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A MIOCENE MAMMALIAN FAUNA FROM SOUTH-EASTERN OREGON

By C. Lewis Gazin

With six plates and twenty text-figures

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INTRODUCTION

In the course of paleontological explorations in southeastern Oregon during the summer field seasons of 1928 and 1929 California Institute parties have been fortunate in securing collections of mammalian remains in Tertiary deposits exposed in the northern portion of Malheur County. Attention was first directed to the so-called Skull Spring occurrence by Mr. C. J. Bush of Harper, Oregon.

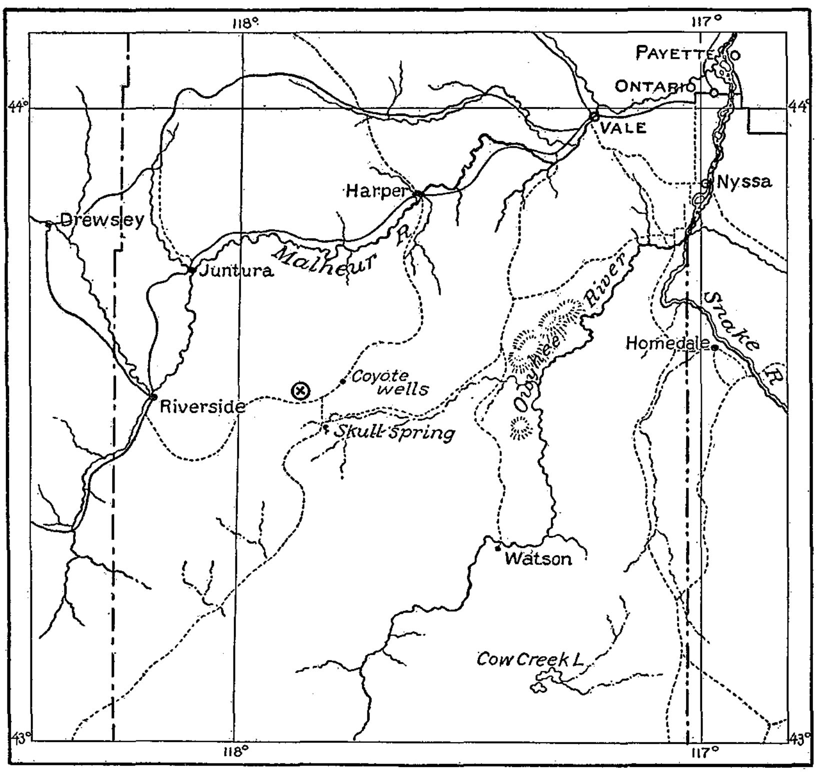


FIG. 1—Index map of a portion of eastern Oregon and adjacent region of western Idaho, showing location ⊗ of Skull Spring fossil vertebrate occurrence.

The fossil locality is twenty-eight miles south of Harper, Malheur County, Oregon, and approximately three miles northwest of Skull Spring. The beds in which the mammalian remains were found occur in a small basin draining southward and eastward into the Owyhee River. The local drainage is a part of a tributary known as Dry Creek or Beaver Creek. The northern margin of the basin is situated on the divide between the Owyhee and Malheur systems. Beyond this divide the gradient is northward through Red Ridge basin and Cottonwood Creek to the Malheur River at Harper flats.

Field operations were conducted with the cooperation of the Carnegie Institution of Washington and were under the direction of Dr. Chester Stock of the California Institute of Technology. The author is indebted to Dr. Stock for the opportunity to study the fauna and for valuable advice and criticism during the progress of the investigation.

The author was associated in the field with Dr. Chester Stock, E. L. Furlong and L. C. Hookway during the first season; and with E. L. Furlong, F. D. Bode, S. W. Lohman and E. R. Inglee during the second summer. Acknowledgment is also made of the courtesy extended by Mr. Donald R. Dickey and staff at the California Institute of Technology in permitting unreserved use of the Dickey collection of Recent mammals. The drawings for the text-figures were made by Mr. John L. Ridgway. The photographs reproduced in the plates have been carefully and accurately retouched by Mr. Ridgway.

PREVIOUS STUDIES IN EASTERN OREGON AND ADJACENT REGIONS

The small basin from which the mammalian fauna has been secured appears to be one of several basins of Tertiary sediments occurring in eastern and southeastern Oregon and in the adjacent region of Idaho. The earlier studies relating to the geologic history of this area include those of Clarence King, E. D. Cope, I. C. Russell, Waldemar Lindgren and F. H. Knowlton. More recent investigations have been conducted by J. C. Merriam, R. W. Chaney, J. P. Buwalda and Kirk Bryan.

A survey of previous paleontological explorations in southeastern Oregon and adjacent regions indicates no special dearth of fossil material. The collections thus far obtained quite clearly indicate the presence of several stages in the Neocene life-record, of which those of the Idaho and Payette formations may be regarded as fairly well established. Determination of age of these deposits and an interpretation of the geologic history have come to rest largely on evidence presented by paleobotany and vertebrate paleontology.

The paleobotanical materials studied by Knowlton [1] and by Chaney [2] are apparently recorded exclusively from the Payette.

Vertebrate remains have been identified or described from the Idaho and Payette beds by Cope, Leidy, Marsh, Lucas, Merriam and

[1] F. H. Knowlton, 18th Ann. Report, U. S. Geol. Surv., Pt. 3, pp. 721-744, 1898.
[2] R. W. Chaney, Amer. Jour. Sci., ser. 5, vol. 9, pp. 214-222, 1922.

Buwalda. A description of the fossil fish from the Idaho formation by Cope [1] in 1883 is perhaps the earliest report concerned with the vertebrate paleontology of this region. In 1898 Lindgren [2] recorded a determination by Leidy of *Mastodon mirificus* and *Equus excelsus* from the Idaho beds and a statement from Marsh that many Pliocene mammalian fossils occur in the bluffs along the Snake River below Weiser. In later collections made in the Idaho beds for Lindgren,[3] F. A. Lucas identified *Mastodon, Castor, Equus, Rhinoceros, Procamelus, Cervus* and an antelope. An equid type in the collection was recognized by Marsh as *Protohippus*. A collection made by Russell [4] included a camel, an edentate and fish remains, which Lucas considered to be of Pliocene age.

Later, in 1917, Merriam [5] discussed the relationship of the Idaho vertebrate fauna to other Pliocene assemblages, and in 1918 [6] described three new species from these beds, *Ischyrosmilus idahoensis, Neotragocerus lindgreni* and *Equus idahoensis*. In 1924 Buwalda [7] recognized the occurrence of Miocene and Lower Pliocene forms in the Payette beds of Idaho. The earlier fauna included a mastodont, *Hypohippus, Merycodus,* camel, rhinoceros, fish and freshwater shells. The material from the later horizon consisted chiefly of *Hipparion* and rodent teeth. The lower Pliocene fauna may correspond to that recognized at Ironside, Malheur County, Oregon, by Merriam [8] in 1916.

RESUMÉ OF GEOLOGIC RELATIONS OF TERTIARY FORMATIONS IN NORTHEASTERN MALHEUR COUNTY, OREGON

The sequence of Tertiary rocks exposed in the region of the Skull Spring fossil occurrence includes the following: (1) a coarse tuff,[9] (2) the Owyhee basalt,[10] (3) the Payette formation, (4) the Idaho formation and (5) capping lavas. Local flows of rhyolite occur at several horizons in the stratigraphic succession. The oldest rhyolite [11] observed occurs between the Owyhee basalt and the underlying tuff. A later extrusion in the vicinity of Skull Spring apparently overlies the basalt series but does not intrude the lake beds. A third period of acidic lava which intrudes the Payette beds is recognized in the vicinity of Succor Creek, Oregon.

[1] E. D. Cope, Proc. Acad. Nat. Sci. Phila., pp. 134-166, 1883.
[2] W. Lindgren, 18th Ann. Rpt. U. S. Geol. Surv., Pt. 3, p. 628, 1898.
[3] W. Lindgren, 20th Ann. Rpt., U. S. Geol. Surv., Pt. 3, p. 99, 1900.
[4] I. C. Russell, U. S. Geol. Surv. Bull. 199, p. 56, 1902.
[5] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, pp. 431-434, 443, 1917.
[6] J. C. Merriam, *Ibid.*, vol. 10, pp. 523-530, 1918.
[7] J. P. Buwalda, Science, n.s., vol. 60, pp. 572-573, 1924.
[8] J. C. Merriam, *Ibid.*, vol. 10, pp. 129-135, 1916.
[9] Exposed in the "Hole in the Ground" along the lower part of the Owyhee River. Blue-green tuff resembling John Day and underlying the basalt in the Steens Mountains west of the Alvord Ranch may be broadly equivalent.
[10] See Kirk Bryan, U. S. Geol. Surv. Water Supply Paper 597-A, pp. 1-72, 1929.
[11] The rhyolite in part at the Owyhee damsite.

The beds at the Skull Spring fossil locality consist principally of ash and lie on the irregular surface of the rhyolite, which in turn appears to overlie the Owyhee basalt. These beds form an isolated occurrence which may have been connected at some earlier time with strata in the basin immediately to the north. The latter beds are apparently traceable between the underlying rhyolite and basic rimrock to the section exposed in the vicinity of Harper flats. If a stratigraphic correlation can be definitely established, as appears quite likely, the fauna secured at the Skull Spring locality would presumably be closely related in time to that of the Payette.

OCCURRENCE AND PRESERVATION OF MATERIAL

The relief in the basin where the fossil materials were found is very low and the exposures are limited in extent. Much of the surface is covered with a growth of sagebrush and is strewn with lava detritus. Many specimens were collected in small dry stream beds along the bases of the more pronounced ridges. Some of the material was residual on the surface of the slopes and other specimens were located in place. No complete skeletons were found. Most of the scattered remains were preserved in nodules which were often so worn as to expose parts of bones or teeth. A large number of nodules not exhibiting organic remains at the surface were broken open and in some instances small rodent skulls were discovered. The nodules were frequently found mingled with rhyolite pebbles in the sandy drainage courses.

SKULL SPRING FAUNA[1]

The following is a list of the forms recognized in the assemblage:

- Carnivora
  - Canidæ
    - Tomarctus, cf. brevirostris Cope
    - Euoplocyon ? sp.
    - Canid ? sp.
    - Amphicyon sinapius Matthew
    - Amphicyon cf. frendens Matthew
    - cf. Pliocyon medius Matthew
    - Hemicyon n. sp.
  - Mustelidæ
    - Mustelid n. sp.
- Rodentia
  - Sciuridæ
    - Sciurus malheurensis n. sp.
    - Sciurus tephrus n. sp.
    - Citellus ridgwayi n. sp.
  - Aplodontiidæ
    - Liodontia alexandræ (Furlong)
  - Mylagaulidæ
    - Mylagaulus, cf. lævis Matthew
  - Heteromyidæ
    - Diprionomys ? oregonensis n. sp.
- Perissodactyla
  - Equidæ
    - Hypohippus sp.
    - Parahippus, near coloradensis Gidley
    - Merychippus isonesus (Cope)
  - Rhinocerotidæ
    - Rhinocerotid sp.
  - Chalicotheriidæ ?
    - Chalicothere ? sp.
- Artiodactyla
  - Tayassuidæ
    - Platygonus ? sp.
  - Agriochoeridæ
    - Ticholeptus ? sp.
  - Cervidæ
    - Dromomeryx, near borealis (Cope)
    - Blastomeryx ? sp.
  - Merycodontidæ
    - Merycodus ? sp. a
    - Merycodus ? sp. b

[1] Material recently secured from a second Skull Spring locality includes mastodon and tapir in addition to many of the forms listed here.

ENVIRONMENT OF FAUNA

Suggestions as to the environmental conditions which prevailed during the period of accumulation of the deposits containing the Skull Spring fauna are presented by the mammalian types occurring in this assemblage. Moreover if the Skull Spring horizon is the direct correlative of the Payette in the region immediately adjacent, further evidence may be reasonably expected from a consideration of the Payette flora.

The Skull Spring fauna is apparently not a plains assemblage in which would usually occur grazing horses, camels, antelopes, rabbits and doubtless other forms. Rather does it suggest a semihumid or perhaps forest environment. Among the perissodactyla occur brachydont horses, particularly *Hypohippus*. Associated with these forms are rhinoceroses and chalicotheres.

Perhaps the most diagnostic types are the rodents, among which are recorded the tree and ground squirrels, and in particular the genus *Liodontia,* a form related to the so-called mountain beaver. It is interesting to note that the Recent *Aplodontia* requires a considerable degree of humidity and an abundance of food plants [1] and is limited in its range to the coastal region of southern British Columbia, Washington, Oregon and northern California. Possibly the genus *Mylagaulus* was characterized by a somewhat similar habitat.

The ecologic significance of the pocket mouse in the Skull Spring fauna is uncertain as Recent genera of this group are not all found living under similar climatic conditions. The present range of heteromyids extends from the humid tropics of Central America to the arid and even cold parts of the Sonoran region. The absence of Lagomorphs in so large an assemblage of rodent material is peculiar and may be of significance, since these forms though present in wooded areas are more commonly found on the plains.

Substantiating evidence is presented by the Payette flora. According to R. W. Chaney [2] the scarcity of sequoia in the Payette suggests a lower humidity than that for the Mascall, but the plant assemblage as a whole indicates greater relief. A dry upland slope with several kinds of oak and other plants and swampy stream or lake borders are suggested. The climatic conditions indicated by the flora are compared with those of northern California and southwestern Oregon. The environment described compares favorably with that required for the habitat of *Aplodontia,* and is probably that in which *Liodontia* lived.

[1] W. P. Taylor, Univ. Calif. Publ., Bull. Dept. Zool., vol. 17, p. 450, 1918.
[2] R. W. Chaney, Amer. Jour. Sci., ser. 5, vol. 9, pp. 214-222, 1922.

STAGE OF EVOLUTION OF FAUNA

The different elements of the mammalian fauna indicate rather uniformly the same time stage in their phylogenetic history. On the basis of the present age-determinations of Tertiary faunal horizons of western North America, the Skull Spring assemblage may be regarded as middle Miocene in age or perhaps slightly later. The canids are those typically occurring in comparable Miocene horizons of the Great Plains region. The genus *Hemicyon* may be an exception. This form exhibits characters which may be reasonably expected at this faunal stage, but the genus is practically unknown elsewhere in America in horizons earlier than the Barstow and Santa Fé. The rodents as a group indicate a Neocene age. The Equidæ include the most diagnostic types and an age-determination of the fauna is based principally on members of this family. *Merychippus isonesus,* for example, occurs at Skull Spring and in the Mascall and Virgin Valley faunas. Unfortunately the artiodactyls are known by very incomplete materials and in most instances their relationships can not be definitely established. *Ticholeptus* has been regarded as characteristic of the middle Miocene, but the occurrence of the genus at the Oregon locality is questioned. Characters displayed by *Platygonus* (?) and *Merycodus* (?) sp. *b* appear to be rather advanced for types occurring in this stage.

RELATIONSHIPS OF FAUNA

The Tertiary horizons most closely related to the Skull Spring stage in time and in geographic propinquity are the Mascall formation of east-central Oregon and the Virgin Valley beds of northwestern Nevada. These deposits may represent with the beds in the vicinity of Skull Spring a nearly contemporaneous accumulation during a period of relatively low relief, following the extrusion of an extensive basalt series.

Merychippus isonesus (Cope) [1] was originally described from the Mascall,[2] and a number of associated forms are common to the two localities. However, the ungulate fauna resembles more closely in its association of types that found in the Virgin Valley beds.[3] A comparison of the three faunal lists is given below.

[1] E. D. Cope, Proc. Amer. Philos. Soc., vol. 26, pp. 451-457, 1889.

[2] See J. C. Merriam and W. J. Sinclair, Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, pp. 195-197, 1907.

[3] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, pp. 204-209, 1911.

SKULL SPRING	VIRGIN VALLEY	MASCALL
		Percomorphi
		Plioplarctus septemspinosus Cope
	Testudinata	Testudinata
	Clemmys sp.	Clemmys saxea Hay
Carnivora	Carnivora	Carnivora
Tomarctus, cf. brevirostris Cope	Tephrocyon kelloggi Merriam	Tephrocyon rurestris (Condon)
	Tephrocyon, compare rurestris (Condon)	
	Tephrocyon sp. a	
	Aelurodon ? sp.	
Euoplocyon ? sp.		
Canid ? sp.		Canis ? sp.
Amphicyon sinapius Matthew		Amphicyon sinapius Matthew
Amphicyon, cf. frendens Matthew		
cf. Pliocyon medius Matthew		
Hemicyon n. sp.		
Mustelid n. sp.		Lutrictis lycopotamicus Cope
		Leptarctus oregonensis Stock
	Bassariscus antiquus matthewi Merriam	
	Felis sp. a ?	
Rodentia	Rodentia	Rodentia
Sciurus malheurensis n. sp.		
Sciurus tephrus n. sp.		
Citellus ridgwayi n. sp.		
Liodontia alexandræ (Furlong)	Liodontia alexandræ (Furlong)	
Mylagaulus, cf. lævis Matthew	Mylagaulus monodon Cope	
	Mylagaulus pristinus Douglass	Mylagaulus sp.
Diprionomys ? oregonensis n. sp.		Diprionomys sp.[1]
		Chalicomys sp.
		Peromyscus (?) sp.
	Lagomorpha	Lagomorpha
	Oreolagus nevadensis (Kellogg)	
	Hypolagus vetus (Kellogg)	Lepus ? sp.

[1] An undescribed specimen in a collection recently obtained from the Mascall.

Skull Spring	Virgin Valley	Mascall
	Proboscidea	Proboscidea
	Mastodont sp.	Mastodont sp.
Perissodactyla	Perissodactyla	Perissodactyla
Hypohippus sp.	Hypohippus, near osborni Gidley	
		Archæohippus ultimus (Cope)
		Archæohippus sp. indesc.
Parahippus, near coloradensis Gidley	Parahippus, compare avus (Marsh)	Parahippus avus (Marsh)
		Parahippus brevidens (Marsh)
Merychippus isonesus (Cope)	Merychippus isonesus (Cope)	Merychippus isonesus (Cope)
		Merychippus seversus (Cope)
		Merychippus relictus (Cope)
		Merychippus insignis Leidy
Rhinocerotid sp.	Aphelops ? sp.	Diceratherium oregonense (Marsh)
		Rhinocerotid sp. & gen. indet.
Chalicothere ? sp.	Moropus merriami Holland and Peterson	
Artiodactyla	Artiodactyla	Artiodactyla
	Perchœrus ? sp.	
Platygonus ? sp.		
Ticholeptus ? sp.		
	Merychyus ? sp.	
		Merycochœrus sp.
		Merycoidodont ? sp.
		Miolabis transmontanus Cope
		Alticamelus altus (Marsh)
Dromomeryx, near borealis (Cope)	Dromomeryx, near borealis (Cope)	Dromomeryx near borealis (Cope)
	Dromomeryx sp. b	Cervine (Palæomeryx ?) sp. a (possibly Dromomeryx)
		Cervine (Palæomeryx ?) sp. b (possibly Dromomeryx)
Blastomeryx ? sp.	Blastomeryx mollis Merriam	
Merycodus ? sp. a	Merycodus, near furcatus (Leidy)	
Merycodus ? sp. b	Merycodus nevadensis Merriam	

The Pawnee Creek Miocene of northeastern Colorado[1] is not far removed from the Skull Spring stage. *Tomarctus*, cf. *brevirostris* Cope, *Amphicyon sinapius* Matthew, *Euoplocyon* ? sp., *Mylagaulus*,

[1] W. D. Matthew, Mem. Amer. Mus. Nat. Hist., vol. 1, Pt. 7, pp. 358-359, 373-374, 1901; Bull. Amer. Mus. Nat. Hist., vol. 16, pp. 281-290, 1902.

cf. *lævis* Matthew and *Dromomeryx,* near *borealis* (Cope) from Skull Spring are forms which are also recognized in the Pawnee Creek fauna. The brachydont horses *Hypohippus* sp. and *Parahippus,* near *coloradensis* Gidley are close to *H. osborni* Gidley and *P. coloradensis* Gidley of the Colorado Miocene.

