THE CREODONTA.

BY

E. D. COPE.

(*From the American Naturalist, March, 1884.*)

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PRESENT knowledge justifies the generalization that, since the Eocene period, the mammalian fauna of the Northern hemisphere has diminished in the number of its species and genera. The Eocene fauna was richer than the Miocene; the Miocene than the Pliocene, and the Pliocene was richer than the modern fauna. With this numerical diminution in species has come increased specialization of structure, which means both greater perfection of mechanism and greater diversity of type.[1]

The order of Carnivora is a universal and well-known factor of the mammalian life of the present period. It was equally so in the Pliocene and Miocene periods. When we come to examine the overflowing life of undoubted Eocene time, we can no longer find mammals which possess the essential characters of the order. The Carnivora are unguiculate gyrencephalous mammalia with a coössified scaphoid and lunar bone of the carpus, called, therefore, the scapholunar bone. They have a grooved astragalus. No scapholunar bone has yet been found in any Eocene mammal in North America, and it is doubtful whether any has been found in Europe. Nevertheless the Eocene fauna did not lack predatory flesh-eaters whose function was like that of the Carnivora of later periods, to restrain the undue increase of all other forms of life. Their variety was greater than that presented by their carnivorous successors on the North American continent, and their numbers were proportioned to the general luxuriance of the life which furnished them subsistence. There were species whose size and powers of destruction equaled those of the bears, lions and tigers of modern times. Species of medium size abounded,

[1] This generalization was published in the Report U. S. G. G. Survey W. of 100th meridian, 1877, IV, p. 385.

while the smaller forms, representing in function the civets and weasels of to-day, were especially numerous.

The systematic position of these animals has been difficult to determine with satisfactory precision, owing to the imperfect knowledge which we possess of their structure. Besides lack of scapholunar bone, they nearly all differ from the Carnivora in their ungrooved astragalus, and their greatly reduced and smooth cerebral hemispheres. Their position then can only be with the Marsupialia or the Insectivora. The superficial resemblances are often to the former order, where the carnivorous types Thylacinus, Sarcophilus, Dasyurus and the opossums, seem to present near affinities, if the structure of the teeth only is to be considered. Laurillard, DeBlainville and Gaudry have, at different times, assigned to them this position. It is true, however, that no one osseous character, except the possession of marsupial bones, has yet been discovered which characterizes the order Marsupialia. It rests chiefly on the characters of its soft parts, especially of the brain and reproductive system. Most marsupials have the angle of the lower jaw inflected; the Eocene flesh-eaters do not. The carnivorous marsupials generally have more than six incisor teeth; the Eocene flesh-eaters have six or less. The marsupials generally have perforated palates; the Eocene forms never display the character. No marsupial bones have yet been found in the Eocene forms (with the possible exception of Mioclænus), so that we cannot yet find the necessary reasons for placing our extinct forms with the order which possesses them. On the other hand the brain was probably marsupial in its internal character, as it certainly was in its external character. Finally, the discovery of the character of the temporary dentition in the Eocene flesh-eaters has added force to the view that they cannot be marsupials. M. Filhol has shown that in Hyænodon there were three temporary molars, and I have proven that there were at least two in Triïsodon. There is, according to Flower, but one in the Marsupialia. It is, however, to be remembered that true marsupials, opossums, occur in the Oligocene in both North America and Europe (genus Peratherium Aym.), and that they resemble their Eocene predecessors very much, especially in the constitution and form of the molar teeth.

The comparison with the Insectivora betrays no such fundamental diversities as that with the Marsupialia. The differences

are of minor import, although in particular cases considerable. In spite of their often large size and evidently predatory habits, the Eocene flesh-eaters must be placed with the Insectivora. But as I have already pointed out,[1] they have contemporaries which must go with them. These are two groups, the one with rodent, the other with edentate tendencies, the Tillodonta and Tæniodonta. The former of these is intimately allied to the living Chiromys of Madagascar, which itself is almost a lemur, by gen-

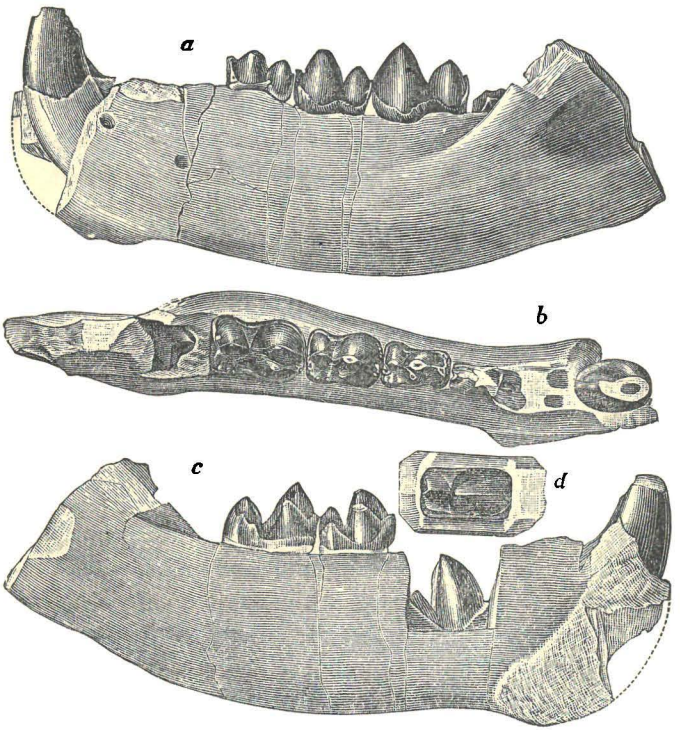


FIG. 1.—Left mandibular ramus of *Tritemnodon quivirensis* Cope, three-fourths nat. size, from the Puerco beds of New Mexico. Fig. *a*, external view, displaying the last temporary molar in place; *b*, the same from above; *c*, the same, internal side, the temporary molar removed and the permanent fourth true molar displayed in the jaw; *d*, the fourth permanent premolar viewed from above. Original; from Vol. IV, Report U. S. Geological Survey Terrs., F. V. Hayden in charge.

eral consent. The whole of this assemblage I have regarded as an order of mammals to which I have given the name of the Bunotheria. In this order there are included six suborders, and

[1] Report U. S. G. G. Surveys W. of 100th meridian, G. M. Wheeler in charge, IV, p. 85, 1877. Proceedings Academy Philadelphia, 1883, p. 77.

the carnivorous type of this series, the group now under discussion, I have called the Creodonta.[1] Its definition is as follows:

Neither incisor nor canine teeth growing from persistent pulps. Hallux not opposable. Superior true molars tritubercular or more simple.

The only character which distinguishes the suborder from the Insectivora is the possession of tritubercular or more simple molars above. This is, as I have shown,[2] a feature of more importance than has been hitherto supposed. The tritubercular molar is the primitive type from which the quadritubercular has been directly derived. It has furnished the starting point for both the carnivorous and the herbivorous dentitions, since it was common to both the clawed and hoofed mammals of the Puerco, or lowest known epoch of the Eocene period.

So far as known, the Creodonta were all plantigrade, and had long tails, and were mostly five-toed. With the possible exception of *Protopsalis tigrinus*, they all had relatively larger heads and shorter legs than the majority of the Carnivora of the present period. This is true of all the recent Creodonta, none of which reach the dimensions of many of the fossil forms.

The contents of the suborder Creodonta display, in their modifications, the usual range of simplicity and complexity consistent with the type, and the families may be arranged in some sort of phylogenetic order, in accordance with this principle. Nevertheless a difficulty arises as to what are ancestral or primitive conditions, and what characters, if any, must be regarded as the result of degradation. As other parts of the skeleton are less frequently obtained, these considerations relate chiefly to the dentition.

In my paper on the Homologies and Origin of the types of Molar Teeth, etc.,[3] I pointed out that the cone was the simple form of tooth from which all others must have been derived. In the Mammalia this may have been modified in several ways simultaneously, but two methods present themselves as the most certain secondary primitive types. The first of these is that of the simple premolar, where the cone is compressed, and is sooner or later followed by a horizontal extension or heel. This type persists in

[1] For greater detail on this topic, see Proceedings Philadelphia Academy, 1883, p. 77.

[2] Proceedings American Philosophical Society, 1883, p. 324. Palæontological Bulletin, No. 37.

