *e.*—*Mesohippus bairdi.* Fore and hind feet. Lower Oligocene (White River), S. Dakota. Three toes on fore and hind foot, the fourth (5th digit) represented on the fore foot by a short "splint-bone." Lateral toes much reduced, but still touching the ground. Size of a prairie wolf. *Price, $4.*

Stage *f′.*—*Mesohippus intermedius.* Fore and hind feet. Upper Oligocene (White River, Protoceras Beds), S. Dakota. Like *M. bairdi*, but larger. *Price, $5.*

Stage *f″.*—*Mesohippus copei.* Hind foot. Upper Oligocene (White River, Protoceras Beds), S. Dakota. Larger than *M. intermedius.* *Price, $3.*

Stage *h″.*—*Hypohippus equinus.* Fore and hind feet. No. 8407 Middle Miocene (Loup Fork), Colorado. Larger than any of the preceding species; size of Shetland pony. Fifth digit of the fore foot reduced to a little nodular rudiment. Side toes still touch the ground. *Price, $12.*

Stage *i‴.*—*Merychippus sejunctus.* Fore and hind feet. Middle Miocene, Colorado. Fifth digit of fore foot a small nodular rudiment, side toes much reduced, not reaching the ground. Size of 3-months-old colt. *Price, $10.*

Stage *j‴.*—*Neohipparion whitneyi.* Fore and hind feet. Upper Miocene (Loup Fork), S. Dakota. Feet and limbs elongate, proportions like those of the deer. Side toes more reduced than in *Merychippus*, size somewhat larger. *Price, $12.*

30. Series of Fossil Horse Skulls.

Illustrating the Evolution of the Horse.

(Stages corresponding with those in No. 29.)

Those now ready are:

Stage *c.*—*Protorohippus venticolus.* Crushed skull and jaws. No. 4832. From mounted skeleton in Cope Collection. Middle Eocene (Wind River), Wyoming. Short-crowned teeth of primitive pattern. Size of fox. *Price, $4.*

Stage *e.*—*Mesohippus bairdi.* Skull and jaws. No. 1477. From Lower Oligocene (Oreodon Beds, White River), Nebraska. Short-crowned teeth of more horse-like pattern. Size of prairie wolf. *Price, $8.*

Stage *h″*.—*Hypohippus equinus.* Skull and jaws. No. 8407. From Middle Miocene (Loup Fork) of Colorado. Teeth much like those of *Mesohippus.* Size of Shetland pony. *Price, $15.*

Stage *i‴*.—*Merychippus sejunctus.* Skull and jaws. No. 8291. Cope Collection. Middle Miocene (Loup Fork) of Colorado. Long-crowned teeth with cement. Pattern intermediate between *Mesohippus* and *Equus.* Size of 3-months-old colt. *Price, $15.*

31. Pantolambda bathmodon *Cope.*

Fore and Hind Feet.

From mounted skeleton in American Museum. No. 2549.

Torrejon Formation (Basal Eocene) of New Mexico.

Primitive ungulate foot, with five toes, first digit semi-opposable, plantigrade step, wide, loosely joined wrist and ankle-bones (giving much flexibility in all directions at the expense of power), and other characters now preserved chiefly among arboreal mammals. The foot approaches nearly those of the more ancient unguiculates or clawed animals. *Pantolambda* was ancestral to the ancient *Amblypoda* (*Coryphodon* and *Uintatherium*), but only a collateral ancestor of the more recent hoofed animals.

Price, $5.

Osborn, Evolution of the Amblypoda, Bull. Am. Mus. Nat. Hist., X, 1898, pp. 183–188, figs. 9, 10, 12.

32. Series of Fossil Camel Feet.

Illustrating the Evolution of the Camels and Llamas.

Although now found only in the desert regions of Asia, Africa, and South America, the Camel family was of North American origin, spreading to other continents only in the Pliocene epoch, and becoming extinct in its original home during the Pleistocene. During the Tertiary the race evolved from small deer-like animals, no larger than jack-rabbits, with sharp, pointed hoofs and separate metapodial bones, to their present size and proportions, the metapodials becoming solidly fused together and a large pad on the foot supporting the weight of the body. Collateral lines of descent also existed, one ending in an animal of singularly giraffe-like proportions, although a true Camel (Giraffe-Camel, see also No. 10, on page 5).

Stage *a.*—*Protylopus petersoni.* Hind limb. No. 2564. Upper Eocene (Uinta), Utah. Separate metapodials, lateral digits represented by short splints, pointed hoofs. Size of jack-rabbit. *Price, $5.*

Stage *b.*—*Poëbrotherium wilsoni.* Fore and hind feet. No. 1364. Lower Oligocene (White River), S. Dakota. Separate metapodials, lateral digits represented by small nodular rudiments, pointed hoofs. Size of vicuña. *Price, $5.*

Stage *e′.*—*Protolabis montanus.* Fore and hind feet. No. 9108. Middle Miocene (Loup Fork), Colorado. Separate metapodials, lateral rudiments fused, hoofs pointed. Size of llama. *Price, $6.*

Stage *f″.*—*Alticamelus altus.* (Giraffe-Camel.) Hind limb. No. 9109. Middle Miocene (Loup Fork), Colorado. United metapodials, greatly elongated, hoofs considerably reduced. Size of small giraffe. *Price, $12.*

33. Protoceras celer *Marsh.*

Fore and Hind Foot.

Protoceras Beds, White River Oligocene, S. Dakota.

Protoceras is the largest of a peculiar group of primitive ruminants characteristic of the White River Oligocene. The fore foot has four fully functional digits, but in the hind foot the lateral digits are reduced to small splints. The animal was somewhat smaller than the musk deer, much less gracefully proportioned, the skull remarkably specialized in the male.

Price, $5.

Scott, Osteology and Relations of *Protoceras*, Jour. Morph., Vol. XI.
Osborn & Wortman, Characters of *Protoceras*, etc. Bull. Amer. Mus. Nat. Hist., IV, 1892, pp. 351–372.

34. Type Specimens of Fossil Equidæ.

	Price.
Equus complicatus Leidy. Upper molar. Pleistocene	*$2.00*
" *excelsus* Leidy. Upper jaw. "	*4.00*
" *occidentalis* Leidy. Upper molars. "	*2.00*
" *pectinatus* Cope. Upper teeth, series. "	*5.00*
Hipparion speciosum Leidy. Upper teeth. Miocene	*3.00*
" *affine* Leidy. " "	*3.00*
" *occidentale* Leidy " "	*3.00*
" *gratum* Leidy " "	*2.50*
" *montezumæ* Leidy. Upper and lower tooth. Miocene	*2.00*
Merychippus mirabilis Leidy. Upper jaw. Miocene	*3.00*
" *insignis* Leidy. " "	*3.00*
Parahippus cognatus Leidy. Upper teeth, "	*2.50*
Parahippus (Desmatippus) crenidens Scott. Upper and lower jaws. Miocene	*6.00*
Anchippus texanus Leidy. Upper molar. Miocene	*1.50*
Hypohippus affinis Leidy. " "	*1.50*
Hypohippus (Anchitherium) equinus. Upper and lower jaws. Miocene	*6.00*
Mesohippus bairdi Leidy. Figured skull and jaws. Leidy, 1869, pl. xx. Oligocene	*5.00*

The patterns of the molars in the above type specimens have been copied with especial care and accuracy on the casts.

35. Phenacodus primævus *Cope.*

Fore and Hind Feet.

Wasatch Formation, Lower Eocene, Wyoming.

The mounted skeleton of *Phenacodus* in the Cope Collection (now in the American Museum) is well known by descriptions and figures in all textbooks of geology and palæontology. *Phenacodus* is the type of the Condylarthra, a very archaic order of ungulates retaining the primitive form of wrist and ankle articulations, five toes on each foot, and pig-like teeth, and considered to represent very nearly the central protungulate type from which all hoofed animals are descended. The size of *P. primævus* was somewhat less than that of a pig.

Price, $10.

Cope, E. D., Tertiary Vertebrata, Rep. U. S. G. S. Terrs., Vol. III, B'k I, p. 435, and plates.

Osborn, H. F., Remounted Skeleton of *Phenacodus*, Bull. Am. Mus. Nat. Hist., X, 1898, pp. 159–164.

36. Euprotogonia puercensis (*Cope*).

Hind Foot.

Torrejon Formation, Basal Eocene, New Mexico.

Euprotogonia was the ancestor of *Phenacodus*, and has a still more primitive type of foot. The five toes are tipped with narrow, claw-like hoofs, and in other characters this foot is intermediate between the hoofed animals (Ungulata) and clawed animals (Unguiculata), and indicates the derivation

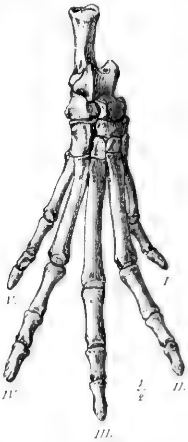

Fig. 5. *Euprotogonia puercensis.*
Hind foot. One-half natural size.

of both from a common ancestor. This species was about the size of a cat, and the cast is taken from an incomplete skeleton in the American Museum.

Price, $4.

MATTHEW, Revision of the Puerco Fauna, Bull. Amer. Mus. Nat. Hist., XI, 1897, p. 305, fig. 12.
OSBORN, Remounted Skeleton of *Phenacodus*, Bull. Amer. Mus. Nat. Hist., X, 1898, p. 159.

