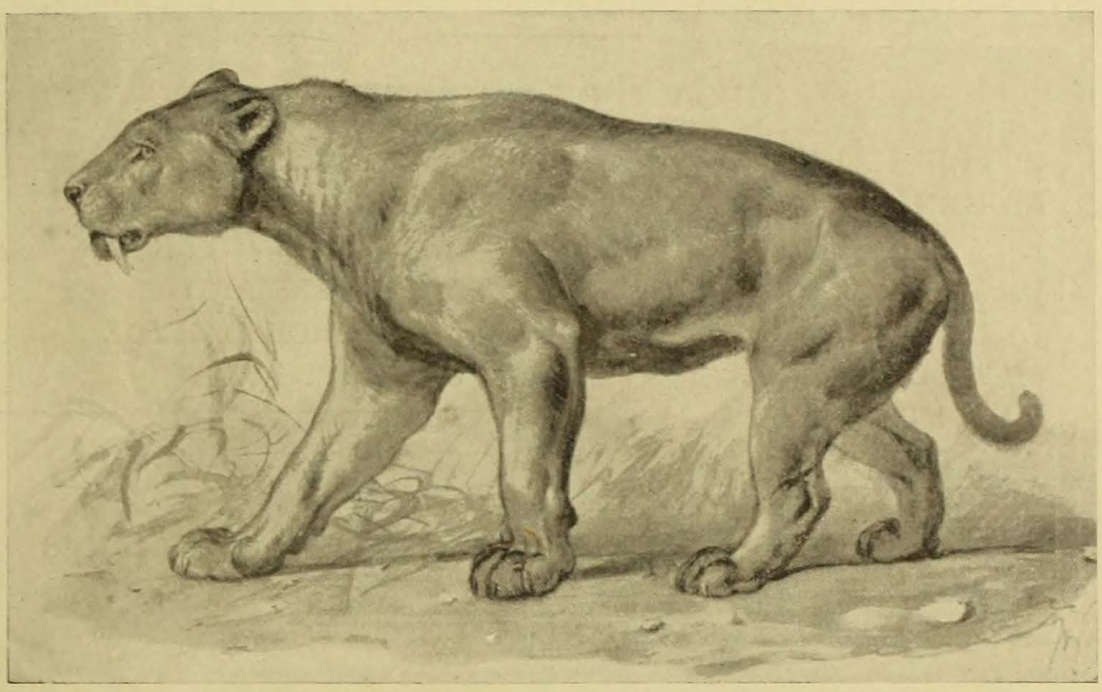
AMERICAN MUSEUM OF NATURAL HISTORY

The Fossil Carnivores

Marsupials and Small Mammals

in the

American Museum of Natural History



BY

W. D. Matthew, Ph.D.

Associate Curator of Vertebrate Palæontology

REPRINTED FROM THE AMERICAN MUSEUM JOURNAL
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Guide Leaflet No. 17

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THE AMERICAN MUSEUM OF NATURAL HISTORY was established in 1869 to promote the Natural Sciences and to diffuse a general knowledge of them among the people, and it is in cordial coöperation with all similar institutions throughout the world. The Museum authorities are dependent upon private subscriptions and the dues from members for procuring needed additions to the collections and for carrying on explorations in America and other parts of the world.

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Annual Members.....	$ 10	Fellows.....	$ 500
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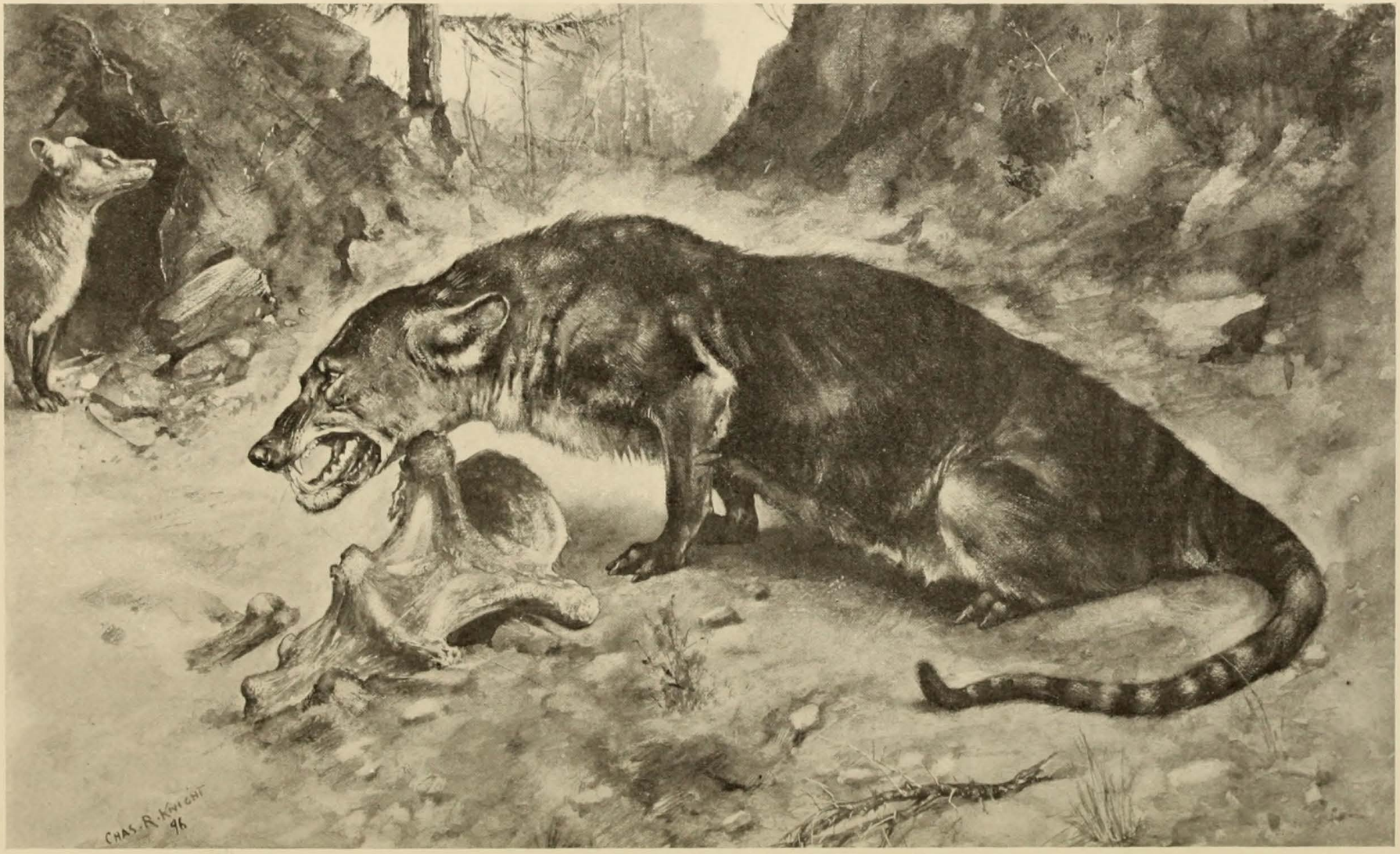

FIG. 1. RESTORATION OF MESONYX, A GIGANTIC CREODONT. UPPER EOCENE OF UTAH. BY CHARLES R. KNIGHT. AFTER OSBORN

The Fossil Carnivores Marsupials and Small Mammals in the American Museum of Natural History.

A Guide Leaflet to the Collections

in the

Department of Vertebrate Palæontology.

By

W. D. MATTHEW, Ph.D.,

ASSOCIATE CURATOR OF VERTEBRATE PALÆONTOLOGY.

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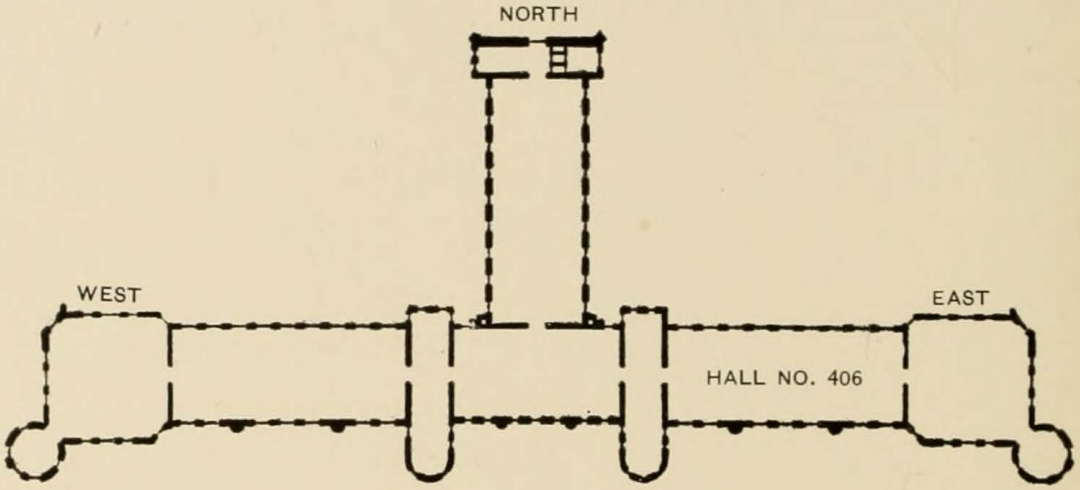

FOURTH FLOOR.

The Collections of Carnivores, Marsupials and Small Mammals upon which this Guide Leaflet is based are exhibited in the northwest quarter of Hall No. 406 of the East Wing, fourth floor of the Museum.

PREFATORY NOTE.

THE collections in the Hall of Fossil Mammals were gathered together under direction of Professor Henry Fairfield Osborn, Curator of the Department, Vice-President and Trustee of the Museum. They are chiefly the result of expeditions to the various Rocky Mountain States, where the richest localities for such specimens are found. These explorations, the funds for which are provided by the generosity of the Trustees of the Museum, have been systematically carried on since 1891. The Cope Collection of Fossil Mammals, purchased in 1894, and various exchange collections from foreign museums, are also exhibited in this hall.

Besides the general guide to the Collection of Fossil Vertebrates, re-issued in October, 1903, a series of special guides, each covering one or more important zoölogical groups, is in course of preparation. These treat of the evolution of each race of animals, and the various problems and theories that are illustrated by the specimens in the hall, more fully than could be done in the general guide.

The present number treats of the Fossil Carnivores, or Flesh-eating Mammals, the Marsupials, or Pouched Mammals, the Rodents, Insectivores, Bats and others, which may be grouped together as Small Mammals. This is the second special guide: the first, treating of the Evolution of the Horse, was published in 1902. Others shortly to appear are on the Titanotheres, the Elephants and the Dinosaurs.

EDITOR.

FOSSIL CARNIVORES, MARSUPIALS AND SMALL MAMMALS

IN THE

AMERICAN MUSEUM OF NATURAL HISTORY.[1]

By W. D. Matthew, Ph.D.

Associate Curator of Vertebrate Palæontology.

I. CARNIVORA.

The Carnivora live principally on the flesh of other animals and have teeth and claws adapted to such food. Most of them, however, eke out their proper food, in times of scarcity, or for mere variety, with berries, nuts, bulbs and roots or even with grass, and some, at certain seasons, find little else available. Carnivores have large canine teeth adapted for cutting or for cutting and chewing, but never for grinding. All of them have claws, and they use their feet in a more varied way than do the Herbivora, for seizing and striking as well as for running and jumping. They walk either upon the entire sole of the foot (bears) or upon the under surface of the toes (dogs, cats etc.), never upon the tips of the toes as do the hoofed animals

There are three divisions:

A, CREODONTA, OR PRIMITIVE CARNIVORA. Extinct land Carnivora with various primitive characters. None now extant.