[3] Journal Academy Nat. Sciences Philada., 1874, March.

the inferior true molars of the Mesonychidæ. The second modification consists in the addition of lateral cusps or spines to the simple cone. Such a type is seen in inferior molars of *Spalacotherium tricuspidens* Ow., of the Jurassic period, and in some of the incisors of *Plesiadapis tricuspidens*[1] Gerv. This form, by the shifting of the two subordinate cusps to the inner side of the principal one, will give a trituberculate molar of the lower series, an exaggeration of which is seen in the South African "mole,"

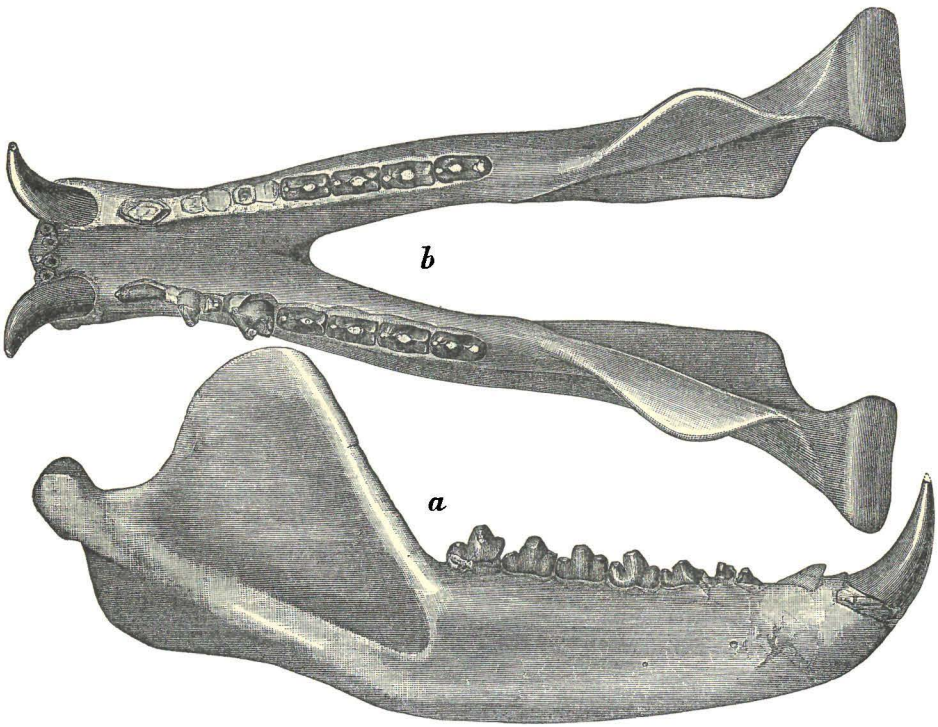


FIG. 2.—Mandible of *Mesonyx ossifragus* Cope, from the Wasatch epoch of the Big Horn river, Wyoming, one-third nat. size. Original. From Report U. S. G. S. Terrs., Vol. III.

Chrysochloris. If a cingulum appears at the posterior base of such a tooth, we have a rudimental "heel," such as is seen in Centetes, and is still better developed in many creodont and marsupial genera, forming the basis of the inferior sectorial tooth of the Carnivora. This, which I have called the "tubercular-secto-

[1] Lemoine. Communication sur les Ossemens Fossiles d. env. Reims, p. 9, pl. II, fig. 13. The superior dentition of this specimen is represented in fig. 6.

rial," is especially well marked in Oxyæna (Fig. 3) and Stypolophus.

All stages of diminution of the anterior of the two inner cusps of the inferior molars may be seen in the genera of Centetidæ, as for instance in Ictops and Diacodon, until a true quadritubercular molar is reached as in Mioclænus. In Miacis and Didymictis one tubercular-sectorial remains with one or more tuberculars. The process of developing a tubercular inferior molar from a tritubercular tooth, is the reverse of what has taken place in the Carnivora, where the tubercular-sectorial has, by loss of parts,

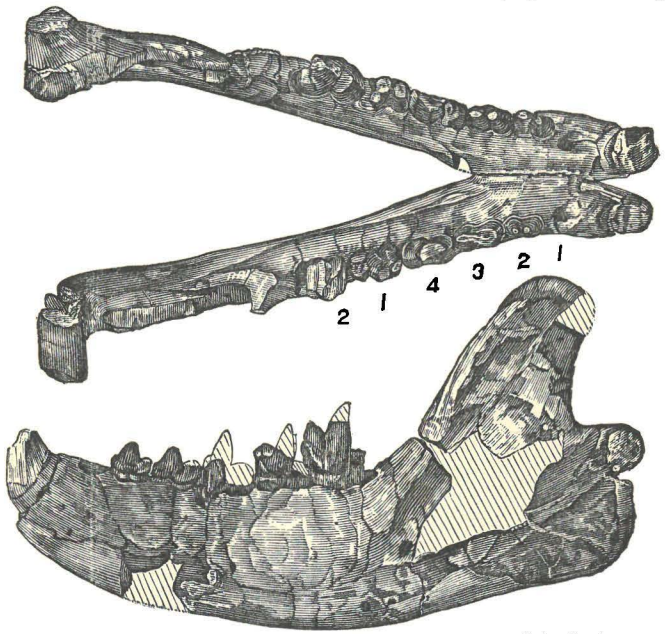


FIG. 3.—*Oxyæna forcipata* Cope, mandible from the Wasatch bed of New Mexico, one-half natural size. Original from Report U. S. G. G. Survey W. of 100th mer. G. M. Wheeler, Vol. IV. The numbers indicate the approximate premolars and true molars.

become a true sectorial. With these explanatory remarks I present the following definition of the families. I have formerly used the shape of the astragalus as a family definition. In the majority of the Creodonta its trochlear face is not grooved. In the Mesonychidæ it is strongly grooved. In Mioclænus and some species of Stypolophus, as well as in the moles, it is slightly grooved:

I. Inferior molars premolariform.

Inferior molars consisting of a cone and heel.....*Mesonychidæ.*
Inferior molars with a blade formed of anterior and median cusps...*Hyænodontidæ.*

II. Inferior molars tritubercular without heel.

No sectorial teeth; tibia and fibula coössified.....*Chrysochloridida.*

III. Inferior molars tritubercular-sectorial or quadritubercular.

a. No superior sectorial teeth.

Tibia and fibula distinct; no zygomatic arch.....*Centetidæ.*

Tibia and fibula distinct; zygomatic arch present.....*Leptictidæ.*

Tibia and fibula coössified; external tubercles of superior molars subconic, no clavicles.....*Mythomyidæ.*[1]

Tibia and fibula coössified; external tubercles two Vs; clavicles.....*Talpidæ.*

aa. First true superior molar sectorial.

Tibia and fibula distinct; no tubercular molars.....*Oxyænidæ.*

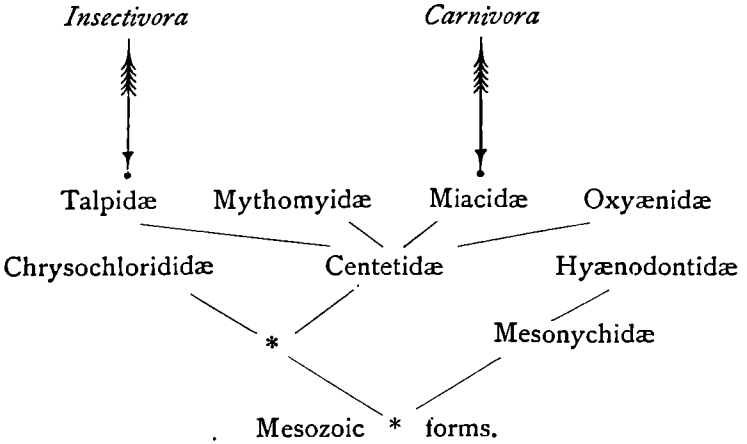
aaa. Fourth superior premolar sectorial.

Tibia and fibula distinct; true molars tubercular.....*Miacidæ.*

The number of genera and species embraced by these families is as follows. The extinct forms only are enumerated, and those of North America are specified:

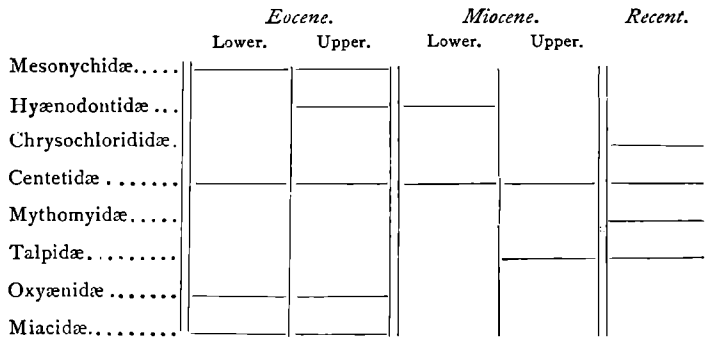
Families.	*Genera.*	*Species.*	*N. America.*
Mesonychidæ	4	7	7
Hyænodontidæ	1	10	3
Chrysochloridida	*	*	
Centetidæ	18	44	37
Mythomyidæ	*	*	
Talpidæ	*	*	
Oxyænidæ	3	7	4
Miacidæ	2	12	12
Totals	28	80	63

The affinities of these families may be expressed in the following diagram, which may be regarded as an attempted phylogeny also:



[1] This family is sometimes called the *Potamogalidæ*. Mythomys is, however, the name first published, with a description, for the typical and only genus.

In geological time the Mesonychidæ, Miacidæ and Oxyænidæ are confined to the Eocene period. The Hyænodontidæ extend through the Upper Eocene and Oligocene or Lowest Miocene formations. The Centetidæ are predominately Eocene, but in North America they are also found in the Oligocene. In recent times they are only known in the islands of Madagascar and Cuba. The Chrysochloridídæ are modern and African, while the Talpidæ commence in the Middle Miocene in Europe, and are as abundant in recent times in the Northern hemisphere. Mythomyidæ are only known as recent in Africa. These relations may be expressed as follows:



The distribution of the genera with relation to the American formations will be considered later.

Mesonychidæ.

In this family the form of the inferior molars is not very different from that displayed by the last lower premolars of carnivorous Mammalia generally. The superior molars are of correspondingly simple structure, in like manner resembling the last premolars of the superior series of Carnivora and some other Mammalia. There are two types in the family. In the first, the astragalus is flat, as in most Creodonta (Fig. 5 *a b*). The only known genus is Amblyctonus, which I have, on account of its astragalus, placed in a separate family, the Amblyctonidæ. This course may be justified by future discovery. The inferior molars also differ from those of Mesonyx in the development of the anterior cusp, thus approaching the Hyænodontidæ (Fig. 4). The bones of *Amblyctonus sinosus* Cope, are about as robust as those of the coyote. They have so far been found only in the Wasatch beds of New Mexico. M. Fischer has described an allied mam-

mal from France under the name *Apterodon gaudryi*. He has not stated how this genus differs from Amblyctonus.