A close time relation is also seen to exist between the eastern Oregon fauna and that from the Lower Snake Creek beds of Nebraska.[1] The large fauna from the latter horizon includes most of the genera recorded from Skull Spring as may be seen by comparing the two lists given below.

SKULL SPRING	LOWER SNAKE CREEK
Carnivora	Carnivora
Tomarctus, cf. brevirostris Cope	Tomarctus brevirostris Cope
Canid ? sp.	Tomarctus temerarius (Leidy)
	Tomarctus confertus (Matthew)
	Tomarctus mortifer (Cook)
Amphicyon sinapius Matthew	Amphicyon sinapius Matthew
Amphicyon, cf. frendens Matthew	Amphicyon ingens Matthew
cf. Pliocyon medius Matthew	Pliocyon medius Matthew
Hemicyon n. sp.	
	Bassariscus antiquus Matthew and Cook
	Leptocyon vafer (Leidy)
Euoploycon ? sp.	Euoplocyon prædator Matthew
	Leptarctus primus Leidy
Mustelid n. sp.	Brachypsalis modicus Matthew
	Brachypsalis obliquidens Sinclair
	Mionictis incertus Matthew
	Mionictis elegans Matthew
	Plionictis glaræ (Sinclair)
	Plionictis parviloba (Cope)
	Sthenictis dolichops Matthew
	Metailurus intrepidus (Leidy)
Rodentia	Rodentia
Sciurus malheurensis n. sp.	
Sciurus tephrus n. sp.	
Citellus ridgwayi n. sp.	
Liodontia alexandræ (Furlong)	
Mylagaulus, cf. lævis Matthew	Mylagaulus lævis Matthew
	Mylagaulus paniensis Matthew
	Ceratogaulus rhinocerus Matthew
	Dipoides curtus Matthew and Cook
Diprionomys ? oregonensis n. sp.	Amblycastor fluminis Matthew
	Peridiomys rusticus Matthew
	Poamys rivicola Matthew
	Lagomorpha
	Hypolagus vetus (Kellogg)
	Insectivora
	Talpa incerta Matthew

[1] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 50, pp. 59-73, 1924.

Skull Spring	Lower Snake Creek
Perissodactyla	Perissodactyla
Hypohippus sp.	Hypohippus osborni Gidley
	Hypohippus pertinax Matthew
Parahippus, near coloradensis Gidley	Parahippus integer Matthew
Merychippus isonesus (Cope)	Merychippus paniensis (Cope)
	Merychippus sejunctus (Cope)
	Merychippus proparvulus Osborn
	Merychippus campestris Gidley
	Merychippus eohipparion Osborn
Rhinocerotid sp.	Aphelops megalodus Cope
	Teleoceras medicornutus Osborn
Chalicothere ? sp.	
Artiodactyla	Artiodactyla
	Prosthennops sp.
Platygonus ? sp.	
	Merychyus sp.
Ticholeptus ? sp.	
	Metoreodon relictus Matthew and Cook
	Pronomotherium siouense Sinclair
	Protolabis fissidens (Cope)
	Protolabis angustidens (Cope)
	Alticamelus leptocolon Matthew
	Alticamelus procerus Matthew and Cook
Dromomeryx, near borealis (Cope)	Dromomeryx whitfordi Sinclair
Blastomeryx ? sp.	Blastomeryx elegans Matthew and Cook
	Blastomeryx (Dyseomeryx) sinclairi (Matthew)
Merycodus ? sp. a	Merycodus necatus Leidy
Merycodus ? sp. b	
	Cranioceras unicornis Matthew
	Drepanomeryx falciformis Sinclair

SYSTEMATIC DESCRIPTION OF MAMMALIAN FAUNA

CARNIVORA

The canid remains consisting of jaw fragments and isolated teeth indicate a varied group of forms. The author is indebted to Dr. Chester Stock for an identification of the specific relations of several of these forms and for a comparison of some of the material with type specimens in the collections of the American Museum of Natural History. A large part of the comparative descriptions were taken from Dr. Stock's notes.

Tomarctus, cf. brevirostris Cope

A maxillary fragment with the two molars, No. 379 C. I. T. Coll. Vert. Pale. (fig. 2), has been referred to this species. A comparison of this specimen with skull No. 18242 Amer. Mus. Coll. labeled *Tomarctus* *brevirostris* Cope and described from the Lower Snake Creek beds [1] shows a similar arrangement of cusps in M1. In the latter specimen the teeth are slightly more worn than in No. 379. In the Skull Spring specimen the protocone, hypocone and metaconule are distinct. The protoconule, if present, was presumably a very small cusp and the wear may have obliterated its identity. A well-defined external cingulum is present and the principal external cusps appear to be slightly farther removed inwardly from the external border than in No. 18242 Amer. Mus. M2 is relatively larger than the corresponding tooth in the latter.

A comparison may also be made with skull No. 18244 Amer. Mus. Coll. from the Lower Snake Creek horizon, of which an excellent cast is available. The molars in this specimen of *Tomarctus brevirostris* are less worn than in No. 379 and are of about the same size and shape. M1 in No. 18244 Amer. Mus. has the inner cusps distinct and the antero-lateral corner of the tooth is nearly as angulate as in No. 379. The principal difference in the two teeth outside of wear is the slightly less transverse width in the Skull Spring M1.

No. 379 is also not far removed from *Tephrocyon rurestris* (Condon) [2] in size, but differs from this species in the shape of M1. The inner basin or heel of this tooth, according to the illustrations, is deflected more posteriorly

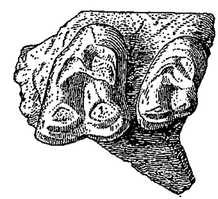


FIG. 2—*Tomarctus,* cf. *brevirostris* Cope. M1 and M2, No. 379 C.I.T. Coll., occlusal view; x 1.0. Skull Spring Miocene, Oregon.

in the type of *T. rurestris* than in No. 379. Also, the antero-external corner of the tooth is less angulate than in the Skull Spring form. However, the positions of the cusps are very similar in the two specimens. No noticeable difference occurs between the two second molars.

Critical determination of relationships of *Tephrocyon* Merriam and *Tomarctus* Cope has not been made, although their generic identity has been suggested by Matthew.[3] The Skull Spring material does not assist materially in the solution of the problem.

	No. 379	No. 18242 Amer. Mus.	No. 18244 Amer. Mus.
	mm.	*mm.*	*mm.*
M1, greatest length along outer side	12.6	13.7	12.5
M1, greatest width normal to outer side	15.6	16.1	16.0
M2, greatest oblique diameter from outer side of paracone to inner side of hypocone	12.8	12.1	12.8
M2, greatest transverse diameter	7.8	7.2	7.8

[1] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 50, pp. 91-96, 1924.

[2] See J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, pp. 6-10, 1906; *ibid.*, vol. 7, pp. 362-364, 1913.

[3] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 50, pp. 88-91, 1924.

Euoplocyon ? sp.

A lower carnassial, No. 392 C. I. T. Coll. Vert. Pale. (fig. 3) is doubtfully referred to the genus *Euoplocyon* Matthew.[1] The specimen is a simple,

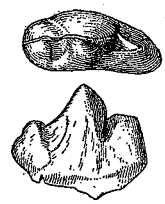


FIG. 3—*Euoplocyon* ? sp. Left lower carnassial, No. 392 C.I.T. Coll., lateral and occlusal views; x 1.0. Skull Spring Miocene, Oregon.

narrow, three-cusped tooth, without metaconid. The heel is compressed antero-posteriorly, single-cusped and trenchant. The specimen shows characters similar to those seen in M$\overline{1}$ of *Cyon alpinus.*[2] No. 392 is a little more than half as large as *Euoplocyon magnus* (Thorpe).[3] Unfortunately, no illustrations or dimensions are given for the type lower jaw of *E. prædator* Matthew, except that it is much smaller than *E. magnus.*

The tooth presumably belongs to a form related to the *Cyon* group or Simocyoninæ. It is not so advanced nor so large as that in *Simocyon* or *Ischyrocyon* and differs from that in *Temnocyon* and *Philotrox* in the absence of a metaconid. No. 392 is similar to M$\overline{1}$ of *Enhydrocyon,* but is not so large and robust.

Some resemblance is also seen to the larger types of mustelids to which it may possibly be related rather than to the Canidæ. *Gulo* has a larger, relatively wider M$\overline{1}$ with higher paraconid and much lower talonid cusp. The heel of M$\overline{1}$ in the wolverine is not so trenchant and shows something of a postero-internal basin. Perhaps a greater similarity may be seen in a comparison of the tooth with M$\overline{1}$ in *Ælurocyon.* The lower carnassial of *A. brevifacies* Peterson[4] is only slightly larger than the Skull Spring tooth, but relatively wider, and has a cusp on the heel which is apparently higher than in *Gulo.* A noticeable difference from No. 392 is evident in that the heel seems to be expanded or offset inwardly in *Ælurocyon,* giving the tooth a more arcuate appearance.

M$\overline{1}$, anteroposterior length	17.9 *mm.*
M$\overline{1}$, greatest transverse width	7.7

Canid ? sp.

The specimen, No. 386 C.I.T. Coll. Vert. Pale. (fig. 4), which is here referred questionably to the Canidæ is a right lower jaw with a fourth premolar, the root portions of P$\overline{2}$, P$\overline{3}$, M$\overline{1}$ and M$\overline{2}$ and an alveolus for P$\overline{1}$. The specimen is broken away immediately behind the second molar. The presence of a third molar can not therefore be definitely determined. The size of M$\overline{2}$, which is a two-rooted tooth, may indicate that M$\overline{3}$ was present.

The form is characterized by an unusually deep ramus for the length of the tooth row. P$\overline{2}$, P$\overline{3}$ and P$\overline{4}$ are two-rooted and anteroposteriorly compressed. P$\overline{4}$ is a simple, conical tooth with a heavy cingulum completely surrounding the base. The anterior, posterior and inner margins of the cone are rather angulate, giving the tooth a triangular outline with a convex

[1] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 50, pp. 103-104, 1924.

[2] See J. L. Wortman and W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 12, pp. 115-118, fig. 2, 1899.

[3] M. R. Thorpe, Amer. Jour. Sci., ser. 5, vol. 3, pp. 440-443, 1922.

[4] O. A. Peterson, Ann. Carnegie Mus., vol. 4, pp. 68-72, 1908.

outer side in dorsal view. The carnassial tooth was large, more than twice as long as the fourth premolar, and possessed sturdy well-separated roots. The second molar was wider transversely across the anterior portion than across the posterior root. The tooth was probably less than two-thirds as wide as it was long. As inferred from the posterior convergence of $M\overline{2}$, the third molar if present was probably of reduced size. The posterior mental foramen is located below $P\overline{4}$, the anterior below a point between $P\overline{2}$ and $P\overline{3}$.

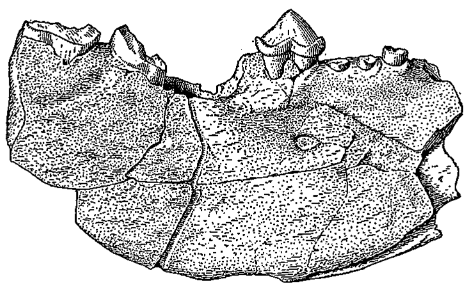


FIG. 4—*Canid* ? sp. Right ramus of mandible with $P\overline{4}$ and the root portions of $P\overline{2}$, $P\overline{3}$, $M\overline{1}$ and $M\overline{2}$, No. 386 C.I.T. Coll., lateral view; x 1.0. Skull Spring Miocene, Oregon.

In many features, as pointed out by Dr. E. R. Hall,[1] the specimen resembles the lower jaw of the mustelid, *Ælurocyon brevifacies* Peterson [2] as for example in anteroposterior compression of the dental series, relative depth of jaw and in massiveness of the carnassial. However, a number of rather important differences between the two forms are noted. The Skull Spring specimen is much smaller, the premolars are simpler and more compressed anteroposteriorly, and the second molar is decidedly larger and perhaps more canid-like.

As to whether this specimen represents the same form as the carnassial which has been referred questionably to *Euoplocyon* there is at present no means of telling. The carnassial No. 392 is of the same size as that indicated by roots of $M\overline{1}$ in No. 386, but $P\overline{4}$ in No. 386 has a heavy cingulum while $M\overline{1}$, No. 392, lacks this character. However, if the two are found to represent the same form, the generic relationship of the Skull Spring type to *Euoplocyon* would probably not be close, inasmuch as $P\overline{4}$ in No. 386 does not conform to the characters of the comparable tooth in the latter genus.

Depth of ramus below $P\overline{4}$	*a*30. *mm.*
$P\overline{2}$ to $M\overline{2}$, greatest length	*a*54.
$P\overline{2}$ to $P\overline{4}$, greatest length	*a*23.
$P\overline{4}$, anteroposterior diameter	9.
$P\overline{4}$, transverse diameter parallel to outer wall	5.4
$M\overline{1}$, anteroposterior diameter	*a*19.5
$M\overline{2}$, anteroposterior diameter	*a*11.

a, approximate.

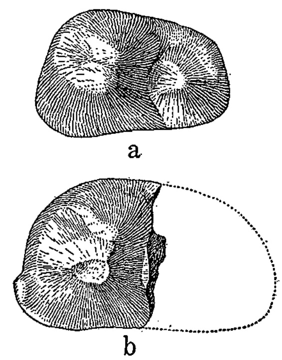
[1] Oral communication.

[2] O. A. Peterson, Ann. Carnegie Mus., vol. 4, pp. 68-72, 1908.

Amphicyon sinapius Matthew

Among the teeth referred to *Amphicyon* there are two lower molars which resemble more nearly *A. sinapius* than any of the other species so far described. The tooth crown, No. 374 C. I. T. Coll. Vert. Pale. (fig. 5*a*). belongs to a second molar of a left ramus. This specimen is only slightly smaller than the type of *A. sinapius,* No. 9358 Amer. Mus. from the Pawnee Creek beds of Colorado.[1] As in *Amphicyon* the three prominent cusps are the protoconid and metaconid in front and the hypoconid behind. In the

FIG.5, *a* and *b*—*Amphicyon sinapius* Matthew. *a*, $M\bar{2}$ of left ramus, No. 374 C.I.T. Coll., occlusal view; *b*, fragmentary $M\bar{2}$ of left ramus, No. 375 C.I.T. Coll., occlusal view; x 1.0. Skull Spring Miocene, Oregon.



Skull Spring specimen the summits of the protoconid and metaconid are less widely separated in transverse direction than in the type of *A. sinapius.* In the Oregon tooth the anteroexternal corner of the tooth is extended more forward and the surface of the protoconid slopes more gradually than in the type. The forward projection of this region of the tooth makes the anteroposterior diameter along the outer side much more than that along the inner side.

No. 375 (fig. 5*b*) is apparently the forward half of $M\bar{2}$ of a left ramus. This tooth is noticeably larger than No. 374, but has essentially the same pattern developed on the occlusal surface as in the latter. As in No. 374, also, the anterior end is obliquely truncated, giving prominence to the antero-external corner. A small cuspule is present on the cingulum in this region of the tooth. The fang supporting the protoconid-metaconid region of the tooth-crown was presumably not so large as that supporting the posterior portion. There is evidence to show that a fusion of two roots characterizes the anterior fang.

This Skull Spring form is not far removed from *A. sinapius* of the Pawnee Creek and from the Amphicyonines of the Snake Creek referred by Matthew to this species.

Comparative Measurements

	No. 374 C. I. T.	No. 375 C. I. T.	Type No. 9358 Amer. Mus.	No. 18258 Amer. Mus.
	mm.	*mm.*	*mm.*	*mm.*
$M\bar{2}$, greatest length measured along outer side	26.0	....	27.1	25.0
$M\bar{2}$, greatest width normal to outer side	17.0	20.0	18.1	17.6

[1] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 16, pp. 288-289, 1902.

Amphicyon, cf. frendens Matthew

The inner half of an upper molar and the trigonid of a lower carnassial are considered as representing another species of *Amphicyon,* possibly *A. frendens.* The carnassial, No. 376, C. I. T. Coll. Vert. Pale. (fig. 6*a*), is noticeably larger than the cotype of *A. sinapius,* No. 9357 Amer. Mus. from the Pawnee Creek beds. The latter represents an unworn crown of M$\overline{1}$.[1] In character of size, No. 376 is more nearly like the type *A. frendens,* No. 18913 Amer. Mus. One noticeable difference between the Oregon specimen and the comparable tooth in *A. sinapius* and *A. frendens* is presented

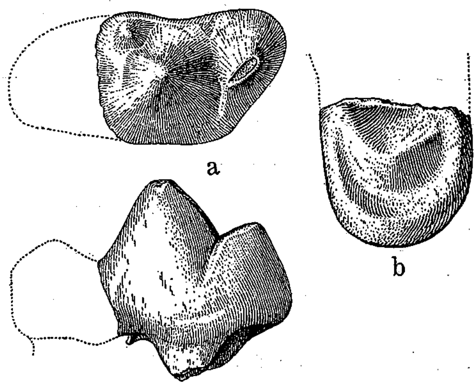


FIG. 6, *a* and *b*—*Amphicyon,* cf. *frendens* Matthew. *a,* Trigonid of right lower carnassial, No. 376 C.I.T. Coll., lateral and occlusal views; *b,* inner half of upper molar, No. 377 C.I.T. Coll., occlusal view; x 1.0. Skull Spring Miocene, Oregon.

by the transverse width taken through the notch separating paraconid from protoconid. With greater prominence of the external border of this tooth opposite the notch, the transverse diameter at this point is greater in the Skull Spring tooth. Moreover, the external border at this point turns more sharply inward toward the anterior end of the tooth. As in *Amphicyon* the paraconid and protoconid form a heavy shearing blade, and the metaconid is relatively small. No. 376 is distinctly smaller than an M$\overline{1}$ referred to *A. ingens.*

The inner half of the upper molar, No. 379 (fig. 6*b*), presumably from the right side, resembles more closely M$\underline{2}$ than M$\underline{1}$. This resemblance is shown by the lowness of the inner ledge of the tooth and by the lowness of the protocone. Moreover, in the tooth fragment, the protocone is farther removed from the inner ledge toward the external side as in M$\underline{2}$. In M$\underline{1}$ the cusp approaches more closely the internal cingulum. In M$\underline{1}$ of *Amphicyon frendens* the intermediate cuspules (protoconule and metaconule) are distinctly larger and better defined than in M$\underline{2}$. While only the inner half of the tooth is present in the Skull Spring specimen, it would appear that distinct cusps representing the protoconule and metaconule and having positions at each end of the protocone crescent are absent. In this respect the Skull Spring type resembles M$\underline{2}$, No. 18914, described but not figured by Matthew under the species *Amphicyon frendens.*

In size, No. 379 resembles most closely *A. frendens* and is distinctly larger than *A. idoneus.* The tooth fragment is actually larger than the corresponding portion of M$\underline{2}$, No. 18914 Amer. Mus. referred to *A. frendens.* The fang supporting this section of the tooth is also heavier than in the Snake Creek specimen. It is larger than the corresponding part of M$\underline{2}$ in *A. sinapius,* skull No. 18257 Amer. Mus. from Snake Creek. In the Oregon

[1] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 16, p. 289, fig. 4, 1902.

specimen the protocone crescent is low, much more so than in the type of *A. frendens*, No. 18914 Amer. Mus., and in this respect No. 379 resembles more closely No. 18914 Amer. Mus. which has been referred to the same species. The crown is more deeply excavated along the inner border of the protocone crescent in the specimen from the Skull Spring horizon. The form of the inner cingulum resembles that in No. 18914.

