ceptible burr there was given off a tine and at a distance of 125 mm. above the burr a second tine was directed forward. Between the two tines the fore and aft diameter is 34 mm.; the transverse, 28 mm. At the distal end of the fragment the diameters are 38 mm. and 30 mm.

Specimen No. 351 of the Iowa State collection is from the same deposit at Correctionville. It belonged to the distal part of the antler. The main stem (Pl. XXXII, fig. 5) has a length of 247 mm., in a straight line. The two tines are given off on the hinder border of the shaft. Of the lower one there remains about 80 mm.; of the upper one, about 150 mm. The anterior border of the shaft is rounded, seeming thus to differ from that of the living caribou. Half-way between the two tines the diameters of the shaft are 58 mm. and 26 mm.

In the collection at the University of Iowa, is a considerable part of a caribou antler attached to a part of the left side of the skull. This specimen bears the number 108. Unfortunately, as too often happens in most collections, no record was ever made of the discovery and no label attached to the specimen. Now, with the finder probably dead, there appears to be no means for determining where it was found or under what circumstances. In all probability it was found somewhere in Iowa. The length of the antler (Pl. XXXIII, fig. 4), from the base to the broken tip, is 507 mm. At the base is given off a tine whose diameters are 34 mm. and 28 mm. Only 45 mm. in length of it remains. At a distance of 105 mm. above the base there is a second tine whose transverse diameter is 26 mm. Half-way between the two tines the diameters of the shaft are 35 mm. and 40 mm. At the distal end of the shaft the hinder border thins to a sharp edge and there was doubtless situated there a third tine. Here, too, the shaft began to turn forward.

Family Bovidae.

Pronghorn, Sheep, Goats, Antelopes, Musk-oxen, Oxen.

Metacarpals and metatarsals of the second and fifth digits rarely present as separate elements; but the extremities of these digits usually present and furnished with small hoofs.

Third and fourth metacarpals consolidated into a single cannon-bone; as are likewise the third and fourth metatarsals. Males and usually, too, the females furnished with horns, which are outgrowths from the frontal bones and which are, except in the giraffes, covered with the corneous sheath. This sheath persistent, except in the Antilocapra. Teeth, i. $\frac{0}{3}$, c. $\frac{1}{1}$, pm. $\frac{3}{3}$, m. $\frac{3}{3}$. The cheek-teeth usually high-crowned and with small or moderate roots.

The earliest known relatives of this widely distributed and numerously represented family are found in the Lower Miocene. Antelopes, sheep, and oxen all existed in the Pliocene and abounded during the Pleistocene. So far as known, none of the family has ever reached Australia or South America, except through the agency of man.

Subfamily ANTILOCAPRINAE.

Parietal bone forming a large part of the roof of the skull; frontals each bearing a large, solid, compressed horn-core; horn-sheaths shed annually; lachrymal bone large, bounding the antorbital vacuity; teeth with high crowns; feet with dew-claws.

The only genus known to belong to the subfamily is Antilocapra, the pronghorn of the plains region west of Missouri river. This animal has usually been regarded as the representative of a distinct family, the Antilocapridæ; but at least as early in 1904 Max Weber (Die Säugetiere, p. 681) recognized its closer relationship to the antelopes and the oxen, and employed the subfamily name Antilocaprinæ. Also, in 1908, Marcus Lyon (Proc. U. S. Nat. Mus., Vol. XXXIV, p. 398) expressed the opinion that the placing of this animal as the representative of a family on an equality with the Cervidæ and the Bovidæ is unnatural; and he refers to Cope's expression of opinion in 1888 that the shedding of the horns, even if normal, did not furnish a character of sufficient value to justify its separation, as a distinct family, from the Bovidæ. The shedding of the horn-sheaths each year, now known to occur in the pronghorn, probably represents a physiological feature which was common among the early hollow-horned ruminants.

Genus ANTILOCAPRA Ord.

Horn-cores straight, compressed, diverging; horn-sheaths recurved at the tips and furnished below and in front with a short anteriorly directed prong.

Only a single species of this genus is known, *Antilocapra americana,* the pronghorned antelope.

Antilocapra americana Ord.

This animal, once very abundant from Missouri river to the Cascade range and from northern Mexico to Saskatchewan river, is now much reduced in numbers and range. It is described by Baird as having a body somewhat larger than that of a sheep, with longer legs and a longer and more erect neck, thus having a greater height than the sheep.

This interesting animal is included here because J. A. Allen, in a paper in 1876 (Amer. Jour. Sci., ser. 3, Vol. XI, p. 48), stated that in the collection of vertebrate remains made by J. D. Whitney, in the lead region of Wisconsin, Iowa, and Illinois, he had found a part of a radius which did not differ appreciably from that of *Antilocapra americana.* It is not known in which of the three states mentioned above the bone was found; but the fact is indicated that this animal once roamed as far east as Mississippi river or beyond it, and that its remains are likely to be found almost anywhere in Iowa. As to the time when this animal occupied the region indicated, we only know that most of the animals found in the lead mines belonged to yet living species. They are, therefore, presumably of post-Wisconsin time.

In order that the bones and teeth of this animal may be recognized when found, a series of measurements have been made on skeletons in the National Museum. Those of the skull and teeth are taken from No. 37088, a male, found in New Mexico. The remaining measurements are from No. 22659.

MEASUREMENTS OF THE SKULL OF PRONGHORN.

Length from front of foramen magnum to front of premaxillae	255 mm.
Length from front of foramen magnum to front of pm.^{2}	160 mm.
Length from front of foramen magnum to front of hinder nares	82 mm.
Distance from rear of occipital crest to front of premaxillae	290 mm.

Distance from rear of occipital crest to line joining rear of orbits	80 mm.
Distance from front of premaxillae to line joining rear of orbits	223 mm.
Width at the rear of orbits	144 mm.
Width of face at front of m.[3]	75 mm.
Width of face above pm.[2]	55 mm.
Width of palate at m.[3]	50 mm.
Width of palate at pm.[2]	33 mm.
Diameter of orbit	48 mm.
From outside to outside of bases of horn-cores	112 mm.
Distance between extremities of horn-cores	175 mm.
Length of horn-cores	310 mm.
Greatest width of horn-cores	52 mm.
Greatest thickness of horn-cores	25 mm.

MEASUREMENTS OF THE TEETH.

Upper Teeth.		Lower Teeth.	
Length, premolar-molar series	67 mm.	Length, premolar-molar series	71 mm.
Length, premolar series	26 mm.	Length, premolar series	27 mm.
Length, molar series	42 mm.	Length, molar series	46 mm.
Pm.[2], length	7 mm.	Pm.[2], length	7.5mm.
width	5 mm.	width	4 mm.
Pm.[3], length	7.5mm.	Pm.[3], length	9 mm.
width	6 mm.	width	5 mm.
Pm.[4], length	8 mm.	Pm.[4], length	10 mm.
width	7 mm.	width	5 mm.
M.[1], length	12 mm.	M.[1], length	11 mm.
width	8.5mm.	width	6 mm.
M.[2], length	13 mm.	M.[2], length	13 mm.
width	9.5mm.	width	7 mm.
M.[3], length	17 mm.	M.[3], length	21.5mm.
width	9.5mm.	width	7.5mm.

The upper teeth (Pl. XXXIII, fig. 5; pl. XXXIV, fig. 3) are characterized by their high crowns and by their prominent anterior and median outer styles. The inner faces of the molars have no accessory columns and no cingula. The lower molars (Pl. XXXIII, fig. 6) are nearly flat on their inner faces; and there are no accessory columns in the valley between the front and hinder lobe. The lower premolars are really more sculptured on their inner and outer faces than are the molars.

MEASUREMENTS OF SKELETON.

Atlas, width behind	75 mm.
Atlas, width fore and aft, near border	67 mm.
Axis, from front of odontoid process to rear of centrum	91 mm.
Axis, width of front end, side to side	45 mm.
Axis, height, near hinder end	49 mm.
Lower jaw, length from incisive border to rear of condyle	238 mm.
Lower jaw, depth at front of m_1	31 mm.
Scapula, length parallel with spine	190 mm.
Scapula, width at dorsal border	117 mm.
Humerus, length, total	202 mm.
Humerus, length from head to inner condyle	186 mm.
Humerus, diameter through head to front of bone	56 mm.
Humerus, diameter at middle of length, fore and aft	26 mm.
Humerus, diameter at middle of length, side to side	20 mm.
Humerus, diameter of distal end, side to side	39 mm.
Ulna, greatest length	260 mm.
Ulna, depth of olecranon process	27 mm.
Radius, total length	218 mm.
Radius, width at upper articulation	36 mm.
Radius, diameter at middle of length, fore and aft	13 mm.
Radius, diameter at middle of length, side to side	21 mm.
Anterior cannon-bone, total length	222 mm.
Anterior cannon-bone, width at upper end	30 mm.
Anterior cannon-bone, diameter at middle of length, fore and aft	14 mm.
Anterior cannon-bone, diameter at middle of length, side to side	16.5mm.
Anterior cannon-bone, diameter across lower end, side to side	30 mm.
Pelvis, total length	227 mm.
Pelvis, from middle of acetabulum to rear of ischium	110 mm.
Pelvis, diameter at front of acetabulum	124 mm.
Femur, total length	242 mm.
Femur, diameter through head to outer side of the tuberosity	60 mm.
Femur, diameter at middle of length, fore and aft	21 mm.
Femur, diameter at middle of length, side to side	20 mm.
Femur, diameter across condyles, side to side	49 mm.
Femur, diameter, fore and aft, on inner side of lower end	66 mm.
Tibia, total length	282 mm.
Tibia, width of upper end	50 mm.
Tibia, diameter at middle of length, fore and aft	18 mm.
Tibia, diameter at middle of length, side to side	21 mm.
Tibia, diameter of lower end, side to side	33 mm.
Hinder cannon-bone, total length	238 mm.
Hinder cannon-bone, width of upper end	26 mm.
Hinder cannon-bone, diameter at middle of length, fore and aft	17 mm.
Hinder cannon-bone, diameter at middle of length, side to side	16 mm.
Hinder cannon-bone, diameter at lower end, side to side	30 mm.
Astragulus, total length	39 mm.
Astragulus, greatest width	22 mm.
Calcaneum, total length	78 mm.

Subfamily **CAPRINAE.**

The Sheep and Goats.

Genus **AFTONIUS** Hay.

Frontal bones furnished with large sinuses at the base of the horn-cores; the latter compressed laterally, but without definite keel in front; strongly curved backwards; straightening near distal end and then directed somewhat inward. Type, the species described below.

Aftonius calvini Hay.

This species is based on two horn-cores and attached portions of the frontal bones supporting them, the two cores having evidently belonged to the same individual (Pl. XXXIV, figs. 4, 5). These were discovered in the Cox gravel pit, at Missouri Valley, Harrison county. They were mentioned by Calvin in 1908 and one of them, the left, was figured (Bull. Geol. Soc Amer., Vol. XX, p. 350, pl. xxiii, fig. 1). Calvin did not attempt to determine the relationship of the animal. The species was described and named by the present writer in 1913 (Proc. Biol. Soc. Washington, Vol. XXVI, p. 6).

While the two frontal bones do not fit together at any point, it is evident that extremely little bone is missing between them. Nevertheless, the lack of this connection leaves it doubtful as to the exact relation of the two horns to each other. There can be no doubt that they were joined as they lay in the gravel from which they were exhumed.

Each of the masses displays a portion of the brain-case; that of the left side showing a surface about 55 mm. square, with depressions for convolutions of the brain, that of the right side a surface 50 mm. by 30 mm. The horn-cores stood on a considerable pedicel. The portion of the frontal around and beneath this pedicel is occupied by large air-sinuses. One of these, in front of the pedestal, is 55 mm. wide and 50 mm. high. The pedicel itself is occupied by a sinus and this extends a short distance into the horn-core.

When the two portions of the specimen have been brought as closely together as permissible (Pl. XXXIV, fig. 4), there is evidence that the brain case had a width of at least 120 mm.; while the width of the skull at the base of the pedicels was at least 150 mm. The animal must therefore have been much larger than the domestic goat. The brain seems to have been as large as that of a bison.

The most striking feature found in the horn-cores is their curvature. In the goats and sheep the curve of the horn is usually a very regular one, the radius of curvature shortening toward the distal end; and this end is usually directed outward. In the horn-cores here described, as shown by the left one, the curve is abrupt at the base, while toward the extremity it is more open; so that the borders, upper and lower, as seen from without are straight. When the core is viewed from above, it is seen that the distal end is directed distinctly mesially.

The following measurements have been taken:

Greatest extent between the extremities of the bone of the left side	205 mm.
Greatest diameter at base of horn-core	75 mm.
Diameter at right angles to this	57 mm.
Greatest diameter 35 mm. from broken extremity of horn-core	51 mm.
Diameter at right angles to this	40 mm.

The mesial face of the horn-core is nearly flat, while the outer face is strongly convex (Fig. 95). In front the two faces pass rather abruptly into each other, but without producing a keel. The hinder border is broad and flat.

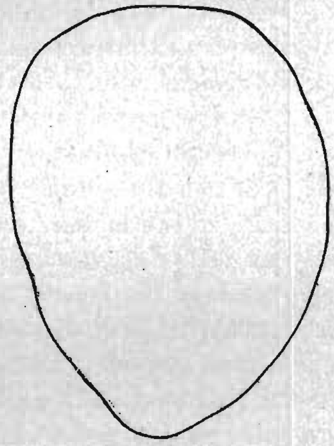

Fig. 95. *Aftonius calvini.* Section of horn-core at its base. X¾. The front of the core is below, the outer face toward the right.

At the base of the horn-core there is a row of large foramina, by which blood-vessels entered the interior of the bone. The surface is rough with pits and with angular grooves for vessels, and on the hinder border these are especially large. On the pedicel there are likewise numerous grooves, but these are mostly straight and parallel and connect above with the pits at the base of the core and with the grooves of the surface.

The writer regards it as quite certain that the relationships of this animal were with the goats, but that it was sufficiently different from any known to constitute a distinct genus. For horn-cores which show similar irregularities of curvature one must examine the species of antelopes which belong to the genus Bubalis.

In the collection at the University of Iowa is a left hinder cannon-bone which was collected from the Elliott pit, at Turin, Monona county. It has the catalog number 276. It is illustrated on plate XXXIV, figs. 1 and 2. The following are the dimensions of the bone. The bone is in good condition, except that it has been slightly worn probably by running water. In parallel columns are given the corresponding measurements of the same bone of the ibex and of the domestic sheep:

MEASUREMENTS OF BONES.

Dimensions Taken	Fossil	Ibex	Sheep
Total length	204 mm.	132 mm.	135 mm
Diameter at upper end, side to side	38 mm.	25 mm.	19 mm.
Diameter at middle of length, fore and aft	28 mm.	14 mm.	10 mm.
Diameter at middle of length, side to side	23 mm.	16 mm.	10 mm.
Diameter across the lower end, greatest	47 mm.	31 mm.	22 mm.

In the upper two-thirds of the shaft the right and left sides are flat and parallel with each other. The front face is marked by a rather shallow longitudinal channel which occupies about one-third of the width of the face. The anterior outer border of the bone is rounded and stands out in front of the anterior inner border. The channel mentioned is rather nearer the outer border of the face. On the hinder face is a channel, which in the upper two-fifths of the bone is broader than the channel of the front face. In the lower two-fifths this channel disappears. The hinder inner border of the bone is more prominent than the outer border; and thus the hinder face looks backward and well outward. A transverse section of the bone taken at the middle of the length would be approximately a trapezoid whose two parallel sides would be greater than the two others.

It is impossible to determine at present the animal to which this bone belonged. It did not belong to Oreamnos, which includes the Rocky Mountain goats, in which the hinder cannon-bone is relatively much shorter and greatly flattened from front to rear. It did not belong in all probability to the moose *Alces shimeki;* for in the American moose this bone is relatively more elongated; besides this, it is the outer hinder border of the shaft which is the more prominent. There are some close resemblances between this fossil cannon-bone and the same bone in the musk-ox; but that of the latter is a much stouter bone and is especially wider across the distal articulation. It could belong only to some related and probably undescribed genus of musk-oxen, if to any of the subfamily.

One naturally thinks of the animal just described, *Aftonius calvini,* which occurs in the same general region and in the same deposit, the Aftonian. Inasmuch as *Aftonius calvini* is regarded as being related to the goats and the sheep, measurements of the corresponding bone in the ibex, representing the goats, and in the domestic sheep are presented alongside the measurements of the fossil. A direct comparison of the metatarsal of the sheep with the fossil shows that the two resemble each other very closely. Certainly the sheep bone is much smaller and relatively slenderer, but the faces and the borders seem to agree as closely as could be expected in two animals of such different sizes. Estimates made show that the bone of the ibex has its proportions much more like those of the fossil than like those of the sheep; although the side-to-side diameter at the middle of the shaft is greater than the fore-and-aft diameter. The details of the faces and the borders of the bone of the ibex, do not agree so closely with those of the fossil as do those of the sheep; but there is nothing to exclude the conclusion that the fossil may have belonged to *Aftonius calvini.* It is therefore assigned there provisionally.

Subfamily OVIBOVINAE.

The Musk-oxen.

Bovidæ with the horn-cores rising close behind the orbits and directed outward and more or less downward and forward, arising well in front of the rear of the occipital crest. Parietal bone forming a considerable part of the upper surface of the skull. Premaxillæ not reaching the nasals. Teeth high-crowned.

These animals appear to have inhabited always the colder parts of the northern hemisphere. Five genera are probably to be recognized: Preptoceras, Euceratherium, Symbos, Boötherium, and Ovibos, all of which are extinct, except the last. The first two are known only from the Pacific coast.

Remains of both Ovibos and Symbos occur in Iowa. No evidences of the former existence here of Boötherium have come to light. Nevertheless, such evidences are likely to be discovered at any time, and for that reason and to show in what way it differs from the other genera, figures of the type species, *Boötherium bombifrons,* and a brief description are here given.

Boötherium bombifrons is known only from a single imperfect skull which was found early in the last century at Big Bone Lick, Kentucky. It belonged to an animal considerably smaller than the living musk-ox. J. A. Allen (Mem. Amer. Mus. Nat. Hist., Vol. I, pl. lv, p. 211) regards it as having been that of an old male. Two characters are conspicuous in this animal. The one is that the horns did not, as they do in Ovibos and did in Symbos, encroach on the upper surface of the skull. As in the bisons and the oxen, the rough surface of the horn-core ceases at the base of the core and forms a burr, thus leaving the space between the cores smooth. The other character is found in the fact that the part of the roof of the skull behind the horns makes a considerable angle with that in front. In Ovibos and Symbos the angle is small or not present. In this respect Boötherium resembles more the sheep and the goats. Both the characters mentioned are well illustrated by the figures here presented (Pl. XXXV). These have been taken from Leidy's work on the Extinct Species of American Ox (Smithson. Contrib. Knowl., Vol. V, art. 3). Various authors have believed that this skull had belonged to a female of *Symbos cavifrons,* but in 1905 (Smithson. Misc. Coll., Vol. XLVIII, p. 181) Osgood pointed out the important differences existing between the two species and he made the species *bombifrons* the type of Boötherium, relegating *cavifrons* to the genus Symbos. Allen in the work cited agrees that the two species are generically different.

The following measurements have been taken by the writer from the skull of *Boötherium bombifrons,* now in the Academy of Natural Science at Philadelphia:

MEASUREMENTS OF SKULL.

Length from occipital condyles to notch for the nasals	263 mm.
Length from occipital crest to notch for the nasals	240 mm.
Height of the occipital crest above lower border of the occipital condyles	137 mm.
Width of skull at the occipital crest	117 mm.
Width of skull at the ear-opening	170 mm.
Width of face at rear of the orbits	180 mm.
Diameter of the orbit, fore and aft	80 mm.
Circumference of base of horn-core	225 mm.
Diameter of base of horn-core on plane of face	70 mm.
Diameter of base of horn-core at right angle to preceding	67 mm.
Length of horn-core along the upper curve	225 mm.
Distance between tips of horn-cores	440 mm.
Distance between bases of horn-cores	150 mm.

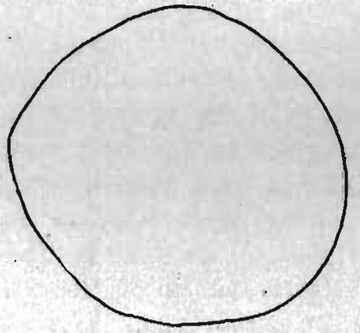

Fig. 96

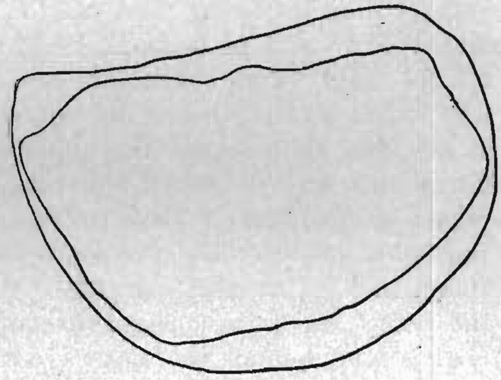

Fig. 97

Fig. 96. *Boötherium bombifrons.* Section of horn-core of the type. X⅔. Taken 25 mm. from the base. Upper surface above, the front at the left.

Fig. 97. *Symbos cavifrons.* Sections of two horn-cores, taken near the base. X⅔. Outer section taken from the type of the species; the inner section from a specimen in Yale University. Front of core above, upper surface to the right.

Figure 96 represents a section of the base of the horn-core of this species. It differs much from the sections of the horn-cores of Symbos.

Genus OVIBOS Blainville.

Musk-oxen with horn-cores directed forward and strongly downward, close to the sides of the skull; the bases broad and flat above and with the horn-supporting surface extending nearly to the midline of the forehead; leaving, however, a narrow space between them. Frontal region nearly straight from front to rear; face of moderate length; cheek-teeth with rather high crowns; in those of the upper jaw the vacant crescent of each lobe sending out on its convex side one or more extensions; lower incisors and canines, small.

At the present day this genus contains what is regarded as a single species, although some of the subspecies have been described as specifically distinct. This animal is known as *O. moschatus,* and is found along the shores of the Arctic ocean east of the Mackenzie river, and in Grant Land and northern Greenland. In prehistoric times one or more species inhabited the region extending from Great Britain across Europe to northern Asia and to Alaska and Yukon Territory. It seems probable that *O. moschatus* has only within a century or less disappeared from the latter two regions. From the Palisades of Yukon river there has been described the extinct species *Ovibos yukonensis.*

Ovibos moschatus (Zimm.)

Within historical times this species has been found in the arctic regions of North America from the Mackenzie, on the lands and islands washed by the Arctic ocean, south to Hudson bay, north to Grant Land, and along the shores of the northern half of Greenland. Its range has now become much more restricted. It, or a species not yet distinguished from it, was, during late Pleistocene times, forced southward by the Wisconsin ice-sheet and again followed this as it withdrew towards the Hudson bay region.

The writer has knowledge of four specimens of a musk-ox belonging to the genus Ovibos and at present not distinguishable from *O. moschatus.* One of these is now in the geological collection at the University of Ohio, at Columbus. This was found in 1894, by W. A. McGinnis, at Youngstown, Ohio. The statement is made that it was discovered under sixty feet of gravel. The horn-cores had been eroded off to their very bases.

The writer has photographs of a part of a musk-ox skull which is in the possession of Dr. Frederick Becker, of Clermont, Iowa, and which was found in that region. His son, Mr. A. G. Becker, has kindly sent me photographs of it. It is described on page 297. It seems to belong to *Ovibos moschatus*.

A third specimen is in the collection at Earlham College, Richmond, Indiana, where the writer has examined it (Geol. Surv. Ind., Vol. XXXVI, p. 641, pl. ix, fig. 2). The specimen was secured by Prof. D. W. Dennis, from the workmen who unearthed it near Richmond.

Another specimen is in the American Museum of Natural History, New York, and this is stated to have been found near Ottumwa, Iowa, by E. L. Lathrop, and sent to Prof. E. D. Cope.

Inasmuch as other specimens of this musk-ox are likely to be found, some of them, it is to be hoped, furnishing skulls with both jaws and teeth and bones of the trunk and limbs, it is thought well to give measurements of the skull and teeth and of some of the principal bones of the skeleton of a specimen of a recent *Ovibos moschatus*. These measurements may serve in the identification of the fossil remains. The measurements of the skull and teeth are taken from a skull, No. 108722, belonging to the Biological Survey of the U. S. Department of Agriculture. The other measurements were obtained from a skeleton belonging to the U. S. National Museum:

MEASUREMENTS OF SKULL.

Length of skull from rear of condyles to front of premaxillae	445 mm.
Length of skull from front of foramen magnum to front of premaxillae	420 mm.
Length of skull from middle of occipital crest to front of premaxillae	463 mm.
Distance from middle of occipital crest to line joining rear of orbits	181 mm.
Distance from front of premaxillae to line joining rear of orbits	287 mm.
From rear of occipital condyles to front of hinder nares	191 mm.
Width at mastoid region	170 mm.
Width at rear of temporal fossae	124 mm.
Width at constriction behind the orbits	122 mm.
Width at rear of orbital ring	236 mm.
Width on maxillary ridge at maxillo-malar suture	147 mm.
Greatest width above pm.^{2}	95 mm.
Width across middle of zygomatic arches	163 mm.
Width of palate between last molars	88 mm.
Width of palate between anterior premolars	49 mm.
Length of lower jaw from incisive border to rear of condyle	365 mm.
Depth of jaw at first true molar	42 mm.

Measurements of the skulls of many individuals of the species are given by Allen in the monograph already cited.

MEASUREMENTS OF TEETH.

Length of upper premolar-molar series	130 mm.
Length of upper premolar series	45 mm.
Length of upper molar series	84 mm.
Length of lower premolar-molar series	136 mm.
Length of lower premolar series	46 mm.
Length of lower molar series	90 mm.

Upper Teeth			Lower Teeth		
$Pm.^2$,	length	14 mm.	$Pm._2$,	length	11.5mm.
	width	11 mm.		width	7 mm.
$Pm.^3$,	length	18 mm.	$Pm._3$,	length	16 mm.
	width	15 mm.		width	9 mm.
$Pm.^4$,	length	18 mm.	$Pm._4$,	length	19 mm.
	width	16 mm.		width	13 mm.
$M.^1$,	length	26 mm.	$M._1$,	length	24 mm.
	width	20 mm.		width	16 mm.
$M.^2$,	length	30 mm.	$M._2$,	length	28 mm.
	width	19 mm.		width	15 mm.
$M.^3$,	length	32 mm.	$M._3$,	length	38 mm.
	width	19 mm.		width	13 mm.

MEASUREMENTS OF SKELETON.

Scapula, length along the spine	335 mm.
Scapula, width of upper end	200 mm.
Humerus, total length	325 mm.
Humerus, from head to inner side, distal end	285 mm.
Humerus, width from side to side at upper end	93 mm.
Humerus, fore and aft diameter at middle of length	52 mm.
Humerus, transverse diameter at middle of length	36 mm.
Humerus, greatest width of distal end, side to side	70 mm.
Radius, total length	298 mm.
Radius, fore and aft diameter at middle of length	22 mm.
Radius, transverse diameter at middle of length	37 mm.
Radius, greatest width at distal end	68 mm.
Ulna, total length	363 mm.
Anterior cannon-bone, length	177 mm.
Anterior cannon-bone, fore and aft diameter at middle of length	20 mm.
Anterior cannon-bone, transverse diameter at middle of length	36 mm.
Anterior cannon-bone, width of the distal end	65 mm.

Pelvis, length	410 mm.
Pelvis, width at acetabula	195 mm.
Pelvis, width at hinder end of ischia	325 mm.
Femur, total length	338 mm.
Femur, length from head in inner side of distal end	338 mm.
Femur, diameter at middle of length, fore and aft	34 mm.
Femur, diameter at middle of length, side to side	36 mm.
Femur, greatest diameter at distal end, side to side	85 mm.
Femur, greatest fore and aft width, distal end	98 mm.
Tibia, total length	340 mm.
Tibia, fore and aft diameter at middle of length	30 mm.
Tibia, transverse diameter at middle of length	37 mm.
Tibia, width of distal end	58 mm.
Hinder cannon-bone, length	187 mm.
Hinder cannon-bone, fore and aft diameter at middle of length	27 mm.
Hinder cannon-bone, width of upper end	44 mm.
Hinder cannon-bone, transverse diameter at middle of length	27 mm.
Hinder cannon-bone, width of distal end	59 mm.

In the male of the living animal the horn passes close to the skull, downward and forward below the eye, then upward and slightly outward in front of the eye, and finally upward, outward and backward. The orbit is thus nearly surrounded by the horn. When the horn is removed from the core, the latter is found to be about one-half the length of the horn. The horns of the females are less strongly developed than in the males and they have a wider space between them.

The upper teeth of Ovibos differ in several respects from those of the bison and of the common ox. The teeth of Ovibos have no cement. This may, of course, be missing in fossil teeth of the bisons; for it dissolves more easily than the other elements. The teeth of Ovibos are not nearly as broad as those of the bisons, but the crowns of the molars are nearly as long, fore and aft. Ovibos, like Bison and Bos, has, on the outer face of each premolar, an anterior and posterior style; and in the true molars, an anterior, a median, and a posterior style. However, in Bison and Bos there are in the premolars and on the molars two intermediate styles which exceed in breadth and prominence the main style; while in Ovibos these appear as mere swellings of the enamel. Bison and Bos have, on the inner face of the true molars, a large column between the two lobes. This is not present in Ovibos.

In Ovibos the lower premolars and molars are both shorter along the crown and narrower than those of the bisons. The true molars of the latter have, on the outer face, between the lobes, a large column of enamel which is missing in the species of Ovibos. The styles on the inner faces are more strongly developed than in the bisons and the common ox.

The teeth of the elk, *Cervus canadensis,* are lower-crowned and broader than the corresponding ones of Ovibos; and they have the styles, especially the intermediate ones, better developed than in Ovibos.

These remarks are to be applied with still stronger force to the teeth of Alces when compared with those of Ovibos.

As already stated two specimens of Ovibos are known which have been found in Iowa. One of these is in the American Museum of Natural History, New York. It appears to have been found at Ottumwa, by E. L. Lathrop; and it had long ago been sent to E. D. Cope, of Philadelphia. The specimen consists of the hinder part of the skull, and this had, before its discovery, been subjected to rough usage, probably in running water; so that all the prominent processes have been worn down. The horn-cores are eroded off nearly to their bases. There is a groove 147 mm. long between the two horn-cores. The individual was an old one. There are no data preserved which throw any light on the geological age of the skull; but it probably belonged to the Wisconsin stage or to the early post-Wisconsin.

The other specimen is likewise a part of a skull. This is the property of Dr. Frederick Becker, of Clermont, Fayette county. He has informed the writer that it was found in the northeast corner of the southeast quarter of section 35 of Clermont township, at a depth of about twenty-six feet in clay. This region is covered with Kansan drift, and it would be of the highest interest if the skull had been found in this drift; but it is much more probable that the clay belongs to a Wisconsin or post-Wisconsin deposit. Mr. A. G. Becker has kindly sent me photographs of this partial skull; and two of these are reproduced, a little less than one-fifth of the natural size (Pl. XXXVI, figs. 2, 3). On comparison with the figure of *Ovibos moschatus,* on the same plate, it will be observed that the arrangement of the horn-cores is the same. Mr. A. G. Becker has furnished certain measurements: From the rear of the skull, as seen in figure 2, to the front, which shows the notch for the nasals, is 272 mm.; the width across the orbits is 225 mm.; the horn-cores are 120 mm. wide at the base.

Genus SYMBOS Osgood.

Horn-cores directed outward, downward, and forward; their upper face flattened at the base. The exostoses of the two sides coalescing at the midline, extending backward to the occipital crest and forward to or beyond the orbits. Space between the horn cores more or less concave. Face much elongated. Borders of orbits not so much produced as in Ovibos. Upper teeth essentially like those of Ovibos, but larger, especially broader, and the vacant crescents of each lobe without extensions, or offsets; lower teeth not yet known.

The type of this genus is Osgood's *Scaphoceros tyrrelli,* later called *Symbos tyrrelli,* found in Yukon Territory. This was based on a nearly complete skull, lacking, however, the lower jaw. In the same genus he included the species long known as *Boötherium cavifrons,* originally described by Leidy. The possibility that *S. tyrrelli* is the same as *S. cavifrons* is discussed below.

Symbos cavifrons (Leidy).

The type of this species is a part of a skull which is now in the Academy of Natural Sciences at Philadelphia. It was discovered many years ago near Fort Gibson, Indian Territory, near the junction of the Neosho river with the Arkansas. It was found in the hut of an Indian, who was using it as a seat. It was described and figured by Leidy in 1853 (Smithson. Contrib. Knowl., Vol. V, art. 3). Figures of the same skull were published in 1905 by Mr. W. H. Osgood (Smithson. Misc. Coll., Vol. XLVIII, pls. xl-xlii). The horn-cores are present, nearly complete, and the base of the skull as far forward as the fronto-nasal notch. One of Osgood's illustrations is here reproduced showing the rear of the skull (Pl. XXXVI, fig. 4).

In this specimen the space between the bases of the horn-cores is rough and pretty deeply concave, with a slight median longitudinal ridge. It is quite evident that the horns of the two sides had, in this genus, coalesced across the forehead. The following measurements were furnished by this skull:

MEASUREMENTS.

Length from condyle to fronto-nasal suture	300 mm.
Length from middle of occipital crest to fronto-nasal suture	285 mm.
Height from bottom of condyles to top of exostosis	220 mm.
Height from bottom of condyles to occipital crest	165 mm.
Width at level of occipital crest	140 mm.
Width at mastoid region	210 mm.
Width at rear of orbits	245 mm.
Width at front of orbits	210 mm.
Diameter of base of horn-core, fore and aft	110 mm.
Diameter of base of horn-core, vertical	75 mm.
Length of horn-core along hinder border	395 mm.
Distance between tip of horn-cores	575 mm.

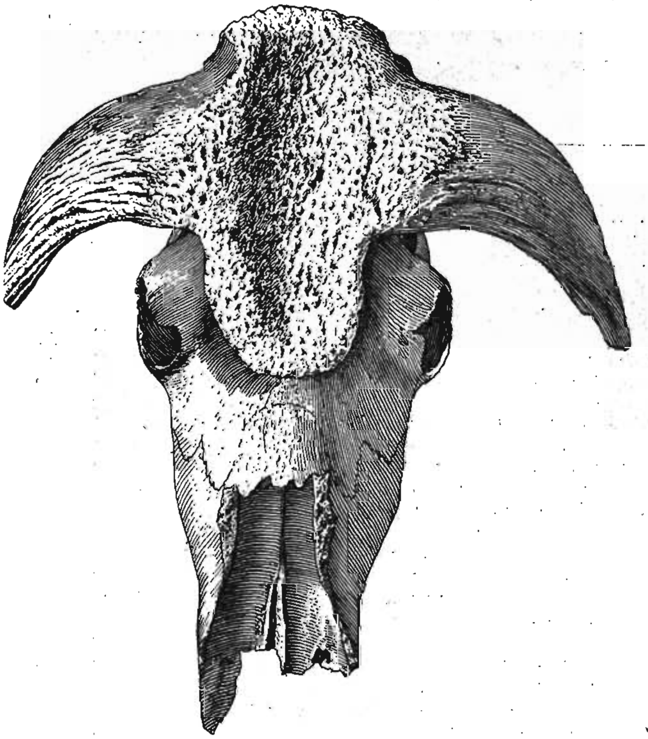

Fig. 98. *Symbos cavifrons.* Front view of skull found at Hebron, Indiana. X 1/6.

The finest known specimen of this species is a skull which was discovered about the year 1904, by some workmen, while digging for the foundation of a railroad bridge, about six miles east of Hebron, Porter county, Indiana. It was found at a depth of about seven feet in a mixture of sand and clay. The specimen is now in the American Museum of Natural History, New York, and has been described by the present writer (Geol. Surv. Indiana, Vol. XXXVI, pp. 635-638, figs. 49, 50) and by J. A. Allen (Mem. Amer. Mus. Nat. Hist., Vol. I, pt. iv, pp. 169-171, fig. 25; pls. xvii, xviii). This skull (Figs. 98, 99) lacks the lower jaw, both premaxillæ, the anterior extremity of the left maxilla, the front two-thirds of the nasals, and all the teeth, except the second molar of the left side. The condition of the bone shows that the skull must have been buried soon after death and that it had suffered no disturbance until found by the bridge-builders. The following measurements are partly from those taken by the author and partly those taken by Allen. In the second column are given the corresponding measurements of the type of *S. tyrrelli*:

MEASUREMENTS.

	Symbos cavifrons	Symbos tyrrelli
From occipital condyles to hinder end of maxillo-premaxillary articulation	478 mm.	416 mm.
From occipital protuberance to front of maxilla	557 mm.	528 mm.
From hinder border of exostosis to fronto-nasal suture	275 mm.	241 mm.
From rear of occipital condyles to front of hinder nares	263 mm.	224 mm.
Width at mastoid region	200 mm.	196 mm.
Width at hinder end of temporal fossae	134 mm.	122 mm.
Width at rear of orbits	252 mm.	222 mm.
Width across occipital condyles	118 mm.	135 mm.
Width across the zygomatic arches	211 mm.	210 mm.
Width of hinder end of basioccipital	72 mm.	71 mm.
Height of skull from bottom of condyles to hinder border of exostosis, at midline	223 mm.	158 mm.
Height of occipital crest above bottom of condyles	180 mm.	125 mm.
Height of front of exostosis above alveolar border	228 mm.	190 mm.
Height of hinder end of nasals above alveolar border	195 mm.	188 mm.
Length of exostosis, on midline	267 mm.	210 mm.
Width of concavity of exostosis, taken at middle of base of horn-cores	125 mm.	90 mm.
Depth of concavity of exostosis, taken as above	36 mm.	40 mm.
Fore-and-aft diameter of base of horn-cores	118 mm.	100 mm.
From tip to tip of horn-cores, as preserved	525 mm.	368 mm.
Length of horn-cores, as preserved	225 mm.	175 mm.
Diameter of orbit	63 mm.	73 mm.
Length of tooth series, as shown by alveoli	182 mm.	172 mm.

The exostosis which occupies the forehead is greatly developed. It extends backward to a point above the occipital crest and forward to a point between the fronts of the orbits. It is very rough. The space occupied by it is concave from side to side; but, unlike the type, there is no median ridge and no ridges bounding the concavity in front and rear. The horn-cores are flattened above, but away from the base the flattening is reduced. The extremeties reached below the orbits and to the front borders of these.

Figure 97 presents sections of two horn-cores of this species. These show that the cores are flattened above.

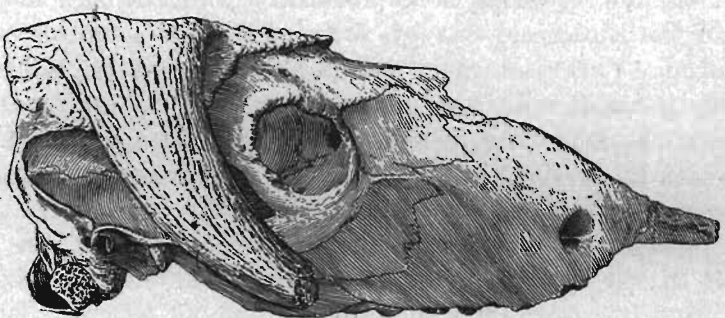

Fig. 99. *Symbos cavifrons.* Side view of skull found at Hebron, Indiana. X 1/6.

In front of each orbit there is a considerable excavation for a gland. The orbits do not projecct so far out from the skull as in Ovibos.

The alveolar border of the maxilla appears to be unusually convex from front to rear. The antorbital foramen is above the second tooth from the front, pm.^{3}. The palatine bones extend forward to the space between the first and the second true molars. One tooth, the left first upper molar, is present. It is considerably worn, but yet rises 25 mm. above the root. The crown has a fore-and-aft length of 38 mm. and a width of 28 mm. It is thus considerably larger than the same tooth in *Ovibos moschatus*. The structure of the tooth resembles that in the latter musk-ox; but the external pillars seem to be less strongly developed, and the walls of the vacant crescents of each lobe are simple.

This skull was found in deposits laid down by water upon Wisconsin drift. Its age may therefore be determined with some accuracy. It may be that it lived along the foot of the Wisconsin glacier, as this was returning northward; or it may have lived after the glacier had retired farther north, but while the climate was yet cold. We may be assured, at any rate, that its period was not pre-Wisconsin.

As already stated, W. H. Osgood has described from the Yukon region a species which he has named *Symbos tyrrelli,* making it the type of the genus. This is in the National Museum and has been studied by the writer with some care. Inasmuch as it retains many of the teeth and one premaxillary, and furnishes many important suggestions regarding *Symbos cavifrons,* the following notes are made; and, through the courtesy of the Biological Survey, some of Osgood's figures are reproduced. Various measurements are given on page 300 in a column parallel with the measurements of *S. cavifrons.* In addition the following measurements are taken on *S. tyrrelli,* but which the writer has unfortunately not taken on the Indiana specimen of *S. cavifrons.* Inasmuch as the premaxillæ of the latter specimen are missing, the first measurement, the basal length of the skull, cannot be obtained. The corresponding measurements of a specimen of *Ovibus moschatus* also are presented. For figure of *S. tyrrelli* see plate XXXVII.

MEASUREMENTS.

	Symbos tyrrelli	Ovibos moschatus
From front of foramen magnum to front of premaxillae (basal length)	528 mm.	420 mm.
From occipital protuberance to line joining rear of orbits	161 mm.	170 mm.
From front of premaxilla to line joining rear of orbits	410 mm.	288 mm.
From front of foramen magnum to fronto-nasal suture (basinasal line)	255 mm.	229 mm.

The measurements just given show that, as compared with the living species of musk-ox, *Symbos tyrrelli* had a remarkably long face; for, while the distance from the occipital crest to the line joining the rear of the orbits is nearly the same in the two specimens measured (161 mm. and 170 mm.), being therefore greatest on the Ovibos, the face of Symbos is one and four-tenth times longer than that of Ovibos. The skulls of *Symbos tyrrelli* and of *S. cavifrons* were as long as that of a horse of average size; although the bodies of these extinct musk-oxen were doubtless considerably smaller than that of such horses.

Symbos tyrrelli differs in some respects from that of *S. cavifrons*. The rear of the skull is much lower than that of *S. cavifrons*, the height of the occipito-parietal suture above the lower border of the condyles being 125 mm. in the former, and 180 mm. in the latter. This might be regarded a character distinguishing decisively the Yukon species from that of our region; but another imperfect skull brought from the same region by Mr. Osgood has the rear of the skull much higher and fully equal to a specimen of *S. cavifrons* from Manitou, Illinois. Other differences between the two supposed species may be cited, but only careful study of additional specimens will enable us to decide as to their relationships.

The type specimen of *S. tyrrelli* contains all the cheek-teeth of the left side and the two hindermost molars of the right side. They are considerably worn, however, and do not offer wholly satisfactory measurements. Pm.^{2}, pm.^{4}, and m.^{1} are worn obliquely, and the latter has little of the crown left. M.^{2} and m.^{3} are in pretty good condition. The following measurements are presented as being about as good as can be obtained. Measurements of the teeth of Ovibos are presented for comparison:

MEASUREMENTS OF THE TEETH.

Teeth		Symbos tyrrelli	Ovibos moschatus
Pm.^{2},	length	19 mm.	14 mm.
	width	18 mm.	11 mm.
Pm.^{3},	length	19 mm.	18 mm.
	wdith	25 mm.	15 mm.
Pm.^{4},	length	20 mm.	18 mm.
	width	26 mm.	16 mm.
M.^{1},	length	27 mm.	26 mm.
	width	27 mm.	20 mm.
M.^{2},	length	34 mm.	30 mm.
	width	32 mm.	19 mm.
M.^{3},	length	49 mm.	32 mm.
	width	33 mm.	19 mm.

It is quite certain that the teeth of *S. cavifrons* were not greatly different from those of *S. tyrrelli*. The measurements of m.[2] in the two specimens differ somewhat, however. That of *S. cavifrons* from Hebron is considerably longer, but it had not been so much worn. A comparison between the figures of the two columns above given shows that, excepting the anterior premolars and the last molars, there are no great differences between the lengths of corresponding teeth in Ovibos and Symbos; while there are great differences in the widths of the corresponding teeth. The teeth of Ovibos are relatively thin; those of Symbos broad. The hindermost molar of Symbos is a very large tooth.

J. A. Allen (op. cit., p. 214) has expressed the opinion that a specimen found near Grand Rapids, Michigan, and described by Mr. Gidley (Proc. U. S. Nat. Mus., Vol. XXXIV, p. 683, pl. lix) as *Boötherium sargenti,* does not belong to Boötherium, but is probably the female of Symbos. The present writer does not share this opinion. He has seen about twenty-five specimens of Symbos, all of which have the great exostosis across the forehead, showing that the horns had coalesced. If these are all males, then but one or two females of the genus have yet been discovered. Among these specimens there is a good deal of variation in the width and the length of the horn-cores. Allen states that in *B. sargenti* there is about the same relative area of exostosis as in the female of Ovibos. It might be supposed, however, that in a genus where the extension of the horns across the forehead of the male had gone so far as in Symbos, it might have proceeded at least proportionately in the female. This had gone as far as it could in the male; is it not possible it had gone about as far in the female and reached the midline? In the many known specimens of Symbos there is a good deal of variation in the width and thickness and length of the horn-cores; and it seems quite probable that some of the smaller horn-cores indicate females. The writer is inclined to look on the type of *S. tyrrelli* as being the skull of a female, perhaps the female of *S. cavifrons*.

The horn-cores of *Boötherium sargenti* are very different from those of Symbos. They are not depressed on the upper surface, as they are in Symbos, but are nearly circular in section. An examination of Allen's text and figures appears to show conclusively that the horn-cores of the female of Ovibos are at most not longer than those of the male. It is reasonable to suppose that the same conditions would be found in Symbos; but in the type of *Boötherium sargenti* the horn-cores are far longer than they are in any known specimen of Symbos, extending far in advance of the orbits and apparently to a line not far behind the front end of the nasals. The type of *B. sargenti* may be the skull of a female, but hardly that of *Symbos cavifrons.*

One of the characters which especially distinguishes *Boötherium bombifrons* is the angle which the plane of the frontals makes with the plane of the parietal portion of the roof of the skull; and Allen recognizes the value of the character. Now, in *Boötherium sargenti* there is a similar angle and one nearly as large. In *B. bombifrons,* judging from the illustration furnished, this angle measures 55°; in *B. sargenti* it measures about 53°. On the roof of the skull of Symbos there is no such angle.

The horn-cores of *B. sargenti* differ from those of *B. bombifrons* certainly in having pushed the exostosis beyond the pedicel and on the forehead. If this character removes the species from *B. bombifrons* there is indicated the need of a new generic name; but an undescribed skull from Alaska shows an intermediate condition.

The writer knows of but one* specimen of *Symbos cavifrons* that has been found within the limits of Iowa. This is the rear portion of a skull which was reported by McGee (Amer. Jour. Sci., Vol XXXIV, 1887, p. 217) as having been found in the loess at Council Bluffs. McGee states that the specimen was found at a point 130 feet above Missouri river and at a depth of twelve feet. This specimen is now in the collection of the Iowa University, having been secured by Doctor Calvin. The catalog number is 107. McGee states that with the skull were found about one-half of the lower jaw, the atlas, a femur, and a number of other bones. The writer has seen none of these bones,

*For a description of an atlas which probably belongs to this species and which has been examined since this report went to press, see page 307.

except the skull. The skull lacks all parts in front of the rear of the orbits. The horn-cores are complete. The following measurements were taken by the writer: From tip to tip of horn-cores, 470 mm.; width of skull at mastoid region, 205 mm.; distance across the occipital condyles, 132 mm.; fore-and-aft extent of the exostosis, 200 mm. Between the horn-cores is a deep concavity.

In case this skull was really derived from the loess, we would probably have to conclude that the animal had lived as long ago, at least, as Wisconsin times. It does not seem improbable that in this region loess was being deposited during the presence of the Wisconsin ice-sheet in the state. Shimek (in a letter) thinks that it is far from certain that the skull was found in loess. There is in that region much Loveland, a slackwater deposit, and the skull may have been buried in this. Inasmuch as this Loveland is regarded by Shimek as having been deposited during the melting of the Kansan ice-sheet, we would have to refer to that time the existence of this species of Symbos. This must not be regarded as impossible, but confirmation of this idea is to be desired. Other specimens certainly belong to Wisconsin or post-Wisconsin stages. McGee (op. cit., p. 220) believes that the skull of this species which was found at New Madrid, Missouri, was derived from the Port Hudson. It is possible that the skull from Council Bluffs really occurred in redeposited loess. The photograph of this skull reproduced on plate XXXVII, fig. 3, was sent to the writer by Doctor Calvin. On the back of it was expressed the opinion that the skull had been found in deposits of unknown age.

Leidy (Proc. Acad. Nat. Sci. Phila., 1870, p. 73) stated that there had been sent to him from the Smithsonian Institution a part of a lower jaw of an animal supposed to be that now known as *Symbos cavifrons*. This jaw had been found in Harrison county, Iowa, in clay, at a depth of twenty-two feet below the surface, on the "bench," or "second bottom" of Boyer river. According to Shimek (Iowa Geol. Surv., Vol. XX, p. 394) these benches are covered by yellow loess; but it seems likely that at the depth of twenty-two feet the loess would be passed through. The specimen is stated to be very friable and encrusted. It was presented to the Smithsonian Institution by

Dr. D. R. Witter, of Woodbine, Iowa. Only the last molar was present and this was much worn. Its dimensions are given by Leidy as being fully two inches, fore and aft, and nearly an inch wide. The present writer has not been able to find this jaw in the collection of the National Museum, where it ought to be. While the jaw is possibly that of *Symbos cavifrons,* one could not be certain of it, since the lower jaw has never been found associated with the other parts of the skull.

Professor John L. Tilton, of Simpson College, has submitted to the writer an atlas which was found a mile and a half east of Indianola by Mr. Herbert D. Perry. The locality is in section 29, township 76 north, range 23 west, Lincoln township. This bone, together with a large vertebra which evidently belonged to one of the elephants, was discovered at a depth of about eleven feet in the process of digging a pier for a bridge over a ravine. The atlas belonged to some species of musk-ox, probably to *Symbos cavifrons.*

A comparison of the atlas of *Ovibos moschatus* with that of a bison shows that the two are quite different in many respects. In the bison the anterior borders of the bone which limit in front and laterally the articular surfaces, are drawn out to rather acute edges. In the musk-oxen these borders have the appearance of having been beveled off at right angles with the articular surface all around, but especially latterly and below. Instead of a sharp edge, the border presents a thickness of 10 mm. to 15 mm. In the bison the right and left anterior articular surfaces pass into each other or are separated by a narrow channel, while in the musk-oxen a prominent ridge descends from the floor of the spinal canal to the lower surface of the bone. The lateral wings of the atlas are considerably thicker in the musk-oxen than in the bison.

The atlas found near Indianola had been rolled and waterworn and the lateral wings and the median part of the arch are broken off; but the bone displays its relationship to the musk-oxen. It differs from the same bone in the existing musk-ox in having the surfaces which extend right and left from the lower median tuberosity to the outer borders of the bone well filled out, instead of being quite concave. Various other differences are observed.