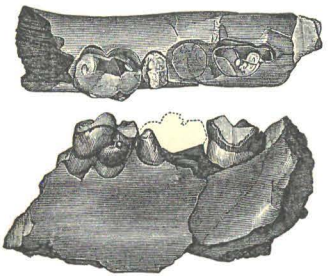


Fig. 4.

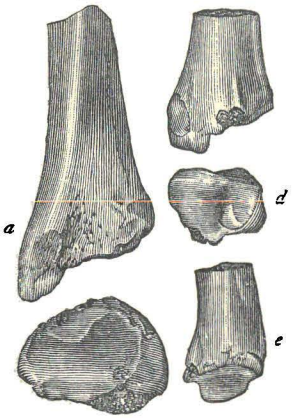


Fig. 5.

FIG. 4.—Part of mandibular ramus of *Ambtyctonus sinosus* Cope, with the last three molars ; upper figure the same, from above; two-thirds nat. size. From the Wasatch beds of New Mexico. FIG. 5.—Distal ends of tibia of, *a–b*, *Amblyctonus sinosus*, and *c d e*, *Oxyæna morsitans* Cope; *b* and *d*, distal views; two-thirds natural size. From the Wasatch beds of New Mexico. Original, from U. S. G. G. Expl. Surv. W. of 100th mer., G. M. Wheeler.

In the genus Mesonyx we have a structure of the astragalus found only elsewhere in flesh-eating mammals in the Hyænodon.[1] Its distal extremity has two well-marked facets, one for the navicular bone and one for the cuboid (Fig. 9). The appearance is that of a perissodactyle mammal, and the astragalus of the Mesonyx might well be taken for that of an ungulate of that suborder. The tibial face of the bone is grooved, another point in which it differs from most of the Creodonta. Still another characteristic peculiarity is seen in the forms of the ungues. These are neither claws nor hoofs, but between the two, resembling the corresponding part in some Rodentia. Their deeply fissured extremities show that they are rather allied to claws than to hoofs (Fig. 10). The narrow navicular facet of the astragalus renders it probable that the inner digit or hallux is wanting, and that there are but four toes in the hinder foot. The form of the trapezium shows that there are but four toes on the anterior foot (Fig. 7). One more character completes the singular ensemble presented by this genus. The zygapophyses of the lumbar vertebræ embrace each other as in the lower perissodactyles and artiodactyles, a character not found in the Carnivora or Insectivora.

[1] Fide Professor W. B. Scott.

Among the Creodonta I have only observed it elsewhere in the genus Mioclænus,[1] but the vertebræ of many of these animals are unknown. It is wanting in Thylacinus and the opossum, and rudimental in Sarcophilus, among marsupials.

Three species of the genus Mesonyx are known, *M. ossifragus*

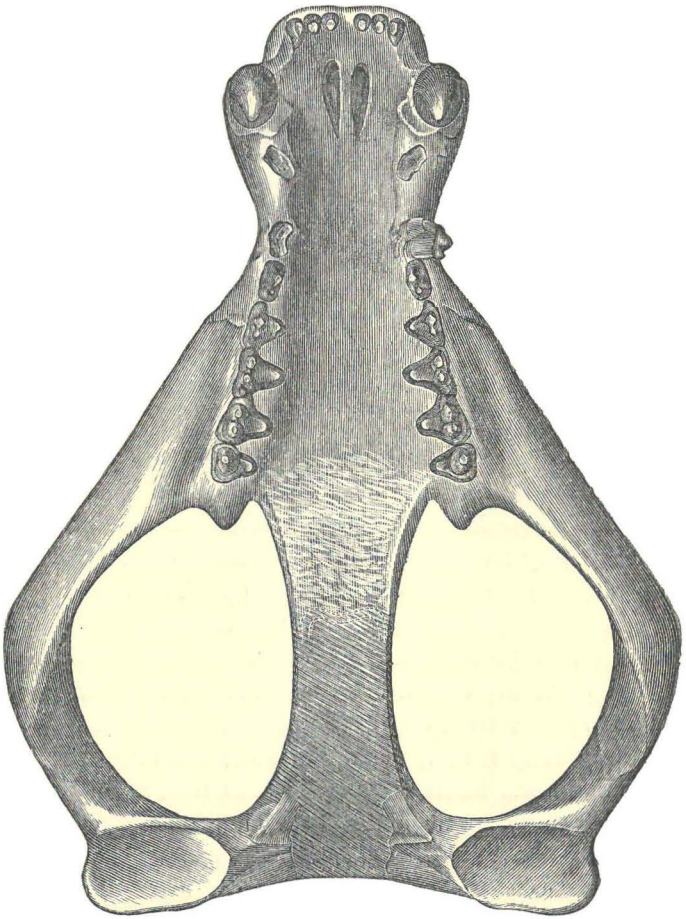


FIG. 6.—*Mesonyx ossifragus* Cope, skull anterior to postglenoid processes, inclusive, from below; one-third natural size. From the Wasatch beds of Wyoming. Original, from Report U. S. Geol. Surv. Terrs., III, F. V. Hayden.

Cope, from the Wasatch Eocene, and *M. lanius* and *M. obtusidens* Cope, from the Bridger. The last named is the type. It is about the size of the wolf, and had more slender feet and claws than

[1] Proceedings American Philos. Society, 1883, p. 543.

the other two. The *M. lanius* was considerably larger than the *M. obtusidens*, equaling the black bear (*Ursus americanus*) in size It had a large head, with a long, rather narrow and truncate. muzzle. The limbs were relatively smaller, not exceeding those of the black bear in length and thickness. The tail was long and slender as in the cats, while the claws were broad and flat as in the beaver.

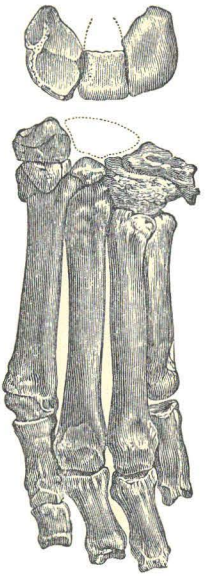


FIG. 7.—*Mesonyx lanius* left anterior foot, one-half natural size. Upper figure first row of carpal bones of right side of same individual, proximal view. Original. From the Bridger beds of Wyoming.

The molar, canine and incisor teeth of my specimen, as well as those of one in the Princeton Museum, are much worn by use. This is especially true of the canines of both, while the crowns of the molars of my Bitter Creek specimen are almost entirely worn away. The same peculiarity is to be observed in the specimens of the allied *Amblyctonus sinosus*, which I obtained in New Mexico. It is probable that these species chewed hard substances. The peculiar approach of the lower canines is a special modification for peculiar habits, which I suspect to have been the devouring of the turtles which so abounded on land and in the waters of the same period. The slender symphysis could most readily be introduced into the shell, while the lateral pressure of the upper canines with the lower, would be well adapted for breaking the bony covering of those reptiles. The breaking of these shells in the attempt to masticate their contents would produce the unusual wear of the teeth observed.

The *Mesonyx ossifragus* is the largest species, its skull exceeding that of the grizzly bear in dimensions (Figs. 2, 6, 8, 9 and 10). It was originally found by the writer in the Wasatch beds of New Mexico, and was afterwards found by Mr. Wortman to be not uncommon in the corresponding formation in Northern Wyoming. From material obtained by this gentleman, we can form a general idea of the form and proportions of the *Mesonyx ossifragus*. We can depict an animal as large as a large-sized American black bear, with a long, stout tail and a wide head as large as that of a grizzly bear. The fore limbs are so much shorter than the hind limbs

that the animal customarily sat on its haunches when on land. In walking, its high rump and low withers would give it somewhat the figure of a huge rabbit. Its neck was about as long as that of an average dog. Its tread was plantigrade, and its claws like those of various rodents, intermediate between hoofs and claws. The animal, to judge from its otter-like humerus, was a good swimmer, although there is nothing specially adapted for aquatic

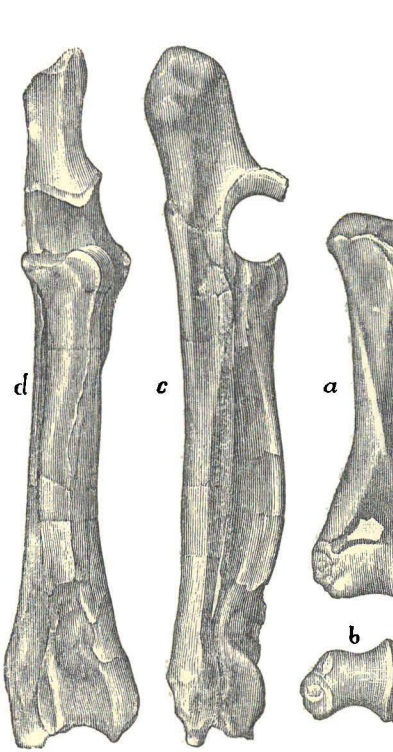


Fig. 8.