Comparative Measurements

	No. 376 C.I.T.	A. sinapius No. 9357 Cotype Amer. Mus.	A. referred to sinapius No. 18258 Amer. Mus.	A. frendens No. 18913 Type Amer. Mus.
	mm.	*mm.*	*mm.*	*mm.*
$\overline{M1}$, anteroposterior diameter from base of metaconid to anterior end of tooth..................	25.5	23.5	23.4	25.7
$\overline{M1}$, transverse diameter at posterior end of base of protoconid..	17.5	15.0	*a* 17.4	20.4
$\overline{M1}$, transverse diameter through notch between paraconid and protoconid....................	17.0	14.3	14.6	15.7
		No. 379 C.I.T.	No. 18914 Amer. Mus.	
$\underline{M2}$, anteroposterior diameter of inner heel......................	....	20.6	18.7	

a, approximate.

Cf. Pliocyon medius Matthew

Among the materials representing the larger canids in the fauna is the heel portion of a lower carnassial, No. 378 C. I. T. Coll. Vert. Pale. (fig. 7), showing a large hypoconid and a subdued entoconid ridge. The crown is

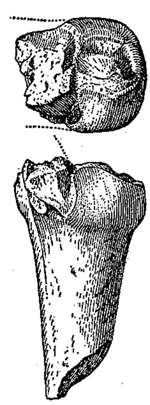


FIG. 7—Cf. *Pliocyon medius* Matthew. Heel of left lower carnassial, No. 378 C.I.T. Coll., lateral and occlusal views; x 1.0. Skull Spring Miocene, Oregon.

supported by a heavy fang or root. This specimen is distinctly smaller than the corresponding portion of $\overline{M1}$ in the cotype of *Amphicyon sinapius*, in No. 18258 Amer. Mus. referred to this species, and in *A. frendens*. In point of size, it comes closest to *Pliocyon medius* Matthew,[1] No. 13848

[1] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 38, pp. 190-194, 1916; Bull. Amer. Mus. Nat. Hist., vol. 50, pp. 113-128, 1924.

and No. 13847 Amer. Mus. Coll. The character of the heel and the position of the hypoconid is much the same as in these specimens. The entoconid ridge is similar to that in No. 13848 Amer. Mus.

Comparative Measurements

	No. 378 C.I.T.	No. 13848 Amer. Mus.	No. 13847 Amer. Mus.
	mm.	*mm.*	*mm.*
$M\bar{1}$, width of heel	14.1	14.7	14.4
$M\bar{1}$, anteroposterior diameter from anterior end of hypoconid to posterior end of tooth	9.6	10.9	11.2

Apparently the Skull Spring locality has yielded a record of the *Amphicyon* group which in its diversity resembles somewhat that of the Lower Snake Creek of Nebraska. Comparable lists of species from the two horizons are given below:

Snake Creek	Skull Spring
A. sinapius	A. sinapius
A. frendens	A., cf. frendens
A. idoneus	
A. ingens	
Pliocyon medius	cf. Pliocyon medius

Hemicyon ? n. sp.

A small upper carnassial (fig. 8) in the collection resembles very strongly the corresponding tooth in the Hemicyoninæ. The specimen is intermediate in size between *Ursavus primœvus* (Gaillard) [1] and *Hemicyon barstowensis* Frick. [2] From the latter species it differs mainly in the larger and slightly

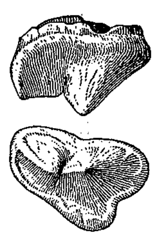


Fig. 8—*Hemicyon* ? n. sp. Right upper carnassial, No. 380 C.I.T. Coll., lateral and occlusal views; x 1.0. Skull Spring Miocene, Oregon.

more prominently projecting protocone. A slight but well-defined cingulum is present externally along the base of the paracone-metacone blade. The internal cingulum is even better defined. The forward border of the protocone is rather sharply demarcated from the inner anterior border of the paracone, distinctly more so than in *H. barstowensis.* The posterior end of the protocone reaches backward to a point slightly in advance of the notch between paracone and metacone. Its position with reference to the paracone does not differ noticeably from that in *H. barstowensis.* The external wall of the paracone-metacone blade appears slightly more indented toward the notch than in *H. barstowensis.* This indentation is less noticeable in *Ursavus.*

[1] See J. W. Gidley, Jour. Mammal., vol. 4, pp. 240-243, 1923.
[2] Childs Frick, Bull. Amer. Mus. Nat. Hist., vol. 56, pp. 27-34, 1926.

Possibly No. 380 represents a deciduous carnassial of *Hemicyon* or of *Amphicyon,* but the very strong resemblance between this tooth and $P\underline{4}$ in *Hemicyon barstowensis,* No. 20821 Amer. Mus., makes the probability of relationship to the amphicyonine dogs seem rather remote.

No. 380 may represent the earliest occurrence of the genus *Hemicyon* in America. It is apparently earlier than the species described from the Barstow or Santa Fé stages. However, a lower jaw from the Pawnee Creek beds in northeastern Colorado, named *Ursavus pawniensis* by Frick,[1] is from approximately the same stage in the Miocene.

Comparative Measurements

	No. 380 C.I.T.	Type No. 20810 H. barstowensis	Cast of No. 20821 H. barstowensis	Cast of No. 17729 Ursavus primævus
	mm.	*mm.*	*mm.*	*mm.*
$P\underline{4}$, anteroposterior diameter.........	19.4	22.1	21.9	12.9
$P\underline{4}$, greatest width across protocone...	12.8	13.3	13.3	8.4
$P\underline{4}$, length of metacone blade.........	7.1	8.4	8.3	4.2

Mustelid[2] n. sp.

Dr. E. R. Hall of the Museum of Vertebrate Zoology, University of California, has kindly consented to examine and report on a mustelid lower jaw, No. 391, in the Skull Spring collection. A skull fragment, No. 393, without teeth may represent the same form. The following tentative statement is a part of a communication from Dr. Hall and is included here pending a more complete published report on this form:

"The fragment of left lower jaw bearing $M\overline{1}$, $P\overline{3}$ and the alveoli of $P\overline{4}$ seems to represent an undescribed species of mustelid intermediate in character as between *Mustela* on the one hand and *Plionictis* and *Martes* on the other. Outstanding characters are the short, fully trenchant talonid of $M\overline{1}$, recalling the condition seen in *Mustela,* but with a distinct, although weakly developed, metaconid on this tooth which occurs in *Martes* but not in *Mustela.* $M\overline{1}$ is small relative to the depth of the lower jaw. $P\overline{3}$ is relatively larger than in *Mustela* but relatively smaller than in *Martes,* thus suggesting that the Skull Spring animal was intermediate to *Martes* and *Mustela* in reduction of the premolars. $M\overline{1}$ is 8.4 mm. long. $P\overline{3}$ is 4.3 mm. long. The jaw itself represents an animal very like *Mustela nigripes* in general size, but with relatively, and actually, smaller teeth."

RODENTIA

Sciurus malheurensis n. sp.

Holotype—No. 129 C. I. T. Coll. Vert. Pale., a skull with the superior dentition.

Paratype—No. 333, a skull without dentition.

Specific characters—Skull moderately large and robust. Rostrum deep and broad. Palate and ventral surface of muzzle wide. Acute portion of zygomatic ridge does not extend anteriorly so far as the dorsal surface of muzzle. Cranium comparatively small and dorsally flat. Basi-occipital region relatively high and narrow. Diastema between I and $P\underline{3}$ long. Fossæ

[1] Childs Frick, Bull. Amer. Mus. Nat. Hist., vol. 56, pp. 106-110, 1926.

[2] This form has now been described as *Martes (Tomictis) gazini* Hall in Jour. Mammal., vol. 12, pp. 156-157, pl. 5, figs. *a-b,* 1931.

are present posterior to incisors and antero-lateral to anterior palatine foramina. Teeth relatively small, quadrate and of a modern type with four prominent transverse lophs and no indication of a fifth median ridge.

Material—The material representing this species consists of the two skulls Nos. 129 and 333. The type specimen is the anterior portion of a skull with most of the dentition (see plate 1, figs. 1 and 1*a*). The right grinding series is complete from $\underline{P4}$ to $\underline{M3}$, lacking only $\underline{P3}$. The left series is not so complete, $\underline{M2}$ and $\underline{M3}$ being the only undamaged teeth. The premaxillaries are well preserved around the incisive alveoli, but the incisors themselves are absent. The paratype is the posterior portion of a skull without teeth (see plate 2, fig. 3). The specimen is not particularly well preserved, inasmuch as the bone has flaked off in many places, exposing a cast of the brain chamber. However, the specimen shows the shape of the brain cavity and the proportions of the occipital region. Also, the position and size of the tympanic bullæ are determinable.

Description—*Sciurus malheurensis* is a large robust squirrel approaching *S. aberti* and *S. niger* in size but smaller than *S. griseus*. The rostrum of No. 129 is broad and deep as in these species, resembling also the Central American form *S. variegatoides* in width of ventral surface of the muzzle. A rather conspicuous feature is the posterior position of the grinding teeth, permitting a very long diastema between the incisor and third premolar. In length of the diastema No. 129 is close to *S. griseus* and far removed from *S. variegatoides*. In association with the posterior position of the cheek-teeth the maxillary portion of the zygoma of No. 129 expands laterally above $\underline{P4}$, whereas in Recent forms the ventral margin of the expansion is above $\underline{M1}$ or perhaps at a point midway in the series. The maxillary portion of the zygoma does not extend as an acute ridge to the dorsal surface of the muzzle as in Recent individuals but passes anteriorly into a rounded bulge about midway between the dorsal and ventral sides.

The dorsal surface of the skull of *S. malheurensis* is noticeably flat, more so than in Recent species of comparable size. This flatness is conspicuous in No. 333 where it is carried backward nearly to the supra-occipital. In a longitudinal profile the Recent skulls are much more convex in the vicinity of the parietals and the posterior portion of the frontals. Accompanying this convexity is the appreciably lower position of the basi-occipital region, more so than in No. 333. Furthermore, behind the rostrum the skulls of Recent forms become very much wider than in *S. malheurensis*. Corresponding to the smaller size of the cranium in the fossil, the occipital region is narrower and the bullæ are closer together than in Recent types having a rostrum of nearly comparable size.

In many respects, as in the characters mentioned above, the skull of *S. malheurensis* resembles that of the Eocene rodent, *Paramys*.[1] This resemblance is most marked in size and shape of cranium, although the brain-case is proportionately larger and a sagittal crest is probably not developed in the Miocene squirrel. *S. malheurensis* is removed from the Eocene forms in other characters, as for example in progressive development of the dentition, apparent ossification of the bullæ, anterior development of the zygoma and in the character of the infra-orbital foramen. The infra-orbital foramen in No. 129 is anteriorly placed as in Recent tree squirrels, and the ventro-lateral margin of the anterior opening is well developed, but not nearly so much as in the ground squirrels.

[1] See W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 28, pp. 45-59, 1910.

The upper teeth in No. 129 from Skull Spring are distinctly smaller than the teeth examined in Recent sciurids of corresponding size. The length of the tooth-row in *S. malheurensis* corresponds to that in the smaller species *S. deppei*.

The individual teeth are quadrate, with four rather prominent transverse crests or lophs. The lophs and basins, however, are not so accentuated as in Recent citellids. The ridges all unite in the protocone internally and terminate externally in the marginal cusps. The anterior crest or style is convex forward, particularly in $M\underline{1}$, and approaches the paracone externally, from which it is separated by a notch. The second loph is nearly straight and terminates in the paracone. A protoconule is not distinguishable on this ridge. The third loph is slightly convex posteriorly and unites directly with the metacone. The metaconule is conspicuous in this ridge, more so than in Recent individuals. The posterior crest is directed backward and outward from the protocone and unites directly with the posterior flank of the metacone. A small cuspule may be present between the paracone and metacone as in $M\underline{1}$.

Relationship—Among the rodents of the North American Tertiary the squirrel types of the Miocene and Pliocene are as yet known by incomplete material. An occasional lower jaw or skull fragment represents the material on which rest the stages which have been recognized between the Eocene and Quaternary forms. Since the Sciuridæ form a rather primitive group, marked resemblances to the Ischyromyidæ are to be noted. Fossil squirrels described from formations ranging in age from upper Oligocene to Pliocene inclusive tend to establish this connection. The material, however, is far too scanty to permit the recognition of the various phyletic series which must have existed with the development of the group in later Tertiary time.

The larger specimen from Skull Spring retains certain features, particularly in the cranial region of the skull, which remind one of an ischyromyid ancestry, although these are associated with characters in the dentition which are decidedly modern. This form may be in or near the line of descent of modern forms, but until more is known of the various stems still living and extinct its position remains uncertain.

A comparison of *S. malheurensis* with middle Tertiary members of the genus *Sciurus* is difficult because many of the types are known only by the lower jaw.

S. arctomyoides Douglass [1] from the Madison Valley beds in Montana is a very much larger form as indicated by the length of the lower tooth series. *S. ballovianus* Cope [2] from the John Day beds of Oregon is decidedly smaller and differently proportioned, having a short and relatively broad cranium. *S. vortmani* Cope [3] also from the John Day deposits and *S. relictus* Cope [4] from the White River beds of Colorado can not be compared satisfactorily with the Skull Spring form because of absence of similar material. *S. vortmani* may be near the same size as indicated by the length of the lower tooth-row. On a similar basis *S. relictus* appears to be a smaller form.

[1] Earl Douglass, Ann. Carnegie Mus., vol. 2, pp. 181-182, 1903.
[2] E. D. Cope, Rept. U. S. Geol. Surv. Terrs., vol. 3, pp. 818-819, 1884.
[3] E. D. Cope, *ibid.*, pp. 816-817.
[4] E. D. Cope, *ibid.*, pp. 817-818.

Comparative Measurements

	S. malheurensis		S. griseus No. 9601*	S. aberti No. 6817*
	No. 129 C.I.T.	No. 333 C.I.T.		
	mm.	*mm.*	*mm.*	*mm.*
Distance from posterior margin of anterior palatine foramina to tip of occipital condyles	....	43.5	49.2	43.9
Greatest width of cranium not including zygomatic portion of squamosal	....	*a* 21.5	28.8	26.8
Width between outer surfaces of bullæ	....	20.0	25.0	24.1
Anteroposterior length of bullæ	....	11.0	12.3	11.0
Depth of muzzle below nasofrontal suture	16.1	15.0–16.0	18.3	15.1
Width of dorsal surface of muzzle across anterior palatine foramina	7.7	*a* 7.7	7.5–8.5	7.5–8.0
Width of palate between M1	8.2	*a* 8.	7.9	8.1
Length of diastema between I and P3	*a* 15.4	....	15.4	15.0
Distance between posterior margin of anterior palatine foramen and P3	10.1	*a* 10.0	9.1	8.7
P3-M3, greatest length	*a* 10.5	....	12.5	11.5
P4-M3, greatest length	9.1	....	11.7	11.0
I, anteroposterior diameter	*a* 4.3	....	3.6	3.1
I, greatest transverse diameter	*a* 2.4	....	1.8	2.0
P4, anteroposterior diameter	2.0	....	2.4	2.5
P4, greatest transverse diameter	2.4	....	2.7	2.4
M1, anteroposterior diameter	2.4	....	2.9	2.5
M1, greatest transverse diameter	2.7	....	3.3	3.1
M2, anteroposterior diameter	2.3	....	3.1	2.7
M2, greatest transverse diameter	2.8	....	3.5	3.1
M3, anteroposterior diameter	2.5	....	3.3	3.2
M3, greatest transverse diameter	2.5	....	3.3	3.2

a, approximate.
* Recent skulls from Donald R. Dickey Collection.

Sciurus tephrus n. sp.

Holotype—No. 332 C. I. T. Coll. Vert. Pale., a skull with right superior dentition.

Specific characters—Skull small and slender. Muzzle relatively long, deep and narrow. Zygomatic ridge as in *S. malheurensis* and does not extend anteriorly to the dorsal surface of rostrum. Diastema between I and P4 elongate, equaling in length that in *S. deppei*. Fossæ posterior to incisors and antero-lateral to anterior palatine foramina are shallow. Teeth near *S. hudsonicus* in size but P4 short anteroposteriorly.

Material—This form is represented by the greater portion of a skull with the grinding teeth P4 to M3 complete on the right side (see plate 1, figs. 2, 2*a* and 2*b*). The third premolar is absent and its alveolus is indistinct, but a tooth may have been present during the life of the animal. The posterior part of the skull and the zygomatic arches have not been preserved.

Description—*S. tephrus* is a small, slender form nearest in size to *S. hudsonicus* and *S. douglassii* among the Recent species. The rostrum is relatively long, deep and narrow. The palate also appears to be rather narrow, but this may be due in part to crushing. The maxillary portion of the zygoma rises anteriorly as a ridge, reaching approximately between the dorsal and ventral sides as in *S. malheurensis*. This ridge is similarly developed in *Ischyromys*, but less so in *Paramys*. In Recent individuals the ridge rises well toward the dorsal surface of the muzzle. The anterior opening of the infra-orbital foramen is a vertical slit placed well ahead of P4. The ventro-lateral portion of the margin of this opening is prolonged ventrally into a small knob which, however, is not so conspicuous as in the citellids. The fossæ posterior to the incisors and antero-lateral to the anterior palatine foramina are present but less developed than in *S. malheurensis*. The diastema between the incisor and fourth premolar is very long in proportion to the size of the skull, approaching that in the larger *S. deppei*.