B, FISSIPEDIA, OR TRUE CARNIVORA. Toes separate; terrestrial or amphibious; preying on land animals. Modern beasts of prey.

C, PINNIPEDIA, OR MARINE CARNIVORA. Web-footed, marine, fish-eating. Seals and Walruses.

Fossil land Carnivora are more numerous and varied than modern kinds. More than 250 fossil species have been described from the United States alone, while but 94 living species are recognized in this country. The majority of the fossil species

[1] This article forms No. 17 of the Museum series of GUIDE LEAFLETS and may be obtained in separate form.

fall into one or another of the living families and are more or less directly ancestral to the modern beasts of prey. The remainder belong to several extinct branches, not ancestral to any of the modern families, and are combined in the rather heterogeneous group of Creodonta. Seals and Walruses have not been found fossil, except in the most recent deposits, and nothing is known of their evolution.

A. CREODONTA, OR PRIMITIVE CARNIVORA.

In all modern Carnivora one tooth in the upper and one in the lower jaw are enlarged and especially adapted to the cutting of flesh. Each consists mainly of a high strong crest, or ridge,

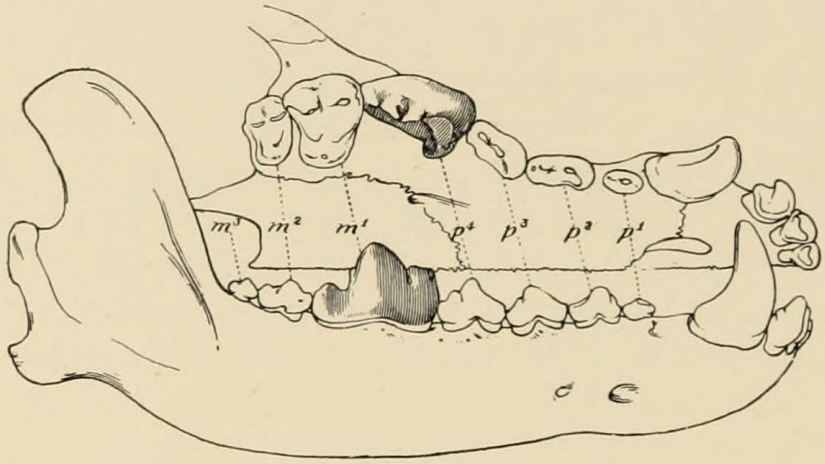

FIG. 2. UPPER AND LOWER TEETH OF THE WOLF
Shows the carnassials or flesh-cutting teeth (the fourth premolar in the upper jaw, the first true molar in the lower)

and the two crests, or "blades," work against each other like the blades of a pair of scissors. These teeth are called the "carnassials," or flesh-teeth. In all the modern Carnivora the fourth (last) upper premolar and the first lower true molar are the carnassial teeth. The fossil species show the gradual evolution of this specialized tooth in the various families of Carnivores. In the Creodonta, on the other hand, there is either no carnassial tooth, or it is developed from other teeth of the series,—in one group the first upper and second lower true molars, in another the second upper and third lower molars. (Compare Figures 2, 3, 4 and 5.)

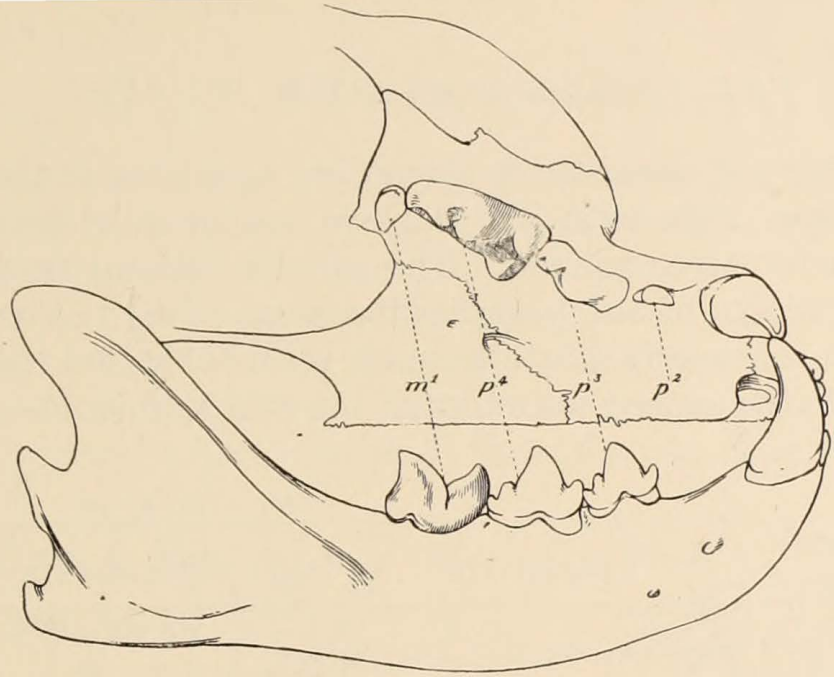

FIG. 3. UPPER AND LOWER TEETH OF THE LION
Shows the carnassials corresponding to those in the Wolf

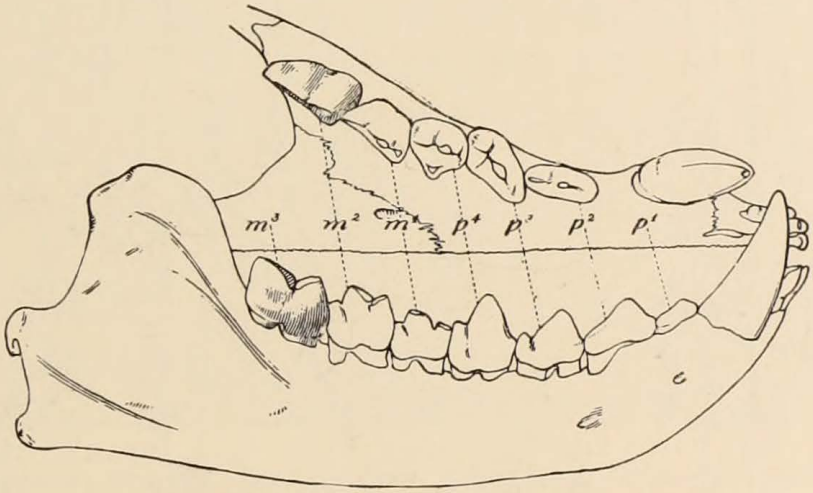

FIG. 4. UPPER AND LOWER TEETH OF HYÆNODON
Shows the carnassial teeth (second upper and third lower molar)

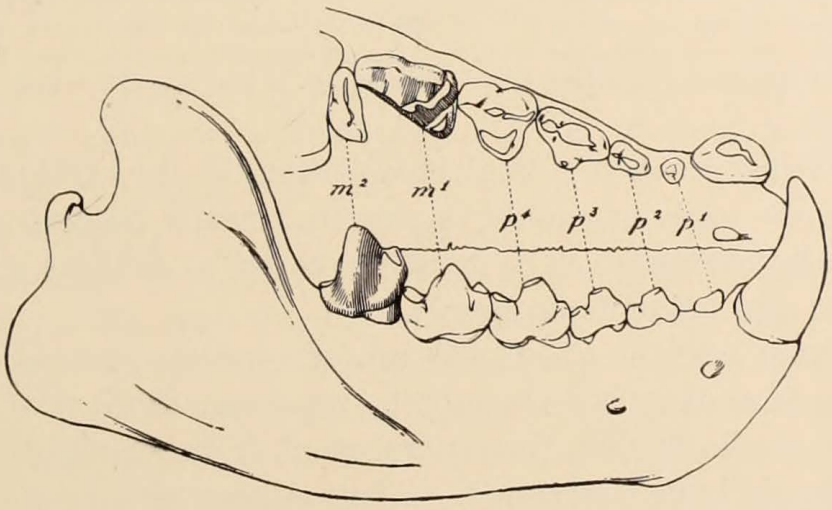

FIG 5. UPPER AND LOWER TEETH OF OXYÆNA
Shows the carnassial teeth (first upper and second lower molar)

Another characteristic of all modern Carnivora is the union of two bones of the wrist, the scaphoid and lunar, which are distinct in most other animals. This gives additional strength to the thumb side of the very flexible wrist. In the Creodonts, these two bones were separate, and it is probable that they were separate in the earliest ancestors of the true Carnivores. Many

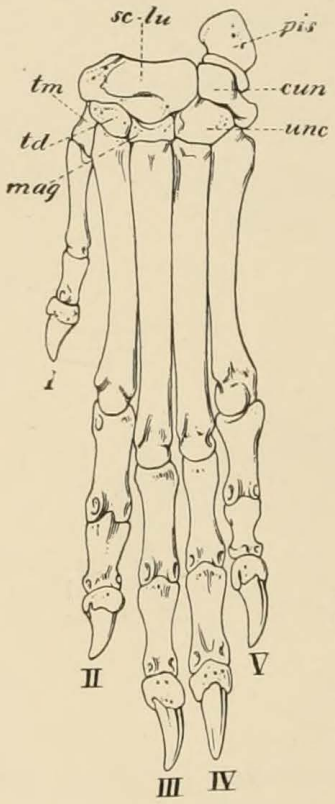

FIG. 6. FORE-FOOT OF THE WOLF

Shows the compact, slender foot, and the scaphoid and lunar bones of the wrist united (*sc-lu*) as in all true Carnivora

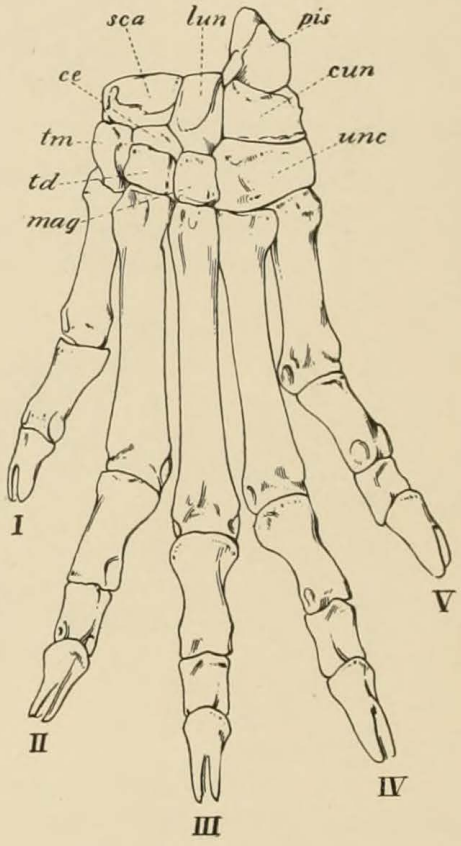

FIG. 7. FORE-FOOT OF HYÆNODON

Shows the shorter and less compact foot, and the separate scaphoid, centrale and lunar bones in the wrist (*sca*, *ce*, *lun*) as in all Creodonta

Creodonts also preserve a small extra bone, the "centrale," which is found now only in monkeys and in certain Insectivora and other small mammals. This bone seems to have been generally present in the ancient mammals.