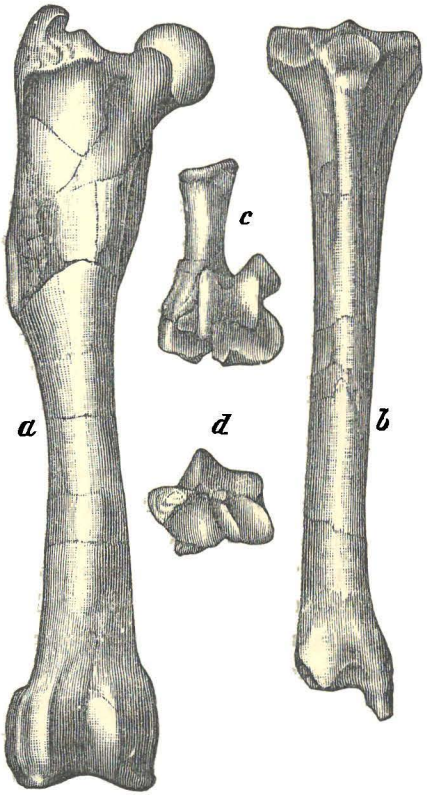


Fig. 9.

FIG. 8.—Anterior limb bones of the specimen of *Mesonyx ossifragus* represented in Figs. 2 and 6, one-third natural size. Fig. *a*, humerus from front; *b*, distal view of distal extremity; *c*, right ulna and radius, external view; *d*, the same from above. FIG. 9.—Posterior limb of *Mesonyx ossifragus*, the individual represented in Figs. 2, 6 and 8, one-third nat. size. Fig. *a*, femur from front; *b*, tibia from front; *c*, astragalus and calcaneum from above; *d*, the same, distal view. From the Big Horn region of the Wasatch epoch.

life in the other bones of its limbs. Its teeth, on the other hand, are of the simple construction of the mammals which have a diet largely composed of fishes. We cannot but consider this animal

as one of the most singular which the Eocene period possessed. In size it was not exceeded by any other flesh-eater of the period, but was equaled by the *Protopsalis tigrinus*. Its anterior limbs were evidently relatively shorter than in the *Mesonyx lanius*.

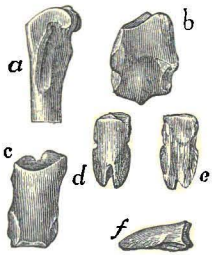


FIG. 10. — Parts of digits of *Mesonyx ossifragus*, one-half natural size. Fig. *a*, metacarpal; *b*, metapodial, distal end; *c*, phalange; *d e f*, an ungual phalange from above, below and side. Original. From the Wasatch beds of Wyoming.

The *Sarcothraustes antiquus* is a large animal from the Puerco epoch of New Mexico, of about the size of the *Mesonyx ossifragus* Its inferior molars have a wide heel as in Amblyctonus. The genus Dissacus Cope occurs in the same formation and locality Its inferior molars (Fig. 11) present an accessory cusp on the inner side of the principal cone. This constitutes the first step towards the tubercular-sectorial tooth of other families. There are two species, the *D. navajovius*, as large as the red fox, and *D. carnifex* Cope, of larger size.

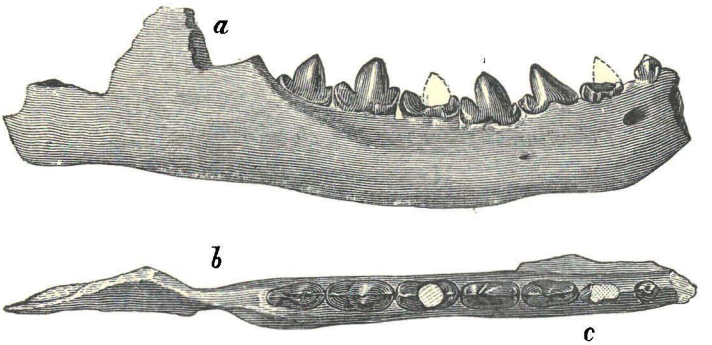


FIG. 11.—*Dissacus navajovius* Cope, right mandibular ramus, three-fourths natural size; *a*, external; *b*, superior views. From the Puerco beds of New Mexico. Original.

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THE CREODONTA.

BY E. D. COPE.

(Continued from the March number, p. 267.)

HYÆNODONTIDÆ.

IN this family the anterior cusp of the inferior true molars is so developed as to form, with the median cusp, a true sectorial blade. The posterior cusp is rudimental, and in the last inferior molar wanting. There is no internal tubercle. In the superior molars, on the contrary, the anterior basal cusp has disappeared, and the posterior one is developed behind the middle one, like a blade. The superior molars, like the inferior, have no internal lobe.

Professor W. B. Scott has studied the posterior limb and the brain-case of a species of Hyænodon, which he describes as follows. I quote from the advance sheets of his paper on this subject, which he has kindly permitted me to use:

"The hind limb is in essentials very like that of Mesonyx of the Bridger Eocene; the femur has a decided third trochanter. The tibia is much like that of Mesonyx, and its distal end is characteristically Creodont in having its astragalus face almost

flat, with only a very slight median ridge for the groove of the astragalus. The internal malleolus is very large.

"The astragalus is but slightly concave from side to side, much less so than in Mesonyx.

"The foot is plantigrade, and the entire length of the calcaneum rested on the ground. Five well-developed digits were present, terminating in short and stout compressed claws; very different from the peculiar depressed ungual phalanges of Mesonyx; otherwise the resemblance of the foot as a whole to that of Mesonyx is very striking.

"The brain case attributed by Gervais to Hyænodon must belong to some other genus, or else our American species differ very radically from the French. In the American species the brain is relatively very small and simple, being but slightly larger than that of Thylacynus, to which animal Hyænodon presents many interesting approximations in the structure of the skull and teeth. The cerebellum of Hyænodon is entirely uncovered by the hemispheres, which in their turn seem to have but three straight longitudinal gyri, presenting the simplest type of the carnivorous brain."

It is highly probable that this family is a derivative of a pentadactyl form of the Mesonychidæ. Its appearance in time corresponds nearly with the disappearance of the latter.

But one genus of this family has been thus far described, the Hyænodon of Laizer and Parieu. Its dental formula is I. $\frac{3}{3}$; C. $\frac{1}{1}$; P-m. $\frac{3}{4}$; M. $\frac{3}{3}$. The last three molars in both jaws are sectorials, and the last of these are the largest, and form the most effective shears for the dividing of animal tissues. The position of these teeth indicates a mouth fissured far posteriorly, and a correspondingly posterior position of the masseter muscle. This structure indicates a weak power of prehension of the canine teeth. This character is sustained by the frequently anteriorly directed inferior canines, and the generally slender mandibular rami. The Hyænodons must be regarded as snappers, and not capable of holding on to a living enemy with much persistency.[1] They were evidently weaker in all points of organism than the modern Carnivora, which no doubt accounts for their extinction. Thirteen species have been described, all but three North American forms being French. The oldest of these, the *H. parisiensis* Kefst., is from the Upper Eocene or Oligocene, or the Paris Gypsum, but its reference to this genus is not yet certain. Gaudry, however,

[1] See On the origin of the sectorial tooth of the Carnivora, AMERICAN NATURALIST, 1876, p. 171.

states that Hyænodon occurs in the Gypse. Seven species are described by Filhol as from the Phosphorites. Some of these (as *H. leptorhynchus* L. & P.) are elsewhere found in the Stam-

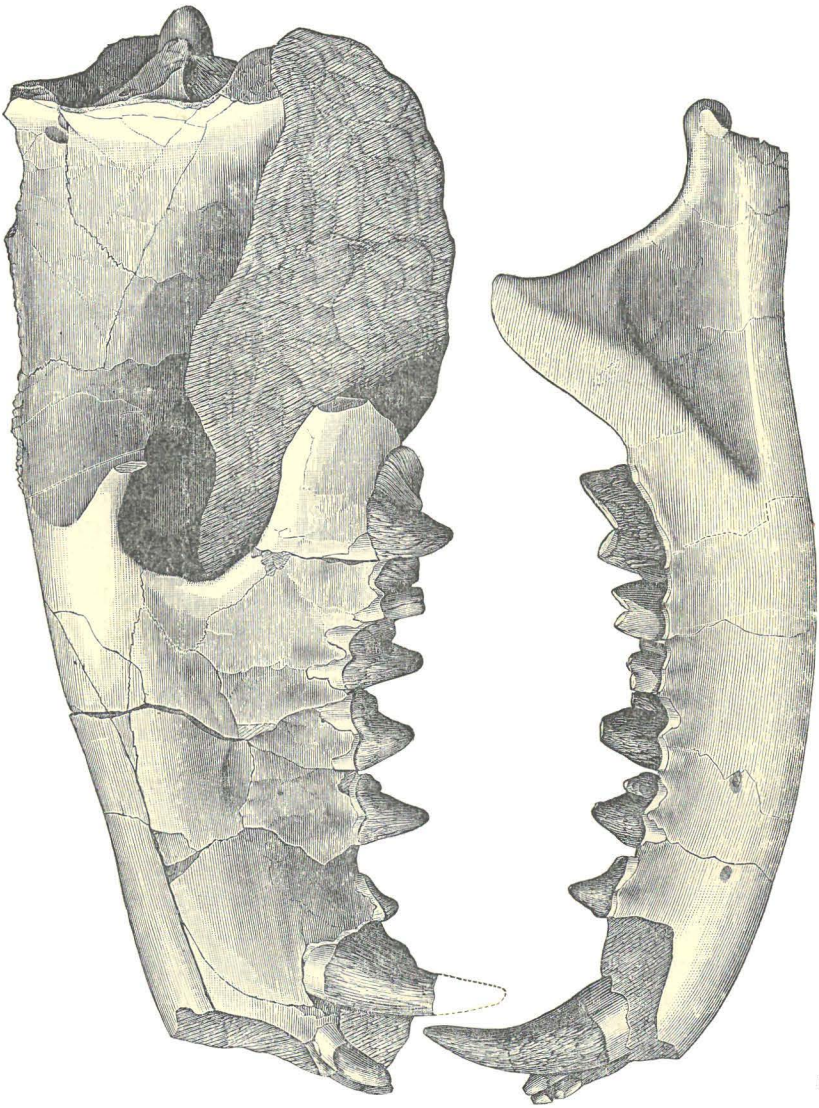


FIG. 12.—*Hyænodon horridus* Leidy, skull one-half natural size. From the White River formation of Nebraska, From Leidy's Extinct Mammalia of Dakota and Nebraska,

pian, a Lower Miocene, but some of them are probably Upper Eocene.[1] The three North American species are from the White

[1] Professor Gaudry thinks the Phosphorites include fossils of different Tertiary epochs.