The cheek-teeth in No. 332 are of moderate size and exhibit considerable wear. The enamel of the occlusal surface in these teeth has been almost entirely worn away. The cusps and crests are subdued and are formed only of dentine, except around the margins of the teeth. $P\underline{4}$ is a small tooth compressed anteroposteriorly with only two transverse ridges of any prominence. The anterior and posterior marginal crests in this tooth are very much reduced. $M\underline{1}$ and $M\underline{2}$ are more quadrate than $P\underline{4}$ and show four transverse crests, of which the fourth or posterior crest is much reduced. On the external margin of these two teeth there is evidence of a small cuspule between the paracone and metacone. $M\underline{3}$ has a prominent crest extending from the protocone to the paracone, with a low marginal ridge of enamel anterior to this. Posterior to the principal ridge is the basined heel. In none of the teeth is there an indication of a distinct protoconule.

Relationships—The difficulty of making adequate comparisons with other Tertiary forms is encountered likewise in a study of the relationships of *S. tephrus*. Because of lack of comparable material, neither the John Day species nor the White River form permit of ready comparison with the type from Skull Spring. Where materials consist only of lower jaw fragments, size becomes the only character on which a comparison can be made.

S. tephrus differs from *S. malheurensis* in several characters, notably in much smaller size. This can not be due to difference in age, inasmuch as the tooth rows are not of comparable length and No. 332 is an old individual. Secondly, the rostrum, though deep, is slender and relatively narrow dorsally, whereas in *S. malheurensis* the rostrum is robust and broad. Thirdly, the diastema between the incisor and $P\underline{4}$ though long in both forms is somewhat shorter in proportion to the length of tooth-row in *S. tephrus*. Fourthly, the fossæ posterior to the incisors are not so well developed in the small form. Lastly, while the pattern of the teeth can not be compared, due to great difference in wear, the anterior grinders are relatively shorter anteroposteriorly in *S. tephrus*.

The position of this form in the phylogenetic series of sciurids is also indefinite. *S. tephrus* may be ancestral to some of the smaller species of living forms, but there is as yet no good evidence to show that modern species originated separately as far back as perhaps middle Miocene time.

Comparative Measurements

	S. tephrus No. 332 C.I.T.	S. malheurensis No. 129 C.I.T.	S. hudsonicus No. 6813*	S. douglassii No. 8706*
	mm.	*mm.*	*mm.*	*mm.*
Depth of muzzle below naso-frontal suture.......	*a* 11.5	16.1	11.8	11.2
Length of diastema between I and P4..........	12.4	16.8	10.8	11.4
Distance between posterior margin of anterior palatine foramen and P4.....	7.0(?)	11.2	7.5	7.7
Width of dorsal surface of muzzle across anterior palatine foramina........	5.0–6.0	7.7	*a* 5.0	*a* 5.0
P4 to M3, greatest length...	6.9	9.1	7.2	8.0
I, anteroposterior diameter.	2.9	*a* 4.3	2.5	2.5
I, greatest transverse diameter....................	1.6	*a* 2.4	1.4	1.4
P4, anteroposterior diameter	1.4	2.0	1.7	2.1
P4, greatest transverse diameter................	1.8	2.4	1.8	2.3
M1, anteroposterior diameter	1.8	2.4	1.8	1.9
M1, greatest transverse diameter................	2.1	2.7	2.1	2.4
M2, anteroposterior diameter	1.8	2.3	1.8	2.1
M2, greatest transverse diameter................	2.2	2.8	2.3	2.6
M3, anteroposterior diameter	2.1	2.5	2.1	2.3
M3, greatest transverse diameter...............	2.0	2.5	2.0	2.3

a, approximate.
* Recent skulls from Donald R. Dickey Collection.

Citellus ridgwayi[1] n. sp.

Holotype—No. 334 C. I. T. Coll. Vert. Pale., a skull with superior dentition.

Specific characters—Skull broad and shallow. Size and length of tooth-row near *Callospermophilus chrysodeirus*. Palate wide and diastema between I and P3 long. Teeth not so progressive as in typical citellids. P3 with simple, conical crown. P4 short anteroposteriorly and with two lophs. M1 and M2 broad, with two prominent lophs of moderate height and with one less prominent crest in front.

Material—The type specimen, No. 334, is the front portion of a skull which extends backward to the anterior wall of the brain-case (see plate 2, figs. 1 and 1*a*). The rostrum is somewhat distorted, the left side having been elevated with respect to the right. A good portion of the right zygoma has been preserved, but very little of the left. The cheek-teeth on the right side are well preserved, but those on the left, except P3 and P4, were exposed and have been somewhat weathered. The incisors have been broken down nearly to the alveolar rims.

A second skull, No. 335 (see plate 2, figs. 2 and 2*a*), which has been referred to this species is more complete but the preservation is not so good as in No. 334. A larger portion of the cranium is present, but the anterior cheek-teeth, P4 and M1, on both sides are absent or poorly preserved.

[1] Named for John L. Ridgway.

A fragment of the maxillaries and frontals of another individual, No. 336, retains the three molar teeth on the right side. The specimen has been referred to *C. ridgwayi* on the basis of the depth of the skull and size of the teeth.

Description—Citellus ridgwayi is a small ground squirrel resembling closely in size *Callospermophilus chrysodeirus* among the Recent forms. No. 334 has the typical shallow muzzle of the citellids, which is ventrally broad in the vicinity of the anterior palatine foramen as well as between the cheek-teeth. No. 335 is similar to the Recent form *C. chrysodeirus* in many respects, as in the shape and position of the zygomatic arch, the shape of the anterior portion of the cranium and the length of the tooth-row. The muzzle in *C. ridgwayi* is slightly shallower toward the rear than *C. chrysodeirus*, and has a longer diastema between the cheek teeth and incisors. The dorsal surface of the skull in No. 335 is less convex longitudinally than in the Recent form, a character which was also noticed in a comparison of *Sciurus malheurensis* with Recent forms. The dorsal surface is also wider between the orbits in both Nos. 334 and 335 than in *C. chrysodeirus*. The outer and anterior margin of the zygoma in No. 334 continues forward on the side of the muzzle as a small ridge, following the contour of the incisor to the alveolus. This ridge is subdued in modern citellids and may not be continuous with the zygoma. The projection from the ventro-lateral margin of the infra-orbital foramen is conspicuous in No. 334.

The cheek-teeth in the type specimen are well worn, but the cusps and lophs are still pronounced. The pattern of the teeth resembles to some extent that in living citellids. Although the transverse lophs are well developed, the teeth show a closer resemblance to *Sciurus* than do the teeth in modern individuals. The teeth are relatively broad transversely in comparison to their length and approach the nearly triangular outline of Recent citellid teeth.

$P\underline{3}$ in No. 334 is a simple, conically crowned tooth, rather robust as in most ground squirrels. $P\underline{4}$ is short anteroposteriorly but wide transversely, and has only two crests developed. There is present on the outer enamel of this tooth a very small cuspule between the paracone and metacone. This cuspule is also present in $M\underline{1}$ but not in the other teeth. $M\underline{1}$ and $M\underline{2}$ are relatively wide teeth. The two central lophs, terminating laterally in the paracone and metacone respectively, are well developed with no indication of a distinct metaconule on the latter ridge, at least not in the present state of wear. The anterior style on the enamel margin of these two teeth is moderately prominent, but the posterior margin is subdued, giving the teeth a three-ridged appearance. While the posterior ridge is often prominent in *Sciurus*, and likewise in a few citellids, the reduction of that ridge appears to be associated with the development of a triangular shaped tooth. $M\underline{3}$ has the usual expanded posterior basin or heel. The protocone-paracone loph is prominent and there is also a ridge running through the posterior heel to the metacone. In the last upper molar of No. 335 this ridge to the metacone is not shown. Modern citellids may have a cusp (metaconule) in this basin and perhaps one or two cuspules on the margin between paracone and metacone.

Relationships—Compared with *C. (Protospermophilus) quatalensis* Gazin,[1] *C. ridgwayi* is less robust, decidedly smaller and has somewhat more

[1] C. L. Gazin, Carnegie Inst. Wash. Pub. No. 404, pp. 64-66, 1930.

modernized teeth. The two species undoubtedly belong to different subgroups, but their position in the phylogenetic tree is not definitely known. *C. (P.) quatalensis,* although more primitive, comes apparently from younger beds than the species *C. ridgwayi* and hence can not belong with the latter in the same phyletic line. The resemblances of the two forms, one to *Otospermophilus* and the other to *Callospermophilus,* might suggest their positions in the phylogenetic series. The close relationship existing between these living groups obviates, however, the possibility of independent origin of the types in less closely related Miocene forms.

C. ridgwayi differs from *C. cochisei* Gidley [1] from the Pliocene San Pedro Valley beds of Arizona in smaller size. The upper teeth in the former species are of relatively greater anteroposterior diameter and P3 is less developed than in *C. cochisei.*

Adequate comparisons can not be made with *C. bensoni* Gidley, [2] also from the San Pedro Valley beds, inasmuch as the upper jaw material of this form is very fragmentary. The paratype, which is a lower jaw, indicates a much larger species than *C. ridgwayi.*

Both of the San Pedro Valley forms are more advanced than *C. ridgwayi,* in possessing comparatively modern dentitions. *C. cochisei* has a dentition approaching that in typical citellids in relative anteroposterior compression of the teeth. As mentioned by Gidley, there is also some resemblance to *Cynomys. C. bensoni* is near *C. beecheyi,* according to Gidley, and hence falls possibly in the subgenus *Otospermophilus.*

Comparative Measurements

	C. ridgwayi		C. (P.) quatalensis No. 30	C. chrysodeirus No. J902*
	No. 334	No. 335		
	mm.	*mm.*	*mm.*	*mm.*
Depth of skull from frontals to palate between M1	....	9.4	10.0 (?)	10.1
Width of palate between M1	*a* 6.9	6.9	8.2	11.3
Length of diastema between I and P3	*a* 13.1	....	11.4	10.7
P3 to M3, greatest length	7.9	*a* 7.9	10.2	7.9
I, anteroposterior diameter	*a* 2.8	*a* 2.7	*a* 3.4	1.9
I, greatest transverse diameter	1.9	*a* 1.9	1.9	1.4
P3, greatest diameter	0.7	....	0.6	1.1
P4, anteroposterior diameter	1.6	....	2.0	1.8
P4, greatest transverse diameter	2.0	....	2.5	2.2
M1, anteroposterior diameter	1.9	*a* 1.8	2.2	1.8
M1, greatest transverse diameter	2.4	*a* 2.3	2.6	2.3
M2, anteroposterior diameter	2.0	2.0	2.3	1.9
M2, greatest transverse diameter	2.4	2.3	2.7	2.4
M3, anteroposterior diameter	2.3	2.2	....	2.2
M3, greatest transverse diameter	2.1	2.0	....	2.2

a, Approximate.
* Recent skulls from Donald R. Dickey Collection.

Liodontia alexandræ (Furlong)

G. S. Miller and J. W. Gidley [3] established the genus *Liodontia* with the species *Aplodontia alexandræ* Furlong [4] as the type. If, as seems advisable,

[1] J. W. Gidley, U. S. Geol. Surv. Prof. Paper 131-E, pp. 121-122, 1922.
[2] J. W. Gidley, *ibid.*, p. 122, 1922.
[3] See G. S. Miller and J. W. Gidley, Jour. Wash. Acad. Sci., vol. 8, p. 440, 1918.
[4] E. L. Furlong, Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, pp. 397-403, 1910.

the Miocene and apparently Pliocene types are to be recognized as generically distinct from the Quaternary representatives of the family, the following characters may serve in part to distinguish *Liodontia* from *Aplodontia.*

Generic characters of Liodontia—Size smaller than *Aplodontia*. Greater anteroposterior convexity to dorsal surface of cranium. Lower jaws less robust. Dental formula: $\frac{1}{1}$, $\frac{0}{0}$, $\frac{2}{1}$, $\frac{3}{3}$. Diastema between I and $P\overline{4}$ relatively short. Teeth hypsodont as in *Aplodontia.* Upper teeth with pattern similar to that in *Aplodontia.* Lower teeth of adult specimens without mesostyle on paramere. Antero-external fold in lower teeth early reduced. Enamel lakes in P $\frac{4}{4}$ retained in relatively late wear.

Revision of species—The type specimen of *L. alexandræ,* No. 11325 Univ. of Calif. Coll. Vert. Pale., is recorded from loc. 1090 (Univ. of Calif.) in the Virgin Valley beds of northwestern Nevada and is considered as Miocene in age. The cotypes, on the other hand, are recorded as having come from locality 1103 (Univ. of Calif.) in the Thousand Creek beds west of Railroad Ridge and immediately to the east of the Virgin Valley basin. The Thousand Creek deposits are regarded as Pliocene in age. An examination of this material, in the light of forms now known from the Skull Spring locality, has led the author to believe that a second species is present in the material from northwestern Nevada, represented by the Thousand Creek specimens. The upper dentitions of *Liodontia* from the two Nevada horizons are not particularly diagnostic, and for that matter differ little except in size from Recent teeth. However, in a comparison of the Thousand Creek lower jaws with a specimen from the Virgin Valley beds referred to *L. alexandræ,* differences in the character of the teeth are noted which may be regarded as of specific importance. The lower jaws from Skull Spring rather uniformly resemble the Virgin Valley specimen, with no tendency toward the characters shown by the Thousand Creek lower jaws.

In view of the distinction which ought to be made between the types from the Virgin Valley Miocene and Thousand Creek Pliocene it appears necessary to revise the description of *Liodontia alexandræ,* utilizing the characters exhibited only by the Virgin Valley specimens, namely the type No. 11325 from loc. 1090 and the referred lower jaw No. 11864 from loc. 1095, which becomes a plesiotype.

Specific characters of Liodontia alexandræ—Size larger than *Meniscomys hippodus* and smaller than *Aplodontia rufa.* $P\underline{4}$ with two strongly developed lateral styles and upper molars with prominent mesostyles. Lower jaw with protuberances below lower ends of teeth. Anteroventral margin of masseteric fossa weak. Inner wall or paramere of lower molars and $P\overline{4}$ without median style. Inner wall of lower molars crescentic with anterior and posterior angles equally developed. Antero-external fold conspicuous in lower molars of moderate wear.

The Thousand Creek material is referred to a new species, for which the name *Liodontia furlongi* is proposed. The type specimen for this species is a lower jaw, No. 11897 Univ. of Calif. Coll. from locality 1103 (Univ. of Calif.). An upper dentition No. 11898 Univ. of Calif. Coll. and an immature lower jaw No. 11909 Univ. of Calif. Coll. from the same locality are considered as paratypes.

Specific characters of Liodontia furlongi—Size similar to that of *L. alexandræ.* Mesostyles on upper teeth slightly more acute. Protuberances on lower jaw less conspicuous. Antero-ventral margin of masseteric fossa strongly developed and extends slightly farther forward. Inner wall of lower molars and $P\overline{4}$ without mesostyle in adult specimen. Very weak mesostyle on lower teeth of immature specimen. Postero-internal angle of lower teeth developed into a prominent style, and antero-internal angle of molars rounded out. Antero-external fold on lower molars prominent in immature stage, but much reduced with advanced wear.

From the above description it is seen that *L. furlongi* differs from *L. alexandræ* in acuteness of styles in upper teeth, in reduction of ventral protuberance on lower jaw, in development and position of masseteric ridge and in character of inner wall of lower teeth. *L. furlongi* approaches *Aplodontia* more closely than does *L. alexandræ* in the reduction of the ventral protuberances and in the development and position of the masseteric ridge.

Description of Skull Spring material—The material from Skull Spring representing *L. alexandræ* consists of a series of six superior dentitions, Nos. 321 to 326 inclusive, C.I.T. Coll. Vert. Pale.; five lower jaws, Nos. 327 to 331 inclusive; and a number of isolated teeth. Specimen No. 321 is more complete than the others and exhibits the shape of the cranium as well as a full grinding dentition. Complete incisors have not been preserved in any of the specimens. Lower jaw No. 327 retains the basal part of the incisor up to the point of its emergence from the alveolus.

Skull—Specimen No. 321, although small, resembles *Aplodontia* in breadth of the cranial region and in the tapering of the skull forward to the frontals. Likewise the skull becomes rather constricted in the region of the olfactory lobes. A noticeable difference exists in the slope or longitudinal profile of the back portion of the skull. In Recent species of *Aplodontia* there is a tendency for the skull to be nearly flat on top, and this character becomes pronounced with age.[1] The posterior portion of the cranium in the fossil is much depressed, giving a more convex profile than is present even in immature specimens of Recent species. As indicated by the teeth, the fossil specimen belongs to a mature individual.

In those specimens in which $P\underline{3}$ is preserved, the tooth is a simple conical column appressed against the antero-internal surface of $P\underline{4}$. The permanent $P\underline{4}$ and molars in the mature specimens are simple hypsodont teeth having evenly rounded lingual surfaces. The external surfaces of the molars have prominent mesostyles extending the vertical length of the tooth. $P\underline{4}$ is slightly longer anteroposteriorly than the molars and is characterized by two external styles.

The series of teeth of the individuals represented in the collection exhibit interesting variations in stages of wear. In No. 326 (see plate 3, figs. 4 and 4*a*) of the upper series, $Dp\underline{4}$ is in place with the anterior molars just erupting. $Dp\underline{4}$ is tending toward hypsodonty, but has three well-developed roots. The two exterior styles extending downward from the root region become pronounced toward the occlusal surface. The cusps are all conspicuous. The paracone and metacone extend ventrally beyond the styles. The protocone is a long crescentic ridge convex internally. A most interesting as well as highly important feature is the centrally located position of the protoconule(?) and metaconule(?). These cusps in the unworn permanent $P\underline{4}$ of Recent *Aplodontia* are more marginally situated. The position of the cusps in the $Dp\underline{4}$ of the Skull Spring form is almost identical with that in $P\underline{4}$ of *Meniscomys hippodus* Cope. The only difference apparently is that in No. 326 the valley folding is somewhat more accentuated than in

[1] W. P. Taylor, Univ. Calif. Publ. Zool., vol. 17, p. 440, 1918.

Meniscomys. In No. 326 $Dp\underline{4}$ is very little worn. Some of the enamel folds are only slightly truncated, others not at all.

The stage of wear in the more mature specimens is indicated by the number of enamel lakes retained by $P\underline{4}$. Specimen No. 323 (see plate 3, fig. 3) from Skull Spring shows four lakes in $P\underline{4}$. Specimens 324 and 325 present a stage of wear similar to that of the type specimen from Virgin Valley, in which three lakes are retained. No. 322 (see plate 3, fig. 2) from Skull Spring has only one basin. Still more advanced wear is exhibited by $P\underline{4}$ in No. 321, which is without lakes. In Recent *Aplodontia* only two lakes are of sufficient depth to endure for any appreciable period in the course of attrition.