37. Stereosternum tumidum *Cope.*

Skeleton.

Upper Permian, near São Paulo, Brazil.

This beautifully preserved skeleton is one of the most ancient and primitive reptiles known, and represents a distinct and very primitive order of Reptilia, the *Proganosauria*, with many characters connecting it with the Amphibia. Skeleton in block, about two feet long, showing all parts except the left fore and hind feet, and with the outlines of the body indicated. By courtesy of the Director of the Geological Survey of Brazil.

Price, $15.

COPE, Contribution to the Vertebrate Palæontology of Brazil, Proc. Am. Phil. Soc., XXIII, 121, 1885; The Carboniferous Genus *Stereosternum*, Amer. Nat., 1887, 1109.
OSBORN, Memoirs Am. Mus. Nat. Hist., Vol. I, Pt. VIII, p. 481, figs. 15–19, and pl. xl, Nov., 1903.

II.—CASTS OF MODELS OF EXTINCT VERTEBRATES BY CHARLES KNIGHT.

Originals presented by J. Pierpont Morgan, Esq.

No. 1. Three-horned Frill-necked Dinosaur. Triceratops prorsus *Marsh.*

The original model was made by Mr. Knight for the National Museum, under direction of Mr. Lucas, and is based on parts of several skeletons there preserved.

Triceratops was one of the last and most remarkably specialized of the Dinosaurs. It was herbivorous, quadrupedal, with elephant-like legs and feet. The skull was of huge size, 6–8 feet long, with long, powerful horns projecting forward, and a great bony frill projecting backward and completely covering the neck. One-tenth natural size. Length of base, 18 inches.

Price, $20.

No. 2. The Duck-billed Dinosaur. Hadrosaurus mirabilis *Leidy.*

The model of this remarkable Dinosaur is based on an almost complete specimen in the Cope Collection, now in this Museum, which will shortly be placed on exhibition as a mounted skeleton. It was found in the Laramie Cretaceous by Messrs. Wortman and Hill, and described by Professor Cope (under the generic name *Diclonius*) in 1883. The animal was thirty feet in length, with a long neck, flattened, duck-like bill, numerous small teeth, small fore limbs, and heavy hind limbs and tail. It was probably of amphibious habits, feeding on soft water-plants. It was covered with a thick, rhinoceros-like hide, parts of which are preserved in Professor Cope's specimen. One-eleventh natural size; length of base, 12 inches.

COPE, Proc. Acad. Nat. Sci. Phila., 1883, p. 97; Am. Nat., 1883, p. 774.

Price, $10.

No. 3. Leaping Carnivorous Dinosaur. Dryptosaurus (Lælaps) aquilunguis *Cope.*

The first Dinosaur described by Professor Cope was *Lælaps aquilunguis* from the New Jersey Cretaceous beds. The model is based upon this fragmentary skeleton and upon the restoration by Professor Marsh of the allied form *Ceratosaurus*.

The Carnivorous Dinosaurs, although smaller than some of the herbivorous kinds, were animals of great size. This species was about fifteen feet long. According to Professor Cope's views, by which Mr. Knight was chiefly guided in making this and the following restoration, the animal was an active and powerful leaper, and the model, representing two fighting *Lælaps*, carries out this conception. One-seventh natural size. Length of base, 18 inches.

COPE, Proc. Acad. Nat. Sci. Phila., 1866, p. 275; Proc. Amer. Philos. Soc., XXX, p. 240, May, 1892.
MARSH, Dinosaurs of North America, pp. 157–163, pl. xiv.

Price, $20 (2 figures, complete).

No. 4. Naosaurus claviger *Cope*.

From the Permian Beds of Texas. This belongs to the primitive Reptilian order *Pelycosauria* of Cope, but represents a highly specialized side-branch, related to the *Rhynchocephalia* or *Proganosauria* as shown by Baur and Case. The precise object of the extraordinary rigid fin on the back is not known; it was humorously suggested by Cope that it might have been used as a sail. It was, perhaps, chiefly ornamental. Different species of Naosaurs reach from three to ten feet in length, and the dorsal fin reaches a length even greater than that shown in the model. One-fifth natural size. Length of base, 12 inches.

COPE, Proc. Amer. Phil. Soc., 1878, p. 510, and subsequent papers.
BAUR & CASE, Morphology of the Skull of the Pelycosauria, Anatom. Anzeiger, Bd. XIII, p. 109, Jena, 1897.

Price, $12.

No. 5. Cervalces americanus (*Harlan*).

This Pleistocene American Elk was of the size and proportions of the living Moose, but had horns almost as large as those of the Extinct Irish Deer of Europe, and expanded in three planes of growth at right angles to each other. The model is based on a remarkably perfect skeleton found in New Jersey and mounted in the Princeton University Museum.

This skeleton was fully described by Professor Scott, in 1885, as possessing characters intermediate between those of the deer and moose. One-fourth natural size. Length of base, 24 inches.

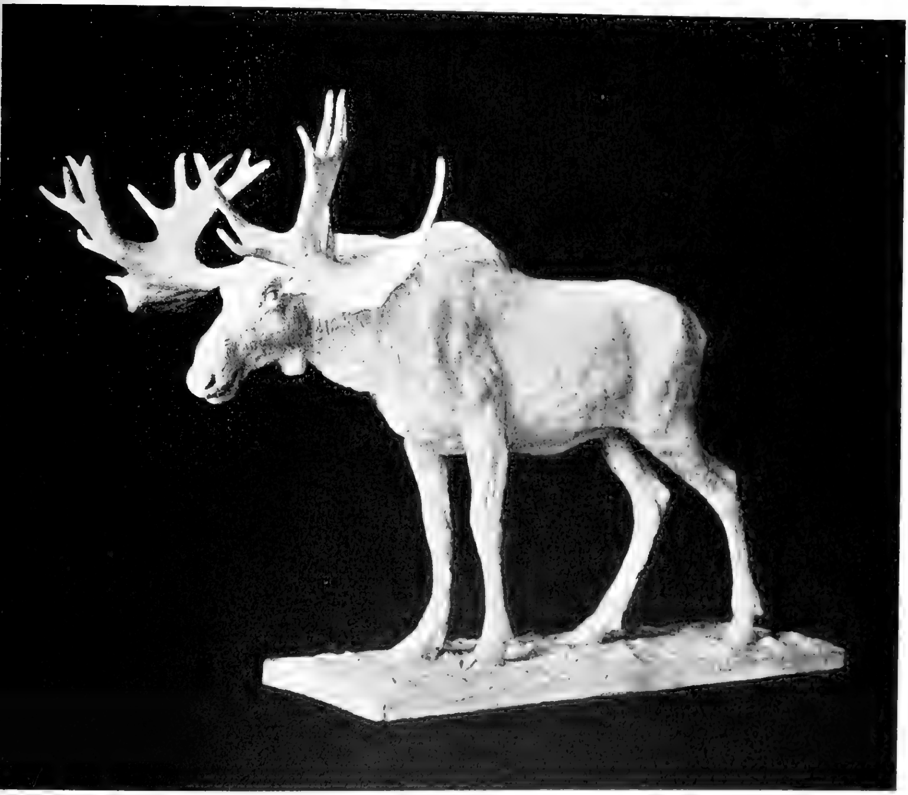

Fig. 6. *Cervalces americanus.* Modelled by Charles Knight from the fossil skeleton in Princeton Museum.

SCOTT, Proc. Acad. Nat. Sci. Phila., 1885, p. [illegible]. *Price*, $[illegible]

No. 6. Long-horned Titanothere. Brontotherium platyceras (S. & O.).

Based on the mounted skeleton and skulls in the American Museum, and on the monographic studies of the Titanotheres by Professor Osborn.

The model represents a charging Titanothere, and illustrates a chief use of the great horns developed in these animals. One-eighth natural size. Length of base, 25 inches.

Price, $20.

No. 7. Series of Heads of Titanotheres.

This series of five heads represents the evolution and polyphyletic development of the Titanotheres during the Lower Oligocene.

a. *Brontotherium platyceras,*
b. *Megacerops robustus,*
c. *Titanotherium ingens,*
d. *Symborodon acer,*
e. *Diplacodon emarginatus.*

One-sixth natural size.

Price, $5 each; for the set, $20.

No. 8. Restored Head of Dinocyon. Dinocyon gidleyi *Matthew.*

Upper Miocene Epoch, Texas. One-fourth natural size.

Based on the skull and jaws in the American Museum. This gigantic dog equalled the polar or Kadiak bear in size, and resembled them in many external characters. One-fourth natural size.

Price, $5.

No. 9. Sabre-tooth Tiger. Smilodon.

This restoration model is based on a complete mounted skeleton of *S. necator* in the American Museum.

Smilodon, of the Pleistocene epoch, was the latest and largest of the Sabre-tooth Tigers, equalling a polar bear in size, and provided with canines which projected seven inches from the jaw. It ranged through the New World from Canada to Patagonia, and probably preyed on the great ground sloths or other gigantic herbivora of the Tertiary Period, to pierce whose thick hide and heavy fur the enormous canines were well adapted. One-sixth natural size. Length of base, 14 inches.

Price, $15.

