THE PLEISTOCENE MAMMALS OF IOWA

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PREFACE

The object of this preface is to render acknowledgments for the aid and advice which the writer has received. First of all, it is appropriate that a tribute be paid to the lamented Professor Samuel Calvin, who was, at the time of his death, Director of the Iowa Geological Survey. It was he who first took up in a comprehensive way the study of the fossil bones and teeth which had been found in Iowa, especially those which had been discovered in the Aftonian interglacial deposits.

Acknowledgments are to be made likewise to present members of the Iowa Geological Survey for willing assistance rendered during the preparation of this report, viz.: to Dr. George F. Kay and Mr. James H. Lees, to Professors B. Shimek, John L. Tilton, A. O. Thomas, and others. From many persons, in all parts of the state, the writer has, in reply to letters of inquiry addressed to them, received information regarding fossils. Their names are mentioned in connection with these fossils. To the Carnegie Institution of Washington must be given credit for permission to complete this report after engaging in its service.

The best fate which can be hoped for this essay is that it may soon render itself obsolete by stimulating additional discoveries.

OLIVER P. HAY.

U. S. National Museum,
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THE PLEISTOCENE PERIOD IN IOWA

Introduction

The writer does not propose here to present an extended treatise on the geology of the Pleistocene period, not even on that of Iowa. For more than elementary information on this subject the reader is advised to consult first of all some general work on geology; and after that various special papers published in the scientific journals, the communications to scientific societies, and the reports of the Federal and State governments. For general information the concluding half of the third volume of Chamberlin and Salisbury's Geology, published in 1906, is especially to be recommended. In this work are cited the most important papers that had appeared at the time of its publication. For details regarding the distribution of glacial deposits in the region east of Iowa, the student should consult the two great treatises of Prof. Frank Leverett, constituting Volumes XXXVIII and XLI of the Monographs of the U. S. Geological Survey. On pages 87 to 99 of the present essay will be found a list of works and shorter papers on the subject, which list, however, does not pretend to be complete. Many of these deal with problems and questions connected with the Pleistocene of Iowa and are of the greatest importance. Finally must be mentioned the numerous volumes that have been issued by the Iowa Geological Survey under the direction of Charles A. White, Samuel Calvin, Frank A. Wilder and George F. Kay. In these volumes the geology of nearly all the counties of the state has been described and mapped with greater or less detail. These volumes constitute a great storehouse of knowledge, to be drawn upon by all who may be interested in the geological history of the state.

Notwithstanding what has just been said, it seems proper that the writer should present here a brief general account of the Pleistocene period, as shown by the records it has left in North America and especially in the state of Iowa.

Definition of the Pleistocene.

The Pleistocene is that period of geological time which immediately preceded that in which we live and which is called the Recent period. Its limits are difficult to define and are, in fact, not wholly agreed upon. The Pliocene passed into the Pleistocene and the latter into the Recent without any notable physical cataclysm or any sudden and wide-extended extinction of animals and plants. A little known epoch, the Ozarkian, is included by some authors in the Pliocene; by others it is placed at the beginning of the Pleistocene. Another epoch or stage, the Champlain, is usually regarded as a part of the Pleistocene; but Osborn has relegated it to the Recent period, and the present writer agrees with him in this.

The Mammals are the animals that we must especially depend upon as the biological means of distinguishing the deposits of the Pleistocene from those of the Pliocene on the one hand and of the Recent on the other, and the different divisions of the Pleistocene from one another. The mammals of the Pleistocene closely resembled those that live on the earth today; but they often differed from those of the present specifically and sometimes generically. The lower animals and the plants of the Pleistocene were almost wholly identical with those that are now in existence.

But the chief characteristic of the Pleistocene period is the record made by certain physical phenomena; that is, by the glaciation of a considerable portion of the northern hemisphere and of restricted portions of the southern. In North America, at one time or another during the Pleistocene, sheets of ice of vast, but unknown, thickness covered our continent as far south as a line beginning at the eastern end of Long Island, thence extending to Staten Island, northwest to the headwaters of Allegheny river; westward along this river and the Ohio to Louisville; across Indiana and Illinois to the mouth of the Mis-

