lar structure but also accounts for the experimental facts as satisfactorily as any mechanical device may. One possible objection is that it does not show directly or without involved reasoning why such compounds as CsI_2 or CsI_4 are not formed. It is a fact that addition of halogens takes place as molecules. When CsI and I_2 are brought together one of the shared pair of electrons in I_2 describes a new orbit around the iodine nucleus originally present in the cesium iodide molecule; in the case of CsI and Cl_2 there is a rearrangement so that the chlorine atom is brought nearest the metal cation. The shared pair in a molecular halogen seems to be a necessary precursor of a shared single electron in the complex anion. Hepta- and nona-iodides are theoretically possible, therefore, but space lattice dimensions limit the number of molecules of halogen which may be bound; hence high halogen content is probably the result of the formation of solid solutions.

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[12] Bragg, J. Chem. Soc. (London), 121, 2766, 1922.

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[14] Slawson, Am. Mineral, 7, 173, 1922, has found by goniometric measurement that the compound $SbBr_3$ crystallizes in the bipyramidal orthorhombic system with the axial ratios .7808 : 1 : 1.1645. It is thus outwardly similar to the alkali polyhalides. The X-ray analysis of this primary valence compound will be of great importance in discovering how the distribution of bromine atoms compared with that for the complex secondary valence anion Br_3^-.

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ART. IX.—*The Generic Distinctions between Merycochœrus* Leidy *and Promerycochœrus* Douglass; by MALCOLM RUTHERFORD THORPE.

(Contributions from the Othniel Charles Marsh Publication Fund, Peabody Museum, Yale University, New Haven, Conn.)

INTRODUCTION.

For nearly a half century there has been considerable misconception, due to a lack of exact knowledge, of what characters distinguish the genus *Merycochœrus*. On account of this, many species were placed within this genus which were very diverse forms and which could not have all been congeneric. In fact, the group became very heterogeneous, with species ranging in age from Upper Oligocene to Pliocene inclusive, and in geographic distribution from South Dakota to Oregon and from Montana to southern California. Douglass,[1] in 1901, removed five species from *Merycochœrus* and placed them under a new genus, *Promerycochœrus*, at that time established by him, with *Promerycochœrus superbus* as the type of the genus.

In addition to the two type specimens, other facts, relative to *Merycochœrus*, are taken from specimen No. 8968 of the American Museum of Natural History. This and other specimens of the same genus, found in 1898, are from horizons D and E, similar beds to those in which the type was found and representing the latest deposits of the White River, of Lower Miocene age. For the genus *Promerycochœrus*, supplementary data were obtained from the large number of individuals in the Marsh Collection in the Peabody Museum.

Merycochœrus Leidy.

Genoholotype: *M. proprius* Leidy 1858, No. 156, U. S. Nat. Mus.* Upper and lower jaws containing nearly complete dentition. Fig.: Leidy, 1869, pl. 10, figs. 1-4.

Paratype: No. 445, U. S. Nat. Mus.* Last left upper molar. Fig.: Same reference as type: pl. 10, fig. 5.

[1] Earl Douglass, this Journal (4), **11**, 82, 1901.

* Bull. U. S. Nat. Mus. No. 53, Pt. II, p. 47, 1907.

Horizon and locality: Hayden's Bed D (Lower Miocene), near Fort Laramie, Niobrara River, Wyoming. Collected by F. V. Hayden in 1857.

History.

This genus was proposed by Leidy[2] in March, 1858, with *M. proprius* as its type. The genus and species were based on several portions of upper and lower jaws, found by Doctor Hayden in the red grit beds of the Niobrara River, near Fort Laramie, Wyoming, which he named Bed D, consisting of "a dull reddish brown indurated grit, with many layers of silico-calcareous concretions, sometimes forming a heavy bedded fine-grained sandstone,"[3] and referred by him to the Miocene. This first description is brief. Leidy does, however, point out important distinctions from *Oreodon.*