In his thesis on the Pleistocene deposits in Warren County, Iowa, page 27, Professor Tilton regarded the beds from which this bone was obtained as belonging to the Aftonian; but he has more recently expressed, in letters to the writer, some doubts regarding this conclusion. It seems probable that the musk-ox to which the atlas belonged lived during one of the glacial stages, either the Illinoian or the Wisconsin.

Prof. John L. Tilton has sent the writer a fragment, 150 mm. long, of the right humerus of some artiodactyl. It was found in an old soil at a depth of 38 feet beneath the river bottom, in making the city well at Indianola. It appears to be quite certain that the bone belonged to some species of musk-ox, probably to a young animal. The bone is much injured. The deposits are probably more recent than the Aftonian.

Subfamily BOVINAE.

The Bisons, Buffaloes and Oxen.

Bovidæ with the horn-cores placed nearer to the hinder outer angles of the skull than to the orbits; directed usually upward and outward. Frontal bones developed posteriorly at the expense of the parietal. Face broad. Premaxillæ not reaching the nasals. Teeth high-crowned, prismatic, with strongly developed styles and accessory columns, and covered with a coat of cement.

The earliest known members of this group appeared in the Pliocene of India and Europe. They were well represented in Europe, Asia, and North America during the Pleistocene. All the species native to America belong to the genus Bison.

The writer has shown (Smithson. Misc. Coll., Vol. LIX, p. 12, fig. 10) that so far as is known no remains of any extinct species of Bison in North America has yet been found in deposits overlying the Wisconsin drift. The provisional conclusion which is drawn from this is that all these species had become extinct before that drift-sheet had disappeared; probably before it had reached its southern limit.

The following analysis of the species and their characters may be of use in determining specimens which may be found. Of these only *Bison bison* and *Bison occidentalis* have yet been discovered within the state; but any of these, except *crassicornis*, may be expected. The species just mentioned has, up to the present, come to the light nowhere except in Alaska and Yukon Territories. The existing species, *B. bison*, appears to have been a late arrival in our region.

It is usually very difficult and unsafe to identify the species of Bison by means of the teeth alone. The teeth, or at least, well-preserved ones, have not been found in the jaws of determinable skulls of all the species, so that the tooth characters have not been satisfactorily made out. Evidently the corresponding teeth of some of the species resembled each other very closely in size and structure. Teeth have been found in Florida which are not distinguishable from those of the living bison. Yet we have no other proof that this bison ever lived there.

Genus BISON H. Smith.

Horn-cores cylindrical, directed outward and upward, usually somewhat backward, rising somewhat in front of the hinder outer angle of the skull.

The type species of this genus is *Bison bison*, the American Bison, or American Buffalo, which once occupied a large part of our continent, but which is now on the verge of extinction. Besides this animal, there existed in North America, during the Pleistocene, several other species of the same genus, as *Bison antiquus, B. occidentalis, B. crassicornis, B. alleni, B. ferox, B. latifrons*, and *B. regius*.

ANALYSIS OF SPECIES OF BISON.

A. Species with the bases of the horn-cores directed at right angles with the longitudinal axis of the face.

1. Horn-cores, measured along the upper curve, equal to about three-fourths the distance between the bases of the cores, and about equal to the circumference of the base............................*antiquus*.

AA. Species with the bases of the horn-cores directed obliquely to the longitudinal axis of the face and nearly toward the orbit of the opposite side.

2. Horn-cores short, stout and curving outward, slightly downward, then upward and backward; length along the upper curve much less than the distance between the bases and not equalling the circumference of the base...*bison*.

3. Horn-cores directed outward, upward, and somewhat backward, the length along the upper curve usually exceeding somewhat the distance between the bases and about equal to the circumference of the base .... *occidentalis*.

4. Horn-cores more elongated and directed considerably downward proximally, thus appearing to sag; tips rising little above the face; the length of the horn-cores exceeding the distance between the bases by from 24 to 70 per cent and the circumference of the base by from 21 to 40 per cent.. *crassicornis*.

5. Horn-cores not sagging at the base; directed outward, upward, and somewhat backward; exceeding the distance between the bases by about 40 per cent and the circumference of the base by from 22 to 32 per cent.. *alleni*.

6. Horn-cores long, heavy, and moderately curved; length along the upper curve more than twice the distance between the bases and exceeding by more than 50 per cent the circumference at the base. Teeth with the enamel of the "lakes" very simple.......... *latifrons*.

7. Horn-curves (as indicated by the type) longer, slenderer, and more curved then in *B. latifrons;* length along the upper curve two and a half times the distance between the bases and exceeding the circumference of the base by 90 per cent. Teeth with the enamel of the "lakes" with reëntering folds................................ *regius*.

Bison bison (Linnæus).

The American Bison; American Buffalo.

Inasmuch as this species has been reported from the state as a Pleistocene fossil, and as its structure is thoroughly known, and as it may therefore serve as standard for the comparison of remains of other fossil bisons, a rather detailed description of it and measurements will be given. These are taken from a mounted skeleton at the U. S. National Museum, No. 12456. Measurements of other specimens are to be found in J. A. Allen's monograph The American Bisons.

MEASUREMENTS OF SKELETON OF THE AMERICAN BISON.

Length, from front of head along the face and straight to hinder end of pelvis	2808 mm.
Height, at the shoulders	1660 mm.
Skull, length from premaxillae to front of foramen magnum	500 mm.
Skull, length from front of premaxillae to rear of condyles	528 mm.
Skull, length from front of premaxillae to occipital protuberance	557 mm.
Distance from occipital crest to front of nasals	445 mm.
Distance from front of premaxillae to front of hinder nares	315 mm.
Distance from front of premaxillae to first premolar	154 mm.
Distance between bases of horn-cores	260 mm.
Width at hinder ends of temporal fossae	177 mm.
Width above first true molar, greatest	212 mm.
Width above anterior premolar, greatest	128 mm.
Width of palate between last molars	115 mm.
Width of palate between anterior premolars	93 mm.
Width at mastoid region	272 mm.

Width at rear of orbits	345 mm.
From occipital protuberance to line joining rear of orbits	210 mm.
From front of premaxillae to line joining rear of orbits	330 mm.
Length of horn-core along upper curve	222 mm.
Length of horn-core along lower curve	275 mm.
Circumference of base of horn-core	275 mm.
Diameter of base of horn-core on plane of face	93 mm.
Diameter of base of horn-core at right angles to latter	83 mm.
Distance between tips of horn-cores	610 mm.
Length lower jaw from front to condyle, straight line	436 mm.
Breadth of atlas	220 mm.
Breadth of axis, in front	127 mm.
Height of spine of first dorsal vertebra	495 mm.
Length of scapula along the spine	490 mm.
Width of upper end of scapula	300 mm.
Humerus, total length	375 mm.
Humerus, length from head to inner side of distal end	315 mm.
Humerus, diameter at middle of length, side to side	60 mm.
Humerus, diameter at distal end, side to side	110 mm.
Radius, total length	335 mm.
Radius, diameter at middle of length, side to side	57 mm.
Radius, diameter at middle of length, fore and aft	36 mm.
Radius, width at lower end, side to side	95 mm.
Ulna, total length	435 mm.
Anterior cannon-bone, total length	206 mm.
Anterior cannon-bone, diameter at middle of shaft, side to side	52 mm.
Anterior cannon-bone, diameter at middle of shaft, fore and aft	33 mm.
Anterior cannon-bone, diameter of lower end, side to side	91 mm.
Pelvis, total length	555 mm.
Pelvis, width at acetabula	280 mm.
Pelvis, width at hinder end of ischia	295 mm.
Femur, total length	450 mm.
Femur, length from head to inner side of distal end	400 mm.
Femur, diameter at middle of length, fore and aft	55 mm.
Femur, diameter at middle of length, side to side	53 mm.
Femur, diameter at lower end, side to side, greatest	128 mm.
Tibia, total length	412 mm.
Tibia, diameter at middle of length, side to side	60 mm.
Tibia, diameter at middle of length, fore and aft	46 mm.
Tibia, diameter near lower end, side to side	78 mm.
Calcaneum, total length	162 mm.
Hinder cannon-bone, total length	255 mm.
Hinder cannon-bone, diameter at middle of length, side to side	40 mm.
Hinder cannon-bone, diameter at middle of length, fore and aft	38 mm.
Hinder cannon-bone, diameter at lower end, side to side	75 mm.

Inasmuch as the teeth of the specimen here measured were too much worn to give satisfactory results, use is made of a skull of a male bison from northern Alberta, British America, No. 172689, U. S. Nat. Mus. The length of this skull is 566 mm. and therefore somewhat greater than that of the skull of the mounted skeleton. In this skull, too, the premolars, especially the lower ones, are much worn and for that reason the measurements of these in another specimen are given:

MEASUREMENTS OF SERIES OF TEETH.

Length, upper premolar-molar series	143 mm.
Length, upper premolar series	60 mm.
Length, upper molar series	87 mm.
Length, lower premolar-molar series	154 mm.
Length, lower premolar series	53 mm.
Length, lower molar series	102 mm.

INDIVIDUAL TEETH.

Upper Teeth	No. 172689	Lower Teeth	No. 172689	No. 38302
Pm.², length	21 mm.	Pm.₂, length	14 mm.	13.5mm.
width	14 mm.	width	10 mm.	9.8mm.
Pm.³, length	22 mm.	Pm.₃, length	19 mm.	19 mm.
width	20 mm.	width	11 mm.	11 mm.
Pm.⁴, length	18 mm.	Pm.₄, length	20 mm.	21.5mm.
width	25 mm.	width	13 mm.	13 mm.
M.¹, length	24 mm.	M.₁, length	25 mm.	25.5mm.
width	26 mm.	width	19 mm.	16 mm.
M.², length	30 mm.	M.₂, length	31 mm.	31.2mm.
width	28 mm.	width	20 mm.	16.5mm.
M.³, length	33 mm.	M.₃, length	47 mm.	42 mm
width	27 mm.	width	20 mm.	16 mm.

The intermediate styles on the outer faces of the upper teeth, those between the horns of the crescents, are strongly developed, being broader than, and fully as prominent as, the primary ones. On the inner side of the upper molars, between the two lobes, is a strong column, which, as the tooth becomes worn, appears on the worn surface as a strong fold of enamel filling up the valley between the lobes. When the tooth becomes worn down to near the roots, this fold disappears.

In the lower molars the intermediate styles are on the inner side of the teeth and project strongly upward on the grinding face. On the outer face, filling up the valley between the two lobes, is a column like that of the upper teeth, which, on wearing down, produces a similar fold of enamel.

In his monograph on The American Bisons, Allen has given measurements and figures which show that cannon-bones, both of the front and hinder limbs, are extremely variable, especially in the side-to-side diameter. The horns of this species are short and stout, the circumference at the base being considerably greater than the length along the upper curve. They are sometimes only slightly curved, usually rather strongly so. They are directed outward, more or less downward and backward, then somewhat upward. Usually a line drawn from the tips of one horn-core to the other will fall behind and about on a level with the occipital crest. Often the forehead is more or less inflated and then the horn-cores are directed more strongly downward. The species may be distinguished in general by the short stubby horn-cores directed outward and backward. The horn-cores of the female are smaller and slenderer than those of the male. Plate XXXVIII presents views of the skull and of the upper and lower teeth. The figures have been reproduced from Allen's work on American Bisons already referred to.

The American Bison, in the early part of the last century, was an abundant animal probably all over the state of Iowa. In order to present its history within the state from that time to its complete disappearance, the following extract is taken from Allen's Monograph, pages 142-143:

It thus appears that the buffalo lingered in western Missouri till about 1820 to 1825. They probably disappeared from southern Iowa at about the same period, but they existed for a much longer time in the northern half of the state. In earlier times (about 1721), Charlevoix found "magnificent meadows" in southeastern Iowa, on Des Moines river, "quite covered with buffalo, and other wild creatures." Major Long, on a trip eastward from Council Bluffs in 1819, found "the skulls and other remains on the plains of the Nishnabotna, and in one instance discovered the tracks of a bull; "but," he adds, "all the herds of these animals appear to have deserted the country east of Council Bluffs." According to Assistant Surgeon Charles C. Keeney, the buffalo was sometimes met with on the open prairies a few miles west of Fort Dodge, on Des Moines river, as late as 1852.

M. Belon, an old French voyageur, whom I met in 1873 on the Yellowstone, acting as interpreter for the expedition of that year, and who moved to Minnesota in 1837, informed me that buffaloes were abundant within fifty miles of St. Paul as late as 1836, and were common on the headwaters of Cedar and Des Moines rivers, on both sides of the Iowa and Minnesota boundary, as late as 1845. They have, however, been for many years extinct throughout the present state of Iowa, with the exception of the occurrence of a few stragglers in the extreme western counties. When I was in the western part of the state in 1867, I was informed that a few still remained in that section, and that up to that time one or more had been killed every year as far south as Greene county. They were represented as being more common farther north, but that no herds were met with south of Sioux river and rarely east of the Missouri. Those found farther east were only stragglers from distant herds. Professor Bessey, of the Iowa Agricultural College, informs me that a few were seen on the bottom-lands below Council Bluffs as late even as about 1869, and also, at about the same time, in the northwestern part of the state—stragglers, of course, from remote herds.

The fossil remains of the American Bison are not infrequently found in Iowa, especially in the western part of the state. In a letter addressed to the writer, dated March 9, 1910, Doctor Calvin wrote: "We have collected a wagon load or more of buffalo bones, including a number of skulls of bulls and cows, from a branch of Cedar creek, east of Turin, in Monona county, Iowa." These remains are in the collection of the University at Iowa City and have been seen by the writer. Regarding the age of these bones Calvin wrote:

The collection represented in the photograph comes from beds of rather uncertain age. They are relatively young; they may be late Pleistocene; they may be post-glacial. Near the Missouri river old valleys had been graded, beaver dams built across them, and buffalo, elk and deer mired in the peaty swamps above the beaver dams. Some change of grade caused the valleys, in their lower courses, to be filled or aggraded to a depth of twenty or thirty feet. Recently another change of grade has resulted in re-excavating the valleys and the buffalo bones are now found at the bottom of these young, narrow deep gulches.

The present writer is informed by Mr. Henry McCall that a number of buffalo heads and elk horns had been picked up on his father's farm, on Beaver creek, about seven miles north of Moorhead, Monona county.

In volume XX of the Iowa Geological Survey, on pages 407-410, Professor Shimek mentions various localities in Harrison and Monona counties where remains of bison have been found. He describes particularly the occurrence of the bones of this animal on Beaver creek, and presents a view of the gully and another of several skulls and other bones of the bison found here. Another locality is near Logan, in Harrison county, on Hog creek.

Prof. Frank A. Wilder (Geol. Surv. Iowa, Vol. XII, p. 190) reported finding many buffalo remains, especially teeth, in the second terrace, at the mouth of a ravine, two and a half miles north of Lehigh, Webster county. With these were mingled articles of Indian workmanship. He mentioned especially a double ring which had been carved from a bone. It was Professor Wilder's view that these remains were probably of late date. They were covered by six feet of silt, on which were growing trees of considerable size.

In the U. S. National Museum there is a part of a skull of a buffalo (Pl. XXXIX, fig. 1) which was found in 1901, near Deloit, Crawford county. It lacks the muzzle, the whole of the upper jaw as well as the lower, and the whole of the cranial base. The horn-cores are present and have a length of only 130 mm. along the lower curve and a fore-and-aft diameter of 52 mm. The greater part of the occipito-parietal suture is yet open. The bone is stained of a dark brown color, appears to be pretty well mineralized, and does not adhere to the tongue. The skull was evidently that of a rather young animal, probably a female. This was found by Mr. R. H. Childress, while excavating a short canal along the railroad for the purpose of straightening Boyer river at that point. The skull and an anterior dorsal vertebra were met with at a distance of seventy-five yards from the main channel of the stream, at a depth of eighteen feet below the surface and six feet below the bed of the river. As to its age geologically one cannot be certain in such a case; but it is doubtful that it belongs to the Pleistocene. It had, however, been buried a long time, for since its burial the stream must have changed its channel and refilled the old one.

The width of this skull at the rear of the orbits is 275 mm.; between the orbits and the horn-cores, 225 mm.

In the collection at Grinnell College, Grinnell, Iowa, there is a partial skull of *Bison bison*. It lacks the lower jaw and the bones in front of the orbits. This skull was found in digging a well near Hubbard, Hardin county. It was deposited in the collection by Dr. N. C. Morse, of Eldora. It is very heavy and appears to be quite thoroughly mineralized. The region is covered with Wisconsin drift.

Prof. Lynds Jones, of Oberlin College, Ohio, has informed the writer that in 1886 he found the skull of a bison at a point about five miles west of Grinnell. It was placed in the museum of the Chapter of the Agassiz Association at Grinnell, and it may now be in the museum of Grinnell College.

Certain bison remains are known which are not determinable. In the collection at Princeton University are two cervical and three dorsal vertebræ which are said to have been taken from the bank of Cedar river, at La Porte City, in the southern part of Black Hawk county. There appears to be no means by which these can be distinguished from the corresponding bones of either of the existing bison, or some of the fossil species. The greatest with of the axis is 195 mm. It is therefore not so large as that of the specimen whose measurements have been given above. The region about La Porte City is covered by Iowan drift and this overlies the Kansan. It may, however, easily be that comparatively recent deposits have been laid down along the river.

In the United States National Museum is a right lower first true molar (No. 1600) which was sent there in 1892 by Dr. V. D. Merrill, from Bear Grove, Guthrie county. The tooth has lost all its animal matter. No details regarding the exact place where found, the kind of soil and the depth, have been preserved, if ever furnished. Bear Grove is located on Kansan drift, but this drift is overlain by loess. It would have been of some interest to know from which deposit, if either, the tooth was derived.

Cranial bones and teeth of probably this species were reported by W J McGee (11th Ann. Rep., U. S. Geol. Surv., p. 431) from near Floyd, Floyd county. They were found at the bottom of fifteen inches of light brown loam, near the top of a twenty-five-foot section along Cedar river. They were accompanied by univalve shells of recent species and partly mineralized wood.

Bison antiquus Leidy.

Although this species has not been reported from Iowa, it is quite certain to be found there at some time and for that reason a brief description is here presented of it. The type specimen was found at Big Bone Lick, Kentucky, a few miles below Cincinnati; a skull referred to the same species was described from California; and a third specimen, which was found near Vincennes, Indiana, is in Earlham College, Richmond, Indiana.

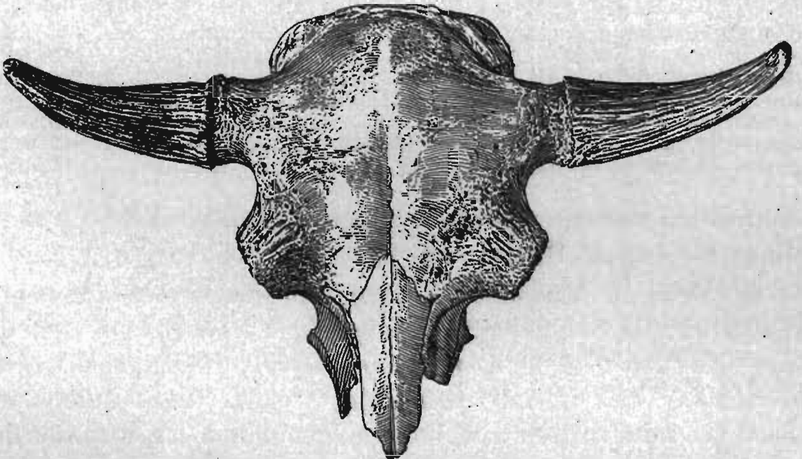

Fig. 100

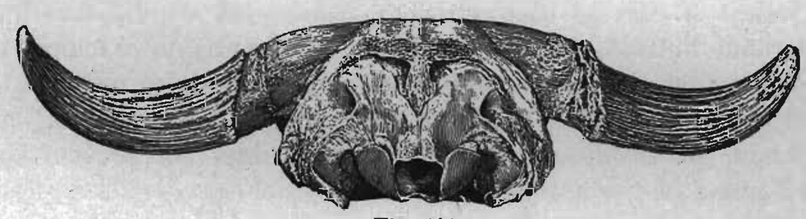

Fig. 101

Figs. 100, 101. *Bison antiquus.* Skull found at Vincennes, Indiana.
100. View from above. x .115.
101. View from rear. x .115.

A figure of a fourth specimen found at The Dalles, Oregon, was published by Thomas Condon (The Two Islands, pl. xxix). The species appears, therefore, to have ranged over a great part of the United States.

The chief characteristic of this species is found in the size and direction of the horn-cores. Figures 100 and 101 are taken from the skull at Earlham College. On examining figure 100 it will be seen that, in a face view, the horn-cores start out at right angles with the midline of the face. In the other bisons the axis of the horn-core is directed nearly toward the orbit of the opposite side. Figure 101, presenting a view of the skull from the rear, shows that the horn-cores pass at first outward and somewhat downward, and that the extremities do not rise much above the skull. The following measurements are given:

MEASUREMENTS ON SKULL OF *BISON ANTIQUUS.*

Width at ear-openings	310 mm.
Width at rear of orbits	360 mm.
Distance between bases of horn-cores	400 mm.
Distance between tips of horn-cores	880 ± mm.
Circumference of base of horn-cores	290 mm.
Diameter of base of horn-core, fore-and-aft	103 mm.
Diameter of base of horn-core, vertical	90 mm.

Additional measurements are given in Volume XXXVI of the Indiana Geological Survey, on page 651.

In the National Museum is a bison tooth which bears the catalog number 2082 and which is labeled as having been sent by Claude D. Brown, from Des Moines, Iowa. It is the left third upper molar and is only moderately worn. It is heavy and thoroughly mineralized and is of a blue color. A considerable part of the cement is retained. The writer finds no characters by which it can be distinguished from teeth of the existing American buffalo, but its condition of fossilization makes it probable that the tooth came from some deposit of older date than the recent soils, sands and gravels in which, so far as we know, *Bison bison* occurs. The tooth does not present the third pillar on the anterior half of the outer face which is present in the last molar of the specimen of *B. occidentalis* described on page 320. The tooth is quite certainly not that of *B. latifrons* or of *B. regius*. It might be that of *B. antiquus;* but the teeth of this are unknown. It is to be regretted that no data regarding the exact locality, the kind of matrix, and the depth have been secured. Such teeth are of practically no scientific value, except to point a protest against such careless collecting.

Bison occidentalis Lucas.

The type of this species consists of the rear of the skull with both horn-cores, the tip of the left one missing. It was found at Fort Yukon, Alaska, by Sir John Richardson. It is now in the National Museum and has the catalog number 4157. It was named and described by Lucas in 1899 (Proc. U. S. Nat. Mus., Vol. XXI, p. 755, pl. lxv). It is here illustrated by two figures (Pl. XXXIX, figs. 2, 3), one presenting a view of the face, the other of the rear. The measurements obtained from this skull are presented in the first column below.

The most complete skull of this species, so far as the writer knows, is one in the American Museum of Natural History, New York. Two views of it are shown here, due to the liberality of the officers of that museum (Pl. XL, figs. 1, 2). Its dimensions are presented in the second column of the table below. This skull was found in the Fox Gulch Mine, near Dawson, Yukon Territory. It lacks, as most specimens of bisons do, the lower jaw. The premaxilla, maxilla, and lachrymal bones of the right side are gone; and in the specimen, as exhibited, these have been restored in plaster. The true molars of the left side are present; but they are somewhat shattered, and are therefore not figured. In the third column are presented the measurements obtained from a mounted specimen in the University of Kansas. This will be further mentioned below.

MEASUREMENTS TAKEN ON SKULLS OF *BISON OCCIDENTALIS*.

	Type	No. 13721 Am. Mus.	University of Kansas
Length from rear of occipital condyles to front of premaxilla	----------	573 mm.	600 mm.
Length from lower lip of foramen magnum to front of premaxilla	----------	537 ± mm.	560 mm.
Length from occipital protuberance to front of premaxilla	----------	600 mm.	615 mm.
Length from occipital protuberance to rear of nasals	266 mm.	285 mm.	271 mm.
Distance from upper lip of foramen magnum to occipital crest	107 mm.	110 mm.	----------
Distance between bases of horn-cores	297 mm.	335 mm.	370 mm.
Width of skull at ear-openings	273 mm.	280 mm.	305 mm.
Width at hinder ends of temporal fossae	175 mm.	200 mm.	195 mm.

MEASUREMENTS OF SKULLS OF *BISON OCCIDENTALIS*—Concluded.

	Type	No. 13721 Am. Mus.	University of Kansas.
Width at constriction between orbits and horn-cores	297 mm.	295 mm.	360 mm.
Width at rear of orbits	355 mm.	355 mm.	397 mm.
Width of muzzle at maxillo-malar sutures	----------	235 mm.	----------
Width of palate between hinder molars	----------	132 mm.	----------
Diameter of horn-core, fore and aft	102 mm.	118 mm.	107 mm.
Diameter of horn-core, vertical	96 mm.	95 mm.	92 mm.
Circumference of base of horn-core	300 mm.	320 mm.	325 mm.
Length of horn-core on upper curve	298 mm.	355 mm.	310 mm.
Length of horn-core on lower curve	365 mm.	420 mm.	375 mm.
Distance between tips of horn-cores	700± mm.	920 mm.	880 mm.
From occipital protuberance to line joining rear of orbits	231 mm.	226 mm.	----------

The following are the dimensions of the three molar teeth in the specimen in the American Museum of Natural History. In the second and third columns are presented the measurements of the corresponding teeth of the American bison, the stage of wear being about the same:

MEASUREMENTS OF MOLAR TEETH.

Teeth	B. occidentalis 13721 A. M. N. H.	B. bison 22638 U. S. N. M.	B. bison 22374 U. S. N. M.
Length of the molar series	92 mm.	92 mm.	93 mm.
M.¹, length	25.5mm.	26 mm.	26 mm.
width	26 mm.	25 mm.	26 mm.
M.², length	31 mm.	33 mm.	33 mm.
width	29 mm.	25 mm.	28 mm.
M.³, length	33 mm.	33 mm.	34 mm.
width	29 mm.	23 mm.	27 mm.

It will be observed that the teeth of the fossil species differ little if any in size from those of the existing American bison. However, a difference is seen in the last molar of the two species. On the anterior half of the outer face there are three styles which descend from the bases of the tooth, instead of the two in the existing bison. That is, the deep valley or groove just opposite the posterior horn of the anterior crescent of

Bison bison is, in *B. occidentalis,* occupied by a style about equal in diameter to the style just behind it and belonging to the hinder half of the outer face of the tooth. This extra style is not present in the other two molars.

It will be seen that in various ways this specimen differs from the type. The skull has exactly the same width, 355 mm., at the rear of the orbits; and the cranial length (from middle of occiput to line joining the rear of the orbits) is practically the same. Nevertheless, other dimensions vary considerably. Similar variations may be observed on comparing a number of skulls of the existing bison. It might be possible, by interpreting too strictly such variations and having a limited number of specimens, to divide *B. occidentalis* into two or more species.

In the University of Kansas, at Lawrence, is the nearly complete skeleton of a specimen of this species. This was found, together with remains of six or seven other individuals, near Russell Springs, Logan county, by Mr. H. T. Martin, many years ago. It is represented by the drawing (Fig. 102). It has already been described by Stewart, Lucas, McClung, and the present writer (Proc. U. S. Nat. Mus., Vol. XXXV, pp. 169-173, figs. 4-6). In the paper just cited are many measurements and corresponding measurements of the bones of an American bison mounted in the National Museum. Many of the bones are somewhat larger than the corresponding ones of the bison with which they are compared; but that bison is not a large one. The extinct species described was probably of about the size of the existing one. Some differences in proportions of some of the bones are indicated; but further comparisons need to be made to establish this.

As is to be expected, the horns which ensheathed the cores are almost always missing, as a result of decay. Nevertheless, in Alaska have been found specimens of this and other species in which the horns are preserved. A figure of a specimen of *B. occidentalis* with the horns is shown in the writer's paper just referred to.

In the Eleventh Volume of the Iowa Geological Survey, p. 160, J. A. Udden reported the discovery of a pair of horn-cores of a

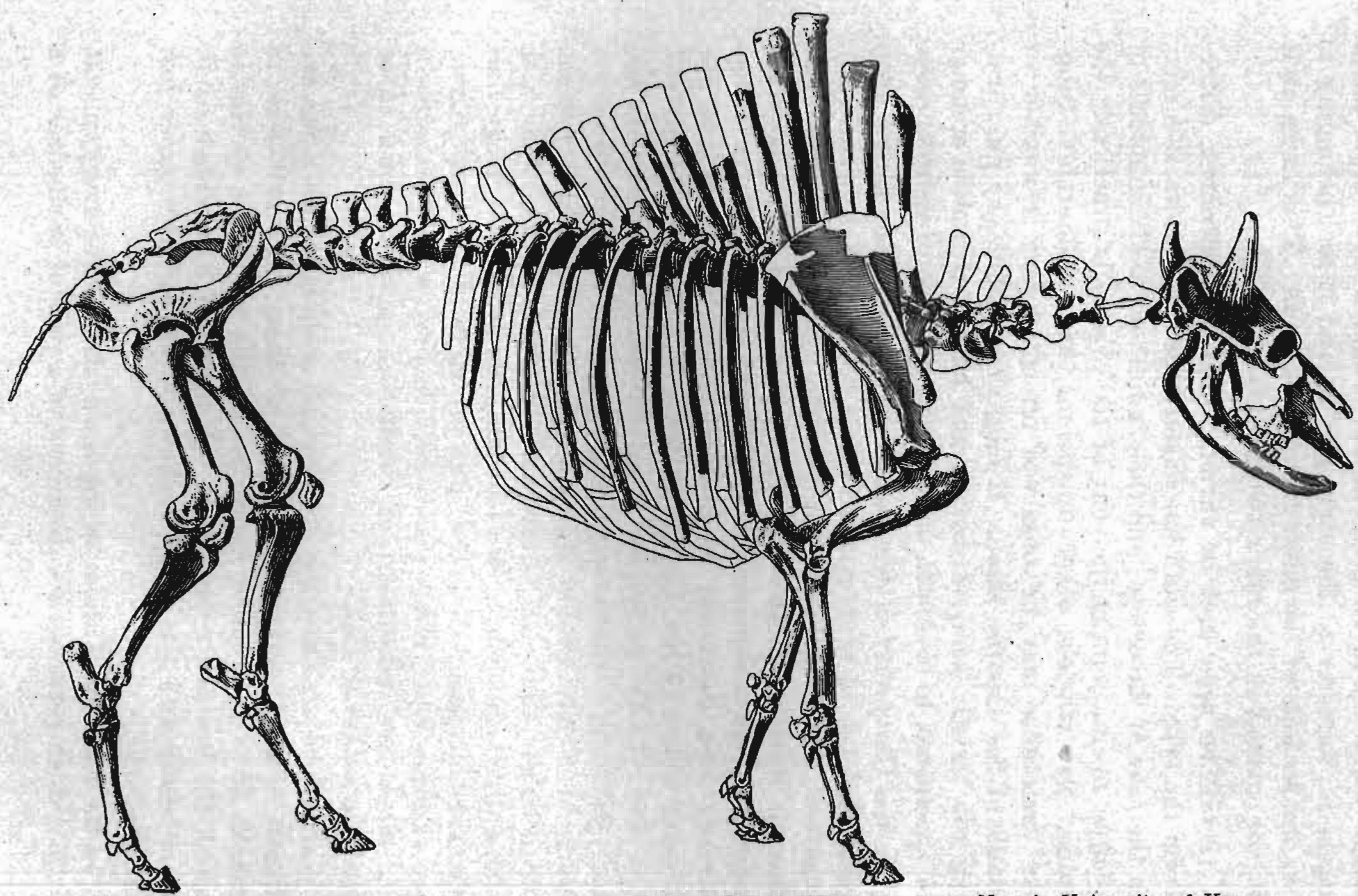

Fig. 102. *Bison occidentalis.* Skeleton of specimen found in Logan county, Kansas. Now in University of Kansas.

bison in Pottawattamie county. These had been met with in digging a well, at a depth of fourteen feet, and they occurred in the loess. The locality is given as being near the quarter post of the east line of section 28, James township (township 76 north, range 40 west). Udden gave the following dimensions:

Measurements	Right core	Left core
Largest circumference	285 mm.	285 mm.
Length measured along inner curve	300 mm.	290 mm.
Length measured along outer curve	370 mm.	360 mm.
Depth of inner curvature	59 mm.	52 mm.

Udden identified this specimen as *Bison latifrons,* but doubtless he employed this term in the broad sense that Leidy gave it. The shortness of the horn-cores shows that it must have belonged to the existing bison, to *B. occidentalis,* or to *B. antiquus.* The fact that the length of the cores along the inner (or upper) curve exceeds somewhat the circumference at the base makes it probable that the skull was not that of *B. bison.* The position of the specimen in the loess also makes it improbable that it belonged to the species just named. The facts in our possession do not enable us to decide between *B. antiquus* and *B. occidentalis.* Inasmuch as specimens of the latter are more abundant, the probabilities are in favor of it.

In the National Museum is a complete left horn-core attached to the greater part of the frontal bone of that side, together with a part of the left temporal. This specimen, which has the catalog number 2349, was sent to the museum in 1878, by Mr. Charles Aldrich, of Webster City, Hamilton county. In a letter dated May 6, 1878, Mr. Aldrich stated that he had, the day before, found the horn-core and frontal bone sticking up out of a gravel bar in the river at that place, which river is the Boone. He further stated that similar dark colored, mineralized, half-petrified bones and teeth were sometimes found in the gravel beds of the river, but he had regarded them as belonging to the elk or the buffalo.

The specimen (Pl. XL, figs. 3, 4) is stained brown and the bone is not adherent to the tongue. It evidently belonged to a rather young animal, since the sagittal and coronal sutures appear to have been yet open. Nevertheless, the dimensions are those of a grown animal. The following measurements have been secured. Those involving the opposite of the skull are necessarily estimated:

Distance between the bases of the horn-cores	326 ± mm.
Width at rear of orbits	340 ± mm.
Width at constriction between orbits and horn-cores	290 ± mm.
Distance between tips of horn-cores	800 ± mm.
Length of horn-core along upper curve	300 mm.
Length of horn-core along lower curve	375 mm.
Length from upper border of base of horn-core to tip, straight	265 mm.
Farthest distance of upper curve from the preceding line	70 mm.

The index of curvature of the horn-core, obtained by dividing the length along the lower curve, multiplied by 100, by the chord of the upper curve (here 265) is 142, which is within the variations found in the horn-cores of *B. occidentalis*. The core is not flattened as much as is usual in the horn-cores of this species, but there is much variation in this character. There appears to be no sufficient reason for not referring the species to *B. occidentalis*.

The chief interest in this specimen is found in the fact that the locality is in the heart of the Des Moines lobe of the Wisconsin drift. The writer has held that no remains of an extinct bison has ever been found in deposits overlying the Wisconsin drift-sheet. Was this horn-core derived from such deposits? It is not probable that it was originally found in this drift itself. Was it derived from some older interglacial deposit which has not yet been recognized there?

According to T. H. Macbride's report on the geology of Hamilton county (Iowa Geol. Surv., Vol XX, pp. 125, 128), the Wisconsin of this county is underlain by Kansan; and this is exposed at places along Boone river, near Webster City. Within the limits of the town there is an exposure of about seventy-two feet of the Wisconsin; but Macbride concluded that the bed of the river was formed by the blue clay (Kansan). There is a possibility, to say the least, that the horn-core in question, as well as the other bones and teeth mentioned by Aldrich, had been washed up out of some as yet unrecognized pre-Wisconsin interglacial deposit at that place.

In the collection at the University of Iowa are some bison remains which were found in what is regarded as post-Kansan deposits at Correctionville, Woodbury county. One specimen, No. 350, is a horn-core; No. 353, the base of a skull. Both of these were found in the Welch gravel pit. The horn-core gave the following measurements:

MEASUREMENTS OF HORN-CORE NO. 350.

Length along the upper curve	292 mm.
Length along the lower curve	365 mm.
Circumference of base	285 mm.
Fore and aft diameter of base	95 mm.
Vertical diameter of base	80 mm.

It seems probable that the horn-core and the fragment of skull belonged to the same individual. A fragment of a left scapula also was found at Correctionville. This fragment rises 204 mm. above the glenoid fossa. So far as observed the scapula does not differ from that of *Bison bison;* but it probably belonged, as did the skull remains, to *B. occidentalis.*

In a gravel pit west of the railroad station at Denison, Crawford county, there was found, in deposits of uncertain age, a large scapula, which appears to have belonged to a bison. The bone is rather light but seems to be mineralized and rings on being struck. It is referred provisionally to *Bison occidentalis.* The following measurements were taken and these are placed alongside of corresponding ones from a scapula of the American bison in the National Museum.

MEASUREMENTS OF SCAPULA.

	Fossil	Recent
Total length parallel with the spine	485 mm.	495 mm.
Greatest width of upper border	220 mm.	295 mm.
Greatest diameter of neck of the bone	69 mm.	87 mm.
Elevation of crest of spine above the bone behind it	37 mm.	58 mm.

In another recent bison scapula measured the width of the upper border was 235 mm.; greatest diameter of the neck, 75 mm.; and the elevation of the spine, 50 mm. Much variation is thus indicated.

Bison alleni Marsh.

This species has not yet been reported from Iowa, but there is every reason for believing that it will be found there. The type specimen, an imperfect horn-core now in Yale University, was found in Blue river, near Manhattan, Kansas. There is a much better specimen in Stanford University, California, which was obtained near American Falls, Idaho. In the National Museum are some injured horn-cores which were found near Minidoka, Idaho. In the same museum is a fine specimen which consists of the rear of the skull with both horn-cores; and these are covered with the horn-sheaths. This was found near Rampart, Alaska. There is still another specimen in this museum, which presents the nearly complete skull and five neck vertebræ. The horn-cores are complete and the larger part of these is en-

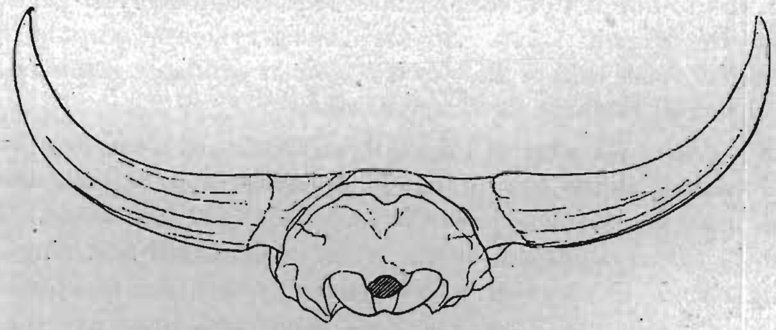

Fig. 103. *Bison alleni.* View of skull from behind, showing curvature of the horn-cores. x .18. From Alaska.

sheathed by the horns. Figures of it are here given (Pl. XLI, figs. 1, 2; text fig. 103). This specimen also was found near Rampart, Alaska.

The species is characterized by moderately long horn-cores, which are directed outward and upward and slightly backward (Fig. 103). When the horns are present the extremities are directed somewhat towards each other. The horn-cores exceed in length the distance between their bases by nearly one-half, and the circumference at the base by about one-quarter of the latter. The length of the horn-core, measured on the upper curve in the specimen here figured, is 600 mm.; in the Stanford University specimen, 720 mm. The circumference at the base of the horn-core in the specimen here figured, is 340 mm.; in the Stanford University skull, 480 mm.

From the Cox pit at Missouri Valley were obtained the distal ends of two cannon-bones of some large ruminant. One of these was figured by Calvin. (Bull. Geol. Soc. Amer., Vol. XX, p. 350, pl. xxii, fig. 3). It is almost certain that they belonged to some species of Bison and the writer refers them provisionally to *B. alleni*. This is done especially because *B. alleni* has already been found associated with a species of camel, *Camelops huerfanensis,* just as at the Cox pit have been found camel remains belonging probably to Camelops. Much better materials are needed in order to decide finally the specific relationships of the Aftonian bison.

Bison latifrons Leidy.

This is another species of extinct bison which has not yet been brought to light in Iowa, but which may be expected. The original specimen was found at Big Bone Lick, Kentucky, and consists of a fragment of the skull with the base of the horn-core attached. The best specimen known was found in Adams county, Ohio, and presents both horn-cores complete and the intervening part of the forehead. Plate XLII, figure 1, arranged from a plate in Allen's work on American Bisons, gives a view of these enormous horn-cores. They have each a length of about 828 mm. along the upper curve and a circumference of 507 mm. at the base. It will be observed that the curvature is moderate. Other specimens of this species have been reported from Texas, Arizona, Georgia, South Carolina, and Florida.

Bison regius Hay.

Only a single specimen, the type skull in the American Museum of Natural History, at New York, is known; but some of the materials referred to *B. latifrons* may really belong here. Two views are here presented of the type specimen (Pl. XLII, figs. 2, 3). This skull was found near Hoxie, Sheridan county Kansas, in 1902. It is characterized by its long, slender, and much curved horn-cores. The distance between the bases of the horn-cores is 362 mm.; the length of the horn-cores, on the upper curve, 910 mm.; the circumference, at the base, 478 mm. Remains of this species are to be expected in Iowa.

Order **Proboscidea.**

The Elephants and Their Kindred.

Mostly large mammals; the feet all with five digits; those of each foot bound together in one mass, and each ending in a hoof. One pair of incisors in each jaw, or missing from one or both jaws. Teeth formed of cones, usually in pairs forming transverse ridges, or of thin plates bound together by cement. Snout usually forming a long proboscis.

This group embraces many extinct forms, as well as the existing elephants. The extinct forms are the stegodons, the bunolophodons, the mastodons, the dinotheres, the palæomastodons, and the mœrotheres. None of the last three groups are found in America. Fossil elephants and mastodons are known from all the great divisions of the globe except Australia.

We have reason to believe that the original home of the order was the continent of Africa. From here the ancestors of the later forms made their way into Europe and southern Asia, meanwhile undergoing continual transformations. From southern Europe their descendants migrated over Europe as far west as Ireland and as far north as Scotland, Denmark and Russia. From India certain species extended probably northeastward into Siberia and crossed over a land bridge that was located probably in the region of Bering Strait. Thence they spread over the whole of North America, through Central America, and over South America.

So far as known, all members of this order were herbivorous in their eating habits. All the members of the Proboscidea with which we have here to deal belonged to the succeeding family.

Family **Elephantidae.**

The Mastodons and Elephants.

Proboscidea in which the outer nares are placed somewhat behind the orbits; symphysis of the lower jaw, short, usually without tusks, if present, relatively small; the upper tusks usually curved more or less strongly upward, sometimes with a band of enamel; cheek-teeth six in each jaw, in the course of the animal's life, the later ones succeeding the earlier from behind.

This family is represented in North America by several extinct species. The best known of these are the common mastodon (*Mammut americanum*), the hairy mammoth (*Elephas primigenius*), and the Columbian mammoth (*E. columbi*).

The characters which distinguish this family are numerous and many of them very striking. Its members have almost always been animals of great size. All are large of body, thick-skinned, straight-limbed, and heavy-footed. The skull is large, not from the magnitude of the brain, but because of the enormous development of air-cells between the outer and inner plates of all the bones of the brain-case and of most of those of the face.

The teeth are remarkable for their form, structure, and manner of appearance in the jaws. In the upper jaw there is always present (at least in the males) a pair of incisors, which project from the mouth as tusks and sometimes reach an enormous size. There may be another pair of tusks in the lower jaw; but, if developed at all, they are usually of small size. There are never any canine teeth. During life, if sufficiently prolonged, there appear on each side of each jaw six cheek-teeth; but not more than four of these are in place at once, sometimes only one. The earliest formed teeth are small, and of simple structure. One after another, younger, larger, and more complex teeth come up behind the first formed teeth and displace them; the sixth appears last of all and is retained until advanced age. The anterior three in each side of each jaw are usually milk-teeth, but, inasmuch as, in some extinct forms, they, or some of them, were displaced by successors arising beneath them the latter would be properly called premolars.

In the vertebral column there are seven neck vertebræ; twenty-three presacrals, nineteen or twenty of which bear ribs; four sacrals, and as many as thirty-one caudals. The shoulder-blade is broad, and it has a much expanded spine. The humerus is long; the radius is slender and crosses the front of the large ulna. The carpals, or wrist bones, are broad and flat; and they and the short metacarpals for the most part form vertical series, not interlocking as they do in most hoofed animals. There are five digits, all with short phalanges and terminating in small hoofs. The bones of all four feet are in life bound together into one mass. Beneath and behind the digits is a great pad of elastic tissue.

The pelvis is large, and the nearly flat hip bones stand out vertically and at right angles with the vertebral column. The socket for the femur looks nearly downward. The femur is long and is without the third trochanter, the process so conspicuous on the inner side of the thigh bone of the horse. The straight and slender fibula runs down on the outer side of the large tibia, and it articulates with the massive but short calcaneum, or heel-bone. The hind foot resembles in form the fore foot, but in life the toes do not stand so nearly perpendicular.

At least four genera of this family have, in the past, existed in North America, Bunolophodon, Rhabdobunus, Mammut and Elephas.

Genus MAMMUT Blumenbach.

The Mastodons.

Elephant-like animals which differ from the true elephants in the character of their teeth, the grinding surface of the tooth being crossed by from two to five roof-like ridges separated by wide, open valleys; each ridge, in the little-worn tooth, divided by a sharp, longitudinal furrow into an inner and an outer cone. Crown not so high as it is in the elephants. Upper jaw with well-developed tusks which are without enamel band; the lower jaw sometimes with one or two short tusks.

The genus is represented in the Pleistocene of North America by at least two species, *Mammut americanum* and *M. progenium*. *M. americanum* forms the type of the genus, which has in the past been usually known under the name Mastodon. Mammut, however, is the earlier name.

Mammut americanum (Kerr).

The American Mastodon.

Teeth of simple pattern, the grinding surface being crossed by from two to five ridges which are separated by open transverse valleys. Lower jaw sometimes furnished with one or two short tusks.

Habitat, the whole of the United States; most, if not the whole, of British America and Yukon Territory. Range in time probably from beginning to end of Pleistocene.

This species (Fig. 104) is by far the best known of any of those belonging to the genus. Hundreds of specimens have come to light in the course of the development of the resources of the country. The first published mention of its bones was made by the celebrated divine, Cotton Mather, in 1717. Every year new finds are reported in the newspapers or in the scientific journals, as a result of excavations and draining operations.

The mastodon was an animal resembling in general form the living elephants; but it was at the same time more heavily built and had thicker, shorter legs, a deeper chest and much broader hips, than the Indian elephant for example.

A comparison of the mounted skeleton of mastodon in the United States National Museum with that of the mounted elephant, a male, twenty years old, shows that the average length of the bodies of the dorsal vertebræ of the mastodon is somewhat greater (about 8 mm., or one-third of an inch) than that of the dorsals of the elephant. As to the bones of the fore limbs, the depth of chest and breadth of the hips, we find the following comparative measurements:

MEASUREMENTS OF MASTODON AND ELEPHANT.

	Mastodon[1]	Elephant
Humerus, length	727 mm.	962 mm.
Humerus, least circumference	355 mm.	310 mm.
Ulna, length	640 mm.	730 mm.
Ulna, least circumference	258 mm.	248 mm.
Femur, length	930 mm.	995 mm.
Femur, least circumference	327 mm.	298 mm.
Tibia, length	535 mm.	622 mm.
Tibia, least circumference	255 mm.	215 mm.
Depth of chest at 6th rib	850 mm.	730 mm.
Width across ilia	1500 mm.	1030 mm.

[1]Note: The femur and the tibia of the mastodon measured above belong to another individual supposed to have been of about the same size as the one furnishing the other bones. Furthermore, the National Museum specimen is a very small one.

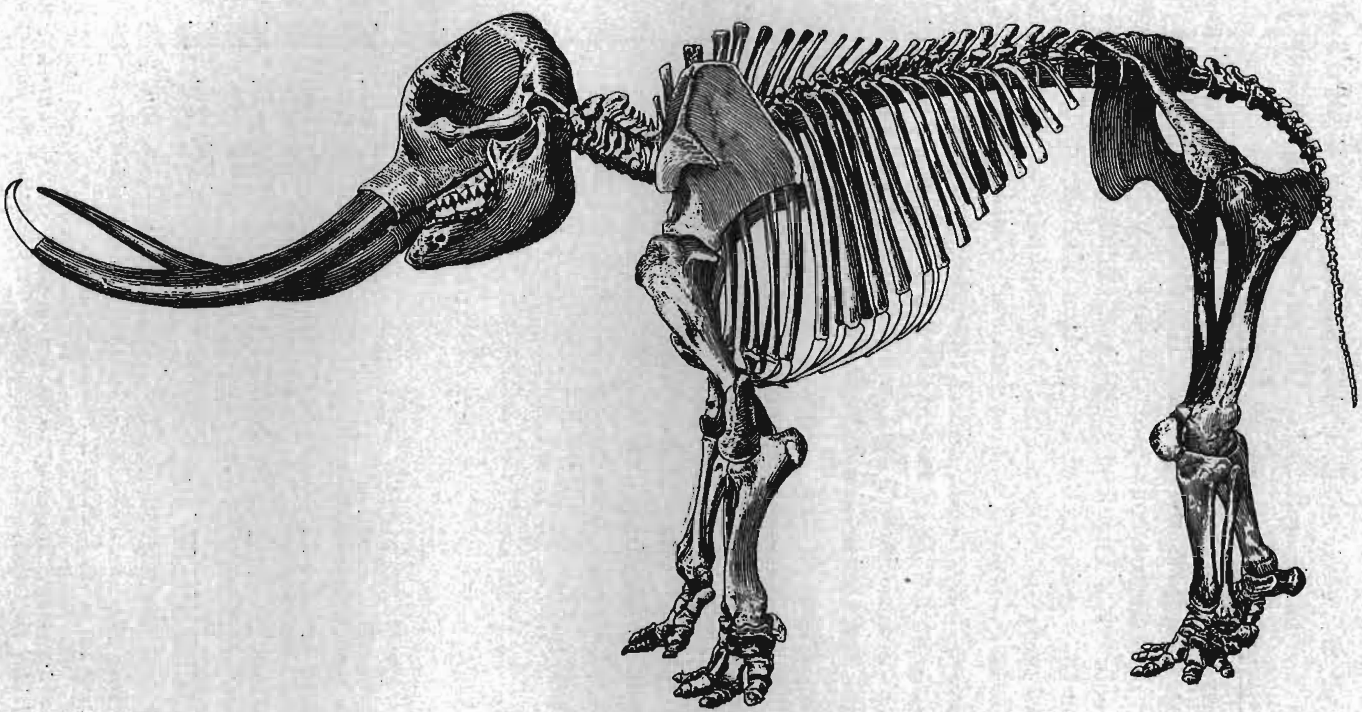

Fig. 104. *Mammut americanum.* Skeleton of a specimen found in Miami county, Indiana. Now in Public Museum, Milwaukee.

It is the wish of the writer to present here such a description of the osteology of the common mastodon as will enable students, collectors, and accidental finders of remains, to identify the species. Of course, if some of the teeth have been found, either alone or with other parts of the skeleton, these at once reveal the nature of the remains. However, bones without teeth come to light sometimes, and even single bones, and these should, if possible, be made distinguishable from bones of any of the species of elephants occurring in our region; but the matter is not always easy; at present it is sometimes impossible.