souri; thence along this river into Montana; and from there westward to the northwestern corner of Washington. These ice-sheets, really several in number, proceeded from three centers, one, the Labradorean, lying east of Hudson Bay; another, the Keewatin, situated immediately west of the bay mentioned; and the third, the Cordilleran, located in British Columbia. From these centers, especially the first and second, the ice streamed out in all directions, but especially towards the south. In the passage of these ponderous, but sluggish, floods of ice, vast quantities of rocks were broken loose, swept along, and for the most part, ground to powder. A great part of these materials was deposited on the rocky or earthy bed of the ice-sheets, or glaciers, and constitutes what we call the *drift,* great masses of clay, with which are mingled here and there immense deposits of sand, gravel, and more or less rounded bowlders. These materials were to a large extent derived from igneous and metamorphic rocks, such as trap, syenite and granite. It is from this cause that we find on our fields bowlders of crystalline rocks which for the most part must have been brought hither from their original exposures in Canada. These bowlders are often planed and scratched and grooved as a result of movement over rocks and stones while held in the grasp of the flowing ice. Another part of the materials brought down by the ice was borne away by streams issuing from the foot of the glaciers. Some of this was deposited, sometimes in great quantities, along the borders of these streams, or was carried down to the mouths of the great rivers, especially the Mississippi. Of course, the farther one goes from the borders of the drift, the finer are the materials that were carried thither.

Usually the clays and sands of the drift are unstratified. However, where water has acted on them, as where streams issued from the borders of the ice-sheet or flowed beneath them, or where lakes and ponds were formed, there may be found more or less stratification of the materials. The thickness of the deposit varies from a few inches to more than 500 feet. It may rest on any of the older formations. The surface of the drift is sometimes level, but usually undulating and sometimes very uneven. The unevenness may be due to the

erosion of flowing waters that have acted on the materials since the disappearance of the ice; but in large part it resulted from the irregular way in which the materials were laid down, or dumped down, by the glacial sheet. Where the foot of the ice-sheet rested for any considerable time there may be found long ridges that are largely composed of coarse materials. Such ridges are called *moraines*. In the depressions of the surface, after the ice retired, were formed lakes and ponds. Since that time many of these have become more or less filled up; and they now form marshes or low wet meadows.

The Pleistocene was, in general, a time of elevation and of extension of the borders of the continent beyond their present limits. The changes in elevation and in the climate during that time had a profound influence on the animal life and on the history of mankind. For these reasons the Pleistocene is regarded as a period distinct from the Pliocene, with which, as Chamberlin and Salisbury say, it would otherwise be united.

Divisions of the Pleistocene.

In the preceding remarks the Glacial epoch has been spoken of as a time without divisions and the ice-sheet as a machine working without interruption. Such for a long time was the prevailing view, and this view is probably still held by a few geologists. It seems now, however, to be demonstrated that during the Glacial epoch there were several glacial stages, and that they were separated by a corresponding number of interglacial stages, during which a mild climate prevailed. The investigations made by various geologists in North America have shown that there were probably five glacial and four interglacial stages. The names of these are given in the following section in the order of their age. The interglacial and postglacial stages are put in italics. Following the last glacial stage there was an interval between it and the beginning of the Recent, corresponding to an interglacial stage and during which there was a mild climate. This has been elsewhere called by the author the Wabash stage. Its type locality is in Indiana, in the basin of Wabash river, where are found remains of many vertebrate animals now extinct. It corresponds in part to the Glacio-lacustrine of Chamberlin and Salisbury.

DIVISIONS OF THE GLACIAL EPOCH AND ITS DEPOSITS.

10. *Wabash.*	5. Illinoian.
9. Wisconsin.	4. *Yarmouth.*
8. *Peorian.*	3. Kansan.
7. Iowan.	2. *Aftonian.*
6. *Sangamon.*	1. Nebraskan.

A brief account of each of these stages will now be given. Unfortunately our knowledge of not one of these is satisfactory.

The Glacial Stages.

The ice-sheets that proceeded from the Cordilleran center have not been well studied and are of no interest to us here. It is probable that from each of the other centers, the Labradorean and the Keewatin, there proceeded an ice-sheet during each of the glacial stages; but it is not yet established that there is a glacial deposit that was laid down by ice that flowed from the Labrador center during the Kansan stage, nor any Illinoian that was deposited by Keewatin ice; nor any Iowan that resulted from a Labradorean glacier. If there were such deposits they are probably wholly covered by later drifts. It may be remarked that Iowa is fortunate in having drift deposits that represent each of the glacial stages.