III. — PHOTOGRAPHS OF MOUNTED SKELETONS.

Bromide enlargements from the original negatives. Size, 18 in. x 22 in.

These photographs are taken from the fossil vertebrates in the American Museum, as an exhibition of the Succession of Vertebrate Life in North America. Other skeletons are in various stages of preparation, photographs of which will be added to this series.

The skeletons show the actual form, proportions, and attitudes of these extinct animals as nearly as they can be determined or the preservation of the specimen permits.

The photographs also exhibit the different methods employed in mounting, each method being adapted to the special condition of the fossil. For example, *Cœnopus tridactylus*, No. 11, and *Tylosaurus*, No. 14, are cases where a LOW RELIEF mounting was necessary. *Amynodon*, No. 18, is an instance of the HIGH RELIEF mounting. In some cases the matrix is wholly or partly the original rock in which the fossil was found; in others it is a close imitation of it, made partly by mingling the rock with plaster, thus giving the visitor and student a truer conception of the original embedding. Other animals are mounted in FULL RELIEF, like a recent skeleton, with the aid of concealed, or partly concealed, iron rods. Except when abundant duplicate material is available, each bone is made easily removable for purposes of study, fastened to its mountings by wire ties or by concealed screws and bolts. The mounting is under the direction of the Curator and of Mr. Adam Hermann, Preparator.

Price of the photographs, $4 each.

1. **Metamynodon planifrons** *Scott & Osborn.*

Am. Mus. No. 546.

This aberrant rhinoceros of the Oligocene epoch was discovered by Garman and described by Scott and Osborn in 1887. The mounted skeleton is a composite from materials obtained by the Amer. Mus. Expeditions of 1892 and 1894 in the Big Badlands of South Dakota. Its length is 9 ft. 7 inches. The general impression is of a very broad, flat skull, with formidable canine tusks; small, but prominent and greatly elevated eye-sockets, and a very broad chest. The fore and hind limbs are quite powerful, but the metapodials are rather slender, especially in the manus. This animal is widely separated from the true Rhinoceros by its four completely functional digits on the fore foot and by the strong development of the canines.

OSBORN & WORTMAN, Perissodactyls of the Lower Miocene, White River Beds, Bull. Am. Mus. Nat. Hist., VII, 1895, pp. 373–375, pll. x, xi.

2. Brontotherium, sp.

Am. Mus. No. 518.

This skeleton represents the largest size and the last stage in the evolution of the Titanotheres, and was discovered by the American Museum Expedition of 1892 in the Upper Titanotherium Beds of South Dakota, absolutely complete as far back as the border of the pelvis. The hind limbs, belonging to different animals, but of the proper proportions, were secured in the same regions of the West in the summer of 1894.

The complete skeleton, about 7 feet 7 inches (M. 2.31) high; 13 feet 8 inches (M. 4.17) long, and 3 feet 10 inches (M. 1.17) broad, probably belongs to an adult female, as we judge from the imperfect development and ossification of the horns, which in males of this period are very long and powerful. An interesting feature of the skeleton is an exostosis and false joint in the centre of the seventh rib, undoubtedly an after-result of fracture.

OSBORN & WORTMAN, *loc. cit.*, pp. 346–352, pll. viii, ix.

3. Hyrachyus agrarius *Leidy.*

Am. Mus. No. 5065.

This is the original skeleton discovered by Professor Cope himself in his explorations in the Bridger Basin (Middle

Eocene) in 1873, and was mistakenly referred by him to *H. eximius*. It was mounted as found, with an incomplete skull, and so figured by Cope in 'The Tertiary Vertebrata.' The American Museum Expedition of 1893 secured a complete skull belonging to this species, and of the proper size, which has been affixed to the skeleton. In order fully to expose the bones, and correct several errors in the original mounting, the entire animal was taken apart and remounted, as here photographed. The animal was about as large as a sheep, and is the oldest known type of Rhinoceros, more directly ancestral to the Hyracodon or Cursorial Rhinoceros of the Oligocene.

COPE, Tertiary Vertebrata, U. S. Geol. and Geog. Sur. Terr's, F. V. Hayden in charge, Final Report, Vol. IV (1885), pp. 657–677, pll. liv, lv, lv*a*, etc.

OSBORN & WORTMAN, Perissodactyls of the White River Beds, Bull. Am. Mus. Nat. Hist., VII, 1895, pp. 367–371.

4. Patriofelis ferox (*Marsh*).

Am. Mus. No. 1507.

This animal was originally described by Leidy from a fragment of the lower jaw. The American Museum Expedition of 1893 procured the complete skeleton, represented in two different animals, in which the skull alone was in an imperfect fragmentary condition, and the teeth, unfortunately, entirely wanting. This animal was as large as a jaguar, and exhibits short, powerful, highly flexed limbs, widely spreading clawed feet, heavy backbone, very deep sagittal crest and small brain case. It is a typical Middle Eocene Creodont, with highly specialized cutting teeth.

WORTMAN, The Osteology of *Patriofelis*, Bull. Am. Mus. Nat. Hist., VI, 1894, pp. 129–164, pl. i.

OSBORN, *Oxyæna* and *Patriofelis* Re-studied as Terrestrial Creodonts, Bull. Am. Mus. Nat. Hist., XIII, 1900, pp. 269–279, pll. xviii, xix.

5. Protorohippus venticolus (*Cope*).

Am. Mus. No. 4832.

This is the famous skeleton described by Cope in 'The Tertiary Vertebrata,' as the four-toed Lower Eocene Horse.

It was found by Dr. J. L. Wortman in the Wind River Beds of Wyoming (Middle Eocene). Since its purchase by the American Museum the entire skeleton has been taken apart and remounted as a walking animal; in the original mounting the animal was represented as pacing. The skeleton is far from perfect, the limbs upon the left side being largely restored, while those upon the right side are complete. The ribs are entirely restored, as is the pelvis. In the remounting of the skeleton these missing parts were studied from the corresponding bones in the well-known form *Mesohippus*.

Cope, Tertiary Vertebrata, pp. 635–647, pl. xlix *a*, *b* and *c*.

Wortman, Species of *Hyracotherium* and allied Perissodactyls from the Wahsatch and Wind River Beds of North America, Bull. Am. Mus. Nat. Hist., VIII, 1896, pp. 81–110.

6. **Hoplophoneus primævus** *Leidy.*

Am. Mus. No. 1406.

The skeleton was procured by the American Museum Expedition of 1894 in the Oreodon Beds of South Dakota, and is one of the most complete fossil skeletons ever found. The only parts missing were some of the processes and spines of a few vertebræ. This animal is characterized by powerful canines protected by a heavy flange upon the lower jaw, and is considered the ancestor of the great Sabre-tooth Tiger *Smilodon*.

Riggs, Restoration of *Hoplophoneus occidentalis* Leidy, Kan. Univ. Quar., V, 1896, pp. 37–52, pl. i.

7. **Palæosyops major** *Leidy.*

Am. Mus. No. 1544.

Palæosyops was one of the first fossils found in the Eocene deposits of the Western States. Materials for this mounted skeleton were secured with great difficulty by the American Museum Expeditions of 1893 and 1895 in the Bridger and Washakie Beds of Wyoming. The skull, fore limbs and foot, and a large part of the vertebral column and ribs belong to a single skeleton, and the parts associated with these were put together after being positively determined as belonging to this species, and as representing individuals of corresponding age. The skeleton is thus believed to represent accurately the original, and there is little restoration, except in the head of the femur. This species is distinguished by the convexity of the forehead, and by the low, flattened cones of the molar teeth, and is not directly ancestral to the later Titanotheres.

EARLE, On the genus *Palæosyops*, etc., Jour. Acad. Nat. Sci. Phila., 1892

8. **Phenacodus primævus** *Cope.*

Am. Mus. No. 4369.

This is the famous skeleton of *Phenacodus* found by Dr. Wortman in the Lower Eocene of the Big Horn Basin, Wyoming, and described by Cope in 'Tertiary Vertebrata' and other publications. It here has an entirely different appearance, and gives us a different conception of the animal from that presented in its original mounting. The skeleton was very largely embedded in the rock, and it required four months of continuous work to remove the limbs, ribs and vertebræ preparatory to remounting. The animal as figured in 'Tertiary Vertebrata' appeared like a plantigrade; it was, however, restored by Sir William Flower in his book upon the Horse as a digitigrade. As here shown, the animal was as digitigrade as the Tapir; the hind limbs are much longer and more powerful than the fore; the tail is of great size. The head, on the other hand, is extremely small, and out of all proportion to the body. It is thus a microcephalic type, in contrast with *Coryphodon*, which is macrocephalic.

COPE, Tertiary Vertebrata, pp. 428–463, pll. lvii*b*–lviii.
OSBORN, Remounted Skeleton of *Phenacodus*, Bull. Am. Mus. Nat. Hist., X, 1898, pp. 159–164.

9. **Coryphodon testis** *Cope.*

Am. Mus. No. 2865.