The skull (Figs. 104, 105; Pl. XLIII, fig. 1) of the common mastodon resembles in a general way that of the true elephants,

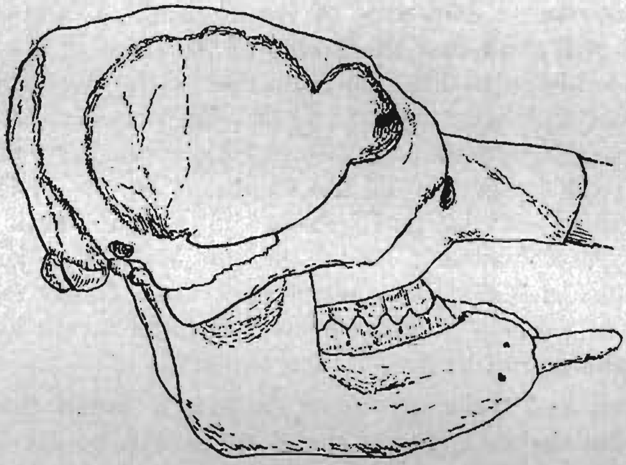

Fig. 105. *Mammut americanum.* Side view of skull of specimen having a small tusk on the left side of the lower jaw. After Falconer and Cautley.

but on close comparison presents important differences. For the most part these differences reveal a lower stage of modification than is seen in the elephants. Comparisons will be made with the skulls of *Elephas primigenius* and *E. columbi.*

The cranium is less elevated than in the species of Elephas just named. This is due to the fact that the diploic layer of the bones of this region is less developed than in the elephants in general. If in a skull of a mastodon a plane be passed through the occipital condyles and the lower border of the orbits, it will be found that the height of the vertex of the skull above this plane equals only about two-thirds the distance from the condyles to the orbits; whereas, in the elephants mentioned, the height of the vertex equals, or nearly so, the whole of the distance mentioned. The alveolar border of the upper jaw lies below the plane mentioned a distance equal to about one-third the distances from the condyles to the orbits; in the elephants, a distance equal to nearly one-half the distance referred to. This great depth of the upper jaw of the elephants is due to the necessity for making room for the great molars.

In the mastodon the external nares are thrown back on the face to a position between the orbits. In the elephants, they are placed above the orbits. In the mastodon the hinder face of the skull is nearly flat; in the elephants it swells out into two great lobes, one on each side of the midline. Examination of the figures will show that the profile of the front of the skull of the mastodon is quite different from that of the elephants. The lower jaw of the mastodon (Pl. XLIII, fig. 2) is more elongated than that of the elephants and it is rather sharply rounded at the angle; the lower jaw of the elephants forms on its lower border a broad curve from its condyle to near the chin. In the mastodon the horizontal part of the jaw is deepest behind; in the elephants it is deepest toward the front. In the mastodon the coronoid process of the jaw rises as high as the condyles; in the elephants not as high as the condyles.

The teeth and tusks are more frequently found than other parts of the skeleton; hence, some space will be given to describing them. The upper tusks are the most striking portion of the skeleton; and the discovery of these often occasions great excitement in the neighborhood where they are found. They are often incomplete when found; more often they are damaged in examining them; and very often they crumble on losing their moisture. The tusks vary greatly in dimensions according to the size, age, and probably, the sex of the animal. Sometimes they attain a length of ten feet or even twelve. They may, in some cases, have a diameter of as much as ten inches at the base. Rarely they are nearly straight; usually moderately curved (Fig. 104); sometimes strongly curved spirally.

At present the writer knows of no way in which to distinguish with any certainty the tusks of the mastodon from those of the elephants that once inhabited our country. The tusks of the latter are likely to be more strongly curved.

The lower jaw of the mastodon has sometimes a single relatively small tusk (Fig. 105); sometimes two; usually none. Sometimes there is found at the chin one or two sockets which once gave support to tusks. These lower tusks are usually only a few inches long; or they may have a length of several inches. They are diminishing inheritances from ancestors which possessed large lower tusks, tusks sometimes larger than the upper ones. The tusks, the upper and probably also the lower ones, were preceded by small milk-tusks; and these are not uncommon objects.

In order to illustrate the internal structure of the tusks of mastodons and elephants a figure is shown on plate LII, figure 4. It represents a part of a tusk of an elephant (mammoth) which was found in Alaska. It was split and somewhat weathered, and shows that the tusk is made up of a succession of hollow cones, each one contained within its predecessor. On the left hand is seen a part of the cavity in which was contained the great mass of pulp at the base of the tusk. The tusks of the mastodon are similarly constructed.

As already stated the cheek-teeth of the mastodon, those employed in the mastication of the food, may rise in number, during the life of the animal, to twenty-four, six on each side of each jaw. Of these six, not more than three of the ones appearing first are in use at the same time; often not more than two (Pl. XLIII, figs. 1, 2) of the later ones remained, and in old age only one. The first tooth to appear is very small, the succeeding ones are successively larger, and the last and hindermost is very large. The three front teeth of the six are known as milk, or decidious, molars; the hinder three, as permanent molars. In great numbers of mammals the milk molars are displaced by a second set, known as premolars. In the bunolophodons some or all of the milk molars were thus displaced and succeeded by premolars; but no premolars have ever been observed in our mastodon.

Each new tooth that appears, both of the milk series and of the so-called permanent series, comes up behind its predecessor, and pushes it forward; and by the time the older tooth is well worn down, it is pushed out of the jaw by the newer one. There is usually to be found, respectively on the front and hinder ends of the tooth, a polished area produced by contact with the predecessor and the successor.

Each tooth consists of the crown and the roots. The crown is in proportion to its size rather low. In its unworn state, it is crossed by from two to five prominent ridges, whose summits are at first sharp. However, soon after appearing through the gums the ridges began to be worn down by attrition against the teeth of the other jaw and against the food. This usually continued until the crown was worn down to the roots. Inasmuch as the front end of each tooth first appeared outside of the gums and began to wear, this is naturally worn down more than the hinder one. As the wear continued, the valley between the ridges gradually became shallower and finally disappeared or nearly so. An examination of a new or little worn tooth shows that there is a very shallow longitudinal valley which crosses all the ridges and divides each of them into an outer and an inner portion. These two portions may be known as the outer and the inner cones. Each cone may, when unworn, show two or three conules at its summit.

In nearly all cases one end of each transverse ridge is nearly perpendicular to the grinding face of the tooth, while the other end slopes away less steeply from the apex to the base. The side of the tooth on which the sloping ends of the ridges are found is, on the lower jaw, the one next the cheeks, while in the upper jaw it is the one next to the tongue.

Both in the lower teeth and in the upper ones, the cones which have the sloping sides, are buttressed by two strong ridges, one of which descends on the front face from the apex to the base, the other on the hinder face of the cone. At the bottom of each transverse valley, the ridge descending from the cone in front and that from the cone behind meet. There might be said to be a ridge running from the front of the tooth to the rear over the peaks and across the valleys. From the disposition of the cones it comes about that when the upper tooth was brought against the lower, the strongly-buttressed cones of each tooth fell between the cones having feeble or no buttresses. In the lower jaw, the weakly-buttressed cones, that is, those with steep sides, are the highest; in the upper jaw, the strongly-buttressed cones are highest. As the teeth became worn down in mastication, it was the strongly-buttressed cones that suffered most; that is, the outer side of the lower teeth and the inner side of the upper teeth, became worn down most.

In the common mastodon of our country there are two cross-ridges on the first and second milk molars; three on the third; three on the first and second true molars; and four or five on the third. This arrangement is indicated by the formula:

$$\frac{2}{2}, \frac{2}{2}, \frac{3}{3}, \frac{3}{3}, \frac{3}{3}, \frac{4 \text{ or } 5}{4 \text{ or } 5}$$

Each tooth of the mastodon, even the relatively small first milk molars, has at least two roots. The larger ones have three or four roots, and some of these are partially divided by deep lateral grooves. There is a tendency toward the formation of two distinct roots for each transverse ridge, but this tendency is only partially achieved. The roots of the lower teeth differ in some respects from the upper ones, inasmuch as they spread laterally to a less extent. The roots of each of the teeth will be described below.

A complete tooth consists of three kinds of material. The greatest part consists of dentine, or ivory. Over this on the crown is a layer five millimeters, more or less, thick, of a harder substance, the enamel. Over the latter, or a part of it, there may be a thin layer of cement, which extends down as a thin crust on the roots.

The crown was the first part to develop. Figure 7 of plate XLV represents the crown of a large tooth that was not yet cut when the animal died. Figure 1 of plate XLVI represents the same tooth seen from the opposite side. No roots had yet become developed and the crown contained a great cavity that was filled with pulp.

In order to facilitate the determination of teeth which may be found, descriptions will be given of those of both jaws, and illustrations will be furnished. Teeth which best illustrate the peculiarities of each sort have been chosen without reference to the locality where they were found.

The teeth of the upper jaw will be first described; and, inasmuch as the last or hindermost molars are the ones most often found, the description will begin with these. In the upper teeth the ridges of the crown run directly across the tooth, and there are two roots at the front of the tooth, except in the case of the first and second milk teeth.

Figure 3 of plate XLIII presents a side view of a moderately worn third upper molar of the left side (No. 2220, National Museum), from Afton, Oklahoma. The extremity of the large hinder root is broken off and is replaced in outline. In this

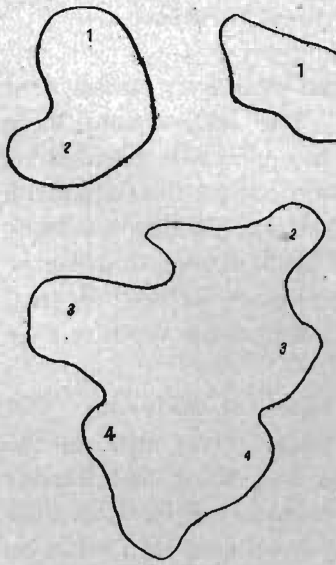

Fig. 106

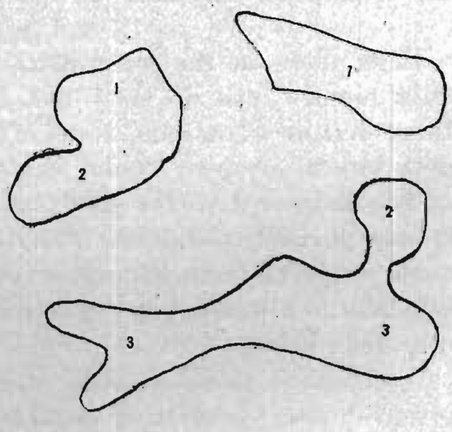

Fig. 107

Figs. 106, 107. *Mammut americanum.* Sections across upper molars of left side reversed so as to appear to be of right molar. x ½.

106. Last upper molar. Number 2220 National Museum. 1. Root supporting first cross-crest, on outer side of tooth; 1, 2, root supporting first and second crests, on inner side; 2, 3, 3, 4, 4, root supporting remaining part of the crown.

107. Second upper molar. Number 2261 National Museum. 1. Root supporting outer half of first cross-crest; 1, 2, root supporting inner ends of first and second crests; 2, 3, 3, root supporting outer end of second crest and the whole of the third.

tooth there are three roots, viz.: outer anterior, which belongs to the outer end of the first crest; an inner anterior, which belongs to the inner ends of the first and second crests; and a posterior, which supports the inner ends of the third and fourth crests and the outer ends of the second, third and fourth. Figure 106 represents a section taken across the roots, but reversed so as to show the arrangement of these in a tooth of the right side, when viewed with the roots turned toward the observer. The arabic numerals on the figure show the transverse ridges to which the lobes of the roots belong. This tooth has a length of 168 mm.; a width of 92 mm.

Figure 3 of plate XLIV shows the crown of a large upper third molar of the right side (No. 2218, National Museum). This, too, was found at Afton, Oklahoma. It had not yet been cut and is therefore wholly unworn. The buttresses on the front and rear faces of the inner cones are well shown. The length of this tooth is 184 mm.; the greatest width, 108 mm.

The second true molar is represented by Figure 1, of plate XLV. This shows the inner face of a left molar from Afton, Oklahoma (No. 2261, National Museum). It had only recently been cut and is worn just through the enamel of the cones of the first transverse crest, and very slightly worn on the second crest. The third crest is untouched. The extremities of all the roots are damaged somewhat, but they had not yet completed their growth. The length of the tooth is 118 mm.; its width is 96 mm. Figure 107 is a section across the roots, of which there are three. It will be seen that the roots were originally covered with a thin layer of cement. During burial this became black in color and much of it was dissolved. For sake of uniformity the drawing representing a section across the roots is reversed, so as to appear as that of a tooth of the right side, seen with the roots toward the observer.

Figure 2 of plate XLV shows the grinding face of a second true molar of the left side (No. 2258, National Museum). This tooth is worn on all the cross-ridges, so that islands of dentine appear on all the cones. On the first two ridges the bottom of the longitudinal valley had been passed, so that the islands of the inner and outer cones had coalesced. Had the wear proceeded a little further, the islands of the inner cones of the first and second ridges would have joined. The tooth has a length of 106 mm. along the crown; a width of 89 mm.

The first molar, represented by figure 3 of plate XLV, is taken from a considerably worn tooth found at Afton, Oklahoma (No. 2243, National Museum). It is a tooth of the right side and is

87 mm. long and 68 mm. wide at the second ridge and 71 mm. at the third. It is considerably worn by mastication. The position of the first crest forms one great island of dentine surrounded by an ellipse of enamel. The two islands of dentine of the second ridge are joined by an isthmus. Four small islands are seen on the hinder crest, one of them belonging to the hinder buttress of the inner cone.

The roots of this tooth diverge considerably to the right and the left. Figure 108 represents a section across these roots, four in number. The pulp cavity had disappeared.

The third deciduous, or milk, molar is usually smaller than the first true molar, but sometimes there is little difference and occasionally it is difficult to distinguish the two. This milk

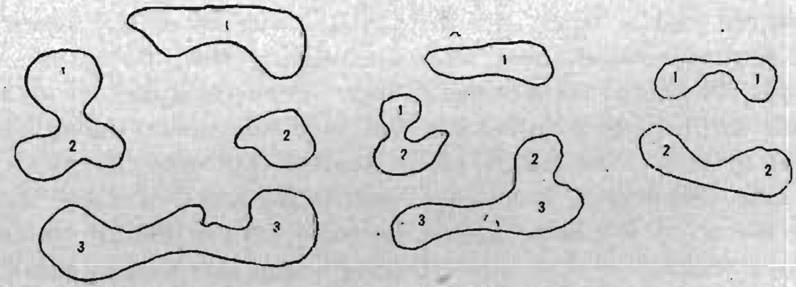

Fig. 108 Fig. 109 Fig. 110

Figs. 108-110. *Mammut americanum.* Section across roots of upper teeth of the right side. x ½.

108. First molar. Number 2243 National Museum. 1, root supporting outer end of first crest; 1, 2, root supporting inner ends of first and second crests; 2, root supporting outer end of second crest; 3, 3, root supporting the third crest.

109. Third milk molar. Number 2236 National Museum. 1, root supporting outer end of first crest; 1, 2, root supporting inner ends of first and second crests; 2, 3, 3, root supporting outer end of second crest and whole of third.

110. Second milk molar. Number 6689 National Museum. 1, 1, root supporting first crest; 2, 2, root supporting second crest.

molar is illustrated by figure 4 of plate XLV. It is a right hand tooth (No. 2230, National Museum) from Afton, Oklahoma. It has a length of 70 mm., an extreme width of 61 mm. There are here three transverse crests; the longitudinal valley is very distinct; the butresses not conspicuous, except the one on the hinder face of the last crest. The enamel is corrugated and the cingulum well developed. There was yet a large pulp cavity. Figure 109 presents sections of the roots of another right third upper milk molar, No. 2236 of the National Museum.

The upper second milk molar is represented by a specimen in the National Museum (No. 6689) belonging to the right side. It is only slightly worn, but the islands of dentine belonging to the anterior of the two cross-ridges have coalesced. The tooth is shown half the natural size by figures 5 and 6 of plate XLV. The enamel is broken away from the inner border and in two places in front. The length is 40 mm., the width at the hinder end is 44 mm. The cingulum is moderately developed at the sides, strongly so at the hinder end.

Figure 6 is a view of the tooth from the outer side. The roots of this tooth are nearly complete, the hinder one having a length of 50 mm., measured from the base of the crown. The blackened coat of cement has been broken away from the outer side of the hinder root. Figure 110 is a section taken across the roots, of which there are two, one for each cross-crest.

The writer has not access to a first upper milk molar. It is rarely found and would belong to an animal that had died at a very early age. The fore-and-aft length of the crown would be about an inch and a quarter (32 mm.); the width about 25 mm.

In the case of the lower teeth the ridges of the crown cross the tooth somewhat obliquely; and there is a single root crossing the anterior end of the tooth. All the other roots are united into a single mass.

An unworn last true molar of the right side (No. 2221, National Museum) is represented by figure 7, plate XLV, and figure 1, of plate XLVI. The first figure mentioned shows the grinding face. There are four distinct ridges that cross the axis of the tooth obliquely from the inside outward and somewhat backward. Behind the fourth crest there is a distinct heel of two tubercles. The cingulum is little developed. Figure 1 of plate XLVI shows the lower surface of the tooth. No roots, or only thin shells of them, had been developed at the death of he animal, and the pulp cavity occupied nearly the whole of the crown.

The length of the tooth is 185 mm.; the breadth at the second crest, 107 mm.; the height of the third inner cone, 76 mm. This tooth is unusually broad for a lower molar. It was found at Afton, Oklahoma.

Figure 2 of plate XLVI, prepared from a considerably worn tooth of the left side (No. 2384, National Museum), found at Afton, Oklahoma, shows five transverse crests besides a tuberculated heel. It will be observed that the anterior crest is worn down so that there is a single ellipse of dentine surrounded by enamel; also, that the dentinal areas of the first and second ridges are about to coalesce where the buttresses have been worn down.

Figure 3 of plate XLVI represents a slightly worn right last molar from near Dawson, Yukon Territory (No. 5101, National Museum). It is worn somewhat on all the crests. The length is 170 mm.; the greatest breadth at the third crest, 96 mm. This specimen is chosen because it illustrates so well the great roots belonging to these teeth when in their prime. The figure, taken from the right side, shows the crown and the roots. Figure 111 presents a cross section of these roots. A large backwardly curved fang occupies by its base that part of the crown furnished

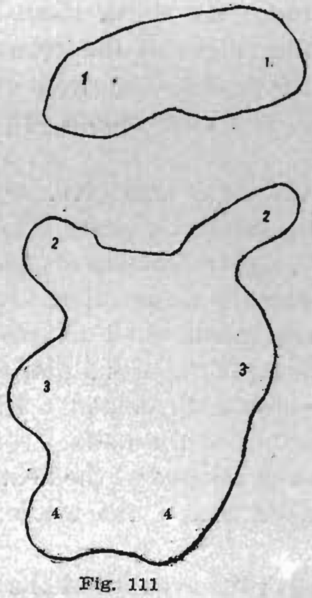

Fig. 111

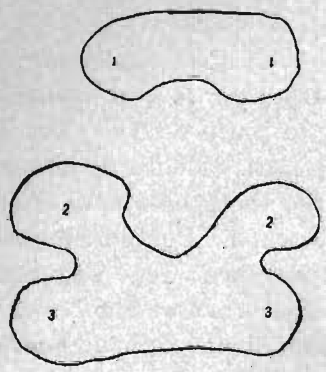

Fig. 112

Figs. 111, 112. *Mammut americanum*. Sections of molars of lower jaw, right side, x½.

111. Third molar. Number 5101 National Museum. The outer side of the tooth is toward the left. 1, 1, root supporting first cross-crest; 2, 2, 3, 3, 4, 4, root supporting remainder of the tooth.

112. Second molar; figure reversed from left side. Number 2228 National Museum. 1, 1, root supporting first crest; 2, 2, 3, 3, root supporting second and third crests.

by the first cross ridge; the hinder root, deeply grooved on the sides, supports the three hinder ridges.

Figure 1 of plate XLVII is taken from a wholly unworn second lower molar of the right side (No. 342, National Museum). It is said to have been found in South Dakota. It shows finely the three crests and the intervening valleys, the buttresses of the outer cones, the corrugations of the enamel, and the cingulum well developed in front and behind, and at the outer ends of the valleys. The summits of all the crests are provided with denticles. While the tooth had evidently been pressing strongly on its predecessor, there is no indication that its successor was exerting pressure on it. There are thin patches of cement on the enamel. There was yet a great pulp cavity. The roots, which probably had already pretty thick walls, have been broken off. The tooth is 121 mm. long, 92 mm. wide at the hinder crest, and 64 mm. high from apex of the hinder inner cone to the base of the enamel.

A slightly worn second true molar of the left side is represented by figure 2 of plate XLVII, from a specimen found at Afton, Oklahoma (No. 2228, National Museum). The three crests are all worn somewhat, the first the most. The figure shows a view taken from the left side. The roots were not quite fully developed and their lower ends are widely open. The layer of blackened cement has been partly removed from the dentine of the roots. Figure 112 is a section across the roots, but reversed so as to appear to be of a tooth of the right side. On the front end of the crown of the tooth is a polished surface where the tooth came into contact with the one in front. Such a polished area does not appear behind; whence is indicated the fact that the last molar was not yet developed enough to exert much pressure on this second one.

The length of this tooth is 118 mm.; its greatest width at the last crest, 96 mm.; height of the front inner cone, 61 mm.; height of the front root, 91 mm.

The first true molar is represented by figure 3 of plate XLVII, taken from a wholly unworn left tooth (No. 2233, National Museum) found at Afton, Oklahoma. The specimen is complete, except that the apex of the anterior inner cone and that of the interior hinder cone have been broken off. There is a large pulp cavity and it is doubtful whether the roots had begun to form. The buttresses of the outer cones are not strongly developed, and some of the ridges on the other cones are nearly as prominent. The cingulum shows in front and behind. The tooth is 92 mm. long, 56.5 mm. wide at the front crest, 62.5 mm. wide at the second crest and 62 mm. at the third crest.

The writer has not access to any first true molar which has developed roots; but Warren, in his monograph on the mastodon, stated that this tooth has two fangs, one which supported the first transverse ridge, and a larger one which supported the other two ridges.

The third milk molar, like the first and second true molars, has three cross ridges, and, in general, resembles the first true molar. It is to be distinguished from the latter principally by its small size; but, as there is variation in size in both these teeth, there may sometimes be some difficulty in the matter. Warren gave as the length of the first true molar figured by him three and a quarter inches, 83 mm.; the milk molar which is represented by figure 4, plate XLVII, is 80 mm. long. Usually, however, there is more difference in the lengths of the two teeth, and the true molar is always broader than the milk molar. The first true molar figured by Warren was two and a half inches wide, 63 mm.; the widest milk molar in my hands (Figs. 5, 6, pl. XLVII) is 56 mm. wide. The smallest milk molar at hand is 71 mm. long and 49 mm. wide behind. The ridges of the third milk molar seem to be somewhat more compressed, or thinner from front to back, than in the first true molar; the enamel is somewhat thinner than in the true molar; the outer end of the anterior valley is often, but not always, blocked by a heavy ridge of the cingulum. Notwithstanding these observed differences, specimens may possibly be found which cannot be certainly distinguished.

Figure 4 of plate XLVII represents a considerably worn last right milk molar (No. 2231, National Museum) which was found at Afton, Oklahoma. Its length is 80 mm.; the width at the third crest, 56 mm. The cingulum had been considerably worn away in front, but it is strongly developed behind, and there is a strong ridge across the outer end of the anterior valley. As will be seen in the figure, the island of dentine corresponding to the first outer cone, had just united with that of the inner cone and with that of the second outer cone. The latter has in like manner joined by a narrow isthmus that of the third outer cone. These outer islands had united through wear of the buttresses. There is even in this tooth a considerable pulp cavity within the hinder root. The walls of this root vary in thickness from 7 mm. to 14 mm.

Figures 5 and 6 of the plate just named are from an unworn tooth found somewhere in Virginia. The enamel is broken off all around the base of the crown and from the inner side of the first and third inner cones. The roots are perfectly preserved.

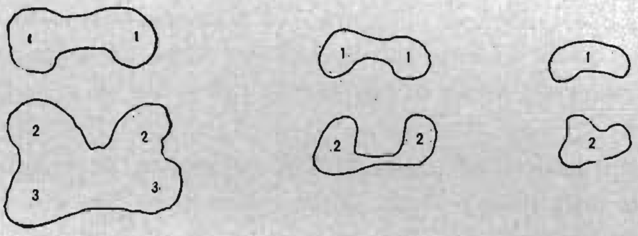

Fig. 113 Fig. 114 Fig 115

Figs. 113-115. Section across roots of lower milk molars of right side. x ½.
113. Third milk molar. Specimen in National Museum. 1, 1, root supporting first crest; 2, 2, 3, 3, root supporting second and third crests.
114. Second milk molar; reversed from tooth of left side. Number 6701 National Museum. 1, 1, root supporting first crest; 2, 2, root supporting second crest.
115. First milk molar. Number 4986 National Museum. 1, root supporting first crest; 2, root supporting second crest.

The tooth is 78 mm. long, 48 mm. wide at the front ridge (making allowance for the missing enamel), and 59 mm. at the third ridge. The enamel is considerably wrinkled. There is a large pulp cavity, and the roots are widely open below. The dentine of these roots is thin. Figure 113 represents a section taken across these roots.

The first and second milk molars are distinguished from all the others by having two instead of three cross ridges. These teeth, especially the first, are rare and would be known only from individuals that had died early in life. On account of their small size, they are not as likely to be collected.

Figure 7 of plate XLVII represents the second lower milk molar of the right side (No. 6690, National Museum). It came from Afton, Oklahoma. Most of the front root has been lost and the whole of the hinder one; and with the last, a part of the hinder cingulum is gone. On the front of the teeth is a polished area, which shows that the tooth had been urging on its predecessor. The length of this tooth is 41 mm.; but it must originally have been slightly longer. The width in front is 32 mm.; at the second crest, 38 mm.. The fissure that separated the inner from the outer cone of each crest is scarcely indicated.

Figure 8 of plate XLVII represents a specimen of this tooth (No. 6701, National Museum), so deeply worn down that the dentine area of the front and hinder crests, and of the front and hinder cingula, have coalesced into one area. It belonged to the left side. The length is 42 mm.; the width in front, 32 mm.; at second crest, 39 mm. Figure 114 represents a section taken across the roots of this tooth; but for sake of uniformity the figure is reversed so as to appear as the roots of a tooth of the right side.

Figures 9 and 10 of plate XLVII represent, as supposed, the first lower milk molar of the right side. It is possible that it is the first upper milk molar. It was found at Kimmswick, Missouri (No. 4986, National Museum). It is pretty well worn, so that the two islands of dentine of the anterior cones are united, and those of the hinder crest on the point of uniting. The tooth is 33 mm. long, front to rear, and 29 mm. wide at the hinder crest. The width in front was greater than appears, for the enamel at each end of the front crest is broken off. The inner cones appear to have been much smaller than the outer cones. The transverse valley is wider at its outer end than at the inner, and seems to have been blocked by a ridge of the cingulum. The front and rear portions of the cingulum are present and moderately broad. There is a pressure area on the rear of the crown. There are two roots on this tooth, the hinder one being the larger. Figure 115 is a section across the roots of this tooth. They were at one time doubtless longer. The apices were probably broken off after burial. Warren states (Monograph, page 65) that the first lower milk molar figured by him had a width of only seven-eighths of an inch, 22.5 mm.

Having described the individual teeth of the common mastodon, it may be a convenience to students and others to have an analytical table for use in distinguishing these teeth from those of other animals, and for locating in the jaw the position of any tooth which may be found. The following is therefore offered.

ANALYSIS OF THE TEETH OF *MAMMUT AMERICANUM*.

A. Teeth varying in size from 70mm. in length and about 50mm. in width to perhaps 200mm. in length and 100mm. in width and not formed of thin plates, but having from 3 to 5 transverse crests crossing the grinding face; or smaller teeth with 2 transverse crests, at least one of them composed of 2 cones, and the crests separated by a transverse open valley. The American Mastodon. (1, 2.)

AA. Teeth of the size of the smaller ones mentioned or still smaller; without distinct crests; or, if present, these connected at one end by a wall, the crest not divided into 2 cones; or valleys filled with accessory tubercles; or teeth composed of thin plates. Not the American Mastodon.

1. Grinding face having the crests directed straight across it; two roots side by side at one end and two other roots (except in the small milk molars). Upper teeth. (*a.*)
2. Grinding face having the crests directed more or less obliquely across it; one relatively small root across one end and one larger behind it. Lower teeth. (*a.*)

a. One crest worn down more than the others; under this crest either one or two roots relatively small compared with the remaining root. Front end. (*b*, *bb.*)

b. Tooth, when held with front end away from the observer and the grinding face toward him, has the more sloping end of the crests, that end with the front and rear buttresses, directed toward the right hand. Tooth of right side of jaw. (*c*, *cc*, *ccc.*)

bb. Tooth, when held as above directed, has the more sloping end, with buttressed cones, directed toward the left hand. Tooth of left side of jaw. (*c*, *cc.*)

c. Tooth with 4 or 5 transverse crests. Third true molar.

cc. Tooth with three transverse crests. (*d*, *dd*, *ddd.*)

d. Tooth with length from about 105mm. to 132mm.; width from about 75mm. to 95mm. Second true molar.

dd. Tooth varying in length from about 80mm. to 95mm.; width from about 63mm. to about 70mm. First true molar.

ddd. Tooth varying in length from about 70mm. to about 83mm.; in width from about 50mm. to about 65mm. Third milk molar.

ccc. Tooth with two transverse crests. (*e*, *ee.*)

e. Tooth about 45mm. long. Second milk molar.

ee. Tooth about 30mm. long. First milk molar.

The rarely found first and second milk molars of the mastodon might be mistaken for the teeth of tapirs or other animals. The teeth of the tapirs have sharp cross ridges, but these are not divided by a longitudinal valley or fissure into inner and outer cones, the cross ridges of the tapir's upper teeth are united at their outer ends by a longitudinal ridge, wholly closing the valley. The same remark applies to the teeth of the rhinoceroses.

A brief discussion will be given of the vertebral column of the mastodon. While the whole of this is not often found it is not unusual for single vertebræ or a few of them to be brought to light.

The vertebral column consisted of seven cervicals, twenty dorsals, three lumbars, and of about twenty-five or thirty caudals,

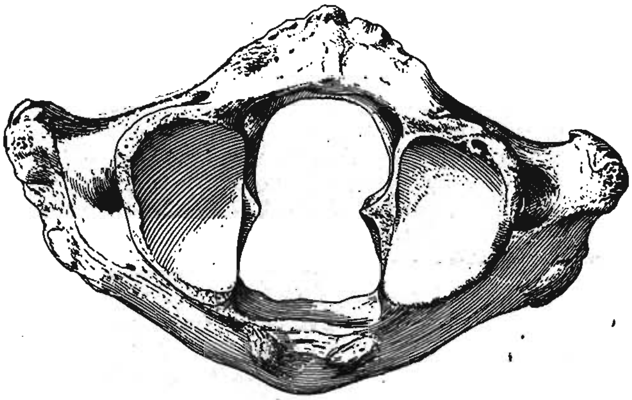

Fig. 116. *Mammut americanum.* Atlas of specimen in National Museum. From Church, Michigan. Seen from front. x ½.

but no specimen has probably been found with all the caudals preserved, at least rescued. It is probable likewise that the number of caudals varied somewhat in different individuals.

The neck of the elephant and mastodon, when compared with that of most other mammals, is extremely short. It was, of course, with the mastodon as with the elephants, impossible for the animal to bring the mouth to the ground when standing.

The neck vertebræ, known as the cervicals, may, except the last one, be distinguished from all the other vertebræ by the fact that there is on each side, in the transverse process, a foramen for the passage of an artery. The seventh has no such foramina, but it differs from the dorsals in having a short slender spinous process, and in having, just behind the base of the transverse process, a smooth concave surface for the head of a rib, and no such surface in front of the process.

With the exception of the second, the vertebræ of the neck were shorter than those of the dorsal region. They were, however, broader than the dorsals.

The first one behind the head, the atlas (Fig. 116), is the broadest of all the cervicals, and its lateral portions form the largest part of the bone. Figure 116 represents this bone, seen from the front and drawn from the mounted specimen in the National Museum. At the anterior end are seen the great, smooth, concave articular surfaces for the condyles of the skull. At the hinder end are somewhat similar surfaces for articulation with the next vertebra, the axis. In the specimen figured, the width of the bone is 335 mm.; the height, 215 mm.; the fore and aft extent on the lower face of the bone, 73 mm. The opening for the spinal cord and odontoid process is 111 mm. high, that part for the spinal cord, the upper division, is 80 mm. wide. According to Warren the breadth of this atlas in the great mastodon described by him and now in the American Museum of Natural History was eighteen inches (462 mm.).

This bone differs from that of the mammoth in having a much larger opening for the spinal cord and the odontoid process, and in having a different section at the midline of the neural arch. Compare figure 116 with figure 135.

The axis, a bone very likely to be found and a characteristic one, differs from all other vertebræ of the spinal column in having a large nipple-shaped process on the front of the centrum, and a large, almost cubical neural spine (Figures 117, 118). On the front of the centrum there is on each side a large smooth articular surface for the atlas, and these meet below the odontoid process. Each surface is 95 mm. high. The front end of the centrum is 166 mm. from side to side. The hinder end of the centrum is somewhat concave and somewhat broader than long.

The spinal canal is large, 72 mm. wide and fully as high. The neural spine is about 85 mm. long and 85 mm. wide.

The axis of the mastodon differs much from that of the mammoth. In the latter the spinal canal is broader than high, the neural arches are shorter and thicker, and the neural spine is considerably longer fore and aft than thick. Compare figures 117 and 118 with figures 136 and 137.

The remaining cervicals are short, and they have short, slender spines. The third, fourth, fifth and sixth cervicals of the National Museum mounted specimen, are each 47 mm. long, and the seventh, 54 mm.; but this is a very small mastodon.

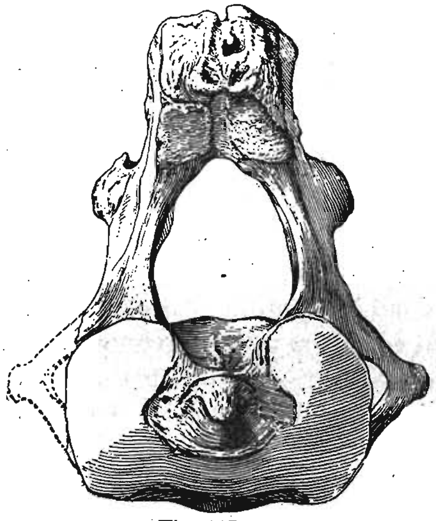

Fig. 117

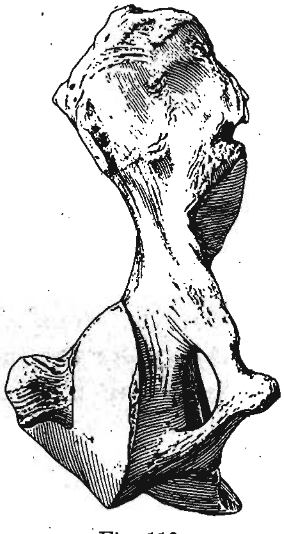

Fig. 118

Figs. 117, 118. *Mammut americanum.* Axis of same specimen as figure 116. x ½.
117. Axis seen from front.
118. Axis seen from left side.

The dorsal vertebræ are those to which were attached the ribs. They are twenty in number; but it may occasionally have happened that the hindermost rib was not developed, thus throwing the corresponding vertebra into the lumbar series. The dorsals may be known from their having short, thick, transverse processes which are not pierced by a foramen, and which arise from the arches; long, medium or short neural spines, which are mostly rather broad from front to back; and from having on each side one or two concavities for the heads of ribs. The anterior fourteen or fifteen have a concavity on each side at each end for the half of a rib-head.

All the dorsals of the mounted specimen in the National Museum have a width of close to 125 mm. They vary in length from 56 to 70 mm. Those of the anterior half of the dorsal series average 59 mm. in length; those of the hinder half average a length of 68 mm. These measurements do not include anything for the intervening cartilages that were present in life. A medium dorsal vertebra of the great Warren mastodon has a width, at the front of the centrum, of 170 mm.

The centra of the dorsals of the mounted Indian elephant in the National Museum, a male twenty years old with a height of a little more than eight feet, vary in length from 52 mm. to 63 mm. The animal, therefore, had a shorter back and longer legs than the mastodon in the same museum.

About six or eight of the anterior dorsals of the mastodon have very long neural spines, and these are directed upward and backward. In the National Museum specimen the third dorsal has a spine 381 mm. (15 inches) long; but in most specimens the spines will be found still longer. The third dorsal of the Warren mastodon had a spine twenty-three inches (600 mm.) long. The succeeding spines gradually became shorter, so that the hinder ones were very short.

The lumbar vertebræ are three in number. They resemble greatly the hindermost dorsals, but have no excavations on the sides of the centra for rib-heads. Their transverse processes are longer than those of the hinder dorsals and stand more directly outward. While the first lumbar centrum has about the same breadth as the last dorsal, the third lumbar is considerably wider, about 150 mm., in the National Museum specimen. Each lumbar in the specimen mentioned, is 70 mm. long on the lower face of the centrum. In the Warren mastodon the first lumbar vertebra, including the transverse processes, has a width of seventeen inches (432 mm.).

The sacrum is that part of the vertebral column which is articulated between the two ilia, or hip-bones. It consists of five vertebræ; but three, in old age at least, are so thoroughly consolidated as to form a single mass. It appears that the first and the last of these vertebræ may remain, even to adult age, unconsolidated with the others, and one or the other may therefore be missing from the specimen found. In old age, the sacrum often becomes wholly consolidated with the hip-bones, and then the bones of the pelvis form a single mass. The sacrum of the mounted specimen in the National Museum, is 400 mm. in length. Its width in front is 275 mm.; behind, 220 mm.

The number of caudals is somewhat doubtful, no specimen having been found with all present. The number varied probably somewhat in different individuals. There were probably about twenty-five or thirty. They are naturally smaller than those of the trunk. The first are largest and have all the elements of a vertebra; those toward the tip of the tail are much reduced in size, and lack all parts, except the centrum. Those of the upper half of the tail have long, flat, outstanding transverse processes and short neural spines. The second caudal of the National Museum specimen, has the centrum 70 mm. long, 86 mm. wide in front, while from the extremity of one transverse process to that of the other is 230 mm. The bases of the processes occupy nearly the whole length of the centrum. In case this part of a mastodon is found, great care should be taken to collect all segments present, especially the terminal ones.

As already stated there were in the mastodon twenty pairs of ribs. Below the upper fourth, the first rib is nearly straight, flat, and paddle-like in form. Its length, in the National Museum specimen, is 510 mm.; at the distal end, the width is 120 mm. The longest rib is the seventh and is 1063 mm. long. In the Warren mastodon, the longest rib is stated to be the ninth and the length fifty-four and three-fourths inches (1390 mm.).

The longest rib of the Indian elephant in the National Museum equals 915 mm. The greatest width of the abdomen is 1000 mm. In the mastodon described here, the width of the abdomen is 1113 mm., as mounted.

The scapula of the mastodon, as well as that of the elephants, is occasionally found. In all these species this bone is large, of a triangular form, and apparently it offers few characters by which the species may be distinguished. Besides its general form and size, the scapula is remarkable on account of the enormous spine which traverses the greater part of the distance from the glenoid fossa to the upper angle. In the scapula of the mounted mastodon in the National Museum, this spine stands above the general level of the outer face of the bone a distance of 160 mm. At its lower end it gives off two great processes, one of which extends downward and slightly forward, the other backward and somewhat downward. The side of the scapula which was applied against the ribs, is not wholly flat, but has a strong ridge, which ascended from the glenoid fossa to the upper angle of the bone. This ridge on the inner face and the spine on the outer face strengthened the bone enormously. Figure 119 has been prepared from the figure of the Warren mastodon.

It is of importance to distinguish, if possible, the scapula of the mastodon from that of the elephants. Unfortunately the writer has at hand no scapula of *Elephas primigenius* with which to make comparisons; but he makes use of a figure of the scapula of the Beresowka mammoth (Fig. 120). It is after a figure by Salensky (Scient. Results, etc., 1903, pl. xvi, fig. 95). The following measurements are presented, which may be of some help. The first measurement is taken from the middle of the inner border of the glenoid fossa to the highest point, or angle, of the bone, where the spine terminates. The second runs from the angle just mentioned to the one which projects backward. The third extends from the angle last mentioned, in a straight line, to the hinder end of the glenoid fossa. The next measurement extends from the hinder angle forward to meet perpendicularly the anterior border of the bone. The fifth gives the length of the glenoid fossa. The sixth measurement is intended to show how far the anterior edge of the bone is removed from the front of the spine, and is taken at the level of the point where the two processes of the spine diverge. As the spine does not arise abruptly, this width cannot be determined with absolute accuracy; but, at present the writer relies mostly on it to distinguish the scapula of the mastodon from that of the elephants. In the second column, under each set of measurements, are quantities obtained by determining what part each measurement is of the first measurement, taken as 100. That is, the figures in the second column of each set represent percentages, which are taken as indices. In the last column are the indices taken from the figure of the scapula (Fig. 120) of the Beresowka mammoth. The actual dimensions the author has not been able to secure.

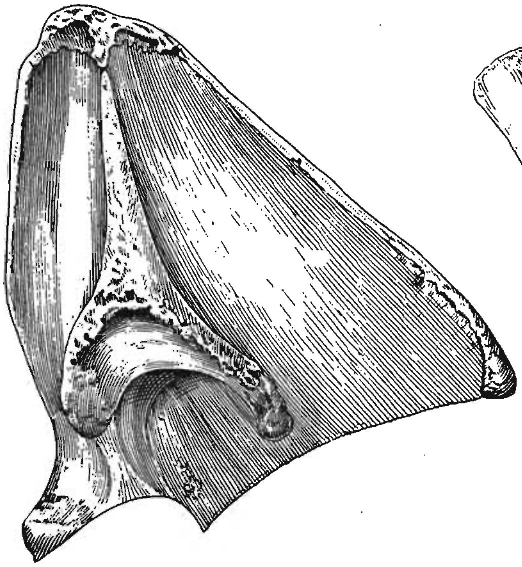

Fig. 119

Fig. 120

Fig. 119. *Mammut americanum.* Left scapula of the Warren mastodon; in American Museum Natural History.
Fig. 120. *Elephas primigenius.* Left scapula of Siberian mammoth. After Salensky.

MEASUREMENTS AND INDICES.

Spaces subtended	Mastodon		Elephas indicus		Elephas africanus		Elephas maximus Indices
	Dimens'ns	Indices	Dimens'ns	Indices	Dimens'ns	Indices	
1. From glenoid fossa to upper angle	685 mm.	100	710 mm.	100	620 mm.	100	100
2. From upper angle to hinder angle	660 mm.	96	600 mm.	84.5	605 mm.	97.5	83
3. From hinder angle to rear glenoid fossa	400 mm.	58.5	410 mm.	58	310 mm.	50	58.4
4. From hinder angle to front border	480 mm.	70	470 mm.	66	400 mm.	64.5	60
5. From front to rear of glenoid fossa	187 mm.	28	198 mm.	26.4	177 mm.	27	------
6. From front of border of bone to base of spine	60 mm.	8.8	38 mm.	5.3	29 mm.	4.6	------

It is not improbable that more specimens of each of the species would modify somewhat the value of the indices. As regards the length of the vertebral border, it is seen that the mastodon resembles more closely the African elephant than the Asiatic (*E. maximus*); while the length of the lower hinder border is nearer the latter. The distance of the front border from the spine is greatest in the mastodon.

Figure 121 shows a section made across the front of the scapula of the mastodon in the National Museum at the level of the parting of the two processes of the spine; while figure 122 shows a section made at the same level on the scapula of the specimen of *Elephas primigenius* in the American Museum of

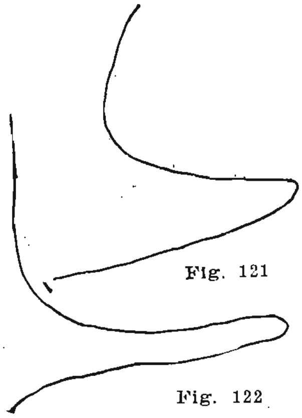

Fig. 121

Fig. 122

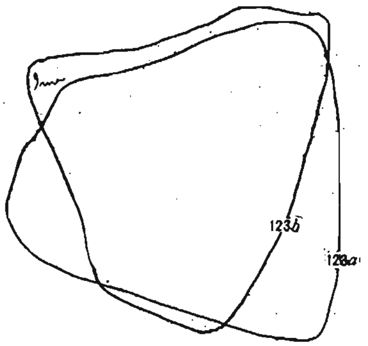

Fig. 121. *Mammut americanum.* Section across front of scapula.
Fig. 122. *Elephas primigenius.* Section across front of scapula.
Fig. 123. Sections across the ulna at the middle of the length. The front of the bones is above, the outer face toward the right.
123a. *Mammut americanum.* From Hillsdale, Michigan; specimen in National Museum.
123b. *Elephas primigenius.* Number 2642 National Museum. From Alaska.

Natural History, New York. The sections are one-half of the natural size. The process toward the right is the front edge of the bone; the line rising is the front of the spine; the lower line shows the inner face of the scapula.

Estimates made from the figure of the great Warren mastodon give the following indices, following the order of the table: 100, 91±, 60±, 76±, 27±, 14±. These agree with those of the National Museum in the greater width of the bone and in the distance of the spine from the anterior border.

Figure 1 of Plate LII, represents a scapula found in 1894 in Muscatine county near Wilton. Its measurements are given on page 388. Its indices, determined in some cases approximately, are, following the same order, 100, 83, 56±, 72, 24, 10±. The writer regards this scapula as belonging to a mastodon.

As regards the proportions of the scapula of *Elephas primigenius* it will probably be found that they vary much. A view of the figure here presented (Fig. 120) shows that the great spine runs very close to the front border of the bone. Too much importance must not be attached to the great differences in width which are presented by figures 119 and 120. Undoubtedly the scapula of the mastodon is sometimes relatively narrower and that of the mammoth relatively wider.

In order to determine to which side the bone belongs place it with the glenoid fossa downward and with the border nearest to the spine forward; the spine will be directed toward the side to which the bone belongs.

The general form of the humerus may be seen in figure 104. It is one of the great bones of the body and one of those most likely to be preserved. It may be easily recognized from its greatly enlarged ends, the slender middle part, the low and rounded head for articulation with the scapula, the semi-cylindrical articulation for the sigmoid cavity of the ulna, the massive deltoid ridge, and the broad supinator ridge. The total length of the humerus of the specimen in the U. S. National Museum, measured in a straight line from the great tuberosity to the distal end on the outer face, is 765 mm.; from the summit of the head to the distal end of the inner face, is 727 mm.; the articular surface at the lower end measures, from side to side, 200 mm. The supinator ridge rises above the lower end of the humerus, 270 mm. Where the shaft is most constricted the diameters are 95 mm. and 120 mm. The total length of the humerus in the Warren mastodon is given as thirty-nine inches (991 mm.). The length of the humerus of the specimen in the National Museum equals that of the centra of eleven and one-half dorsal vertebræ: whereas, in the Indian elephant, the humerus nearly equals the length of fifteen vertebræ.

To determine to which side the bone belongs, stand it with the head upward, the bicipital groove directed forward and the deep cavity at the lower end into which the olecranon of the ulna fits looking backward; then the supinator ridge and the great deltoid ridge will be directed toward the side to which the bone belongs.

The ulna is the principal bone of the forearm. It may be recognized by the great sigmoid cavity for articulation with the lower end of the humerus, the enormous rough process standing backward from this articulation, the triangular shaft, and the rounded articulation at the lower end for some of the bones of the wrist. Figure 104 shows the general form of the bone. In the case of the mounted specimen in the National Museum, the ulna is 640 mm. long in a straight line. The line joining the hinder with the front end of the greater sigmoid cavity (that which receives the humerus), is 130 mm. long. At the lower end of the cavity is a notch that receives the upper end of the radius. The shaft is triangular; the outer face, at the middle of the length of the bone, having a width of 85 mm.; the front face, 87 mm.; the inner (or hinder) face, 95 mm. The lower end articulated with the lunar, the cuneiform, and the pisiform bones of the wrist. The bone is crossed in front by the radius. In the Warren mastodon the ulna has a total length of 864 mm.

Figure 123a represents a section across the left ulna of the mastodon, taken at the middle of the length. Figure 123b shows a corresponding section of the ulna of *Elephas primigenius,* a specimen found in Alaska.

To determine the side to which the bone belongs, stand it with the larger end upward, the rough olecranon process and the concavity of the shaft of the bone backward, the great sigmoid cavity looking forward; then the olecranon process will incline more toward the side to which the bone belongs; on that side, too, will be the sharp ridge which descends from the olecranon to form the hinder outer border of the bone; the smaller of the two processes that enclose the upper end of the radius will be on the same side; at the lower end of the bone, the rough face, with two eminences separated by a groove, will look toward the same side; while the flat surface for the lower end of the radius will be directed toward the opposite side.

The ulna of the mammoth, *E. primigenius,* differs in being slenderer in proportion to the length; in having the outer face divided by a ridge which, starting at the outer of the two processes which embrace the upper end of the radius, runs downward and backward to the outer eminence at the lower end of the bone. This ridge is indicated on the left side of the section, figure 123b. The upper half of the front face is more excavated than in the mastodon.

The radius is a relatively slender bone and is much twisted and bent. It occupied a position in front of the ulna, bending around below to the inner side of the latter. The head of the radius lay, in life, in a notch in the border of the great sigmoid cavity of the humerus; and its upper extremity forms a smooth concave surface which articulated with the lower end of the humerus. The lower and larger end of the bone is flattened on the outer face for union with the lower end of the ulna. The lower extremity presents a large smooth articular surface, the

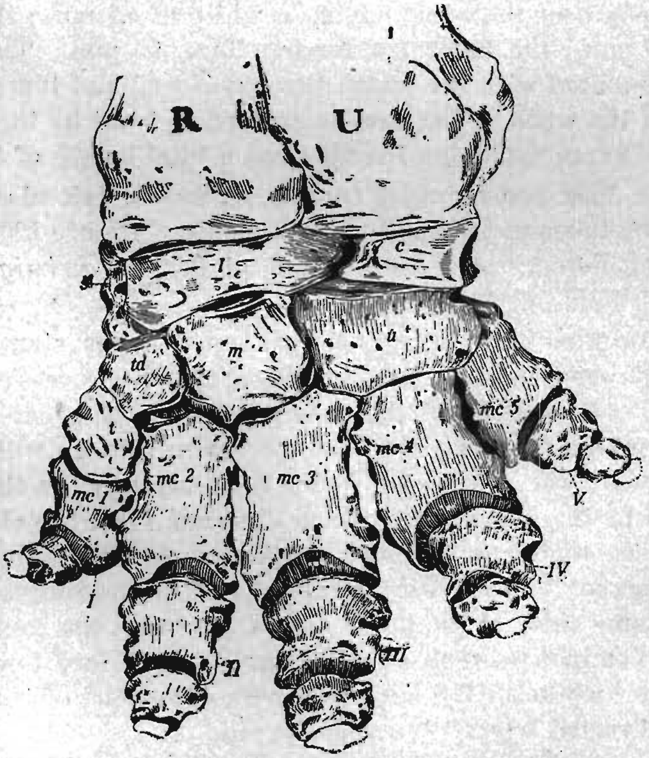

Fig. 124. *Mammut americanum*. Left fore foot seen from in front. *R*, radius; *U*, ulna; *I*, inner digit; *V*, outer digit; *c*, cuneiform bone; *l*, lunar; *s*, scaphoid; *td*, trapezoid; *m*, magnum; *u*, unciform; *mc 1* to *mc 5*, the metacarpals.

greater part of which is applied to the lunar bone, but a small part thereof to the scaphoid. In the National Museum mounted specimen this bone is 600 mm. long; the upper end is 103 mm. wide, its lower end, 133 mm. The diameters at the middle of the shaft are 43 mm. and 52 mm. respectively. The radius of the Warren mastodon is 737 mm. long and 165 mm. across the lower end. No rule for distinguishing this bone from that of the mammoth can at present be given.