In 1869, Leidy[4] showed wherein this genus differed from *Oreodon. Merycochœrus* is more than a third larger than *Eucrotaphus ? (Oreodon) major;* the infraorbital arch has a depth two and a half times as great as in the latter and is directed much more abruptly inward than in *Oreodon.* Its anterior origin is above the forward portion of the second molar; face abruptly narrowed, and apparently prolonged, "giving it a narrow, snout-like appearance as in the Hog"; side of face "forms a wide, unbroken, transverse concavity from the infraorbital arch to the position of the canine alveolus"; large infraorbital foramen above the interval of the first and second molars; lachrymal fossa very broad and concave; orbit more elevated than in *Merycoidodon* and its anterior border "on a line with the interval of the second and third molars"; incisive foramina large; premaxillaries completely coössified; concavity of lower jaw below anterior molar teeth; P^1 separated by wide diastemata between C and P^2; P^2 crowded and inserted obliquely; crowns of first and second upper premolars narrower in proportion to their length and breadth than in *Merycoidodon;* the hypocone of P^3, a festooned basal ridge enclosing two mammillary tubercles.

[2] J. Leidy, Proc. Acad. Nat. Sci. Phila., 10, 24-25.
[3] F. V. Hayden, Ibid., p. 149.
[4] J. Leidy, Jour. Acad. Nat. Sci. Phila. (2), 7, 110, 112, 1869.

In 1870, Leidy[5] made another species, *M. rusticus,* which was an intermediate form between *Merycochœrus proprius* and *Merycoidodon.* In the following year,[6] he again tried clearly to define *Merycochœrus* and emphasized four characters: abruptly narrowed face; shallow lachrymal fossæ; posterior position of infraorbital foramen; and great depth of infraorbital bridge, the depth being 2 inches in *M. proprius,* 1.5 in *Promerycochœrus* (*Oreodon*) *superbus,* and ¾ of an inch in *Eucrotaphus? major.*

By 1873, Leidy[7] was convinced that *Merycochœrus* was a valid genus. In his synopsis of generic characters there are some not previously noted. The molars are hypsodont, and before the crown of M^3 was fully erupted, the triturating surface of M^1 was so worn that it presented simply a broad dentiñal surface bordered with enamel. The length and antero-posterior diameters of the crowns of the premolars exceed the transverse, except in the last upper one. The summits of the lobes of the premolars, especially those of the upper ones, are in advance of the middle of the crowns and maintain this position even when worn. The suture between the maxillary, lachrymal, and malar descends nearly vertically, curving backward only at its lower part.

Another important observation made by Leidy at this time was that, due to the large infraorbital and mental foramina, together with the other peculiarities of the face, it is quite possible that *Merycochœrus* "was provided with large prehensile lips, or probably a short proboscis."

It is well to note here that, while the material on which the genus *Merycochœrus* was based is more or less fragmentary, yet Leidy in the several references has outlined quite clearly the various elements and characters of the genus. The knowledge of the characters of the genus became confused in 1876, probably due to an article by G. T. Bettany,[8] in which he describes two new forms supposedly of *Merycochœrus* from the John Day region.

[5] J. Leidy, Proc. Acad. Nat. Sci. Phila., 22, 109, 1870.
[6] J. Leidy, 2d (4th) Ann. Rept., U. S. Geol. Surv. Wyoming and Portions of Contiguous Terr., 347, 1871.
[7] J. Leidy, Rept. U. S. Geol. Surv. Terr., 1, 201, 202, 204, 1873.
[8] G. T. Bettany, Quart. Jour. Geol. Soc., London, 32, 259-273, 1876.

Since Bettany based his data on specimens (of *Promerycochœrus*) entirely different from Leidy's type, he added factors which did not occur in the genus to which he ascribes his new species. He confused *Merycochœrus* and *Promerycochœrus*, so that his generic characters are a combination of both genera and do not apply to the former alone, as he supposed.