Coryphodon is the characteristic large mammal of the Lower Eocene or Wasatch. Its remains are usually found scattered,

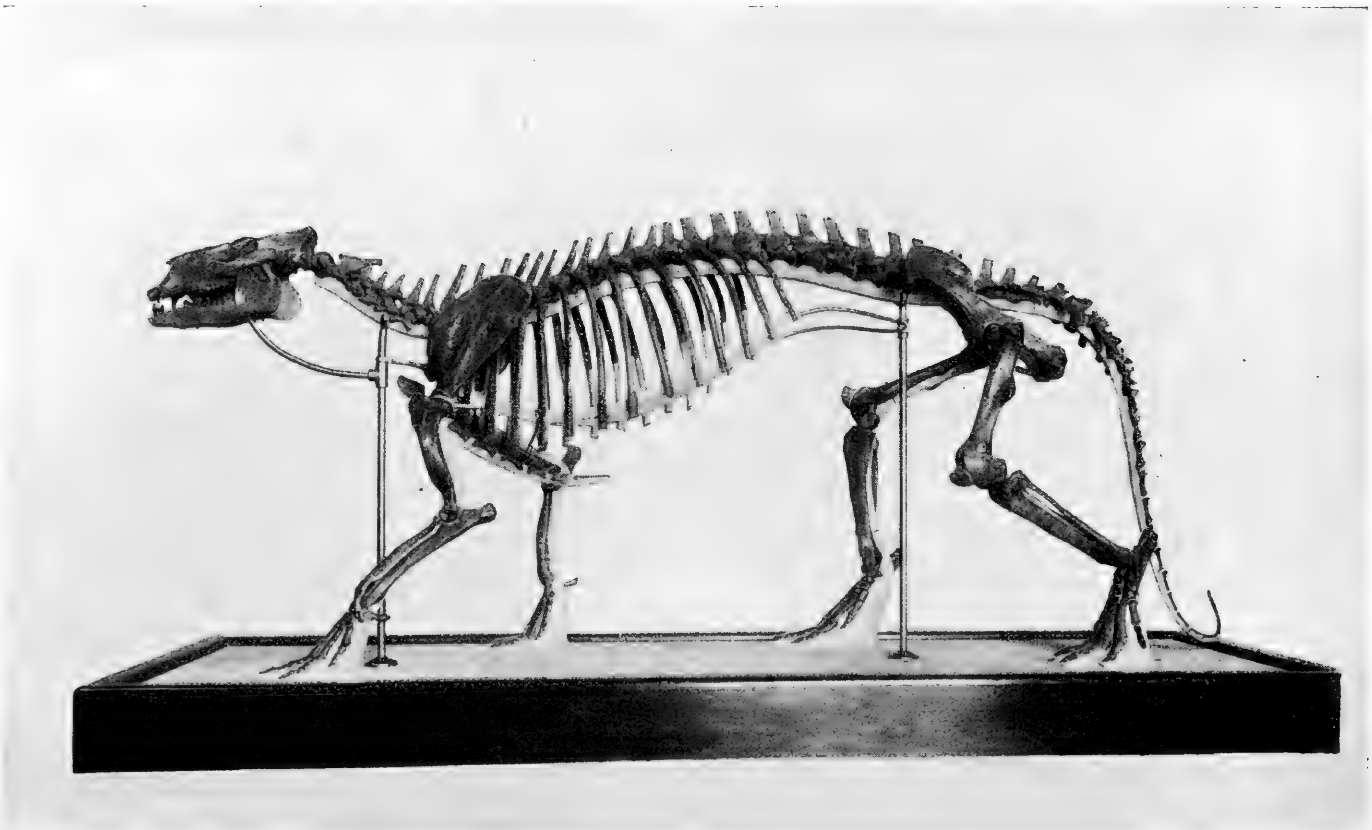

Fig. 7. Mounted skeleton of *Phenacodus primævus* in the American Museum of Natural History. One-twelfth natural size.

and it was not until 1896 that the Museum Expeditions enabled us to mount the complete skeleton. The animal exhibits a curious mixture of primitive and specialized characters, the former being dominant in the limbs and body, the latter appearing in the skull and feet. The flat-topped skull with slight rudiments of frontal and parietal horns, the spreading, hippopotamus-like front teeth, the short elephantine feet and broad pelvis, are the most noticeable specialized characters. *Coryphodon* was nearly related although not directly ancestral to the Uintatheres (*Dinoceras*) of the Middle Eocene or Bridger Beds.

The skeleton as mounted is composed of a number of individuals of the same species, size and age, collected by the Museum Expedition of 1896.

OSBORN, *Coryphodon radians* Cope, A Complete Skeleton of *Coryphodon*, Bull. Am. Mus. Nat. Hist., X, 1898, p. 81.
Coryphodon testis OSBORN, Evolution of the Amblypoda, *ibid.*, pp. 189–204.
See also MARSH, Am. Jour. Sci., 1893, p. 321.

10. **Teleoceras (Aphelops) fossiger** (*Cope*).

Am. Mus. No. 2604.

This Rhinoceros was the most abundant large animal of the Upper Miocene of Western America. Its bones are found in some localities (such as the famous quarry at Long Island, Phillips Co., Kansas) in great numbers and remarkably well preserved, but the individuals are not distinguishable. This skeleton, made up of many individuals of appropriate size, is mounted with concealed steel rods traversing the bones and only two visible main supports. The male probably bore a small horn, which was rudimentary or absent in the female. The animal had much shorter legs and a heavier body than any modern Rhinoceros, the principal measurements being: height at shoulder, 4 ft. (M. 1.22); at pelvis, 3 ft. 8 in. (M. 1.12); total length, 10 ft. 3 in. (M. 3.12); greatest girth or chest circumference, 9 ft. 2 in. Its size was about that of the largest living species, except in the height. The neck was short, the head rather small, the body extremely thick and barrel-like, the belly almost reaching the ground.

OSBORN, Bull. Mus. Comp. Zoöl., XX, p. 92; Bull. Am. Mus. Nat. Hist., X, 1898, p. 51.

WILLISTON, Restoration of *Aphelops fossiger*, Kans. Univ. Quar., 1894, p. 289, pl. viii.

11. **Cænopus tridactylus** (*Osborn*).

Am. Mus. No. 538.

This skeleton was found by the American Museum Field Party in 1892, and was the first skeleton mounted by the Department; although very complete it is considerably crushed, and has been mounted in low relief. The skeleton as it lay in the rock was doubled over on itself; it has been straightened out and a missing fore limb modelled in plaster, otherwise it is in the position that it had in the rock. The matrix is chiefly plaster, colored and chipped to imitate the surface of the gray sandstone original. Length from tip of nasals to bend of tail, 7 feet 9 inches. The animal was about the size of the living Sumatran Rhinoceros, but was hornless, or with rudimentary *paired* horns on the male.

OSBORN & WORTMAN, Fossil Mammals of the Lower Miocene White River Beds, Bull. Am. Mus. Nat. Hist., VI, 1894, pp. 206–207, pl. iii.

OSBORN, Mem. Am. Mus. Nat. Hist., Vol. I, Pt. IV, Oct., 1899.

12. **Phenacodus wortmani** *Cope*.

Am. Mus. No. 4378.

This small species of *Phenacodus* was found by Dr. Wortman in the same beds as *P. primævus*. This skeleton was mounted in the original matrix in the Cope Collection, but has been chiselled out of the rock and remounted in low relief, the missing parts of the bones being restored in plaster. Each bone is easily removable for separate study.

COPE, Tertiary Vertebrata, p. 464, pl. xxix*e*.

13. **Cænopus occidentalis** (*Leidy*).

Am. Mus. No. 1132.

This characteristic Rhinoceros of the Middle Oligocene of the West is ancestral to *C. tridactylus* of the Upper Oligocene, and thus leads to the Dicerathere line. *C. occidentalis* was hornless, somewhat smaller than the living Sumatran Rhinoceros and more lightly proportioned. This skeleton is mounted in full relief.

OSBORN, Mem. Am. Mus. Nat. Hist., I, Pt, III, April, 1898.

14. **Tylosaurus dyspelor** (*Cope*).

Am. Mus. No. 221.

Upper Cretaceous (Niobrara) of Kansas.

Tylosaurus dyspelor was one of the largest of the Mosasaurs, great marine lizards, distantly related to the living Monitor Lizard (*Varanus*), but adapted to strictly aquatic life. This fine skeleton, found by Mr. W. G. Bourne, is twenty-eight feet long and exceptionally perfect, even the cartilages being preserved. The skeleton is mounted in the original matrix and position.

OSBORN, Mem. Am. Mus. Nat. Hist., I, Pt. IV, October, 1899.

15. **Protoceras celer** *Marsh.*

Am. Mus. No 1236.

Upper Oligocene (White River, Protoceras Beds), S. Dakota.

Protoceras was the largest of a group of Primitive Ruminants found in the White River Beds, which had two toes in the hind foot, four in the fore foot. The proportions are nearly those of the smaller deer, but with shorter limbs and neck. The male skull bore several bony bosses comparable to the bosses on a giraffe skull instead of true horns or antlers; the female was hornless. This skeleton is that of a female, and is mounted in high relief.

MARSH, Am. Journ. Sci., 1891, Jan., p. 81; 1893, Nov., p. 407; 1897, Sept., p. 165.

OSBORN & WORTMAN, Characters of *Protoceras*, Bull. Am. Mus. Nat. Hist., IV, 1892, p. 351.

SCOTT, Osteology and Relations of *Protoceras*, Jour. Morph., XI, p. 303.

16. **Oxyæna lupina** *Cope.*

Am. Mus No. 107.