River or Oligocene horizon, and no species is known from later formations. The species range in size from that of the *H. vulpinus* Gerv., which equals a red fox, to that of an American black bear, as the *H. heberti* Filhol, and *H. horridus* Leidy (Fig. 12). The latter species is from the bad lands of Nebraska.

Leptictidæ.[1]

This family is very nearly related to the Centetidæ, which are now living in Madagascar. The only character by which I dis-

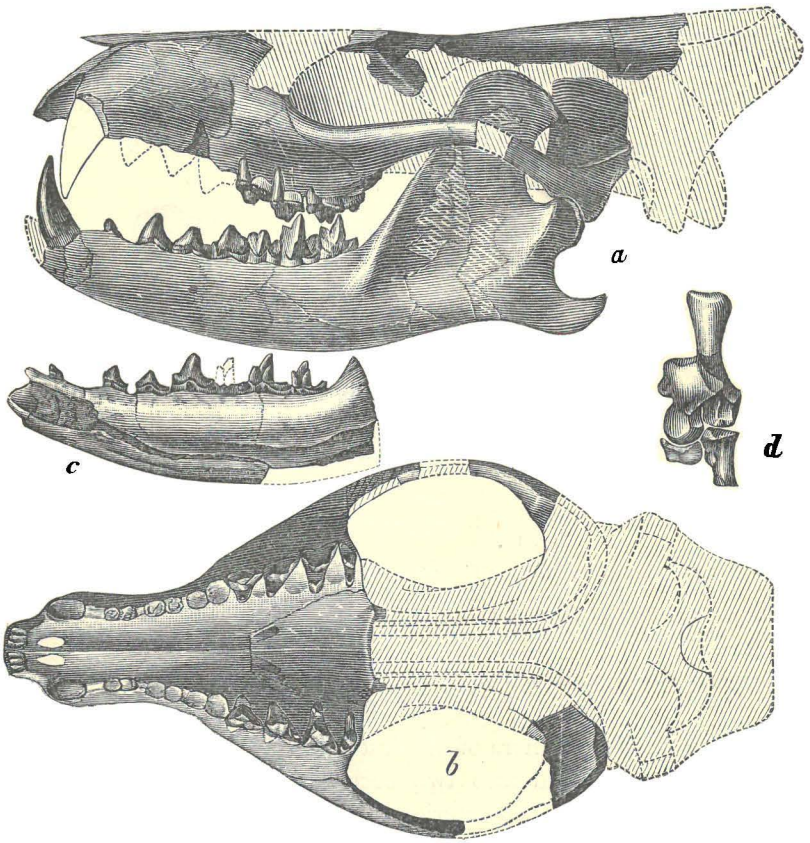


Fig. 13.—*Stypolophus whitiæ* Cope, skull and part of posterior foot of two individuals, two-thirds natural size. Figs. *a–b* from the Wasatch beds of the Big Horn river, Wyo. Figs. *c–d* from the basin of the Wind river, Wyo. Fig. *c*, internal side of part of right mandibular ramus. Fig. *d*, left tarsus minus cuneiform bones, from above. Original, from Vol. III, Report U. S. Geological Survey Terrs., F. V. Hayden.

tinguish it is by the presence of the zygomatic arch, a part of the skull which is absent in the Centetidæ (Fig. 13). The Leptictidæ

[1] This family is included in the Centetidæ in the first part of this paper, p. 261.

are no doubt the ancestors of the Centetidæ; and their later types, as Leptictis, approach the existing family in their dentition quite closely.[1] The earlier types display great variety in their dentition, and give ground for distinguishing many genera.

Two groups are easily recognized among the Leptictidæ. In the first of these the last or fourth inferior premolar is a simple premolariform tooth, different from the inferior true molars, and without any internal cusp. In the second division the fourth inferior premolar is either like the true molars or approximates their form by the presence of an internal tubercle. To the latter group belongs the genus Chriacus, which from the slight development of the fourth inferior premolar (Fig. 14) approximates the first division. The genus may, however, be improperly referred to the Creodonta.

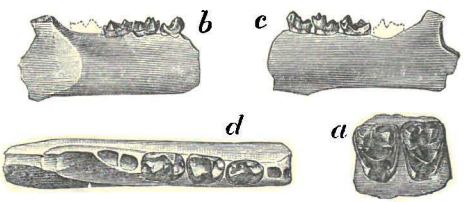


Fig. 14.

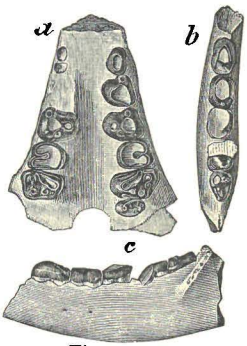


Fig. 15.

FIG. 14.—*Chriacus angulatus* Cope, right ramus of mandible and part of maxillary bone with teeth; from the Wasatch beds of the Big Horn, Wyoming. Figs. *a* and *d* twice natural size. Figs. *b–c* natural size. Fig. *a*, first and second true molars from below; *b*, ramus from external side; *c*, the same, internal side; *d*, the same from above. FIG. 15.—*Mioclænus turgidus* Cope, part of skull and lower jaw of one animal, two-thirds natural size. From the Puerco beds of New Mexico. Original, from Vol. III, Report U. S. Geol. Survey Terrs.

There are seven genera of the first division of the family. These may be distinguished into two sections. In one of these there are three well-developed anterior cusps of the inferior true molars, forming a tubercular sectorial tooth; in the other the anterior

[1] Enough is now known of the mammalian fauna of Madagascar to convince us of its decidedly Miocene and, to some degree, Eocene character. The lemurs and Centetidæ approximate nearly the Eocene types; the Chiromys is near the Eocene Tillodonta, while the closest allies of the carnivorous genus Cryptoprocta are found in the Lower Miocene of France and the Middle Miocene of Oregon. The Oligocene descendants of the Eocene types appear to have persisted in Madagascar. The reptiles are not African but are South American.

cusp is rudimental or wanting, and the tooth approximates more or less the quadrituberculate condition. In the latter subsection there are three genera. The first of these, Mioclænus Cope, has the inferior true molars quadrituberculate and of equal elevation; the first true molar may have an anterior or fifth tubercle. The external cusps of the superior true molars are distinct and conical. In Triisodon Cope, the inferior true molars only are known. These have four cusps with a rudimental anterior fifth. They differ from the corresponding cusps in all the other genera in being compressed so as to have fore and aft cutting edges. Diacodon Cope, is the third genus. Its superior molars are like those of Mioclænus, but the two anterior cusps of the lower true molars are much elevated, the posterior are rudimental, and there is a rudimental fifth in front.

Mioclænus presents the only truly quadritubercular lower molars in the suborder. It is so far known only from the Puerco or oldest Eocene of North America. There are nine species known

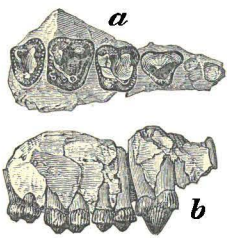


Fig. 16.

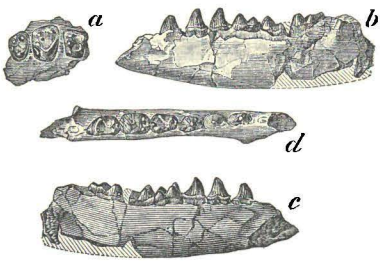


Fig. 17.

FIG. 16.—*Mioclænus corrugatus* Cope, last four molars on maxillary bone from below, two-thirds natural size. From the Puerco beds of New Mexico. Fig. *a*, from below; *b*, from right side. FIG. 17.—*Mioclænus subtrigonus* Cope, parts of maxillary and mandibular bones two-thirds natural size; from the Puerco beds of New Mexico; *a*, superior true molar teeth from below; *b*, left mandibular ramus, external side; *c*, do. inner side; *d*, from above. From Report U. S. Geol. Survey Terrs., Vol. III.

so far, which range from the size of a mink (*M. minimus*) to that of a wolf (*M. ferox*) in the sizes of their jaws, but in the case of the *M. ferox*, of which a good deal of the skeleton is known, the body was relatively smaller. The species differ in the form of the third superior premolar, and in the robustness of their inferior premolars. The *M. turgidus* (Fig. 15) represents the type with robust premolars, and the *M. subtrigonus* (Fig. 17) those with more compressed premolars.

We can read the nature of the primitive mammal, *Mioclænus terox*, in so far as the materials permit. It was an effective flesh-eater, and probably an eater of other things than flesh. It had a long tail and well-developed limbs. It had five toes all around, and the great or first toe was not opposable to the others, and may have been rudimental. The feet were plantigrade and the claws prehensile. The fore feet were well turned outwards. There were, perhaps, marsupial bones, but this point is not yet certainly determined. The presence of a patella distinguishes it from marsupials in general. Its embracing glenoid cavity of the skull, and form of the inferior molars, resemble those of the Arctocyonidæ.

This species is about the size of a sheep. The bones are stated by Mr. Baldwin, who discovered it, to be derived from the red beds in the upper part of the Puerco series.