The most ancient Creodonts are of especial interest to students, because they are thought to represent more nearly than any other fossils known, the central stock from which most modern mammals have descended. They appear already numerous

and varied, at the dawn of the Age of Mammals, and the different kinds become more and more specialized throughout the Eocene epoch. Meanwhile the true Carnivores appear in increasing numbers and gradually crowd out the Creodonts until the last of them has disappeared by the end of the Oligocene epoch. In their evolution the different Creodont groups specialized on much the same lines of development as those the true Carnivores took

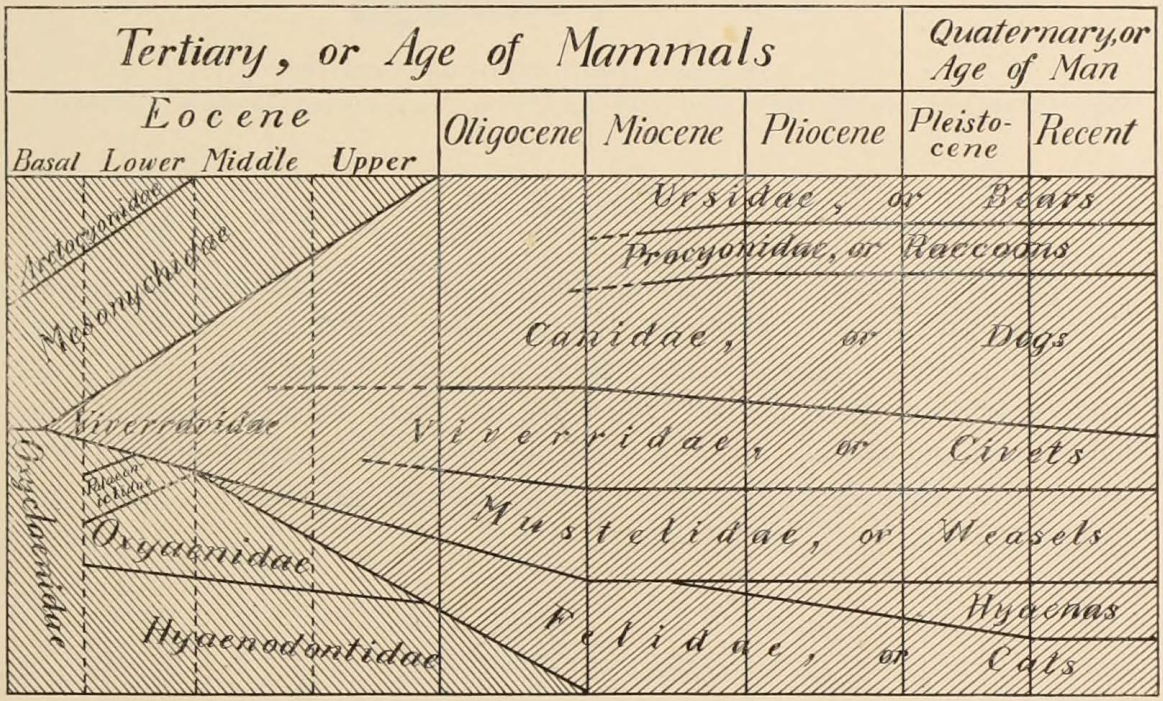

Diagram showing how the true Carnivora crowded out the Creodonta or Primitive Carnivora during the Tertiary Period.

Creodonta. *True Carnivora.*

FIG. 8

afterwards. They were more or less wolf-like, weasel-like, cat-like or bear-like, according to the nature of their food and the manner of attacking their prey.

Fossil remains of flesh-eating animals are by no means as common as those of Herbivora, and the remains of Creodonts are especially rare, and mostly fragmentary. The great majority have been found in the Eocene fossil fields of the Western United States. This Museum is peculiarly rich in these rare and interesting fossils. Out of the 113 American species it possesses all the known specimens of 50 and the types or other good

specimens of 48 others (including three complete mounted skeletons), while only 15 species are not represented.

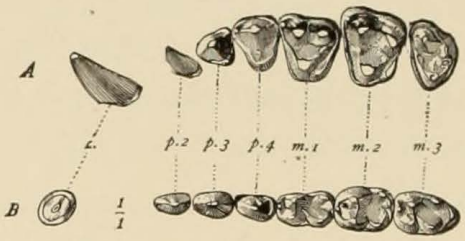

FIG. 9. UPPER AND LOWER TEETH OF TRICENTES

Represents the most primitive type of teeth of the Carnivora, with no specialized carnassials. Natural size

Oxyclænidæ.

Types: *Chriacus*, *Tricentes*, *Deltatherium*. Upper and lower jaws.

Small primitive animals with unspecialized teeth resembling those of lemurs. Only fragmentary specimens have been found, and but little is known about them. They are the most ancient group of the Creodonts and appear to have been nearest to the central stock from which the other Creodonts and Carnivores are descended. They are found only in the Basal Eocene.

Arctocyonidæ.

Types: *Arctocyon*, skull (cast); *Clænodon*, jaws and feet; *Anacodon*, jaws.

Bear-like omnivorous Creodonts with sharp canine teeth and the crowns of the molars flattened and wrinkled on the surface. The animal walked on the entire sole of the foot, and had large sharp claws like the modern bears. As in all these ancient mammals the brain was very small, as can be seen in the skull of *Arctocyon*.

Palæonictidæ.

Palæonictis, front of skull and jaws.

This rare and primitive group of Creodonts is thought by some authors to be the remote ancestor of the Cat family. It is found only in the Lower Eocene.

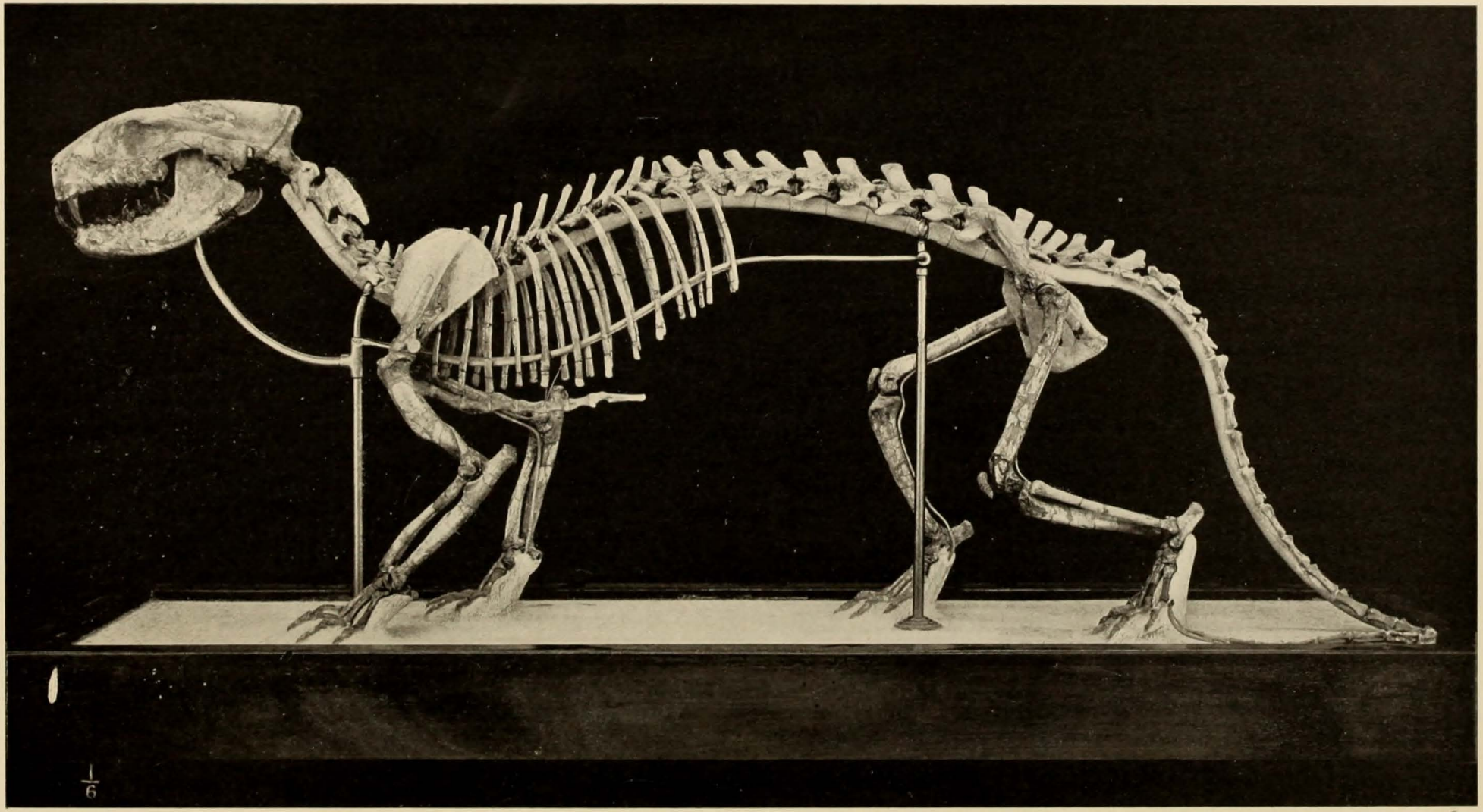

FIG. 10. MOUNTED SKELETON OF OXYÆNA LUPINA, AN ANCIENT TYPE OF CREODONT FROM THE LOWER EOCENE OF WYOMING

One-sixth natural size. After Wortman

Oxyænidæ.

Types: *Oxyæna* and *Patriofelis*, skeletons.

Somewhat resembling the larger Mustelines, such as the Otter and the Wolverine, with short heavy jaws adapted to seize and hold their prey, with long body and with short powerful limbs adapted for leaping, climbing or swimming, but not for swift running. The tail was extraordinarily long, and was larger than in any of the modern Carnivora. The teeth were adapted for flesh-eating, the first upper and second lower molar being enlarged and specialized for cutting the flesh. (See Fig. 5.)

Oxyæna, from the Lower Eocene, was about as large as a Wolverine. The head is disproportionately large, and the tail as long as the entire body and head. The brain-case is very small, and the space for jaw-muscles very large, the whole organization much inferior to that of modern flesh-eaters. Powerful and savage it no doubt was, but far from having the keen intelligence, speed and endurance of the Carnivora of to-day.

The mounted skeleton of this rare animal is due to a fortunate accident. In the Cope Collection there was an incomplete and fragmentary skeleton collected in 1881 in Northern Wyoming by Dr. J. L. Wortman. In 1891 Dr. Wortman, while collecting for this Museum in the same region, discovered another fragmentary skeleton, also incomplete. After the purchase of the Cope Collection by the Museum, these two specimens were compared and found to be parts of the same individual, together constituting a nearly complete skeleton, which has been mounted and placed on exhibition, with the missing parts restored in tinted plaster.

In *Oxyæna* the last upper molar has disappeared, and the second possesses a large shearing blade placed transversely to that of the first molar. In *Patriofelis* of the Middle Eocene the second molar has become very small, and all the flesh-cutting is done by the first molar, shearing against the second lower molar. The teeth are therefore a stage farther advanced in specialization.

The *Patriofelis* skeleton is composed of two individuals of the same species which were found at the same horizon and locality. The animal was about as large as a jaguar, and massively pro-

portioned, with short heavy limbs and broad blunt-clawed feet. It has been thought that *Patriofelis* was of aquatic habits, and more or less nearly ancestral to the Seals; but it was more probably terrestrial, as its teeth indicate adaptation to flesh food, not to fish eating. The limbs and face most nearly resemble those of the short-legged Mustelines, otter, mink etc., among modern animals, and some of these are aquatic or semi-aquatic; but this resemblance may be merely because in both animals the limbs are short and heavy.