Nothing can be said here regarding the causes of the phenomena of the glacial epoch. A vast body of literature has grown up on the subject and to this the student must have recourse. Nor can we pretend to determine with any exactness how long it has been since the beginning of the glacial epoch. It may be as much as one or two millions of years. We do not know exactly what was the condition of the surface of the drift-covered region before the advent of the first glacial stage. It had all, during most of the Pliocene at any rate, been dry land, probably well elevated, and had suffered much erosion. Much of it was therefore hilly and seamed by stream-beds and ravines. There is a "driftless area" occupying a part of northeastern Iowa, southeastern Minnesota, northwestern Illinois, and southwestern Wisconsin; and it has been supposed that this represents quite well the sort of surface that was presented at the beginning of the Pleistocene by much of the area now covered by drift. The drainage lines of that early time differed

from those of the present, and borings have disclosed many old channels of which no traces appear on the surface. On that old rough and seamy surface, often rocky and probably often infertile, there was laid down a deposit of clay, sand, and some gravel and bowlders, that forms now a level or undulating surface and constitutes a soil rich in the elements that are needed to support vegetable and animal life. The rocks and the mountains in the north were torn down, ground to powder, and spread out to make a garden for a nation.

The Nebraskan Stage.—The oldest known sheet of drift in Nebraska and Iowa is known as the Nebraskan, east of the Appalachians as the Jerseyan. The latter drift was laid down by the Labradorean glacial ice; the former by ice proceeding from the Keewatin center. The Nebraskan drift is, so far as determined, wholly overlain by later deposits; so that it is recognized only from exposures where streams and ditches and railroad excavations have gone down through the overlying deposits. It is, of course, sometimes reached in the digging and boring of wells. The body of this drift consists of a dark blue, sometimes almost black, clay. On exposure it is likely to break up into small angular blocks and fragments and is therefore said to be a joint-clay. It is more compact than any of the other drifts and more impervious to water. It has been called the abomination of well diggers and road workers. In this deposit there is often found a good deal of clear quartz sand and many small nodules of yellow or orange sand. The bowlders are usually small and often consist of coarse granite. In this Nebraskan drift are frequently found pieces of wood, apparently spruce, cedar, etc., suggesting that the glacier had overwhelmed an ancient forest.

This deposit possibly underlies most of the drift-covered region of Iowa, although the overlying Kansan doubtless extended somewhat farther south. The Nebraskan is exposed at various points in western Iowa, but seems to have been first recognized in gravel pits at Afton Junction. It is met with in many places in southeastern Iowa in wells and sections, as at Davenport and Muscatine. Along the Mississippi above Fort Madison are exposures of drift 180 feet in height, of which the upper fifty or sixty feet are Illinoian; while the lower 120 feet

are probably Kansan, but possibly in part Nebraskan. J. A. Udden (Iowa Geol. Surv., XI, p. 102 seq.) reported the presence of pre-Kansan drift at many places in Louisa county. Beyer (Iowa Geol. Surv., VII, p. 231) found in Marshall county a section which presented at the bottom a blue till which he supposed to be sub-Aftonian. Shimek states (Bull. Geol. Soc. Amer., XXIII, 1912, p. 137) that the finest section showing Nebraskan drift is to be seen on the Iowa side of the Big Sioux river, in Lyon county. The exact location is given as the southwest quarter of section 33, township 99 north, range 48 west. Fully sixty feet of Nebraskan are shown here, with its base disappearing in the river. It contains many bowlders. Above it come Aftonian sands, capped by about two feet of silt which contains shells; while above the silt is Kansan drift. Along the river mentioned are to be found many sections in which are shown Nebraskan, Aftonian and Kansan deposits.

This Nebraskan deposit filled the old preglacial valleys sometimes to a depth of 100 feet, but on the old uplands it is thin or wanting.

The Kansan Stage.—At the close of the Nebraskan stage the glacial ice-sheet retired and the climate became milder. Animal and plant life took possession of the surface of the Nebraskan drift deposits. This mild interval constituted the Aftonian stage, about which more will be said below. At length this ended, and gradually there supervened the rigorous Kansan stage.

Nowhere is the Kansan drift better displayed than in Iowa; although it is found in Missouri, Kansas and other states toward the northwest. A reference to the map shows that it forms the upper deposit of drift over about the western fourth and the southern third of the state, besides a narrow band which runs northward near the eastern border. It does not, however, constitute the surface deposit over the whole of this great region; inasmuch as it is itself usually covered, especially along the larger streams, by a deposit of fine materials known as the *loess*. The latter is, however, often thin and the Kansan is seen beneath it along streams and in railroad cuts. The loess may be missing in the south central part of the state.