The genus Triïsodon includes as yet but one species, the *T. quivirensis* Cope, which is only known from the rami of the lower jaw. These bones are shorter and more robust than those of the coyote, and indicate an animal of perhaps the size of the wolverine (Fig. 1, p. 257). It was evidently strongly carnivorous in its diet, and was a capable biter. Its remains are from the Puerco of New Mexico.

Diacodon includes seven species, two from the Wasatch Eocene, the others from the Puerco. The former are much the smaller (Fig. 18), while those of the Puerco vary in dimensions from the size of a common weasel (*D. assurgens*) to that of a wolf (*D. conidens*). The five species of the Puerco were formerly referred by me to the genus Triïsodon, but are now more properly placed in Diacodon. The only species in which the superior molars are known is the *D. conidens*, where they are generally identical with those of Mioclænus.

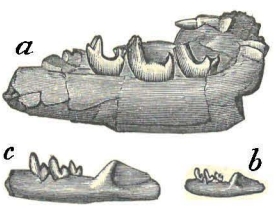


FIG. 18.—Jaws of species of Diacodon from the Wasatch bed of New Mexico. Fig. *a*, *Diacodon alticuspis* Cope, right mandibular ramus, inner side, twice natural size. Fig. *b*, *D. celatus*, left mandibular ramus, natural size; *c*, same, twice natural size. Original, from the Report U. S. G. G. Surv. W. of 100th mer., G. M. Wheeler.

Of the four genera of the first division of the Leptictidæ, which possesses tubercular sectorial teeth, but two are found in North America, while three of them have been discovered in Europe.

The typical and most widely distributed genus is Stypolophus

Cope (Fig. 13). It has compressed premolars, except the fourth superior, which is conic with two basal lobes. In Proviverra Rütimeyer, this tooth is triangular and cutting. One species has been found in the Swiss Eocene. Quercitherium of Filhol is distinguished by its very robust premolars. Like Proviverra it has but one rather small species. It is from the French Phosphorites. Stypolophus has the two cusps of the superior true molars close together, forming twin cusps, and they have behind them a heel, which is cutting. Two species have been discovered in the French Phosphorites, one of which, the *S. caylusi* of Filhol, is preserved to us in the most perfect skull of a Creodont known. From it I have restored the skull of the *S. whitiæ* (Fig. 13). It has elevated sagittal and posterior crests for the insertion of the temporal muscles, and the brain-case is very small. A cast of the brain displayed to Mr. Filhol the following characters: The hemispheres are small, and leave the cerebellum and the posterior edge of the middle brain uncovered. Anteriorly they contract to an isthmus which separates them from the large olfactory lobes. The hemispheres display three longitudinal convolutions, and very little indication of sylvian fissure. Of the American species, five are known from the Wasatch, and four from the Bridger beds.

Nearly allied to Stypolophus is the genus Didelphodus Cope, which only differs from it in the possession of but three superior premolars. The single species, *D. absarokæ* Cope, is about the size of a skunk, and has been obtained in the Wasatch Eocene beds of the Big Horn river, Wyoming (Fig. 19).

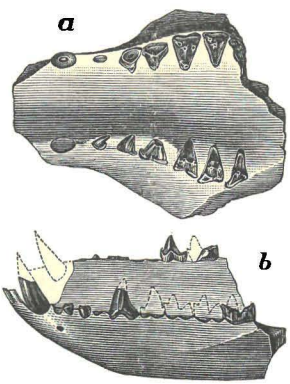


FIG. 19.— *Didelphodus absarokæ* Cope, muzzle and corresponding part of mandible of one individual, natural size. Original, from Vol. III, Report U. S. Geol. Surv. Terrs.

There are six genera of the second section of the family Leptictidæ, *i. e.*, those with the fourth inferior premolar more or less like the true molars. In five of these genera the canines and incisors have the proportions usual in carnivorous animals, but in the sixth, Esthonyx Cope, the canines are smaller than some of the incisors. In this respect Esthonyx esembles some of the genera of

Centetidæ, and other recent families both of Creodonta and Insectivora (Fig. 23). Of the genera with large canines, Chriacus has already been mentioned as having a simple fourth premolar with only an internal cusp to distinguish it from the genera of Sect. 1 of the family. Its true lower molars have an anterior V of three connected cusps. This is also the character of the inferior molars and fourth premolar of Deltatherium (Fig. 20), which is also peculiar in having but $\frac{3}{3}$ premolars, and a diastema. In the three genera which remain, the anterior or

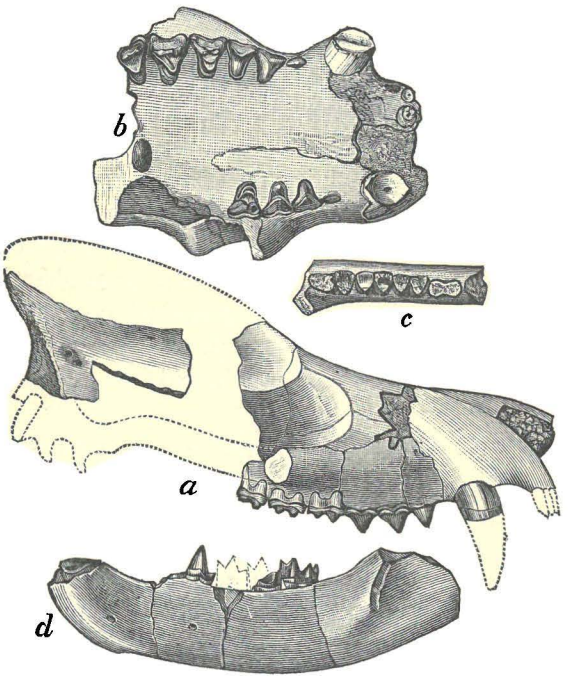


FIG. 20.—*Deltatherium fundaminis* Cope, skull and ramus mandibuli, two-thirds natural size, from the Puerco beds of New Mexico. Figs. *a b c* from one individual; Fig. *d* from a second animal. Fig. *a*, right side of cranium; *b*, palate, from below; *c*, mandible, part, from above; *d*, left ramus, outer side. From the Report U. S. Geol. Survey Terrs., Vol. III. Original.

fifth cusp of the true molars is rudimental. They differ from each other in the structure of the third superior premolar. In Ictops Leidy, this tooth has two external and one internal cusps; in Mesodectes Cope, there are one external and one internal cusps, and Leptictis Leidy, there is no internal cusp, and the external one is simple.

There are certainly three, and probably four, species of Chri-

acus The typical and largest species, *C. pelvidens* Cope, is from the Puerco Eocene of New Mexico; the smallest species, *C. angulatus* Cope, is from the Wasatch beds of New Mexico and Wyoming (Fig. 14). Perhaps it is near this genus that Tricentes Cope, should be placed. The latter only differs from Chriacus in the possession of but three superior premolars.[1] I have suspected that it belongs near Microsyops and Mixodectes in the Lemuroid series. There are three species, none larger than a skunk. The type, *T. crassicollidens*, is known from parts of two crania. The *T. inæquidens* was not larger than a gray squirrel.

The *Deltatherium fundaminis* Cope (Fig. 20), is one-half larger than the Virginian opossum, and much more robust. Its molar teeth are very opossum-like, while its canine teeth are relatively larger and stouter. The crowns of the canines are especially effective as weapons, from their vertical direction and form, their sharp anterior and posterior cutting edges, and their sides grooved like many blood-letting instruments. The sagittal crest is high, and the muzzle is short and wide, so that a decidedly bull-dog expression belonged to this animal. It is the most specialized form of the family and of the Puerco epoch, and was one of the most abundant. There are two other less known species of Deltatherium.

[1] See Proceeds. American Philosoph. Society, 1883, p. 315.

(*From the American Naturalist, May, 1884.*)

THE CREODONTA.

BY E. D. COPE.

(Continued from the April number, page 353.)

THE genus Ictops is found from the Bridger epoch up into the Oligocene or White River Miocene. It thus has much the range of the genus Hyænodon. There are three species, of which I give a cut (Fig. 21) of the *I. bicuspis* Cope, from the Wind River beds of

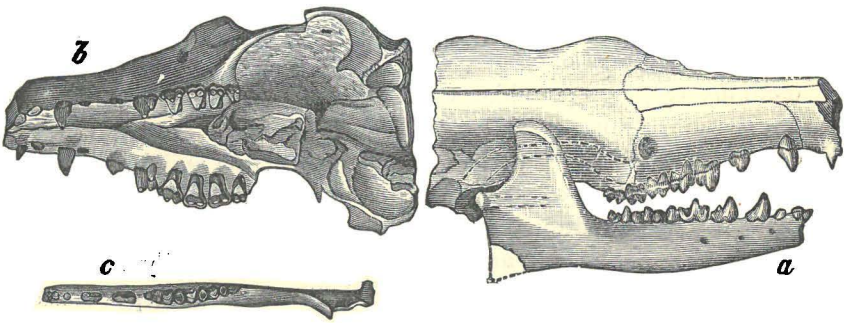


FIG. 21.—*Ictops bicuspis* Cope, skull, natural size. Fig. *a*, oblique view of right side; *b*, do. of inferior side, injured posteriorly; *c*, mandibular ramus from above. From the Wind River Eocene, Wyoming. Original, from Report of U. S. Geol. Survey Terrs., Vol. III.