Mandible—The lower jaws of *L. alexandræ* from Skull Spring resemble in shape the mandible of *Aplodontia* but are much smaller. The marginal portion of the posterior part of the ramus has not been preserved in any of the specimens. No. 327 (plate 4, figs. 5, 5*a* and 5*b*) and No. 330 (plate 4, figs. 3, 3*a* and 3*b*) show enough of this region to indicate the direction of the condyle, the coronoid and the anterior and posterior processes of the angle. The angulation is apparently the same in Recent forms. The basal portion of the ascending ramus branches perhaps somewhat higher in the fossil jaw and is situated closer to the crowns of the teeth. The antero-ventral margin of the masseteric fossa is not so robust as in Recent forms. The diastema between I and $P\overline{4}$ in No. 327 is comparatively short. No. 327 exhibits an interesting development of a series of knobs along the ventro-external surface of the jaw, corresponding in position to the lower extremities of the four teeth. A similar development is seen in lower jaw, No. 11864 Univ. Calif. Coll., from Virgin Valley, Nevada.

Three stages of wear of the teeth are represented by the series of lower jaws. The most immature specimen, No. 331 (plate 4, fig. 1), possesses a very little-worn $P\overline{4}$ and the first two molars. The premolar has two pronounced longitudinal infolds. One is formed in the anterior surface of the tooth and the other in the external surface, anterior to the median portion of the tooth. The talonid region is broad and large compared with the narrow trigonid portion. The occlusal surface of the tooth is marked by two basins. The posterior basin is well back in the heel and the anterior and larger basin is more centrally located and extends into the protoconid(?) and paraconid(?) or metaconid(?) columns. There is only the faintest trace of a median style on the internal side of the tooth. This style is rather well developed in milk and permanent premolars of Recent individuals. Furthermore, an anterior style is present in the milk tooth of Recent *Aplodontia,* giving rise to a small enamel lake between protoconid(?) and paraconid(?) with continued wear. A similar isolated lake is formed in $P\overline{4}$ by an anterior union of the protoconid(?) and paraconid(?) columns and is exhibited at a stage of moderate wear. With further attrition this lake also disappears.

$P\overline{4}$ in specimens No. 327 and No. 328 is worn to a stage where the posterior basin has been obliterated. The median lake is still present, as are likewise the two anterior folds. In No. 328 (see plate 4, figs. 4, 4*a* and 4*b*), a small groove is present just posterior to the external fold. The greatest wear is exhibited by $P\overline{4}$ in specimens No. 329 and No. 330 in which the median lake is lost. In No. 330 the anterior groove is compressed, but in No. 329 (see plate 4, fig. 2) this character is somewhat obscure and the enamel does not appear to be continuous across the front of the tooth. The inner surface of the tooth has a compound curvature anteroposteriorly, concave outward in the posterior part. This is true of the other specimens as well.

All the inferior molar teeth in the various individuals recorded from Skull Spring show a crescentic inner tooth margin which is concave lingually. There is no evidence of an inner median style characteristic of Recent forms. An absence of the style is noted also in the premolars, but a very feeble deflection occurs in $P\overline{4}$ of No. 331. A pronounced antero-external fold is present in the molars of No. 331 and diminishes farther down the tooth-crown. This fold is also conspicuous in $M\overline{3}$ of specimens No. 327 and No. 328. In Recent specimens the fold remains prominent in all the molars to a rather late stage of wear.

Relationships—Aplodontia (?) *asiatica*[1] differs from the Nevada and Oregon material in many respects. The median horizontal crest in the masseteric fossa dividing the areas for attachment of the *masseter medialis* and *masseter lateralis* muscles is not conspicuous in any of the lower jaws of *L. alexandræ* or of *L. furlongi,* but is traceable in many specimens of *A. rufa.* The teeth in the lower jaw described by Schlosser[2] show a stage of wear in which $P\overline{4}$, $M\overline{2}$ and $M\overline{3}$ still retain the median lake, $M\overline{1}$ does not. The antero-external fold is present on all four teeth. This fold is also present on the three teeth of an immature lower jaw No. 331 from the Skull Spring horizon and is conspicuous in teeth, not too much worn, of *A. rufa.* The external curvature of the molar teeth is not noticeably different from that in the Skull Spring material.

A.(?) *asiatica* is apparently a primitive branch from the aplodont stock which may have separated from the American group at a time when the development had reached a stage somewhere between *Meniscomys hippodus* and *Liodontia alexandræ.* If the Asiatic form occurs in association with *Hipparion richthofeni* its position in time and space obviates the possibility of origin of the Nevada forms of *Liodontia* from this type as suggested by Schlosser.

The specimen, No. 19798 Univ. Calif. Coll., from the upper Miocene Cedar Mountain beds of west-central Nevada[3] may represent $Dp\underline{4}$ of *Liodontia alexandræ* or of some closely related species. The position of the enamel lakes agrees with that in No. 326, and the divergence of the roots is not less than that in the Skull Spring $Dp\underline{4}$. In No. 326, however, $P\underline{4}$ is not shown and $M\underline{1}$ has just erupted and is extremely hypsodont. The Cedar Mountain horizon is regarded as somewhat later than the stage represented by the Skull Spring and Virgin Valley faunas.

The derivation of *Aplodontia* from *Meniscomys hippodus* has been suggested by several writers among whom may be mentioned Cope, Matthew and Gidley, Furlong, J. C. Merriam, Taylor and Schlosser. The intermediate position of *Liodontia* between *Meniscomys hippodus* and *Aplodontia rufa* has been considered by Furlong and by Taylor. The derivation of *Liodontia* from *Meniscomys hippodus* is further indicated by the characters exhibited in the milk tooth of specimen No. 326 from Skull Spring.

[1] M. Schlosser, Palæont, Sinica, vol. 1, pp. 30-31, 1924.
[2] M. Schlosser, *op. cit.,* plate II, fig. 15, 1924.
[3] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, pp. 177-179, fig. 14, 1916.

Comparative Measurements

	L. alexandræ					A. rufa*
	No. 321 C.I.T.	No. 322 C.I.T.	No. 323 C.I.T.	No. 324 C.I.T.	No. 11325 Univ. Calif. Type	No. 8671
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Depth of skull between frontals and palate...	11.7	...	...	...	.....	19.3
Width of palate between $P\underline{4}$..........	4.0	4.3	4.2	...	4.5	5.1
Width of palate between $M\underline{3}$..........	3.5	...	...	...	4.5	6.0
$P\underline{3}$-$M\underline{3}$, greatest length.	11.1	11.7	...	...	*a* 12.5	17.8
$P\underline{4}$, anteroposterior diameter..........	3.3	3.5	4.0	4.0	*a* 4.0	4.8
$P\underline{4}$, greatest transverse diameter..........	3.0	3.4	3.6	3.9	4.0	5.4
$M\underline{1}$, anteroposterior diameter..........	2.2	2.4	2.4	2.6	2.5	3.9
$M\underline{1}$, greatest transverse diameter..........	3.0	2.9	3.5	3.4	3.0	4.7
$M\underline{2}$, anteroposterior diameter..........	2.6	2.5	2.5	2.8	2.5	3.7
$M\underline{2}$, greatest transverse diameter..........	2.6	2.9	3.2	3.0	3.0	4.2
$M\underline{3}$, anteroposterior diameter..........	2.6	2.6	...	...	*a* 3.0	4.4
$M\underline{3}$, greatest transverse diameter..........	2.4	2.4	...	...	.....	3.7

	L. alexandræ				A. asiatica	A. rufa* No. 8671
	No. 327 C.I.T.	No. 328 C.I.T.	No. 329 C.I.T.	No. 11864 Univ. Calif.		
Depth of ramus at $P\overline{4}$..	8.1	7.5	*a* 7.7	8.3	...	15.5
Depth of ramus at $M\overline{2}$.	7.0–8.0	8.3	*a* 7.6	8.7	6.6	12.8
Length of diastema between I and $P\overline{4}$......	(?)5.0	...	...	...	9.5	13.3
$P\overline{4}$ to $M\overline{3}$, greatest length..............	11.0	11.0	11.4	11.4	10.5	16.4
$P\overline{4}$, anteroposterior diameter..........	3.2	3.3	3.4	3.2	3.5–4.5	4.4
$P\overline{4}$, greatest transverse diameter..........	2.3	2.4	2.5	2.2	.....	3.9
$M\overline{1}$, anteroposterior diameter..........	2.6	2.5	2.7	2.5	.....	3.7
$M\overline{1}$, greatest transverse diameter..........	2.3	2.3	2.3	2.2	.....	3.7
$M\overline{2}$, anteroposterior diameter..........	2.6	2.6	2.8	2.6	.....	3.7
$M\overline{2}$, greatest transverse diameter..........	2.2	2.1	2.3	2.0	.....	3.2
$M\overline{3}$, anteroposterior diameter..........	2.7	2.6	2.8	2.7	.....	4.0
$M\overline{3}$, greatest transverse diameter..........	1.9	1.8	1.8	1.8	.....	3.0

a, Approximate.

* Recent skulls from Donald R. Dickey Collection.

Mylagaulus, cf. lævis Matthew

This aberrant rodent in the Skull Spring fauna is represented in the collection of the California Institute by five skulls or portions of skulls, four lower jaws, approximately thirty isolated teeth, the distal part of a humerus, and the proximal end of a femur. The most complete skull, No. 68 C. I. T. Coll. Vert. Pale. (plate 5, figs. 1, *1a*, and *1b*), was worked out of a nodule and is fairly well preserved. The right zygoma and tooth series were exposed and weathered away. P4, M2 and M3 are present in the left maxillary. No. 69 is less completely preserved, but a portion of the left ramus of the mandible is still attached to the skull. M2 and M3 are preserved on both sides with P4 only on the left. Nos. 365, 366 and 367 are fragments of skulls with teeth. No. 366 (plate 4, fig. 6) is an immature individual with an unworn P4 and the first two molars present. The three isolated lower jaws, Nos. 70 (plate 5, figs. 2, *2a*, and *2b*), 368 (plate 5, figs. 4, *4a*, and *4b*), and 369 (plate 5, figs. 3, *3a*, and *3b*), are fairly well preserved except for their posterior portions and incisors.

Specimen No. 68 from Skull Spring approaches more closely *Mylagaulus lævis* of the lower Snake Creek beds than to any other species so far described. The Oregon specimen is slightly larger than the Snake Creek *M. lævis* and is distinctly larger than the type from the Pawnee Creek beds. The curvature of the zygomatic arch is very similar to that in No. 17576 of the Amer. Mus. Coll. from the lower Snake Creek horizon. No. 68 differs in this respect very decidedly from skulls of *M. vetus, Ceratogaulus rhinocerus* and *Epigaulus hatcheri,* whose zygomatic arches are not so much expanded antero-laterally. No. 68 possesses a more slender arch than either the Snake Creek *M. lævis* or the type of *C. rhinocerus,* and the post-orbital process of the zygoma is more prominently developed. The post-orbital process of the frontal and the superior orbital notch are fully as conspicuous in No. 68 as in Amer. Mus. No. 17576. The temporal crests, while farther apart anteriorly behind the post-orbital processes than in Amer. Mus. No. 17576, approach each other more closely posteriorly than in the latter. The crests are much more widely separated in the horned forms, *C. rhinocerus* and *E. hatcheri.* A conspicuous difference between No. 68 and the Snake Creek *M. lævis* is in the slope of the occiput. In No. 68 the surface slopes more gradually downward and backward from the dorsal rim. In this character No. 68 differs also from Amer. Mus. No. 9456 (skull type) of *C. rhinocerus.* However, No. 69, a more fragmentary skull from Skull Spring, shows a steeper occiput, but on the basis of the teeth appears to be specifically identical with No. 68.

The fourth upper premolars from Skull Spring are concave externally in vertical profile and have on their sides an antero-external and an antero-internal groove which usually become more conspicuous with advanced wear, particularly the internal groove. These teeth show a minimum of five lakes corresponding to the five basins in *Meniscomys hippodus* and the milk tooth of *Liodontia alexandræ.* The maximum number of lakes occurring at one time in any of the specimens in the collection is seven, although apparently this number may be increased to eight or nine. The molars are small and simple, and only the second and third are present in mature individuals.

The three lower jaws, Nos. 70, 368 and 369, are of approximately the same size but vary somewhat in thickness. No. 70 is the heaviest jaw and in thickness approaches the type of *M. monodon* but is not so deep. *M. vetus,* although close in size to the lower jaw, No. 70, is somewhat more slender, in which respect it may resemble No. 368. The fourth premolars in the Skull Spring specimens are, however, larger than in the type of *M. vetus*. *M. paniensis* and *M. novellus* are distinctly smaller forms, as are also *M. pristinus* and *M. proximus*.

The lower fourth premolars from Skull Spring are large teeth, which in cross-section become long and narrow with advanced wear. In little-worn teeth, grooves are conspicuous on the sides, particularly on the antero-external and postero-internal surfaces. These grooves may not persist throughout the length of the tooth. The enamel lakes on the crown are arranged obliquely along the inner and outer walls, the elongation being antero-external to the long diameter of the tooth. The pattern is noticeably uniform throughout the specimens in the collection. The number of lakes is usually six and occasionally seven. The seventh lake may possibly be produced through a division of the second of the three internal lakes. The corresponding tooth in the types of *Mylagaulus vetus, M. paniensis* and *M. pristinus* has five lakes, and in *Mesogaulus ballensis* four are present. On the other hand, *Mylagaulus monodon* has seven major lakes and a referred specimen has two minor lakes in addition.

Relationships—The derivation of *Mylagaulus* from *Meniscomys* was first discussed by Cope,[1] later by Riggs,[2] and still later by Matthew.[3] A consideration of the enamel pattern in $P\underline{4}$ of an immature mylagaulid, No. 366 from Skull Spring, further suggests this relationship. The tooth is practically unworn and shows, as does $Dp\underline{4}$ of *Liodontia alexandræ* from Skull Spring, a close approximation in arrangement of cusps and basins to that in $P\underline{4}$ of *Meniscomys hippodus*.

The Skull Spring specimen, No. 68, approaches rather closely skulls of Recent *Aplodontia rufa* in size. There is a striking similarity in many characters between *Mylagaulus* and *Aplodontia*. This has been pointed out by Gidley[4] in a discussion of the relationships of *Epigaulus* and by Matthew[5] in a statement concerning *M. lævis*. A similar appearance is most noticeable in the dorso-ventral compression of the skull, in lateral expansion of the zygomatic arches and the occipital region of the skull and in the general proportions of the lower jaws. The outstanding differences lie in the heaviness of the zygoma in the mylagaulid, the shape of the brain case, the presence of post-orbital processes and ridges, the less-deflected angle of the lower jaw and in the character of the teeth.

Apparently the greatest divergence between *Aplodontia* and *Mylagaulus* exists in their separate dental development. The dentition in *Aplodontia* has become extremely hypsodont, the external styles are emphasized, the enamel lakes reduced and the several teeth in the jaws tend toward a uniform pattern with no very great difference in size. In the mylagaulid dentition on the other hand, the fourth premolar is developed at the expense of all the other cheek-teeth, the fossettes are emphasized and the external styles are reduced at an early stage. Hypsodonty is developed to a varying degree in the different teeth of the series, best shown in the enlarged premolar and least in the first molar.

[1] E. D. Cope, U. S. Geol. and Geog. Surv. Terrs., vol. 4, pp. 384-385, 1878.
[2] E. S. Riggs, Field Columbian Mus. Publ. 34, Geol. Ser., vol. 1, pp. 183-186, 1899.
[3] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 50, pp. 81-84, 1924.
[4] J. W. Gidley, Proc. U. S. Nat. Mus., vol. 32, pp. 628-635, 1907.
[5] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 50, pp. 78-81, 1924.

Comparative Measurements

	M., cf. lævis	
	No. 68 C.I.T.	No. 69 C.I.T.
	mm.	*mm.*
Greatest width from median line of skull to outer surface of zygoma...	34.5	......
Distance from occipital crest to naso-frontal suture..................	27.0	*a*30.0
Distance from anterior surface of $P\underline{4}$ to tip of condyle................	48.5	*a*41.2
Width of palate between $P\underline{4}$....................................	*a*5.0	*a*5.0
Length of superior grinders, $P\underline{4}$, $M\underline{2}$ and $M\underline{3}$........................	16.8	*a*15.5
$P\underline{4}$, anteroposterior diameter at alveolar border......................	*a*9.0	*a*9.0
$P\underline{4}$, greatest transverse diameter at alveolar border.................	6.3	5.9
$M\underline{2}$, anteroposterior diameter..................................	3.5	3.6
$M\underline{2}$, greatest transverse diameter...............................	4.3	4.2
$M\underline{3}$, anteroposterior diameter..................................	3.0	2.8
$M\underline{3}$, greatest transverse diameter...............................	3.7	3.2

	M., cf. lævis			M. vetus	M. monodon
	No. 70 C.I.T.	No. 368 C.I.T.	No. 369 C.I.T.	No. 18905 Type*	No. 8327 Type*
	mm.	*mm.*	*mm.*	*mm.*	*mm.*
Depth of jaw at posterior end of $P\overline{4}$....................	*a*14.5	*a*13.2	14.7	14.6	*a*16.4
Thickness of jaw at anterior end of masseteric area.......	*a*10.2	*a*6.4	*a*9.0	6.3	8.3
Length of inferior grinders, $P\overline{4}$, $M\overline{2}$ and $M\overline{3}$..............	*a*17.7	17.8	16.8	....	....
$P\overline{4}$, anteroposterior diameter at alveolar border..........	9.5	9.9	9.8	7.9	*a*9.8
$P\overline{4}$, greatest transverse diameter at alveolar border......	*a*5.0	4.4	4.8	4.3	*a*6.0
$M\overline{2}$, anteroposterior diameter..	....	3.8	3.7	....	....
$M\overline{2}$, greatest transverse diameter......................	....	3.5	3.4	....	....
$M\overline{3}$, anteroposterior diameter..	....	3.3	3.6	....	....
$M\overline{3}$, greatest transverse diameter......................	....	2.4	2.3	....	....

a, approximate. * Amer. Mus. Coll.

Diprionomys ? oregonensis n. sp.

Holotype—No. 371 C. I. T. Coll. Vert. Pale., a fragmentary skull and lower jaw, from locality 57 near Skull Spring, Malheur County, Oregon.

Paratype—No. 370, a skull from the same locality.

Specific characters—Skull near size of *Heteromys desmarestianus psakastus*. Cranium broader and slightly longer. Interparietal larger. Diastema between I and $P\underline{4}$ and that between I and $P\overline{4}$ approximately as in *H. d. psakastus*. Teeth slightly larger than in *Heteromys*. Incisors without grooves. Upper and lower cheek-teeth three-rooted, brachydont and cleft nearly as in *Perognathus*. Antero-internal fold on posterior column of $P\underline{4}$ curves outward. Anterior column of $P\overline{4}$ divided by fold from posterior surface in moderate wear. Transverse ridges on upper molars irregular. Lower molars oval with transverse ridges uniting first near middle of teeth. Third molars smaller than second molars.

Material—The Skull Spring locality has produced a remarkable group of specimens representing pocket mice. The collection includes four skulls and a lower jaw. The skull of the type, No. 371, is only partially preserved, but shows the shape of the cranium and has a complete left grinding dentition. The lower jaw of the type is the right ramus which has all of the teeth preserved. The jaw was found in place in the same nodule with the skull, but had weathered away below the roots of the teeth. The paratype, No. 370, is in a better state of preservation than other specimens. The skull is not complete behind the cheek-teeth, but the rostrum retains both incisors. The left grinding series is in perfect condition. Skull No. 372 retains the cranium but is incomplete anterior to $P\underline{4}$. The left cheek-teeth and most of the right are present. In a poorly preserved skull of an old individual, No. 373, the major portion of the dentition is present, including the incisors.