Place the larger end of the bone downward, with the sharper edge of this lower end forward and the lowest process of the bone toward the rear, the smooth articular face for the upper end of the ulna backward; then the flattened face of the lower end will look toward the side to which the bone belongs.

The fore foot of the mastodon (Figs. 124, 125) was greatly like that of the elephants. It was a foot that in most respects was very primitive, in that it retained all of the elements typical of the wrist and all of the five digits. Besides this, none of the metacarpals is lengthened, as we find some of them in most of the hoofed animals. The foot was very short and was undoubtedly furnished with a pad of connective tissue behind the digits, with the result that these, in walking, were directed strongly downward, as well as forward; that is, the animal was digitigrade. There were certainly small hoofs at the end of each digit, as in the elephants.

Fig. 125. *Mammut americanum.* Left fore foot seen from the left, or outer side. *p*, pisiform; *ses*, sesamoids. Other explanatory letters as in figure 124.

The bones of the wrist, with the exception of the pisiform, are short and flat, with broad upper and lower smooth articulatory surfaces for movable union with one another, with the bones of the fore arm, and with the metacarpals. The names and connections of the wrist bones may be learned from the figures above referred to, reproduced from Warren's monograph. The terminal phalanges of the digits are represented only in outline, inasmuch as they have probably never yet been found. They were certainly much reduced in size and may not have been present. As to distinguishing them from the corresponding bones of the various fossil elephants, the means for doing this hardly exist as yet; at least, the work has not yet been done. Where mastodon remains are found, care should be taken to collect the smaller, as well as the larger bones. If the feet are present the bones of each foot, if not already mixed with the bones of the other feet, should be kept separate; and, if possible, the bones of each digit separate from those of the others.

The pelvis (Fig. 126) consists of the sacrum, which has already been described as a part of the vertebral column, and the two innominate bones. Each of the latter was composed, in early life, of three bones, the ilium, the ischium, and the pubis,

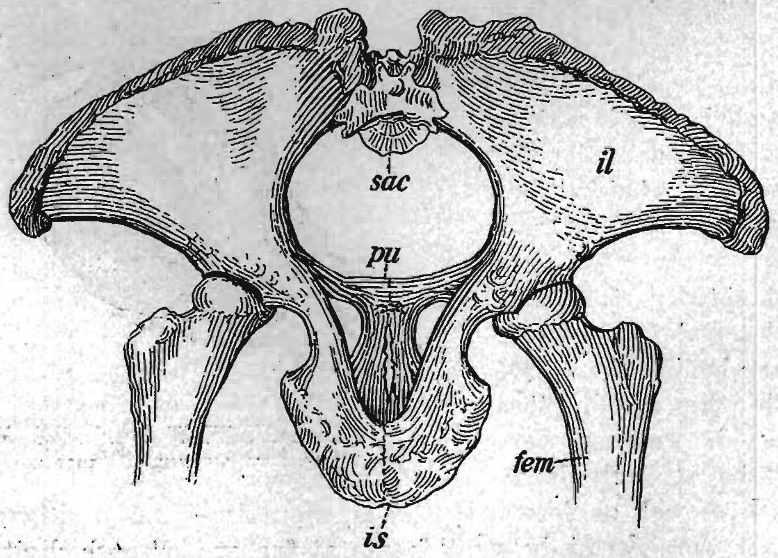

Fig. 126. *Mammut americanum.* Pelvis as seen from behind. After Warren. *fem.* femur; *il,* ilium; *is,* ischium; *pu,* pubis; *sac,* sacrum.

which joined one another at the socket for the femur. In old age the innominate bones may become ankylosed with the sacrum.

The pelvis of the mastodon was enormously wide, much wider than that of the mammoth and that of the living elephants. Like those of the elephants, the ilia are nearly flat on the front face, that face which corresponds to the inner face of most animals, and they stand out at nearly right angles with the spinal column. In the case of the mounted specimen in the National Museum, the distance from the outer extremity of one ilium to that of the other is 1425 mm. (fifty-six inches). In the Warren mastodon the width is given as six feet two inches (1880 mm). Figure 126, re-drawn after Warren, represents the pelvis seen from the rear. In this specimen all the bones are thoroughly consolidated. The width of the pelvis in the mastodon in Milwaukee (Fig. 104) is 1625 mm.; and the one in Earlham College has a pelvis 1900 mm. wide.

The acetabulum, which received the head of the femur, is a cup-shaped cavity and looks nearly directly downward. In the National Museum specimen its diameter is 150 mm. (six inches).

The pelvis of the mastodon differs in several ways from that of the mammoth and the other elephants. Especially is it distinguished by the greater breadth, as compared with the centra of the dorsal vertebra. In the case of the National Museum specimen, the width is equal to twenty-two and four-tenths vertebræ of average length; while, in the Indian elephant, the width is equal to nineteen and four-tenths dorsals of average length.

In the elephants the supra-iliac border descends from its articulation with the sacrum to its outer angle in a uniform curve, a part of a circle; while in the mastodon the border is nearly straight in most of its course.

The femur is a long and relatively slender bone, with a flattened shaft and expanded ends. Its general form may be seen from figure 104. In the National Museum specimen the femur is supplied from an animal found at Kimmswick, Missouri. This has a length of 870 mm. The head has a diameter of 140 mm.; at the middle of the shaft, the greater diameter is 130 mm.; the least, 70 mm. The width across the articulatory surfaces of the lower end is 182 mm. The Warren mastodon's femur measures, from the upper surface of the head to bottom of the inner condyle, 1025 mm. The side-to-side extent of the lower articular surfaces is 254 mm.

The femur is somewhat stouter than that of the mammoth (as represented by a specimen from Alaska). In the latter, the greater diameter, 146 mm., at the slenderest part of the bone, is contained in the length (1110 mm.), seven and six-tenths times; while in the femur of the mastodon above described, the diameter given is contained in the length six and seven-tenths times.

Figure 127 presents a section of the left femur of the National Museum specimen, taken at one-third the length of the bone above the lower end. It will be seen that here the bone is quite

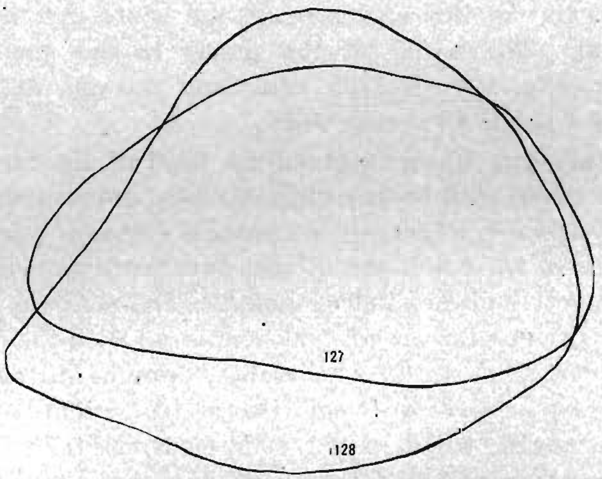

Fig. 127 *Mammut americanum.* Section of left femur, taken one-third the length of the bone above the lower end. x ½.
Fig. 128. *Elephas primigenius.* A section taken as in figure 127. x ½. In these figures the front of the bones is above; the outer border toward the left.

flat, the width being nearly twice the thickness. This is to be compared with a section, taken at the same height, from an Alaska femur, almost certainly that of a mammoth (Fig. 128). Here the thickness is about four-fifths of the width.

To determine to which side the femur belongs, stand the bone with the head upward, with the hollow behind the great trochanter looking backward and with the surface for the patella forward. Then the great trochanter will be on the side to which the bone belongs. At the lower end the straighter border, ascending from the condyles, will be on that side.

The patella, or knee-pan, is a solid bone of considerable size that is very likely to be preserved. Its length, in the leg from Kimmswick, Missouri, is 120 mm.; the width, 116 mm.; the thickness, 80 mm. The surface which was applied to the lower end of the femur is smooth, concave up and down, convex from side to side. The other surfaces of the bone are convex and rough. In the great Warren mastodon the patella has a length of 178 mm. and a width of 152 mm.

The tibia is one of the larger bones of the skeleton. It is straight and has the ends considerably enlarged. The upper end, cut off nearly at right angles with the length of the bone, presents two smooth concave surfaces for articulation with the condyles of the femur. On the rear of the outer tuberosity is a smooth surface for the head of the fibula. The lower end of the tibia has a smooth articular surface which fitted against the astragalus. It is concave from front to rear. On the inner side of the lower end is an eminence, the internal malleolus, which extended down against the inside of the astragalus. Outside of the articulation for the heel-bone is another surface, looking downward and outward, for union with the fibula. The National Museum specimen, the tibia of which is from Kimmswick, Missouri, presents the following measurements:

Length in a straight line	550 mm.
Transverse diameter of upper end	200 mm.
Greatest diameter of shaft, where smallest	90 mm.
Shorter diameter of shaft, where smallest	65 mm.
Diameter from side to side at lower end	160 mm.

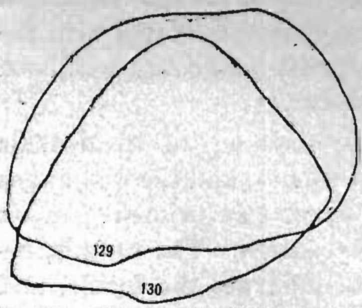

Fig. 129. *Mammut americanum.* Section across tibia at one-third the length of the bone above the lower end. x ½.

Fig. 130. *Elephas primigenius.* A section of the tibia taken as in figure 129.

The tibia of the Warren mastodon has a total length of 712 mm.

Figure 129 represents a section of the tibia of the National Museum mastodon, taken two-thirds the length of the bone from the upper end, while figure 130 shows a section taken at the same level on the tibia of a mammoth from Alaska. It will be seen that, at the point where the sections are taken, that of the mammoth is much more triangular than in the mastodon.

To determine the side to which a tibia belongs place the bone with the larger end upward, the tuberosity for the extensor muscles forward and the great concavity in the upper half of the bone directed backward; then, at the upper end, the smaller concave surface will be on the side to which the bone belongs, as will also the smooth surface for the fibula. At the lower end the sloping surface for the lower end of the fibula will also be on that side.

The fibula is a long slender bone, with flattened faces and sharp ridges, and with one end moderately enlarged, the other considerably so. At the smaller, upper end is a smooth surface which looked forward and was applied against a smooth surface on the back of the outer condyle of the tibia. The lower end of the bone has articular surfaces for three bones, the tibia, the astragalus, and the calcaneum. That for the tibia is on the inner face of the fibula and looks inward and upward. That for the astragalus, just below that for the tibia, is long and narrow and looks inward. That for the calcaneum is larger and looks inward and downward. The length of this bone, from Kimmswick, Missouri, forming a part of the mounted specimen in the National Museum, is 520 mm.; the length of that of the Warren mastodon, is twenty-six inches, or 660 mm.

In order to determine to which side a fibula belongs, place the larger end downward with the process that descends the lowest in front; also, with the smooth surface that articulates with the tibia in front. Then the rough external malleolus will look toward the side to which the bone belongs.

The hinder foot (Fig. 131, 132) is made up of the tarsals (ankle bones), the metatarsals (instep bones), and the phalanges (the toe bones). The foot, like the hand, was primitive in its construction, and had the digitigrade position. The figures, reproduced from Warren's monograph, illustrate the forms, and positions, and connections, of the various bones, and the names are given in the explanations.

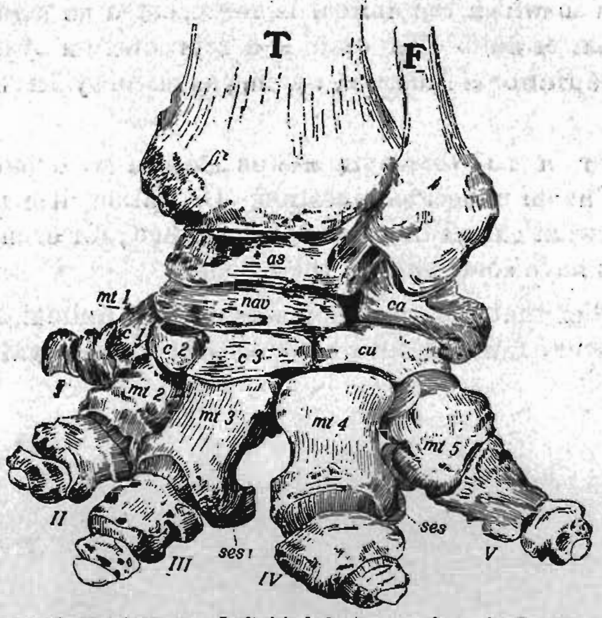

Fig. 131. *Mammut americanum.* Left hind foot, seen from in front. After Warren. *T*, the tibia; *F*, the fibula; *I*, inner digit; *V*, the outer digit; *mt 1* to *mt 5*, the metatarsals; *as*, astragalus; *ca*, calcaneum; *nav*, navicular; *cu*, cuboid; *c1*, *c2*, *c3*, the internal, middle, and external cuneiform bones; *ses*, sesamoids.

The tarsus consists of the astragalus, the calcaneum, or heel-bone, the navicular, the three cuneiform bones (internal, middle, and external) and the cuboid. These resemble closely those of the elephants, but doubtless close comparison would enable one to establish differences.

There are supposed to have been two phalanges in the first digit and three in each of the others, but the terminal ones have not been found, and it is possible that some or all of them had become abortive.

As in the case of the fore foot, there are in the hind foot certain small nodular bones that are known as sesamoids. They were placed below the articulation of the metatarsals. There was a pair of them to each of the five toes.

The metatarsals, five in number, are short, thick bones, which resembled the corresponding bones of the fore feet. The third and fourth are the largest.

In his book Animals before Man in North America, Professor Frederick A. Lucas published a restoration of the American mastodon in which the animal is represented as being covered with a coat of hair. The plate is a reproduction of a painting, now in the National Museum, which was made by Mr. J. M. Gleeson.

Whether or not this animal was clothed with hair may be regarded as an undecided question. Or, rather, it may be questioned to what extent they were thus clothed; for even the living elephants have some hair on their bodies.

The belief that the mastodon was a hairy animal appears to rest on a very few and not wholly convincing observations. Un-

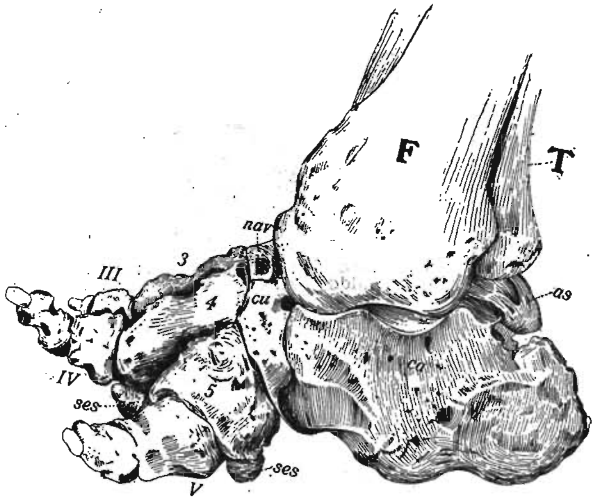

Fig. 132. *Mammut americanum.* Left hind foot, seen from the left or outer side. Explanatory letters as in figure 131.

fortunately no cadaver has yet been discovered preserved in frozen soil, as in the case of the hairy mammoth. In 1801 (Medical Repository, New York, Vol. IV, pp. 213, 214) Hon. James G. Graham, wrote a letter to Dr. S. L. Mitchell, in which, speaking of some mastodon remains found at Montgomery, New York, he stated that "there was found hair of the mastodon 3 inches long and of a dun color."

A judge, Sylvanus Miller, writing to Dr. S. L. Mitchell in the same year and in the same journal, pages 211, 213, announced the discovery and appearance of a skeleton found in Ulster county, New York. He wrote: "Around and in the immediate vicinity were locks and tufts of hair of a dun brown, of an inch and a half to two and a half inches long; and, in some instances, from four to seven inches in length.''

In volume III of Blainville's Ostéographie des Mammifères, on page 340, is a statement that some bones of a mastodon had been found near the mouth of Wabash river at a depth of sixty feet. It is further said that with these bones were found some portions of skin and hair. So far as is known none of these specimens of hair were preserved.

Prof. James Hall, in describing the finding of a small molar tooth at Stafford, Genesee county, New York, wrote as follows: ''Its situation was beneath the muck and upon a deposit of clay and sand. A large quantity of hair-like confervæ, of a dun brown color, occurs in the locality, and so much does it resemble hair, that a close examination is required to satify one's self of its true nature.''

It is therefore possible that some of the old observers mistook such confervæ for hair of the mastodon. It seems quite improbable that skin of the mastodon would have been preserved for so long a time in southern Indiana.

As to the food of the mastodon, not much is known that is wholly satisfactory. From the numerous sharp cusps on the tooth, it was by the earliest observers concluded that the mastodon was a carnivorous animal; but that idea was soon abandoned. About 1806 some remains of a mammoth were discovered in Wythe county, Virginia. Bishop Madison reported that at a depth of five and one-half feet the finders had struck upon the stomach. The contents of the viscus were carefully examined and found to be perfectly preserved. They consisted of half-masticated reeds (''a species of Arundo, or Arundinaria, still common in Virginia''), of twigs of trees, and of grass and leaves. The bishop was very positive on the subject, but admitted he had not seen these things himself.

In 1846 Prof. Asa Gray, the botanist, reported (Proc. Bost. Soc. Nat. Hist. Vol. II, p. 92) on some materials that had been found occupying the place of the stomach of a mastodon skeleton discovered on Schooley Mountain, New Jersey. He found pieces of wood, evidently of branches one, two, and three years old, broken quite uniformly into bits of half an inch or so in length, with only now and then traces of bark remaining. The wood was not fossilized and only partly decayed. From the examination of thin slices Professor Gray concluded that the wood was that of some conifer, a spruce or fir, rather than a pine. The structure agreed closely with that of similar branches of the common hemlock spruce.

In 1874 Dr. J. G. Hunt, of Philadelphia, gave the results of his examination of some substances which had been supposed to come from the stomach of a mastodon found at Wayland, New York. He found abundant remains of cryptogams and flowering plants, stems and leaves of mosses, and a fragment of probably a rush. Pieces of woody tissue and of bark of herbaceous plants and spiral vessels were abundant. "It thus appears that the animal ate his last meal from the tender mosses and boughs of flowering plants growing on the banks of streams and margins of the swamps rather than fed on submerged plants; and it is probable, moreover, that the pines, cedars, and their allies formed no part of the mastodon's food."

From Gray's and Hunt's results one may conclude that mastodons varied their diet according to their tastes and circumstances. Other observations on supposed stomach contents of mastodons have been made, but they lack accuracy of observation and of determination.

The subject is discussed at greater length in Warren's Monograph on the Mastodon, edition of 1852, page 144.

Mammut progenium, new species.

This species of mastodon, believed to be distinct from *Mammut americanum*, is based on a lower jaw, No. 292 of the collection of vertebrate fossils at the University of Iowa. This jaw was found apparently in 1910, in the Cox gravel pit, at Missouri Valley, Harrison county, Iowa. It was described and figured by Calvin in 1911 (Bull. Geol. Soc. Amer., Vol. XXII, p. 213, pls. xx and xxi) under the name *Mastodon americanus*. Figures are here presented which are made from the same photographs as those used by Calvin (Pl. XLIV, figs. 1, 2), but reduced in size. The following may be presented as the diagnosis of the characters of the species as represented by the type.

Two lower tusks present throughout life; these much larger than those occasionally found in *M. americanum;* symphysis of lower jaw longer than in *M. americanum;* chin less constricted at the symphysis, as viewed from above, and not truncated in front.

The animal which possessed this jaw was a very old one. Only the last molar was left in each side of the jaw, and this was worn down to the very roots. The following are the dimensions of this jaw as furnished by the measurements of Calvin and the writer.

Length from front of symphysis to hinder border just above the angle	830 mm.
Length from front of symphysis to rear of condyles, in straight line	920 mm.
Height of coronoid process above lower border of the jaw	425 mm.
Height of condyles above lower border of jaw	410 mm.
Length of the symphysis	212 mm.
Height of the jaw at the front of $m._3$,	192 mm.
Thickness of the jaw at the front of $m._3$	120 mm.
Width of the ascending ramus, from rear of the condyle	290 mm.

A computation shows that the length of the symphysis equals 23 per cent of the length of the jaw from front of the symphysis to the rear of the condyle. In the mounted specimen of mastodon in the National Museum the corresponding percentage is fifteen; in the case of a jaw of a rather young specimen, with m_1 just coming into use, No. 188, National Museum, the percentage is seventeen; and this is found to be true in the drawings of jaws found in Warren's monograph. The symphysis of *Mammut progenium* is therefore relatively much longer than in *M. americanum.* The length of the symphysis may also be compared with the width of the ascending ramus. In the mounted mastodon in the National Museum the symphysis equals fifty-four per cent of the width of the ramus; in No. 188 of the National Museum, fifty-six per cent; in *M. progenium,* eighty per cent.

It will be observed that the form of the lower jaw, when observed from below or above, is quite different from that of *M. americanum.* In the latter the front of the jaw is somewhat drawn out, then truncated in front. Behind this, the outer border of the jaws diverge rapidly and usually to, or almost to, the condyles. The jaw shown on plate XLIII, figure 2, shows this divergence in the hinder half of the rami less than usual. In the jaw of *M. progenium* the rami cease to diverge opposite $m._3$ and there is even some constriction. There appears to be no reason for supposing that there is here any distortion from post-mortem pressure.

Occasionally in the lower jaw of *M. americanum* there is a single tusk, rarely two of them. These have been already discussed. The great anatomist, Richard Owen, concluded that the animals with the lower tusk or tusks were males; the others, females. He believed that the single tusk was always found on the right side; but the Warren mastodon has it on the left. It seems probable that one or both tusks may be shed even at an advanced age of the animal. The tusk rarely exceeds about an inch in diameter and a foot in length; although the extremity is often missing.

Now, in the lower jaw of the extremely old animal under description here, both tusks were present. Their presence is indicated by the widely open sockets. The vertical diameter of the socket measured, the right, is 73 mm.; the transverse diameter, 50 mm. These measurements show that the tusks were far larger than those now and then found in *M. americanum*. The depth of the socket is 160 mm. The measurements show likewise that the tusks were considerably compressed, the horizontal diameter being about two-thirds of the vertical. What the form and the length of these tusks were, beyond the sockets, we can only surmise. In the collection is a small tusk, No. 25, found in the Cox gravel pit at Missouri Valley, which presents the appearance of having belonged to a lower jaw (Pl. LII, fig. 3). Its distal end is missing and the proximal end is somewhat injured. The tusk is considerably curved and what remains of it is 570 mm. long. About 200 mm. from the basal end one diameter is 67 mm.; the other, 56 mm., and the flattening is in the plane of the curve. It seems not improbable that this tusk was the lower tusk of a specimen of *M. progenium;* but naturally this cannot now be proved.

In the type jaw the lingual gutter is somewhat peculiar in being overhung on each side by the upper borders of the jaw. These approach until they are only 28 mm. apart. On the outer face of this part of the jaw the surface is concave as it rises to the dental border.

In this specimen the penultimate molar, $m._2$, had been pushed out on the right side of the jaw before the death of the animal; that of the left side seems to have been lost after death, for there remains a part of one root. As stated, the crown of $m._3$ is worn down to its base. The grinding surface of the left molar forms a concavity which is surrounded by a ring of enamel; but on the right side a part even of this is missing. This attrition of the tooth had so weakened it that, before the death of the animal, the teeth had each split into two parts. The inner wall of each had broken at the middle of the second crest and the cleft had run backward and outward to near the hinder end of the tooth. That this had occurred before death is evident, as Calvin remarked, from the fact that the edges of the fracture had been rounded off. The right tooth has another cleft, which crosses its front; but Calvin concluded that this was a post-mortem break. It is not improbable, however, that it happened under the strain of chewing just before death of the animal.

It is evident that the hinder molar had four transverse crests and a heel which was essentially a crest.

It appears barely possible that the crowns of these teeth did not have the simple pattern which is seen in *M. americanum,* but that the transverse valleys were more or less clogged up with accessory conules, now all worn away; but the writer did not get that impression when studying the teeth. In this case the animal would probably come under Cope's genus Tetrabelodon; which name, however, it seems, must give place to Bunolophodon Vacek. It seems rather that the animal was related closely with *M. americanum,* of which it may be regarded as the Aftonian ancestor. The writer believes that lower tusks will be met with more frequently and of larger size in the early Pleistocene mastodons than in those of later deposits. In those found in deposits overlying the Wisconsin drift, the tusks are usually wanting or of relatively small size, and when present usually single. Unfortunately, in the case of many of the specimens of so-called Tetracaulodons, we do not know the localities where they were found. Some certainly occur in post-Wisconsin deposits. Those found by Koch were in deposits outside of the drift region; some described by Hays were thought to have come from Big Bone Lick, on the border of the Illinoian drift; and they probably belonged to the interglacial stage following the Illinoian drift epoch. In case the teeth of the animal here described had the structure supposed, it is probable that other mastodon teeth which have been referred to *M. americanum* really belonged to *M. progenium*. It is to be hoped that other and better preserved materials will soon come to light.

In the Peyton gravel pit, at Pisgah, Harrison county, was found the left ramus and symphysis of the lower jaw of a mastodon, which was figured by Calvin under the name *Mammut americanum* (Bull. Geol. Soc. Amer., Vol. XX, p. 352, pl. xxv, fig. 2), and which has the number 2 in the collection at the State University of Iowa. This jaw has so many resemblances to that of the type of *M. progenium* that it is referred provisionally to that species. The jaw (Pl. XLVIII, fig. 1; pl. LII, fig. 2) is remarkably large. From the rear of the hinder tooth to the front of the symphysis measures 675 mm. In the case of a large jaw in the National Museum, from unknown locality, the corresponding measurement is only 470 mm.; in the small mounted mastodon it is only 420 mm. The symphysis is 185 mm. long. The lingual gutter is 90 mm. wide at a point 75 mm. behind its front end, and it narrows both forward and backward. On its upper border the symphysis inclines strongly downward; on its lower face, slightly downward, as the front is approached. In the front of the jaw are sockets for two tusks. The diameter of each is 45 mm. and the opening is circular. These sockets extend into the jaw a distance of 175 mm. They enter the bone in such a way that the tusks must have been directed downward at an angle of about 45° from the line of the molars. The floor of each socket is slightly convex; from which fact we may infer that the tusks were curved somewhat downward.

At the front of the anterior tooth the jaw is 175 mm. high and 110 mm. thick; in front of the hindermost tooth the height is

185 mm.; the thickness, 155 mm. The outer face of the jaw is very convex vertically. The inner face is slightly concave in a vertical direction, but nearly flat at the front of the hindermost tooth.

In this left ramus there are present all three of the true molars. The length of the tooth line is 380 mm. $M._1$ is 81 mm. long and 67 mm. wide. It is worn down until the face is nearly flat, but not yet to the roots. $M._2$ is 113 mm. long and 87 mm. wide at the rear. Wear has affected the front two crests and very slightly the hinder one. $M._3$ is a large tooth, the length being 195 mm.; the width, 96 mm. at the third crest. Evidently it had not yet come through the gum. There are practically five crests, the hinder being something more than a talon. Like the other crests, its summit is divided by a longitudinal cleft.

Genus RHABDOBUNUS Hay.

Elephantine animals whose upper tusks were probably without an enamel band; inferior tusks wanting and the lower jaw much shortened. Hindermost molars of the type species with cross-crests composed each of two blunt cones whose enamel is strongly fluted; transverse valleys blocked by contact of the principal cones.

The type of this genus is Leidy's *Mastodon mirificus.* It was retained in the genus Mastodon by Cope. Others (Matthew, Lull, Schlesinger) have placed it in the genus Dibelodon of Cope. The present writer is not able to follow those authors who place this species in the same genus as *Mammut americanum.* It was his intention to refer it provisionally to Dibelodon, but on studying the history of this name he found that it is not available. When Cope proposed this term Dibelodon (Proc. Amer. Philos. Soc., Vol. XXII, 1884, p. 7) he took as its type Leidy's *Mastodon shepardi,* believing, on the strength of materials observed in Mexico, that the lower jaw possessed no tusks. Later (Geol. Survey Texas, Fourth Ann. Rep., 1893, p. 58, pl. xv) he described a lower jaw, found in Texas, which he believed to belong to *M. shepardi* and which had in it the base of a strong tusk. This caused him to refer *M. shepardi* to the genus Tetrabelodon. Evidently, therefore, Dibelodon must be regarded as a synonym of Tetrabelodon, unless it can be shown that Cope's Texas jaw did not really belong to *M. shepardi.* Whether or not some or all of the other species which have at times been included under the name Dibelodon, will be found to be congeneric with *Rhabdobunus mirificus,* cannot now be decided; but other species appears to belong to a different genus. It is not unlikely that the generic diagnosis of Rhabdobunus will have to be modified when more complete materials shall have been discovered.

Rhabdobunus mirificus (Leidy).

This species was founded on the greater part of a lower jaw which was discovered by F. V. Hayden within the present state of Nebraska. In Leidy's earliest description (Proc. Acad. Nat. Sci. Phila., 1858, p. 10) he reported that the type jaw had been found in the valley of Niobrara river. In 1873 (Contributions, etc., p. 330) he stated that it had been described from the Pliocene of Loup Fork river; also, that it had been reported from Niobrara river. It seems probable that the latter statement made is the correct one. On the jaw is printed by Leidy's hand "Loup Fork of Platte River." Of the type jaw the left ramus was figured in Leidy's work "The Extinct Mammalian Fauna of Dakota and Nebraska," plate xxv, figures 1 and 2. This part of the jaw is now in the collection of the National Museum. The right side of it is in the Philadelphia Academy's collection. Leidy's figure shows that the jaw has suffered slight injuries since the illustration was made.

It has been supposed that this species belonged to the Pliocene or even to the Miocene. However, in Leidy's work last cited, on page 251, it is stated that Hayden had observed mastodon remains, probably belonging to this species, in association with those of Hipparion and Elephas, at the head of the Loup Fork branch of Platte river, between that point and Niobrara river, and in the course of the latter. This seems to indicate the presence of Pleistocene deposits in that region; and, certainly *Elephas columbi* is there found. Furthermore, Leidy stated that in the Smithsonian collection, he had seen jaws and teeth of what he regarded as *Mastodon mirificus* and *Equus excelsus* from Sinker creek, Idaho. Here again we have Pleistocene age indicated. The writer has found here the Equus tooth referred to, but not the specimen referred to *M. mirificus.*

Leidy's two figures of the left side of the jaw are here reproduced but on a smaller scale (Pl. XLVIII, figs. 2, 3), being only one-fourth of the size of the object itself. These figures show the structure of the last molar and of the part of the jaw remaining, especially of that part of it in front of the tooth. Judging from Leidy's figures and measurements it is concluded that 30 mm. of the tip of the chin has been lost since it was figured. The following measurements are taken partly from Leidy's paper, partly from the specimen itself:

MEASUREMENTS OF TYPE OF *RHABDOBUNUS MIRIFICUS.*

Greatest breadth of the jaw from outside to outside of the rami and passing through the fifth crest of the molars (Leidy)	413 mm.
Distance from tip of chin to rear of the molar, in straight line (Leidy)	431 mm.
Distance from tip of chin to middle of line joining rear of molars (Leidy)	419 mm.
Length of the symphysial gutter from rear of symphysis (Leidy)	122 mm.
Greatest thickness of the left ramus below the fourth crest	150 mm.
Least thickness of jaw, just behind the symphysis	68 mm.
Height of the jaw at the front of the tooth	150 mm.
Height of the jaw near the hinder end of the tooth	125 mm.
Total length of the tooth at the base of the crown	212 mm.
Width of tooth at the base of the third crest	80 mm.

A feature of the jaw in which it is different from that of *Mammut americanum* is that it comes to an acute point in front, instead of being truncated. This shows that there were at no time of life any lower tusks. A very remarkable character of the jaw, as compared with that of *Mammut americanum,* is found in the condition of the upper border in front of the molar present. This animal was doubtless well along in life, having only the last molar left in the jaw. This molar is worn on the grinding surface back to and on the fourth crest. Nevertheless, the anterior crest lacks 25 mm. or 30 mm. of being worn down to the base. In *Mammut americanum* at this stage of wear there would certainly be yet present the preceding molar; and, at every stage of wear, its socket, filled up perhaps with bone, would be in evidence. In the jaw under consideration, however, the alveolar border is acute from the front of the molar present to the tip of the chin; and there is not the slightest indication that any other tooth had ever been present. The second true molar must have been shed a considerable time before the death of the animal. No sign of wear of the front of the molar present against its predecessor is observed; but the front of the tooth shows some injury sustained during life, perhaps through caries, and this might have removed any surface polished by attrition against another tooth. The explanation of the absence of the socket of the second molar is, as may be seen on examining the jaw of an elephant, that the last molar has moved forward and occupied it completely.

The tooth, itself, is narrower in proportion to its length than in *M. americanum*. There are six cross crests and behind the last of these a small talon. Each of the crests was composed of two blunt cones, or tubercles. The two cones are pressed so closely together that the longitudinal valley is a mere fissure, above which the summits of the cones rise but little. Likewise, the transverse valleys which are so widely open in the American mastodon, are here blocked up, except near the summits of the cones, the valley being somewhat deeper at its inner end than at the outer. These valleys are not, as is so commonly the case, among the mastodon-like animals, obstructed by the development of accessory conules, or tubercles, but through the expansion of the cones themselves. The inner half of the outer cones is broader from front to rear than the outer half, and the contiguous broader portions are pressed closely together, thus, as it were, forming a broad dam across each valley. Outside of the dam each valley is rather widely open. The expanded part of each outer cone corresponds in position to the buttresses seen in the teeth of the American mastodon.

The inner cones are not so closely appressed as the outer cones, except at their bases.

The striking character of the teeth is the fluting of the enamel. The enamel of the inner half of the outer cone and the outer two-thirds of the inner cones, is thrown into folds which run from the base to the summit. Where the tooth is worn down these folds appear as thick festooned bands of enamel, as Leidy has described them. Of these folds there are about six in each cone of the transverse crests. In the type specimen the cones of the first and second crests are worn down below the bottom of the longitudinal valley between them, so that the dentine of the outer cone is joined to that of the inner. The next two crests had not yet been abraded to the bottom of the longitudinal furrow; while the fifth had not been worn through the enamel of the summits of the cones, and that of the sixth crest had not been touched.

Over the whole of the sixth crest there is a coat of cement; and all the crests, with their cones, were probably originally so covered. Patches of cement still appear in the valleys of the hinder part of the tooth. Unfortunately, in the anterior two-thirds of the tooth, the enamel of the outer and inner faces has been broken away.

The anterior part of the roots of the tooth is buried in the jaw, so that it cannot be examined. At the rear a part of the root is exposed. Under the hindermost crest this root has a length of 75 mm., but a portion of its lower extremity is missing.

Leidy had in his possession no upper teeth of this species. Fortunately, these have been found in Iowa. Many years ago a well was being dug on the farm of Severin Jensen, about two miles east of Akron, Plymouth county. The exact locality, as given by Professor Shimek, is the northwest quarter of section 33, township 93 north, range 48 west. The well was sunken probably to the Nebraskan drift. At a depth of twenty feet two teeth, some fragments of tusks, and some cranial bones of a large animal were found. These remains were met with in a bed of ferruginous sand over which lies Kansan drift. They are now in the collection at the University of Iowa. They were at first regarded as belonging to an elephant; later, as the remains of the American mastodon. Calvin first recognized the teeth as appertaining to Leidy's *Mastodon mirificus;* and he published a description of them and a figure of the last molar of the right side of the jaw (Bull. Geol. Soc. Amer., Vol. XX, pl. xxvii). The investigations made by Shimek (Bull. Geol. Soc. Amer., Vol. XXI, p. 126) show that the deposit belongs to the Aftonian stage. Thus the fact that this species belonged to the lower Pleistocene has been established. The fragments of tusks and of the skull have not been fitted together, on account of the small size of the pieces. Prof. A. O. Thomas reports that he has examined carefully the fragments of the tusk without finding any evidences of an enamel band. He has sent the writer a piece showing a strip of the outer surface about 45 mm. wide. This is covered by a layer 2 mm. thick of harder ivory, but there is no enamel present. Of course, the enamel band might show elsewhere, in case it were present.

Two figures are here published of the right tooth of this specimen, one (Pl. L) showing the grinding surface, the other (Pl. XLIX, fig. 2) the inner face. Both are from photographs furnished the writer by Professor Calvin. On the figure of the grinding surface certain results of mineral stains have been touched out, which somewhat interfered with the view of the folds of enamel. The left tooth does not show the structure of the tooth quite so well as the right one. This tooth resembles closely that figured by Leidy. There are present, as in the type, six cross-crests; but, in addition, there is a more prominent talon consisting of four tubercles. In this hinder region, too, there is an accessory tubercle between the two cones of the last two crests. In fact, these teeth might be regarded as having seven crests. A tubercle is found at the end of one or two of the transverse valleys. The right tooth has a length, as measured by Calvin, of 216 mm. The left tooth is slightly larger; Calvin gives as the length 222 mm. and a width of 83 mm. at the second cross-crest. The writer made the length of the left tooth 230 mm. In the hinder half of this tooth, between the cones and on their bases, is seen an abundant coating of cement.

The roots of these upper teeth resemble closely those of the corresponding teeth of *Mammut americanum*. In front there is a powerful root which supports the greater part of the anterior crest. It is curved backward until its tip is situated above the middle of the length of the tooth. In front, on the inner side of the tooth, is another strong root which supports the inner ends of the first and second crests; a very large, much grooved root supports the outer end of the second crest and all the others behind the second. Another tooth of the collection, No. 267, from an unknown locality, is the last left upper molar. It has only five crests and a large rounded talon. It is only slightly worn and shows the cones standing out quite freely from one another, except at their bases.

NOTES ON THE MASTODONS WHICH HAVE BEEN FOUND IN IOWA.

It is intended here to give especial attention to the discoveries of mastodons, *Mammut americanum, Mammut progenium,* and *Rhabdobunus mirificus,* which have been made in Iowa, and to indicate on a map (Plate LIII) the locations of these discoveries. Doubtless many finds of these animals have been made which have never been reported; and probably a few which have been reported have escaped the writer's notice. It is thought to be most convenient to discuss these discoveries by counties and to take these in their alphabetical order. It is to be understood that in some cases it is doubtful whether the identifications have been correctly made, and that the remains may really belong to some of the elephants. Possibly such cases ought not to have been entered on the map.

It is found that mastodon remains have been met with in twenty-two counties, possibly more. It will be observed that few have been found in the northeastern third of the state. It is difficult at present to explain this, for mastodon remains occur in southwestern Wisconsin and in southern Minnesota. We can hardly doubt that at various times during the Pleistocene period mastodons inhabited northern Iowa. It is possible that remains left there have been concealed by later deposits. That region is covered mostly by Iowan and Wisconsin drifts; but we know that the American mastodon lived after the time of the latter drift, and three localities furnishing remains of it are shown on the Wisconsin lobe in Iowa. It is not improbable that attention has not been directed towards finding, preserving, and reporting these objects. It would be preferable to consider those mastodons together which are found in deposits of the same age; but, unfortunately, one cannot yet always be sure of the age of the deposits.

On the map here shown (Pl. LIII) the locations of the specimens described are indicated by black dots within each of which is a white number. A corresponding number precedes in parenthesis the description of the specimen. In a few cases, however, two localities very near each other are placed under the same number.

Benton County. *(1).* From Netta C. Anderson's list of mastodon and mammoth remains found in Illinois and Iowa (Augustana Library Pubs., No. 5, p. 25) it is learned that a rib and a tooth, supposed to belong to *Mammut americanum,* have been found in the alluvium of Bear creek, near Shellsburg. The tooth is said to have been well preserved and to have been about the size of a five or six-pound flat-iron. Probably a large mastodon tooth just out of the earth and soaked with water would have the weight mentioned. The tooth is in the possession of Mr. J. A. Burns, a son-in-law of Mr. J. Grubb, living at Shellsburg. Mr. Burns informs the writer that the tooth was found in the creek, in section 33, township 85 north, range 9 west. The tooth is a last molar with four cross-crests and a heel. It is not less than six inches long and a little more than three wide. Nothing definite is known regarding the age of the tooth. The region is covered by Iowan drift, but this overlies the Kansan; and the tooth may have been washed out of almost any of the interglacial deposits.

Boone County. *(2).* In the collection of the Iowa State Historical Department, at Des Moines, there are preserved from this county various remains which belong to the American mastodon. These were presented to the museum by Mr. L. Hamilton. There is nothing to show in what part of the county they were found, nor any indication of the conditions under which they occurred. The location being doubtful, the number on the map is placed at the center of the county, near the town of Boone. There is likewise nothing to show how many individuals are represented.

An upper third true molar of the left side, little worn, has the catalog number 4520. There is also a jaw without the ascending rami and without the teeth, except some roots only. This has the number 4511. Besides these parts, which may without difficulty be identified as to genus and species, there are other parts which quite certainly belonged to a mastodon. There are a left scapula and the lower end of another of the left side, thus indicating two individuals. An ulna is represented by the upper half; and the pelvis by an acetabulum and the surrounding parts. There is also an atlas, a section of whose upper arch agrees with that of the American mastodon.

The surface deposit in Boone county consists of Wisconsin drift; but this is doubtless underlain by the Kansan sheet. In fact, the latter appears to be reached at some distance above the river level. The mastodon bones may have been found in some deposit on the Wisconsin drift or in some interglacial deposit below this. These remains would be much more valuable had even the exact locality of discovery been given.

Carroll County. In the State University geological collection is the distal end of a tibia which was found at or near the town of Carroll. This bone appears to have belonged to a mastodon. The locality is on the border of the Wisconsin drift and the animal probably lived after this drift was deposited.

Clayton County. (*31*). Prof. A. O. Thomas, of the State University of Iowa, has sent the writer a photograph and notes on a mastodon tooth which was found in a gravel pit two miles east of Garber. The exact locality is section 32, township 92 north, range 3 west. The age of the gravels is said to be uncertain, these being either Kansan or Iowan valley trains, their freshness making them more probably the latter. The tooth is evidently an upper second true molar. It is in the hands of a private collector.

Clinton County. (*3*). In the Chicago Academy of Science is an upper last left molar of *Mammut americanum* which is said to have been found near Clinton. It was presented to the Academy by J. W. Foster, the geologist. The tooth has five cross-crests. From the same place, there is in the Academy a slender tusk which has been regarded as that of *Elephas primigenius,* but this cannot at present be considered as certain.

(*4*). From Mr. Louis Rockrohr, living near Bryant, Clinton county, the writer has received a photograph of a mastodon tooth which he had unearthed while loading some gravel, at a depth of about eight feet below the original surface of the ground. The tooth is the last left molar. It appears to have been wholly unworn, and it shows the bases of the roots. Perhaps some parts of these have been lost since the death of the animal. There are apparently five cross-crests. The tooth has a length of seven and one-half inches (190 mm.) and a width of four and one-half inches (115 mm.). The region about Bryant is covered with Kansan drift. It seems hardly probable that this bed of gravel was below this Kansan drift. It must belong to a post-Kansan stage; but beyond this the writer makes no conjectures.

Crawford County. (5). In the University of Iowa collection there is a tooth of a mastodon, *Mammut americanum,* which was found at Denison, by Mr. James Mill.

It was formerly supposed that the gravel pits at Denison belonged to the Aftonian stage, but this is now regarded as uncertain (Shimek, Bull. Geol. Soc. Amer., Vol. XXII, p. 212). The various species which have been discovered there have been mentioned on page 56.

In 1909 (Bull. Geol. Soc. Amer., Vol. XX, p. 352) Calvin reported from Denison fragments of two tusks and a tibia (op. cit. pl. xxv, fig. 5). The tusks can be referred to *M. americanum* only provisionally. One of these tusks has in the State University collection the number 28. It is about three and a quarter feet long (1028 mm.) and has a diameter of 108 mm. The surface is smooth. The other fragment, No. 29, is about 950 mm. long, with a diameter equal to that of No. 28. Its surface is striated lengthwise.

Dallas County. (6). In the Bulletin of the Geological Society of America, Volume XXII, page 215, Professor Calvin reported that in 1876 a complete skeleton of *Mammut americanum* was found at Adel. It was met with in a peat deposit which partly filled a "kettle" on the surface of the Wisconsin drift. Nothing is known as to what became of this valuable find. As to its geological age we can hardly be in doubt. The animal had certainly lived and died after the passing of the Wisconsin ice-sheet.

Greene County. (7). In the collection of the Iowa State Historical Department, at Des Moines, there is a scapula of the right side which is labeled as coming from Rippey, in Greene county. It is credited to B. F. Osborn. The height of this bone is 790 mm. The spine has its base so far from the front edge of the bone that almost certainly *Mammut americanum* is indicated. There is no record regarding the circumstances under which the discovery was made. As this region is wholly covered with Wisconsin drift, the animal must have lived in the stage succeeding it. In the same collection there is a humerus, No. 4514, from the same place and probably a part of the same individual.

Harrison County. Many remains of mastodons, as well as of other animals, have been discovered in the Aftonian deposits of this county. The greater number of these are referred to *Mammut americanum.*

(8). a. First of all must be mentioned the lower jaw which is described on page 368 under the name of *Mammut progenium.* This was found at Missouri Valley.

b. Number 89 of the collection at the University of Iowa is a fragment of a tooth found by Professor Shimek at the Cox gravel pit, two miles southeast of Missouri Valley.

c. Number 247 is a second upper right molar which was collected at the Cox pit by Claude Cox. The length of the crown is 103 mm.; the width, 80 mm. It is worn on all the crests. Roots are present.

d. Number 15 is an upper left molar, apparently the first. It was collected at the Cox pit by Professor Shimek. Its length is close to 95 mm.; its with, 75 mm. In front are two roots, one on the outside supporting a part of the first crest; another supporting the second crest and a part of the first. Behind these is another broad root. Inasmuch as this tooth has four roots, it is possibly a very small second molar.

e. Number 26 is a much worn lower second molar, all the crests being obliterated and all the dentinal areas opening into one another. The hinder root had been absorbed; the anterior root was yet of full length, 140 mm., but with its borders partially absorbed. This, too, was found in the Cox pit.

f. Number 90 is a last left upper molar, a good tooth, but with a part of the first crest wanting. It had hardly begun to wear. The talon is really a two-pointed crest. The tooth originally had a length close to 195 mm. It is stained very black. From the Cox pit.

g. Number 12 is an upper last molar of the left side. It is little worn and the roots are nearly complete. There are four crests and a heel of two large tubercles. Found in the Cox gravel pit.

The writer has not been able to perceive that this tooth differs in any way from others of *Mammut americanum;* but there is a possibility that it belonged to *Mammut progenium.* The writer has thought the tooth worthy of illustration, and is is therefore shown on plate LI, figs. 1, 2, of two-thirds the natural size. The same tooth was figured by Calvin (Bull. Geol. Soc. Amer., Vol. XX, pl. xxv, to the left of fig. 6).

h. Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 352) mentions a scapula which was found in the gravel pit at Missouri Valley, but which was allowed to fall to pieces. Of course, it is impossible to say whether it belonged to a mastodon or to one of the elephants.

i. In the collection in Iowa City is a fragment of the skull of some proboscidean, consisting of the basi-occipital region and the contiguous parts, including the right articulation for the lower jaw. This is illustrated by figure 3 of plate XLIX. While it has not been practicable to bring this fragment into direct comparison with the skull of a mastodon and of the elephants, an examination of the photograph in the presence of skulls seems to indicate that the fragment belonged to a mastodon. It may, therefore, be regarded as that of *Mammut americanum;* but it is possibly that of *M. progenium.*

j. In the oft-mentioned Cox pit was found a right ischium, No. 30 of the collection at Iowa University. A cross section was taken at a distance of 125 mm. from the acetabulum. Here the greater diameter of the bone is 68 mm.; the thickness, 51 mm. The section resembles more closely that of *Mammut americanum* than it does that of any of the elephants.

(9.) In the Peyton gravel pit, at Pisgah, was found the lower jaw and teeth which were briefly described and figured by Calvin. It has already been described on page 372 and referred provisionally to *Mammut progenium.*

Henry County. (10). In Netta C. Anderson's list, p. 27, Prof. T. E. Savage reported that teeth and bones of a mastodon had been dug up in making a well near or in Mount Pleasant. The remains are said to have been met with in, or immediately below, Kansan drift. They probably were in Aftonian deposits.

The teeth and bones are reported to be now in the Iowa Wesleyan College, at Mount Pleasant.

(11). In the Anderson list it was reported by Prof. Frank Leverett that some mastodon teeth had been found somewhere about Salem; but Leverett had not himself seen the teeth. They might therefore have been those of a mammoth.

In the same list Dr. J. M. Shaffer, of Keokuk, stated that two mastodon teeth had been dug up near the bank of Skunk river in this county.

Jackson County. (12). In the Anderson list, already referred to, on page 27, Prof. W. H. Norton reported that an atlas and two vertebræ of some proboscidean had been found at Maquoketa. These might, of course, have belonged to some one of the elephants.

Lee County. (13). In the catalog of Netta C. Anderson, on page 28, Justus M. T. Myers, of Fort Madison, reported he had found on Lost creek a leg bone, two pieces of a tusk, and one of the short ribs of a mastodon. It is easy to see that these might quite as well have belonged to one of the elephants. Myers also reported that a molar had been found on Sugar creek. It is to be regretted that a record has not been made regarding the disposition of these remains, so that one might examine them. On the map the dot numbered 13 is placed arbitrarily for both finds; inasmuch as these were not definitely located.

In the collection at the Iowa Wesleyan College, at Mt. Pleasant, is a complete last lower molar, with fine roots. Mr. Charles Buetner, of Burlington, who presented the tooth, has informed the writer that this tooth was found in a creek three miles due west from Ft. Madison.

Linn County. (14). In the Anderson list, Prof. W. H. Norton, of Cornell College, reported that a small molar and the crown of a large molar had been found near Springville, on or in Iowan drift. These teeth are now in the collection of Cornell College, Mount Vernon, Iowa.

In the same list, Prof. F. C. Baker, of the Chicago Academy of Science, reported that in that collection there is a part of a tusk of a mastodon which was found in a gravel pit at Bertram, Linn county. This might, however, be the tusk of a mammoth.

Lyon County. (*16*). The writer has received a letter from the Henry Kahl Company and another from Mr. Fred C. Smith, of the Sioux City Academy of Science, reporting the discovery of two large tusks at Doon, on the line of the Great Northern Railroad. They were unearthed by a steam shovel. The tusks were much broken as they came out; and besides this they soon crumbled. They were found in a bed of gravel at a depth of about twenty-five feet below the surface. These gravels probably belong to the Aftonian.