The Kansan may appear at the surface or is soon met with in sinking wells. It is composed of a clay that is light blue or gray, where not weathered; but it may vary to brown, yellow, and even red according to the amount of weathering it has suffered. On exposure it breaks up into irregularly shaped masses. It is not so tough and compact as the Nebraskan. As compared with later drifts, there are relatively few bowlders; but there are more of these than in the Nebraskan. Quartzites and greenstones are more common materials. In a number of cases there have been found enclosed in the Kansan drift masses of Nebraskan drift and of Aftonian sands and gravels, indicating that the Kansan glacier had plowed up these older deposits in a frozen state and had incorporated them with its other materials.

The ice-sheet that laid down the Kansan drift had its origin in the center west of Hudson Bay. This sheet appears to have reached over into Illinois only a short distance, as in Adams and Hancock counties (Leverett, Mon. 38, p. 106); but it extended into Missouri as far as the river of this name and its border, in a general way, follows this river far to the northwest. Doubtless the Kansan drift exists in nearly every part of the state of Iowa, if we except the driftless area along Mississippi river above Clinton. It has been found in wells and along streams at various points within the areas occupied by the Iowan and Wisconsin drifts. Within the Iowan drift region there are areas of greater or less extent where the Iowan is missing or extremely thin and the Kansan is at or close to the surface. An examination of the Iowa Geological Survey's reports on the counties within the Wisconsin and the Iowan drift areas will give exact information on these relations. It is known to exist along Mississippi river below Clinton, where it is covered by Illinoian drift.

After the withdrawal of the Kansan ice-sheet the surface of the Kansan drift was exposed for unknown ages to the erosive action of running water, to the chemical influences of water and air, and to the physical effects of heat and cold. A large part of its surface was borne away by the streams which thus made for themselves wide and often deep valleys. Hence the surface became more or less broken. The soil in its upper portions also

became more or less leached and modified. These modifications would have been further extended had it not been for the loess that was at a considerably later period laid down on the drift. The Kansan is often found to be overlain in some localities by a considerable thickness of coarse materials, known as the Buchanan gravels. It is supposed that these gravels were deposited by flooded streams which issued from the retiring sheet of ice.

In the western part of the state occurs a deposit which has been named by Shimek the Loveland. It is a fine-grained, tough, reddish deposit, quite different from the loess, with which it has been included. Shimek thinks (Iowa Geol. Surv., Vol. XX, pp. 371-375) that it was laid down in slack water during the melting of the Kansan ice-sheet.

The Kansan glacial stage was followed by the mild interglacial Yarmouth. Then came on the Illinoian glacial stage.

The Illinoian Stage.—While the Kansan represents the greatest extension southward of any ice-sheet that proceeded from the Keewatin center, the Illinoian marks the greatest extension of the ice from the Labradorean field. In the eastern part of the United States, the Illinoian is apparently wholly buried by the Wisconsin drift; but the former makes its appearance south of the edge of the latter in north-central Ohio. From a point in the southern part of Ashland county the border may be followed south and southwest to Ohio river above Cincinnati, thence to this city, where it crosses the Ohio and continues close to the river nearly to Louisville. From there it runs southwestward to the mouth of Wabash river, and then westward across Illinois to the Mississippi near Carbondale. It then keeps on the eastern side of the river to the vicinity of Fort Madison, Iowa. Here the great glacier that left this drift pushed on across the river a distance of about 25 miles. This transgression on Iowa territory extended north to a point about half way between Davenport and Clinton, Iowa, so that Illinoian drift now occupies parts of Scott, Muscatine, Louisa, Des Moines, Henry, and Lee counties. In thus pushing itself into Iowa the glacier forced the Mississippi to seek a new channel westward of the ice border. This channel, at present

wholly abandoned or occupied in part by relatively small streams, begins above Savanna, Illinois, and enters the Mississippi again just below Fort Madison. Its course may be observed on Plate VI of Monograph 41 of the U. S. Geological Survey and on Plate III of Vol. XIV of the Iowa Geological Survey. Nowhere else does the Illinoian drift from the Labradorean field appear in Iowa, and none is known there that came from the Keewatin center.