The confusion produced by Bettany's article was further increased by Cope[9] in 1884, in a "Synopsis of the Species of Oreodontidæ," wherein he says, "I can only distinguish this genus [*Merycochœrus*] from *Eucrotaphus* by the confluence of the premaxillary bones." In this reference Cope described three new species of *Merycochœrus*, two of which do not belong under this genus and one is very doubtful. He lists seven species, chiefly separated on a basis of the position of the infraorbital foramen, as follows:

1.	Infraorbital foramen above middle of Pm^4	3 species
2.	" " " M^1	2 "
3.	" " " anterior border of M^2	2 "

Under No. 3 are Leidy's two species, *M. proprius* and *rusticus*, which he differentiates specifically as follows:

Zygoma originating above second molar; large; incisors small *M. rusticus*

Zygoma originating above third true molar; larger; incisors large *M. proprius*

Of these seven species, the only one whose position in the genus is not open to at least some doubt is *M. proprius* Leidy, the type of the genus. Five of the above seven are now referred to *Promerycochœrus*, and the other, *M. rusticus*, is still left provisionally in *Merycochœrus*. From Leidy's statements and drawings, the zygoma originates above M^2 in both species in division 3 above.

Coming down to 1898, forty years after the genus was established, an expedition from the American Museum of Natural History to northeastern Colorado discovered several complete skulls and skeletons of *Merycochœrus*. These have been ably described by Matthew[10] and show the true *Merycochœrus* beyond doubt.

[9] E. D. Cope, Proc. Am. Philos. Soc., 21, 520-521.
[10] W. D. Matthew, Mem. Am. Mus. Nat. Hist., 1, pt. 7, 1901.

Promerycochœrus Douglass.

Type species: P. (Oreodon) superbus (Leidy) 1870.

Cotypes: Skull (pl. 1, fig. 1 of Leidy 1873), University of Oregon. Also the following in the Peabody Museum of Yale University: No. 10152, anterior halves of both mandibles with symphysis; left ramus enclosed in matrix (pl. VII, fig. 11 of Leidy 1873). No. 10153, portion of right mandible, with three premolars and first molar (pl. II, fig. 16, pl. VII, fig. 9). No. 10153a, portion of right mandible with M_3, anterior half of M_2, and M_1 (pl. VII, figs. 7 and 8). Other cotypes, not figured, consisting of mandibular and skull fragments, are Nos. 10151-10151b, 10967a-c, 10968-10968c.

Horizon and locality: Upper John Day (Upper Oligocene), Bridge Creek, John Day River, southwest corner of Wheeler County, Oregon. Collected by Rev. Thomas Condon in 1869.

History.

Paleontologists were first made aware of the great John Day fossil localities in 1870, when Leidy[11] reported on a collection of vertebrate fossils sent to the Smithsonian Institution by Rev. Thomas Condon, of Dalles City, Oregon. These fossils were collected by the latter in the valley of the John Day River, at Bridge Creek, in the southwest corner of Wheeler County, Oregon. Most of the specimens belonged apparently, as Leidy says,

"to a species of *Oreodon,* larger than any previously discovered and equalling in size *Merycochœrus proprius.*"

This species was designated as *Oreodon superbus,* and its characters thus outlined: Form and constitution of cranium the same as in *Merycoidodon culbertsoni;* large inflated bullæ; face rather more abruptly narrowed in advance of the orbits than in *Eucrotaphus ? major,* but not to the same degree as in *Merycochœrus proprius;* infraorbital arch deep, equalling 1½ inches, and less than that of *M. proprius;* orbits comparatively small; lachrymal fossa shallow, and much like that in *Merycoidodon gracilis;* infraorbital foramen intermediate in position between that of *M. proprius* and the White River Oreodons; jaws not so robust as in *M. proprius,* and bone less thick; teeth agreeing in size and constitution with *M. proprius,* but premolars and canines of the

[11] J. Leidy, Proc. Acad. Nat. Sci. Phila., 22, 111-112.

latter less compressed laterally, and somewhat narrower antero-posteriorly; total length of skull estimated at 14 inches; crown of lower canine (P_1) one inch wide antero-posteriorly, and the three premolars behind it occupying a space of 2 1/3 inches. In 1871, in a brief redescription of this species, Leidy[12] recorded that the canines and premolars are proportionately wider and thinner than the Badlands *Merycoidodon*. Drawings of *Oreodon superbus* were first published in 1873 by Leidy,[13] and a few additional factors were noted: "In most of the specimens the temporal surfaces slope from the sagittal crest with a slight sigmoid curve"; the course of the squamous suture is followed by a pair of grooves, one in front and the other behind, the former always more or less distinct and the latter very often barely perceptible; bullæ ovoidal, with the antero-posterior diameter the greater and extending from the paramastoid process to the middle line of the glenoid articular surface, and projecting below it for half their length; forehead flatter than in *Merycoidodon culbertsoni*.