It is, of course, impossible to say whether these tusks belonged to a mastodon or to an elephant. They are mentioned here to preserve the record.

In 1911 (Bull. Geol. Soc. Amer., Vol. XXII, p. 215) Doctor Calvin reported the finding of a large atlas at Rock Rapids, which he supposed belonged to a mastodon. The writer believes that it is the atlas of a mammoth *Elephas primigenius*, and it will be described on another page.

Mahaska County. (*17*). In the collection of the Iowa State Historical Department, at Des Moines, there is an upper right last molar which is labelled as having been found in this county. The collector was J. D. Davis, of Des Moines. It is unfortunate that no other facts were recorded about it. One would like to know in exactly what part of the county the tooth was found, at what depth, and in what kind of deposit. This county is covered by Kansan drift, but it is quite certain that it is underlain by Nebraskan, and that between the two may occur Aftonian. Besides this, a considerable amount of loess is found overlying the drift. It would be of some interest to know in which of those several deposits the tooth was buried. The dot with the number 17 is placed arbitrarily in the center of the county.

Monona County. (*18*). Professor Shimek (Iowa Geol. Surv., Vol. XX, p. 343) reported the finding of a large tusk (Pl. XLIX, fig. 1) nearly eight feet long on the outer curve, and a molar of *Mammut americanum*, in the Wilkenson well, in the northwest quarter of section 6, township 85 north, range 42 west. This is near Mapleton. The remains were found at a depth of from thirty-five to forty feet, in loose sand and gravel. These were regarded as belonging to the Aftonian. The tusk has a diameter at the base of about 350 mm. and is therefore very large. The curve is all in one plane. If a line joins the two extremities, the middle of the fragment of tusk is 580 mm. distant from the line. This specimen was received from the Sioux City Academy of Science and has the number 234 in the collection of the State University of Iowa.

Nos. 204-211 of the Iowa University collection are fragments of the skull of the same mastodon. No. 203 is the upper end of an ulna found in the same well.

(19). The identity of the proboscidean remains found near Castana is in doubt.

a. In the collection of the Iowa State Historical Department, at Des Moines, is a large tusk, number 5537, which is labeled as having been found at Castana. It may be that of a mastodon or of one of the elphants.

b. Shimek (Bull. Geol. Soc. Amer., Vol. XXI, p. 131) records the fact that some years ago a fragment of a large scapula was obtained from an old gravel pit, near Maple river, opposite Castana. The bone has the number 91 in the collection at Iowa University. This may or may not belong to Mammut; and it is not certain that the bone is a part of a scapula. It was collected by Mr. J. B. P. Day.

(20). In the Elliott sand pit, located in the northeastern part of Turin, Monona county, have been found various species of Aftonian vertebrates, as Mammut, Camelops, Equus, etc. *Mammut americanum* is represented by a last molar (Calvin, Bull. Geol. Soc. Amer., Vol. XX, p. 355; Shimek, op. cit., Vol. XXI, p. 129). This molar belonged to the right side. All the crests are more or less worn and the roots are in their prime. The bones and teeth from this pit were found in gravel at a depth of about ten or twelve feet below the top of the Aftonian.

Muscatine County. (21). The proboscidean remains found in Muscatine county, are of somewhat doubtful identity. J. A. Udden (Iowa Geol. Surv., Vol. IX, p. 352) quotes a report made to the president of Iowa University on some bones found on the banks of Mud creek (or Mad creek, as it sometimes called), near the town of Wilton, in the northern part of the county. It was not determined whether the bones belonged to a mastodon or to a mammoth. No teeth were found. Calvin gives measurements of the scapula, two ribs, the first dorsal vertebra, the right tibia and a humerus. From Prof. A. O. Thomas the writer has received a photograph of this scapula, which photograph had been preserved by Doctor Calvin. This is reproduced on plate LII, figure 1. It appears to be that of a mastodon. The following measurements were given by Calvin: Length from glenoid cavity to the superior angle, thirty-nine inches (991 mm.); width from posterier angle to opposite border, twenty-eight inches (712 mm.); diameters of glenoid cavity, nine and one-half inches (241 mm.) and five and one-half inches (140 mm.); circumference of head, thirty-two and one-half inches (826 mm.). Calvin at that time regarded the deposits as being modified drift. It has been thought too that the deposits are of Sangamon age. Udden (Augustana Lib. Pubs., No. 5, p. 52) stated that the remains were found in Illinoian drift.

Udden (Iowa Geol. Surv., Vol. IX, p. 360) stated that Professor Witter had found in the loess at Muscatine a tusk and teeth of either a mammoth or a mastodon. Shimek (Bull. Geol. Soc. Amer., Vol. XXI, p. 139) states that Witter found here a fragment of a molar of *Elephas primigenius,* and that this was derived from a layer of Aftonian gravel about one foot thick.

Page County. (22). Dr. Charles A. White, formerly State Geologist of Iowa, reported (Geol. Surv. Iowa, Vol. I, 1870, p. 353) thus: "In the valley of the Nodaway River, near Clarinda, some teeth of the mastodon have been found." Calvin (Iowa Geol. Surv., Vol. XI, p. 413) stated that large bones which, from the description, must have belonged to mammoth or mastodon, were brought up from a depth of ninety or ninety-five feet, with pieces of bark or wood. The place was near Blanchard. Calvin thought that there was indicated here an old preglacial valley.

Plymouth County. (23). It was from a well two miles east of Akron that were found the remains which have been, on page 377, described as *Rhabdobunus mirificus.* The bones were first reported on by Prof. J. E. Todd. Further particulars are given by Todd in Netta C. Anderson's list, page 33. They were regarded as being in the upper part of the till, under loess. The well was described by Shimek (Bull. Geol. Soc. Amer., Vol. XXI, p. 126). The sand and gravel in which the bones occurred were regarded by Calvin and Shimek as Aftonian.

(24). From Le Mars, Calvin (Bull. Geol. Soc. Amer., Vol. XXII, p. 215) reported having received a part of a pelvis. This has the catalog number 259 in the University collection. This is a part of the left ilium, the whole of the acetabulum, and a part of the ischium and of the pubis. A section taken across the ischium, just where the groove begins which leads into the acetabulum, agrees well with that from the small mounted mastodon in the National Museum; but the fossil appears to have belonged to a still smaller animal. The section is triangular, with the groove just mentioned in the base of the triangle. The height of the bone here is 86 mm.; the greatest thickness 55 mm. The section taken across the pubis shows that the bone is broadly rounded above and in front, but flattened on the lower side and on the side bounding the ischio-pubic foramen. The two diameters are each 65 mm. In the case of *Mammut americanum* the shorter diameter forms only seventy per cent of the greater; in the Asiatic elephant it forms eighty-one per cent. The fragment found at Le Mars can hardly have belonged to *M. americanum.* It must have belonged either to *M. progenium* or more likely to *Rhabdobunus mirificus,* which seems to have been a small animal. Or the bone described may have belonged to one of the elephants. What with the injured condition of the bone and the difficulty of making direct comparison with identified materials, it is impossible to say certainly to what genus it belonged.

In the collection of the Sioux City Academy of Science is a part of a tusk of a proboscidean, which was found at a depth of forty feet from the surface in the Grimes pit, one mile northeast from Le Mars.

Polk County. (25). In the collection of the State Historical Department at Des Moines, there is an upper last molar which appears to have been found at Des Moines and presented by Mr. L. Hamilton. It has five crests. The number is 459.

Inasmuch as there are found in the immediate vicinity of Des Moines Kansan drift, Wisconsin drift, and loess, together with probably interglacial and postglacial accumulations, it is desirable that care be taken to collect every scrap of fossil material and to record the exact spot where it was found and the exact geological level. The numerous brick yards in and about the city would make such collections easily possible.

Poweshiek County. Dr. J. A. Udden (Augustana Lib. Pubs. No. 5, p. 53) reported a mastodon from Grinnell; but Professor Norris, of Grinnell College, informs me that this was a mammoth. It is possible, however, that Udden had information of a mastodon also.

Sac County. Dr. Calvin (Geol. Soc. Amer., Vol., XXII. p. 215) mentioned a fragment of a scapula, with the glenoid cavity and a part of the spine. The writer is inclined to regard this as having belonged to Elephas and it will be there mentioned.

Scott County. (26). At Davenport, as stated by J. A. Udden (Iowa Geol. Surv., Vol. IX, p. 356), mastodon remains have been found in the western part of the town. Udden concluded that the remains, whatever they were, had been buried in Sangamon soil resting on Illinoian drift. Leverett (Monograph U. S. Geol. Surv., Vol. XXXVIII, p. 166), in discussing the geological position of the bones, thinks that they may have been derived from Sangamon soil and redeposited in the loess. But, if the remains occurred in the loess, may the animal not have lived at the time the loess was being deposited? Finally it appears not improbable that through some error the remains above referred to are those of the mammoth which was found in a railroad cut west of Davenport. See page 446.

Story County. Prof. M. Stalker, of Ames, Iowa, noted (Iowa Geol. Surv., Vol. IX, p. 210) the finding of some "mammoth" bones at this place. There were some vertebræ, a part of a left femur and of a tibia; but no teeth. We are not informed whether comparisons were made with other authenticated materials or not. The bones may have belonged to a mastodon.

Van Buren County. *(27).* In the collection at Iowa University there is a lower left last molar (Cat. No. 382) which is recorded as having been found in the bed of Chequest creek, near Milton, about 1890, by W. B. Bell. Most of the anterior crest is missing. The whole length was about 170 mm.; the width is 107 mm.

(28). In the collection of the Iowa State Historical Department, Des Moines, is a right humerus which is said to have been found at Selma and presented by A. B. Adams. The width of the distal articular surface from side to side is 205 mm. The diameter of the shaft, where constricted, is 150 mm. from side to side; 125 mm. fore and aft. The constricted part is relatively thicker than in the mounted mastodon in the National Museum, and still more so as compared with the existing elephants. The bone probably belonged to *Mammut americanum.*

Wapello County. *(29).* From a place about six miles south of Ottumwa there was reported (Kansas City Rev. Sci. and Industry, Vol. III, 1879, p. 242), by Mr. Houbler, the discovery of a tusk of a mastodon. When found it was entire. Naturally it might quite as well have been the tusk of a mammoth.

In the collection at the Iowa Wesleyan College, at Mt. Pleasant, are two ribs of a mastodon which are labeled as having been found at Ottumwa and presented by Rev. E. C. Brooks. The innominate bones of a proboscidean, labeled as having been found in Des Moines river, in 1859, probably belong with the ribs.

(33). This number records a left femur which the present writer regards as having belonged to a mastodon and which was found in the gravels along Des Moines river, near Eldon. This femur, according to Prof. M. F. Arey, is now in the Natural History collection at the State Teachers College, at Cedar Falls.

Warren County. *(30).* In Howe's Annals of Iowa, Volume II, 1883, page 102, A. R. Fulton described, under the name *Elephas americanus,* a tooth which, as the description plainly shows, and as appears to have been recognized by Fulton, was that of a mastodon. This had been found on Limestone creek, a mile and a half west of the village of New Virginia.

Genus ELEPHAS Linnaeus.

Proboscidea whose teeth are composed of thin, relatively broad and deep plates of dentine, which is covered by a layer of enamel; the various plates thus formed held together by intervening plates of cement, which also covers the whole exposed part of the teeth; number of plates varying in the different teeth and in the different species. No tusks in the lower jaw. Skull, high and arched.

Although the teeth of our modern elephants and of most extinct forms differ greatly from those of the American mastodon, there have been found in southern Asia a few extinct species, referred to the genus Stegodon, whose teeth show intermediate conditions. There can be no doubt that the teeth of the elephants have been evolved from teeth resembling those of some of the mastodons. If the transverse ridges of a mastodon's tooth should increase in height and in number, and should become more and more compressed, and the cement should increase in amount, so as to bind together all the plates thus formed, a tooth would result like that of the elephants.

The skull of the elephants is more elongated than that of the mastodons, giving the animals a more intellectual appearance; but this is not due to any great increase in the size of the brain, but to the greater development of the air-cells in the bones of the roof of the skull. This increase in the size of the skull results from the necessity of providing a support for the great tusks and a broad surface for attachment of ligaments and muscles for sustaining the head.

Inasmuch as the structure of the skeleton of the elephants is in general like that of the mastodon, which has been explained, the various bones will not be described; especially since characters for accurately distinguishing some of the bones of the two genera have not yet been discovered. It is proper, however, to deal somewhat more in detail with the teeth.

The tusks will not be described, since they resemble only too closely those of the mastodon. For an illustration of the internal structure see plate LII, figure 4. They are often more curved spirally, but this seems not to be a character that can be relied on. The teeth of the elephants belong to the kind called hypsodont, or high-crowned; that is the height of the tooth is great in comparison with its length along the plane of wear and especially with the size of the roots. The roots are indeed rather feebly developed. The result is that the tooth has an immense body which must be worn down before the tooth is no longer useful. If one shall examine an elephant tooth that has been somewhat worn by use, it will be seen that the worn face is crossed by bands of three different kinds of materials. There are thin plates, often running more or less zigzag across the tooth and standing a little above the other bands. These are composed of enamel. They are arranged in pairs and between the two plates of each pair, is a plate of dentine, or ivory. The ivory is not quite so hard as the enamel and is worn down a little deeper. The two plates of enamel and the enclosed flat core of dentine form a composite mass that is often called a plate. Here they will be called *ridge-plates*. These are really flattened pockets of enamel filled with dentine, and the teeth are called "thick-plated" or "thin-plated," according to the thickness of the ridge-plates; although these terms are sometimes used with reference to the enamel only. They are separated from one another by plates of a softer material, the cement, which serves to bind the ridge-plates together. On the sides of the tooth, especially where the cement has been dissolved off, as it often is in fossil teeth, the ridge-plates appear as rounded ridges rising from the base of the tooth to the summit.

As in the mastodons, there exist in the course of the animal's life six teeth on each side of each jaw. The three anterior of these correspond to the milk teeth, or deciduous molars, of most other mammals; the hinder ones to the true molars. The three deciduous molars are not succeeded by premolars coming up beneath them, except in the extinct primitive elephant, *Elephas planifrons*. Early in life the front, or first, tooth appears and begins to wear. Soon afterwards the second one appears behind it and gradually pushes the first one forward; so that, by the time it is worn down to the roots, it is pushed out of the jaw. The third one comes up behind the second and at length replaces it, and so on with the others; until the last one, late in life, has taken sole possession of its side of the jaw. Naturally, the first tooth is small and is formed of a small number of ridge-plates. The succeeding teeth are in their turn larger and have a greater number of ridge-plates. In the existing African elephant, the first tooth has three plates; the second, six; the third, seven; the fourth, seven; the fifth, eight or nine; the sixth, ten or eleven. In the mammoth, *Elephas primigenius*, the teeth are far more complicated, and the ridge-plates are represented by the formula, dm. 1, $\frac{4}{4}$; dm. 2, $\frac{6-9}{6-9}$; dm. 3, $\frac{9-12}{9-12}$; m. 1, $\frac{9-15}{9-15}$; m. 2, $\frac{14-16}{14-16}$; m. 3, $\frac{18-27}{18-27}$. Thus, it is seen, any tooth in the series may, in different individuals, vary in number of ridge-plates; but the extremes in the formula are rare. In the Indian elephant and the mammoth, the formula is usually given as 4, 8, 12, 12, 16, 24, for both upper and lower teeth.

As far as possible, the teeth of our fossil species are here illustrated; so that the student may determine the species and the place of the tooth in the series. Difficulties, however, are likely to arise when the observer has in his hands only a part of a tooth. A tooth may lack a part for one or all of three reasons: It may have been damaged after the death of the animal, or it may have lost its anterior end from being worn down too near the roots during life and breaking off and falling out of the mouth bit by bit, or the animal may have died before certain parts of the tooth had fully developed.

It is usually possible to distinguish an upper tooth from a lower one by the shape of the worn face. In the upper teeth this face is likely to be convex from before backward; while in the lower teeth, it is likely to be concave. The upper teeth are likely to be larger, especially higher-crowned, than a lower tooth of the same number in the series. A lower tooth is likely to be pretty concave from front to rear on one lateral face, and convex on the other; the upper teeth less so. As to the side of the jaw to which any tooth belonged, in the lower tooth the concave lateral face was directed outward; in the upper tooth the concave or flattened side was directed inward. The front end of a tooth may be known by its being worn down more than the hinder end. Finally, in the upper teeth the abraded ends of the ridge-plates run directly across the tooth; those of the lower jaw are likely to be directed obliquely across the tooth, the outer ends being swung backward.

In the United States there existed during Pleistocene times at least three distinct species of mammoths, or elephants. These are known as *Elephas primigenius, E. columbi,* and *E. imperator*. The former appears to have been confined mostly to the glaciated region, ranging thence north to Alaska; but teeth belonging to it occur also in North Carolina. *E. columbi* occupied especially our southern and western states and Mexico; but its remains are found also in the glaciated area and apparently even in Alaska. *E. imperator* was a large species that has been found only in the region of the Great Plains. It existed in the early Pleistocene and may have become extinct soon afterwards. The other two species are found in deposits overlying the Wisconsin drift; and they probably existed until the close of the Pleistocene. All three species have been found in the Pleistocene deposits of Iowa.

Elephas primigenius Blumenbach.

The Hairy Mammoth.

Tooth formula, $\frac{4}{4}, \frac{6-9}{6-9}, \frac{9-12}{9-12}, \frac{9-15}{9-15}, \frac{14-16}{14-16}, \frac{18-27}{18-27}$. The ridge-plates thin, varying from about 7 to 12 in a line 100 mm. long. The plates, of at least the upper teeth, parallel with one another, and little bent. The rear of the last upper molars usually strongly arched. Roots of the teeth rather strongly developed. The sheaths for the base of the tusks very long.

This species is better known than any other fossil elephant. During the Pleistocene it had a range greater than that of almost any other mammal that has not been distributed by man. Its remains occur from Ireland and England across the continent of Europe and Asia to Bering Strait, and from Alaska to the Atlantic ocean and south over the glaciated region, and to North Carolina. It is the species whose cadavers have in numerous instances been found in the frozen soils of Siberia, so perfectly preserved that they could be eaten by dogs and even men.

Outside of Siberia, its remains occur for the most part only in a scattered condition; and it is usually only a tooth or a few of them, or a tusk, that is found. Sometimes scattered limb-bones are discovered. It is only rarely that anything like a considerable part of a skeleton is found; and then this is treated with little respect. While there are in the United States, as Lucas has said, at least fifteen mounted skeletons of the mastodon, the writer knows of but one mounted skeleton of *Elephas primigenius*. This is the one that was found in Grant county, Indiana, and is now in the American Museum of Natural History, in New York. Through the liberality of this museum the writer is enabled to produce here a drawing of that splendid skeleton.

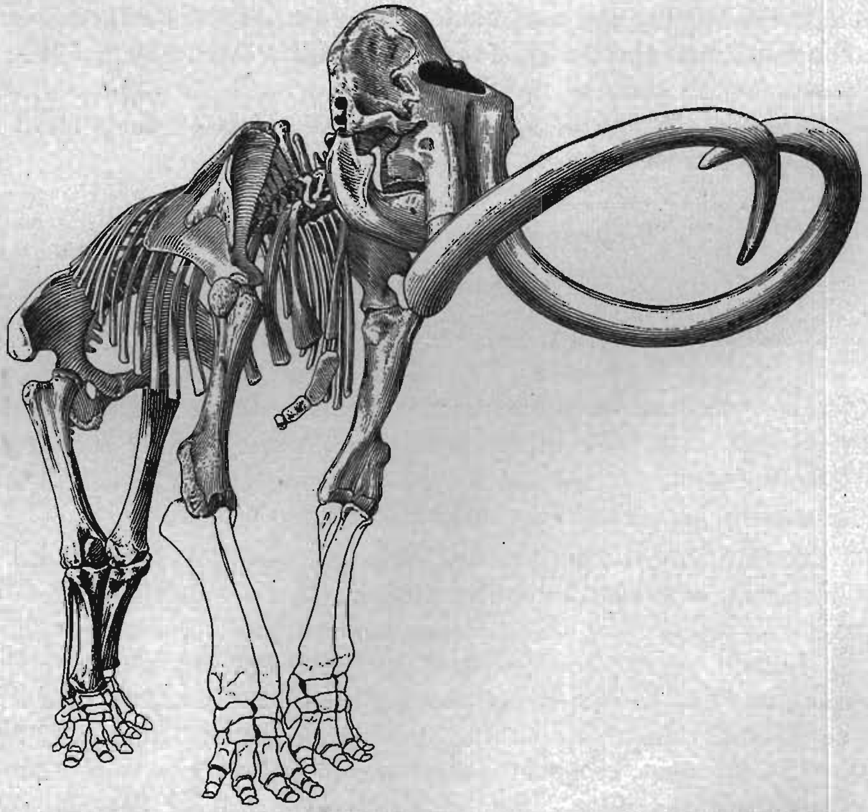

Fig. 133. *Elephas primigenius*. Skeleton found in Grant county, Indiana, and now in American Museum Natural History, New York. Oblique view.

In this skeleton (Fig. 133) the skull had been damaged slightly, but not so as to injure it for study. All the feet, wrist and ankle bones were gone and both ulnæ and radii. These parts have been restored in plaster as seemed to be justified from other species. It seems probable that the radius and ulna have been made too long, with the result of lifting the animal somewhat too high at the shoulders. The shoulder joints stand about 200 mm. higher than the hip joints. In the living elephants these joints are about on the same level. As to the tusks, it has usually been supposed that they curved so as to direct the points outward; but, in mounting the animal, it was found that they would not enter the sockets in any way than to throw the extremities inward; and this arrangement agrees with recent determinations in Siberian specimens.

The following measurements are taken from the explanatory label of this specimen.

Base of tusks to drop of tail	13 ft., 3½ in.;	5.43m.
Length of right tusk, outside curve	11 ft., 4½ in.;	3.47m.
Height at the shoulders	10 ft., 6 in.;	3.20m.
Length of thigh bone	4 ft., 1½ in.;	1.24m.
Width across the pelvis	4 ft., 10 in.;	1.47m.

It may be noted that in taking the oblique photograph, the hinder parts of the skeleton are made to appear relatively smaller, and the tusks and foreparts relatively larger than they should appear.

The following measurements were taken by the writer. These may serve the student in identifying other bones supposed to belong to the genus.

Width of skull behind	750 mm.
From postorbital processes to ear-opening	335 mm.
From ear-opening to line extended from occipital condyles	210 mm.
From nasal opening to bottom of sheath for tusk	715 mm.
From bottom of nasal opening to summit of crown	570 mm.
From summit of crown to occipital foramen	500 mm.
From condyle of lower jaw to the beak, following curve of jaw	900 mm.
Height of the lower jaw under middle of $m._3$	170 mm.
Thickness of the lower jaw under middle of $m._3$	160 mm.
Greatest width of the lower jaw	555 mm.
Lateral extent of the atlas	400 mm.
Vertical diameter of the atlas	210 mm.

The bodies of the anterior dorsal vertebræ are close to 68 mm. long. Gradually they lengthen, until the hinder ones become about 75 mm. long. Twelve of the hinder dorsals, including the intervening plates that represent the intervertebral cartilages, measure 1030 mm., the average being 86 mm. each. The length of the longest rib, the seventh, is 1470 mm.; length of first rib, in a straight line, 625 mm.; its distal end, 155 mm. wide.

Length of the front border of the scapula	910	mm.
Width from the hinder angle to the front at right angles to the spine	600	mm.
Length of humerus from head to bottom of inner articulation	1135	mm.
Transverse width of upper end of humerus	300	mm.
Transverse width of lower articulation	250	mm.
Width of pelvis, total	1470	mm.
Width of pelvic opening	395	mm.
Height of pelvic opening	445	mm.
Length of pubic symphysis	482	mm.
From top of acetabulum to uppermost point of ilium	660	mm.
Femur, length from head to distal end	1240	mm.
Greatest diameter of middle of the shaft	155	mm.
Least diameter of middle of the shaft	92	mm.
Femur, extent of lower articulation from side to side	230	mm.
Tibia, length	735	mm.
Tibia, side-to-side width of upper end	245	mm.
Tibia, side-to-side diameter, middle of shaft	106	mm.
Tibia, fore-and-aft diameter, middle of shaft	100	mm.
Tibia, side-to-side diameter of lower end	205	mm.
Tibia, fore-and-aft diameter of lower end	155	mm.
Fibula, length	710	mm.
Fibula, width of upper end	78	mm.
Fibula, width of lower end	123	mm.
Fibula, greatest diameter of middle of shaft	48	mm.

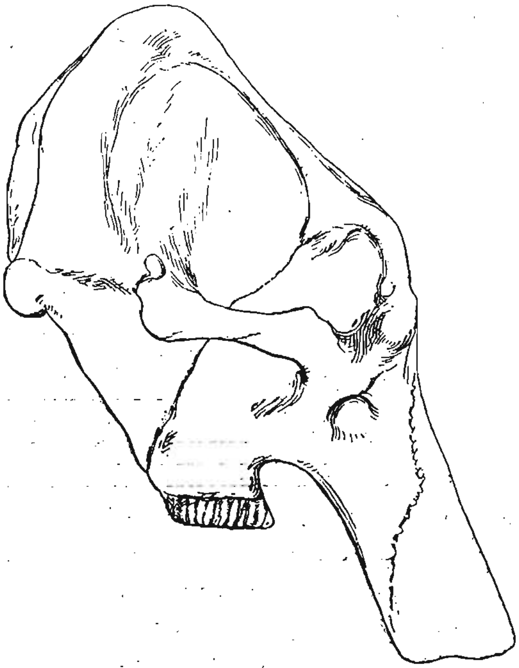

Fig. 134. *Elephas primigenius*. Side view of skull of Siberian specimen. From Falconer.

The teeth are placed in the jaws so that little except their worn faces can be seen. The worn part of the crown of the upper one, the last molar, measures about 285 mm. in length; that of the lower last molar, about 255 mm. The teeth had been relatively little worn, about to the 15th ridge-plate, leaving the arched hinder boundary of the tooth intact. An illustration (Fig. 134) redrawn from a figure in Falconer's atlas presents a lateral view of the skull of *Elephas primigenius.* This is to be compared with that of the skull of the mastodon (Fig. 105) and with that of the skull of *E. columbi* (Plate LXI, fig. 1). The lower jaw of *E. primigenius* is represented on Plate LVII, fig. 3. It is at present difficult to point out the differences between the skulls of the two species of elephant just mentioned. The materials for comparison are rare and those existing in museums have not yet been sufficiently studied. Moreover, the skulls of the different individuals of the same species show much variability in form, according to age, sex, race and individuals; and it would require detailed studies in order to determine the permanent characters. At present, it appears that the sheath which encloses the bases of the tusks is much longer in *E. primigenius* than it is in *E. columbi.*

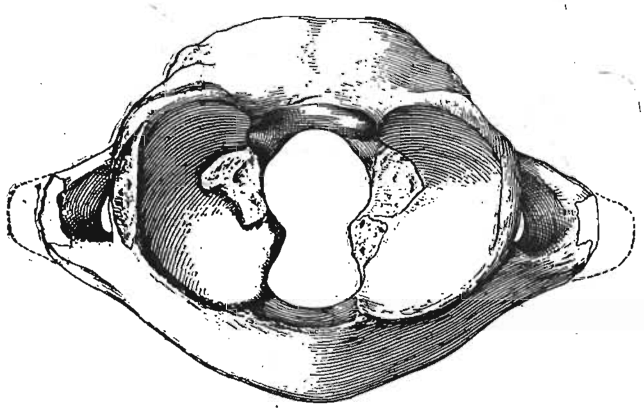

Fig. 135. *Elephas primigenius.* Atlas found on Old Crow river, Alaska. x ¼.

Figure 135 presents a view of the atlas of *E. primigenius* as this bone is seen from the front. It is to be compared with a similar view of the atlas of the mastodon (Fig. 116). Figures

136 and 137 represent the axis of the species of the elephant here described; and these figures are likewise to be compared with similar illustrations of the axis of *Mammut americanum* (Figs. 117, 118). The atlas and the axis are bones which are likely to be preserved and which appear to offer characteristic features in the different species.

It is proposed to give descriptions of the various teeth of this species; and it ought to be said here that it is impossible to make out from a single tooth all the characters that distinguish a tooth which occupies that position. Each one, whether milk tooth or molar, was constantly undergoing change partly

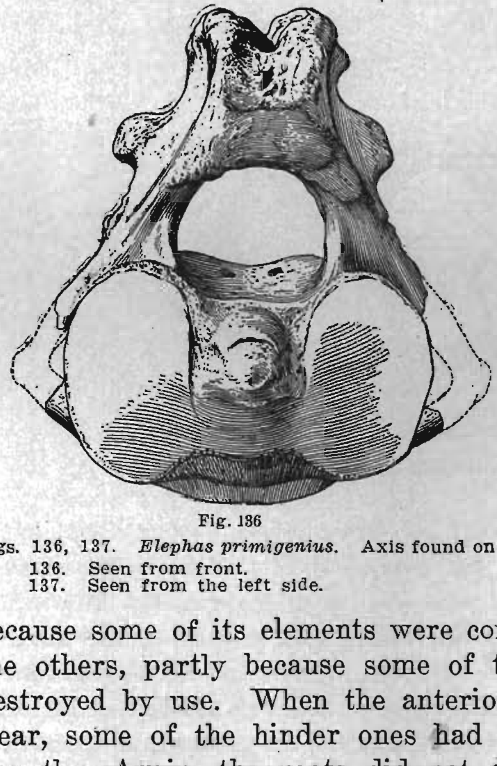

Fig. 136

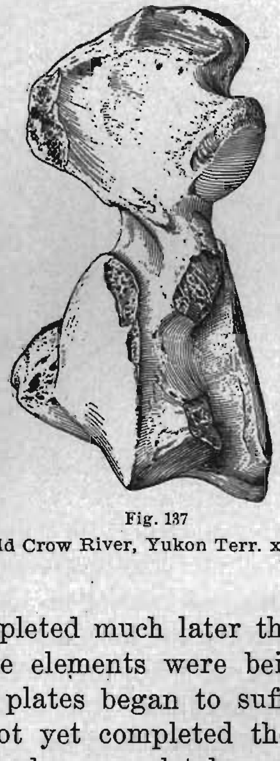

Fig. 137

Figs. 136, 137. *Elephas primigenius.* Axis found on Old Crow River, Yukon Terr. x ¼.
136. Seen from front.
137. Seen from the left side.

because some of its elements were completed much later than the others, partly because some of the elements were being destroyed by use. When the anterior plates began to suffer wear, some of the hinder ones had not yet completed their growth. Again, the roots did not develop completely until the crown had been considerably worn. To know any tooth of any order, therefore, it is necessary to study specimens taken at various stages of development and wear.

The first milk tooth is not known to the writer by any American specimen of the species. It would belong to an elephant that had died probably before it was two years old. Being a small tooth it would be less likely to be observed and saved than the larger teeth. An upper one was figured by A. Leith Adams (Palæontog. Soc., Vol. XXXIII, pl. ix, fig. 3) which had been found in England. The length of the crown was 20 mm. and its width 15 mm. It had only four ridge-plates, and a small imperfect plate (talon) in front and another behind. The figures are here reproduced (Pl. LII, figs. 5, 6), showing the teeth of the natural size. The same writer, on the same plate, figured the corresponding lower tooth, which resembled closely the upper one. They likewise are here reproduced (Pl. LII, figs. 7, 8).

The second milk teeth are nearly as rare as the first ones. The writer knows of no upper one from American sources. Therefore, two of A. Leith Adams' figures are reproduced (Pl. LIV, figs. 1, 2). They show a tooth worn somewhat, which probably belonged to the right side (Adams, Palæont. Soc., London, Vol. XXXV, pl. x, figs. 3, 3*a*). The length of this tooth seems to have been 56 mm.; its width, 38 mm. It appears to have had only six ridge-plates with front and rear talons. Figure 1 of the plate cited shows the fangs of the root with tips broken off. There is a single anterior, a double median, and a single rear fang.

The lower second milk molar is represented in the National Museum by a much worn tooth of the left side, which was brought from Alaska (Pl. LIV, figs. 3, 4). The length of the crown is 73 mm.; the width, 48 mm. There may be counted eight ridge-plates and front and rear talons. The tooth is especially valuable because it shows the root. The anterior fang, supporting the inner ends of the three anterior plates seems to have been mostly absorbed. The hinder fang, long and curved backward, supports the greater part of the crown. This tooth is larger than any of the same order of teeth described by Adams, which ranged from 39 mm. in length of crown and 21 mm. in width to 63 mm. in length and 33 mm. in width. There is, however, no other disposition to be made of the tooth.

Inasmuch as the tooth just described is greatly worn it gives us no conception of the form of the tooth on emerging from the gum. To give such knowledge, another of Adams' figures is reproduced (Pl. LIV, fig. 5). This presents a side view of a tooth which was wholly unworn and whose roots were undeveloped. There are six plates and front and rear talons. The front of the tooth is toward the left hand. The length is given as 50 mm.; the width, 17.5 mm. It is to be observed that the ridge-plates stand at right angles with the base.

The last milk teeth, above and below, show usually a great increase in size over their predecessors. The average length of the upper one is about 120 mm.; the average width about 50 mm. Adams states that the length of this tooth may be as little as three and one-half inches (90 mm.) and as much as five and one-half inches (140 mm.). Thus the size varies widely. He remarks that these teeth are abundant in collections, but he does not figure an upper one. No complete upper tooth of this order is present in the National Museum. Figure 1 of Plate LV shows, in front of the first true molar present, the hinder end of the last milk molar. The greater part of it had been worn down to the roots and then pushed out of the jaw. Remains of only five plates remain. The width of the tooth is nearly 60 mm.

As an upper tooth of this order the writer identifies No. 4836 of the National Museum (Pl. LIV, fig. 6). This tooth was sent many years ago from Waverly, Ohio. It had only begun to wear, only four or five anterior plates having been attacked. It appears to have belonged to the right side. There are present the anterior talon and eleven ridge-plates. There are missing probably one plate and the posterior talon. Two of the hinder plates present had not completely developed their bases. The distance from the base of the first plate to the rear of the hinder one at the middle of its height is 100 mm. What is missing may have added 20 mm. The height of the fifth plate is 110 mm.; that of the eighth, 116 mm. It will be observed that the plates make an angle of about fifty degrees with the base. There are eight plates in a line 75 mm. long, making ten in a 100 mm. line. Where the anterior plates are worn the enamel is very thin. The summits of the unworn plates are furnished each with from eight to ten digitations.

The lower last milk molar has about the same size as the corresponding one of the upper jaw. Four, whose measurements are given by Adams, have an average length of 109 mm., although Adams states that the width of the lower tooth is seemingly the same as the upper which varies in width from 39 mm. to 62 mm. To illustrate the form of this tooth when partially worn, two of Adams' figures of an English specimen are reproduced one-half the size of nature. One of these (Pl. LIV, fig. 7) gives a view of the inner face of a right tooth, while the other, figure 8, of the same plate, illustrates the grinding surface. The length of this tooth was 117 mm.; the width, 53 mm.; the height of the ninth plate, 95 mm. There are ten ridge-plates in a line 100 mm. long. The enamel is described as being "very thin and without the faintest indication of crimping." This description will serve to show that that writer's idea was that the foldings of the enamel must be much deeper than in this specimen to constitute what he called crimping.

As will be observed, there is an anterior fang in front, supporting three plates, and behind this the base of another great root. By the time the tooth had become worn down half-way, this hinder root would doubtless have had the form shown in the case of the second milk molar figured on plate LIV, figure 3.

In the National Museum, No. 6558, from Alaska, is a lower last milk molar which has lost perhaps only one plate and the rear talon. These are, in the figure (Pl. LIV, fig. 9), restored in outline. The tooth had only recently been cut when the animal died; for only five or six plates had suffered wear, and these only a little. In fact, the wear had not reached through the digitations. There are present the anterior talon, apparently two of them, and twelve ridge-plates. From the base of the front plate to the rear of the twelfth is 85 mm.; the greatest width, 53 mm.; the height of the seventh plate, 91 mm. There are six plates in a line 50 mm. long. In front may be observed the base of the anterior fang and behind it that of the great hinder fang. The whole tooth is covered with cement, which, cracking along the edges of the ridge-plates, renders these visible.

The first true molars, upper and lower, are next to be considered. Adams tells us that a small first true molar may be easily mistaken for a last milk molar and *vice versa;* indeed, he says, the chances of such deceptions are the lot of the most experienced manipulators of proboscidean teeth. The only certainty is to be had in finding the molar in the jaw, with a predecessor, or in having a milk molar smaller than any known first true molar, or a true molar larger than any known milk molar.

Plate LV, figure 1, represents a part of the right maxilla of a mammoth, No. 6656, of the National Museum. It was found in Alaska. There is presented a view of the grinding face of the first true molar. In front of this tooth is the rear of the last milk tooth; while behind it is a hollow cavity in which was hidden the germ of the second molar. The first molar of this specimen has a length of 132 mm. and a width of 60 mm. It will be noted that this tooth falls below the maximum size of the last milk tooth; but the presence of this last tooth in the maxilla makes it certain that the identification is correct. This tooth is so thoroughly covered over with cement that it is difficult to count the number of ridge-plates; but there appear to be twelve, with front and rear talons. Nine of the anterior plates have suffered attrition. On about six of these the wear had not extended down to the bottoms of the digitations; and so there are seen, in the place of each plate, three or four ellipses of enamel.

The tooth above described is so firmly imbedded in the maxilla that a side view of the base of the crown and of the roots cannot be obtained; furthermore the writer has at hand no other tooth of this same order from which to make an illustration; and A. Leith Adams does not give a view of this tooth from the side. In appearance it would not differ greatly from the upper second molar (Pl. LV, fig. 3).

The lower first molar is represented by a tooth in the collection of the University of Iowa, No. 324 (Pl. LV, fig. 2). This was found by Wm. H. Walker, near Marengo, Iowa, in alluvial gravel, along Bear creek. It belonged to the right side of the jaw. There are twelve plates and the usual talons. Five plates occupy a line 50 mm. long. The length from the base of the first plate to the rear of the convexity is 125 mm.; measured along the base, 133 mm. The width is 56 mm. In size it falls a little below the maximum of the last milk molar, as given by Adams (length five and one-half inches, width two and one-half inches). The tooth, therefore, is possibly the third milk tooth; but it is probably the first lower molar.

The tooth here described has the grinding face worn back nearly to the last plate; but the front has not been worn down quite so much as might be expected. There are two partially developed fangs in the root, one in front, supporting three plates, and the base of the hinder fang. The average length and width of this tooth is about the same as in the corresponding upper one, perhaps somewhat less. Calvin reported and figured a good lower jaw which was found in alluvium along Iowa river, near Marengo (pages 74, 436). The teeth present are regarded as the first true molars. They are not worn to the base in front, but are worn to the last plate behind. There are thirteen plates with front and rear talons. The length is 156 mm., the width 67 mm. The enamel is considerably crinkled in its course across the teeth.

The second upper molar could hardly be represented by a better tooth than the one which furnishes figure 1 of plate LVI. This tooth is No. 6556 of the National Museum, and it, too, came from Alaska. It is to a large extent covered with cement, which became fissured in drying. There appear to be sixteen ridge-plates, besides front and rear talons. Posteriorly the crown has a backward projection, between which and the root is a concavity in which lay the front end of the last molar. From the base of the first ridge-plate to the rear of the occiput-like protuberance is 188 mm.; from the same point in front to the rear of the base of the crown is 146 mm.; the width is 80 mm. An unusual feature of this tooth is its great height, the height of the thirteenth plate being 175 mm. The roots of the tooth are mostly hidden in a part of the jaw bone which remains. The figure shows this bone on the outer face of the tooth. It is crowded with large air-cavities. In front there is a single rather small root; behind this some fangs in pairs; and at the rear a single fang (as yet hollow, like a shell), which supports all the ridge-plates behind the twelfth. Figure 4 of plate LV presents a view of the grinding surface of this tooth. The enamel is moderately thin. There are ten ridge-plates in a line 100 mm. long.

The average dimensions of a number of upper second molars measured by Adams are about 171 mm. for the length and 70 mm. for the width. The longest tooth had a length of 202 mm.; the widest, a width of 77 mm. The tooth above described and figured is slightly wider than the widest one mentioned by Adams.

Another tooth which belongs here is No. 21 of the collection at the University of Iowa. This was found in a gravel pit at Denison, Crawford county, Iowa, and was figured by Calvin (Bull. Geol. Soc. Amer., Vol. XX, pl. xxiii, fig. 2). His figure is reproduced here (Pl. LVI, fig. 2). This tooth does not show the excessive height seen in the Alaska tooth just described. The Denison tooth has lost probably two plates from the rear, there being present the anterior talon and fourteen ridge-plates. In a 100 mm. line across the plates eleven are counted. The length from the base of the first plate to the rear of the eleventh is 160 mm. The height of the ninth plate is almost exactly the same. The unworn part of the grinding surface is quite exactly parallel with the base of the crown, and the plates are parallel with one another. Adams (Palæont. Soc., Vol. XXXIII, pl. ix, fig. 1) has figured a tooth which greatly resembles the one just described. It was, however, somewhat older, is slightly more worn, and has the bases of the roots developed.

Figure 2 of plate LVII illustrates a more worn tooth of this order from Alaska, No. 6566, of the National Museum. It belonged on the right side. There are fifteen ridge-plates and the usual talons. The length along the base of the crown is 107 mm.; from the base in front to the rear of the projection behind, 140 mm. The width is 70 mm. The enamel is thin. The fangs of the root were developed, but some have been broken off. An attempt has been made to restore some of them in outline. There is a pair in front; two other pairs in the middle of the length; and a large hinder fang. Figure 3 of plate LV represents the second upper molar of the left side of almost certainly the same individual and shows the roots in better condition. The fangs are in pairs except the hindermost large one.

To illustrate the lower second molar there is here presented (Pl. LVIII, fig. 3) a figure of one of the right side which was found a year or two ago in Greene county, Pennsylvania. The corresponding tooth of the left side was contained in the jaw. The tooth figured measured 160 mm. in length, 65 mm. in width and 100 mm. in height at the ninth and fifteenth ridge-plates. There are sixteen plates in the tooth, with front and rear talons. The cement is preserved on the part of the tooth which was outside of the bone of the jaw. There are eleven plates in a line 100 mm. long. As is seen, there is one fang in front, supporting three plates; while behind this the dentine had begun to spread over the pulp to form the hinder fang. Only nine of the plates had been attacked by attrition. Had the animal died before the tooth was cut, the anterior end of the tooth would have shown, where is now seen the worn surface, a sort of rounded boss. On the worn edges of the ridge-plates the enamel is very thin.

As shown by other specimens, the hinder fang of this tooth, when the crown became well worn down, was nearly as wide as the crown and was directed downward and backward, somewhat like that of the second milk tooth shown on plate LIV, figure 3.

Figure 3 of plate LVII presents a view of a nearly complete lower jaw in the National Museum, No. 6666, from Alaska. In it are both second lower molars, well worn down; and behind them, concealed in the jaw, are both third molars. The ridge-plates of these had not united firmly and are now lying loose in the cavity of the jaw. Every plate of the second molars had come into use. The figure is one-fifth of the natural size.

The third molars, the last acquired by the animal, are the ones most frequently found. They are, of course, the largest teeth in each series and they contain the greatest number of ridge-plates, typically twenty-four. It is stated that the number may vary from eighteen to twenty-seven, but the extremes are of rare occurrence.

The third upper molar is represented by figure 1 of plate LVIII. This figure is prepared from a tooth (No. 6564, National Museum) yet in a fragment of the jaw, which was, with the one of the opposite side, found in Alaska. It belonged to the right side and the figure presents a view of the outer face. The tooth still preserves a large part of its cement. The length along the base of the ridge-plates is 228 mm.; the width is 82 mm. The height of the seventeenth ridge-plate is 130 mm. These plates were not as high as those of the second upper molar from Alaska, described above. There are eleven plates in a line 100 mm. long. The fangs of the root are partly shown. In front there is a pair, of which one is presented in the figure as broken off near the base. Behind this are three or four pairs of small snags, and at the rear the great single fang. This is now hollow; but, in still older specimens, it is filled up solidly. It will be observed that this tooth has no occiput-like protuberances at its rear. This is because there was no other tooth behind it to press it more or less out of its natural shape.

Figure 2 of the same plate presents a side view of one of the last upper molars of the hairy mammoth which was found in Grant county, Indiana, and which is now mounted in the American Museum of Natural History, New York. The photograph was furnished the writer by Prof. A. D. Hole, of Earlham College, who saw the tooth shortly after the animal was exhumed. The watch shown in the figure has a diameter of 51 mm. From this it is estimated that the tooth has a length along the bases of the ridge-plates, of over 285 mm. The width is 93 mm. Although the tooth is not greatly worn, the fangs, or, at least, all but the hindermost one, were well developed. The hindermost one was probably still a hollow shell. If this is compared with similar teeth from Alaskan specimens of *Elephas primigenius,* they will be seen to agree in form; while the rear of this tooth differs from that of teeth of *E. columbi.* Figure 2 shows also the grinding surface of the other upper molar.

Neither of the teeth above figured give us an exact idea of the form of the last molar before it began to be worn through mastication of the food. This lack is supplied by a fine specimen in the Milwaukee Public Museum, photographs of which have been furnished the writer by the director, Henry L. Ward. The specimen was found in Milwaukee. It consists of the second and the third upper molars of both sides, and a part of the right and left maxillæ. A view of the teeth of the right side is here presented (Pl. LIX). The second molars are worn down in front to the roots, not so deeply behind. The figure shows that the hinder fang was a large one. This tooth measures 175 mm. along the grinding surface. The hinder molars had just pushed the tips of the anterior plates through the gum. No roots were yet developed on this tooth and the bases of the hindermost plates were not completed. The grinding border of the tooth is parallel with the line of the bases of the ridge-plates (at least, when these are completed) and the plates are nearly parallel with one another. The form of the tooth is a trapezoid. There are present twenty plates, but one or more, probably about four, are missing from the hinder end. The length from the base of the first plate to the middle of the hindermost one present is 260 mm. The whole tooth is covered with cement, which on drying, has shrunken and cracked. It will be noted that the lower border of the hinder molar makes an angle of about 120° with the grinding surface of the tooth in front of it. This hinder tooth stood thus in a nearly perpendicular position in the jaw, and only one corner of it at first came into use. Before, in old age, the hinder plates were ground down, the tooth would have turned through an angle of about 60°. By that time the large hinder root would have developed so that the hinder plates might be held together under the strain of mastication.

In concluding the description of *Elephas primigenius* the writer calls attention to Plate LX, which presents a restoration of this species as represented by specimens found in the flesh, frozen in the ice in Siberia. This restoration is one that was published by the Russian paleontologist, E. Pfizenmayer, in volume XLII of the Verhandlungen der kaiserlichen mineralogischen Gesellschaft of St. Petersburg. The figure forms plate VII of that paper. It is through the courtesy of Dr. Pfizenmayer that this plate is presented. The figure is intended to show the form of this interesting animal, its covering of hair, and its bleak environment.

Elephas columbi Falconer.

Tooth formula apparently not differing from that of *E. primigenius;* the number of ridge-plates in the hindermost molars varying from probably 18 to 28. The ridge-plates usually thicker than those of *E. primigenius;* the enamel plates likewise thicker and liable to be more channeled and crimped. Ridge-plates more likely to be dish-shaped and bent than in the other species mentioned. The sheaths for the bases of the tusks shorter than in *E. primigenius.*

This species, which has often been confounded with the hairy mammoth, is entirely distinct from it, as is revealed by many dental and skeletal characters. Instead of being a rare species, its remains are, even in the glaciated states, fully as abundant as those of *Elephas primigenius;* while in most of the southern states it is the only species found. On the Great Plains it is more often found than *Elephas imperator*. Teeth found in the Pacific coast seem to belong to it; while several teeth in the National Museum seem to indicate its presence in Alaska at some time during the Pleistocene. It is found also in Mexico.

Notwithstanding the wide distribution of the species and the numerous remains that have come to light, nothing like a complete skeleton has yet been found; and such remains of the limbs as have come to light have not yet been sufficiently studied to enable us to distinguish them in all cases from those of the hairy mammoth. It is particularly important that all skeletal parts of this and other species of elephants that shall be found associated with teeth shall be preserved. In this way we may at length determine the differences existing between the three species found in Iowa.

Through the generosity of the American Museum of Natural History, the writer has the privilege of presenting here a reproduction of a photograph taken from a mounted skull in that museum (Pl. LXI, fig. 1). This skull was obtained many years ago, so it is thought, in Whitman county, in the southwestern part of the state of Washington, but its origin is somewhat uncertain.

As will be observed, the skull has suffered some injury. Above, the outer plate of the bones of the brain-case has been weathered off; but this has the advantage of exposing some of the numerous large air cells which occupy the space between the outer and the inner plates of bone. The zygomatic arch has been mostly restored in plaster, as well as the articular process of the lower jaw and the top of the coronoid process. Only a part of each tusk is preserved, about 400 mm.

The following measurements of it have been taken by the writer:

From the vertex to the lower floor of the external nares	490 ± mm.
From the nasal opening to the end of the sheath for the tusk, the distal ends of the latter being somewhat damaged	490 mm.
Width of the occipital region	840 mm.
Width at the postorbital processes	776 mm.
Height from the occipital condyles to the vertex	690 mm.
Anteroposterior diameter of the base of the tusks	155 mm.
Side-to-side diameter of the base of the tusks	150 mm.

The lower jaw has a long pointed chin, extending beyond a perpendicular from the front of the tooth about 175 mm.; also, this chin falls much below the distal end of the sheath for the tusk. The lower jaw is 160 mm. thick below the front of the coronoid process. Its depth at this point is 150 mm.; and at the front tooth, 195 mm. This lower jaw probably belonged to another individual, since the upper and the lower teeth are in different stages of wear. In the upper jaw the second true molar is present. It shows only about twelve ridge-plates, but three or four anterior ones had probably been worn down and had fallen out, for there must have been about sixteen. The last true molar is present, but only the front of it had come into use. The tooth in the lower jaw is the third molar in a more advanced stage of wear, being worn back to the twelfth ridge-plate or farther.

A comparison of this skull with those of the hairy mammoth discloses some differences.—(1). In the latter there is a large angle between the plane of the forehead and that of the sheaths of the tusks. (2). In most specimens of *Elephas primigenius* the forehead is quite concave, in *E. columbi* it is nearly flat. (3). In *E. primigenius* the sheaths of the tusks are much longer than they are in *E. columbi,* being usually as long as the distance from their bases to the vertex, and extending downward below the chin.

When we come to compare the teeth there are certain differences which appear to be quite constant. The teeth of *E. columbi* are larger and coarser-plated than the corresponding teeth of *E. primigenius.* In *E. columbi* usually the hinder ridge-plates lean forward toward the anterior ones, while in *E. primigenius* the plates are all or nearly all parallel. However, in the lower teeth of *E. primigenius,* the hinder ones may lean forward, and in rare cases the plates in the teeth of *E. columbi* may be parallel with one another. In *E. columbi* the base of the crown of the teeth is nearly always convex, while in *E. primigenius* it is nearly straight. This is more nearly true of the upper teeth in *E. primigenius,* than of the lower ones, where it may be curved. The hinder border of the upper molars of *E. primigenius* is strongly arched in the half worn teeth; in *E. columbi* the outline of this rises in a straighter slope from the front to the rear. In *E. primigenius* the various ridge-plates are nearly flat; while in *E. columbi* they are often concave on one face and convex on the other, often both in the length of the plate and across it. Finally, the enamel of the ridge-plates is much thinner in the teeth of *E. primigenius* than in those of *E. columbi.*

The various teeth of this elephant will, as far as possible, be here described and figured. On account of the great size of the true molars and the convenience of representing all of the teeth on the same scale, it is found necessary to make the figures only one-third of the natural size. An exception to this rule is made in favor of the figures of the first milk molar which, on account of its small size, is represented of the natural size. Most of the teeth of *E. primigenius* are represented one-half of the size of nature. It is not possible, at present, to obtain specimens of each order of tooth of *E. columbi* in all desirable stages.