The Illinoian drift was originally of a bluish color, but through oxidation since deposition it has changed mostly to yellow; but it may be brown, or even red. The clay is more compact than that of the succeeding drifts. It appears originally to have contained much lime, and this seems to have acted as a cement to harden the mass. In general, this drift resembles the Kansan; but not having been so long subjected to the influence of the elements the upper portion has not been weathered so deeply. It is said to have the carbonate of lime leached out to a depth of five to seven feet. The surface has not been so much eroded as that of the Kansan; and away from the larger streams it is in nearly its original condition. The thickness of this deposit varies much, of course. Leverett states that the average thickness is about fifty feet; but in old valleys, it may be as much as 100 or 200. In Iowa, however, the thickness is usually from ten to thirty feet, but may be as much as fifty feet along the western edge.

As localities where the Illinoian drift may be studied in Iowa, Calvin mentions the region between Durant and Davenport and that between Columbus Junction and Morning Sun or Mediapolis. In the Illinoian tract wells often pass through the Illinoian into the underlying Kansan; and in so doing they are likely to pass through old soils and peat beds that belong to the Yarmouth interglacial stage. They might even penetrate to the Aftonian and Nebraskan. The Illinoian is in some cases underlain by a thin sheet of loess, sometimes by the Buchanan gravels. This loess will be referred to below.

For a list of the vertebrated animals which are supposed by the writer to have existed during the Illinoian stage see under the Sangamon, on page 34.

It has been estimated that from 140,000 to 540,000 years have elapsed since the Illinoian stage; but the time may have been less or even more.

The Iowan Stage.—Probably long after the disappearance of the Illinoian glaciers and after the close of the succeeding mild interglacial Sangamon stage glacial conditions were resumed and another sheet of ice was pushed southward from the Keewatin center. What was the extent of this glacier is unknown. In Iowa its drift occupies a belt lying across Worth, Mitchell, and Howard counties on the north line of the state and extending south and southeast and covering a considerable part of Marshall and Tama counties, and nearly the whole of Benton, Linn, and Jones counties. It also passes through Cedar and Clinton counties and reaches Mississippi river below the town of Clinton. It has been supposed to occupy a portion of northwestern Illinois, but there are reasons for doubting this. Its area in Iowa is about 80 miles wide and 100 miles long. On the western side it is overlapped by the younger Wisconsin. It was itself laid down on the surface of the Kansan after this had been long exposed to stream erosion and had been much broken. The Iowan is a very thin sheet of drift. It appears mostly on the lower levels of the old Kansan surface and may be wholly missing on the more elevated parts. There are considerable areas within its field where the Iowan is missing. Its maximum thickness is given by Calvin as about twenty feet. In Cerro Gordo county it is so thin that the plow turns up the decomposed Devonian shales. In Butler county, at the heart of the Iowan area, the thickness is said to be nowhere more than seven or eight feet.

This drift is remarkable for the size and freshness of its bowlders. One of these in Cerro Gordo county is reported to have a length of twenty-five feet, a width of twenty-three feet, and a height of eleven feet above the ground. These bowlders present sharp angles and show few indications of long exposure to the weather. They are scattered without relation to the sloughs and water courses and are sometimes the only evidences of the presence of the Iowan drift. This drift appears originally to have con-

tained little calcareous matter. The clay is yellow and thus contrasts with the blue of the underlying Kansan. The surface has suffered extremely little erosion and the streams are wide, shallow, sluggish, and almost on a level with the surrounding country; in fact are sometimes on a higher level than the plain. There are no lakes, and no well defined moraines.

It is proper to state that the existence of the Iowan as a distinct sheet of drift has been seriously called in question. This has been done especially by Professor Leverett (Zeitschrift Gletscherkunde, IV, pp. 282-299). In defense of his position Dr. Calvin published what appears to the present writer to be a very convincing paper (Jour. Geology, XIX, pp. 577-602). The whole question needs and is undergoing further investigation; but evidently there is present a drift that is different from any other yet recognized. This is admitted by Leverett, who says in the paper cited: "The writer, therefore, is inclined to regard this so-called Iowan district as possibly of Illinoian age, though recognizing that it differs considerably from the Illinoian district of the Labrador ice field."

In the Preliminary List of Papers announced for the twenty-fifth meeting of the Geological Society of America, 1912, Professor Leverett presents an abstract of a paper which contains the following paragraph:

> The so-called Iowan drift may stand in about as close relation to the Illinoian as do the later Wisconsin moraines to the earlier Wisconsin. It does not seem to be separated from the Illinoian drift by a definite interglacial stage, but instead to represent a substage or stadium of the Illinoian. It may, therefore, be advisable, pending further study, to apply to it the double name Later Illinoian or Iowan.