Marsh[14] established the genus *Eporeodon* in 1875, based on the presence of large bullæ and larger size than *Merycoidodon*. The type of the genus is *E. occidentalis* Marsh from Oregon. As *Oreodon superbus* was large, had prominent inflated bullæ, was from the same formation in Oregon, and in other ways resembled *Eporeodon*, he placed it in his new genus. This species was, however, placed by Cope[15] in 1879 under the genus *Eucrotaphus* in his faunal list, without stating any reasons therefor, while in 1884[16] he once more changed it to *Merycochœrus superbus*. In his key to the species, he laid emphasis on the position of the infraorbital foramen above the middle of P^4; expansion of the posterior part of the zygoma; moderate posterior production of the palate; "squamosal part of zygoma less expanded anteriorly and with rounded border; head elongated; premaxillary bone not produced; otic bulla larger, compressed, extending anterior to postglenoid process; size large." As seen above, Cope did not have a clear understanding

[12] J. Leidy, 2d (4th) Ann. Rept. U. S. Geol. Surv. Terr., 346-347.
[13] J. Leidy, Rept. U. S. Geol. Surv. Terr., pp. 213-214.
[14] O. C. Marsh, this Journal (3), 9, 250.
[15] E. D. Cope, Bull. U. S. Geol. Surv. Terr., 5, 59.
[16] E. D. Cope, Proc. Am. Philos. Soc., 21, 251.

of Leidy's *Merycochœrus,* and he had no hesitancy about making the genus embrace a form so distinct and diverse as *M. superbus.*

Up to and including a part of 1901, there had been referred to the genus *Merycochœrus* thirteen species, as follows: *M. proprius, rusticus, laticeps, madisonius, elrodi, compressidens, obliquidens, altiramus, superbus, leidyi, chelydra, macrostegus,* and *montanus.* In January of that year, Douglass[17] described some Montana forms of *Merycochœrus,* and concluded that the genus as then understood contained many forms which were widely different from the generic type, *M. proprius* Leidy. He therefore proposed the provisional name *Promerycochœrus,* with *Oreodon superbus* as the type. The last five species enumerated above were then placed in *Promerycochœrus. M. altiramus* is now placed in the genus *Pronomotherium* Douglass, and the other seven species were left in *Merycochœrus* by Douglass, who considered the forms under the new genus as being ancestral to *Merycochœrus,* "as all with the exception of *Promerycochœrus montanus* are older, and some of the species are perhaps in the direct line of *Merycochœrus.*"

Matthew[18] had also come to the same conclusion as Douglass, that some of these species should be placed under a new genus, and in April of the same year he proposed the name *Paracotylops,* with *O. superbus* as the generic type.

Before concluding the history of the genus *Merycochœrus,* a summary of the main factors shows (1) that Leidy, in various references, had described a fairly well-defined genus previous to and including the year 1873; (2) that Bettany, in 1876, considered certain forms from Oregon as belonging to *Merycochœrus,* although Leidy, six years before, had described a species practically the same as Bettany's *M. temporalis* and had designated it as *Oreodon superbus;* (3) that Cope also allowed considerable latitude to the genus, describing two new species from Oregon, and one from Montana, in 1884, as well as placing Leidy's *O. superbus* in the genus; (4) that between and including the years 1858 and 1901, thirteen species of widely varying forms and

[17] E. Douglass, this Journal (4), **11**, 82.
[18] W. D. Matthew, Univ. Calif., Bull. Dept. Geology, 2, No. 9, 296, 1901.

ranging from Upper Oligocene to Middle Miocene in age, had been referred to *Merycochœrus;* and (5) that Douglass and Matthew reached the conclusion in 1901 that the genus should be divided, the former proposing *Promerycochœrus* and the latter *Paracotylops,* and both taking *Oreodon superbus* as the generic type.