HYÆNODONTIDÆ.

Types: *Sinopa*, skull and other parts; *Hyænodon*, skeleton and skulls.

Two groups of animals are included in this family, one represented by *Sinopa*, small long-bodied weasel-like animals with teeth little specialized, suggesting those of the Opossum, the other by *Hyænodon*, which was larger, proportioned more like the Tasmanian Wolf, with teeth highly specialized for flesh-cutting. The first group was probably arboreal, the second terrestrial in habit.

In *Sinopa*, which was characteristic of the Eocene, the crowns of the molars are triangular and each has a longitudinal shearing edge in front and one transverse. In *Hyænodon* of the Oligocene the transverse shear has disappeared completely, the longitudinal shear is concentrated especially on the third lower and second upper molar, the third upper molar has disappeared, and the teeth are as highly specialized for flesh-cutting as those of the living Cats. (See Fig. 3.)

Hyænodon lived during the Oligocene epoch and was the last survivor of the Creodonts. In proportions it singularly resembles the Thylacine, or Tasmanian Wolf, of the rough bush-land of Tasmania. The head is of very large size, with long jaws and large teeth, adapted to snapping rather than seizing and holding on to the prey. The feet had large, rather blunt claws, not retractile, and the animal appears to have walked on the toes, like the dogs and cats, not resting the sole on the ground as do the bears. (See Fig. 6.) A finely preserved skeleton and several skulls from the Big Badlands of South Dakota are mounted in the collection. The largest skull is nearly a foot long.

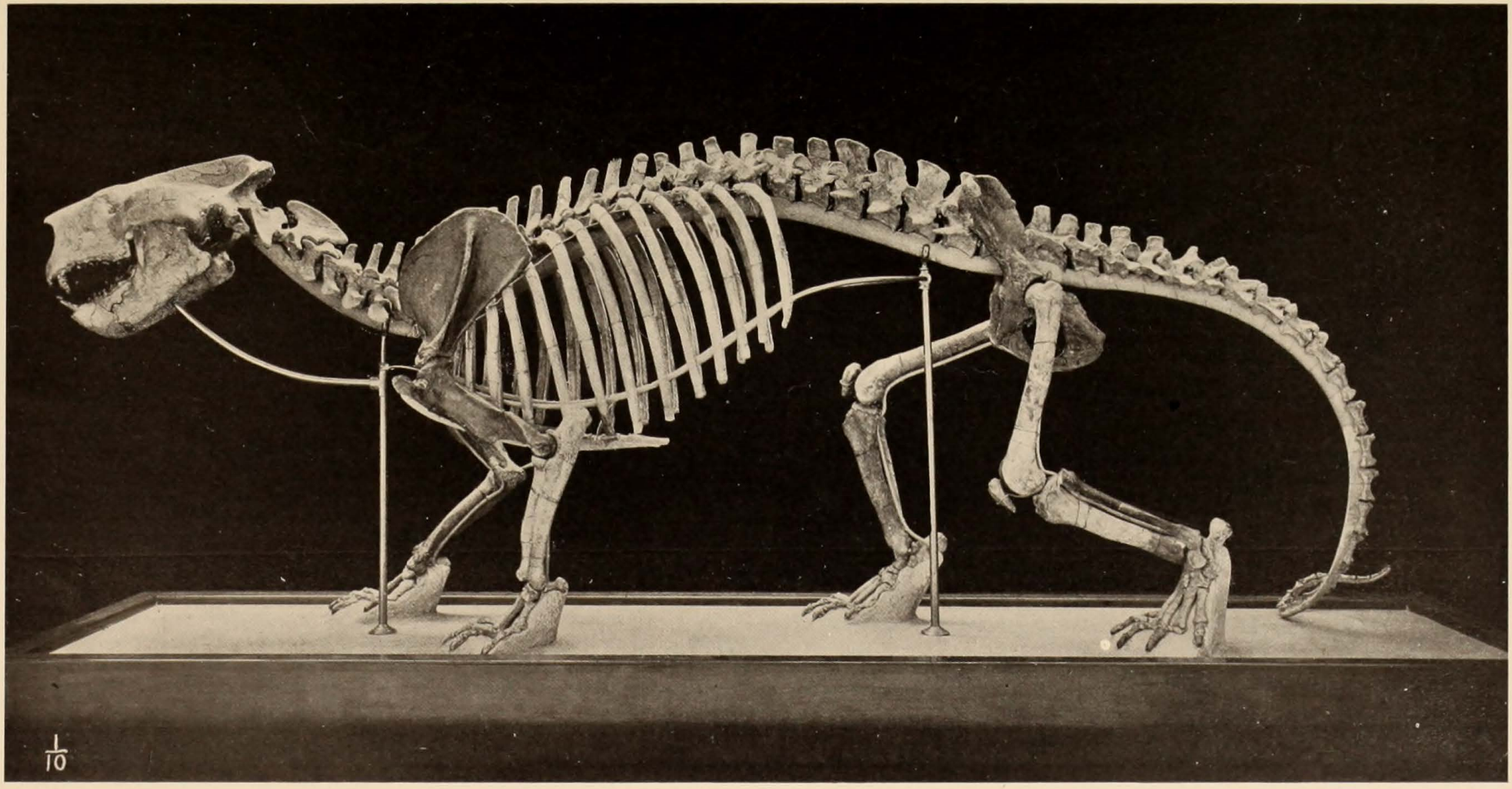

FIG. 11. MOUNTED SKELETON OF PATRIOFELIS FEROX, A CREODONT FROM THE MIDDLE EOCENE OF WYOMING

One-tenth natural size. After Osborn

MESONYCHIDÆ.

Type: *Mesonyx*, skull etc, Wall-case No. 6.

These animals had the limbs and feet specialized for swift running, and the feet tipped with flat hoof-like claws. The teeth are quite peculiar, they have no shearing edges, and the crown is composed of three rather high blunt-topped conical cusps. In

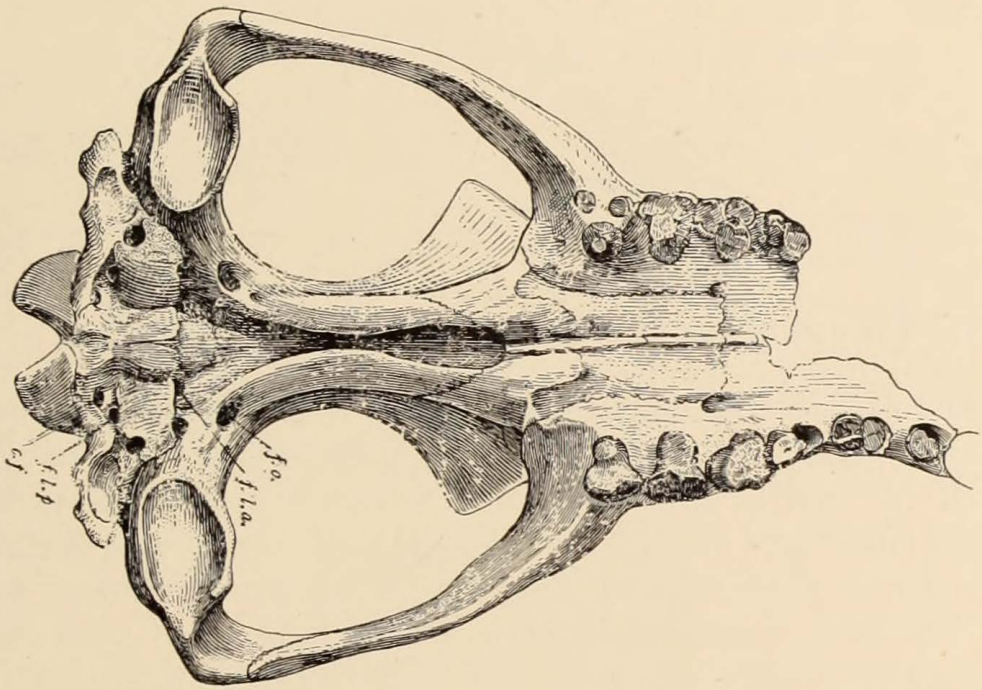

FIG. 12. SKULL OF MESONYX

Upper Eocene of Utah. After Osborn

the upper jaw these are in a triangle, one cusp inside, two outside; in the lower jaw they are in series, the central one being much the highest.

The Mesonychidæ are found in all the Eocene strata from the oldest to the youngest, and show a series illustrating the gradual evolution of their peculiar type of tooth. The massive blunt-cusped teeth, generally very much worn, suggest that they were used for crushing bones or other hard food, and that the animal fed upon carrion, like the modern hyæna. (See Fig. 1.)

B. FISSIPEDIA, OR TRUE CARNIVORA.

There are seven [1] families of living Carnivora, four of which are cosmopolitan, being found in all the continents except Australia, while one (the Raccoons) is peculiar to America, and two (the Civets and the Hyænas) are peculiar to the Old World. The families are:

1. URSIDÆ, or Bears (Black Bear, Grizzly, Polar Bear etc.).
2. PROCYONIDÆ, or Raccoons (Raccoon and some rarer animals).
3. CANIDÆ, or Dogs (Wolves, Foxes, Jackals).
4. VIVERRIDÆ, or Civets (Civet, Mongoose etc.).
5. MUSTELIDÆ, or Mustelines (Weasel, Otter, Badger, Skunk etc.).
6. FELIDÆ, or Cats (Lion, Tiger, Leopard, Puma, Lynx etc.).
7. HYÆNIDÆ, or Hyænas.

The predaceous animals of Australia and the islands near to it are all Marsupials, or Pouched Mammals, except a wild Dog which was probably introduced by man. The range of the families of true Carnivora in former geological epochs was the same as now, except that South America had no true Carnivores until the Pliocene epoch, their place being taken by carnivorous Marsupials related to those which still inhabit Australia. In general the fossil true Carnivores are placed without difficulty in one or another of the families still surviving; but the earliest known ancestors of all these families were so much alike that it is hardly possible to say in which family they should be placed, and they are conveniently grouped together under the name of VIVERRAVIDÆ, or Ancient Civets, as the Civets among all the modern Carnivores are least altered from the primitive stock. As time went on these primitive Carnivora became more clearly differentiated, so that in the Miocene epoch all the modern families are easily distinguishable. (See Fig. 8.)

[1] Besides these seven families there are a few rare and peculiar Carnivora which are placed in families by themselves, but these are of no geological importance and need not be considered here.

Ursidæ, or Bears.

The Ursidæ, or Bears, are the largest living Carnivora, and are not exceeded in size by any one of the extinct forms. They are less strictly carnivorous than most of the others, since they live in large part upon berries, nuts, roots and other vegetable food. The Polar Bear is an exception, feeding entirely upon animal food, fish and seals. Skulls of two extinct bears are shown in the collection, the Californian and European Cave-Bears.