Of *the first milk teeth,* upper and lower, the writer has seen no specimens. Leidy (Trans. Wagner Institute Sci., Vol. II, p. 17, pl. iii, figs. 6, 7) describes one from Ocala, Florida. His figures are here reproduced (Pl. LXI, figs. 2, 3). This tooth is said by Leidy to measure 18.5 mm. fore and aft, and 17 mm. transversely. It is little worn and it is not determined whether it belonged to the upper series or to the lower. It had already developed its roots.

The only example of *the upper second milk tooth* at present accessible to the writer is No. 1614 of the National Museum. It was obtained from the phosphate beds of South Carolina, and it is black in color. The tooth belonged to the left side. It had been worn in front on only three ridge-plates. The hinder plates had not completed their growth, and there are no roots. There are eight plates and the front talon. The hinder talon appears to have been split off. The length, from the base in front to the middle of the hinder plate, is 101 mm. The greatest thickness is in front and amounts to 57 mm. The height of the fourth plate is 94 mm. On the tooth there is a more or less complete covering of cement. Through this, on the grinding edge, appear five or six digitations on each of the three hinder ridge-plates. On the anterior plates these digitations had hardly been worn to their bases. The tooth is represented by figure 4 of plate LXI.

In the publication cited above and on the same page, from the same locality, Leidy described and figured an upper second milk molar. His figures are here reproduced of one-third the natural dimensions (Pl. LXI, figs. 5, 6). The length from front to rear is 110 mm.; the greatest thickness, 46 mm. It appears to have eight ridge-plates with front and rear talons. The roots are pretty well developed.

The lower second milk tooth is represented by figures 7 and 8 of plate LXI. The number of the tooth in the National Museum is 6662. This tooth was received, with many others of this species, from Afton, Oklahoma. It is a considerably worn tooth and larger than the upper one, just described. Apparently the anterior talon and the first ridge-plate are broken off. There are present six plates and a talon which is practically another plate. The length of the tooth, from base in front to the rear of the hinder talon, is 135 mm. The width, not including the cement, is 69 mm. There are five and one-half or six plates in a line 100 mm. long, and the enamel is thick. The roots of the tooth appear to have completed their growth; but, unfortunately, they are mostly broken off. There is left the base of one in front and that of one large hinder one. In all probability this was as broad behind as the tooth and had its extremity directed considerably backward. There is no lower tooth of this order which presents the form of the crown before it began to be worn down.

As *the third upper milk molar* of *E. columbi* the writer identifies a tooth which is in the collection of the Philadelphia Academy (Pl. LXII, fig. 1). It was obtained at Big Bone Lick, Kentucky. It is a wholly unworn tooth and, of course, shows the original form of the crown; there are no roots. The bases of the hinder plates were not yet complete, but probably nearly so. The height of the plates diminishes rapidly from front to rear. The length of the tooth, from the base of the anterior plate to the hinder one, is 145 mm.; the thickness, 75 mm.; the height of the first plate, 143 mm. There are present twelve ridge-plates, besides front and rear talons. A line 100 mm. long passes across eight of these plates, a number greater than one might expect in this species; but the tooth is certainly not that of *E. primigenius*.

No *upper third milk molar* with good roots is accessible. Number 6663 of the National Museum, from Afton, Oklahoma, probably belongs here, but it may be the first true molar. It is worn down to the roots in front and evidently some part had broken away and been ejected from the animal's mouth. There are present eight plates and traces of another in front. There were originally probably twelve plates. The length of the specimen, along the grinding face, is 143 mm.; the width is 75 mm. The specimen gives some indications regarding the roots. These appear to have been completely developed, but they were badly treated in taking the tooth from the ground. In the rear is the base of the great fang which supported at least half of the crown.

It is now 60 mm. high and evidently a considerable part of its extremity is missing. This extremity, or tip, was yet hollow. In front of this fang are seen four others. On the opposite side of the tooth are corresponding but smaller fangs. None of these are free, but are united by one border to a median plate of dentine. Probably, however, the extremities of three fangs were free.

Figure 2 of plate LXII represents a side view of a tooth brought by Mr. A. G. Maddren, of the U. S. Geological Survey, from Old Crow river, in Yukon Territory, within about two degrees of the Arctic ocean. It is No. 6669 of the National Museum. It is believed to belong to this species, and it quite certainly did not belong to *Elephas primigenius*. It is interpreted as the left *lower third milk molar*. The hinder ridge-plates are damaged and had not yet been fully developed at their bases. The tooth had only recently come through the gum, for it is worn only slightly on four ridge-plates. No roots had been formed. On the front end is an oblique flat surface which had been produced by pressure and wear against its predecessor. It will be observed that the hinder plates lean strongly forward. There are counted thirteen plates. From the angle of inclination of the hinder fragment, it is believed that none are missing. The greater length is 180 mm.; the width, 67 mm.; the height, 135 mm. There are seven ridge-plates in a 100 mm. line. The number approaches, therefore, that found in some specimens of *E. primigenius*. The enamel is much thicker than in specimens of the last-named species.

Figure 3 of plate LXII represents a greatly worn tooth of the right side, No. 6052 of the National Museum, which, with its fellow in a part of the lower jaw, was found near Glendive, Montana. The figure represents the tooth as seen from the right side. It is probably the third milk molar, but it is impossible to say just how much had been worn from the front when the animal died, and it may be the first true molar. Eight plates and traces of another in front are present. The length along the grinding surface is 155 mm.; the width is 75 mm. Were there three more plates, the length would be near 200 mm. The specimen is of most value as showing the roots. In the rear is a great fang which, behind, begins with being nearly as broad as the crown. Towards its tip, which is broken off, it was directed strongly backward. In front of it are fangs which by one border cling to a median plate of dentine and are free only near their tips. At the very front of the tooth, as preserved, was a pair of long slender fangs free from their bases to their tips. The one on the side shown in the figure has been broken off, but the socket is shown. The one on the opposite is in a notch in the front border of the jaw and had apparently had its anterior edge split off when a part of the crown had broken off. The double fang in front appears to be unusual and its presence may be due to absorption, preparatory to ejection, of the anterior part of the tooth from the mouth. Near the front border of the jaw is seen the mental foramen. A similar foramen occurs nearly opposite it on the inner side of the jaw.

The writer has access to no tooth which can be certainly identified as the *first molar of the upper jaw.* Formerly (Geol. Surv., Indiana, Vol. XXXVI, p. 737) the author identified as belonging here a tooth which was found many years ago by E. D. Cope, in New Mexico. However, a renewed examination of that tooth makes it more probable that it belongs farther back in the series. It is impossible to say how much of the front of the tooth was lost before the death of the animal. As already stated, No. 6663 of the National Museum, a considerably damaged tooth, may really belong here. As in the case of the last milk molar and the first molars, upper and lower, of *E. primigenius,* it will probably be found that in the same teeth of *Elephas columbi,* it will be sometimes difficult to distinguish them. Had one a number of good series of both the upper and the lower of these teeth, some characters might be found which would serve to separate them.

The *first lower true molar* is shown by figures 4 and 5 of plate LXII, a tooth (No. 2256, National Museum) of the left jaw, from Afton, Oklahoma. It is worn down in front nearly to the base and backward to nearly the last ridge-plate. A part of the small anterior root is preserved, but the hinder root had not yet been developed. The length of the tooth is 200 mm.; the width of the grinding face, 78 mm.; the height of the hinder plates, 132 mm.

There are eleven plates, with front and rear talons. On the grinding face there are six ridge-plates in 100 mm. As will be observed, the sides of the tooth are yet, to a great extent, covered with cement. The enamel of the ridge-plates is thick and crimped. This is a beautifully preserved tooth.

The *second upper permanent molar* appears to be represented in the National Museum by No. 287, without known locality (Pl. LXIII, fig. 1). This tooth was used for illustration by the author in a report to the State Geologist of Indiana (Vol. XXXVI, pl. xxiv, fig. 2), but in the explanation of the plate it is wrongly called the third molar. It appears to be too small to be the last molar, and if such would have the minimum of ridge-plates. In front, this tooth is worn down to the bottom of the first ridge-plate and backward to the thirteenth. There are eighteen or nineteen plates present, a number slightly larger than expected; but we do not know well yet the extent of variation in this species. The length of the tooth along the base, in a straight line, is 300 mm.; the width, 78 mm.; the height of the thirteenth plate, 195 mm. The plates are bent as they ascend, as seen on the sides of the tooth. There is an unusually small amount of cement between the various plates. There are eight plates in a 100 mm. line. The base of the crown is strongly convex. On the anterior half of this tooth there remains a considerable amount of cement.

As belonging here the writer identifies a tooth (Pl. LXIII, fig. 2) which is in the collection at the University of Iowa and which has the number 167. It was found by Prof. B. Shimek, in the Peckenpaugh gravel pit, at Logan, Harrison county, Iowa, in Aftonian deposits. There are present fourteen ridge-plates and the anterior talon. The hinder plates had not completed their growth and it is probable that about two are missing. On the other hand, it is possible that this is a first true molar with somewhat more than the typical number of plates. The height of the eighth plate, 160 mm., appears to be against the latter supposition. The distance from the front of the grinding face to the rear of the last plate is 192 mm.; from the base of the first plate to the rear of the last plate, about 175 mm. The width of the tooth is 70 mm. There are eight plates in a line 100 mm. long.

It will be observed that the tooth regarded as the third upper milk molar (Pl. LXII, fig. 1) would resemble the tooth here described, if the front plates of the former had been worn down to the seventh or eighth from the front.

The *lower second molar* seems to be represented by No. 2254, of the National Museum, from Afton, Oklahoma (Pl. LXII, fig. 6; Pl. LXIII, fig. 3). The hinder part, probably about three plates, is missing. There are thirteen present, besides the short one, the talon, in front. The tooth is worn but little, only on the anterior five plates. There are seven plates in a 100 mm. line. It will be seen from the figure that they are curved as they ascend; while the anterior and the hinder ones converge toward their summits. The length of this specimen, from the summit of the anterior talon to the base of the hindermost plate present, is 225 mm.; from the base of the anterior plate to that of the hinder one present, 180 mm. Three additional plates would have made the basal length about 220 mm. The height of the sixth plate is 135 mm. In the unworn condition there was evidently a rounded boss which occupied the front and upper angle of the tooth. Each of the unworn ridge-plates ends above in seven or eight digitations, of which the outer one on each end of the row is considerably larger than the others.

Figure 4 of plate LXIII is a tooth which was collected somewhere in Alaska, by Mr. A. G. Maddren, of the U. S. Geological Survey. It is No. 6668 of the National Museum. By the writer it is identified as the lower second molar of the left side. The tooth certainly did not belong to *Elephas primigenius,* as shown by the coarseness of the plates, seven in a 100 mm. line, by the form of the tooth, by the bent condition of the ridge-plates, and by the thickness of the enamel. Unfortunately the front of the tooth is injured, but it is evident that not more than the first plate, with the talon, is gone. Counting one missing there were nineteen present, including the rear talon, practically a plate. That is in excess of the supposed typical sixteen, but perhaps sixteen is not typical of the number of plates in the penultimate molar. This individual tooth had suffered wear on only five or six plates, and on these it had hardly gone through the digitations. The whole tooth is covered with a coating of cement. The length of the base in a straight line exceeded little, if anything, 277 mm.; the thickness, 90 mm.; the height of the sixth plate, 140 mm. No roots had begun to form.

The *third permanent molars,* upper and lower, are more numerous in collections than any of the other teeth. They are large and powerful organs. Notwithstanding the number of these teeth, the writer can furnish no illustration of an upper one which had not yet begun to wear.

Figure 1 of plate LXIV is taken from No. 2247, of the National Museum, an upper ultimate molar which was found at Afton, Oklahoma. The tooth has lost a little of the rear, probably one plate and the talon. Counting thus there were twenty plates. In front it is worn down to the roots and it is not improbable that a few plates had there worn out and disappeared; however, the number in this tooth is probably sometimes reduced to twenty. We may expect twenty-four or even more. The length of the tooth, as preserved, is 340 mm. The height of the tooth at the seventh plate is 215 mm.; the greatest thickness is 100 mm. There are six, in some places seven, plates in a line 100 mm. long. It will be observed that the base is very convex; also that the ridge-plates are much bent on their way from the base to the summit. The summits converge distinctly. Those of the plates in front, in this specimen, are turned so strongly backward, that the plane of wear cuts the front borders at a very acute angle. This causes the anterior lamina of enamel of each ridge-plate to stand out very prominently. Under the bases of the ridge-plates, from the fourth to the ninth, inclusive, is a mass apparently of coalesced fangs. Others in front have been broken off, apparently in getting the tooth out of the ground.

The base of the crown of the upper molars of *Elephas columbi* is usually pretty strongly convex, as in the tooth just described, and this character may be employed to distinguish the teeth of this species from those of *Elephas primigenius;* but to this rule, as to most others, there are some exceptions. To illustrate this there is presented here (Pl. LXIV, fig. 2) a figure of a large upper last molar which was found near Mount Angel, Clackamas county, Oregon. The length from front to rear is 355 mm.; the greatest height along the thirteenth plate is 193 mm. From the photograph received from Rev. P. Ambrose Walsh, it appears that there are present twenty-one ridge-plates. There are of these five and a fraction in a line 100 mm. long. It will be observed that the base of the crown is nearly straight. The tooth is also remarkable because of the fact that the ridge-plates are not warped as they proceed from the base to the summit. The specimen presents a good view of the roots of the last upper molar. The number of these small roots is remarkable, there being one, or a pair of them, for nearly every ridge-plate. Those in the rear had not yet completely developed. It is quite probable that most of these fangs are free only at their very extremities, while along the greater part of their length they are attached by one border to a median plate running the length of the tooth. This tooth is so different from the one shown on the same plate that it may be suspected to belong to some undescribed species.

The structure of the last lower molar may be illustrated (Pl. LXV, fig. 1) by a little-worn tooth of the right side which was found in Tipton county, Indiana, by Prof. Erwin H. Barbour, of the University of Nebraska. It is a part of the Morrell collection at the university named. This tooth has suffered only a little wear on about three of the broad plates; it gives therefore an idea of the form of the tooth when first coming into use. The base is strongly convex. The anterior ridge-plates have their summits turned considerably backward, while those of the rear lean forward. There are twenty-two plates present and one or two are missing from the rear, where they had not yet become well consolidated. From the front to the rear of the tooth, in a straight line, the length is 280 mm. The height of the fourth plate is 152 mm. This tooth, of course, had developed no roots. There is in the National Museum a very similar tooth, No. 6017, which was found somewhere along Missouri river in Montana.

Figure 2 of plate LXV is prepared from a photograph of a lower jaw found near Mount Angel, Oregon. It belonged probably to the same individual to which appertained the last upper molar of plate LXIV, figure 2. Here there is seen the front of the lower jaw, with its long beak, and the jaw contains both of the last molars. In front of each of these molars is seen a cavity in the jaw which was occupied by the hinder fang of the second molar. The length of the last molar may be judged from the fact that the worn surface of the left one is 216 mm.; from the tip of the beak to the front of this great molar is 280 mm. It will be observed that the hinder plates pitch strongly forward, as in the tooth from Tipton, Indiana.

To indicate the size which the last molars of *E. columbi* may attain, it may be stated that there is in the State Museum at Lincoln, a lower tooth, which has the length of 407 mm. Prof. Erwin H. Barbour informs me that this tooth has twenty-eight ridge-plates. This may include the talons.

Elephas imperator Leidy.

Tooth formula not well known; the hindermost molars having apparently from sixteen to twenty ridge-plates; the teeth large, with thick ridge-plates and thick enamel; the ridge-plates often concave on their hinder face and more or less warped; those of the hinder half of the lower teeth leaning strongly forward.

This is a species not yet well known, although various parts of its skeleton have been collected. The type was collected many years ago by F. V. Hayden, on the Loup Fork of Platte river and therefore somewhere near the center of Nebraska. It is now in the National Museum and is designated by the number 185. Leidy figured the specimen in 1869 (Extinct Mamm. Fauna, Dak., Neb., p. 254, pl. xxv, fig. 3). He regarded the tooth as probably the penultimate molar, and in the publication just referred to was inclined to refer it to Falconer's *Elephas columbi*. On account of the great breadth of the tooth, the present writer believes it is the last molar, and probably that of the right side of the skull. This type is only a fragment, however, consisting of eight anterior ridge-plates of a much worn tooth. It is probable that some plates in front had worn down and fallen from the animal's mouth before its death. There were evidently some roots present, and these were probably broken off about the time of the discovery of the specimen. The breadth of the grinding face is 125 mm., but of this about 5 mm. on each side belongs to the cement. There are hardly five ridge-plates in a line 100 mm. long and crossing the plates at right angles. The enamel plates are each nearly as thick as the layer of dentine enclosed by them. The plates of cement intervening between the ridge-plates are somewhat, but not greatly thicker than the plates of dentine. The face of each enamel plate which is directed toward the plate of cement is moderately striated from the base to the summit, but this striation is not deep enough to be called crimping. At their inner and outer margins the ridge-plates are turned backward so as to make each one deeply concave on the hinder face, convex on the front face.

The discovery of additional specimens bearing the essential characters of the type specimen make it very certain that they belonged to a species distinct from both *Elephas primigenius* and *Elephas columbi.*

Some fine elephantine teeth were found by W. H. Holmes, in a spring, near Afton, Oklahoma. Two of these, an upper and a lower, were figured by Holmes (Report U. S. Nat. Mus., 1901, pls. viii, ix), and were, on the authority of Frederick A. Lucas, referred to the species here described. Through the courtesy of the National Museum the present writer is permitted to present figures of these teeth (Pl. LXVI, figs 1, 2; Pl. LXVII, fig. 1). The upper tooth, figure 1 of the plate first cited, has the catalog number 2216. It was without doubt the last upper molar of the left side. In front it is worn down to the base. The surface of wear extends back to the ninth plate. There are counted sixteen plates. The anterior talon is missing on account of wear, and the posterior one is broken off. It seems not unlikely that at least two ridge-plates are missing, either in front or behind. The plates are very thick, there being hardly five of them in a 100 mm. line. It will be observed that the plates are bent as they pass from the base to the summit. In another tooth, which is broken, it is seen that the hinder faces of the plates are considerably dish-shaped. It will be observed likewise, that the plates converge toward their summits. The base of the tooth is very convex.

The length of the tooth, from the base of the first ridge-plate to that of the hindermost, is 350 mm. The thickness is 126 mm., more than one-third the length of the tooth. The height of the ninth plate is 250 mm. As will be noted, the plane of wear, at the stage represented by this tooth, strikes the summits of the plates very obliquely.

Had there been other plates in front, the plane of attrition would have been nearly parallel with them. From the direction taken by the anterior plates, it seems probable that the tooth had not yet lost any considerable part of its bulk through wear.

From Afton, with the tooth described above, was brought another great tooth, No. 2217, of the National Museum, which belonged to the right side of the lower jaw. This is shown on plate LXVI, figure 2; and plate LXVII, figure 1. It is possible that it belonged to the same individual, but of this we cannot be certain. It is worn back to about the ninth ridge-plate; in front, down to the base of the front plate. One cannot be wholly certain that one or more plates have been worn out and have disappeared in front; but because of the small number and because no anterior root is present it is thought that at least two are gone. The length from the base of the anterior plate present to that of the hinder one, is 297 mm. The greatest width, taken at one-half the height of the tenth plate, is 125 mm.; the height of the ninth plate is, in a straight line, 170 mm. At the middle of the inner and outer faces there are only three and a half ridge-plates crossed by a line 100 mm. long. At the rear there are five plates in such a line. There are to be counted sixteen ridge-plates and a posterior talon. These are about as thick as the cement plates. The enamel is thick and considerably crimped.

The lateral view of the tooth shows that the anterior plates are directed at first forward as they ascend, but at mid-height, they are turned somewhat backward. The hindermost plates lean strongly forward. The base is very convex. Unless the anterior roots are missing through wear, very feeble ones were developed in front, none at all in the rear. One rather striking feature in the tooth is the way in which it becomes thinner toward the base. For example, a ridge-plate which measures 125 mm. in width at half its height, is only 75 mm. wide at the base. On account of the great size of the two teeth above described, the writer has regarded them as the hindermost molars, upper and lower. It is noticed that these have only sixteen ridge-plates present. It is possible that the number of these varies, as it does especially in *Elephas primigenius,* but to some extent in all species of elephants.

Again it is possible that these teeth, large as they are, are only the penultimate molars; but on neither of them is there seen at the rear any surface against which another tooth had pressed. And in this connection may be mentioned a great lower jaw which is in the collection of the Philadelphia Academy of Science. This has no label, but the writer has reasons for believing that it is one found by E. D. Cope, at Wellington, Kansas, and described by him in the Journal of that Academy, volume IX, 1894, page 453. This jaw is somewhat damaged, but there are present, on the left side, about two-thirds of a great molar, and on the right side a nearly complete one, regarded as the hindermost. The bone is broken away from the inner face of the right molar, thus exposing well its ridge-plates. It is pretty certain that one ridge-plate is missing in front, and one or more at the rear. Eighteen plates are present. From the front of this tooth to the base of the hindermost plate is 435 mm., a little more than seventeen inches. The height of the tenth plate, in a straight line, is 180 mm.

The various ridge-plates take about the same course on their way from base to summit as in the tooth above described from Oklahoma. On the hinder end of the tooth, on the grinding surface, six plates outcrop in a distance of 100 mm.; but on the side of the tooth, at one-half of the height, there are only three and one-half plates in 100 mm. It can hardly be doubted that this jaw belonged to *Elephas imperator.*

In the American Museum of Natural History, New York, there are remains of two elephants which seem to be referable to the present species. One of these was found near Beeville, Bee county, Texas. In this specimen there are present both upper molars in the maxillæ; and both tusks are preserved. The latter have a length of thirteen feet along the outer curve.

The other specimen was found in the canyon of the Tulea creek, in Briscoe county, Texas. This specimen has the catalogue number 10598. The right ramus and symphysis indicate a large and massive jaw. From the front of the beak to the rear of the condyloid process measures 780 mm., close to thirty-one inches. A large molar is present which was slightly injured in front and which has been restored in plaster. The hinder end is imbedded in the bone and cannot be wholly observed. Sixteen plates are counted and there are doubtless at least two more. The part of the tooth in view measures 300 mm.; but the bases of the hinder plates evidently extend still further backward. On the outer face of the tooth there are four ridge-plates in a 100 mm. line.

The greater part of the right fore limb was secured. The height of this, including the scapula, is eleven feet, five inches. The corresponding limb of Jumbo, a very long-legged elephant, is ten feet.

The following measurements have been secured from these limbs:

MEASUREMENTS OF FORE-LIMBS.

Bones Measured	Elephas imperator	Jumbo
Humerus, length from upper surface of the head to the lowest part of the inner articular surface for the ulna	1080 mm.	1080 mm.
Humerus. greatest diameter of shaft at constriction	180 mm.	180 mm.
Humerus, shortest diameter of shaft at constriction	142 mm.	125 mm.
Humerus, width of lower articulation, in front	280±mm.	235 mm
Ulna, from upper border of greater sigmoid cavity to lower end	1030 mm.	980 mm.
Ulna, fore-and-aft diameter at middle of shaft	120 mm.	120 mm.
Ulna, side-to-side diameter at middle of shaft	145 mm.	130 mm.
Radius, length, in straight line	956 mm.	----------
Radius, side-to-side diameter, at middle of shaft	82 mm.	52 mm.

From the Aftonian gravels of the Peyton pit, at Pisgah, Harrison county, Iowa, Prof. B. Shimek secured a large right upper molar which was described and figured by Calvin as *Elephas* *imperator* (Bull. Geol. Soc. Amer., Vol. XX, p. 351, pl. xxiv). The same figure is here reproduced (Pl. LXVII, fig. 2). The author has examined this tooth and has concluded that it must be referred to *E. imperator*. His measurements differ somewhat from those given by Calvin. The writer found that the greatest length was 330 mm.; the length from the base of the anterior plate to the base of the hinder, 315 mm.; the thickness, 110 mm.; the height of the twelfth plate, 200 mm. Calvin gives as the length 290 mm., having evidently measured in a different way. The thickness given by him is 108 mm., a trivial difference. The height as given by Calvin is 265 mm, indicating that the height is nearly as great as the length, which is far from the case.

The tooth was worn back to the twelfth ridge-plate. The unworn part of this edge of the tooth is straight to the summit of the hinder plate. The base of the crown is far from having the convexity seen in the upper molar from Afton, Oklahoma. There are present eighteen ridge-plates and front and rear talons. On the sides of the tooth a 100 mm. line crosses five and one-half ridge-plates. The enamel is thick and somewhat crimped.

It will be observed that this tooth differs in form from the tooth from Oklahoma. The base is nearly straight, instead of being very convex. The tooth is not so high in proportion to its length. If, however, the Oklahoma tooth had been worn back to the twelfth plate, the difference would not be so great. The ninth plate of the Pisgah tooth must have been considerably higher than the twelfth. This tooth was evidently longer in proportion to its height than was the one from Oklahoma. Such variations occur in all the species. It will be observed that in the tooth from Pisgah, the ridge-plates do not converge toward the summit of the tooth, but are parallel with one another; also, that, although more worn than the Oklahoma tooth, the wear had not come down to the base of the first plate.

On account of the large size of this tooth and its thickness and the small number of its ridge-plates, the writer assigns it, as did Calvin, to *Elephas imperator*. The alternative would be to regard it as being a hindermost molar of *Elephas columbi*, with ridge-plates in a minimum number, of maximum thickness and of maximum width.

From the same pit at Pisgah, Calvin has (op. cit., pl. xxv, fig. 4) figured a part of a humerus. The head and the tuberosities are missing, as well as the external condyle and the condyloid ridge. The total length of the fragment is 840 mm. The great humerus of the specimen of *E. imperator,* from western Texas (p. 425) is 1080 mm. long and it is probable that this Pisgah humerus would fall little short of being as long.

Calvin, as cited (plate xxv, fig. 5), represented a large femur which was found at Pisgah in the Peyton pit. This had lost the head and the great trochanter. The length of the part remaining is 1140 mm. The femur of the specimen of *E. primigenius,* in the American Museum of Natural History, New York, measures 1240 mm. The Pisgah femur certainly exceeded this when intact. In the New York specimen the greatest diameter, at the middle of the shaft of the femur, is 155 mm.; in the Pisgah femur, it is 175 mm.

NOTES ON REMAINS OF ELEPHANTS WHICH HAVE BEEN FOUND IN IOWA.

As in the case of the mastodons the occurrences of elephant remains in Iowa will be taken up in the alphabetical order of the counties in which they have been found; and such notes will be furnished as seem to be useful regarding the remains themselves and of the deposits in which they were buried. The number in parenthesis following the name of the county refers to the map forming plate LXVIII.

Allamakee County. (1). Near Postville. In 1904 Mr. Thos. French, living four miles north of Postville, found four teeth, the lower jaw, parts of tusks, scapula, some leg bones, and some vertebræ, of an elephant, which were sticking out of the banks of Yellow river. The teeth measured each eleven and one-half inches in length and weighed thirteen and one-half pounds. Mr. French has informed the writer that he still has these teeth and bones. Not having seen them or photographs of them, the writer cannot say to what species they belonged. This locality lies within the driftless region. The superficial deposits there consist mostly of the insoluble remains of Paleozoic rocks, overlain by loess. It is impossible to determine at present the age of the clay in which these remains above mentioned occurred, beyond the fact that they are Pleistocene.

Black Hawk County. (2). Waterloo. In the collection of the Iowa State Historical Department, at Des Moines, are three teeth of an elephant which the writer refers to *Elephas primigenius.* These have the catalog numbers 4525, 4527, and 4532. They were presented to the Department by Mr. J. W. Wilby and were found, in 1897, in a sand pit, at Waterloo, at a depth of seven feet from the surface. No. 4527 is the last upper molar of the right side and No. 4532 the same molar of the left side; and these belonged evidently to the same individual. They are worn back to the eighteenth ridge-plate. No. 4525 is worn to the roots in front and to the last ridge-plate behind. It seems possible that it is the second right molar of the individual which possessed the two molars first mentioned; but more probably it belonged to another individual. At the stage of wear of the last molars, the second molar would probably have been worn out. The last molar of the right side has a length of 280 mm. along the base; the height of the eighteenth plate is 170 mm. There are twenty-two ridge-plates and seven and one-half plates in a 100 mm. line.

It is impossible at present to determine at what stage of the Pleistocene the sands were laid down which contained the teeth here described. The county is covered with Kansan drift, overlain mostly by Iowan.

Cedar County. (3). Near Clarence. Prof. W. H. Norton (Iowa Geol. Surv., Vol. XI, p. 377) reported having found two small molars of an Elephas, in a nearly perfect state of preservation, on the farm of Mr. A. T. Whitnell, in the southeast quarter of the southeast quarter of section 6, township 81 north, range 1 west. This is about five miles nearly southeast of Clarence. Professor Norton informs the writer that these teeth were found in the bed of a small creek and probably had been washed out of a bed of gravel. The region is covered by Kansan drift; but whether these teeth belong to pre-Kansan or to post-

Kansan deposits, the writer does not know. Considering the fact that this immediate neighborhood is overlain by Iowan drift, it seems more probable that the teeth are of post-Kansan times. The teeth are in Cornell College, but the writer has not seen them.

Cerro Gordo County. (4). Clear Lake. In the Iowa State Historical Department's collection is a part of a lower jaw of an elephant, which was found by Mr. H. I. Smith, in the vicinity of Clear Lake, in 1898. In it are two teeth which appear to have eighteen ridge-plates; but, inasmuch as the teeth are well sunken in the jaw, their form and structure cannot be well studied. As seen, they are 230 mm. long and 93 mm. wide. They are probably the hindermost molars; and the species is *Elephas primigenius.* The enamel is somewhat thicker than usual and considerably channeled, but hardly crimped. There are eight ridge-plates in a 100 mm. line.

Clear Lake, the lake itself and the town, is situated on the eastern border of the Des Moines lobe of the Wisconsin drift. It seems probable, therefore, that the jaw here described belongs to post-Wisconsin deposits; but our information regarding the exact place of discovery of the jaw, and the depth and character of the matrix containing it, is not exact enough to permit a well-formed opinion. It is furthermore not improbable that *E. primigenius* continued to live in close proximity to the borders of the great glacier which deposited the last drift sheet.

From H. C. Smith, of Mason City, son of the finder of the specimen, the writer has received the statement that he has, without success, tried to learn the particulars regarding the discovery of this specimen.

(49). Mason City. On page 85 will be found an account of the finding of a fine elephant tooth near this place. It is believed by the writer to belong to *Elephas primigenius.*

Cherokee County. (5). Near Cherokee. In the collection of the State University of Iowa is a tooth, No. 325, which the writer refers to *Elephas columbi.* It is a lower molar, either the penultimate or the ultimate, of the lower jaw. It shows sixteen ridge-plates, but these are all worn; and it is probable that some are missing from the front. The length along the base is 305 mm., and this base is convex. On the sides of the tooth there are six ridge-plates in a 100 mm. line. The hinder plates are bent and they lean forward. The enamel is thick and crinkled. The width of the grinding face is 90 mm. This tooth was found in the summer of 1909, at a depth of about sixteen feet below the surface, in what is known as the Turner sand and gravel pit, three miles north of Cherokee.

The writer is informed by Mr. Richard Herrmann, of Dubuque, that about 1875 there was found in a gravel pit of the Illinois Central Railroad, on the east side of Little Sioux river, a tusk, which had a length of nine feet. The greater part of this was for some time in a saloon in Fort Dodge; a piece three feet long was placed in a railroad office at Dubuque. It is, of course, impossible to say whether this tusk belonged to a mastodon or an elephant.

Clayton County. (47). Wagner Township. This number marks the finding of mammoth teeth in sections 5, 16, and 23, of township 94 north, range 5 west. The information was imparted by Rev. J. Gass, of Postville, Allamakee county. It is not known to which species they belonged nor what has become of the specimens.

Clinton County. (6). Clinton. In the collection of the Davenport Academy of Science there is a lower molar of the right side which is labeled as having been found at Clinton, Iowa, and presented by Thos. J. Frazier. The length is about 250 mm. along the base and this is convex. There are present sixteen ridge-plates, but all of these had been brought into use; and it is not unlikely that already some of the front plates had been worn out. These plates are somewhat bent, and there are six of them in a 100 mm. line. This tooth is referred to *Elephas columbi.*

In Nettie C. Anderson's list, F. C. Baker reported that there are in the collection of the Chicago Academy of Sciences a tooth and a tusk of an Elephas which were found at Clinton. The tooth was presented by J. W. Foster.

Crawford County. *(7).* *Denison.* Calvin described from this locality two elephant teeth which are to be referred to *Elephas primigenius.* One of these has been described and figured here (p. 406, Pl. LVI, fig. 2) as the second upper molar. It has the number 21. It was noticed by Calvin (Bull. Geol. Soc. Amer., Vol. XX, pl. xxiii). The other tooth was secured at Denison by Professor Shimek and is the last upper molar of the right side. It has the catalog number 294. It is partly enclosed in the injured maxilla, which shows a portion of the socket for the tusk. Calvin gave a description and figure of this tooth (Bull. Geol. Soc. Amer., Vol. XXII, p. 212, pl. xx. His figure shows the grinding face. Another figure is here published (Pl. LXIX, fig. 1) which shows a side view of the tooth and of the portion of the maxilla. In front, the tooth is worn down to the roots; toward the rear the wear extended to about the twenty-second plate. The length along the base is 330 mm.; the width, 110 mm.; the height of the twenty-second plate, 160 mm. There are a little more than eight plates in a 100 mm. line. The cement covers the tooth so completely that the exact number of ridge-plates cannot be determined, but there appear to have been about twenty-seven. As an individual peculiarity of this tooth, some of the anterior ridge-plates are divided at the middle of the width of the tooth. Other specimens are known which present the same peculiarity. The alveolus for the tusk was at least 186 mm. in diameter.

The age of the Pleistocene deposits at Denison has not been exactly determined. It was formerly thought by the Iowa geologists that they belonged to the Aftonian stage; but this is now regarded as doubtful. Shimek (Bull. Geol. Soc. Amer., Vol. XXII, p. 212, footnote) states that they form a river terrace, without overlying drift or loess; and no underlying drift could be found. The terrace beds show some evidences of redeposition. It appears that at this locality are some drift beds which are covered by loess. It was at Denison there was found the type of *Cervalces roosevelti.* *Mammut americanum* has also been discovered at this place, likewise *Elephas primigenius,* and the scapula of a species of Bison. The present writer refers, provisionally, the deposits in which vertebrate remains have occurred at Denison to the Sangamon.

Davis County. (8). Near Floris. In Nettie C. Anderson's list, Justus M. T. Myers wrote as follows: "In 1862, I found in the Des Moines river, near Floris, two mastodon teeth, one weighing fourteen pounds, the other four pounds." The larger tooth was certainly that of an elephant, probably of *Elephas columbi;* for no mastodon tooth weighs so much. This throws doubt on other determinations made by Mr. Myers. The point on Des Moines river nearest to Floris is about six miles distant.

Des Moines County. (9). Burlington. In the collection of the State University of Iowa is a large upper molar which, under the number 22, is recorded as having been found at Burlington. No details regarding the exact locality and conditions of burial have been furnished. The tooth is worn to the root in front and probably a few ridge-plates had been worn off. The length along the base is 255 mm. The rear is convex and about 115 mm. high. The base is straight. There are about nine plates in a 100 mm. line. There is a strong posterior root and four pairs of small roots. There are some irregularities displayed by the ridge-plates on the grinding face. Some of those in front divide at the middle into two loops, as in the case of the tooth just mentioned, from Denison. Some of the hinder plates do not run straight across the tooth, but have both their inner and outer ends thrown backward; and one of them is divided on the inner half into two plates. The tooth belonged to *Elephas primigenius.*

As to the stage of the Pleistocene in which this animal lived, we can form no judgment.

In the collection in Iowa Wesleyan College is a tooth which appears to belong to *Elephas columbi.* It has been restored somewhat in plaster. It shows twelve or thirteen ridge-plates and must therefore be the first true molar of the upper jaw; but it is so large as to suggest possibly *E. imperator.* Mr. Buetner, of Burlington, who presented the tooth, told the writer that it had been found in Flint creek, about two miles from Burlington.

Dubuque County. (50). Near Dubuque. Mr. Richard Herrmann, of Dubuque, founder of the Herrmann Museum, has informed the writer that some years ago there was found, at Horse Shoe Bluff, three miles below Dubuque, a large mammoth tooth. Where the tooth is now is not known. Nor is it known to which species it belonged.

In the Herrmann Museum is an upper last molar of *Elephas primigenius* which was found along the Illinois Central railroad, eleven miles west of Dubuque. See page 82. This tooth measures in length 306 mm. along the base and 210 mm. in height at the sixth plate. There are present twenty-two ridge-plates and probably one or two are missing from the front. The width is 100 mm. There are seven plates in a 100 mm. line. The rear is arched; the plates rise from the base in a somewhat sinuous course; and the enamel is thin.

At Dubuque the writer was shown, by Dr. H. G. Knapp, a small, but characteristic fragment of a tooth of *Elephas primigenius,* which had been found in making a drift toward a lead crevice, at a point about one-half mile from Center Grove. The land was owned by Mr. William Brunskill.

Fayette County. (10). West Union. Number 42 of the collection at the University of Iowa is a part of an upper molar with some plates missing from the front and others from the rear. There are twelve remaining. A 100 mm. line extends across about eight of the ridge-plates. The base was apparently nearly straight, as was also the unworn part of the grinding edge. The tooth is regarded as that of *Elephas primigenius.*

(11). Near Clermont. In Nettie C. Anderson's list, page 28, Prof. T. E. Savage reported a mastodon tooth from near Clermont, which was in the possession of Mr. C. E. Allen, of Clermont. Mr. Allen has sent the writer a drawing which shows that the tooth is that of Elephas, probably *Elephas primigenius.* Professor Savage has kindly informed the writer that the tooth came from materials filling the valley of Turkey river. He believes that these were deposited during the melting of the Wisconsin ice-sheet. If this is true, the animal which bore the tooth lived at the close of the Wisconsin stage or afterwards. Near this same place was found a part of a skull of the musk-ox *Ovibos moschatus.* Mr. Allen states that the tooth was taken

out of the gravel pit of the Rock Island Railway between Clermont and Elgin, Iowa, and that it was found at a depth of about twenty feet. The tooth, or what remains of it, is in the possession of Mr. Allen.

Floyd County. (12). Marble Rock. In the collection of the State University of Iowa is an upper last molar of the right side, which was found during the summer of 1912 at Marble Rock, by Prof. A. O. Thomas, of the State University. It is figured on plate LXIX, figure 2, of about seven-twenty-fifths the natural size. It is identified as that of *Elephas primigenius.*

It was discovered in a pit in a large gravel deposit which is a post-Wisconsin valley train formed at the time of the withdrawal of the Wisconsin ice-sheet. From the same pit had been taken previously a large tusk and one or two imperfect molars. The upper molar, of which the writer has received a photograph, is well preserved. It was worn down to the base in front and backward to about the last ridge-plate. Of these there appear to have been at least twenty. It is possible that a few had disappeared from the front. The length is 235 mm.; the width, 98 mm. In this tooth, again, about seven of the anterior ridge-plates are divided by a cleft into an inner and an outer loop. The enamel is rather thin and quite free from any channeling.

Other imperfect molars just referred to, from the same locality, are Nos. 17 and 299 of the University collection. The former shows a well-worn tooth presenting thirteen plates, but some at the rear are missing. It is possible that this tooth was the left second molar. The enamel is thick. The writer, on examining this tooth, was inclined to refer it to *Elephas columbi;* but this may be an error.

Number 299, mentioned above, is a fragment of a much-worn lower molar and shows ten plates. It seems to belong to *Elephas primigenius.*

Franklin County. (13). Near Hampton. The writer has received from Mr. William Brandt, of Hampton, photographs of a tooth of *Elephas primigenius,* which he found, January 1, 1913, in a sand pit close to Beed's lake, near Hampton. The locality is in section 19, township 92, range 20. The tooth was met with at a depth of about six feet below the surface. It is stated that it measures seven inches in length. It seems to be the upper left second true molar. It appears to have sixteen ridge-plates, with the usual talons. There are nine plates in a 100 mm. line, and the enamel is thin and little crinkled. The roots are well-developed and retain between them parts of jaw-bone. This locality is on the border of the Des Moines lobe of the Wisconsin drift-sheet and it is most probable that the animal lived at a time when the foot of the glacier was not far away.

Harrison County. (14). Missouri Valley. From the Claude Cox gravel pit at this place was obtained, by Professor Shimek, an upper right second true molar of *Elephas primigenius.* It has the catalog number 16 in the collection at the State University of Iowa. The grinding border is worn about one-half of its length and it has been considerably weathered. The hinder plates had not completed their growth at the base. All the plates run parallel with one another, and the unworn part of the grinding border is parallel with the base. Fourteen plates are present, with front and rear talons. The anterior roots are well-developed. The roots of the anterior half of the tooth are in pairs. It appears to the writer that this tooth is that of *Elephas primigenius* rather than that of *Elephas columbi.*

A jaw found in the Cox pit is referred by Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 351, pl. xxv, fig. 2) to *Elephas imperator.* This jaw has the catalog number 1. Both horizontal rami are present, but most of the inner walls bounding the alveoli are broken away. No tooth, or part of a tooth, remains. The jaw is somewhat larger than that of *Elephas primigenius,* No. 3, of the collection. From the outside of one ramus to that of the other, immediately in front of the origin of the coronoid process, is 450 mm. The height of the jaw, at the front of the socket for the tooth, is 177 mm. The width of the lingual gutter is 160 mm. The tooth socket has a depth of about 150 mm. Its lower portion appears to have contained a root, probably an anterior root, of the tooth. Behind this the socket is narrowed by a wall of bone 25 mm. thick, which appears to have been a septum between the anterior root and a succeeding one. Behind this septum is seen a part of a socket for another strong root. On the inner face of the outer wall of the alveolus which contained the great last molar, are grooves which were occupied by the ridge-plates on the outer face of the tooth. Five of these grooves are crossed by a line 80 mm. long. This would amount to six ridges in 100 mm. It appears to the writer that it is more probable that this jaw belonged to *E. columbi.* The lingual groove has a width of 82 mm.; while that of No. 3, regarded as *Elephas primigenius,* is only 54 mm. wide.

Other teeth found here are regarded by Calvin as belonging to *Elephas columbi.* Vertebræ from this pit, Nos. 269 and 253 of the collection at Iowa City, probably belong to Elephas.

(15). Logan. For the collection at the University of Iowa was collected by Shimek the fine upper second molar of *Elephas columbi* which has been figured in this work (Pl. LXIII, fig. 2). This was found in the Peckenpaugh sand pit and now has the catalog number 167. Mr. Charles L. Crow, of Logan, informs the writer that he has from the same pit, another elephant's tooth, not complete, however.

(16). Pisgah. In the Peyton pit at this place was obtained the fine tooth which is shown on plate LXVII, figure 2, and referred to *Elephas imperator.* The history of the tooth has been given on pages 57 and 425. This pit is regarded as being made in Aftonian deposits.

From the Peyton pit were obtained the large imperfect humerus and the large nearly complete femur which have already been described under *Elephas imperator* on page 427.

Iowa County. (17). Marengo. In alluvial gravel, along Bear creek, in the northwest quarter of the northwest quarter of section 25, township 81 north, range 11 west, was found the fine first lower molar which is figured on plate LV, figure 2. It belonged to *Elephas primigenius.*

In alluvial deposits along Iowa river, near Marengo, was found the lower jaw which, under the name of *Elephas columbi,* Calvin figured in his first paper on the Aftonian mammalian fauna (Bull. Geol. Soc. Amer., Vol. XX, pl. xxv, fig. 3). The jaw is nearly complete and contains the first true molar of each side in a fine state of preservation. Behind these in the cavity of the right side of the jaw are some of the plates of the penultimate molar. The molars present have a length of 156 mm. and a width of 70 mm. They are worn to the hinder plates. Of these plates there are thirteen, besides the front and rear talons. There are nine plates in a 100 mm. line. The enamel is rather thin and somewhat bent or crinkled in its course across the grinding surface of the tooth, a condition which is caused by a channeling of the faces of the enamel plates. These teeth are somewhat larger than usual, but the number of plates shows that they cannot be the second true molars. It seems to the writer that this jaw belongs quite certainly to *E. primigenius.*

Jefferson County. (18). Walnut Township. J. A. Udden (Iowa Geol. Surv., Vol. XII, p. 428) stated that in the bed of Walnut creek had been found a well-preserved lower jaw of an Elephas. The entire specimen weighed 50 pounds. The finder of this specimen, Mr. Josia Bales, in a letter, informed the writer that he still owned the jaw. Not having seen it, the writer cannot form an opinion regarding the species.

The locality is in Walnut township; more exactly in the northwest quarter of section 28, township 73 north, range 8 west. This region is covered with Kansan drift; but Nebraskan drift is present, as well as loess and alluvium. Udden stated that it was not evident to which division of the drift the jaw belonged.

Johnson County. (19). Near Iowa City. In the collection at the State University of Iowa is a tusk of some proboscidean which was taken from the bed of Iowa river, a few miles below Iowa City. On account of its strong curvature and its slender proportions this tusk is supposed to belong to a species of elephant. It is illustrated on plate LVII, figure 1. It is now in two pieces but when it was found these were joined. The length is somewhat more than six feet, the diameter only about three inches and a quarter. It is not known to what stage of the Pleistocene this tusk belonged.

Lee County. (20). In Nettie C. Anderson's list, on page 28, Mr. Justus M. Myers stated that he had found, in a creek below Montrose, a molar of *Elephas primigenius;* and in Sugar creek, a molar of another extinct elephant which he could not determine.

Linn County. (21). Cedar Rapids. From Mr. B. L. Wick, attorney at Cedar Rapids, the writer has received a letter and two photographs of an elephant tooth which was discovered in November 1911, by Mr. D. Feiereisen. He was engaged in pumping sand from the bed of the river and the tooth became lodged in the mouth of the suction pipe. This tooth has a length of 280 mm. and a height of 203 mm. It presents sixteen ridge-plates, but some may be missing in front. It appears to be the second molar of the upper jaw. It is referred to *Elephas primigenius.*

The exact locality is near the southeast corner of the southwest quarter of the southwest quarter of section 27, township 83 north, range 7 west. This is within the limits of the town. It is impossible to determine in what deposits the tooth was originally buried.

Louisa County. (22). Wapello. In the collection at the State University of Iowa is a tooth, referred to *Elephas primigenius,* which was found at or near Wapello. It has the catalog number 61. It appears to be the second lower molar. There are fifteen ridge-plates present; but, as the tooth is worn to the base in front, a few plates may be missing. To what stage of the Pleistocene it belonged is not known.

(23). Near Columbus Junction. From Mr. E. B. Tucker, attorney at Columbus Junction, the writer has received letters and photographs, giving details regarding some elephant teeth which were found about five miles northwest of that town by Mr. W. A. Devore. The exact locality is the northeast quarter of the southwest quarter of section 34, township 76 north, range 5 west. These teeth are referred to *Elephas primigenius.* One is a lower molar, apparently $M._2$, and appearing to have fifteen plates and front and rear talons. The length is given as eight inches (203 mm.). There are close to nine plates in a 100 mm. line. The other teeth are much more worn and appear to be the first molars, right and left.

These teeth were found in a gully; and, being together, it is evident that they had just been washed out of their resting place. To what stage of the Pleistocene this soil belongs might be determined by a competent geologist on the spot. Udden

(Iowa Geol. Surv., Vol. XI, p. 102) states that the drift-sheet now known as Nebraskan, called by him at that time Albertan, underlies that part of the county, and along some of the streams is brought into view. In places Aftonian sands and peats are exposed, while this is overlain by Kansan till. On the southeast quarter of section 21 of the township in which the teeth here described were found, there is, according to Udden, an exposure presenting what was supposed to be Albertan (Nebraskan) till below, followed by Kansan till, and above this latter a leached Sangamon soil. Above the last, there is a covering of loess. From which of these were the teeth derived?

(24). Near Morning Sun. J. A. Udden (Iowa Geol. Surv., Vol. XI, p. 110) stated that some years ago there were dug out of the bed of Otter creek, near the center of the northwest quarter of section 25, township 73 north, range 4 west, a tooth, lower jaw, part of the pelvis, several ribs, and a large part of a tusk of an elephant. Udden probably did not see these remains himself, and their identification must remain somewhat doubtful. He expressed the opinion that the materials forming the banks of the creek resembled Sangamon soils.

(25). Near Grand View. J. A. Udden, on the page just cited, reported that a tooth, supposed to be that of an elephant, was once taken out in digging a shallow well on a tributary to Indian creek, in section 28, township 73 north, range 3 west.

Lyon County. (26). Rock Rapids. In the collection at the State University of Iowa is an atlas of a proboscidean, No. 314 (Pl. LXIX, fig. 3), which was found at a depth of five feet, in gravel at Rock Rapids. The extreme width of the bone is 420 mm.; the extreme height, 225 mm.; the distance across the articulations for the condyles of the skull, 255 mm.; across the articulation for the axis, 190 mm. The writer has compared a section across the neural arch of the atlas with similar sections of the atlas of *Elephas primigenius* and of *Mammut americanum,* with the result that the bone is referred to the former species. The proportions of the bone agree with this conclusion. This bone was found in what was supposed to be a train of gravel, which had been carried down from the border of the Wisconsin ice-sheet. Its age would therefore be either the Wisconsin or early post-Wisconsin (Wabash).

In the pit which furnished the atlas here described there were found, at a depth of from twenty-eight to thirty feet, a proboscidean cervical vertebra (No. 315), a dorsal vertebra (No. 316), and the distal end of a humerus (No. 317). All these bones including the atlas, were collected by Rev. J. J. Bushnell and Mr. A. W. Wright.

Mahaska County. (27). Near Oskaloosa. In the collection at Iowa City is the right innominate bone which belonged to some species of proboscidean, and which was found in Skunk river about three and one-half miles north from Oskaloosa and a mile and a quarter east of the Minneapolis & St. Louis railroad bridge. It is illustrated on plate LXIX, figures 4 and 5. Dr. Mark F. Boyd, of Oskaloosa, informed the writer that this bone was brought from the bed of the river by a fisherman whose hook and line became fastened to it. The bone was presented to the State University. Photographs of it have been sent the writer by Prof. A. O. Thomas, who has likewise furnished various measurements. Corresponding measurements on the mastodon, *Mammut americanum*, and the Asiatic elephant, *Elephas maximus*, have been made for a comparison, with the purpose of determining, if possible, to what species the fossil bone belonged.

MEASUREMENTS.