Wyoming. In this form, as in Leptictis, the incisors and canines are spaced. The White River species is the *Ictops dakotensis* Leidy. But one species of Mesodectes is known, the *M. caniculus* Cope, from the White River beds of Northeastern Colorado I discovered a good deal of its skeleton, which furnishes an idea of its general characters. Its skull, like that of the *Leptictis haydeni* Leidy, possesses the marsupial character of a subsquamosal foramen (Fig. 22 *ss*), but the resemblance to this order includes besides only the dentition. There is a large keeled præsternum, stouter and shorter than that of a mole, suggesting a burrowing habit, but the humeri are not robust. The neck is very short, and the cervical vertebræ are without neural spines. The cerebral hemispheres of the brain leave the olfactory lobes and the cerebellum entirely exposed, and are wide and short. They are smooth, but the sylvian fissure is visible. This animal was about the size of the European hedgehog (*Erinaceus europæus*).

As yet but one species of Leptictis is known, the *L. haydeni*

Leidy (Fig. 22). This animal has been found in the White River beds of Nebraska. It is about the size of the *Mesodectes caniculus*. It resembles the gray fox of North America in the rib-like temporal ridges of its skull.

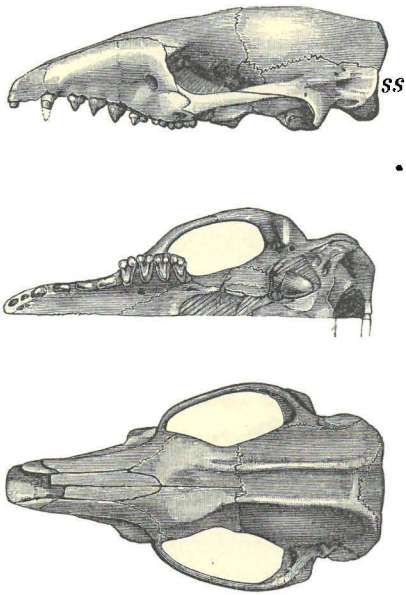


FIG. 22.—*Leptictis haydeni* Leidy, skull, natural size, from the White River beds of Nebraska. From Leidy, Extinct Mammalia of Dakota and Nebraska. *ss*, subsquamosal foramen.

The remarkable genus which I have called Esthonyx, is exceptional in the family in the large development of its second inferior incisors at the expense of the others. One or more of the superior incisors has been supplanted by the large development of the one that remains. The canines are moderately reduced, and the premolars are $\frac{3}{3}$ (Fig. 23). The last premolars of both jaws are more or less like true molars. The inferior true molars support two V's, of which the anterior is the more elevated. A good deal of the skeleton of the *E. burmeisteri* Cope, is known. Its distinct scaphoid and lunar bones are represented in Fig. 24 *b b'*. It had five digits in the manus. The cervical vertebræ are more robust than the dorsal, and the tail is long and large. The characters of this genus approximate it to the true hedgehogs (Erinaceus), and I formerly placed it in the same order. The tritubercular superior molars separate it widely. Nevertheless I suspect that it stands in ancestral relation to the Erinaceidæ.

I have described five species of this genus, of which two are from the Wasatch of New Mexico, two from the corresponding beds of Wyoming, and one, *E. spatularius*, from the Wind River bed of Wyoming. *E. acutidens*, of the Big Horn region, is the largest, equaling a red fox in the size of the skull. The skeleton of *E. burmeisteri* shows, however, that, as in other Creodonta, the

limbs are smaller in relation to the skull than in modern Carnivora. The least species is the *E. acer* of New Mexico.

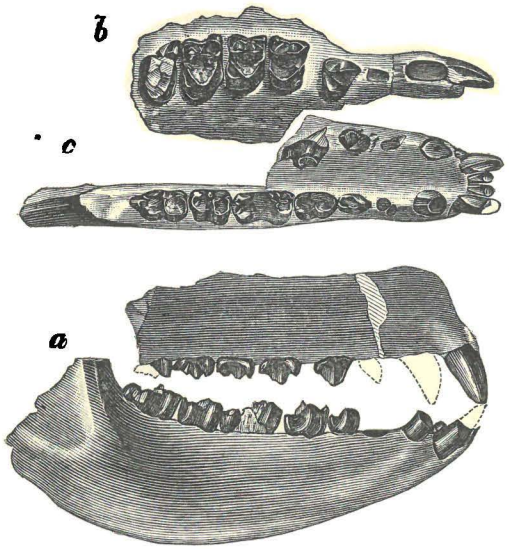


Fig. 23.

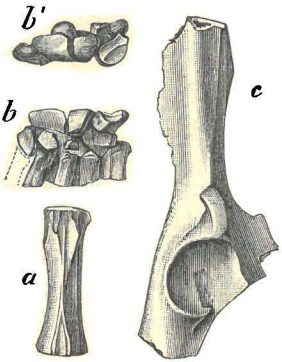


Fig. 24.

FIG. 23.—*Esthonyx burmeisteri* Cope, part of skull with lower jaw, from the Wasatch epoch of the Big Horn, Wyoming. two-thirds natural size; Fig. *a*, lateral view; *b*, inferior; *c*, superior views. The superior jaw consists of two pieces. FIG. 24, bones of specimen represented in Fig. 23, same proportions. Fig. *a*, caudal vertebra; *b*, carpus from front; *b'*, do. proximal view; *c*, part of innominatum, external view. Original, from the Report U. S. Geol. Survey Terrs., F. V. Hayden, Vol. III.

OXYÆNIDÆ.

The genera of this family are best explained by the following analytical table. The pertinence to it of the genus Thereutherium Filh., is not certain. The only genera which present the character of the narrow transverse third superior true molar, are Oxyæna and Pterodon.

I. Inferior molars with three anterior cusps.

Cusps obtuse; fourth premolar with tubercular heel; formula $\frac{3}{3}\ \frac{3}{3}$.....*Palæonyctis.*[1]
Cusps acute; heel of fourth premolar cutting; formula $\frac{3}{4}\ \frac{3}{2}$.....*Oxyæna*

II. Inferior molars partly tubercular-sectorial, partly sectorial.

Superior molars unknown.....*Protopsalis.*

[1] These characters are derived from an examination of the type of DeBlainville, preserved in the Mus. Jardin des Plantes, which the permission of Professor Gervais enabled me to make. Other characters of the fourth premolar, which I have hitherto copied from others, are inexact.

III. Inferior molars sectorial.

Last superior molars transverse; others with two median cusps; formula $\frac{3}{3}\ \frac{3}{3}$,
Pterodon.

Last superior molar subround; others with one median cusp; formula $\frac{3}{4}\ \frac{3}{2}$,
Thereutherium.

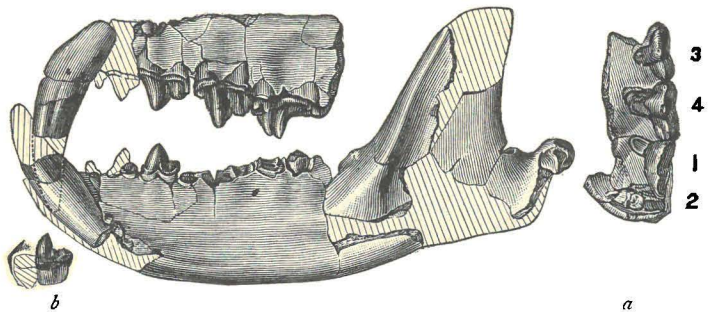


FIG. 25.—*Oxyæna lupina* Cope, jaws, one-half natural size, from the Wasatch beds of New Mexico. Fig. *a*, maxillary bone with teeth, from below; *b*, last superior molar, from behind. Original from the Report U. S. G. G. Survey W. of 100th mer., G. M. Wheeler.

Of the above genera Oxyæna and Protopsalis only are American. Thereutherium Filhol, includes a species, *P. thylacoides*, with a skull of the size of that of a skunk, which has been obtained from the Phosphorites of France. There are two species of Pterodon, both robust flesh-eaters. The *P. dasyuroides* of De Blainville is one of the longest known of the Creodonta. The *Palæonyctis gigantea* Blv., is found in the plastic clays near Paris. Its dentition approaches that of Amblyctonus.

The Oxyænas have the characteristic peculiarities of the Creodonta and of the carnivorous marsupials in their general proportions. The head was relatively larger, and the limbs were smaller than in true Carnivora. The feet were plantigrade, and had five toes anteriorly and posteriorly. The hind foot was either divided so that the external two toes opposed the internal three, or were divergent and connected by a median web. If not divided, the entire foot was directed outwards from the line of the calcaneum. In the latter case the hallux may have been opposable, as in the opossum, but in a much less degree. The tail was long and stout (Fig. 26).

Species of this genus were abundant during the Wasatch epoch in New Mexico and Wyoming, and probably over the entire continent. They have not yet been reported from higher Eocene beds, not even occurring in the Wind River. A small species is

found in the Puerco. A species (*O. galliæ*) has been recently detected in the Eocene of France by M. H. Filhol.

The dentition of the Oxyænas indicates sanguinary habits (Fig. 25). From the measurements, which are confirmed by more than one other skeleton, it can be seen that there is in the *Oxyæna forcipata* (Fig. 3, p. 260), a remarkable disproportion between the size of the skull and that of the limbs. While the dimensions of the jaws are like those of the jaguar, those of the limbs do not exceed those of the cheetah, while the digits are not only much shorter, as those of a plantigrade animal, but are more slender. The ungual phalange preserved, shows that the claws had no prehensile power, and were not effective as weapons or for digging. This is a further indication that the species of Oxyæna were aquatic in their habits.