Below are listed the major differences between *Merycochœrus* and *Promerycochœrus.* These factors are based chiefly on the skulls, for the skeletal elements of all the Merycoidodontidæ are very similar, except for size differences. According to Matthew,[19] the skeleton of *Merycochœrus* most closely resembles that described by Scott[20] as *P. montanus.* The writer has attempted to show the broad differences between typical specimens of each genus. Many examples of *Promerycochœrus* in the Marsh Collection show certain minor individual variations which indicate a relationship to *Merycochœrus,* as would be expected. However, I am inclined to the belief that the John Day forms became extinct, at least in that basin, long before the end of Lower Miocene time, and that therefore they did not evolve forms closely allied to the Great Plains *Merycochœrus.*

	Merycochœrus Leidy 1858 *M. proprius* Leidy	*Promerycochœrus* Douglass 1901 *P. superbus* (Leidy)
	SKULL	SKULL
Shape	Short	Elongate
Size	Smaller than *Promerycochœrus*	Larger by about 2 inches (types)
Resemblances	Similar to Loup Fork Mastodons (Matthew)	Similar to *Eporeodon*
Upper contour	Extremely marked sigmoid curve from occiput to prosthion	Nearly straight line with either a very slight slope or none at all from occipital crest
Side view	Nearly right triangular	Oblong
Top view	Almost an equilateral triangle	Triangular with very small angle at apex
Nasals	Much reduced, extending only a little beyond M^1	Unreduced, normal, or somewhat elongated, extending close to incisor border
Premaxillæ	Coössified along entire inner margins and with maxillæ	United at tips only

[19] W. D. Matthew, Mem. Am. Mus. Nat. Hist., 1, pt. 7, 408-412, 1901.
[20] W. B. Scott, Trans. Am. Philos. Soc., 17, 150-162, 1893.

Face	Abruptly narrowed in advance of orbits; with rugosities and ridges for muscular attachment; wide, unbroken transverse concavity from infraorbital arch to canine alveolus; turning abruptly outward and backward from above true molars	Not abruptly narrowed in advance of orbits; smooth, with no ridges or rugosities; divided by a convexity, continuing forward and upward from anterior border of zygomatic arch; turning much more gradually outward and backward
Cranium	Very short, rising steeply from posterior part of nasals to occiput	Normal, fairly long, and only slightly, if any, higher than posterior part of nasals
Occiput	Higher, crests much less overhanging; short and about twice as broad as in *Promerycochœrus;* V-shaped above foramen magnum, in form of a slightly convex ridge in a wide concavity formed by mastoid plates	Much lower, crests overhanging markedly; long and narrow; oblong shaped, narrow, strongly convex above foramen magnum
Sagittal crest	None	Long
Infraorbital foramen	Above interval between M^1 and M^2	Above P^4 to anterior part of M^1
Lachrymal fossæ	Wide, shallow, not confined to larchrymal bone	Shallow (*superbus*) to deep (*macrostegus*), confined entirely to lachrymal bone
Orbits	Looking upward very markedly; much higher above jaws, but same distance below top of skull; proportionally smaller; anterior border on line with interval between M^2 and M^3	Not directed upward nearly so much; much lower above jaws, but same distance below frontals; larger; anterior border above anterior lobe of M^2
Maxillo-lachrymomalar suture	Descends nearly vertically, curving backward only at its lower extremity	Descends vertically but a short distance, then sweeps backward for two-thirds its length, as in *Merycoidodon*
Frontals	Nearly flat, with somewhat of a convexity, both transversely and antero-posteriorly	More convex transversely, flat antero-posteriorly
Wings of transverse crest	Wide apart	Nearer together
Mastoid plates	Project laterally in nearly same plane to a width equal to nearly three-fifths length of skull (Matthew)	Very much less widely developed
Condyles	Smaller, basisphenoid shorter and narrower	Larger, basisphenoid short and narrow, also basicranial angle much greater in most species
Transverse crests	Nearly covered by cancellous tissue	No cancellous tissue
Posterior part of skull	Cancellous osseous tissue (diploë) extensively developed	No cancellous tissue, or but extremely little, but very variable in width