	Fossil	Elephas maximus	Mammut americanum
Length from outer extremity of ilium to rear of ischium	722 mm.	720 mm.	900 mm.
Length of lower median symphysis	356 mm.	345 mm.	405 mm.
Length of upper border of ilium, straight line	478 mm.	680 mm.	840 mm.
Width of hinder end of each ischial bone	241 mm.	235 mm.	305 mm.
Circumference of ilium; where narrowest	486 mm.	345 mm.	520 mm.
Circumference of ischium; where narrowest	222 mm.	205 mm.	210 mm.
Circumference of ischio-pubic bar; where narrowest	109 mm.	103 mm.	250 mm.

It will be seen that the measurements of the fossil agree much more closely with those of the Asiatic elephant than with those of the mastodon. We are evidently justified in concluding, at least, that the bone was not that of a mastodon. Unfortunately, the writer has at hand no pelvis of a fossil elephant with which to compare the bone from Skunk river. We may, however, provisionally refer the bone to *Elephas primigenius;* but we must keep in mind that it might belong to *Rhabdobunus mirificus.*

As to the stage of the Pleistocene during which the animal lived we can form no certain conclusion. The region is covered by Kansan drift, and it is possible that the bone is as old as the Aftonian.

Marshall County. (28). Near Albion. In Nettie C. Anderson's list, on page 29, Prof. W. H. Norton reported that a large molar of a mammoth, in a perfect state of preservation, had been found in Iowa river, near Albion, and presented to Cornell College. The grinding surface of the tooth is well worn. The writer has not seen this tooth.

Mills County. (29). Malvern. J. A. Udden (Iowa Geol. Surv., Vol. XIII, p. 170) reported that, in 1879, bones of a mammoth were exhumed from the lower part of the loess. These were met with, in grading for the Chicago, Burlington & Quincy Railroad, at the crossing of First Avenue and Railway Street. There were, as reported, three teeth, part of a tusk, and two long bones.

(30). Near Glenwood. Here were found bones which were referred by Prof. J. E. Todd to *Elephas americanus.* They have already been mentioned on page 77. As there stated, the bones are in Tabor College.

(34). Henton Station. In the collection at the State University of Iowa is an elephant tooth, No. 300, which was found here. It has been labeled *Elephas imperator* and it is probably the tooth referred to by Calvin (Bull. Geol. Soc. Amer., Vol XXII, p. 212). The length of the tooth, as preserved, is 180 mm. There are ten ridge-plates present; but, inasmuch as it is worn to the base in front, some plates are probably missing there. The maximum width of the tooth is 81 mm., but in front the width is only 71 mm. The height of the third plate from the rear is 91 mm. There are five and a half or six plates in a 100 mm. line.

Calvin regarded this tooth as the third milk molar of *E. imperator*. Possibly it was the first true molar. The writer is inclined to refer it to *E. columbi*, rather than to *E. imperator*. One might reasonably expect the tooth occupying the position in the last-mentioned species to be larger.

No. 301, of the collection mentioned, is another fragment of an elephant tooth from the same locality.

Monona County. (31). Turin. In the collection at the Iowa State University are some teeth from Turin which Calvin referred to *Elephas columbi* (Bull. Geol. Soc. Amer., Vol. XXII, p. 212). In the same collection is a cervical vertebra figured on a small scale by Calvin (Bull. Geol. Soc. Amer., Vol. XX, pl. xxv, fig. 8). This is quite as likely to belong to a species of mastodon.

(48). Mapleton. In the Griffin well on the east side of section 17, township 85 north, range 42 west, was found a tooth, which has been referred to *Elephas imperator*. It was found in the Aftonian sand. The tooth is now in a private collection.

Montgomery County. (51). Near Red Oak. In the collection of the Iowa Historical Department at Des Moines, is a much worn lower right molar, the next to the last one, which is labeled as having been found in the vicinity of Red Oak. It was presented by Messrs. William Boll and Son of the town mentioned. It is regarded as belonging to *Elephas columbi*. It has the catalog number B 264. The donors of this tooth have informed the writer that it was brought up in a sand pump from the bed of Nishnabotna river in 1912.

Muscatine County. (32). Sweetland township. J. A. Udden (Iowa Geol. Surv., Vol. IX, p. 350) reported that elephant bones had been found near the center of the southwest quarter, section 12, township 77 north, range 1 west. They were in a peat deposit which contained also large pieces of gymnospermous wood. It was stated that the bones were in Mr. Charles Wier's museum at Muscatine. These remains were believed by Udden to occur in Sangamon soils. To which species these bones belonged is not known to the writer.

The writer has received a letter from Mrs. Sada Wier Rolland, of Muscatine, stating that on the death of her father, James M. Wier, owner of the museum referred to, the relics were donated to the Muscatine library, there to remain as long as it was in existence.

(33). Muscatine. F. M. Witter (Proc. Iowa Acad. Sci., Vol. I, pt. 2, p. 67) reported the finding of a part of an elephant's tooth about one mile above the mouth of Mad creek, in Muscatine. At this point there is a nearly perpendicular bank about forty feet high, which is capped by loess. About ten feet below the top is a layer of gravel one foot thick; and in this gravel was found the tooth. This gravel may represent the Sangamon stage.

In the State University of Iowa the writer saw a tooth, apparently the right second upper molar, which had been found at Muscatine, in a railroad cut. This tooth was deposited there temporarily.

Polk County. (35). Des Moines. In the collection of the Iowa Historical Department is a tooth, No. 4529, which is labeled as having been found near the Osceola bridge. It appears to be the next to the last lower molar of the right side. There are present thirteen ridge-plates and the front talon; but some plates are missing from the rear. The twelfth plate is 80 mm. wide and 127 mm. high. There are eight and one-half plates in a 100 mm. line. A root was being formed under the anterior four or five plates. The enamel is rather thick and somewhat crinkled in its course across the grinding face. This tooth is believed to belong to *Elephas primigenius.* To the same species is referred a lower penultimate molar, No. 4530, found by Mr. Jesse F. Cockerham in the gravel pit at the north end of Sixth Avenue bridge in Des Moines; also a small molar numbered 4528, which was found at the same place in 1903 and presented by Mr. J. E. Stout. Number 4531 is a femur, without the articular ends, which was found at the same pit and presented by Dr. Clifford Losh. It is the femur of an elephant.

Number 4526, of this collection, was found in the vicinity of Des Moines and was presented by Mr. L. Hamilton, in 1883.

It is the last lower molar. It is worn to the roots in front and to the last plate in the rear. Some plates in front, together with the large anterior root, are missing. Eighteen plates are present. These rise in a curve and lean toward the front of the tooth. The base is quite convex. The grinding face is 90 mm. wide. There are seven plates in a line 100 mm. long. This tooth is referred to *Elephas columbi*.

(36). Town of Polk. Beyer (Iowa Geol. Surv., Vol. IX, p. 211) reported that a perfectly preserved molar tooth of *Elephas primigenius* was found in 1898, by an employee of the Chicago and North Western Railway at this place. No additional information was available and the tooth has, so far as scientific purposes are concerned, probably been lost. The locality is within the area of the Wisconsin drift, and it is to be regretted that we cannot know what was the relation of this tooth to that drift. It is probable that Beyer did not, at the time he wrote, regard *E. columbi* as a species distinct from *E. primigenius*.

In Nettie C. Anderson's list, on page 34, L. S. Ross stated that the femur of a mammoth, in a good state of preservation, had been taken from a sandbar of Raccoon river in Polk county.

Pottawattamie County. (37). Council Bluffs. Number 309, of the collection of the University of Iowa is an upper molar, probably the penultimate, but possibly the first true molar. It was obtained by Professor Shimek from a collection in the Council Bluffs High School. It is supposed to have been found near the city. It is worn back to the eighth ridge-plate, which is 160 mm. high. The width of the tooth is 80 mm. It is supposed to belong to the Aftonian stage. The writer identified it as *Elephas columbi*.

(38). Washington Township. In section 34, township 75 north, range 41 west, according to J. A. Udden (Iowa Geol. Surv., Vol. XI, p. 260) were found some bones of an elephant. They appeared to be buried in the loess.

Poweshiek County. (39). Grinnell. In Science, ser. 1, volume IV, 1884, page 46, Prof. H. W. Parker, of Grinnell College, reported the recent discovery of elephant remains within the city. They were found in digging a cellar, at a depth of from five to eight feet. Prof. H. W. Norris informs the writer that three molars were found. One of these had a length of fifteen inches and had evidently been somewhat longer. A piece of tusk seven and one-half feet long, with a diameter of eight inches at the base and four inches at the distal end was found. Previously, other bones, probably of the same animal, had been found not far away. The remains are preserved in Grinnell College.

Through the kind permission of Professor Norris the writer has been enabled to examine this specimen. It undoubtedly belongs to *Elephas primigenius*. The teeth and bones were found at a depth of about five feet at the northeast corner of Main and Fourth streets. The hindermost left molar is worn back to the sixth plate and probably two plates are missing from the rear. The tooth is somewhat more elongated than usual, but it presents a fine example of the little worn last molar of this species. The anterior plates project in front of the base. From the worn extremity of the anterior plate to the base of the last one present the distance is 380 mm. The length along the little curved base is 280 mm. The height of the seventh plate is 212 mm.; that of the twenty-fifth plate, the hindermost one present, is 105 mm. The width of the tooth is 100 mm. The unworn part of the grinding border is nearly parallel to the base. The enamel is thin. Another tooth appears to be the upper second molar, M^2, probably of the right side. There are ten ridge-plates in the specimen, which measures 100 mm. in length. There is present a third tooth labelled as belonging to the specimen, apparently M_2, of the left side. Much of the front had been lost before the death of the animal. There is present the strongly developed hinder root. There are only eight plates in a 100 mm. line and the enamel is thick. The width is 86 mm. The tooth resembles that of *E. columbi* and it seems possible that there has been a mixture of two individuals.

E. H. Barbour (Science, ser. i, Volume XVI, 1890, p. 263) recorded the finding of another specimen about one-half mile from that of 1884, at a depth of about twenty feet. Many bones were met with, but all badly broken. One well-worn molar was saved. May it be the tooth last mentioned in the preceding paragraph?

Sac County. (40). Lake View. In the collection of the State University of Iowa is a part of a scapula which was found in a gravel pit near this place. By Calvin (Bull. Geol. Soc. Amer., Vol. XXII, p. 215) it was thought to belong probably to a mastodon; but, from the nearness of the spine to the front of the bone, the writer concludes that it belonged more probably to a species of elephant. The locality is on the border of the Wisconsin drift-sheet, and it is most probable that the animal belonged to the species *Elephas primigenius,* and that it lived near the foot of the old glacier which deposited this drift.

Scott County. (41). Davenport. In 1876, W. H. Pratt (Davenp. Acad. Sci., Vol. I, p. 96) gave an account of the finding of some elephant remains which had been exposed in a cut along the Chicago, Rock Island and Pacific railroad just west of Davenport. Some molars, a tusk, and some bones were found. They were said to be preserved in the collection of Griswold College, at Davenport.

It seems that the same remains are now in the collection of the Davenport Academy, where the writer has examined an upper last molar and a tusk, said to have been found in a railroad cut west of the town. The molar is a little worn, on only five ridge-plates. Twenty of these are present, with an anterior talon; but a few plates are missing from the rear. The unworn grinding border and the straight base are nearly parallel, with the anterior plates projecting in front of the base. The total length is 270 mm.; the height of the tenth plate, 180 mm. There is no reason for doubting that this tooth belonged to *Elephas primigenius.*

The piece of tusk is 1800 mm. long, nearly six feet. The diameter at the base is 130 mm. The tusk forms about a semicircle.

Pratt, as cited, showed that these remains were found in a layer of bluish gray clay, from three to five feet thick, which contained some land snails, and that this was immediately above a bed of brown peat one foot thick. Norton (Iowa Geol. Surv., Vol. IX, p. 482) referred to this section and concluded that the drift below the peat was Illinoian, and that the peat itself and the ancient soil beneath it belonged to the Sangamon. Shimek, however, regards the peat and the ancient soil as belonging to the Aftonian; the bluish gray clay, as being post-Kansan (Yarmouth) loess. For other remarks on the subject and additional references to literature see page 62. If Shimek's interpretation is correct, the present writer would be inclined to refer the elephant bones to the Illinoian stage, the animal having lived there when the edge of the Illinoian ice-sheet was not far away.

(42). Big Rock. In the collection of the Davenport Academy is a tooth of an elephant which lacks some plates both in front and at the rear and which has, besides, been weathered. It is probably a first molar. It is referred provisionally to *Elephas columbi.* It was found at Big Rock by Mr. A. W. Manchester. Nothing is known regarding its stratigraphical relations.

(43). Buffalo. In the collection at Davenport there is a part of a large upper molar which, with some bones, was found on the farm of Mr. Sullivan, near Buffalo.

Tama County. (44). Tama. From Mr. Fred Herschel, of Tama, the National Museum has received a fine tooth of *Elephas columbi.* It is the lower right second true molar. Fourteen ridge-plates can be counted, but it is worn down to the base in front, and evidently a few plates, perhaps two, are missing. The anterior root likewise is missing. The total length is 266 mm.; the width, 92 mm. The tooth is worn back to the last plate and this has a height of 115 mm. There are only five ridge-plates in a line 100 mm. long. Mr. Herschel informs the writer that this tooth was found sticking in the bank of Iowa river, about one-half mile south of Tama. This valley is, according to Savage (Iowa Geol. Surv., Vol. XIII, p. 244, map), filled with alluvium. The age of the tooth is therefore uncertain.

Warren County. (52). Near Indianola. In the collection at Simpson College the writer has seen a lumbar vertebra which quite certainly belonged to some species of Elephas. This has already been mentioned on page 84. In his excellent paper on Pleistocene Deposits in Warren County Professor Tilton mentions this vertebra, also a thigh bone three feet long found in section 19 of township 77 north, range 23 west. The latter, however, may have belonged to a mastodon.

In Netta C. Anderson's catalog, page 38, a report was made by Professor Tilton, of Simpson College, of some bones which had been found six feet below the bottom of a ravine, near Indianola. They were supposed to be buried in Kansan drift. Among these bones was the vertebra mentioned in the preceding paragraph.

Washington County. (45). Mr. T. Gass (Proc. Davenport Acad. Sci., Vol. III, 1883, p. 177) gave an account of the discovery of some bones of an elephant on the farm of Mr. Jerry Hoppin in this county. It was stated by Mr. Gass that the farm was on section 14, township 22, range 3, but this is an evident error. From Mr. Marsh W. Bailey, of Washington, Iowa, the writer has learned that the farm in question is described as the northwest quarter of section 14, township 74 north, range 8 west of the fifth principal meridian. This would be in the southern part of the county, north of Skunk river, and seven or eight miles west of south of the town of Washington.

Mr. Gass reported that two upper molars had been found, besides a fragment of a tusk, some vertebræ, the scapula, some leg bones, and fragments of ribs. These were found in the bed and banks of a small stream within an area having a diameter of fifteen feet, and about six feet below the surface of the level ground; and they were buried in a sedimentary deposit of black mud, composed chiefly of vegetable mold, with some clay. From the fact that so large a part of the skeleton was lying there, it is evident that the animal's original resting place was there and that the deposit was not modern alluvium. It seems certain that some interglacial deposit had been cut into by the stream.

Mr. Gass stated that the grinding surface on each tooth was eleven inches long and four and three-quarters wide.

From Mr. William Hesseltine, of Brighton, Iowa, who was present when these bones were exhumed, the writer learns that the remains were found about the center of the section named and near the forks of the east branch of Walnut creek. Mr. Hesseltine further states that the bones were sold to a man in Muscatine for a private museum. It is now known that this was Mr. James M. Wier, who at one time had a museum in Muscatine and who placed his collection in the Public Library of that town. Mr. Hesseltine further informs the writer that in the summer of 1886 his brother, Albert Hesseltine, found a mammoth's tooth on a rock ripple in the west branch of Walnut creek. The exact locality is given as the northwest quarter of the southwest quarter of section 15. This would be about a mile distant from where the other tooth was found. Mr. Hesseltine enclosed a sketch showing the appearance of the tooth, according to his recollection. It was undoubtedly the tooth of an elephant.

Woodbury County. (46). Correctionville. In the collection at the State University of Iowa is a much worn proboscidean tooth which was found at or near this place. It has been referred to *Elephas primigenius.* No details regarding its discovery are given. In this same locality were found parts of a skull of *Bison occidentalis* and pieces of antlers of a caribou. It seems probable that these remains are to be assigned to the Sangamon or to the very beginning of the Wisconsin. It is not unlikely, however, that the bison and the caribou belonged to different stages of the Pleistocene.

Order **Rodentia.**

Squirrels, Marmots, Beavers, Rats, Muskrats, Gophers, Porcupines, Rabbits, etc.

Animals varying in size from very small to medium. Digits usually five on all the feet and furnished with claws. Teeth reduced in number; two functional incisors in each jaw; no canines; never more than three premolars. Incisors growing from persistent pulps, usually with enamel on only the front face, so that those teeth become chisel-like through use. A long space between the incisors and the cheek-teeth. Mandibular condyles elongated fore and aft. Auditory bullæ developed. Orbit opening freely into the temporal fossa. Premaxillæ reaching the frontals. Living mostly on vegetable food.

The Rodentia may be said to swarm over the whole habitable globe. In time they are known to us from the early Eocene. By systematists they are divided into two suborders:—1. The Duplicidentata, including the hares and rabbits and the picas; 2. The Simplicidentata, containing all the other rodents. The Duplicidentata differ from the other rodents in many ways, but conspicuously in the fact that just behind the upper incisors is another pair of much smaller size. The hares and rabbits have inhabited North America since the Miocene.

Few remains of Rodentia have yet been found in Iowa. Their bones and teeth, being of small size, are likely to be overlooked; but we may confidently expect that in time many species will be found in the Pleistocene deposits of the state.

It has been proposed (Gidley, Science, Vol. XXXVI, 1912, p. 245) to separate the Duplicidentata from the other Rodentia and to regard them as a distinct order, under the name of Lagomorpha. To the writer at present the two groups appear to have too many characters in common to justify this separation. Their relationship seem to be well expressed by regarding the two groups as suborders.

Suborder **SIMPLICIDENTATA.**

No rudimentary incisors behind the functional pair in the upper jaw. Never more than two premolars in the upper jaw or more than one in the lower. Cheek-teeth either with or without definite roots. Space between the rows of upper teeth usually less than that between the lower.

The Simplicidentata are divided into at least three superfamilies; the Sciuromorpha (squirrels, beavers, etc.), the Myomorpha (rats, fieldmice, etc.), and the Hystricomorpha (porcupines, guinea pigs, etc.). These divisions are based especially on the structure of the zygomatic arch, the size of the infraorbital foramen, and the manner of origin of the angular process of the lower jaw.

Superfamily SCIUROMORPHA.

The Squirrels, Flying Squirrels, Woodchucks, Beavers, Giant Beavers, etc.

Infraorbital foramen small, the zygomatic arch mostly formed by the jugal; the process of the maxillary which reaches backward under the jugal lacking much of reaching the zygomatic process of the temporal bone. Angular process proceeding from the lower side of the alveolus for the incisor. Tooth formula, i $\frac{1}{1}$, c. $\frac{0}{0}$, pm. $\frac{1\text{-}2}{1}$, m. $\frac{3}{3}$.

Under this superfamily come the squirrels, the chipmunks, the spermophiles, and the ground-hogs, none of which are yet known to occur fossil within the state; but some of which may be confidently looked for in cave and fissure deposits, as well as in alluvial and peat deposits, and even in drift, into which they may have burrowed. In the same group belong the beavers, remains of which have been found in the Aftonian of Iowa.

In the group Sciuromorpha the writer places without hesitation the family Castoroididæ, notwithstanding the fact that most authors have relegated it to the Hystricomorpha. Its relationships are too close to the beavers to permit it to be removed far from them. Max Weber (Die Säugetiere, 1904, p. 512) goes so far as to place Castoroides in the family of beavers.

Family Castoridae.

The Beavers.

Infraorbital foramen very small. No postorbital processes. Angular process of lower jaw rounded, with its lower edge turned inward. Teeth, i. $\frac{1}{1}$, pm. $\frac{1}{1}$, m. $\frac{3}{3}$. The single premolar of each row resembling the molars; it and the molars consisting each of transverse lamellæ of enamel and without roots, the pulps being persistent. Tibia and fibula coössified.

Besides the existing genus Castor, this family includes three or four extinct genera, one of which, Steneofiber, lived from the Oligocene into the Pliocene.

Genus **CASTOR** Linnæus.

The Beavers.

Skull strongly constricted behind the orbits. Basioccipital with its lower surface deeply excavated. Teeth without true roots, with persistent pulps and continuing to grow until late in life. Cheek-teeth in a series which converges forward, the teeth diminishing in size backward. Face of crown traversed more or less completely by lamellæ produced in the upper teeth by three infoldings of the enamel from the outer side and one from the inner; this arrangement reversed in the lower teeth. Vertebræ of the tail with elongated transverse processes.

In the beavers the incisors are large, much curved, and the hinder end extends back to the anterior cheek-tooth. The enamel is confined to the front of the tooth and is of a deep orange color, which, however, may disappear in the fossil. Of the four cheek-teeth the single premolar on each side is the largest.

Castor canadensis Kuhl.

The American Beaver.

On the arrival of white men on this continent the beaver occupied the region from Mexico and the Gulf of Mexico north to about the limits of forests, extending northwesterly into Alaska. Its range now is much restricted.

Geologically it occurs in deposits which we must believe belong to very early Pleistocene, as at Christmas Lake, Oregon; Hay Springs, Nebraska; the Aftonian deposits of western Iowa; and the Port Kennedy cave, in Pennsylvania.

As remains of the beaver will certainly continue to be found in Iowa, some measurements of various parts of the skeleton are here given to facilitate identification. The measurements are taken in straight lines between the points mentioned. Other specimens may be larger or smaller. As aids to the identification of this species figures are furnished of the skull and teeth (Pl. LXX, figs. 1-4).

MEASUREMENTS.

Length of skull from rear of condyles to front of premaxillae	143 mm.
From rear of condyles to rear of hard palate	47 mm.
Width across mastoids	69 mm.
Least width just in front of ear-openings	46 mm.
Greatest width across zygomatic arches	105 mm.
Interorbital space	26 mm.
Width across snout at middle of nasals	33 mm.
Distance from the incisors to front of premolars	50 mm.
Length of series of cheek-teeth	31 mm.
Width of palate between the premolars	7 mm.
Width of palate between the hinder molars	16 mm.
Lower jaw from rear of condyle to front of symphysis	101 mm.
Lower jaw from rear of angle to front	108 mm.
Lower jaw, width across condyle	68 mm.
Lower jaw, width across angular processes	92 mm.

Upper Teeth.			Lower Teeth.		
$Pm.^4$	length of crown	9 mm.	$Pm._4$	length	11 mm.
	width	10 mm.		width	7 mm.
$M.^1$	length	7 mm.	$M._1$	length	8 mm.
	width	9 mm.		width	9 mm.
$M.^2$	length	7 mm.	$M._2$	length	8 mm.
	width	8 mm.		width	9 mm.
$M.^3$	length	6.5mm.	$M._3$	length	8 mm.
	width	7 mm.		width	7 mm.

Scapula, length from glenoid fossa, along spine	84 mm.
Scapula, greatest breadth	48 mm.
Humerus, length	86 mm.
Humerus, width at lower end	34 mm.
Ulna, length	118 mm.
Radius, length	85 mm.
Pelvis, length	187 mm.
Pelvis, width at acetabula	104 mm.
Pelvis, greatest width at hinder end	103 mm.
Femur, length from head to inner condyle	110 mm.
Femur, width at lower end	42 mm.
Tibia, length	132 mm.
Fibula, length	121 mm.
Caudal vertebrae, breadth of 4 anterior, across processes	75 mm.

The scapula may be distinguished from any others of its size by the long process which descends from the outer border of the high spine, to a point below the head, leaving a broad notch between the latter and itself. The humerus is characterized by its flattened shaft and lower end, and by having on its outer border, just above the middle, a strongly projecting deltoid process. The femur likewise is flattened and has on its outer border, at the middle, a process known as the third trochanter. Many references to the skeleton of the beaver may be found below in the description of *Castoroides ohioensis.*

In the collection at the State University of Iowa, with the catalog number 349, is a part of the left ramus of the lower jaw of a beaver which it appears necessary to refer to the existing species, *Castor canadensis* (Pl. LXX, fig. 5). This was found by Prof. I. A. Williams, in the Cox pit, at Missouri Valley. Its age is Aftonian. The ascending ramus and the angular process are missing, as well as the last molar and all of the incisor which protruded beyond the jaw. The total length of the fragment is 85 mm. The following measurements are made on this specimen and corresponding ones on a jaw of a recent specimen at the State University of Iowa.

MEASUREMENTS.

	Fossil	Recent
Height of the jaw in front of the premolar	29 mm.	30 mm.
Height of the jaw at $m._1$	26 mm.	25 mm.
Greatest thickness of the jaw below $m._1$	17 mm.	17 mm.
Length of worn faces of the three teeth present	25 mm.	24 mm.
Length of worn faces of $m._1$ and $m._2$	16 mm.	16 mm.

In the fossil specimen the folds of enamel are directed from the inner side of the tooth outward and somewhat strongly forward, while in the specimen with which it was compared they are directed at right angles to the front-to-rear axis of the tooth; but recent specimens are observed which show the same arrangement as is seen in the fossil. We might, indeed, expect that the species had undergone some changes since the time of the Aftonian; but we shall need much better materials in order to establish the fact, if such it is.

Family Castoroididae.

The Giant Beavers.

Infraorbital foramen very small. No postorbital process. Angular processes greatly developed. Tooth formula as in the beaver, i. $\frac{1}{1}$, c. $\frac{0}{0}$, pm. $\frac{1}{1}$, m. $\frac{3}{3}$. The incisors of enormous size and furnished with numerous longitudinal grooves. The premolar of each row resembling in structure the molars; these composed of from three to five compressed plates of enamel held together by plates of cement. Fore feet unknown; the hinder five-toed.

Besides the genus Castoroides of North America this family is made to include Amblyrhiza, a not well-known fossil genus found on some of the islands of the West Indies.

As already remarked above, Max Weber regards these genera as belonging to the family Castoridæ. Until recently authors have referred the family to the superfamily Hystricomorpha (Hystricoidea). This was done because the angular process arises on the outer side of the alveolus of the incisor, as in the porcupines. The relationship of the Castoroides with the beavers is, however, so close that it cannot well be far removed from the latter. At the same time it possesses so many peculiarities that the retention of a special family for it seems to be necessary.

Genus CASTOROIDES Foster.

Form and proportions beaver-like. Cheek-teeth composed of plates (apparently flattened tubes) of enamel united by plates of cement; the upper premolars and first two molars with three, the last molar with four of these enamel plates; the lower premolar with four enamel plates, the molars with three. Upper and lower cheek-teeth in series that diverge strongly backward. Hinder part of nasal cavity divided into distinct passages, an upper and a lower.

So far as known, this genus includes only a single species, the one here described. The materials known from the early Pleistocene are, however, rather meager.

Castoroides ohioensis Foster.

The Giant Beaver.

The first account of this remarkable animal, accompanied by a scientific name, was published by the geologist, J. W. Foster (Second Ann. Rep. Geol. Surv. Ohio, 1838, page 81). It had, however, been mentioned, with figures, by S. R. Hildreth in 1837 (Amer. Jour. Sci., XXXI, p. 80). These accounts were based on a somewhat damaged skull that had been discovered near Nashport, Muskingum county, Ohio, in excavating a canal through a peat swamp. The bones found consisted of a radius, and upper incisor, and a lower jaw containing an incisor and the four cheek-teeth. Where these remains now are is not known to the present writer.

Since that time numerous specimens of the species have been found in the country from central New York to the Great Plains, and from Florida to Minnesota. Indeed, in the U. S. National Museum is a part of a femur which was brought by Mr. A. G. Maddren, of the U. S. Geological Survey, from Yukon Territory, nearly up to the Arctic ocean.

As to its continuance in time, it has been found in deposits that belong very near the beginning of the Pleistocene, notably at Hay Springs, Nebraska; Christmas Lake, Oregon; and in the Aftonian deposits of Iowa. In all these cases it has been found associated with camels and horses. On the other hand numerous specimens have been found in deposits that overlie the last, or Wisconsin, drift, notably in Indiana, Ohio, and Michigan. This shows that the animal was present in our region long after the glacial ice had disappeared.

The finest specimen of this species that has been discovered is that now in the museum of Earlham College, at Richmond, Indiana. It was found in a swamp in the eastern part of Randolph county, Indiana. It was reported by the finders to have been discovered "standing in the natural position." This individual was one not quite grown and many of the bones lack their epiphyses.

This specimen furnished a more or less damaged skull, but the lower jaw was complete. The fourth to the seventh cervicals are missing. The second, third, fifth, and sixth dorsals are gone. However, Moore (Amer. Geologist, Vol. XII, p. 68) stated that nineteen were present. Of the caudals there are fourteen present. It was believed by Moore that the hindermost one of these fourteen was about the seventeenth from the sacrum. Of the sternum, the presternum and the xiphisternum were recovered. The essential parts of both scapulæ are present. The fore feet are wholly missing and are known from no other specimen. The pelvis lacks only the symphysis of the ischia and a part of the pubic region. The hinder feet lack all the ankle bones except both astragali and one calcaneum. All the metatarsals are present except one. The right hind foot lacks all the digital bones, except the first phalange of the third digit; the left foot, all the digital bones, except the first phalange of the third digit, and the first and second of the fourth digit.

This skeleton was described and figured by Joseph Moore in the American Geologist, Vol. XII, pp. 68-74, with plate xii, and in the Journal of the Cincinnati Society of Natural History, Vol. XIII, pp. 138-169, with 25 text-figures.

The bones of the specimen were mounted; and in so doing the parts missing were restored in some material which was made to imitate as nearly as possible the color and appearance of the bone. It is, therefore, sometimes difficult to determine whether a particular part is real or artificial. This is a practice that ought to be discouraged.

The line-drawing shown here (Fig. 138) has been made by R. W. Weber after a photograph of this specimen at Earlham College. However, where any part is missing in this skeleton, but is known from other specimens, it is represented in the usual way. Where any part is missing from this and all other specimens, as in the case of the hinder cervical vertebræ, some of the caudals, the fore feet and parts of the hinder feet, the bones are traced only in outline. Such parts were restored after the beaver.

The total length of this specimen, measured along the curve of the back, as mounted, is seven feet and two inches (2185 mm.). This is about twice the length of a good-sized beaver; but the specimen was probably not quite full-grown. Another individual whose limb bones are larger, is preserved in the Field Museum

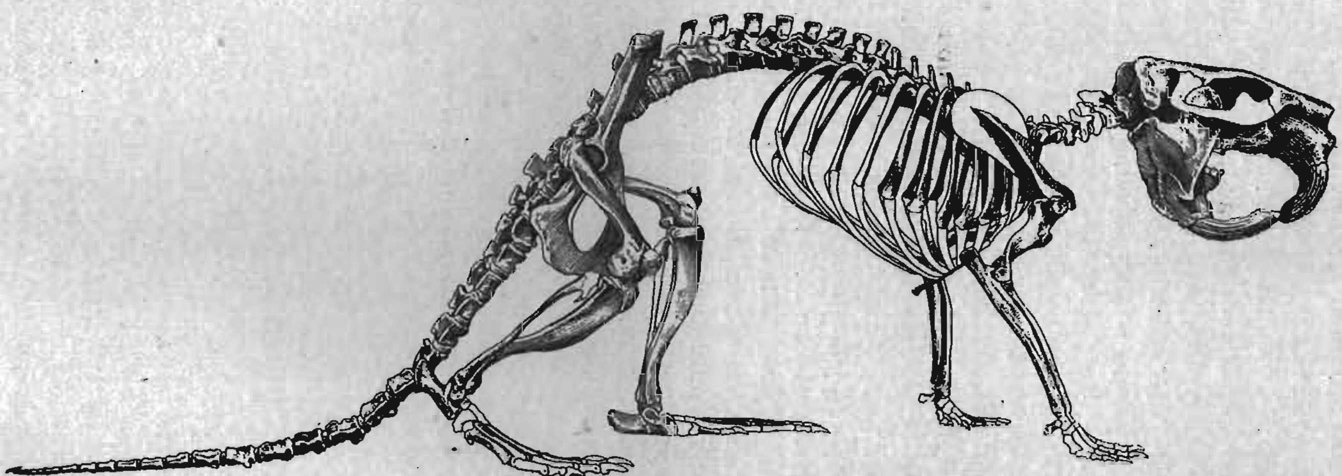

Fig. 138. *Castoroides ohioensis.* Skeleton in Earlham College, Richmond, Indiana.

of Natural History, Chicago. It is probable that large individuals attained a length of eight or nine feet; that is, more than twice the length of the beaver, and therefore of more than eight times the bulk of the latter.

Of the skull of the Earlham specimen there are present the lower jaw, with all of its teeth; the maxillæ, with all the grinding teeth, except the right premolar and the last right molar; the premaxillæ and their incisors; the vomer, the palatines and the right molar. The rear of the skull has, therefore, been restored artificially.

From the front of the premaxillæ to the line joining the hinder ends of the last molars is 195 mm. Just in front of the malar bones, the width of the face is 77 mm., the height, 88 mm. Each nasal bone is 32 mm. wide. At the anterior molar tooth the width of the palate is only about 10 mm.; between the last molars, it is 36 mm. From the rear of the incisors to the front of the first grinding tooth, the distance is 105 mm. The great upper incisors are complete. When the nasal bones are lifted, these teeth are seen to extend backward somewhat behind the suture between the maxillæ and the premaxillæ. In a specimen belonging to the American Museum of Natural History these incisors are seen to extend backward to the premolar. Each forms about a semicircle and, in the Earlham specimen, is about 210 mm. long, measured along the outer curve. On this curve they project forward and downward 100 mm. beyond the premaxillæ. The width of each is 24 mm.; the fore-and-aft thickness, 23 mm. The length of the row of grinding teeth, measured on the worn faces, is 66 mm. (Pl. LXXII, fig. 7).

The following are the dimensions of these teeth on the worn faces:

MEASUREMENTS OF UPPER PREMOLARS AND MOLARS.

Teeth	Earlham Specimen		Logansport, Indiana, Specimen	
	Length	Width	Length	Width
$Pm.^4$.	15 mm.	17 mm.	17 mm.	16 mm.
$M.^1$,	12 mm.	16 mm.	16 mm.	14 mm.
$M.^2$,	13 mm.	14 mm.	15 mm.	13 mm.
$M.^3$,	16 mm.	12.5mm.	18 mm.	14 mm.

In the lower jaw the distance from the front of the symphysis to the line joining the angular processes is 161 mm.; to the angle itself, 185 mm. From the outside of one condyle to the other is 110 mm.; from one angular process to the other, 210 mm. The length of the symphysis along its upper face is 65 mm. At the anterior grinding tooth the height is 70 mm. The distance between the anterior grinding teeth is 18 mm.; between the last molars, 50 mm. The length of the grinding surfaces of the whole row is 70 mm. (Pl. LXXII, fig. 8). The individual teeth measure as follows:

MEASUREMENTS OF LOWER PREMOLAR AND MOLARS.

Teeth	Length	Width
$Pm._4$,	20 mm.	12 mm.
$M._1$.	17 mm.	13 mm.
$M._2$.	17 mm.	13 mm.
$M._3$,	16 mm.	12 mm.

At its insertion each incisor has a width, from side to side, of 20 mm.; fore and aft, of 21 mm. It projects beyond the bone 140 mm. In a specimen in the American Museum of Natural History it is seen that the lower incisor extends backward to about 30 mm. behind the hindermost molar and outside of the deep pit on the outer face of the ascending ramus and below the condyle. The cheek-teeth are placed above the incisor, as in the beaver; not outside of it as they are in Dolichotis, a hystricomorph.

The atlas has a maximum width of 93 mm. and a height of 45 mm. The articular surfaces for the skull indicate a motion in this joint mostly up and down. The axis is consolidated with the third cervical. The same is true in a beaver at hand. The axis is nearly as wide as the atlas. Moore described with some detail the dorsal vertebræ. He concluded that the length and bulk of the spinal column from the atlas to the sacrum did not differ much from that of an adult man, being twenty-one inches in length. However, a few pieces were missing and most of the epiphyses are gone also. In general the structure of the vertebræ is the same as in the beaver. There were doubtless, as in most other rodents, nineteen dorsals and lumbars taken together. Moore concluded that there were probably fourteen thoracic vertebræ and five lumbars. On the upper side of the centrum of each of the dorso-lumbars is a pair of large foramina opening into the spongy interior, as in the beaver and some other rodents. The lateral extent of the first thoracic vertebra is given as fully 75 mm., but the width of the succeeding ones diminishes to the fifth. The last, or fifth, lumbar has strong lateral processes and measures, from the tip of one process to the other, 92 mm.

In the beaver there are four sacral vertebræ, and Moore stated that that is the number in the mounted specimen of Castoroides. The lateral winglike processes of the hinder ones are broken off. Moore gave as the length of the four sacrals 5.12 inches. So far as the writer could see, there are in the sacrum, as mounted, only three sacrals, and the free vertebra behind the third one was included by Moore among the caudals. In the beaver there are four sacrals. The three sacrals seen in the Earlham specimen measure 90 mm. in length. As already stated, there are preserved fourteen caudal vertebræ. Moore concluded that there were originally about twenty-three or twenty-five, as in the beaver. These vertebræ resemble much those of the beaver, but the centra of the proximal ones and the transverse process are not so long, thus indicating that the tail was not so broad. For example, the greatest width of the seventh in a beaver is 60 mm.; in the Castoroides, 75 mm.; whereas, its proportional width would be at least 120 mm. Of ribs, Moore stated that there were eight right and twelve left. As the writer determined, there are in the mounted animal eleven on the right side, eight on the left. It is possible that parts of ribs joined to artificial materials were overlooked. The parts of the sternum present resemble the corresponding parts in the beaver. The acromion process of the scapula is relatively shorter than in the beaver, and is compressed parallel with the axis of the body. In the beaver it is compressed on the opposite plane.

The humerus has a length of 135 mm., measured from the head to the inner side of the articulation for the ulna. Moore's statement, that the length is 7.36 inches, is probably a typographical error for 5.36 inches. The width across the upper end is 55 mm.; across the lower end, 53 mm. On the outer border just above the middle is a strong deltoid process. The ulna had, in life, a length of about 230 mm. On the outer face, as in the beaver, there is a deep longitudinal fossa, extending from the sigmoid cavity to beyond the middle of the length of the bone. The radius, with its missing distal epiphysis, probably measured 170 mm. The length of the radius to that of the humerus is 1.33; in the beaver, 1.06. This appears to be due to the fact that the humerus of Castoroides is, relatively to the length of the animal, shorter than in the beaver. The anterior extremities of the ilia are restored. The original length of the pelvis was close to 300 mm., extending over the length of ten vertebræ; whereas, in the beaver, it extends along eight of them; nevertheless, it appears to be relatively shorter than that of the beaver. The structure of the innominate bones resembled closely that of the corresponding bones of the beaver.

The femur, with its restored distal epiphysis, measures 165 mm. from the head to the distal articular surface; from the greater tubersoity, 185 mm. The bone is broad and flat, being 70 mm. wide across the condyles at the lower end. Where the shaft is narrowest, about the middle, the diameter, from side to side, is 30 mm.; the thickness, 22 mm. It will be seen that the shaft is much more constricted at the middle than it is in the beaver. Likewise, the third trochanter is placed above the middle; not at the middle, as it is in the beaver. In proportion to the length of the animal, the femur is shorter in Castoroides than in the beaver.

The greatest length of the tibia is 253 mm.; the breadth of the upper end, 56 mm. It greatly resembles the same bone in the beaver. The fibula had a length originally of 218 mm. It is coössified with the tibia for a distance of about 95 mm., differing thus from that of the beaver.

So far as the bones of the hinder foot are preserved, they indicate a foot greatly like that of the beaver, but shorter relatively to the length of the body. A skeleton of a beaver before the writer, has its length contained in that of the mounted specimen of Castoroides just two and one-eighths times. Its whole leg measures 360 mm., omitting the claw phalange of the fourth digit. The leg of Castoroides, omiting the same phalange, ought then to measure 763 mm.; it measures only 655 mm. The femur ought to measure 230 mm.;it measures only 185 mm. The tibia ought to measure 285 mm.; it measures only 253 mm. The foot, omitting the unknown claw phalange, ought to measure, from the heel, 308 mm.; it measures only 252 mm. It appears evident, therefore, that the giant beaver was a relatively shorter legged animal than the beaver.

The skull of Castoroides (Pl. LXXI, fig. 1) resembles rather closely that of the beaver, but there are important differences, as has been pointed out by others. In the beaver the width of the rear of the skull is almost exactly one-half its length; in the giant beaver the width is about a tenth more than half the length. In the beaver the auditory bullæ are much inflated and the basioccipital is deeply hollowed out on the underside; in the giant beaver the bullæ are little inflated and the basioccipital has two shallow excavations separated by a median ridge. In the beaver, the jugal bone extends forward to the lachrymal, while the malar process of the maxilla reaches backward a little behind the orbit; in Castoroides, the jugal reaches forward to the middle of the orbit only, while the malar process passes about as far backward as in the beaver, indeed, somewhat farther. In the beaver the infraorbital foramen opens out at the premaxillo-maxillary suture in front of a sharp descending ridge; in Castoroides, the ridge is not developed and the opening is at a considerable distance behind the suture. In the beaver the narrowest part of the brain-case is in front of the middle of the skull and between the orbits; in the giant beaver it is at the middle of the length of the skull and just behind the orbits.

The most remarkable structure in the giant beaver is found in the hinder part of the nasal chamber, which is divided into two distinct passages, an upper and lower. There is nothing of the kind found in the beaver. The distance between the roof of the nasal chamber (formed by the basisphenoid and presphenoid) and its floor (formed by the palatines and maxillæ) had become much higher than in the beaver, relatively twice as high, being 40 mm. or more. In the specimen already mentioned as belonging to the American Museum of Natural History, this chamber is 60 mm. high. Just in front of the basioccipital is found the hinder opening of the superior nasal passage, rising in the basisphenoid and passing forward. The hinder part of this passage opens, in the skeleton, into the brain-cavity; but was, in life, shut off from it by membranes. The hinder opening of the lower passage is at a lower level and further forward.

All the changes in this region appear to have come about in order to accommodate the development of the large internal pterygoid muscles, which had their insertion in the pterygoid fossæ. In the beaver these fossæ are small; in Castoroides they are enormous, each having a transverse diameter of 23 mm., a horizontal extent of 67 mm., and a height of 32 mm. In front, the hinder end of the palatine has been deeply excavated; behind, the pterygoid fossa had encroached on the anterior end of the auditory bulla. The external pterygoid plate grew outward and backward, so as to lie outside of the hinder end of the alisphenoid canal and the foramen lacerum anterius. To accommodate further the internal pterygoid muscle, the internal pterygoid plate was pushed inward, so that it came into contact with the one of the opposite side at the middle of the height of these plates. In this way the hinder end of the nasal passage was constricted into a upper and lower passage.

As already stated, the upper passage opens out posteriorly by a horizontal, pear-shaped opening just in front of the basioccipital. The length of the opening is about 25 mm.; its width is 16 mm. The hinder opening of the lower passage is triangular in shape and is bounded in front by the palatine; at the sides by the internal pterygoid plates. Behind the molar teeth the partition between the two passages is, as already stated, formed by the inner pterygoid plates. In front of these the partition is continued by ascending plates from the right and left palatine bones, which plates touch at the mid-plane. Still in front of these, the right and left maxillæ come into contact and continue the partition somewhat further forward. The upper ends of the molars of the opposite sides are here very close together. Finally just behind the bases of the upper incisors the inner walls of the maxillæ part and permit the lower canal to rise into the nasal cavity, meeting here the anterior end of the upper canal.

Some further description of the teeth of this species ought to be presented. The incisors are relatively much larger than in the beaver. In a specimen of the latter the teeth project a distance beyond the bone equal to hardly twenty-five one-hundredths the length of the skull; in a fine specimen of Castoroides, from Logansport, Indiana, the exposed part equals forty-two one-hundredths the length of the skull; while in a specimen from Lenawee county, Michigan, the exposed part is a little more than one-half the length of the skull. In the mounted specimen at Earlham, the whole length of the upper teeth was about 210 mm.; in a Michigan specimen, about 250 mm.

The lower incisors are still longer. Those of the mounted specimen at Earlham, are about 250 mm. long; another tooth in that institution, from Greenville, Ohio, is 280 mm. long, is somewhat spirally curved, and is twisted on its axis. It forms nearly a semicicle.

Contrary to what is usual in rodents, the enamel is not confined to the front of the tooth, but passes around on its whole outer face. It is missing on the hinder and inner faces. The enamel is longitudinally grooved, with the grooves separated by sharp ridges. The enamel may be more or less wrinkled transversely, so as to make that part of the tooth rough. The median, or inner, face of each incisor is flat, but these faces are not applied to each other, except at their distal ends. Along most of the exposed portions they are separated by processes of the premaxillæ. The hinder face of the incisor is slightly concave from side to side. At the extremity they are not worn off like the sloping face of a chisel, as they are in the beaver, but in such a way that there is formed between and in the two a deep pit which received the tips of the lower incisors.

The upper incisors differ from the lower ones in being more strongly curved, in having the side-to-side diameter greater, and in having the transverse section approximately square, instead of being triangular with one side convex. In a specimen in the American Museum of Natural History the fore-and-aft diameter of the upper incisor is 24 mm., the side-to-side diameter, 25 mm. These diameters in the lower incisor are respectively 25 mm., and 22 mm. In the upper incisor the outer face rounds gradually into the front and the hinder faces and the greatest side-to-side diameter is at the middle of the section. In the lower incisor the outer face passes abruptly into the hinder face and very gradually into the front face; while the greatest side-to-side diameter is at the rear of the section.

The grinding teeth of the upper jaw all lean strongly backward; those of the lower jaw, forward; just as in the beaver. Each one is composed of a number of flattened tubes of enamel which contain each its portion of dentine; while the several tubes of enamel are held together by a mass of cement. The structure of these teeth resembles closely that found in the capybara; and is on a small scale like that of the elephants. In the three anterior upper teeth there are three of the enamel tubes; in the last molar there are four. These cross the tooth obliquely, passing from the outside inward and slightly backward. In the lower jaw the anterior tooth, the premolar, has four plates, or tubes; the others, three each. The plates are directed here, also, inward and rather strongly backward.

The angular process of the lower jaw (Pl. LXXI, fig. 2) is strongly developed. The inner face is deeply excavated, and there is a wide shelf of bone along the lower border. Thus a large surface was furnished for the insertion of the powerful internal pterygoid muscle.

As to the habits of this animal we can make inferences. We may be sure that it was a vigorous gnawer of hard substances. It was almost certainly an aquatic animal. Probably like the beaver it was addicted to cutting down trees and building dams and lodges for the protection of itself and young from cold and enemies. The tail was less expanded than that of the beaver, and possibly the animal had not learned yet to slap the water with it for sport and as a signal of danger. It may have been more flexible, and therefore a better aid in swimming than that of the beaver.

Remains of Castoroides have been found in Iowa in only two places, Turin, Monona county, and near Oakland, in Pottawattamie county. However, there is, in the collection at the State University of Iowa, an upper molar which was found in the Collins gravel pit at Sioux Falls, South Dakota, which is very near the northwestern corner of Iowa. This was secured by Prof. B. Shimek and is mentioned by him (Bull. Geol. Soc. Amer., Vol. XXIII, p. 143) as having been discovered in the lower sand and gravel of the pit. It belongs certainly to the Aftonian.

In the collection just mentioned, with the catalog number 279, is a piece of a water-worn incisor of Castoroides which was found in the Elliott pit, at Turin. It is mentioned by Calvin in his last paper on the Aftonian fauna (Bull. Geol. Soc. Amer., Vol. XXII, p. 215). This, too, is to be regarded as belonging to the Aftonian.

Figures 1-3 of plate LXXII present three views of an upper left incisor which, as Calvin stated, was pumped up in sand from Nishnabotna river, near Oakland. Calvin (op. cit., pl. xxiii, figs. 1, 2) regarded this as a lower incisor, but the curvature is greater than in the lower incisors of other specimens and exactly that of the upper ones; and the transverse section (Pl. LXXII, fig. 4) is that of an upper incisor. Figure 5 of the plate cited presents a section of the left upper incisor of a skull in the American Museum of Natural History, No. 10383, found in Berrien county, Michigan, while figure 6 represents a section of the left lower incisor. It will be observed that the section of the Oakland tooth is identical with the section of the upper tooth of the Michigan specimen. The cutting extremity of this tooth is broken off, but a part of the bevelled surface remains. The length of the fragment, measured along the outer curve, is about 170 mm.; the fore-and-aft diameter is 26 mm. There is nothing about the tooth which indicates a species different from the well-known *Castoroides ohioensis.*

Calvin expressed the opinion that the discovery of this tooth furnished fairly clear evidence that the sand of the Nishnabotna valley belongs to the Aftonian. Inasmuch, however, as this species is found likewise in old filled-up ponds and lakes which lie on the Wisconsin drift, the evidence must be regarded as inconclusive.

So far as the writer is aware, no other species of Rodentia belonging to the suborder Simplicidentata have been found fossil in Iowa. Near-by, however, in the crevices of the lead-bearing rocks near Galena, Illinois, there were found, about 1860 or previously (Leidy, Geol. Surv. Wis., Vol. I, 1862, p. 424), some remains of the ground-hog (*Marmota monax*), the pocket-gopher (*Geomys bursarius*), and of an undetermined species of meadow mouse (*Microtus*).

Suborder DUPLICIDENTATA.

(Lagomorpha.)

A pair of small incisors arising against the hinder face of the upper pair of functional ones. The incisors invested on all sides with enamel. Always three upper and two lower premolars. Upper molars two or three; lower molars three. Premolars resembling the molars in structure and both sets furnished with transverse ridges of enamel on grinding surface; roots with persistent pulps. Rows of upper cheek-teeth more widely separated than are the lower rows. Fibula coössified with the tibia and articulating with the calcaneum.

Under this suborder are included two families, the Ochotonidæ (Lagomyidæ) and the Leporidæ. The first named family comprises the picas, or tailless hares, small animals which live in holes among the rocks, in mountainous countries of south-eastern Europe and northern Asia, and in our Rocky Mountains. In the early Pleistocene, species of these animals inhabited the mountains of the eastern United States. No remains of these have yet been found in Iowa. The Leporidæ include the rabbits and hares. They are distributed over most of the world, being without representatives only in Madagascar, Australia, and most oceanic islands.

The Leporidæ may be defined as follows:

Family Leporidae.

The Hares and Rabbits.

Duplicidentata of usually light build, having the limbs fitted for rapid running. Clavicle incomplete. Skull laterally compressed. Tooth formula: i. $\frac{2}{1}$, c. $\frac{0}{0}$, pm. $\frac{3}{2}$, m. $\frac{2}{3}$. Last upper molar much reduced and rarely wanting.

This group differs from the Ochotonidæ in being usually of larger size and in having longer limbs and a longer tail. The Ochotonidæ have a broader skull, and the tooth formula is i. $\frac{2}{1}$, c. $\frac{0}{0}$, pm. $\frac{2-3}{1-2}$, m. $\frac{2}{3}$. In the rabbits the hindermost upper molar, m.^{3}, is much smaller than the others; in the Ochotonidæ this molar is wholly wanting and the hindermost one present, m.^{2}, is about as large as the one in front of it.