Skull—In size the specimens are close to *Heteromys*, being somewhat larger than *Liomys* and much larger than species of *Perognathus*. The cranium is long and broad, more so than in *Heteromys*, and perhaps more compressed dorsoventrally. The specimens do not exhibit a disproportionately large inflation of the cranium, characteristic of *Dipodomys* and *Microdipodops*. The enlargement seen in the latter genera has altered the shape of the parietals and reduced the size of the interparietal considerably. In *D.* (?) *oregonensis* the parietals are apparently similar to those in *Liomys* or *Heteromys*. The interparietal is actually larger than in these pocket mice. The rostrum is long and moderately slender with nasals protruding beyond the incisors as in other pocket mice. The rostral region is not so reduced as in the kangaroo-rats, nor is the palate between the cheek-teeth relatively as wide. The diastema between the incisors and $P\underline{4}$ in Nos. 370 and 373 compares favorably in length with that in *Heteromys*, being longer than the average of *Liomys*.

Upper dentition—The cheek-teeth in *D.* ? *oregonensis* are perhaps a little larger than in *Heteromys*, but are much more brachydont and three rooted, resembling *Perognathus* in these characters. The separate teeth are approximately three-quarters as long as they are wide and decrease in size posteriorly, but not so rapidly as in *Liomys* and *Perognathus*. The pattern resembles to a marked degree that seen in *Perognathus* but is somewhat simpler and suggestive of *Liomys* in this respect.

The upper dentitions present in the collection exhibit varying stages of wear. No. 370 with least wear possesses the most complicated pattern on the occlusal surface of individual teeth. The anterior column of $P\underline{4}$ in this specimen is simple and oval in shape. The posterior column is somewhat crescentic in shape and has on its anterior concave surface two re-entrant folds, indicating a three-cusped origin for this column or ridge. The external of the two re-entrant folds is approached by a weak postero-external fold on the convex surface of the column, emphasizing the three-fold division of the ridge. The internal of the two anterior folds is much more deeply impressed and curves outward, nearly parallel to the postero-internal surface of the column. The corresponding fold in *Heteromys* and *Liomys* curves inwardly; it is not emphasized in *Perognathus*. The crowns of the first and second molars show, as in *Perognathus* and in young specimens of *Liomys*, evidence of a development from a six-cusped tooth. The transverse fold in these two teeth is deeply impressed, nearly as much as in *Perognathus*, but more so than in *Liomys* or *Heteromys*. The posterior ridge of the third molar is reduced transversely and may have been single-cusped. The ridges are connected internally in $M\underline{2}$ and $M\underline{3}$ at the stage of wear reached in these teeth.

The wear in No. 371 has increased the crown surface of the anterior column of $P\underline{4}$, which almost touches the surface of the posterior column. The infoldings on the anterior surface of the latter column are much reduced. The two ridges in $M\underline{1}$ are connected internally as in the posterior molars. The enamel on the ridges of the molars is still slightly irregular, but the median valleys are very shallow.

In No. 372 wear has obliterated the valleys of the molars, except for an external notch in the crown. $P\underline{4}$ is a very simple type of tooth, but the two columns are still distinct. The crown heights in this specimen are low.

The greatest wear has been reached in No. 373, in which the two columns of $P\underline{4}$ have united. $M\underline{1}$ is oval in shape with no trace of an external notch. Apparently $M\underline{2}$ and $M\underline{3}$ have been worn down to the roots.

The upper incisors in Nos. 370 and 373 are of approximately the size seen in *Heteromys*. These teeth are without grooves, in which respect *D.* ? *oregonensis* differs from *Perognathus, Dipodomys* and *Microdipodops,* and is like *Heteromys* and *Liomys*.

Lower dentition—The lower grinding teeth of No. 371 are also brachydont and show a stage of wear in which the transverse folds are about to be obliterated. Unlike the upper teeth, the ridges unite first near their middle, but persist longest on the inner margin.

The two columns of $P\overline{4}$ are of nearly equal size, the posterior being slightly wider than the anterior. The folding has been slightly more pronounced on the inner side of this tooth. The inner fold upon reaching the center of the tooth branches forward across the middle of the anterior column almost to its anterior surface, thus dividing the column into two equal parts. The forwardly directed fold is shallow, but at an earlier stage in the history of this tooth must have divided the column into two cusps. The external fold or notch has only recently become separated from the inner. The tooth was probably four-cusped at an early stage of wear, but the depth of folding differs slightly from that in *Perognathus* and *Liomys*.

The lower molar teeth are nearly oval in shape and are divided by folds from both the inner and outer walls. In $M\overline{1}$ the transverse ridges are still separated; however, the ridges of the remaining two molars are connected. A small pit is present in the anterior part of the occlusal surface of $M\overline{3}$.

The lower incisors differ little from those in *Heteromys* other than being perhaps slightly broader anteriorly.

Comparison—Among Recent forms *Diprionomys* ? *oregonensis* appears to resemble most closely *Heteromys* in size and in proportions. In character of the dentition the species from Skull Spring lies between *Perognathus* and *Liomys*. The fossil shows only a very remote resemblance to such forms as *Dipodomys* and *Microdipodops*.

The Skull Spring form is much more brachydont than the later Tertiary species of *Diprionomys*. The type species *D. parvus* Kellogg[1] from the Thousand Creek beds of northwestern Nevada, in addition to being more hypsodont is much smaller than the Oregon form, but the pattern of $P\overline{4}$ may not differ greatly from that in the latter. *D. magnus* Kellogg,[2] from the

[1] Louise Kellogg, Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, pp. 433-434, 1910.
[2] Louise Kellogg, *ibid.*, pp. 434-435, 1910.

same locality in the Thousand Creek beds, has apparently a larger $P\overline{4}$ and smaller molars than *D.* ? *oregonensis*. The pattern of $P\overline{4}$ is also different and the lower incisor is relatively broader and shorter anteroposteriorly.

The species of *Diprionomys* from the Fish Lake Valley beds of west-central Nevada are smaller types with more hypsodont teeth. *D. tertius* Hall[1] is actually smaller than *D. parvus*. *D. quartus* Hall[2] is between *D. parvus* and *D. magnus* in size, and shows certain points of resemblance to *Dipodomys* and to *Liomys*.

The pattern of the lower teeth of *D.* ? *oregonensis* resembles to a marked degree that seen in the illustration of *Peridiomys rusticus* described by Matthew[3] from the lower Snake Creek beds of Nebraska. Lower jaw No. 371 of *D.* ? *oregonensis* shows relatively greater wear than the type of *P. rusticus*, but may be in reality more brachydont, as indicated by a comparison with the illustrations and with a cast of the type. The alveolar length of the lower tooth-series of *P. rusticus* is considerably greater than that of *D.* ? *oregonensis* and the length of the diastema between I and $P\overline{4}$ is relatively shorter. Although the two types exhibit considerable disparity in size, they may ultimately prove to be congeneric. The similarity in pattern of the teeth between *D.* ? *oregonensis* and *P. rusticus* is greater than that between the Oregon form and any previously described species of *Diprionomys*.

Perognathus furlongi Gazin[4] from Upper Miocene beds in southern California is a smaller form showing an unmistakable relationship to the Recent species of that genus. The rostrum is deep dorso-ventrally but is much narrower than in *Diprionomys* ? *oregonensis*. The cheek-teeth are more strikingly perognathoid, and in addition the incisors are grooved as in Recent forms.

Phylogenetic history—The heteromyid species recorded in the Skull Spring fauna is the earliest form which may be tentatively referred to the genus *Diprionomys*. Both *D.* ? *oregonensis* and *Peridiomys rusticus* appear to belong to approximately the same time stage in the Miocene. The brachydont dentition and the prominence of the folds in the teeth of these Miocene forms suggest that the brachydont, cuspate character of the teeth in *Perognathus* is a more primitive type among Recent forms. The increased hypsodonty seen in specimens from the upper Miocene Fish Lake Valley beds and from the Pliocene Thousand Creek deposits indicates a more progressive development leading perhaps toward forms such as *Dipodomys*.

The ancestry of the living genera is still uncertain, but the broad range of species in the *Diprionomys* group may include forms from which one or more of the Recent groups have developed. The group probably does not contain the ancestor of *Perognathus* as the occurrence of *P. furlongi* in beds of Upper Miocene age in Cuyama Valley precludes a derivation of this form from *Diprionomys*.

[1] E. R. Hall, Univ. Calif. Publ., Bull. Dept. Geol., vol. 19, pp. 297-298, figs. 2-4, 1930.
[2] E. R. Hall, *ibid.*, pp. 298-301, figs. 5-8, 1930.
[3] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 50, p. 85, 1924.
[4] C. L. Gazin, Carnegie Inst. Wash. Pub. No. 404, pp. 66-67, 1930.

Comparative Measurements

	D. ? oregonensis	
	No. 371 C.I.T.	No. 370 C.I.T.
	mm.	*mm.*
Distance from naso-frontal suture to posterior end of skull	26.0	....
Greatest transverse width of cranium	15.3	....
Depth of skull between palate and dorsal surface	*a*8.3	*a*8.5
Width of palate between $P\underline{4}$	*a*2.4	*a*2.4
Length of diastema between I and $P\underline{4}$	....	*a*9.4
Alveolar length, $P\underline{4}$ to $M\underline{3}$ inclusive	6.1	5.5
I, anteroposterior diameter	....	1.5–1.7
I, greatest transverse diameter	....	1.0
$P\underline{4}$, anteroposterior diameter (occlusal surface)	1.6	1.3
$P\underline{4}$, greatest transverse diameter	2.0	1.7
$M\underline{1}$, anteroposterior diameter	1.3	1.2
$M\underline{1}$, greatest transverse diameter	1.8	1.6
$M\underline{2}$, anteroposterior diameter	1.2	1.1
$M\underline{2}$, greatest transverse diameter	1.7	1.6
$M\underline{3}$, anteroposterior diameter	1.2	1.1
$M\underline{3}$, greatest transverse diameter	1.6	1.3
	D. ? oregonensis No. 371 C.I.T.	P. rusticus No. 18894*
Length of diastema between I and $P\overline{4}$	*a*4.5	*a*4.3
Alveolar length of $P\overline{4}$ to $M\overline{3}$ inclusive	5.4	6.9
I, anteroposterior diameter	1.5	....
I, greatest transverse diameter	1.0	....
$P\overline{4}$, anteroposterior diameter (occlusal surface)	1.3	*a*1.6
$P\overline{4}$, greatest transverse diameter	1.5	*a*1.9
$M\overline{1}$, anteroposterior diameter	1.2	*a*1.5
$M\overline{1}$, greatest transverse diameter	1.7	*a*2.2
$M\overline{2}$, anteroposterior diameter	1.3	*a*1.5
$M\overline{2}$, greatest transverse diameter	1.7	*a*2.1
$M\overline{3}$, anteroposterior diameter	1.2	....
$M\overline{3}$, greatest transverse diameter	1.4	....

a, approximate. * Amer. Mus. Coll. (cast)

PERISSODACTYLA

Hypohippus sp.

Three upper teeth, Nos. 342, 343 and 344 C. I. T. Coll. Vert. Pale., and a lower jaw fragment, No. 341 C. I. T. Coll. Vert. Pale., with $P\underline{3}$(?) and $P\underline{4}$(?) comprise the better preserved portion of the material which has been recognized as belonging to the genus *Hypohippus*.

In the upper teeth the transverse lophs are smooth, compressed anteroposteriorly and are united with the ectoloph. The protocone and hypocone are of equal size. The crown in No. 342 (fig. 9*a*) is wide transversely in comparison to its anteroposterior diameter. This tooth is worn to a stage where the hypostyle is approaching a union with the metaloph. No. 344 (fig. 9*b*) is relatively long anteroposteriorly and is only slightly worn.

The two lower teeth in specimen No. 341 (fig. 9*c*) show an early stage of wear. The teeth are high crowned and show a pronounced cingulum on the labial side, which terminates posteriorly in a low cusp on the side of the entoconid. The metaconid-metastylid column is slightly notched on the lingual surface near the summit and the posterior portion of the column is compressed transversely, forming a ridge down the flank of the cusp. Furthermore, this column appears to be the posterior termination of the

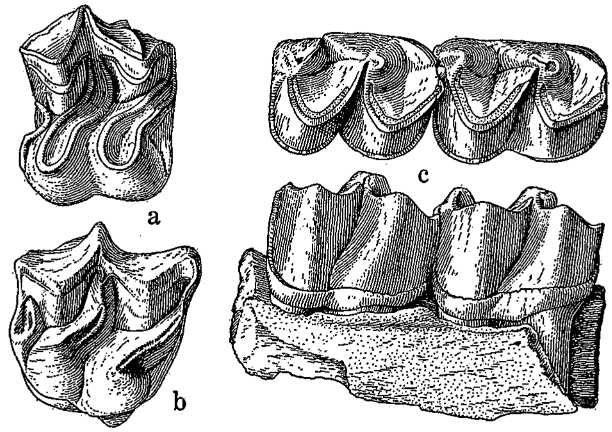


FIG. 9, *a*, *b*, and *c*—*Hypohippus*, sp. *a*, Right upper cheek-tooth, No. 342 C.I.T. Coll., occlusal view; *b*, right upper cheek-tooth, No. 344 C.I.T. Coll., occlusal view; *c*, lower cheek-teeth, No. 341 C.I.T. Coll., lateral and occlusal views; x 1.0. Skull Spring Miocene, Oregon.

protoconid crescent, having a less direct union with the hypoconid crescent, which in turn terminates in the entoconid. There is no indication of an internal cusp between the metastylid and entoconid.

The Skull Spring *Hypohippus* resembles *H. osborni* Gidley [1] in pattern and height of crown but is closer to *H. equinus* (Scott) [2] in size. The species is not nearly so large as *H. (D.) nevadensis* Merriam [3] which occurs in the Cedar Mountain [4] and Fish Lake Valley [5] faunas of Nevada. The lower teeth in No. 341 resemble the teeth in the lower jaw from Virgin Valley [6] in many respects, but lack the small exterior cusp between the metastylid and entoconid. The Skull Spring species is perhaps nearer the Virgin Valley form than to any other type which has been described. Were more complete material available from either Virgin Valley or Skull Spring this form might be shown to be specifically distinct from both *H. equinus* and *H. osborni* of the Great Plains region.

[1] J. W. Gidley, Bull. Amer. Mus. Nat. Hist., vol. 23, pp. 930-931, 1907; H. F. Osborn, Mem. Amer. Mus. Nat. Hist., vol. 2, pt. 1, p. 207, 1918.

[2] W. B. Scott, Trans. Amer. Philos. Soc. (n.s.), vol. 18, pp. 94-122, 1894; H. F. Osborn, *ibid.*, pp. 203, 206, 1918.

[3] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, pp. 419-427, 1913.

[4] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, pp. 182-186, 1916.

[5] C. Stock, Univ. Calif. Publ., Bull. Dept. Geol., vol. 16, pp. 61-68, 1926.

[6] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, p. 258, fig. 28, 1911.

Comparative Measurements

	Antero-posterior diameter	Greatest transverse diameter
	mm.	*mm.*
Upper molar or premolar, No. 342........	*a*23.0	26.3
Upper molar or premolar, No. 343........	*a*23.4	*a*29.0
Upper molar or premolar, No. 344........	25.7	*a*25.9
$\overline{P3}$, No. 341.........................	23.2	15.7
$\overline{P4}$, No. 341.........................	22.9	16.3

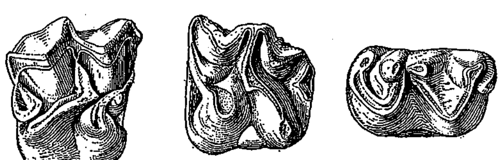
a, approximate.

Parahippus, near coloradensis Gidley

Two upper molars, Nos. 345 and 347 C.I.T. Coll. Vert. Pale., and a lower premolar (?), No. 346, are the only specimens which can be assigned with any assurance to *Parahippus*.

No. 345 (fig. 10*a*) is a well-preserved upper tooth in early wear. The crown is high with external ribs on the paracone and metacone. No. 347 (fig. 10*b*) is also in early wear but is not so well preserved, the ectoloph being partially damaged. A noticeable feature in both teeth is the marked elevation of the protoconule. The crochet is much better developed in No. 345, and a slight plication is also present on the opposite side of the metaloph. In the latter specimen the hypostyle is large with central basin, and shows a tendency to unite with the ectoloph earlier than with the metaloph. In No. 347 a portion of the cingulum is developed on the anterior side of the tooth; this appears to have been broken away in No. 345. Furthermore, a small cusp or portion of the cingulum is present between the protocone and hypocone in No. 347. This is not present in No. 345.

The external side of the lower tooth is fairly high crowned and exhibits a rugose surface. The metaconid and metastylid are distinctly separate for nearly half the height of the crown. The cingulum is conspicuous only on the



a b c

FIG. 10, *a*, *b*, and *c*—*Parahippus*, near *coloradensis* Gidley. *a*, Right upper cheek-tooth, No. 345 C.I.T. Coll., occlusal view; *b*, left upper cheek-tooth, No. 347 C.I.T. Coll., occlusal view; *c*, left lower cheek-tooth, No. 346 C.I.T. Coll., occlusal view; x 1.0. Skull Spring Miocene, Oregon.

anterior and posterior ends of the tooth, the posterior end terminating in a well-developed hypoconulid. A very small cusp is present between the protoconid and hypoconid.

The Skull Spring form is near *Parahippus coloradensis* Gidley [1] in size, height of crown and external ribbing on paracone and metacone. It differs

[1] J. W. Gidley, Bull. Amer. Mus. Nat. Hist., vol. 23, p. 932, 1907; H. F. Osborn, Mem. Amer. Mus. Nat. Hist., vol. 2., pt. 1, pp. 93-94, 1918.

perhaps from the latter species in simplicity of pattern and prominence of protoconule.

In *P. pawniensis* Gidley [1] the teeth are apparently shorter crowned and there is a greater tendency for the hypostyle to unite with the metaloph than in No. 345. The external ribs on the paracone and metacone in *P. pawniensis* are only faintly indicated, while those in No. 345 are not particularly heavy.

The Skull Spring material differs from teeth of *P. avus* in smaller size and perhaps in degree of hypsodonty. Also there is no sign of cement on any of the teeth. Lower tooth, No. 346, is approximately the same length as lower teeth from the Virgin Valley beds compared to *P. avus*, but is narrower and lower crowned. However, additional fragmentary lower teeth from Skull Spring indicate somewhat larger sizes.

P. brevidens (Marsh) [2] from the Mascall has relatively large and heavily cemented teeth. Nevertheless, Nos. 345 and 347 resemble this species in many respects as in shape of the hypostyle and protocone, and also in the ribbing of the paracone and metacone. The metaloph in *P. brevidens* tends to be more crenulate than in the Skull Spring form.

It is noteworthy that the form occurring at Skull Spring does not appear to be referable to either *P. brevidens* or *P. avus* from the Mascall.