Depth of malar below orbit	Two inches	One and a half inches in *superbus*, exceeded somewhat in other species
Zygomatic arches	Nearly one-half deeper than in *superbus* and differ from all *Promerycochœri* in the uniform continuous upward and outward slope of external surfaces (Matthew)	Less deep, and more nearly V-shaped, whereas in *Merycochœrus* they are wide U-shaped
Zygomatic margin	Expanded into a flat, sharp-edged plane surface, facing outward and upward	Flat, subround-edged plane to slightly concave surface, nearly vertical
Squamosal	Extends to opposite posterior end of M^3. Extends posteriorly, with flat surface, facing upward and outward, nearly an inch wide, with parallel sharp edges, curving backward and upward and ending in a long flat process pointing backward, upward, and inward about opposite the condyle (Matthew). Bony tissue especially thick along antero-superior border, forming prominent ridge	Normally extends beneath orbit. Much narrower, with parallel rounded edges, ending in a nearly vertical process, sometimes truncated, at or slightly below level of sagittal crest. No bony tissue along antero-superior border, but normal groove on either side of suture present
Proboscis	Probably present	Absent
Lower jaw	Concave below anterior molar teeth	Flat to convex, below anterior molars
Incisive foramen	One, large	Two, large
Muzzle	Slightly round	Square
Palate	Much wider posteriorly	Narrow posteriorly, as outer lines of teeth from C to M^3 are usually nearly parallel
Masseteric fossa	Much less deep	Usually quite deep
Neck	Very short	Normal
	LIMBS	LIMBS
Legs and feet	Very short	Short
Ungues	Short and wide	Short
	TEETH	TEETH
Form	Hypsodont	Brachydont
Premolars (upper)	Crowded, individually unreduced; premolar series reduced in length; P^{1-2} with greater breadth in relation to length and thickness; P^2 crowded and inserted obliquely; hypocone of P^3 a festooned basal ridge, enclosing two mammillary tubercles; P^1 simple, with internal cingulum, set somewhat obliquely; length and antero-posterior diameters of crowns exceed transverse, except in last upper one	Spaced; premolar series unreduced in length; P^{1-2} with less breadth; P^2 not normally crowded or inserted obliquely; P^3 normal; P^1 simple, with discontinuous internal cingulum; length and antero-posterior diameters of crowns exceed transverse except in P^{3-4}

Molars (upper)	Rapidly increase in size from 1 to 3; length of M^3 about equal to that of M^1 and M^2; M^3 very much the largest; they protrude gradually, so that before M^3 is fully erupted, the triturating surface of M^1 is obliterated. An analogous case is seen in *Bothriodon*, except that the teeth are brachydont in the latter genus; the metastyle of M^3 is robust, posterior half of tooth rotated inward, so that the metastyle is in line with the middle of the tooth row	Increase only moderately and gradually from 1 to 3; length of M^3 equal to that of M^2 plus posterior cone of M^1; M^3 not much larger; do not show the characteristics of eruption as in *Merycochœrus;* the metastyle of M^3 is moderately robust and not rotated so far inward
Molars (lower)	More hypsodont, increasing rapidly in size from 1 to 3	Brachydont, increasing gradually in size from 1 to 3
Premolars (lower)	Equal to, or slightly less than, length of M_{1+2} and anterior lobe of M_3 (Douglass); P_{2-3} crowded, P_2 set obliquely in jaw	Nearly or quite equal to length of molar series (Douglass);* P_{2-3} crowded, not normally set obliquely, but sometimes so; much variation here
Incisors	Small, brachydont, much less spatulate	Normal, but much more spatulate
Canine	Directed more forward	Directed straight downward or slightly backward
	SKELETON	SKELETON
	Like that of *P. montanus*	Except for size, similar to that of *Eporeodon*
	AGE	AGE
	Lower to Middle Miocene	Upper Oligocene
	LOCALITY	LOCALITY
	Near Fort Laramie, on Niobrara River, Wyoming	Bridge Creek, John Day River, Oregon

* Lower premolar series here includes P_1 (caniniform premolar)