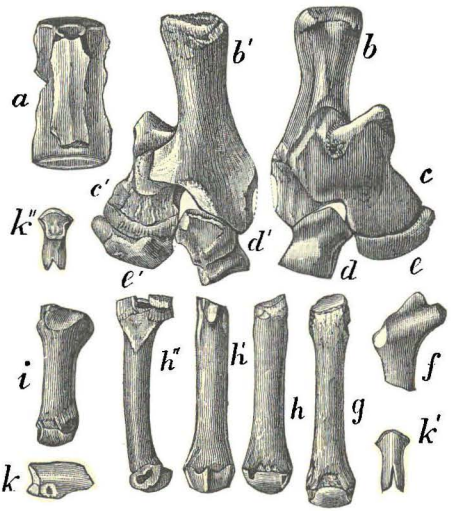


FIG. 26.— *Oxyæna forcipata* Cope, posterior foot and (*a*) caudal vertebra, two-thirds natural size. Figs *b*, calcaneum, *c*, astragalus; *d*, cuboid; *e*, navicular bone; from above; *b' c' d' e'*, the same from below. Figs. *f g h i*, metapodial bones; *k*, ungual phalange from above, right side and below. From the Wasatch beds of the Big Horn, Wyoming. Original, from the Report U. S. Geol. Survey Terrs., F. V. Hayden, Vol. III.

But one species of the genus Protopsalis is known, the *P. tigrinus* Cope, which shares with the *Mesonyx ossifragus* the distinction of being the largest of the Creodonta. It is from the Wind River beds, which possess a fauna mainly of Bridger character, but with an admixture of Wasatch forms.

The form of the sectorial tooth, together with that of the metatarsal, approximates this genus to the Felidæ more closely than to any other family of existing Carnivora. The resemblance seen in the sectorial (Fig. 27 *a*) is, however, probably delusive, as it is not the same tooth as the sectorial of the Carnivora. The resemblance in the metatarsal is real, as the characters are unlike those of Canidæ or Hyænidæ. The feet are evidently larger than in many of the Creodonta, as the proximal extremity of

the metatarsal is as large as that of a lion.

It is possible that the genus Patriofelis of Leidy belongs to this family, but its dental characters are not described with sufficient precision to enable this question to be decided. The inferior molar series is short, including, according to Leidy, only five teeth. The *P. ulta* Leidy, has a jaw the size of the puma. It is from the Bridger beds of Wyoming.

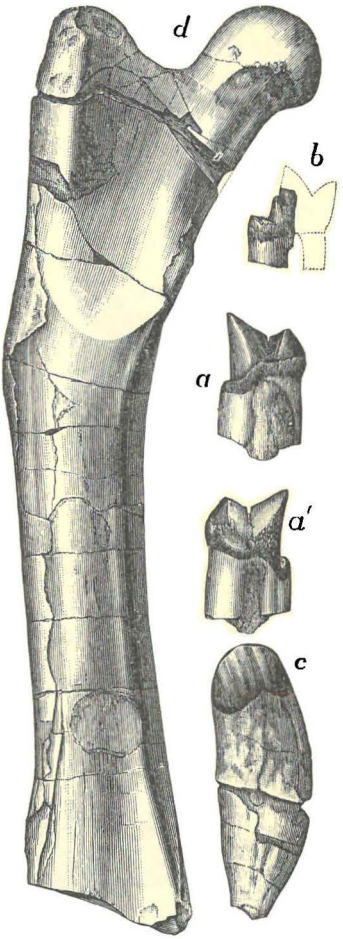


FIG. 27.—*Protopsalis tigrinus* Cope, one-half nat. size. Fig. *a*, probably last inferior molar, innerside; *a'*, external side; *b*, penultimate inferior molar, inner side; *c*, inferior canine, external side; *d*, femur, anterior view. From the Wind river of Wyoming. Original, from Report U. S. G. Survey Terrs., III.

MIACIDÆ.

In this family we have the point of nearest approximation of the Creodonta and Carnivora. This is indicated by the fact that the sectorials of this family are true sectorials, both by position and form, such as are not elsewhere met with in the Creodonta. The genera might readily be taken for members of the Canidæ and Viverridæ, but for the structure of the astragalus, which is thoroughly Creodont. There is no trochlear groove of the tibial face, and in Didymictis it is so oblique that the internal malleolar face looks partly upwards. There are two genera known, Miacis Cope, with two inferior tubercular molars, and Didymictis Cope, with but one.

Five species of Miacis have been described, two of which are from the Wasatch and three from the Bridger beds. The former are distinguished from the latter by the larger size of the second tubercular molar, which has two roots. The later species, of which the type *M. parvivorus* Cope, is one, have but one such

root. None of the species exceeded the gray fox in size, and the Bridger species at present known, are much smaller.

Didymictis has a greater range in time than Miacis. Eight species have been described, two of which are from the Puerco horizon and six from the Wasatch. The genus is probably represented by other species in the Bridger. There are three divisions of the genus. In the first the premolars are not lobed on their posterior margins; here belong *D. primus* and *D. haydeni-*

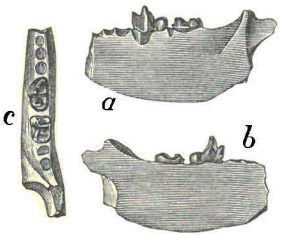


Fig. 28.

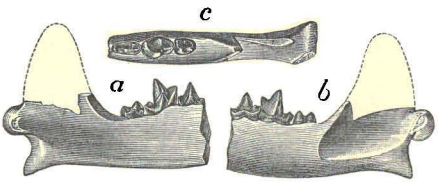


Fig. 29.

FIG. 28.—*Miacis brevirostris* Cope, left mandibular ramus, two-thirds natural size. Fig. *a*, left side; *b*, inner side; *c*, from above. From the Wasatch beds of the Big Horn. FIG. 29.—*Didymictis massetericus* Cope, left mandibular ramus, two-thirds natural size, from the Big Horn river, Wyoming. Fig. *a*, inner side; *b*, external side; *c*, superior view. Original, from the Report U. S. Geol. Survey Terrs., Vol. III.

anus (Fig. 30) of the Puerco. The others have the lobes in question, but two of them, *D. curtus* Cope, and *D. massetericus* Cope

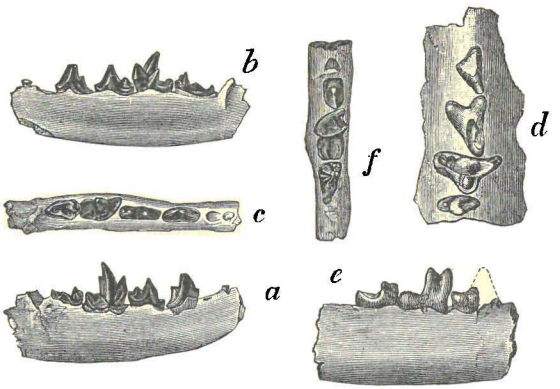


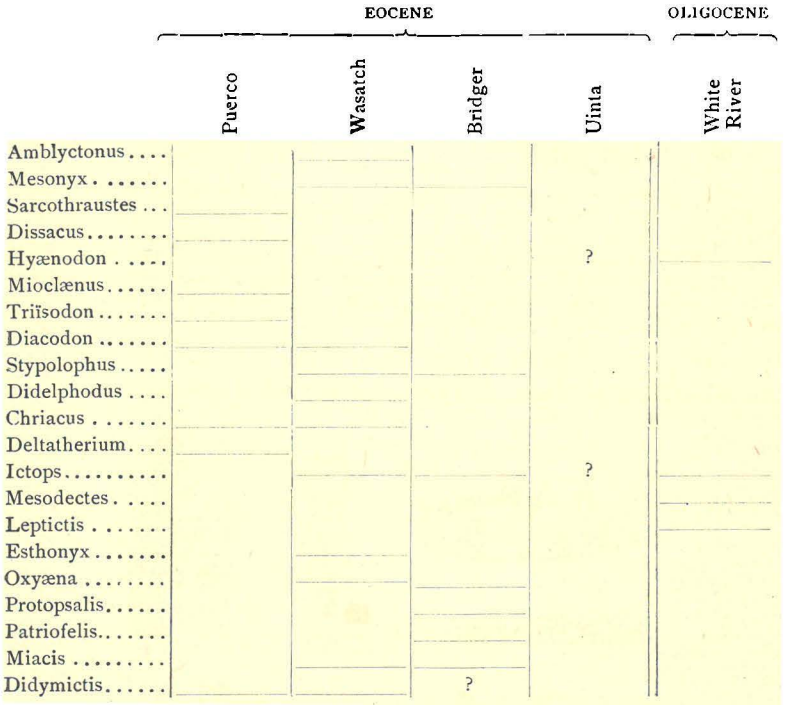
Fig. 30.

FIG. 30.—*Didymictis dawkinsianus* Cope, natural size; from the Wasatch beds of the Big Horn, Wyoming. Fig. *a*, external side; *b*, internal side; *c*, from above. Figs. *d*, *e*, *f*, *Didymictis haydenianus* Cope, jaws natural size, from the Puerco formation of New Mexico. Fig. *d*, maxillary bone with teeth, from below; *e*, left ramus mandibuli, inner side; *f*, do., from above. All original, and from the Report U. S. Geol. Survey, Terrs., F. V. Hayden in charge, Vol. III.

(Fig. 29), have a short subcircular tubercular molar, while that of

the other species is an elongate oval. The tendency in the genus has been to complicate the premolars and shorten the tubercular in the course of time. The smallest species is the *D. dawkinsianus* (Fig. 30), from both the Big Horn and Wind River beds, an abundant and acute-toothed species. The largest species is the *D. altidens* Cope, whose jaws are more robust than those of the coyote.

I append the following table showing the distribution of the genera of Creodonta in the North American Tertiary formations:



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