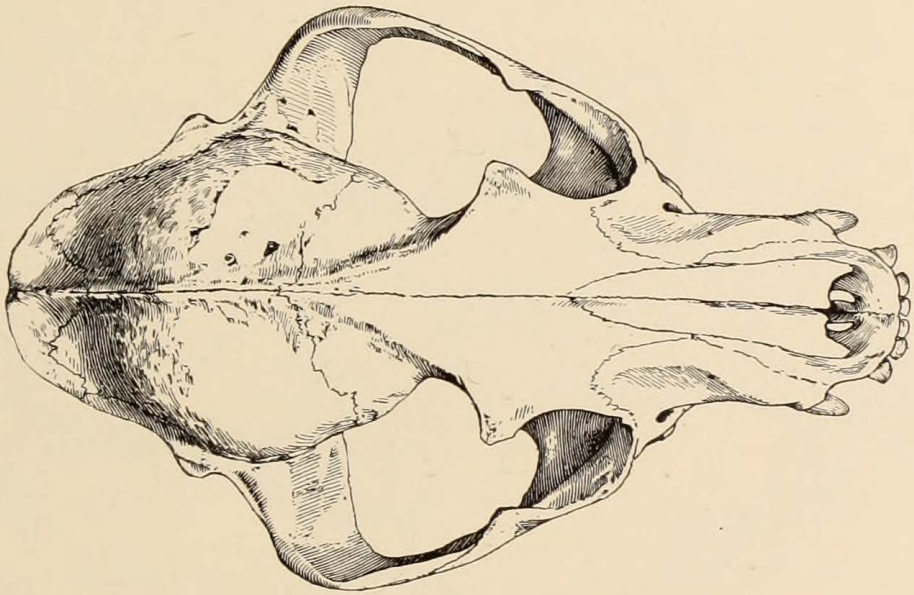

FIG. 13. TOP VIEW OF SKULL OF PHLAOCYON
A link between raccoons and primitive dogs. Lower Miocene of Colorado. Natural size

These get their name from the fact that their remains are chiefly found in caves, where they hibernated, probably, during the cold season, as do modern bears.

Procyonidæ, or Raccoons.

The Procyonidæ are found only in North and South America, with the exception of the Panda of India, which is doubtfully referred to this family. Fossil raccoons very much like the living species are found in the Pleistocene strata of various parts of the United States, and in cave deposits. In the Oligocene and Miocene epochs lived two more primitive genera which

illustrate the evolution of these animals from the primitive civet-like Carnivora of the Eocene epoch. The Miocene stage, *Leptarctus*, is very little known; only a lower jaw and an upper tooth have been found. Of the Oligocene stage, *Phlaocyon*, a nearly complete skeleton was found in 1898, of which the skull, jaws, limbs and feet are on exhibition. This unique specimen is one of the best preserved fossil Carnivores in the collection. It is intermediate between the civet-like ancestors of the dogs (*Daphœnus* and *Cynodictis*) and the modern raccoons. The

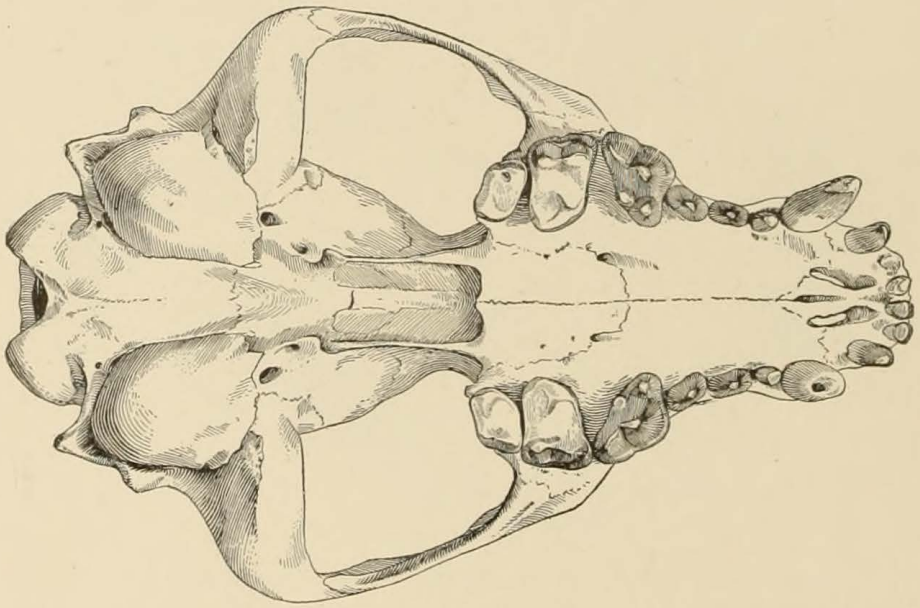

FIG. 14. UNDER SIDE OF SKULL OF PHLAOCYON

A link between raccoons and primitive dogs. Lower Miocene of Colorado. Natural size

shape of the skull is raccoon-like, but the number of teeth is the same as in the dogs, while their form is intermediate between the two types. The limbs and feet are also intermediate. It is probable, therefore, that the Dogs and Raccoons are derived from a common ancestral stock. Specimens found in Europe indicate that the Bears are likewise derived from this common stock, and that the three families have diverged, the Dogs becoming terrestrial flesh-eaters, living largely in open country, the Bears omnivorous and living in the woods, the Raccoons omnivorous and arboreal.

Canidæ, or Dogs.

The living species of Canidæ—Wolves, Coyotes, Foxes—are found only in the most recent deposits (Pleistocene). A great variety of extinct species is known, some of which are the ancestors of modern forms, while others belong to side branches which have not survived. Most remarkable of these side branches were the Amphicyons or Bear-like Dogs, some of which were of huge size, equalling the modern Polar Bear—see skull and backbone of *Dinocyon* in wall-case No. 8. A large series of skulls of vari-

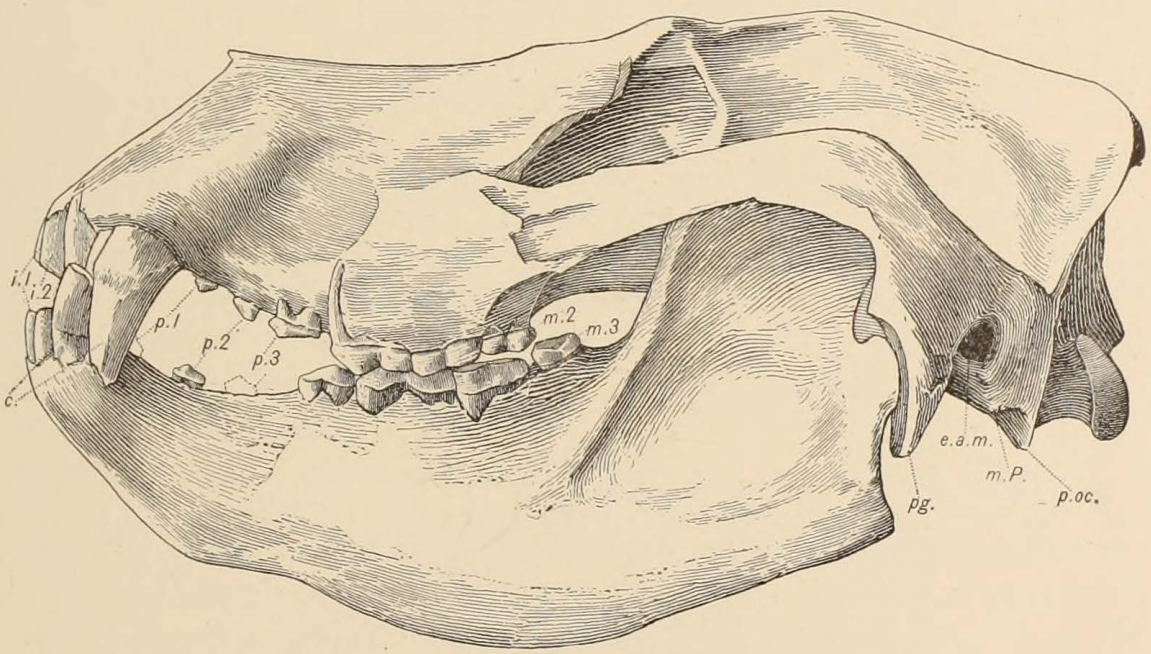

FIG. 15. SKULL OF DINOCYON
A gigantic extinct dog from the Upper Miocene of Texas. One-fourth natural size

ous extinct Dogs of the Oligocene and Miocene epochs is shown in the table-case. These indicate the evolution of the modern species from animals much more like the Civets in proportions and in the character of their teeth. It has been possible to trace out the probable direct lineage of at least two of the modern dogs, the Dhole of India, and certain South American foxes, through these North American fossil species. Other fossil species belong to races of Canids now extinct.

The increase in brain capacity from ancient to modern animals is well shown in this series of skulls. All ancient Dogs had small brains of inferior organization to their modern descendants.

Viverravidæ.

Type: *Viverravus*, skull etc. Table-case.

The Viverravidæ resemble the modern Civets more nearly than any other modern Carnivora. They differ from them in fact in various primitive characters not very noticeable. The brain-case is much smaller in proportion; the scaphoid and lunar bones are sometimes not united; but the form and number of the teeth and proportions of the body were not different from those of modern Civets, except that the skull was larger and the limbs were shorter. They were probably the ancestors of the modern Carnivora, except the Cat family. (See Fig 8.)

Viverridæ, or Civets.

A few specimens of fossil Civets from Europe are shown in the collection. They are not found fossil in America, but it is probable that they are descended, without much change in character, from the Viverravidæ shown in the opposite side of the same table-case.

Mustelidæ, or Mustelines.

Types: *Bunœlurus*, *Plesictis*, *Mustela*, *Conepatus*, skulls.

The Mustelines are mostly small or of medium size, savage and blood-thirsty, solitary and forest-loving or aquatic. The Otters are aquatic and live mainly on fish; the Badgers are burrowing animals, and live mainly on burrowing rodents etc.; the Martens, Ferrets and Skunks are arboreal and terrestrial.

These different kinds of Mustelines seem to have separated as early as the Oligocene epoch, for even then we find Martens, Skunks and Otters distinguishable. But they were much more alike then than now, and all of them have many characters linking them with the Civets, indicating that the two families had a common origin. Compare the difference in teeth between *Bunœlurus* and *Potamotherium* with the difference between their modern descendants the Marten and the Otter; also compare the *Bunœlurus* teeth and skull with those of a civet. Note also the comparatively small brains of the Oligocene Mustelines as *Bunœlurus* and *Plesictis*. Their Miocene descendants (*e. g.*, *Mustela ogygia*

skull) had larger brain capacity, and the modern forms still larger and better-developed brains. This indicates that slow but steady

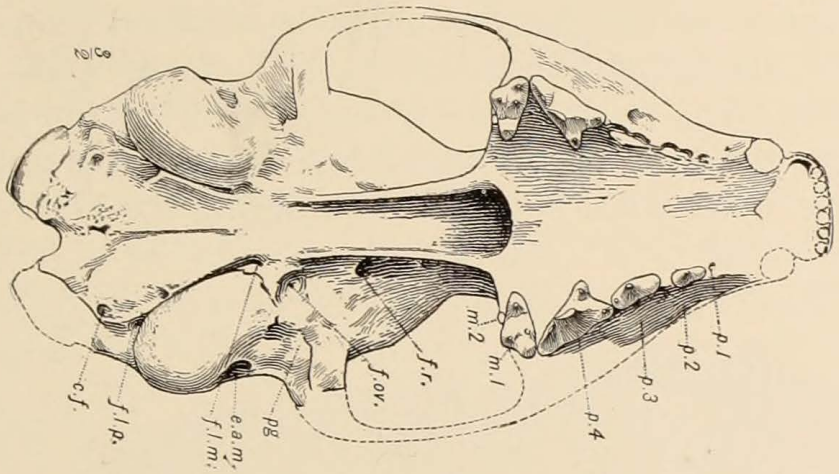

FIG. 16. SKULL OF THE PRIMITIVE MUSTELINE BUNÆLURUS

Oligocene of Colorado. Three-halves natural size. Viewed from the under side to show the teeth

increase in intelligence which has occurred in almost all the lines of evolution among quadrupeds. *Superiority of brain is the final test by which, in the long run, the persistence of a race is decided.*

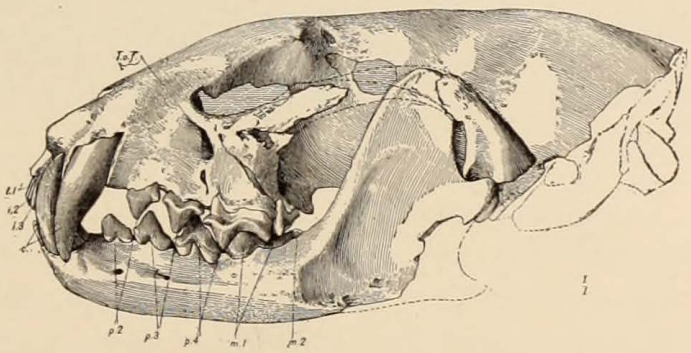

FIG. 17. SKULL OF MUSTELA OGYGIA

An extinct species of marten, from the Middle Miocene of Colorado. Side view, natural size

FELIDÆ, OR CATS.