Lower Eocene (Wasatch), Big Horn Valley, Wyoming.

Oxyæna was a typical Creodont or Primitive Carnivore. Large head, with small brain and long, powerful jaws, short, bandy legs, short, subplantigrade feet, and long tail, are the most marked primitive characters.

This skeleton was pieced together with great labor out of two fragmentary specimens, one found by Dr. Wortman in 1881 and described by Cope in 'Tertiary Vertebrata' (Specimen No. 2), the other found in 1891 and described by Osborn and Wortman in the American Museum Bulletin for 1892. On comparing these two specimens it was found that they belonged to the same individual, and that the skeleton was nearly complete, though broken into innumerable fragments. The skeleton is mounted in full relief, every bone being removable.

WORTMAN, Restoration of *Oxyæna lupina* Cope, etc., Bull. Am. Mus. Nat. Hist., XII, 1899, p. 139.

17. **Equus scotti** *Gidley.*

17a. **Equus scotti** and **Protorohippus venticolus.**

Am. Mus. No. 10612.

Pleistocene, Rock Creek, Llano Estacado, Texas.

This skeleton is one of eight found together by J. W. Gidley of the American Museum Expedition of 1899. It shows as mounted the zebra-like proportions of this native American wild horse, especially seen in the large head and deep jaws, short barrel, small limbs and feet.

GIDLEY, A new Species of Pleistocene Horse from the Staked Plains of Texas, Bull. Am. Mus. Nat. Hist., XIII, 1900, pp. 111–116; and Revision of American Species of *Equus*, *ibid.*, 1901, XIV, pp. 91–140.

18. **Amynodon intermedius** *S. & O.*

Am. Mus. No. 1931.

Upper Eocene (Uinta) Utah. Found by A. O. Peterson, American Museum Expedition, 1895.

Amynodon was a collateral ancestor of the large Aquatic Rhinoceros, *Metamynodon*, of the Oligocene epoch, and is largely intermediate, both in size and in characters of the skull and skeleton, between it and the Middle Eocene Rhinoceros. This skeleton is mounted in high relief.

19. **Mastodon americanus** (*Kerr*).

Pleistocene Epoch, Newburgh, New York.

Remains of *Mastodon* have been found in numerous localities scattered all over the Eastern States and Mississippi Valley, and mounted skeletons are to be seen in several American and European museums. This skeleton was found in a peat bog near Newburgh, N. Y., and is one of the largest; size, 9 feet high, 18 feet long as mounted. The Mastodons differed strikingly from the Mammoths in proportions, as well as in the number and character of their teeth, form of skull and curve of tusks.

20. **Platygonus leptorhinus** *Williston.*

Pleistocene Epoch, Kansas.

This skeleton is one of nine found together in Western Kansas and described by Prof. Williston in 1894. The proportions and pose of the skeleton at once suggest the living peccaries (*Dicotyles*), from which *Platygonus* differed chiefly in its larger size, more specialized feet and teeth.

21. **Oreodon culbertsoni** *Leidy.*

Oligocene Epoch, Big Badlands, S. Dakota.

Oreodon was first described by Joseph Leidy in 1851, and is the most abundant and characteristic fossil of the Big Badlands. This species is of the size of a peccary, and the skeleton, a composite of two very perfectly preserved individuals obtained by the American Museum Expedition of 1894, shows somewhat similar proportions, but is much more primitive in characters, and in most respects has departed comparatively little from the old ancestral type of the Artiodactyla.

22. **Hyænodon horridus** *Leidy.*

Am. Mus. No. 1375.

Oligocene Epoch, Big Badlands, South Dakota.

This finely preserved skeleton was found by the American Museum Expedition of 1894, and is all one individual, the few missing parts being restored in tinted plaster. *Hyænodon* is the best-known and the most highly developed of the Creodonta, and is found both in Europe and America. This species is about the size of the Tasmanian Wolf (*Thylacinus*), which it resembles to a striking degree in proportions of limbs and feet and in many characters of the skull.

23. **Pantolambda bathmodon** *Cope.*

Basal Eocene, San Juan Basin, New Mexico.

Pantolambda is the most ancient mammal of which the entire skeleton is known. This mount is a composite of several incomplete skeletons obtained by the American Museum Expedition of 1896 in the Torrejon (Upper Puerco) horizon of Northwestern New Mexico. It exhibits the short, crooked legs, five-toed, plantigrade feet, long, heavy tail, arched back, primitive skull, with heavy jaws and small brain case, and many other characters which were the common heritage of the early mammals from their reptilian ancestors.

OSBORN, Evolution of the Amblypoda, Bull. Am. Mus. Nat. Hist., X, 1898, pp. 183–188.

24. **Hypohippus equinus** (*Scott*).

Middle Miocene, Pawnee Buttes, Colorado.

This three-toed Horse is not in the direct line of descent of the modern horses, but on a somewhat conservative side-branch. The skeleton is as large as that of a Shetland pony and is mounted in full relief in a walking pose. The head, limbs, and feet are in exceptionally fine preservation. The side view shows best the general proportions of the animal; the view from behind, which best displays the small lateral digits, can also be supplied. *Hypohippus* is closely related to *Anchitherium* of the Lower Miocene, from which it is probably directly descended. This skeleton was found by Mr. Brown of the American Museum Expedition of 1901.

25. **Ichthyosaurus quadriscissus** *Quenstedt.*

Jurassic Period, Holzmaden, Wurttemberg.

This fine skeleton was presented to the American Museum by the Royal Natural History Museum of Stuttgart, through Prof. Eberhardt Fraas. It is of especial interest as showing that the Ichthyosaurs were viviparous instead of egg-laying reptiles. The skeletons of seven young (unborn) Ichthyosaurs can be seen, partly in, partly washed out of the body-cavity.

26. **Portheus molossus** *Cope.*

Upper Cretaceous (Niobrara) of Kansas. Found by C. H. Sternberg.

This great fish is characteristic of the marine Upper Cretaceous chalk formation of Western Kansas. It was related to the modern Tarpon of Florida but of gigantic size, this skeleton being 18 feet in length. The head and tail are especially fine; the ribs and fins are mostly restored in plaster. It is much flattened and is mounted in low relief.

27. **Hippopotamus liberiensis** *Morton.*

The Pigmy Hippopotamus of the West Coast of Africa is a rare species, almost extinct. This skeleton is semi-fossil, and was presented by the Museum of Christiania, Norway.

28. **Ornitholestes hermanni** *Osborn.*

Upper Jurassic (Como), Wyoming.

This beautiful little skeleton, about seven feet in length, represents a little-known group of Carnivorous Dinosaurs adapted for swift running and the seizing of a light and agile prey. The tail is extremely long, slender, and whip-like, the hind limbs long and the feet like those of a bird, while the small fore limbs are modified into remarkable prehensile organs, the first and second digits greatly elongated and opposed, with large curved claws, the third digit small and slender, and the fourth atrophied.

Osborn, Bull. Am. Mus. Nat. Hist., XIX, 1903, pp. 459–464.

29. **Mesohippus bairdi** *Leidy.*

Middle Oligocene (White River), South Dakota.

This classic species represents an early stage in the evolution of the Horse. It is smaller than the modern Dorcas Gazelle, and has three toes on each foot, the lateral toes slender but reaching to the ground. Vestiges of the first and fifth digits are still preserved in the fore foot. *Mesohippus* is somewhat peculiar in the unusual length of the hind limbs as compared with the fore; in other respects it is intermediate between the four-toed horses of the Eocene and the modern horse.

Scott, W. B., On the Osteology of *Mesohippus* and *Leptomeryx*, Jour. Morph., V, 1891, pp. 301–406.

Farr, Notes on the Osteology of the White River Horses, Proc. Amer. Phil. Soc., XXXV, 1896, p. 147–175.

30. **Merycodus osborni** *Matthew.*

Middle Miocene, Pawnee Creek Bed, Colorado.

Merycodus is a collateral ancestor of the modern Pronghorn Antelope of Western North America, but is distinguished by large, branching, deciduous antlers like those of the Deer.

The bony rudiments of lateral toes, present in nearly all deer but absent in all antelopes, are still preserved in *Merycodus*, but exceedingly minute, much smaller than in the deer. The animal was of about the size of the Dorcas Gazelle.

MATTHEW, W. D., A Complete Mounted Skeleton of *Merycodus*, Bull. Am. Mus. Nat. Hist., XX, 1904, pp. —.

See also SCOTT, W. B., Bull. Mus. Comp. Zoöl., XX, 1890, p. 82 (*Cosoryx furcatus*).

IV.—PHOTOGRAPHS OF RESTORATIONS, BY CHARLES KNIGHT.

Presented by J. Pierpont Morgan, and exhibited in the Department of Vertebrate Palæontology. Bromide enlargements from the original negatives. Size, 18 in. x 22 in.

These photographs are from a series of large water colors executed for the American Museum by the animal painter, Mr. Charles Knight, under direction of Prof. Osborn, with suggestions and criticisms by other palæontologists, the object being to increase the popular interest in these extinct animals, and to give a fuller and truer idea of their anatomy and external form than is afforded by the skeleton.