There are at present recognized as existing, in North America, four distinct genera of this family: Lepus, Sylvilagus, Brachylagus, and Romerolagus. The last named genus contains a single species, which occupies a very restricted tract on the northwestern slopes of Popocatepetl and Iztaccihuatl in Mexico. Brachylagus likewise contains a single species which is found in parts of Nevada, Oregon, and Idaho. The genus Lepus includes, in North America, fourteen distinct species, these occupying the whole of the continent, except parts of Mexico and that part of the United States lying between the Gulf of Mexico and the Great Lakes, and between the Atlantic on the east and western Wisconsin and western Arkansas. However, in this excepted area *Lepus americanus* ranges southward from New York to Virginia in the Allegheny mountains. In the existing fauna *Lepus campestris,* the white-tailed jack rabbit, extends its range eastward in Iowa to Mississippi river. No species of the genus has yet been found fossil in Iowa.

The genus Sylvilagus likewise includes fourteen North American species. These inhabit the continent as far north as the Great Lakes and the British American boundary. Remains of a single species, the cottontail rabbit (*Sylvilagus floridanus*) have been reported from the Pleistocene of Iowa.

For details regarding the osteology and the classification of the Duplicidentata, with numerous illustrations, the reader is referred to a paper by Marcus W. Lyon on the Classification of the Hares and their allies, in Vol. XLV of the Smithsonian Miscellaneous Collections, 1904. Another important paper is E. W. Nelson's The Rabbits of North America, being No. 29 of North American Fauna, published by the Department of Agriculture. The student of the Rodentia cannot overlook the great work of Tycho Tullberg, Ueber das System der Nagetiere, published in 1899.

Leporidæ have existed in North America from the time of the Lower Miocene. A species referred to Lepus has been described from the John Day Miocene of Oregon. Cope recognized *Lepus sylvaticus* (*Sylvilagus floridanus*) from Port Kennedy cave in Pennsylvania. The same species is credited to the fauna of the Conard fissure in Arkansas, by Barnum Brown; besides *Lepus americanus* and another called *Lepus giganteus*.

A few brief remarks may be made on the osteology of the rabbits and hares, since remains of some of these animals are likely at any time to be found in Iowa. The following suggestion may easily be acted upon: In case any bones are found which may be suspected to be those of a rabbit, it will not be difficult, anywhere in Iowa, to secure a skeleton of one of the existing species and to compare the fossil bones with this skeleton.

The form and structure of the skull and teeth of a rabbit may be seen from the figures here presented (Pl. LXXIII, figs. 1-4). A word may be said regarding the teeth. The upper incisors have a groove running along the anterior face; the lower incisors have no such groove. The cheek-teeth are high, the upper ones rising in the maxillary bone to a line above the lower level of the orbit; the lower ones descending nearly to the lower border of the jaw. None have true roots. The upper teeth (Pl. LXXIII, figs. 3, 5) are much broader than long on the grinding face. This face of each tooth is traversed by three ridges of enamel, except in the front premolar and the last molar. The median ridge is produced by a fold of the enamel which begins at the inner end of the tooth and extends nearly to the outer end. The lower cheek-teeth (plate cited, figs. 4, 6) are about as long as broad and the grinding surface is crossed by three ridges of enamel. The outer face of these lower teeth has a deep groove and two ridges; except in the case of the anterior one, where are two grooves and three ridges. The vertebral column has twenty-six vertebræ in front of the sacrum. The cervicals have short or no spines. The spines of the thoracic ribs are mostly long and slender; those of the lumbar are shorter and broader from front to rear. At each side of the front of the neural spines of the lumbars is a high and broad process. The lateral processes of the lumbars are long, flat, and widened at the outer ends. In the sacrum one broad vertebra joins the ilia. The tail is short, slender, and sometimes nearly missing.

The scapula is triangular, relatively narrow above, and especially slender just above the glenoid cavity. The spine is high, the acromion process is separated from the body of the bone by a deep notch, and at its lower end it has a slender process which is turned directly backward. The bones of the fore leg are slender. The ulna and radius are considerably bent and beyond the middle of the length are bound immovably together. There are five digits, the first short, and all ending in claws.

The innominate bones are elongated. The ilia are somewhat scoop-shaped in front. The pubic and ischiadic parts of the right and left bones join along the midline below. The bones of the hind leg are long and slender. On the outer side of the upper end of the femur there is a third trochanter. The fibula is extremely slender. In its lower half it is coössified with the tibia; but it continues on until it articulates with the heel-bone. The hinder foot is long and has four slender digits, the inner, or first, one not being developed.

Genus **SYLVILAGUS** Gray.

The Cottontails, and the Brush, Swamp, and Wood Rabbits.

Leporidæ in which the interparietal bone remains distinct in adult age; the supraorbital process narrow and leaving a small or no notch between it and the frontal. Anterior cervical vertebræ shortened, the length at the midline of the neural arch of the third being about equal to the width of the arch; the third, fourth, and fifth ribs not especially wider than the others; radius and ulna having about the same diameter at the middle of their length.

The above characters distinguish the species of Sylvilagus from those of Lepus. In the latter genus the interparietal bone becomes fused with the supraoccipital; the supraorbital processes are broader and stand out further from the frontals; the cervical vertebræ are narrower, the neural arch of the third being much longer than wide and the third, fourth, and fifth ribs being much broader than the others.

Sylvilagus floridanus (Allen).

The Cottontail Rabbit.

About the year 1888 a well was sunken on the border of the town of Yarmouth, in Des Moines county. The section found here has already been given on page 27. Soon after the well was completed it was visited by Prof. Frank Leverett. In the materials of the dump he found some bones which were identified by Dr. Fredrick W. True, of the National Museum, as having belonged to two species, one of which is the rabbit, then called *Lepus sylvaticus,* but now known as *Sylvilagus floridanus*; the other species, the common skunk, *Mephitis mephitica.* This discovery was first announced by W J McGee (Eleventh Ann. Rep. U. S. Geol. Surv., 1891, p. 495). The matter is discussed by Leverett in his report on the Illinoian drift-sheet (Monogr. XXXVIII, pp. 42, 124). The bones were found in a bed of peat, the thickness of which is fifteen feet. This is overlain by thirty-four feet of later deposits. The peat belongs to the Yarmouth stage of the Pleistocene.

The parts which belonged to the skeleton of the rabbit were a portion of the pelvis and the upper part of the femur. These bones ought to be in the National Museum, but the writer has not yet been able to find them; hence no further comparisons and descriptions can be made of them. Inasmuch as this species is recorded from the state, it may be well to give some measurements of the more important parts of the skeleton, in the hope that additional materials may come to light. These measurements are taken from a specimen in the National Museum, No. 49624. On plate LXXIII, figs. 1-4, are shown illustrations of the skull of the same specimen. The animal was collected in Monroe county, New York, and belongs to the form now known as *Sylvilagus floridanus mearnsi.* The same subspecies ranges west to central Kansas and north to central Minnesota.

Figures 5 and 6 of the plate cited, taken from Lyon's work, mentioned above, present views of the grinding surfaces of the premolars and molars of the right side of both jaws. It will be observed that there exist important differences between them.

In these figures the premolars are at the upper ends of the rows of teeth.

In a second column are given the corresponding measurements of *Lepus campestris*, the white-tailed jack-rabbit, a much larger species than the cottontail and one which is reported to range over nearly the whole of Iowa.

MEASUREMENTS OF SKELETONS OF RABBITS.

	Sylvilagus floridanus	Lepus campestris
Skull—		
Length from lower border of the foramen magnum to front of premaxillae (basilar length)	62 mm.	80 mm.
Distance from foramen magnum to rear of hard palate	31 mm.	43 mm.
Distance from line joining front of anterior premolars to front of premaxillae	25 mm.	29 mm.
Width across mastoid processes	26 mm.	30 mm.
Width across zygomatic arches	35 mm.	47 mm.
Interorbital width	19 mm.	33 mm.
Width of palate between first true molars	13 mm.	15 mm.
Length of upper tooth row, at base	15 mm.	20 mm.
Length of grinding surface of $m.^1$	2.5mm.	3 mm.
Width of grinding surface of $m.^1$	5 mm.	6.5mm.
From rear of condyle to front of symphysis of lower jaw	57 mm.	72 mm.
Length of lower tooth row, at base	14 mm.	20 mm.
Length of grinding surface of $m._1$	3 mm.	4 mm.
Width of grinding surface of $m._1$	3 mm.	4 mm.
Vertebrae and ribs—		
Length of the seven cervicals	52 mm.	76 mm.
Length of the twelve thoracic vertebrae	93 mm.	135 mm.
Length of the seven lumbar vertebrae	105 mm.	137 mm.
Width of the first sacral	24 mm.	37 mm.
Width of the fourth rib	4 mm.	9 mm.
Anterior limb—		
Length of scapula parallel with the spine	57 mm.	80 mm.
Width of the upper end	32 mm.	50 mm.
Greatest length of the humerus	65 mm.	102 mm.
Fore-and-aft diameter at middle of length	5 mm.	8 mm.
Side-to-side diameter at middle of length	3.5mm.	6 mm.
Total length of ulna, in straight line	75 mm.	123 mm.
Total length of radius, in straight line	64 mm.	105 mm.
Posterior limb and arch—		
Total length of innominate bone	70 mm.	93 mm.
Width of pelvis at upper borders of acetabula	30 mm.	48 mm.
Greatest length of femur, in straight line	83 mm.	122 mm.
Fore-and-aft diameter at middle of length	5 mm.	7 mm.
Side-to-side diameter at middle of length	7 mm.	10 mm.
Length of the tibia	97 mm.	140 mm.
Fore-and-aft diameter of tibia at middle of length	5 mm.	8 mm.
Side-to-side diameter of consolidated tibia and fibula at middle of length	7 mm.	8 mm.

Order **Ferae.**

(Carnivora).

The Flesh-eating Mammals.

Mammals which, in nearly all cases, subsist on animal food; teeth usually fitted for seizing and dividing such nutriment; canine teeth greatly developed. The feet each with four or five digits; these ending in claws. Clavicle missing or rudimentary. First digit not opposable to the others. Lower jaw working by a hingelike movement.

To this order there are assigned three suborders, viz.; the wholly extinct group, the Creodonta; the Fissipedia, and the Pinnipedia. None of the first-named suborder is known to have existed later than the Miocene, and hence need not be considered here. The Pinnipedia include the seals and the walruses, and did not exist in Iowa during the Pleistocene. The Fissipedia are represented in the Aftonian of Iowa by a very few species.

Suborder **FISSIPEDIA.**

The Bears, Hyenas, Dogs, Cats, etc.

Carnivora having the first digit on all the feet shorter than the others; incisors, with rare exceptions, $\frac{3}{3}$; canines large; the fourth premolar of upper jaw and the first molar of lower forming a special cutting tooth, the sectorial; hinder tooth adapted for crushing and grinding.

The Fissipedia are represented in the known Pleistocene fauna of Iowa by species belonging to three families. These are the Ursidæ (bears), the Mustelidæ (weasels and skunks), and the Canidæ (dogs and wolves). In other parts of the country a variety of species of Felidæ (cats) have been found; and an extinct species of raccoon, belonging to the Procyonidæ, was described many years ago from Galena, Illinois.

Family **Ursidae.**

The Bears.

Clumsily-built carnivores with plantigrade feet; digits, five in all the feet. Tooth formula, i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{4}$; m. $\frac{2}{3}$; anterior three premolars likely to have been shed early in life; sectorial teeth (pm.^{4} and m.$_1$) much less differentiated than in the dogs. Molars with rather flat and much tuberculated crowns. Post-orbital part of skull longer than the remainder. Humerus with a foramen on the inner side of the distal end.

The bears have today a wide distribution, being found in Europe, Asia, northern Africa, North America and South America. In the latter continent there is found only a single species. In time they may be traced back to the Middle Miocene in northern Africa and to the upper Miocene in Europe. None are known to have existed in America before the beginning of the Pleistocene. They probably reached the continent from Asia, over some land connection in the region of Bering Strait.

Many of the bears are omnivorous in their habits, and a few seem to live mostly on vegetable food.

Two genera belonging to this family are known from the Pleistocene of North America, Ursus and Arctodus. The first is represented in Iowa; the latter, not.

Genus URSUS Linn.

Bears with the three anterior premolars small and often wanting; first premolar close to the canine. Upper and lower sectorials smaller than the succeeding molars. Crowns of molars broad, flat and tuberculated. All the feet with five well-developed digits, armed with large, compressed claws.

Of this genus three species have been found fossil in the United States, viz.: *Ursus americanus, U. procerus,* and *U. amplidens. Ursus procerus* Miller is known from a single skull found near Hamilton, Ohio. *U. amplidens* was found at Natchez associated with Megalonyx, Mylodon, Ereptodon, *Equus complicatus, Odocoileus virginianus,* Mammut and *Ursus americanus.* Possibly the age of this assemblage is Aftonian; but not improbably they lived about the time of the Sangamon.

Ursus americanus Pallas.

The Brown Bear of the Eastern United States.

Remains which have been referred to this species have been found in various localities. As just mentioned, Leidy recognized it among bones sent from Natchez, Mississippi, and Cope identified it on remains found in the Port Kennedy cave, in eastern Pennsylvania. Barnum Brown reported finding it, or a very closely related species, in the Conard fissure, in northern Arkansas. Calvin (Bull. Geol. Soc. Amer., Vol. XXII, p. 209, pl. xviii) described and figured the right ramus of a lower jaw of a bear which had been found in the Cox gravel pit, at Missouri Valley, Harrison county. As elsewhere expressed, the present writer believes that the abundant vertebrate remains which have been brought to light in the Port Kennedy cave belong to the early Pleistocene, probably to the Aftonian stage; while the fauna of the Conard fissure is later, representing probably the Illinoian glacial stage. That bears existed in this country early in the Pleistocene is now confirmed by Calvin's discovery.

It is not at all improbable that, in case we were in possession of complete materials, these early bears would prove to be specifically distinct from *Ursus americanus;* yet they must have been, at most, not far removed from it.

The jaw found at Missouri Valley (Pl. LXXIII, fig. 7) belonged to an old individual. The teeth remaining in the jaw are much worn. There are present the canine, the last premolar and the first molar. The second and third molars had fallen out after the death of the animal, possibly after the exhumation of the specimen, and we can determine their size only from the sockets.

The following measurements have been made on this jaw. For comparison, corresponding measurements have been made on two jaws in the National Museum.

MEASUREMENTS OF BEARS' SKULLS.

Dimensions Determined	Fossil	No. 3798 National Museum	No. 37128 National Museum
From front of jaw to rear of condyle	194 mm.	190 mm.	195 mm.
Length of symphysis	60 mm.	60 mm.	66 mm.
Diameter of base of canine, fore and aft, at bone	24 mm.	21 mm.	17 mm.
Diameter of base of canine, side to side, at bone	13 mm.	12.3mm.	11.3mm.

MEASUREMENTS OF BEARS' SKULLS—Concluded.

Dimensions Determined	Fossil	No. 3798 National Museum	No. 37128 National Museum
$Pm._4$, length	11 mm.	9 mm.	9 mm.
$Pm._4$, width	6.5mm.	5.1mm.	5 mm.
$M._1$, length	20 mm.	20 mm.	20 mm.
$M._1$, width at rear	10.5mm.	10 mm.	10 mm.
$M._2$, length of socket	19.5mm.	20 mm.	19 mm.
$M._3$, length of socket	16 mm.	13 mm.	16 mm.
Length of the tooth row, last two from sockets	67 mm.	67 mm.	67 mm.
Length of the diastema	29 mm.	37 mm.	38 mm.
Height of jaw at diastema	38 mm.	40 mm.	41 mm.
Height of jaw, at $m._1$	46 mm.	43 mm.	46 mm.
Height of coronoid process	82 mm.	87 mm.	88 mm.

The thickness of the fossil jaw below the molars, is 18 mm. In No. 3798 this thickness is 17 mm.; in No. 37128, it is 17 mm. The outer face of the jaw of the fossil is slightly convex up and down, while the inner face is slightly concave. The distance from the front of the canine to the front of $pm._4$ is 55 mm., about the same as in specimens of *U. americanus*.

It will be observed that the canine of the fossil jaw is much larger than that of the specimens with which it is compared. No specimen has been found which has this tooth quite so large as that of the fossil. When the measurement is made along the lower border of the enamel, the fossil shows a fore-and-aft diameter of 19 mm.; No. 3798, a diameter of 17 mm.; and No. 37128, a diameter of 11 mm. The diastema of the fossil is unusually short; but this is due partly to the great size of the canine.

Inasmuch as bones and teeth of bears are likely at any time to be discovered in Iowa, the writer furnishes here some measurements of the teeth and the more important bones of the skeleton, for the purpose of aiding in their identification. The following measurements of the skull and teeth are taken on No. 3798 of the National Museum. This skull was obtained in the state of New York:

MEASUREMENTS OF BEARS' SKELETONS.

Measurements	Ursus americanus
Skull:	
From front of premaxillae to rear of occipital condyle	283 mm.
From front of premaxillae to lower border of foramen magnum	261 mm.
From front of premaxillae to rear of occipital crest	301 mm.
From front of premaxillae to front of nasals	63 mm.
From tips of nasals to line joining tips of postorbital processes	93 mm.
From front of premaxillae to line joining postorbital processes	154 mm.
From line joining tips of postorbital processes to rear of sagittal crest	178 mm.
Breadth of snout across bases of canines	68 mm.
Least breadth of snout behind canines	60 mm.
Breadth at upper border of lachrymals	66 mm.
Breadth across postorbital processes	97 mm.
Width across mastoid processes	148 mm.
Width across zygomatic arches	185 mm.
Breadth of palate between first molars	43 mm.
Breadth of palate between hinder ends of last molars	44 mm.
Width across palatine bones at front of palatine notch	40 mm.
Width of palatine notch between the pterygoids	21 mm.
Greatest depth of palatine notch between the pterygoids	24 mm.
Depth of snout at midline at front of m.[1]	58 mm.
Depth of skull at midline between auditory bullae	75 mm.
Length of palate from front of premaxillae to line joining the hinder ends of m.[2]	121 mm.
Distance from front of premaxillae to front of palatine notch	144 mm.
Width across occipital condyles	60 mm.
Width of each occipital condyle	16 mm.
Width of the mastoid process	32 mm.
Length of the lower jaw from front to line joining the rear of the condyles	183 mm.
Outside of one condyle to that of the other	155 mm.
Height of coronoid process from bottom of angle	81 mm.
Length of symphysis, lower face	60 mm.
Teeth:	
Length of base of canine	22 mm.
Breadth of base of canine	15 mm.
Length of pm.[4]	13 mm.
Breadth of pm.[4]	9 mm.
Length of m.[1]	18 mm.
Width of m.[1]	13 mm.
Length of m.[2]	27 mm.
Breadth of m.[2]	14 mm.

The skull of the bear differs from that of the dog and the wolf in its greater size, its relatively greater breadth, the more advanced position of the front of the orbits, the shorter and thicker snout, the smaller premolars, and the very small, instead of very large, sectorials. In the wolf and dog the hard palate ends at the rear of the last molar; in the bear it extends an inch behind the molar. The bear has only two upper molars; the wolf and the dog, three.

The following measurements of the limb bones are taken from a specimen in the National Museum. The epiphyses had not yet united with the shaft of many of the bones, and the animal may have lacked a little of having its full size:

Scapula. length parallel with the spine	168 mm.
Scapula, width of upper end	127 mm.
Humerus, total length	250 mm.
Humerus, from head to distal end	250 mm.
Humerus, fore-and-aft diameter at middle of shaft	37 mm.
Humerus, transverse diameter at middle of shaft	23 mm.
Radius, length	218 mm.
Radius, diameter at middle of shaft	20 mm.
Ulna, total length	255 mm.
Ulna, diameter at middle of shaft	23 mm.
Pelvis, length from front of ilium to rear of ischium	
Pelvis. width at acetabula	
Pelvis, width near end of ischia	
Femur, length from head to inside of lower end	292 mm.
Femur, diameter at middle of shaft	25 mm.
Femur, length from top of great trochanter to lower end	282 mm.
Tibia, total length	227 mm.
Tibia. fore-and-aft diameter at middle of shaft	21 mm.
Fibula, total length	200 mm.
Fibula, diameter at middle of shaft	7 mm.

Family **Mustelidae.**

The Otters, Badgers, Skunks, Weasels, Etc.

Carnivora with reduced dentition, the tooth formula being i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{3-4}{3-4}$, m. $\frac{1}{2-1}$. The sectorial upper premolar and the sectorial lower molar well differentiated from the succeeding tooth. Body usually elongated and the limbs short.

The Mustelidæ are widely distributed over the world, but they are missing from Australia. In Europe they date from the Upper Eocene; in America, from the Oligocene. In the Pleistocene, they became abundant.

This family is divided into three subfamilies, the Lutrinæ (land-otters and sea-otters), the Melinæ (the skunks, badgers, etc.), and the Mustelinæ (the martens, minks, and weasels). Of the first and the last subfamilies no remains have yet been reported from Iowa. The Melinæ are represented by one skunk.

Subfamily MELINAE.

The Skunks and Badgers.

Limbs are more elongated than in the otters and weasels; the feet longer. Upper sectorial triangular and usually smaller than the very broad molar present. Lower sectorial elongated, with large basin-like heel.

Genus MEPHITIS Geoffroy and Cuvier.

Heavily built mustelids with tooth formula i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{3}{3}$, m. $\frac{1}{2}$. The upper sectorial considerably smaller than the molar. Heel of the lower sectorial nearly as long as the rest of the tooth. Palate ending behind nearly on a line with the hinder borders of the molars. Postorbital processes small or nearly wanting. Auditory bullæ little inflated.

The skunks of this genus inhabit the greater part of North America. Nine species are now recognized. The genus was revised in 1901 by Arthur H. Howell, of the Biological Survey (N. Amer. Fauna, No. 20, pp. 1-62, with pls. i-viii), the name Chincha being adopted. Gerrit S. Miller (Bull. 79, U. S. Nat. Mus., pp. 107-111) gives a list of the existing species.

From the Pleistocene there have been described seven species of this genus, most of them from the Port Kennedy cave, in Pennsylvania. From the Conard fissure in northern Arkansas, Barnum Brown described a form which he regarded as belonging to *Mephitis mephitis.* This species has been reported from the Port Kennedy cave, but Cope, in his last paper on the fauna of this cave did not recognize *M. mephitis,* but three other species, all extinct. True identified *M. mephitis* from Yarmouth peat, at Yarmouth, Iowa. At the time the latter identification was made, about 1881, the name *Mephitis mephitis,* or *mephitica,* was applied to most of the skunks of the eastern half of North America. It is now restricted to a large skunk which inhabits the region extending from Nova Scotia into the province of Keewatin. The skunk of this genus which now inhabits Iowa is known as *Mephitis mesomelas.* While probably all or most of the recognized existing species are tenable, they are closely related and their skulls vary comparatively little, and their skeletons probably still less. It would, therefore, probably be impossible to determine, with certainty, to which of the known species a single bone, as a scapula, belonged. It is, indeed, possible that, when the Yarmouth peat was being deposited, the boreal species *Mephitis mephitica* inhabited Iowa; but until materials have been found which are more characteristic, we cannot speak with assurance. The remains found at Yarmouth are, therefore, referred only provisionally to *M. mephitis.*

It is quite certain that species of this genus existed in this country at all times during the Pleistocene.

Mephitis mephitis (Schreber).

The circumstances attending the discovery of remains of skunk in the Yarmouth peat, at Yarmouth, Iowa, have already been mentioned in the discussion of *Sylvilagus floridanus,* on page 472. A single bone, a scapula, was found; and this, Dr. F. W. True was not able to distinguish from that of the most abundant skunk known to inhabit the eastern part of the United States. This, at that time, went under the name given above, but it is now known as *Mephitis putida.* This is not known to extend, at present, so far west as Iowa.

Inasmuch as fossil remains of skunks are liable to be found in the state of Iowa, it is thought proper to furnish illustrations (Pl. LXXIV, figs. 1-6) and measurements of the skull and measurements of some of the bones of the skeleton. There are first given measurements of the skull of a specimen of *Mephitis mephitis,* No. 110191, of the Biological Survey, found at Oxford House, Keewatin; in the second column those of the skull of *Mephitis putida,* No. 3523, of the National Museum, secured in Massachusetts:

MEASUREMENTS OF THE SKULLS OF *MEPHITIS MEPHITIS* AND *MEPHITIS PUTIDA.*

	Mephitis mephitis Biological Survey	Mephitis putida National Museum
From front of premaxillae to rear of condyle	79 mm.	70 mm.
From front of premaxillae to lower border of foramen magnum	71 mm.	65 mm.

MEASUREMENTS OF SKULLS—Concluded.

	Mephitis mephitis Biological Survey	Mephitis putida National Museum
From front of permaxillae to rear of occipital crest, at midline	80 mm.	71 mm.
From front of premaxillae to line joining postorbital processes	38 mm.	35 mm.
From front of premaxillae to rear of hard palate	32 mm.	29 mm.
From rear of hard palate to foramen magnum	39 mm.	36 mm.
Width across occipital condyles	21 mm.	17 mm.
Width across mastoid region	44 mm.	38 mm.
Greatest width across the zygomatic arches	48 mm.	43 mm.
Width of snout at roots of canines	21 mm.	19 mm.
Least width just behind postorbital processes	20 mm.	19.5mm.
Width across postorbital processes	23.5mm.	22 mm.
Interorbital width	23 mm.	20.5mm.
Width across hinder molars, at base, in front	31.5mm.	27 mm.
Width across the incisors	11.5mm.	10 mm.
Canine, height	11 mm.	12 mm.
Canine, length of base	5 mm.	4 mm.
Canine, width of base	3.5mm.	3 mm.
Fourth premolar, length	8 mm.	7.5mm.
Fourth premolar, width	6 mm.	5 mm.
First molar, length	7.5mm.	6.5mm.
First molar, width	9.5mm.	8 mm.
From front of symphysis to middle of line joining condyles	50 mm.	45 mm.
Height of coronoid process	27 mm.	22 mm.
Width across the condyles	44 mm.	42 mm.
Length of first molar (sectorial)	11.5mm.	9.5mm.
Width of sectorial at rear	5 mm.	3.5mm.

The following measurements have been taken from a skeleton of *Mephitis putida*, No. 3523, of the National Museum, the skull of which is measured above:

MEASUREMENTS.

Scapula, length parallel with spine	40 mm.
Scapula, width near upper end	23 mm.
Humerus, total length	54 mm.
Humerus, width of upper end through head and greater tuberosity	13 mm.
Humerus, fore-and-aft diameter at middle of length	7 mm.
Humerus, side-to-side diameter at middle of length	4.5mm.
Humerus, greatest width at lower end	17 mm.
Ulna, total length	54 mm.
Ulna, greatest diameter at middle of length	4.5mm.
Radius, total length	43 mm.
Radius, greatest diameter at middle of length	4 mm.
Radius, greatest diameter at distal end	9.5mm.

Pelvis, greatest length	60 mm.
Pelvis, from front of ilium to center of acetabulum	37 mm.
Pelvis, width at front of ilia	37 mm.
Pelvis, width across upper borders of acetabula	30 mm.
Pelvis, width at rear of ischia	41 mm.
Femur, total length	61 mm.
Femur, width through head and greater trochanter	16 mm.
Femur, fore-and-aft diameter at middle of length	5 mm.
Femur, side-to-side diameter at middle of length	5.5mm.
Femur, greatest width across condyles	14 mm.
Tibia, total length	64 mm.
Tibia, diameter of upper end	15 mm.
Tibia, fore-and-aft diameter at middle of length	5 mm.
Tibia, side-to-side diameter at middle of length	4 mm.
Tibia, transverse diameter of lower end	10 mm.
Fibula, total length	55 mm.
Fibula, diameter at middle of length	2.5mm.

The measurements of the skulls show that *Mephitis mephitis* is a larger animal than *Mephitis putida.* There are other characters, derived from the living animals, which distinguish them.

Family Canidae.

The Dogs, Wolves, and Foxes.

Skull rather elongated. Auditory bullæ inflated. Tooth formula, i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{4}$, m. $\frac{2-3}{3}$; the sectorial tooth strongly developed, the lower one with cutting edge, the upper one transversely extended. Second upper molar broader than long. Premolars increasing in size backward. Feet digitigrade; first digit of fore foot very short; that of the hind foot vestigial. Digits with moderate, non-retractible claws.

The Canidæ have at present a world-wide distribution. In Europe numerous genera existed from the time of the Upper Eocene; and in North America from the time of the Oligocene. Several species existed in our country during the Pleistocene, but it is not certain that any remains have been found within the limits of Iowa. In 1862 (Geol. Surv. Wis., p. 422) Wyman announced wolf remains from Blue Mounds, Wisconsin, which he could not distinguish from the common gray wolf, *Canis occidentalis.* He also stated that the skull and most of the teeth of another wolf, not distinguishable from the coyote. *Canis latrans,* had been discovered in the lead region, but the state is not mentioned. It was from the collections made by James Hall, and may have been found by him in Iowa during his occupancy of the office of State Geologist of Iowa.

Genus CANIS Linn.

Dogs having the tooth formula, i.$_{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{4}$, m. $\frac{2}{3}$. Upper molars wider than long, the hindermost one small. Last two molars of lower jaw small. Heel of lower sectorial usually narrower than the body of the tooth. Postorbital processes inflated and their upper surfaces turned strongly downward toward the extremity of the processes.

In the foxes the heel of the lower sectorial is as wide as, or wider than, the body of the tooth; the postorbital process has on its upper surface a depression, and this surface is not turned downward toward the tip of the process.

Canis mississippiensis Allen.

In 1876 J. A. Allen (Amer. Jour. Sci., ser. 3, Vol. XI, p. 49) described some remains of a wolf which had been found by Prof. J. D. Whitney in the lead region of Iowa, Wisconsin, and Illinois. Allen stated that the remains consisted of a femur, two tibia, and a humerus; and he indicates that possibly these formed a part of the wolf bones which were mentioned by Jeffries Wyman as having been found at Blue Mounds, Wisconsin. Allen concluded, however, that Wyman could not, because of the large size of the bones, have mistaken them for those of the gray wolf. Accordingly he described them under the name given above. It was not known in which of the three states named the bones were found.

Allen mentions the fact that Leidy had, in 1854, described a large wolf from a part of an upper jaw which had been found along Ohio river, in Indiana, and to which is now applied the name *Canis dirus*. Inasmuch as there were no teeth or jaws associated with the lead region specimen, Allen concluded that it would be better to describe it under a provisional name, awaiting the discovery of additional materials.

In 1873 Leidy described a lower jaw of a wolf which had been found in California, and this he referred to the same species as that based on the Indiana jaw. Recently J. C. Merriam (Mem. Univ. Calif., Vol. I, No. 2, pp. 217-246, pls. xxv-xxviii, text figs. 1-26) has referred to *Canis dirus* a large part of the abundant wolf materials which had been recovered from the asphalt beds of Rancho La Brea, near Los Angeles, California. Merriam's materials include practically every part of the skeleton. In making his identification he had the benefit of the type specimen of *Canis dirus,* which belongs to the collection of the Philadelphia Academy.

The following table is in part copied from Allen's paper; but there is added a third column in which are given corresponding measurements taken from bones of *Canis dirus,* secured at Rancho La Brea. These measurements have been sent the writer by Doctor Merriam. Those of the humerus are taken on No. 19793 of the collection at the University of California; those of the femur from No. 19795; those of the tibia from No. 19794.

COMPARATIVE MEASUREMENTS OF BONES OF *CANIS MISSISSIPPIENSIS, CANIS LUPUS* AND *CANIS DIRUS.*

	Canis mississippiensis	Canis lupus	Canis dirus
Humerus, total length	223 mm.	176 mm.	240 mm.
Humerus, greatest diameter of proximal end	55 mm.	44 mm.	62 mm.
Humerus, antero-posterior diameter of head	41 mm.	34 mm.	47.7mm.
Humerus, greatest transverse diameter of distal end	46 mm.	37 mm.	55.1mm.
Humerus, greatest antero-posterior diameter of inner condyle	36 mm.	28 mm.	43 mm.
Humerus, least circumference of shaft	62 mm.	50 mm.	70.3mm.
Femur, total length	----------	193 mm.	260 mm.
Femur, transverse diameter of axis and great trochanter	----------	45 mm.	66.4mm.
Femur, transverse diameter of condyles	43 mm.	35 mm.	54.5mm.
Femur, antero-posterior diameter of inner condyles	53 mm.	39 mm.	62.7mm.
Femur, least circumference	56 mm.	44 mm.	73.4mm.
Femur, length of corresponding parts (distal two-thirds)	155 mm.	123 mm.	----------
Tibia, total length	244 mm.	200 mm.	237 mm.
Tibia, transverse diameter of head	47 mm.	38 mm.	55.4mm.
Tibia, antero-posterior diameter at most elevated point of the tuberosity	43 mm.	35 mm.	57.3mm.
Tibia, transverse diameter of distal end	31 mm.	24 mm.	38.2mm.
Tibia, least circumference of shaft	52 mm.	43 mm.	69.6mm.

A comparison of the lengths of the humerus and tibia of the two individuals measured above shows that Allen's species was taller by one-fifth than the gray wolf. Allen regarded his species as being nearly twice the size of the gray wolf, but in that he evidently referred to the relative bulks; and this would be true.

Allen's *Canis mississippiensis* has sometimes been referred to Leidy's *C. dirus*. It would, therefore, be interesting if a direct comparison of the bones described by Allen could be made with the corresponding bones of *Canis dirus;* but this at present, is impracticable. Merriam has, in his paper on *Canis dirus,* given only the lengths of the humerus, femur, and tibia. He has, however, as already stated, very obligingly sent the writer measurements corresponding to those taken by Allen; and these are presented in the third column of the table given above. These measurements show that the wolf from the lead region had nearly the same size as that which lived at La Brea, the humerus measured by Merriam being slightly longer, the tibia slightly shorter. As indicated by such measurements as could be taken on both femora, that of the La Brea wolf was much larger. It must not be forgotten, however, that all three bones measured belonged to as many individuals.

PERCENTAGES OF DIAMETERS AND LEAST CIRCUMFERENCES OF HUMERI AND TIBIÆ TO THEIR LENGTHS.

Dimensions Considered	Canis mississippiensis	Canis lupus	Canis dirus
Humerus total length, taken as unity	100	100	100
Greatest diameter of proximal end	22.9	24.6	25
Antero-posterior diameter of head	19.9	18.3	18.9
Greatest transverse diameter of distal end	22.9	20.6	21
Greatest antero-posterior diameter of inner condyle	17.0	16.1	15.9
Least circumference of shaft	29.0	27.8	28.4
Tibia, total length, taken as unity	100	100	100
Transverse diameter of head	23.3	19.2	19
Antero-posterior diameter at most elevated point of tuberosity	24.2	17.6	17.5
Transverse diameter of distal end	16.1	12.6	12
Least circumference of shaft	28.9	21.3	21.5

It will be observed that the corresponding ratios found in the last two columns are remarkably close to each other, showing that these two animals, although of very different dimensions, were built much alike. When we compare the corresponding ratios in the first and the second columns we find that they are farther apart. This is shown especially in the comparisons of the tibiæ of the three species. *Canis mississippiensis* appears to have been an animal with relatively much heavier limbs than either the living wolf (called above *C. lupus*) or *C. dirus,* as represented by the bones found at La Brea.

As regards the geological age of *Canis mississippiensis,* nothing can be affirmed. The writer sees no good reason for believ-

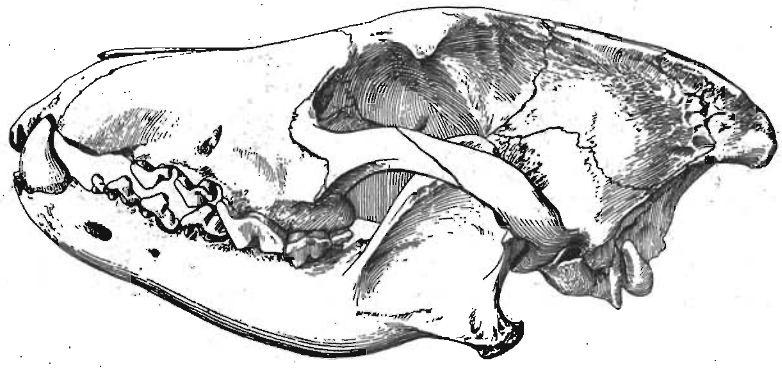

Fig. 139. *Canis dirus.* Skull and lower jaw seen from the side. x 1-3. From La Brea, California.

ing that they antedate the close of the Wisconsin stage. Many of the other mammals which have been found in the lead crevices belong to extinct species, several of them to extinct genera. There have been discovered there, Mammut, Megalonyx, Platygonus, Bison, Cervus, Odocoileus, Antilocapra, Canis, Procyon, Anomodon, Arctomys, Geomys, Sylvilagus and Arvicola. Of the extinct genera it is certain that all were yet in existence after the disappearance of the Wisconsin ice-sheet; unless it be Anomodon, about which we know practically nothing. As to the bison found in the crevices, Allen stated that it was an extinct species; but he does not give his reasons for his conclusions. So far as the writer knows there were found only limb bones, mostly broken; and Wyman stated that they were all of the size of the same parts of the buffalo and closely resembled them. *Canis mississippiensis* may, therefore, be post-Wisconsin in age.

We cannot be certain regarding the age of the type of *Canis dirus*. It was found associated with *Megalonyx jeffersonii*, a tapir, a horse, an Odocoileus which was supposed to be the

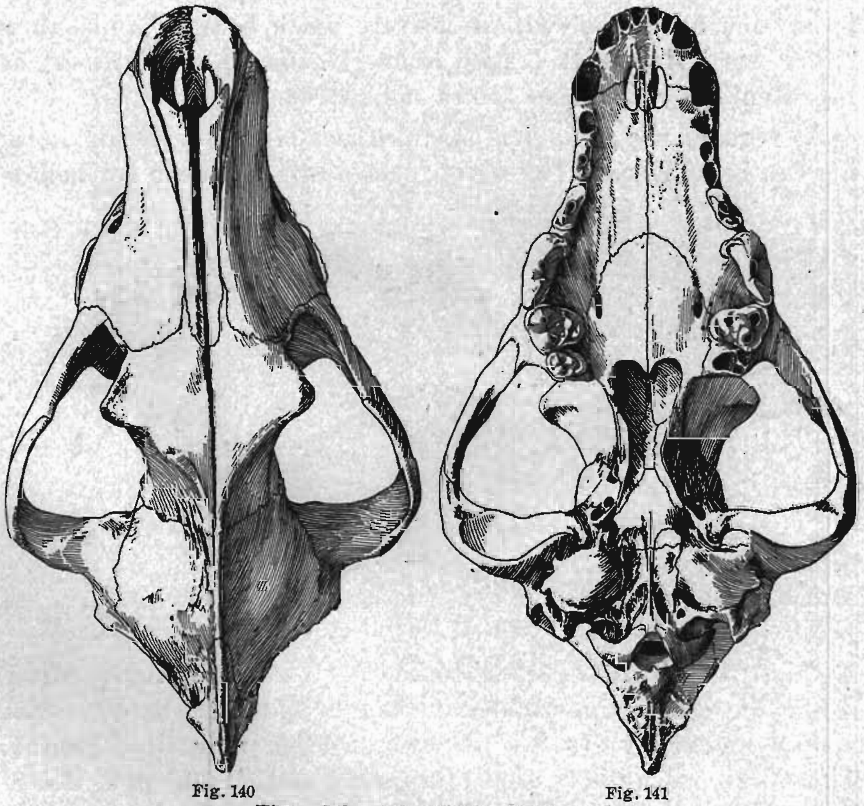

Fig. 140 Fig. 141

Figs. 140, 141. *Canis dirus*. x 1-3.
140. Skull seen from above.
141. Palatal view of skull.

Virginia deer, and a Bison supposed to be the yet existing buffalo, but which is more probably an extinct species. No horse or tapir remains have yet, so far as the writer can learn, been found in post-Wisconsin deposits; and, it is therefore probable that the wolf remains belong to pre-Wisconsin times. There appear to be no reasons for believing that the animals mentioned in this paragraph, likewise those found at Big Bone Lick, Kentucky, are as old as the Aftonian, during which time lived numerous horses and camels. The writer is inclined to assign these all to the Sangamon stage, that immediately following the Illinoian stage. The position of the bones in the deposits forming the banks of Ohio river seems to confirm this conclusion.

As to the age of the California specimens which have been referred to *Canis dirus,* there can be no doubt that they belong to the early Pleistocene.

The question then arises: Did *Canis dirus* continue to exist from the beginning, or near the beginning, of the Pleistocene to its close? The writer has so much doubt as to the probability of this that, fortified by the differences which appear to exist between the bones of the California specimens and those of Allen's *C. mississippiensis,* he prefers to retain the name just mentioned for the remains found in the lead region.

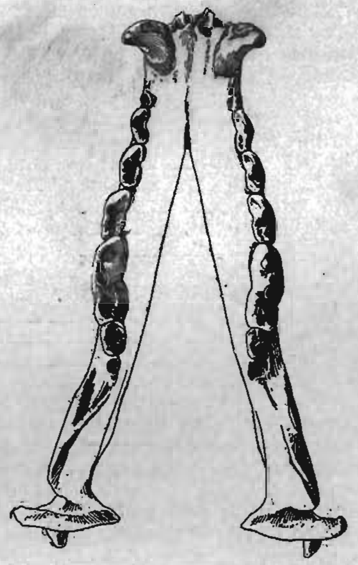

FIG. 142. *Canis dirus.* Lower jaw seen from above. x 1-3.

Inasmuch as skulls, teeth, and other parts of the skeleton of wolves are likely to be found in Pleistocene deposits of Iowa, it is thought well to present views (Figs. 139-142) of the skull of *Canis dirus,* as represented by a California specimen and to give measurements of its skull and of the teeth. Furthermore, to aid in distinguishing wolves of the size of the gray wolf from the larger ones, such as *C. mississipiensis,* and from the smaller ones, as the coyote, measurements are given of various bones of a specimen of the gray wolf. The latter measurements are placed in the second column of the table of measurements of *C. latrans,* on page 493. The measurements here given of the skull of *Canis occidentalis* are taken from a skull coming from Texas.

MEASUREMENTS OF THE SKULLS OF *CANIS DIRUS* AND OF *CANIS OCCIDENTALIS.*

	Canis dirus	Canis occidentalis
Front of premaxillae to hinder end of occipital crest	300 mm.	253 mm.
Front of premaxillae to hinder end of occipital condyles	260 mm.	235 mm.
Width of skull across zygomatic arches	170 mm.	128 mm.
Width of skull at rear of $pm.^4$	100 mm.	78 mm.
Width of skull at rear of $pm.^1$	53 mm.	44 mm.
Width at interorbital space, least	62 mm.	41 mm.
Width across postorbital processes	85 mm.	54 mm.
Width at constriction behind postorbital processes	50 mm.	43 mm.
Fore-and-aft diameter of orbit	45 mm.	37 mm.
Distance from $m.^2$ to front of articulation for lower jaw	55 mm.	50 mm.
Width of posterior nares	30 mm.	21 mm.
Long diameter of auditory bulla	29 mm.	29 mm.
Outside of one bulla to that of the other	75 mm.	65 mm.
Front of premaxillae to posterior nares	138 mm.	123 mm.
Front of canine to rear of $m.^2$	123 mm.	101 mm.
Canine, diameter fore-and-aft	18 mm.	15 mm.
Canine, width	13 mm.	9 mm.
Pm^2, length	16 mm.	15 mm.
$Pm.^2$, width	8 mm.	7 mm.
$Pm.^3$, length	19 mm.	16 mm.
$Pm.^3$, width	9 mm.	7 mm.
$Pm.^4$. length	32 mm.	25 mm.
Pm^4, width behind the claw	13 mm.	12 mm.
$M.^1$, length	19 mm.	16 mm.
$M.^1$, width	25 mm.	22 mm.
$M.^2$, length	11 mm.	9 mm.
$M.^2$, width	16 mm.	13 mm.
Lower jaw from front to rear of condyle	212 mm.	185 mm.
Height of jaw between $pm._2$ and $pm._3$	33 mm.	26 mm.
Height of jaw between $m._1$ and $m._2$	40 mm.	32 mm.
Canine tooth, fore-and-aft diameter	18 mm.	15 mm.
Canine tooth, transverse diameter	13 mm.	10 mm.
$Pm._1$, length	6 mm.	6 mm.
$Pm._1$, width	5 mm.	5 mm.
$Pm._2$, length	16 mm.	14 mm.
$Pm._2$, width	7 mm.	6.5mm.
$Pm._3$, length	16.5mm.	14.5mm.
$Pm._3$, width	8 mm.	6.5mm.
$Pm._4$, length	20 mm.	16 mm.
$Pm._4$, width	10 mm.	9 mm.
$M._1$, length	35 mm.	29 mm.
$M._1$, width	13 mm.	12 mm.
$M._2$, length	13 mm.	12.5mm.
$M._2$, width	10 mm.	9 mm.
$M._3$, length	10 mm.	----------
$M._3$, width	15 mm.	----------

Canis latrans Say.

The Coyote; the Prairie Wolf.

In J. D. Whitney's report on the lead region already referred to, Wyman stated that in Professor James Hall's collection there were some wolf remains which he could not distinguish from the corresponding parts of the prairie wolf, *Canis latrans*. These parts consisted of a portion of the skull which contained nearly the whole series of upper teeth, excepting the incisors, the first premolar on both sides, and the last molar on the right. Here again we are uncertain in which of the three states which share the lead region the skull was found; but the probability is that it was in Iowa. Where this skull now is, if yet in existence, the writer does not know.

The coyote belongs among the smaller species of wolves. Its present range is from northwestern Indiana to Missouri and thence northwest to the Rocky mountains and Alberta. Geologically the species appears to have existed since the early part of the Pleistocene, having been found in Oregon and Nebraska in company with horses and camels. However, the reference to this species of remains found in Oregon may prove to be erroneous.

Should any bones be found which are suspected to belong to a wolf, it would be well to compare them with the corresponding parts of the domestic dog. These may usually be obtained without great difficulty. Should the relationships to the wolves be proved, recourse may be had to measurements. In order to make this possible the following measurements are furnished. Those of the skull are taken from No. 12893, of the National Museum. For measurements of the skull of *Canis occidentalis*, see the second column on page 490.

Plate LXXV offers views of the skull, lower jaw, and teeth of this species. The figures are from a skull in the National Museum, which was obtained at old Fort Kearney, Nebraska.

MEASUREMENTS OF THE SKULL OF THE COYOTE.

Front of premaxillae to end of occipital crest	190 mm.
Front of premaxillae to end of occipital condyles	178 mm.
Width of skull at ear-openings	55 mm.
Width of skull across zygomatic arches	93 mm.
Width of skull at pm.^{4}	58 mm.
Width of skull at pm.^{1}	28 mm.
Width of skull at interorbital space, least	30 mm.
Width of skull across postorbital processes	44 mm.
Width of skull behind postorbital processes	32 mm.
Diameter of orbit, fore-and-aft	28 mm.
Distance from m.^{2} to front of articulation for lower jaw	28 mm.
Width of posterior nares	16 mm.
Long diameter of auditory bulla	21 mm.
Front of premaxillae to rear of hard palate	92 mm.
Front of canine to rear of m.^{2}	89 mm.
Canine, upper, diameter, fore-and-aft	13 mm.
Canine, upper, diameter, side-to-side	6.5mm.
Canine, lower, diameter, fore-and-aft	9 mm.
Canine, lower, diameter, side-to-side	6 mm.

Pm.^{2}, length	11 mm.	Pm.$_2$, length	11 mm.
width	4 mm.	width	4 mm.
Pm.^{3}, length	12.5mm.	Pm.$_3$, length	12 mm.
width	4.4mm.	width	5 mm.
Pm.^{4}, length	20 mm.	Pm.$_4$, length	13 mm.
width, behind claw	7.5mm.	width	6 mm.
M.^{1}, length	13 mm.	M.$_1$, length	23 mm.
width	17 mm.	width	8 mm.
M.^{2}, length	7 mm.	M.$_2$, length	10 mm.
width	11 mm.	width	6 mm.
		M.$_3$, length	4.5mm.
		width	3.3mm.

The following measurements of parts of the skeleton are taken from a specimen in the National Museum, No. 1011, the skull of which had a length to the condyles, of 165 mm. Therefore the skeleton may be slightly undersized. In the second column are given corresponding measurements of the gray wolf, *Canis occidentalis,* taken from a specimen captured at Fort Kearney, Nebraska. It has the number 6508 in the National Museum. The length from the front of the premaxillæ to the rear of the condyles is 241 mm., only 6 mm. greater than the skull measured on page 490.

MEASUREMENTS OF PARTS OF THE SKELETONS OF *CANIS LATRANS* AND OF *CANIS OCCIDENTALIS*.

	Canis latrans	Canis occidentalis
Scapula—		
Length, parallel with the spine	105 mm.	174 mm.
Breadth near the upper end	52 mm.	90 mm.
Breadth of the neck	17 mm.	41 mm.
Humerus—		
Total length	153 mm.	212 mm.
Greatest length through the head and greater tuberosity	35 mm.	51 mm .
Fore-and-aft diameter at middle of length	11 mm.	22 mm.
Side to-side diameter at middle of length	9 mm.	16 mm.
Greatest width at the distal end	26 mm.	52 mm.
Ulna—		
Extreme length	185 mm.	241 mm.
Greatest diameter at middle of length	7 mm.	11.5mm.
Radius—		
Extreme length	161 mm.	204 mm.
Width of proximal end	15 mm.	23 mm.
Greatest diameter at middle of length	10 mm.	16.5mm.
Shortest diameter at middle of length	6 mm.	11.5mm.
Greatest width at lower end	19 mm.	31 mm.
Pelvis—		
Extreme length	113 mm.	182 mm.
Width between upper borders of acetabula	58 mm.	90 mm.
Greatest width at front of ilia	63 mm.	113 mm.
Greatest width across ischia	86 mm.	127 mm.
Height of front of ilium	35 mm.	66 mm.
Least width of ilium in front of acetabulum	15 mm.	26 mm.
Femur—		
Extreme length	161 mm.	216 mm.
Distance through head to outside of great trochanter	31 mm.	46 mm.
Fore-and-aft diameter at middle of length	10.5mm.	15 mm.
Side-to-side diameter at middle of length	9.5mm.	16 mm.
Greatest width across condyles	24.5mm.	39 mm.
Tibia—		
Extreme length	182 mm.	221 mm.
Side-to-side width of upper end	28 mm.	43 mm.
From front of tuberosity to rear of inner articulation	31 mm.	49 mm.
Fore-and-aft diameter at middle of length	10 mm.	16 mm.
Side-to-side diameter at middle of length	10 mm.	17 mm.
Greatest width across lower end	17 mm.	28 mm.
Fibula—		
Extreme length	169 mm.	206 mm.
Greatest diameter at middle of length	2 mm.	5.5mm.

In the effort to determine whether a particular canine skull belonged to the coyote, to some other species of wolf, or to some breed of common dog, one must take into account first, the size of the skull and then its general form. The skull of the coyote is long, relatively narrow, with elongated narrow snout. The canine teeth of the coyote are relatively longer and thinner than those of the domestic dogs. In fact, all of the teeth are larger in proportion to the skull than in the domestic dogs; and the cusps and ridges are more prominent, as seen in the little worn teeth.

As to the geological age of the remains of the coyote reported from the lead region, the reader is referred to remarks under *Canis mississippiensis*, on page 487.