(Sabre-Tooth Tigers)

Types: the mounted skeletons of *Smilodon* and *Hoplophoneus*, skeleton of *Dinictis* in block, skulls of *Hoplophoneus*, *Dinictis*, *Archælurus*.

Almost all the fossil Cats belong to a division now extinct, in which the upper canine teeth were enlarged into great curving, flattened, sharp-edged tusks, sometimes seven inches long.

Smilodon of the Pleistocene epoch was as large as a polar bear, and exceedingly muscular, especially in the great massive fore-limbs. The claws in the mounted skeleton (upright case) are larger than the largest lion claws. One of the great tusks is complete, the other was broken off during the lifetime of the

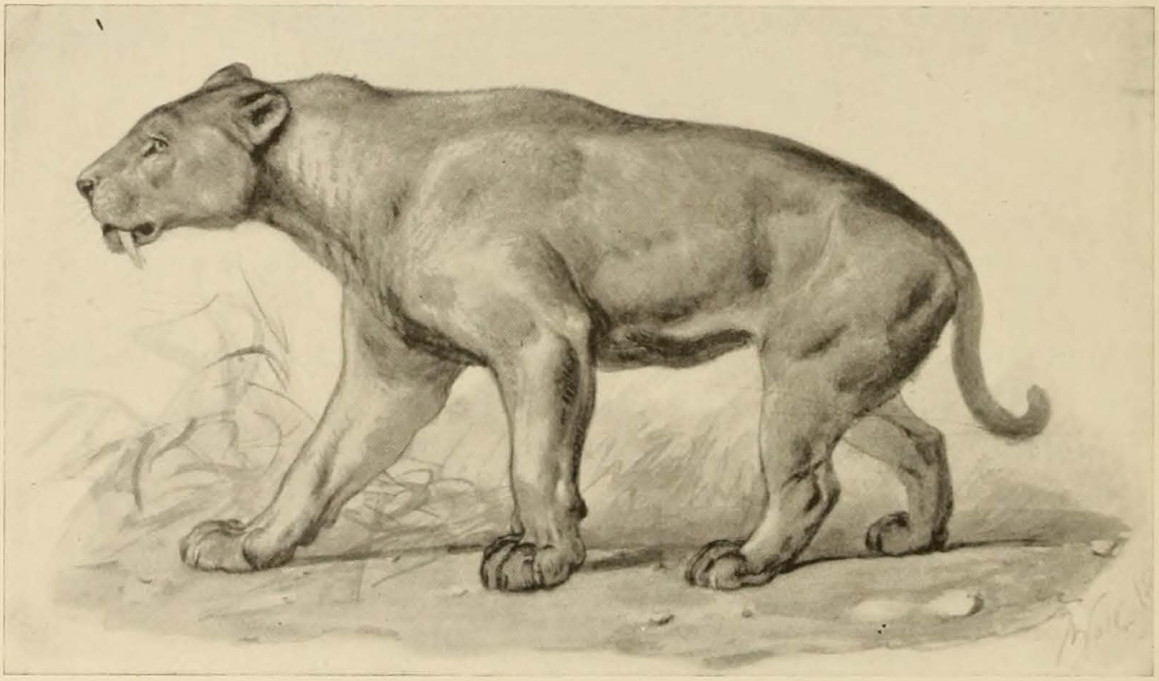

FIG. 18. THE GREAT SARBE-TOOTH TIGER, SMILODON
Pleistocene of South America. Restoration by Wolff. Courtesy of Dr. Elliott

animal, for the stump shows evidence of considerable wear after it was broken. This skeleton was found near Buenos Aires in Argentina along with the remains of gigantic ground-sloths (*Megatherium*) and tortoise-armadillos (*Glyptodon*) which may well have been the prey of this most terrible of all the Carnivora. But the Smilodons ranged all over the New World, and like the nearly allied *Machœrodus*, which was distributed over all the northern continents, were contemporaries of primitive man. Whether our palæolithic ancestors ventured to contend with this gigantic foe, we do not know, but the structure of its skeleton indicates that, although more powerful than the lion and the

tiger, it was not nearly so active and intelligent, and that it was fitted to prey upon the slow-moving giant pachyderms of the Quaternary rather than upon active, alert and intelligent animals, least of all perhaps upon man. In the extinction of the Sabre-Tooth Tiger we may rather regret the passing away of a singular and magnificent type of the beasts of prey than rejoice over the disappearance of a dangerous enemy to the human race.

The ancestral Sabre-Tooth Tigers of the older geological epochs were smaller and less specialized. The skeleton of *Hoplophoneus* illustrates their general character and size. This is the most perfect specimen in the collection, every bone being present, and all, with a few unimportant exceptions, complete and perfectly preserved. *Hoplophoneus* was proportioned somewhat like a leopard, but with shorter smaller limbs and very short spreading feet. *Dinictis* had longer limbs, but the teeth were less specialized. *Archælurus* and *Nimravus* were more primitive types, linking the Sabre-Tooth with the ancestors of the true Cats.

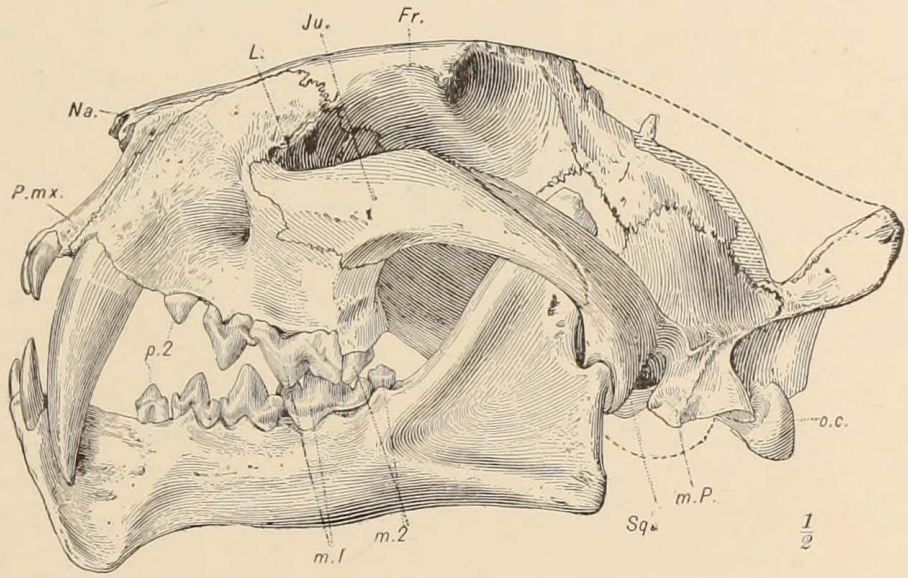

FIG. 19. SKULL AND LOWER JAW OF DINICTIS
Primitive Sabre-Tooth Tiger from the Oligocene of Colorado. One-half natural size

Habits of the Sabre-Tooth Tigers. The modern great Cats kill their prey usually by biting it in the neck so as to break the spinal column. They pursue as a rule the long-necked, thin-skinned

ruminants, which are the most abundant herbivores of to-day, seldom molesting the short-necked, thick-skinned pachyderms such as the rhinoceros and the elephant. The Sabre-Tooth appears to have used his great canine fangs in a quite different method of attack; the whole structure of the animal indicates that he struck them forcibly into the side of his prey, the mouth gaping wide meanwhile, and then presumably withdrew them with a ripping, tearing stroke, leaving a great gash whereby a

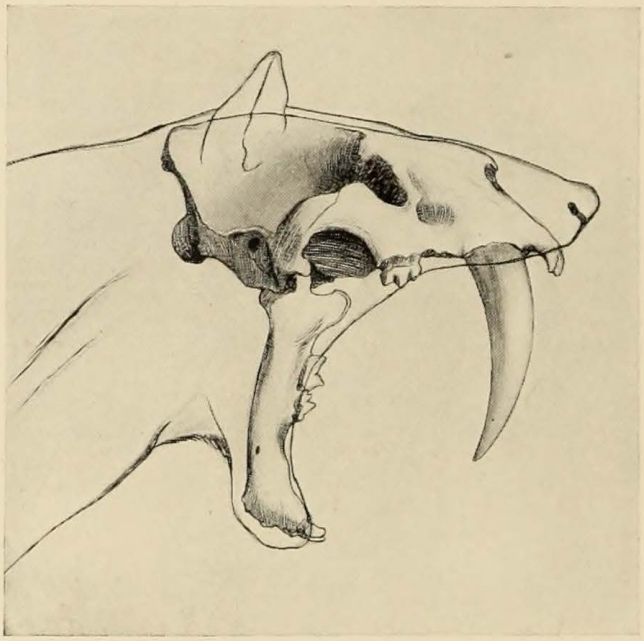

FIG. 20. THE HEAD OF SMILODON. OUTLINE RESTORATION
To show the widely gaping jaw. By Chas. R. Knight

large animal would soon bleed to death. By this method he would be peculiarly fitted to attack the great pachyderms, with which his exceptional muscular strength especially fitted him to cope while his lack of speed and agility would render him much less dangerous to the swift-footed ruminants and horses of the time. We may infer therefore that, while the true Cats were evolved to prey upon the larger swift running quadrupeds and developed speed and agility to catch their prey, the Sabre-Tooth was evolved to prey upon the powerful and massive contingent of the Herbivora, and developed enormous muscular strength and peculiar weapons of attack to cope with these animals.

The true Cats are not common as fossils, and our collections

contain only a few fragmentary specimens. They can be traced back as far as the Oligocene epoch, without any great change in character, but their earlier history is a blank. It appears probable that they are derived along with the Sabre-Tooth Tigers from some undiscovered group of Creodonts more nearly related to *Palæonictis* than to any other known fossil type.

Hyænidæ, or Hyænas.

Fossil Hyænas are common in the cave deposits of the Old World, but none have been found in this country. In the older formations of Europe there has been found a series of extinct forms which appear to connect the Hyænas with primitive Civets (*Ictitherium*, *Palhyæna*). These are not represented in our collections.

C. PINNIPEDIA, OR SEALS.

This group of Carnivora is exclusively adapted to marine life. They are found fossil in sediments of marine origin, but are very rare, and nothing is known of their evolution. They are almost unrepresented in our collections. An incomplete skull of an extinct species of Walrus found near Atlantic City, N. J., shows that the range of this animal formerly extended much farther south than now.