Comparative Measurements

	Antero-posterior diameter	Greatest transverse diameter	Height of paracone	Height of hypoconid
	mm.	*mm.*	*mm.*	*mm.*
Upper molar, No. 345	17.8	21.1	12.6	...
Lower premolar (?), No. 346	19.8	11.5	....	9.6

Merychippus isonesus (Cope)

This species is represented in the collection by a maxillary fragment, No. 337 C.I.T. Coll. Vert. Pale., with P4(?) and M1(?), a fragment of a mandible, No. 340 C.I.T. Coll. Vert. Pale., with P2 to M3 inclusive, and a large number of isolated teeth. There are also several toe bones and tarsal and carpal elements which are referred to this form.

The upper teeth are long crowned [3] and usually heavily cemented. The external styles are prominent, the mesostyle tending to be compressed anteroposteriorly. The fossettes are large and open in early wear as in the type specimen. [4] The crenulation of the enamel walls of the fossettes is well developed in a moderately early stage of wear, but much simplified as the crown is shortened. The hypocone is united with the metaloph in very early wear, but retains a relatively narrow isthmus until slightly before the stage is reached in which the protocone is united with the protoloph. The union of the protocone takes place in fairly well worn teeth.

Specimen No. 337 (fig. 11*a*) from Skull Spring resembles very closely P4 and M1 of the type, No. 8175 Amer. Mus. Cope Coll. The prefossette and postfossette in P4 (?) are open and separated by only a thin plate of

[1] J. W. Gidley, *ibid.*, p. 932, 1907; H. F. Osborn, *ibid.*, pp. 92-93, 1918.

[2] H. F. Osborn, *ibid.*, pp. 89-90, 1918.

[3] Several less hypsodent teeth in the collection, showing relatively little wear, may indicate the presence in the fauna of a second species of *Merychippus*.

[4] H. F. Osborn, Mem. Amer. Mus. Nat. Hist., vol. 2, pt. 1, p. 102, fig. 75, 1918.

enamel (metaloph). The protoconule is just in contact with a projection from the metaloph in the vicinity of the pli caballin. In the postfossette the pli hypostyle is very conspicuous. The protocone is isolated, but develops a long projection toward the protoconule. The hypocone is connected with the metaconule by a rather long and narrow isthmus. M1(?) is similar to P4(?) in general appearance. However, the fossettes are closed and the plications on the intervening portion of the metaloph

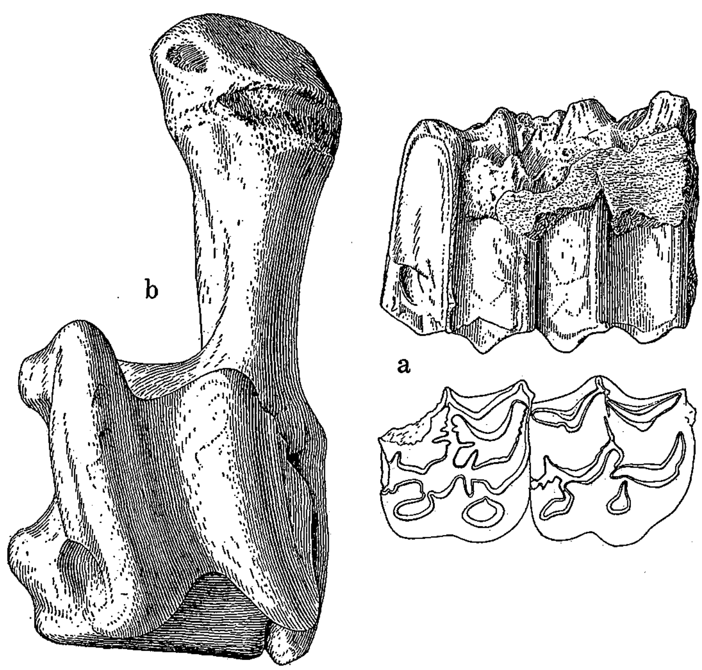


FIG. 11, *a* and *b*—*Merychippus isonesus* (Cope). *a*, P4(?) and M1(?), No. 337 C.I.T. Coll., lateral and occlusal views; *b*, astragalus and calcaneum, No. 459 C.I.T. Coll., anterior view; x 1.0. Skull Spring Miocene, Oregon.

are prominent. The pli caballin and pli protoconule are well developed and the protocone is more nearly oval than in P4(?).

The lower teeth are long crowned and the amount of cement which has been deposited is variable. The protoconid and hypoconid are evenly rounded and the external median fold between these cusps is deeply impressed in moderate wear. The groove between the metaconid and metastylid is well defined for a considerable portion of the length of crown. The postero-internal basin or fold is usually not so simple as the fold between the parastylid and metaconid, the enamel frequently having two plications between the metastylid and entoconid.

The lower teeth of specimen No. 340 (fig. 12) are well worn and the enamel folding on the lingual side has been reduced to a series of notches and shallow grooves. The external fold still penetrates the greater part of the tooth width in all of the crowns. These teeth exhibit a fair covering of cement.

The teeth in this collection seem closer in structure and in stage of development to *Merychippus isonesus* from the Mascall formation in east-central Oregon than to any other species figured by Osborn.[1] The teeth in No. 337 are strikingly like the corresponding teeth in the type collected by Wortman, suggesting a contemporaneity of the Skull Spring and Mascall faunas.

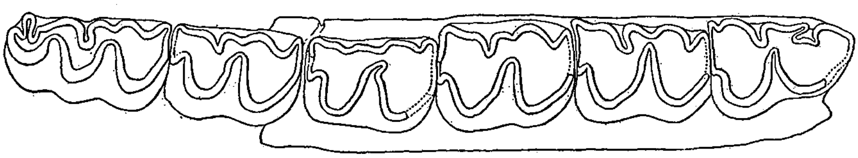


FIG. 12—*Merychippus isonesus* (Cope). $\mathrm{P}\overline{2}$ to $\mathrm{M}\overline{3}$ incl., No. 340 C.I.T. Coll., occlusal view; x 1.0. Skull Spring Miocene, Oregon.

Measurements

	Antero-posterior diameter	Greatest transverse diameter	Approximate height of crown
	mm.	*mm.*	*mm.*
$\mathrm{P}\underline{2}$, No. 338...........	26.5	19.6	20.0
$\mathrm{P}\underline{4}$ (?), No. 337........	21.9	21.4	28.0
$\mathrm{M}\underline{1}$ (?), No. 337.......	*a* 20.6	20.7	26.0
$\mathrm{M}\underline{3}$, No. 339..........	20.4	19.1	21.0
$\mathrm{P}\overline{2}$-$\mathrm{M}\overline{3}$, No. 340........	112.3	....	....
$\mathrm{P}\overline{2}$, No. 340...........	18.6	12.2	8.0
$\mathrm{P}\overline{3}$, No. 340...........	17.8	13.3	9.0
$\mathrm{P}\overline{4}$, No. 340...........	18.1	13.4	11.0
$\mathrm{M}\overline{1}$, No. 340...........	17.0	12.5	9.0
$\mathrm{M}\overline{2}$, No. 340...........	17.1	11.9	10.0
$\mathrm{M}\overline{3}$, No. 340...........	21.0	10.5	13.0

a, approximate.

Rhinocerotid sp.

Fragments of bones and teeth which have been recognized as belonging to the Rhinocerotidæ are unfortunately not sufficiently complete to permit generic identification. The material consists of tarsal and carpal elements, ungual phalanges, the distal end of a tibia and fragments of teeth. The latter indicate a fairly hypsodont form.

Chalicothere ? sp.

An incomplete lower tooth, No. 348 (fig. 13), possibly represents a chalicothere in the Skull Spring fauna. The tooth is well worn and brachydont with a cingulum conspicuous on the posterior end and between the protoconid and hypoconid.

[1] H. F. Osborn, *ibid.*, pp. 98-126, 1918.

Measurements

Anteroposterior diameter of lower tooth, No. 348..........	30.-35. *mm.*
Transverse diameter of lower tooth, No. 348..............	16.5

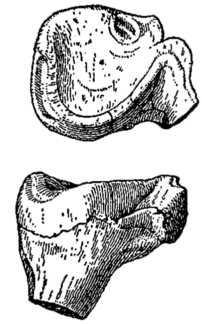


FIG. 13—Chalicothere ? sp. Lower tooth fragment, No. 348 C.I.T. Coll., lateral and occlusal views; x 1.0. Skull Spring Miocene, Oregon.

ARTIODACTYLA

Platygonus ? sp.

A second upper molar, No. 381 C.I.T. Coll. Vert. Pale. (fig. 14), in the collection belongs apparently to a large suilline type. The tooth is of approximately the same size and appearance as M2 in the type of *Platygonus texanus* Gidley [1] from the Pliocene of Texas. The molar is nearly rectangular with anteroposterior and transverse diameters approximately equal. The four large cusps are little worn and are surrounded by a heavy cingulum. The enamel is very rugose, particularly on the inner cusps. The latter tubercles are not so simple and conical as the outer pair but are of pyramidal shape.

The genus *Platygonus* has been recorded heretofore principally from the Pliocene and Pleistocene, and the recognition of this form in the Miocene fauna of Skull Spring remains an open question for want of more complete material.

Measurements

Anteroposterior diameter	21.7 *mm.*
Transverse diameter	*a*21.5

a, approximate.

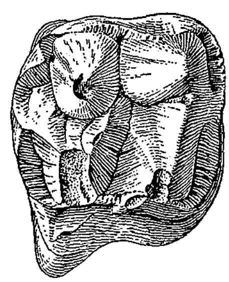


FIG. 14—*Platygonus* ? sp. M2, No. 381 C.I.T. Coll., occlusal view; x 1.33. Skull Spring Miocene, Oregon.

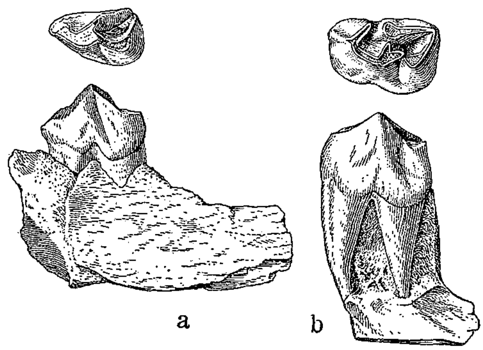
Ticholeptus ? sp.

The recognition of oreodonts in the assemblage is based on isolated teeth. A definite generic identification on the basis of the fragmentary material now available is not trustworthy, but certain characters exhibited by the teeth are suggestive of *Ticholeptus* or of some closely allied type.

[1] J. W. Gidley, Bull. Amer. Mus. Nat. Hist., vol. 19, pp. 477-482, 1903.

In the collection are several lower premolars which possess characters considered by Loomis [1] as indicative or perhaps diagnostic of the genus *Ticholeptus*. Two specimens of $P\overline{4}$ show a well-developed bifurcation of the anterior end of the anterior crescent. Apparently this character is also seen in *Metoreodon*, but in the latter genus the posterior basin of the tooth is reduced and in $P\overline{3}$ the anterior crescent entirely encloses the anterior basin, which is not the case in the Skull Spring material. $P\overline{3}$, No. 387 (fig. 15*a*), in the Skull Spring collection is simple and resembles the illustration of the comparable tooth in *Ticholeptus* as shown by Loomis,[2] except that the

FIG. 15, *a* and *b*—*Ticholeptus* ? sp. *a*. $P\overline{3}$, No. 387 C.I.T. Coll., lateral and occlusal views; *b*, $P\overline{4}$, No. 388 C.I.T. Coll., lateral and occlusal views; x 1.0. Skull Spring Miocene, Oregon.



posterior basin is open postero-internally. Fourth premolars Nos. 388 and 389 show a postero-external impression or furrow on the outer enamel wall which becomes less conspicuous with further wear. Loomis [3] notes the presence of an external infolding of the enamel on the premolars in *Metoreodon*.

A specimen representing apparently a large oreodont premolar in the collection may demonstrate the presence of another form generically distinct from *Ticholeptus* (?) sp., with size characteristics like those of *Merycochoerus*.

Dromomeryx, near borealis (Cope)

Four horn-core fragments, two of which are fairly well preserved, and several isolated jaw fragments and teeth in the collection indicate the presence of *Dromomeryx* in the fauna.

The best specimen, a left horn-core, No. 351, retains a part of the supra-orbital margin and about six inches of the horn. This specimen resembles the left horn-core seen in the illustration of No. 827 of the Carnegie Museum [4] referred to *Dromomeryx borealis* (Cope), except that the Oregon specimen appears to be more robust. Furthermore, the horn-cores from Skull Spring are markedly curved with the concavity to the front, more so than is indicated in the illustrations of the type of *D. borealis*.

An upper jaw fragment, No. 449 (fig. 17*a*), with portions of $M\underline{2}$ and $M\underline{3}$ referred to this genus, shows a small accessory lobe on the posterior side of $M\underline{3}$. This is not seen in the figures given by Douglass [5] for either *D. borealis* or *D. americanus* (?).

[1] F. B. Loomis, Bull. Amer. Mus. Nat. Hist., vol. 51, pp. 1-17, 1924.
[2] F. B. Loomis, *ibid.*, p. 11, 1924.
[3] F. B. Loomis, Amer. Jour. Sci., ser. 4, vol. 50, p. 289, 1920.
[4] Earl Douglass, Ann. Carnegie Mus., vol. 5, pl. 59, 1909.
[5] Earl Douglass, *ibid.*, pl. 63, 1909.

The character of most of the lower teeth of this form is known from three lower jaw fragments, Nos. 349, 350 and 450, which indicate a rather large species. No. 350 (fig. 17*b*) has $\overline{P3}$, $\overline{P4}$ and $\overline{M1}$ complete. The teeth are relatively longer anteroposteriorly and narrower than in *Dromomeryx whitfordi* Sinclair[1] from the Snake Creek beds. The jaws and teeth are

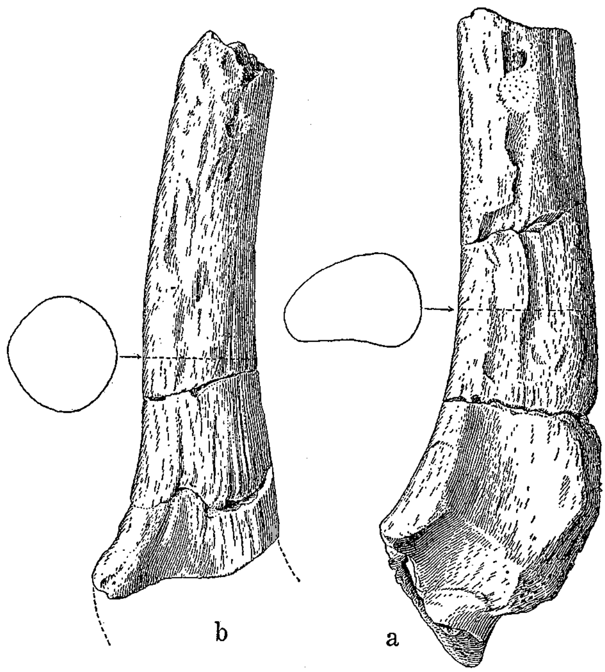


FIG. 16, *a* and *b*—*Dromomeryx*, near *borealis* (Cope). *a*, Left horn-core, No. 351 C.I.T. Coll., outer view; *b*, right horn-core, No. 453 C.I.T. Coll., outer view; x 0.50. Skull Spring Miocene, Oregon.

noticeably larger than in *D. americanus* and possibly *D. madisonius*. Compared with *D. borealis* the Skull Spring form may not be larger, and a close resemblance is seen in the pattern of the lower teeth, although the "Palæomeryx-fold" is not so conspicuous in the latter species.

Measurements

	No. 351	No. 449	No. 350
	mm.	*mm.*	*mm.*
Anteroposterior diameter of horn at point 75 mm. above orbit.....	36.5	....	....
Transverse diameter of horn at point 75 mm. above orbit.......	25.0	....	....
$\underline{M3}$, anteroposterior diameter......	....	*a* 20.0	....
$\underline{M3}$, greatest transverse diameter...	....	*a* 24.0	....
$\overline{P3}$, anteroposterior diameter.......	....	....	16.0
$\overline{P3}$, greatest transverse diameter...	....	....	8.7
$\overline{P4}$, anteroposterior diameter.......	....	....	16.7
$\overline{P4}$, greatest transverse diameter...	....	....	10.5
$\overline{M1}$, anteroposterior diameter......	....	....	19.5
$\overline{M1}$, greatest transverse diameter...	....	....	12.3

a, approximate.

[1] W. J. Sinclair, Proc. Amer. Philos. Soc., vol. 54, pp. 94-95, 1915.

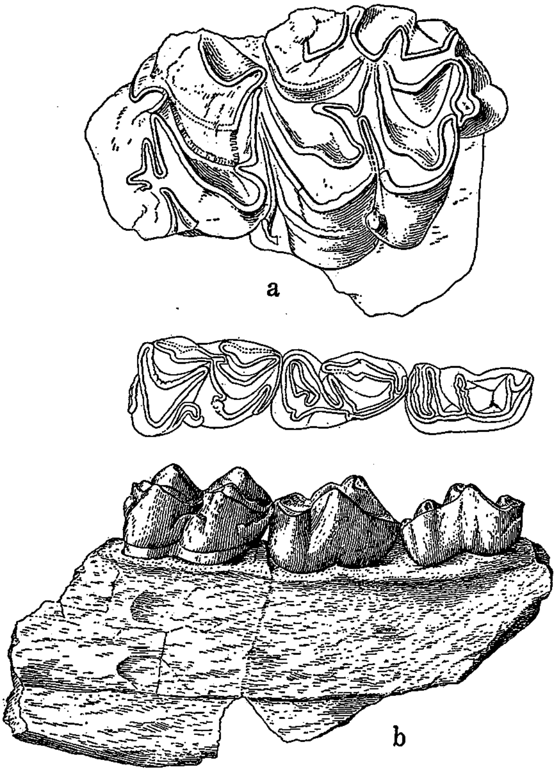


FIG. 17, *a* and *b*—***Dromomeryx***, near ***borealis*** (Cope). *a*, Fragmentary left upper molars, $M\underline{2}$ and $M\underline{3}$, No. 449 C.I.T. Coll., occlusal view, x 1.5; *b*, fragment of right ramus of mandible with $P\overline{3}$, $P\overline{4}$ and $M\overline{1}$, No. 350 C.I.T. Coll., lateral and occlusal views, x 1.0. Skull Spring Miocene, Oregon.

Blastomeryx ? sp.

A milk fourth premolar, No. 452 (fig. 18*a*), and an upper molar, No. 451 (fig. 18*b*), in the collection may represent the occurrence of *Blastomeryx*

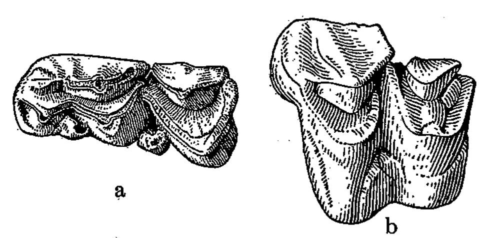


FIG. 18, *a* and *b*—***Blastomeryx*** ? sp. *a*, $Dp\overline{4}$, No. 452 C.I.T. Coll., occlusal view; *b*, upper molar, No. 451 C.I.T. Coll., occlusal view; x 2.0. Skull Spring Miocene, Oregon.

in the Skull Spring fauna, although these teeth are of relatively large size. The milk tooth is decidedly brachydont and carries an external basal cuspule between the first and second columns as well as one between the second and third. The enamel basin of the third column is separate, but those of the first and second columns are confluent. The referred upper molar is also very brachydont and has an internal cingulum and cuspule between the protocone and hypocone.