The artist begins each study by preparing a number of models in wax, based upon the actual proportions and muscular indications of the skeleton, and by a series of preliminary sketches, representing different attitudes, habits, and surroundings. Thus the position of all the joints and angles of the feet and limbs is true to life. The lips, nostrils, and gape of the mouth are determined by comparison of the length of the nasals, size of the anterior nares, character and position of the teeth, with similar parts in the remotely related living forms. The eyes are carefully located and proportioned. Up to this point the animal is a fairly correct representation of the original. On the other hand, the shape of the ears, the color and epidermic characters of hair and hide are largely imaginative, except in so far as they are suggested by relationship to modern allies, as of *Protorohippus* to the Horse, or of *Cænopus*, *Metamynodon*, and *Hyracodon* to the Rhinoceros.

These restorations are copyrighted and the photographs are sold with the understanding that they are to be used only for exhibition purposes, and are not to be copied or adapted for publication.

Price of the photographs, $4 each.

1. Patriofelis, Middle Eocene Creodont.

This animal is based upon studies of the skeleton mounted in the American Museum Collection (No. 1507). The following quotation from an article by Dr. Wortman explains the picture: "The broad, flat, plantigrade feet, with their spreading toes, suggest at the first glance their use for swimming. The eversion of the feet, together with the general clumsiness of the limbs point, moreover, to the fact that the animal was not an active runner. . . . He was perhaps not as expert a swimmer as the seals are now, but was sufficiently active in the water to capture turtles." This is perhaps the least original and successful of the restorations, being modelled somewhat too closely upon the Otter. More recent studies by Osborn have cast much doubt upon the aquatic habits of the animal as indicated by Wortman.

Originally reproduced by Osborn in 'Prehistoric Quadrupeds of the Rockies,' Century Magazine, September, 1896.

WORTMAN, The Osteology of *Patriofelis*, Bull. Am. Mus. Nat. Hist., VI, 1894, pp. 119–64, pl. i.

OSBORN, *Oxyæna* and *Patriofelis* Re-studied as Terrestrial Creodonts, Bull. Am. Mus. Nat. Hist., XIII, 1900, pp. 269–279.

2. Protorohippus venticolus, Four-toed Lower Eocene Horse.

The studies for this animal were based upon skeleton No. 4832, mounted in the American Museum Collection. The very primitive characters of this early stage in the evolution of the Horse are especially seen in the short neck and legs, the heavily muscular part of the limb extending much further down in proportion to the lower leg and foot. The arched back and short head are likewise striking characters. The striping of the neck and fore quarters is based upon the fact that the young of all modern species of Equidæ show a more or less marked tendency to striping in these parts. The animal in life was about 4 hands, or 16 inches, in height at the withers.

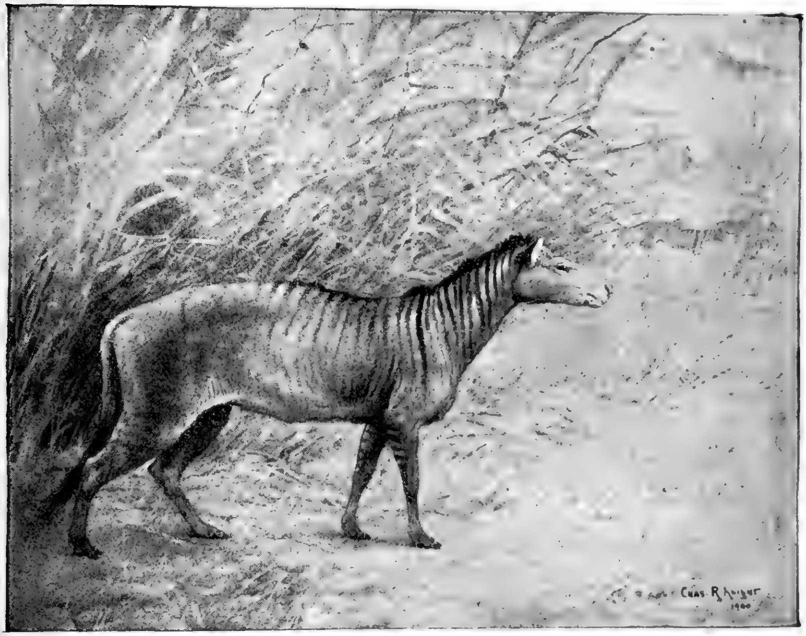

Fig. 8. Restoration of the Four-toed Eocene Horse *Protorohippus*. Height at withers sixteen inches.

Originally reproduced by Lucas in McClure's Magazine. 1899.

Cope, Tertiary Vertebrata, U. S. Geol. & Geog. Sur. Terrs., F. V. Hayden in charge, Final Report, IV (1885), pp. 635–647, pll. xlix, *a*, *b*, *c*.

3. Cænopus, A Hornless Upper Oligocene Rhinoceros.

The study is based upon the complete mounted skeleton, No. 538, in the American Museum, of *Cænopus tridactylus*. This animal compares in its dimensions and in the general characters of its skeleton with the Two-horned Rhinoceros of

Sumatra; and Mr. Knight's studies for this picture were practically based upon that living type.

Osborn & Wortman, Fossil Mammals of the Lower Miocene White River Beds, Bull. Am. Mus. Nat. Hist., VI, 1894, p. 206, pl. iii.

4. Protoceras, Six-horned Upper Oligocene Ruminant.

The characters of this animal are known from complete female skeletons in the American Museum of Natural History and the Princeton Museum, and a very complete series of male and female skulls, secured by the American Museum Expeditions of 1892 and 1894. As exhibited, there is a wide contrast between the male and female skulls, the latter being entirely devoid of horns. The very marked recession of the nasals has suggested the presence of a long, somewhat expanded upper lip, as in the modern Saiga, while the coloring of the animal is based upon that of the North American Pronghorn Antelope.

Originally reproduced by Osborn in the Century Magazine, September, 1896.

Osborn & Wortman, Characters of *Protoceras* Marsh, Bull. Am. Mus. Nat. Hist., IV, 1892, pp. 351–371.

5. Metamynodon, Aquatic Middle Oligocene Rhinoceros.

The study is based upon the mounted skeleton, No. 546, in the American Museum, and represents the general conception of the animal as aquatic. The opinion as to the aquatic habits of *Metamynodon* was very largely due to the studies made for this drawing in which it became apparent that the very elevated position of the orbits, the widely expanding ribs, and the four complete spreading toes in the fore foot, strongly suggested the general build of the Hippopotamus. This aquatic life is, moreover, consistent with the presence in the same beds of two other types of Rhinoceros, it being improbable that the three types were all land animals.

Originally reproduced by Osborn in the Century Magazine, September, 1896.

Osborn & Wortman, Perissodactyls of the Lower Miocene White River Beds, Bull. Am. Mus. Nat. Hist., VII, 1895, pp. 373–375 pll. x, xi.

6. Elotherium, Giant Upper Oligocene Suilline.

These animals have been depicted from very complete remains in the American and Princeton Museums, and represent the largest type of Oligocene Elothere, namely, the *E. ramosum* of Cope, or *E. imperator* of Marsh. The great flanges below the cheeks for the attachment of the masseter muscles presented peculiar difficulties, and it is possible that they are not here exhibited with sufficient expansion. The head is of enormous size, but the chest is small, and the limbs are comparatively tall and stilted, as here represented. The very remote relationship to the Pig and to the Hippopotamus is suggested in the bristles and in the form of the lips. *Elotherium* is in a general way a sort of dry-land hippopotamus, as *Metomynodon* is an aquatic rhinoceros; in the one case the dry-land type, in the other, the aquatic type, has become extinct.

Originally reproduced by Osborn in the Century Magazine, September, 1896.

Marsh, Am. Jour. Sci., XLVII, 1894, p. 408, pl. ix.

7. Megacerops, Long-horned Lower Oligocene Titanothere.

This group of male, female, and young is based upon skulls belonging to different sexes and ages, in the American Museum Collection, as well as upon the complete skeleton, No. 518, mounted in the American Museum. There is no doubt that the females had smaller skulls, with imperfectly developed horns and narrow zygomatic arches, while the males of the same species had extremely long, recurved horns. The extension of the premaxilla and the overhanging of the nares by the rudimentary nasals indicate that there was not space for a proboscis, but rather a prehensile upper lip, which suggests the same structure in the Rhinoceroses.

Originally reproduced by Osborn in the Century Magazine, September, 1896.

Osborn & Wortman, Perissodactyls of the Lower Miocene White River Beds, Bull. Am. Mus. Nat. Hist., VII, 1895, pp. 346–352, pll. viii, ix.

8. Uintatherium, Six-horned Middle Eocene Amblypod.

The male and female here represented are based upon skeletal material as yet unmounted in the American Museum Collection, also upon the reconstruction published by Professor O. C. Marsh. The structure of the male skull, as here represented, corresponds with the largest type ever found, that of the *Uintatherium cornutum* skull, discovered by Professor Cope himself, and now in the American Museum. There is no indication of a proboscis, nor is there any reason to believe that the bony protuberances bore horns, many of them expanding at the tip, as is never the case with true horn-cores. The tusks, both in male and female, are found chiefly worn upon the posterior surface, a fact which suggests that they were used upon branches in drawing leaves and shrubs into the mouth, as represented in the female figure in the rear. Their chief function was probably as weapons of defence or attack, the exceptionally wide gape of the jaw, as indicated by the position and form of its muscular attachments, giving room for their use in a very effective manner.