II. CHIROPTERA, OR BATS.

The Bats are the only mammals capable of true flight, although there are certain kinds of squirrels, marsupials and the so-called "flying lemurs," which can extend portions of the skin into a sort of parachute to assist them in taking long leaps from bough to bough. The wings of Bats are chiefly an extension of the skin membrane between the fingers, which are greatly elongated; those of birds on the contrary are chiefly composed of feathers which grow from the whole length of the arm and hand, although mainly from the second digit of the hand.

Fossil remains of Bats are exceedingly rare except in cave deposits, and do not teach us much about the evolution of this singular group of mammals. They resemble the Insectivora more than any other

order in teeth and skull, but we know practically nothing of when or how the great wing-membranes were developed, except that they must have been of very ancient origin, for in the Oligocene epoch this feature was as fully formed as now. A few fragmentary jaws and wing bones are shown in the collection.

III. INSECTIVORA.

Hedgehogs, Moles, Shrews etc. Table-case.

Small mammals of rather inferior organization with claws on the toes five digits on each foot, simple teeth with sharp cusps on the crowns and no gnawing teeth.

The Insectivora are an order of animals defeated and disappearing in the struggle for existence, owing to the superior

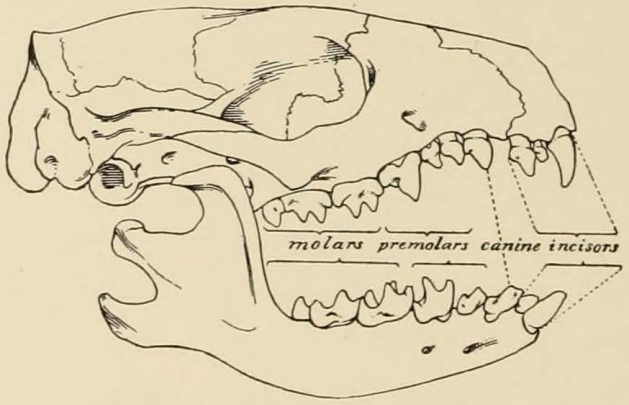

FIG. 21. SKULL OF THE HEDGEHOG.
A surviving type of the insectivora. Natural size

intelligence or better adaptation of their competitors. To escape utter destruction they have been forced into one or another peculiar mode of existence or method of defense, or have been driven to take refuge in the remoter corners of continents or in oceanic islands, where competition is less severe. The Hedgehogs have survived by virtue of their stout and efficient prickly coat, which deters almost any carnivorous animal from meddling with them. The Moles have taken refuge in the earth, where their rivals are few, and they are out of reach of most enemies. The Shrews are partly protected by their unpleasant odor, partly by their small size, nocturnal habits and burrowing or otherwise

concealing themselves. The other Insectivora are inhabitants of the larger tropical islands—Cuba, Madagascar and some East Indian islands—or of South Africa, but have disappeared from the great northern continents, Europe, Asia and North America, where the struggle for existence has been most severe and where all the higher types of mammals have been evolved.

The Insectivora are a very ancient order of mammals, and in past geological periods they were of more importance than now; in fact they have been considered by many scientists as representing more nearly than any other living order the primitive central group from which all other mammals have descended. Through the "Age of Mammals" they progressed less than most other orders and several families of them became extinct during that time, while the Moles and Shrews diverged from nearly similar habits to their present peculiarities, and the Hedgehogs, probably, acquired their coat of spines.

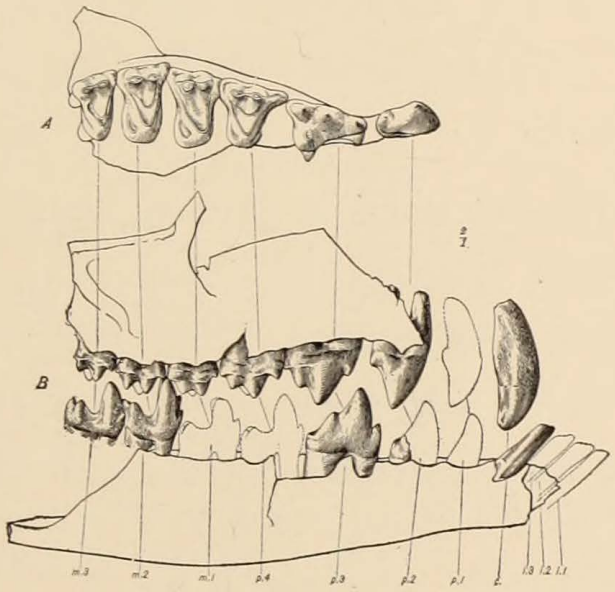

FIG. 22. ICTOPS ACUTIDENS
Upper and lower teeth, showing the "tritubercular" molars. Oligocene Epoch, Montana. Twice natural size

LEPTICTIDÆ, OR PRIMITIVE HEDGEHOGS. Extinct.

Tritubercular molar teeth. Two incisors in upper dentition. Premolars unreduced, the last one molariform. Tibia and fibula fused, ulna and radius separate. Size and proportions like the modern

Hedgehog, skull long and pointed. Eocene and Oligocene epochs, North America.

A series of skulls of these little animals is shown in the table case. They differ from the true Hedgehogs in many archaic characters and there is no reason to suppose that they wore a prickly coat. The "tritubercular" teeth are a primitive characteristic.

ERINACEIDÆ, OR HEDGEHOGS. Living.

Quadritubercular molar teeth. Three incisors in upper dentition. Premolars often small, sometimes reduced in number, the last one molariform. Tibia and fibula united, ulna and radius separate. Skull rather short in the Hedgehog, long and pointed in certain allied East Indian animals. Oligocene to Recent epochs, Europe and America.

Part of the skull of a true Hedgehog of an extinct genus, *Proterix*, from the Oligocene of South Dakota, is shown in the table case, besides jaws of the Miocene genus *Galerix* from Europe.

TUPAJIDÆ, OR TREE-SHREWS.

Living. Borneo.

MACROSCELIDÆ, OR JUMPING-SHREWS.

Living. Africa.

SORICIDÆ, OR SHREWS.

Living. Europe, Asia, northern Africa and North America.

Incisors and premolars reduced in number, the incisors forming a pair of sharp-pointed pincers, molars quadritubercular. No zygomatic arch. Oligocene to Recent. Europe and North America.

More than half of the species of living Insectivora come under this family, but all are of small size, mostly nocturnal, hiding in burrows or beneath leaves or roots during the day. They feed on insects, for which purpose the pincer-like incisors and the sharp little cusps of the molar teeth are well adapted. Fossil Shrews are found in the Oligocene and later formations of both Europe and North America, but only fragmentary remains have been discovered. A few are on exhibition.

Talpidæ, or Moles.

Living. Europe, Asia, northern Africa and North America. Eocene to Recent in Europe and North America.

Completely subterranean; fossorial or burrowing. Incisors not pincer-like. A zygomatic arch present. Fore-limb very short and powerful, specialized for digging.

A small skull of a primitive Mole, *Proscalops*, from the Miocene of Colorado is on exhibition. It is Shrew-like in several respects, showing an approach between the now distinct families of Moles and Shrews. Other fragmentary remains of Moles are shown.

Potamogalidæ.

Living. Madagascar and West Africa. Aquatic animals with long eel-like tails.

Solenodontidæ.

Living. Cuba and Hayti.

Centetidæ.

Living. Madagascar.

Fossil species supposed to be related to these animals are found in the Eocene (*Centetodon*) and Lower Oligocene (*Microp-*

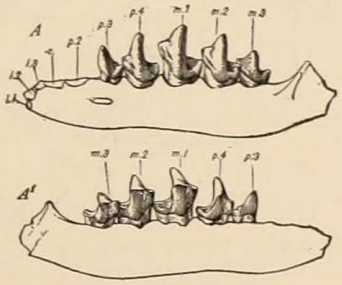

FIG. 23. MICROPTERNODUS BOREALIS

A small and primitive extinct insectivore. Lower jaw, inner and outer view, twice natural size. Oligocene Epoch, Montana

ternodus) of North America. This and the following family are more primitive than any other mammalia in the construction of their teeth.

CHRYSOCHLORIDÆ.

Living. South Africa.

These are known as Cape Golden Moles and take the place of the true Moles in South Africa. A fossil species has been found in the Miocene of Patagonia, indicating that they formerly inhabited both southern continents.

ADAPISORICIDÆ.

Extinct. Lower Eocene. France. Imperfectly known.

DIMYLIDÆ.

Extinct. Lower Miocene. Europe.

Only two molars in upper and lower jaw, the second quite small. Premolars reduced, no canine. Jaws are exhibited in the table-case.

IV. RODENTIA, OR GNAWERS.

Mice, Squirrels, Beavers, Hares, Porcupines etc.

Small mammals with claws on the toes, five digits on each foot, the teeth reduced in number, a pair of upper and lower incisors specialized for gnawing. The gnawing teeth grow continually from per-

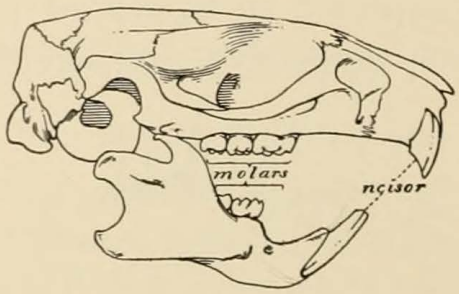

FIG. 21. SKULL OF THE RAT
The most familiar type of the rodentia. Natural size

sistent pulps, during the lifetime of the animal. They have enamel only on the anterior surface and wear to a chisel-like edge which is continually renewed by the more rapid wear of the dentine behind the enamel.

The Rodents are the most numerous group of mammals, but they are almost all small. There are probably now more different

species of rodents than of all the other mammals put together, and they are found in all sorts of places; some are terrestrial, others arboreal, others fossorial or subterranean, others amphibious. They live chiefly on vegetable food, such as grasses, fruit and nuts.

During the Tertiary period Rodents were probably equally numerous; but their remains are so small that they are apt to escape the attention of collectors. Even so they are among the most common of fossil mammals. Most of them belong to families still living.

MURIDÆ. Rats, Mice, Muskrats, Meadow-mice etc.

This is the largest group of the Rodents; there are more than 170 recognized species in North America alone. Several species have been found rather abundant in the American Badland formations. In the White River beds, *Eumys*, allied to the White-footed Mouse, is common; *Paciculus*, allied to the Wood-Rat, is found in the John Day beds; Muskrats and Meadow-mice occur in the Pleistocene.

GEOMYIDÆ. Pocket Gophers.

Found only in North America. Fossil Pocket Gophers occur in the John Day and later formations in the Western States.

HETEROMYIDÆ. Pocket Mice.

Found only in North America. Fossil Pocket Mice are rather common in the White River and John Day formations.

SCIURIDÆ. Squirrels, Prairie Dogs, Woodchucks etc.

Fossil Squirrels, not easily distinguishable from the modern forms, are found in the Oligocene and later formations of the United States. Prairie-Dogs occur in the Pleistocene.

HAPLODONTIIDÆ, OR SEWELLELS. Oligocene to Recent.

The Sewellel, or Mountain Beaver, is a peculiar little burrowing Rodent found only in the western Coast Region of North

America. A tiny fossil Rodent, *Meniscomys* of the Oligocene epoch, is thought to be ancestral to it.