Measurements

Anteroposterior diameter of upper molar	*a*13.	*mm.*
Transverse diameter of upper molar	*a*12.8	
Anteroposterior diameter of milk P$\overline{4}$	15.	
Greatest transverse diameter of milk P$\overline{4}$	6.8	

a, approximate.

Merycodus ? sp. a

An immature lower jaw, No. 383, with Dp$\overline{4}$ and the first two molars in place, appears referable to this genus or possibly to *Blastomeryx.* An upper molar, No. 384, may belong to the same species.

Dp$\overline{4}$, No. 383 (fig. 19*a*), is well worn, so that the enamel lakes in the first two columns are much reduced. A basal cuspule is present on the outer side between the second and third columns, but not between the first and second. This tooth is smaller than the milk tooth which is referred to *Blastomeryx* ? sp. The two molar teeth are rather hypsodont, the second molar showing very little wear. A basal cuspule occurs between the protoconid and hypoconid columns in M$\overline{1}$; however, M$\overline{2}$ does not show this character. M$\overline{3}$ has apparently not erupted. The anterior fold or projection of the cingulum which characterizes the lower molars of *Blastomeryx* is very much reduced, being represented by only a feeble ridge which does not extend to the occlusal surface. The anterior column of both molars exhibits a noticeable postero-external flexure which becomes indistinct with further wear.

This specimen possesses apparently an association of characters similar to that recorded for *Merycodus ? ramosus* (Cope) by Matthew.[1] The molars approach in degree of hypsodonty those seen in *Merycodus,* and the anterior cingular projection of the lower molars is reduced as in this genus. However, size, the presence of an external basal cuspule in M$\overline{1}$, and the brachydont Dp$\overline{4}$ are characters suggestive of *Blastomeryx.*

Measurements

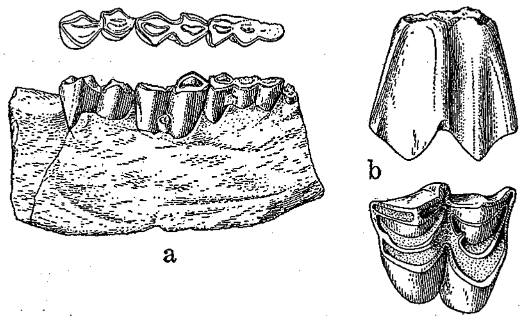
Dp$\overline{4}$-M$\overline{2}$ inclusive	29.3	*mm.*
Depth of jaw below M$\overline{2}$ along inner side	*a*17.	
Dp$\overline{4}$, anteroposterior diameter	10.4	
Dp$\overline{4}$, greatest transverse diameter	4.1	
M$\overline{1}$, anteroposterior diameter	9.1	
M$\overline{1}$, greatest transverse diameter	4.5	
M$\overline{2}$, anteroposterior diameter	10.2	
M$\overline{2}$, greatest transverse diameter	4.5	

a, approximate.

[1] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 20, pp. 122-123, 1904.

Merycodus ? sp. b

The single first column of a very hypsodont M$\overline{3}$(?), No. 385 (fig. 20), may represent a more advanced species of *Merycodus* in the fauna. The form is apparently as large and as progressive as ?*Merycodus altidens* Matthew [1] from the Upper Snake Creek beds.



19

20

FIGS. 19, *a* and *b*—*Merycodus* ? sp. a. *a*, Right ramus of mandible with Dp$\overline{4}$, M$\overline{1}$ and M$\overline{2}$, No. 383 C.I.T. Coll., lateral and occlusal views, x 1.0; *b*, upper molar, No. 384 C.I.T. Coll., lateral and occlusal views, x 2.0. Skull Spring Miocene, Oregon.

FIG. 20—*Merycodus* ? sp. b. Fragment of molar, No. 385 C.I.T. Coll., lateral view; x 1.0. Skull Spring Miocene, Oregon.

Measurements

Height of column	*a*30. *mm.*
Greatest anteroposterior length	7.8
Greatest transverse width	6.3

a, approximate.

[1] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 50, pp. 200-201, 1924.

PLATE 1

FIGS. 1, 1*a*—*Sciurus malheurensis* n. sp. Skull, No. 129 C.I.T. Coll. Fig. 1, ventral view; Fig. 1*a*, lateral view; x 2.5.

FIGS. 2, 2*a*, 2*b*—*Sciurus tephrus* n. sp. Skull, No. 332 C.I.T. Coll. Fig. 2, ventral view; fig. 2*a*, lateral view; fig. 2*b*, dorsal view; x 2.5. Skull Spring Miocene, Oregon.

1

2

1a

2b

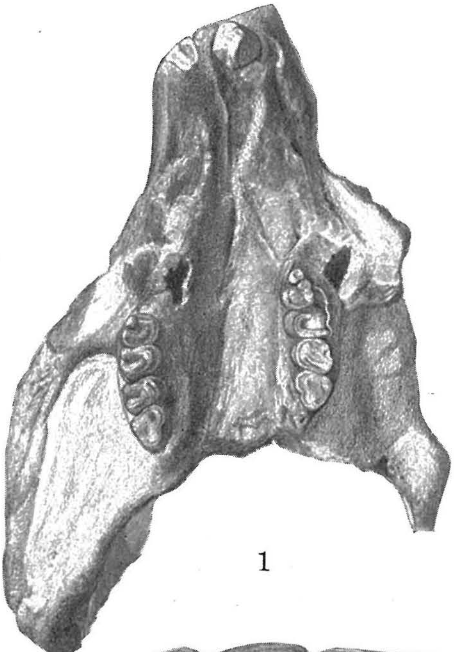
2a

PLATE 2

FIGS. 1, 1*a*—*Citellus ridgwayi* n. sp. Skull, No. 334 C.I.T. Coll. Fig. 1, ventral view; fig. 1*a*, lateral view; x 2.5.

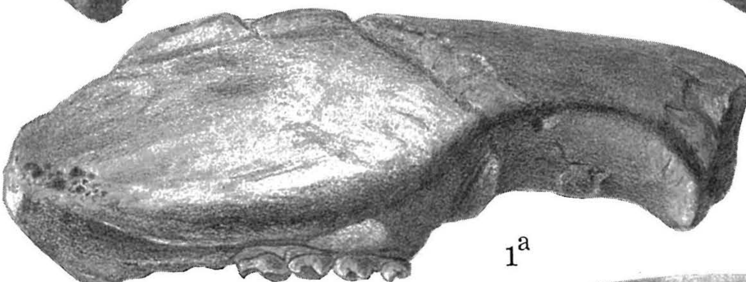
FIGS. 2, 2*a*—Skull, No. 335 C.I.T. Coll. Fig. 2, ventral view; fig. 2*a*, lateral view; 2.5.

FIG. 3—*Sciurus malheurensis* n. sp. Skull, No. 333 C.I.T. Coll. Lateral view; x 2.0. Skull Spring Miocene, Oregon.



1

2



1a

2a

3

Plate 3

Liodontia alexandræ (Furlong). Skull Spring Miocene, Oregon.

Figs. 1, *1a*, *1b*—Skull, No. 321 C.I.T. Coll. Fig. 1, ventral view; fig. *1a*, lateral view; fig. *1b*, dorsal view; x 3.0.

Fig. 2—Superior dentition, No. 322 C.I.T. Coll., occlusal view, x 3.0.

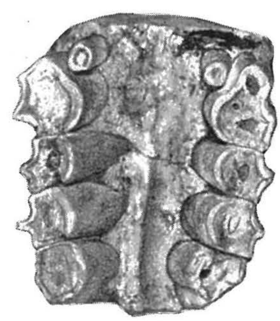
Fig. 3—Superior dentition, No. 323 C.I.T. Coll., occlusal view, x 3.0.

Figs. 4, *4a*—Immature superior dentition, No. 326 C.I.T. Coll. Fig. 4, occlusal view; fig. *4a*, lateral view; x 5.0.

1

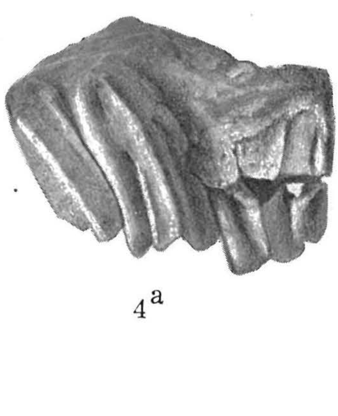
1b

1a

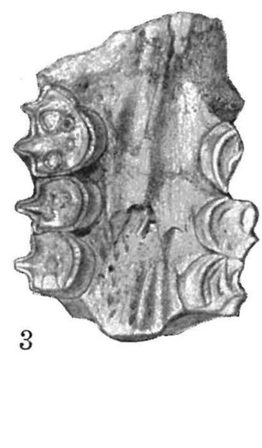


2

4



4a



3

Plate 4

Liodontia alexandræ (Furlong)

Fig. 1—Right ramus of mandible, No. 331 C.I.T. Coll. Occlusal view of dentition, x 3.0.

Fig. 2—Right ramus of mandible, No. 329 C.I.T. Coll. Occlusal view of dentition, x 3.0.

Figs. 3, *3a*, *3b*—Left ramus of mandible, No. 330 C.I.T. Coll. Fig. 3, occlusal view of dentition; figs. *3a*, *3b*, lateral views; x 3.0.

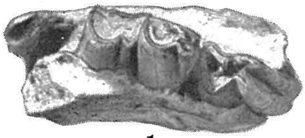
Figs. 4, *4a*, *4b*—Left ramus of mandible, No. 328 C.I.T. Coll. Fig. 4, occlusal view of dentition; figs. *4a*, *4b*, lateral views; x 3.0.

Figs. 5, *5a*, *5b*—Left ramus of mandible, No. 327 C.I.T. Coll. Fig. 5, occlusal view of dentition; figs. *5a*, *5b*, lateral views; x 3.0.

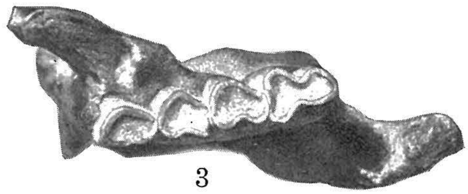
Mylagaulus, cf. *lævis* Matthew

Fig. 6—Immature superior dentition, No. 366 C.I.T. Coll. Occlusal view, x 2.0.

Skull Spring Miocene, Oregon.



1



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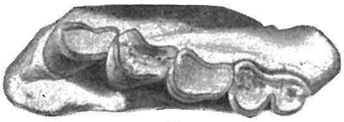

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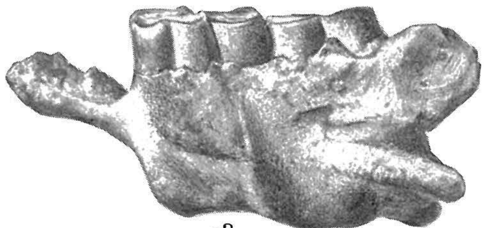
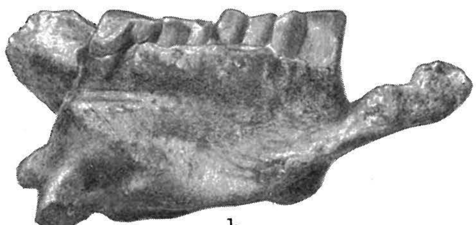


3a

4



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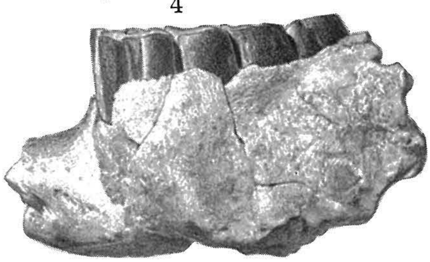
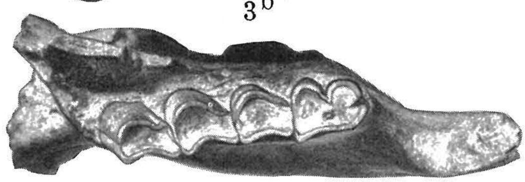


4a



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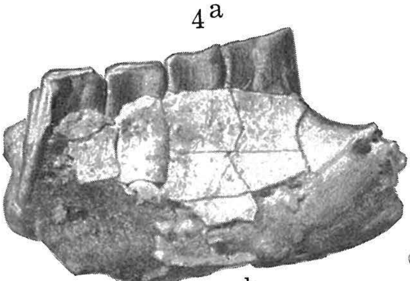
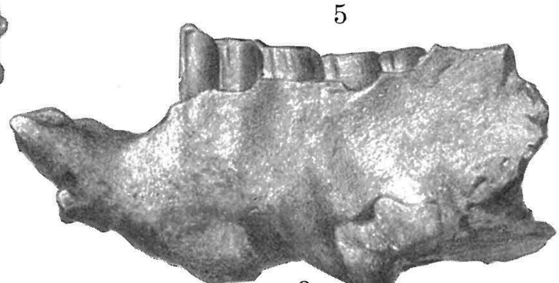
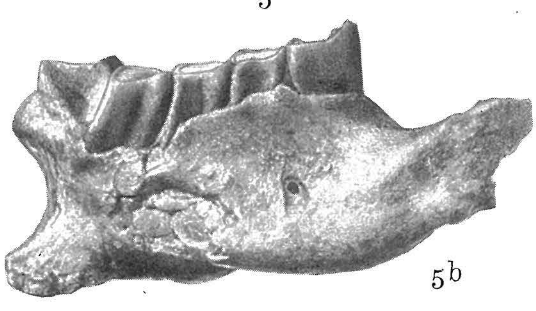


4b



5a

6



5b

Plate 5

Mylagaulus, cf. *lævis* Matthew. Skull Spring Miocene, Oregon.

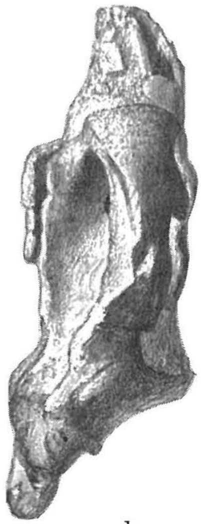
Figs. 1, *1a*, *1b*—Skull, No. 68 C.I.T. Coll. Fig. 1, ventral view; fig. *1a*, dorsal view; fig. *1b*, lateral view; x 1.0.

Figs. 2, *2a*, *2b*—Left ramus of mandible, No. 70 C.I.T. Coll. Fig. 2, dorsal view, x 2.0; figs. *2a*, *2b*, lateral views, x 1.0.

Figs. 3, *3a*, *3b*—Left ramus of mandible, No. 369 C.I.T. Coll. Fig. 3, dorsal view, x 2.0; figs. *3a*, *3b*, lateral views, x 1.0.

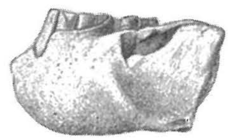
Figs. 4, *4a*, *4b*—Left ramus of mandible, No. 368 C.I.T. Coll. Fig. 4, dorsal view, x 2.0; figs. *4a*, *4b*, lateral views, x 1.0.


1


1^{b}

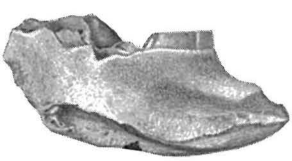

1^{a}


2

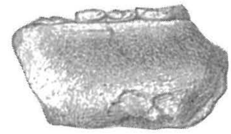

3^{a}

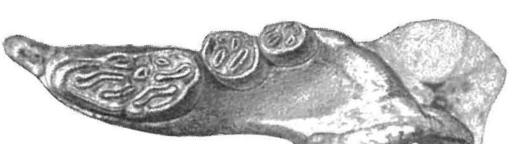

2^{a}


3


2^{b}


4^{a}


3^{b}


4


4^{b}

PLATE 6

Diprionomys ? oregonensis n. sp.

FIGS. 1, 1*a*—Skull, No. 370 C.I.T. Coll. Fig. 1, ventral view; fig. 1*a*, lateral view; x 4.0.

FIGS. 2, 2*a*—Skull, No. 371 C.I.T. Coll. Fig. 2, occlusal view of superior dentition, x 4.0; fig. 2*a*, dorsal view, x 2.0.

FIGS. 3, 3*a*—Skull, No. 372 C.I.T. Coll. Fig. 3, occlusal view of superior dentition, x 4.0; fig. 3*a*, dorsal view, x 2.0.

FIG. 4—Inferior dentition, No. 371 C.I.T. Coll. Occlusal view, x 4.0.

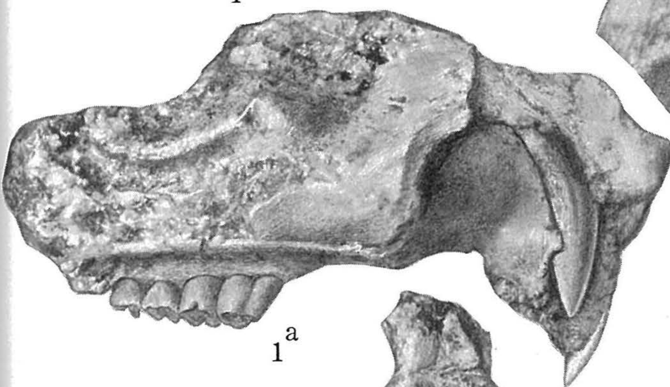
Mylagaulus, cf. *lævis* Matthew

FIG. 5—Fourth premolars, Nos. 516-531 incl. C.I.T. Coll. 1st and 2d rows, right and left $P\overline{4}$; 3d and 4th rows, right and left $P\underline{4}$; occlusal views; x 2.0.

Skull Spring Miocene, Oregon.

1

3



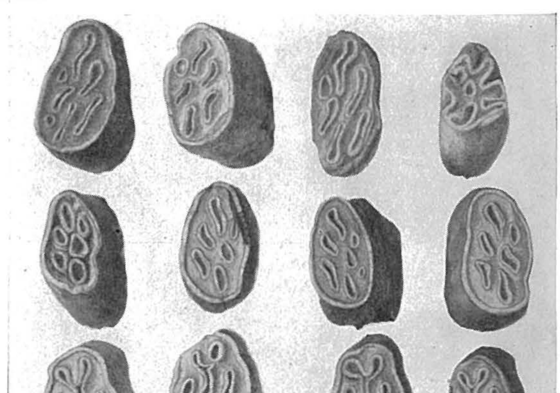
1a

2a

3a

2

4



5

S
J
A
3
P
n

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CARNEGIE INSTITUTION OF WASHINGTON

Papers Concerning the Palaeontology of California, Oregon and the Northern Great Basin Province

CARNEGIE INSTITUTION OF WASHINGTON
July 1932