Originally reproduced by Osborn in the Century Magazine, September, 1896.

COPE, Tertiary Vertebrata, pp. 569–587, pll. xxxvii–xlii.
MARSH, The Dinocerata, U. S. Geol. Sur. Mon., X, pp. 1–243, pll. i–lvi, 1886.

9. Hyracodon, Cursorial Oligocene Rhinoceros.

This restoration is based also upon material in the American Museum and Princeton Collections. The general conception of *Hyracodon* as a running type was outlined by Scott in 1883. These animals thus presented the widest contrast to the swimming Rhinoceroses, or *Metamynodon*, on the one side, and the low-land or swamp Rhinoceroses, the *Aceratheres*, on the other. The upper molar teeth, however, closely resemble those of the Rhinoceros, and form the motive for the resemblance to this animal, which is given in the face. The trunk and limbs, on the other hand, resemble very closely those of the primitive horses. Hence the motion characteristic of the galloping horse is given to the skeleton.

Originally reproduced by Osborn in the Century Magazine, September, 1896.

Scott, Osteologie von Hyracodon Leidy, Festsch. f. Gegenbaur, 1896, pp. 353–383, pll. i–iii.

10. Mesonyx, Omnivorous Middle Eocene Credont.

This huge animal is represented preying upon the skull of an Uintathere, in order to give some conception of its size. The skull, as represented in the American Museum Collection, No. 1892, is extremely large and armed with very blunt teeth, wearing down in old age, indicating that the animal was omnivorous, or lived partly upon turtles or decaying animal food. The form of this body is derived from a complete skeleton in the Princeton Museum, which has been figured by Scott. It slopes backwards, the posterior quarters being rather small; the tail is extremely long and powerful, the general proportions resembling somewhat those of the Tasmanian Wolf.

Originally reproduced by Osborn in the Century Magazine, September, 1896.

Scott, New and Little-known Creodonts, Jour. Acad. Nat. Sci. Phila., IX, 1887, pp. 155–185, pll. v–vii.

Wortman, Studies of Eocene Mammalia in the Marsh Collection, Part I, Carnivora, Am. Journ. Sci., XII, 1901, pp. 285, 377, 421; XIII, 1902, p. 39.

11. Palæosyops, Eocene Hornless Ancestral Titanothere.

This animal is based upon the complete skeleton mounted in the American Museum, and is represented as having somewhat the habits of the Tapir, living in low, marshy land, and feeding entirely upon the softer kinds of leaves and grasses, since its teeth are entirely unadapted to hard grasses or the more silicious plants. According to the studies of Earle, the animal was devoid of a proboscis, but had an elongated, prehensile upper lip. The slender fore feet are very similar in proportions to those of the aquatic Rhinoceroses.

Originally loaned for reproduction in Harper's Magazine, 1897.

Earle, On the genus *Palæosyops*, etc., Jour. Acad. Nat. Sci. Phila., IX., 1892, pp. 267–388, pll. x–xiv, and restoration, p. 314.

12. Mastodon americanus, North American Pleistocene Elephant.

This animal is executed from the skeleton in the American Museum of Natural History, and it is characterized by being partly hairy, in contrast with the extremely hairy northern variety of the Mammoth, and in view of the probability that all the more primitive elephants were coated with hair. It has distinctly the low, flat skull of the African Elephant, whereas the Mammoth had the high, prominent forehead characteristic of the Indian Elephant. The skeleton is also distinguished by enormously large, projecting feet, larger than in any existing species, and by the relative shortness of the limbs, also a primitive feature. This restoration, therefore, while based upon studies of the elephant, exhibits the characteristic proportions which distinguished the Mastodon externally.

Originally executed for reproduction in Harper's Magazine, 1897.

13. Dryptosaurus (Lælaps), Carnivorous Cretaceous Dinosaur.

In this and the four following restorations Mr. Knight was guided largely by ideas and sketches given him by Prof. Cope shortly before the latter's death. They are based upon specimens in the Cope Collection now in the American Museum, and upon restorations by Professor Marsh of related types.

This Dinosaur, represented in the photograph as engaged in combat, was of considerable size, about fifteen to twenty feet in length, and well armed in teeth and claws. Prof. Cope considered that the long hind limbs and heavy tail indicated great leaping powers, in spite of its large size, and the restoration is made in accordance with this idea. *Dryptosaurus* was allied to *Ceratosaurus* of Marsh and to the European *Megalosaurus*.

Cope, Proc. Acad. Nat. Sci. Phila., 1866, 275; Proc. Am. Phil. Soc., XXX, p. 240, May, 1892.

Marsh, Dinosaurs of North America, pp. 157–163, pl. xiv.

14. Elasmosaurus, Long-necked Cretaceous Plesiosaur.

Elasmosaurus was one of the largest of the marine reptiles which inhabited the Cretaceous seas. It was related to the

European *Plesiosaurus*, which it resembled in shape, except in the flattened tail. It is represented in the restoration as capturing a young *Portheus*, one of the large, bony fishes of the period. A skeleton in the Museum of the Philadelphia Academy of Natural Sciences, and another more complete in the Cope Collection (but both lacking the skull), served as the basis for the restoration. The Plesiosaurs differed greatly in the length and flexibility of the neck, as well as in size.

COPE, Cretaceous Vertebrata, U. S. Geol. & Geog. Surv. Terrs., F. V. Hayden in charge, Final Report, II, pp. 75–88.
DAMES, Abh. k. preuss. Akad. Wiss. Berlin, 1895, pp. 75–80; Natural Science, Jan., 1898, p. 48.

15. Agathaumas, Three-horned Cretaceous Dinosaur.

These herbivorous Dinosaurs were of great size and had large heads armed with three horns, and a great projecting crest or frill protecting the neck. The body may have been covered with small bony plates (scutes). This restoration is based on a reconstruction of the skeleton of *Triceratops prorsus* by Prof. Marsh. *Agathaumas sphenocerus* Cope, shown in the picture, is distinguished by the large anterior median horn and small posterior paired horns.

COPE, Amer. Nat., 1886, p. 716; 1892, p. 768.
MARSH, Dinosaurs of North America, Ann. Rep. U. S. Geol. Surv., 1896.

16. Naosaurus and Dimetrodon, Spine-backed Permian Lizards.

These ancient reptiles represent an early specialized branch of the primitive Rhynchocephalians. Their most remarkable character is in the enormously elongated dorsal spines of the vertebræ, with (in *Naosaurus*) or without (in *Dimetrodon*) transverse bars of bone. The restoration is based on a number of incomplete skeletons in the Cope Collection.

COPE, Proc. Amer. Phil. Soc., 1878, p. 512.
BAUR & CASE, Morphology of the Skull of the Pelycosauria, Anatom. Anzeig., Jena, 1897, XIII, p. 109.

17. Hadrosaurus, Duck-billed Cretaceous Dinosaur.

Drawn from the unusually complete skeleton of *Hadrosaurus* (*Diclonius*) *mirabilis* Leidy, in the Cope Collection now in the American Museum. This very specialized genus is found in the Upper Cretaceous of New Jersey and Wyoming. It was herbivorous, and probably amphibious, with long neck and heavy hind quarters. It had a broad, duck-like, horny bill, and back of it a magazine of numerous small, rod-like teeth, not less than a thousand in each jaw, set on end in several close-set rows, and wearing to a tesselated-pavement-like grinding surface. The length was about thirty feet.

The skeleton of a nearly related genus, *Claosaurus*, is mounted in the Yale Museum.

Cope, Proc. Acad. Nat. Sci. Phila., 1883, p. 97; Amer. Nat., 1883, p. 774.

18. Siberian Mammoth or Hairy Elephant.

Unlike the living elephants, the Mammoth ranged into arctic countries, and is here restored with its appropriate environment, taken from the region of the Taku Glacier, Alaska. It was a contemporary of primitive man, and its enormous size is therefore fitly indicated by the contrast with human figures in the background. In this instance the color and texture of the hide is certainly known, from the mammoth carcasses which have been found frozen in the palæocrystic ice of northern Siberia, and parts of which are still preserved in the St. Petersburg Museum.

19. Cervalces, Pleistocene American Elk.

Cervalces was as large as the Moose, but is distinguished by its magnificent antlers, spreading in three directions, outward, upward, and forward, and attaining a size and complexity unequalled by any living species. The fine skeleton in the Princeton Museum served as a basis for this restoration, the superficial characters being studied from the Moose.

Scott, Proc. Acad. Nat. Sci. Phila., 1885, p. 191.

20. Condylarth or Primitive Hoofed Mammal Phenacodus.

Lower Eocene Epoch.

This is drawn after the famous skeleton discovered by Wortman and described originally by Cope, and as remounted by Osborn.

Phenacodus belongs to the group of Primitive Ungulates from which all the modern hoofed animals are descended. It is in many respects like the clawed animals (Unguiculates) from which the hoofed animals (Ungulates) branched off. Five toes on each foot, pig-like teeth, arched back, short legs, narrow chest, lank sides, long tail, all are characters of the primitive clawed animals still retained by *Phenacodus*, but lost by modern hoofed animals.

OSBORN, Remounted Skeleton of *Phenacodus primævus*, Bull. Am. Mus. Nat. Hist., X, 1898, p. 159.
COPE, Tertiary Vertebrata, pp. 428–463, pl. lvii *b*–lviii.