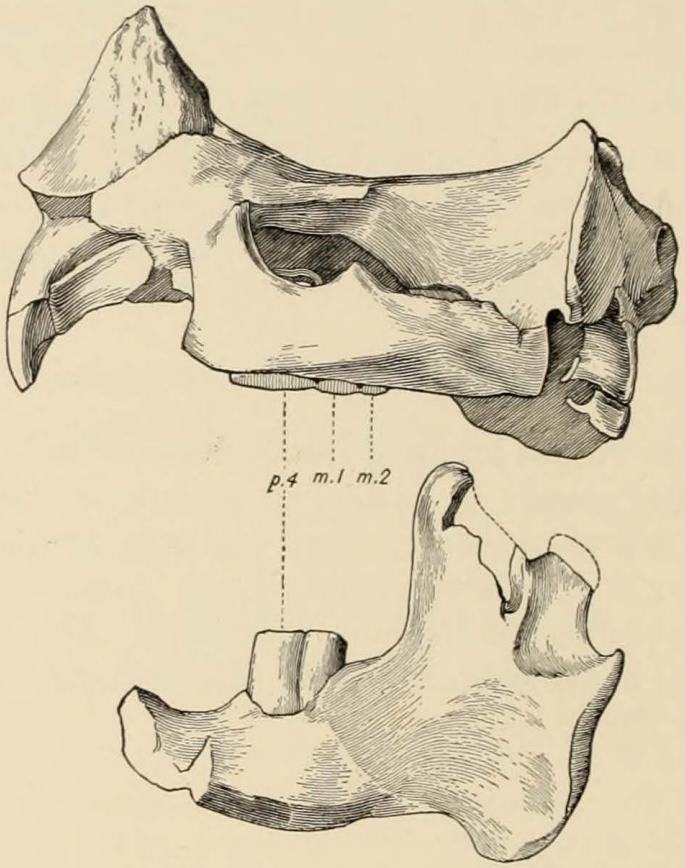

FIG. 25 THE HORNED RODENT, CERATOGAULUS
Skull and lower jaw. Middle Miocene of Colorado. Natural size

MYLAGAULIDÆ. Extinct. Miocene.

Curious little Rodents with digging claws on the fore-feet, very wide short head and peculiar teeth. One skull in the case, the *Ceratogaulus*, or Horned Rodent, shows a large boss indicating a horn on the nose, which gives it an odd likeness to a rhinoceros skull. They are very rare fossils, found only in North America.

CASTORIDÆ. Beavers. Oligocene to Recent.

Fossil Beavers of small size have been found in the Tertiary beds of both America and Europe and several skulls are shown in the collection. In the Quaternary beds are found remains of Beavers scarcely to be distinguished from the living species.

Ischyromyidæ.

Extinct. Eocene and Oligocene.

These were Rodents with teeth more or less like Squirrels, but with skulls more like those of Porcupines and Beavers. They are more ancient than any living rodent families, for they were common in the Lower and Middle Eocene, while no other rodents appear until the Upper Eocene. Several skulls and parts of skeletons of *Ischyromys*, *Paramys* etc. are on exhibition.

Castoroididæ.

Extinct. Pleistocene.

Intermediate between beavers and hystricomorphs, but of very large size. *Castor ohioensis* equalled a black bear in size. A skull and jaw of this rare animal are shown in wall case No. 8. Its remains are usually found in bogs, along with those of the mastodon.

South American Rodents.

All the extinct and most of the living Rodents of South America belong to a division more nearly related to the porcupine than to anything else. Some of the living ones, as the Paca and Capybara are of quite large size.

A series of skulls and jaws of extinct rodents from the Miocene of South America is exhibited in the table-case.

There are certain extinct European Rodent families which are thought to be more nearly related to the South American Rodents than to any others, and the remains of several of these forms are exhibited in the case for comparison beside them.

Leporidæ. Hares and Rabbits.

In the White River Badlands remains of fossil Hares are very abundant. They are more primitive than the modern species in the construction of the teeth, and are placed in the genus *Palæolagus* ("Ancient Hare"). In the later formations of America the rabbits belong to the modern genus *Lepus*.

LAGOMYIDÆ. Picas, or Tailless Hares.

These are little animals looking like small Rabbits, but have fewer teeth. They are found in high mountain regions in the Old World and likewise in western North America. They have

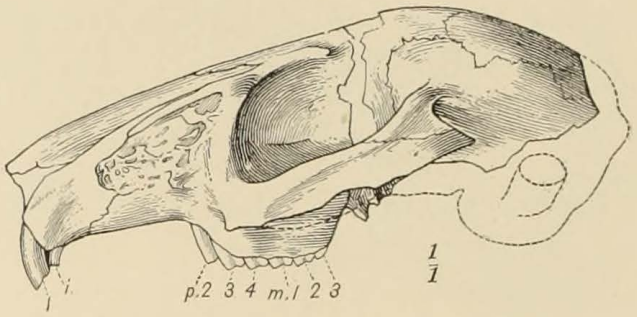

FIG. 26. SKULL OF PALÆOLAGUS
An ancestor of the hares. Oligocene of Colorado. Natural size

been found fossil in Europe, but in America occur only in the latest geological epoch; in the Old World they seem to have taken the place of the true Hares, which were limited to the New World until the end of the Tertiary period.

V. MARSUPIALIA.

All the living marsupials are inhabitants of Australia and the adjacent islands, except the Opossums and a rare genus of Rat-

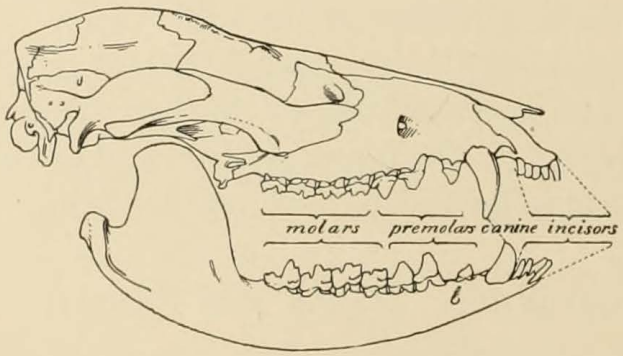

FIG. 27. SKULL OF THE OPOSSUM
Shows the peculiar dentition of the marsupials. Half natural size

Kangaroos from South America. In Australasia they take the place of the mammals of the other continents, none of which occurs

there.[1] Fossil marsupials related to the existing ones of the same region are found in Australia; one gigantic extinct Wombat, *Diprotodon*, is shown in case 6. In South America in the Miocene strata are found remains of various carnivorous marsupials and also of Rat-Kangaroos; a skull and other materials are shown in the collection. In the Eocene and Oligocene of Europe and North America, are found small jaws scarcely to be separated from those of the Opossum except by size. The primitive trituberculates of the Cretaceous period, in the table-case, may also have been marsupials.

VI. MULTITUBERCULATES.

This ancient group of mammals lived during the Age of Reptiles, and became extinct at the beginning of the Age of Mammals. Only jaws, teeth and other fragmentary remains have been found, and it is quite uncertain whether the group is related to the Marsupials or to the Monotremes (*Ornithorhynchus* etc.). Some resemble the Marsupial Rat-Kangaroos, others mimic the Rodents in form. The largest and best known is *Polymastodon* of the basal Eocene; the oldest shown in the case is the tiny *Ctenacodon* of the Jurassic period. *Chirox* and *Ptilodus* of the Cretaceous and basal Eocene are most like the Rat-Kangaroos.

VII. MESOZOIC TRITUBERCULATES.

A number of very small and fragmentary jaws and teeth of Trituberculates from strata of the Jurassic and Cretaceous periods of the Age of Reptiles are exhibited here. They are interesting because they are the most ancient of mammals and show the method of their evolution from reptilian ancestors. Some are thought to be related to the Marsupials, others more nearly to the Insectivores, but until more perfect specimens are found, little can really be stated with certainty about them. Enlarged models of three of these specimens are shown in the case, besides casts and original specimens of many more.

[1] The only exceptions are the dingo, or wild dog, which was probably introduced by man and a few small rodents and bats.

The *Dromatherium* and *Microconodon* casts and models represent two little jaws which are the oldest mammals known. They were found in the Triassic coal-beds of North Carolina, and have a type of teeth intermediate between the primitive three-cusped form of mammals and the simple one-cusped tooth of Reptiles.

THE ORIGIN OF MAMMALS.

The several groups of small and mostly primitive mammals which we have gone over in this guide-leaflet furnish a great deal of evidence, direct and indirect, as to the characters and appearance of the ancestral group or groups from which all mammals are supposed to be descended.

The most ancient mammals, the Multituberculates and Mesozoic Trituberculates of the Age of Reptiles, are known only from rare and very fragmentary remains and many more or less contradictory hypotheses have been advocated as to the relations of these little known groups to the Tertiary mammals which succeeded them and to the lower vertebrates (reptiles and amphibians) which preceded them in geological history. The consensus of present opinion is that mammals in general evolved from an unknown stock of reptiles most nearly related to the Theriodontia [1] which flourished at the end of the Palæozoic era; that they soon split into two branches, one of which (Monotremes) survives without very great change in the egg-laying mammals of Australia. The other more progressive branch again split, one division giving rise to the Marsupials, the other to the Placentals, the latter including all the remaining groups of mammals. The Multituberculates represent a side branch, but whether of Marsupials or of Monotremes is uncertain. The Trituberculates of the Mesozoic era were more nearly in the direct line; some appear to be in the Marsupial branch, others more doubtfully in the Placental branch. But all these conclusions are largely hypothetical.

When we come to the Tertiary mammals, we can speak much more certainly, as these are far more completely known. All the modern races of mammals, as we trace them back towards their

[1] Exhibited in the Hall of Fossil Reptiles, south side.

beginnings, approximate more and more towards a central type which is most nearly represented among known fossils by the earliest Creodonta (Oxyclænidæ) of the dawn of the Tertiary. The Insectivora and Rodentia are also groups of mammals which in most respects have not departed very far from this primitive type. Its general characters are, (1) Small size; (2) Small brain of low organization; (3) Forty-four teeth of simple construction, with sharp cusps, the molars, premolars, canines and incisors of different form, the molars having the "tritubercular" pattern; (4) Limbs and neck flexible and of moderate length, tail very long and powerful, probably prehensile; (5) Feet with five digits on each foot, claws on the toes, the thumb more or less opposable.

These characters appear to indicate an arboreal mode of life rather than any other, and we may suppose that during the Age of Reptiles the ancestors of the mammals were tree-living animals, feeding chiefly upon insects. They were insignificant in size and unimportant in numbers, quite overshadowed by the great and numerous reptilian fauna which flourished during that long era. They possessed, however, the two most important elements of final success in the evolutionary struggle; a brain which, though inferior to that of their descendants, was superior to the brain of all other contemporary vertebrates, and a construction of the joints of limbs and feet more mechanically perfect than in any other animals. By the further improvement and elaboration of these factors of success, they were enabled to displace all their rivals, and become dominant upon land and to some extent upon the sea. Their invasion of the aërial province, already occupied by the highly developed and specialized birds, has been less successful, but of the once dominant reptile fauna of the land, almost nothing remains. The triumphant mammals have branched and re-branched, diverged into countless specializations in adaptation to peculiar modes of life, some of which have survived, while others have become extinct, but always the prime factors of success in the long run have been those which gave them their original advantage over their reptile competitors. Finally the truth that the supremacy in intelligence is first in importance, is best illustrated by the present dominance of man over the whole terrestrial world.

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