21. Hornless Amblypod Coryphodon.

A short-footed, hoofed animal of the Lower Eocene Period.

This remarkable animal was related to the huge Uintatheres. It had five very short toes on each foot. The anterior teeth suggest those of the Hippopotamus, but the grinding teeth are entirely different. The neck is short, the body rather long, with many archaic characters. The legs are short and clumsy, the upper joint disproportionately long. The brain is remarkably small. At the sides of the top of the skull are bony projections prophetic of the posterior horns of the Uintathere.

Coryphodon was probably an amphibious animal living in the marshes and rivers bordering the ancient Wasatch Lake. Its large tusks were used presumably in rooting up water-plants, and were also formidable weapons of defense against the larger flesh-eating animals of that period. Its general appearance was unlike that of any modern animal, for, although it combined some characters of such dissimilar beasts as the Bear, Elephant, and Hippopotamus, it had many peculiarities of its own.

OSBORN, Bull. Am. Mus. Nat. Hist., X, 1898, pp. 81–91.

22. Primitive Sabre-tooth Tiger Hoplophoneus.

Oligocene Epoch.

The most striking difference between Sabre-tooth Tigers and the great living cats is in the long, flattened sabre-like upper canine teeth, which in *Smilodon* (Restoration No. 31) were seven inches long. These teeth could pierce the hides of rhinoceroses and other thick-skinned animals common in America in the Oligocene Period, against which the shorter fangs of modern lions would be ineffective. The legs were shorter and more muscular than those of the larger modern cats, the animal more powerful, but by no means as swift-footed.

SCOTT & OSBORN, Bull. Harv. Mus. Comp. Zoöl., 1887, p. 153, pl. i.

RIGGS, Restoration of *Hoplophoneus occidentalis*, Kans. Univ. Quar., V, 1896, pp. 37–52, pl. i.

23. Short-legged American Rhinoceros Teleoceras.

Upper Miocene Epoch.

Teleoceras, the last known survivor of the Rhinoceros race in America, was also the largest; and its fossil remains are so abundant in certain localities as to indicate that it lived in great herds upon the plains, like the Bison in more modern times.

The body was as long and heavy as that of the living Indian Rhinoceros, but the legs were so short that the belly nearly reached the ground, giving the animal the squat proportions of the Hippopotamus. The male had a small horn on the end of the nose; the female was hornless.

OSBORN, Complete Skeleton of *Teleoceras fossiger*, Bull. Am. Mus. Nat. Hist., X, 1898, pp. 51–59, pll. iv, iv*a*.

WILLISTON, Restoration of *Aphelops fossiger*, Kans. Univ. Quar., 1894, p. 289, pl. viii.

SCOTT & OSBORN, Bull. Harv. Mus. Comp. Zoöl., pp. 92–99, pl. ii.

24. Amphibious Dinosaur Brontosaurus.

Upper Jurassic Period.

In the Reptilian Age, preceding the Age of Mammals, great reptiles were dominant on land and water. The Dinosaurs, or

Giant Reptiles, were the chief inhabitants of the lowlands and marshes. Preëminent in size among these were the Sauropoda, or Amphibious Dinosaurs, a herbivorous group, mostly of gigantic size, from forty to seventy-five feet in length,—the greatest of land animals living or extinct, and exceeded in size only by the modern Whales.

The long neck and small head enabled them to lie concealed in marshy bayous and lagoons, the body generally immersed, the head foraging for food without easily attracting the attention of the great carnivorous reptiles which lived at this time. The long and massive tail was useful both as a support and a propeller.

Brontosaurus was among the largest of the Sauropoda, seventy feet in length and about eighteen feet in height to the arch of the back. The thigh-bone is six feet long, and weighs in its petrified condition 500 to 600 pounds.

MARSH, Dinosaurs of North America, Sixteenth Ann. Rep. U. S. Geol. Surv., 1896, pp. 166–175, pl. xlii (*Brontosaurus excelsus*).
OSBORN, Bull. Am. Mus. Nat. Hist., X, 1898, p. 219.

25. Great Marine Lizard or Mosasaur Tylosaurus.

Upper Cretaceous Period.

This restoration is made from the complete skeleton, thirty feet long, in the American Museum.

The Mosasaurs were carnivorous Sea-Reptiles abundant in the warm, shallow seas of the Upper Cretaceous Period, but not yet found earlier or later. Large flat head, short neck, four paddle-limbs like the flippers of whales, vertically flattened, swimming tail. Length of different species, from twelve to forty feet. Their nearest living ally is the Monitor Lizard (*Varanus*) of the Nile Valley.

OSBORN, A Complete Mosasaur Skeleton, Osseous and Cartilaginous, Memoirs Am. Mus. Nat. Hist., I, Pt. IV, Oct., 1899, pll. xxi–xxiii and text illustrations.
WILLISTON, Kansas Univ. Quar., VIII, 1899, pp. 39–41; Univ. Geol. Surv. Kansas, IV, Pt. V, pp. 83–221, pll. x–lxxii.

26. Great Irish Deer Megaceros.

Pleistocene Epoch. Europe.

Drawn from the skeleton mounted in the American Museum. *Megaceros* exceeded any living deer in the spread of its antlers, in some cases ten or even eleven feet from tip to tip. In size it is about equalled by the Moose, but the proportions were somewhat different, approaching those of the Fallow Deer (*Cervus dama*) to which it was more nearly related. The most abundant and complete remains have been found in the bogs of Ireland, but the animal ranged all over Western Europe. It is not found in America.

27. Primitive Mastodon Trilophodon.

Miocene Epoch.

Based upon a skull and incomplete skeleton in the American Museum, and upon the restored skeleton of *T. angustidens* by Prof. Gaudry. These Miocene ancestors of the Mastodons and Elephants were much less specialized than their later descendants. This is especially seen in the small tusks in both upper and lower jaws, the upper ones curving down, the lower ones straight, and both with an external or anterior enamel band like the incisors of rodents,— in the shorter trunk, as indicated by the characters of the skull, in the limbs of moderate length and toes much less reduced than in the Pliocene and Pleistocene proboscidians.

28. Great Carnivorous Dinosaur Allosaurus.

Upper Jurassic Period.

This great carnivorous reptile was a contemporary of the huge Sauropoda. That it preyed on their carcasses is certain, for the bones are often found fossil with scorings and scratches on their softer surfaces which might well have been made by this animal, and its broken-off teeth, still more frequently found close by, suggest that it was more greedy than prudent in its feasts. But the *Allosaurus* was likewise well adapted in teeth and claws to attack a living prey, and it is quite probable that this was the enemy from whose attacks the huge *Brontosaurus* sought refuge by habitually burying his great unwieldy body beneath the water, as indicated by the skeleton structure and illustrated in our restoration (No. 24) of that beast.

In the *Allosaurus* restoration Mr. Knight has represented him as preying upon the carcass of a Brontosaur, using the powerful bird-like hind feet in somewhat the same manner as does a vulture or other bird of prey.

29. Amphibious Dinosaur Diplodocus.

(In preparation.)

30. Ichthyosaur, or Great Fish-Lizard.

Jurassic Period.

The discoveries of Ichthyosaurs, with the outlines of body and tail preserved, in the great slate-quarries of Holzmaden in Wurttemberg, as described by Professor Fraas in 1892, have considerably altered our conceptions of this classic fossil reptile. We now know that it had a high, triangular back fin and broad, forked tail, like that of the shark, except that the vertebral column ran into the lower wing instead of the upper wing of the tail. The Holzmaden specimens, worked out with wonderful skill and care by Herr Hauff, give the outlines of almost all parts of the body, so that there is little (except as to color) left to conjecture or inference in this restoration.

Mr. Knight has associated with the old Ichthyosaur a little school of new-born young whose proportions and size are taken from the seven little Ichthyosaur skeletons contained within the body-cavity of the large skeleton in the American Museum.

31. Great Sabre-tooth Tiger Smilodon.

Pleistocene Epoch.

Based on the complete skeleton in the Cope Collection, found in the Pampean formation near Buenos Aires, and now mounted in the American Museum.

Smilodon may well be considered the most terrible of all beasts of prey. It equalled in size the largest Polar Bear, and was probably of the most savage and ferocious disposition, fearing nothing, and accustomed to prey on the largest and best-defended of the great herbivora. It did not indeed equal the modern large cats in activity, but it far surpassed any of them in strength, especially in the fore limbs and neck. The extraordinarily powerful attachments for the sterno-mastoid and cleido-mastoid muscles indicate the tremendous force with which the great seven-inch upper canines could be driven into the flesh of the prey, while the extremely wide gape of the jaw, indicated by the form and arrangement of its muscular attachments, gave free play for these powerful weapon-teeth.

The relatively small and low hind quarters and short, small tail give the *Smilodon* an appearance quite unlike the modern great cats, and the characters of skull and neck vertebræ indicate that it carried its head low, and was little able to raise it.

IN PREPARATION.

32. Oxyæna lupina.
33. Platygonus leptorhinus.
34. Oreodon culbertsoni.
35. Poëbrotherium wilsoni.
36. Hyænodon horridus.
37. Cynodictis gregarius.
38. Dinictis squalidens.
39. Pantolambda bathmodon.
40. Hypohippus equinus.
41. Elephas imperator.
42. Ornitholestes hermanni.