The Iowan glacial stage was succeeded by the Peorian interglacial. This in turn was followed by the Wisconsin glacial stage.

The Wisconsin Stage.—East of central Ohio the last ice-sheet, the Wisconsin, pushed itself far enough south to conceal with its deposit that of all preceding ice-sheets, except in a few localities. From about Ashland county, Ohio, west to central and northern Illinois the Wisconsin failed to reach the limits attained by the Illinoian glacier. In Ohio and eastern

Indiana the Wisconsin border is not removed many miles from that of the Illinoian; but after passing south of Indianapolis the Wisconsin border continues west, to cross Wabash river near Terre Haute. Thence it proceeds to Shelbyville, Illinois; thence northwest to Peoria; and then turning northward it enters Wisconsin somewhere east of the middle of the boundary line between the latter state and Illinois. Thence it swings westward around the driftless area into Minnesota and turning again southward into Iowa, reaches the city of Des Moines. Thence running off northwestward it crosses the southwestern corner of Minnesota and enters South Dakota; but at once it turns back and follows near the western side of the Missouri to near the Nebraska line. Thereupon it returns northward to about the boundary line of British America and finally strikes westward to the Pacific coast. The result in Iowa is that a great tongue-shaped lobe 125 miles long and, where it enters the state, nearly ninety miles wide, extends southward to Des Moines.

The Wisconsin drift is distinguished by the great amount of coarse materials, sand, gravel, and bowlders that it contains and by the number and size of its moraines. A nearly continuous terminal moraine marks its border; and within the border, especially in Illinois, Indiana, and Ohio, are others which indicate lines along which the glacier halted for long periods during its recession. The clay of this drift is of a lighter yellow than the Iowan, but the lower unweathered portions are often bluish. It usually contains a large amount of limestone in the form of flour or of pebbles. This material has been leached out of the soil to a depth much less than in the older drifts. The Wisconsin drift is less compact and hard than the preceding drifts, notwithstanding its abundant calcareous element. This sheet is much thicker than either the Iowan or the Illinoian and is sufficiently thick to hide completely the pre-Wisconsin topography. The Wisconsin is further characterized by the great number of lakes and ponds that are scattered over its surface. It has suffered relatively little erosion, so that the streams have not been able to work back to the original depressions on its surface and to drain them.

The Wisconsin of Iowa displays its usual characteristics. As will be seen from the map, its eastern and western borders are stamped by moraines, and there are smaller ones within its area. Calvin stated that in Hancock county there is a morainic ridge about 100 feet high. Along the western border, as Calvin stated, the surface is marked by hundreds of knobs and ridges of gravel. This feature culminates in the Ocheyedan mound in Osceola county, so prominent that it is visible on all sides at a distance of 25 miles. In many places around the border of this Wisconsin lobe the outwash from the glacier has covered whole townships with sheets of gravel; and trains of gravel are found along many of the streams leading away from the lobe. It is interesting to observe that the area covered by the Wisconsin drift is occupied by numerous small lakes, while few or none occur outside of it; also that nearly all the streams of Iowa take their origin within or close to this lobe of the Wisconsin.

To those who may be curious to know how long it has been since the end of the Wisconsin stage, it may be said that Chamberlin and Salisbury give the time as between twenty thousand and sixty thousand years.

One can not doubt that during the prevalence of the Wisconsin, as indeed of each of the other glacial stages, a host of animals, among them many vertebrates, were living in our country. All the surface south of the great ice fields was populated. Many of the hardier species doubtless lived very near the border of the glaciers. Among them we may be very sure were the hairy mammoth, *Elephas primigenius,* and more than one species of musk-oxen. To this stage may be assigned specimens of the existing musk-ox, *Ovibos moschatus,* which have been found near Clermont, Fayette county, and at Ottumwa, in Wapello county; also possibly the skull of the extinct musk-ox *Symbos cavifrons* which was discovered many years ago at Council Bluffs. Here, too, may be placed the specimens of *Elephas primigenius* found in the neighborhood of Clermont, as well as the elephant represented by a lower jaw found at Clear Lake, Cerro Gordo county. These specimens are described on pages following this.

The Interglacial Stages.

Having taken this brief view of the various glacial stages and the results of their activities we must consider the interglacial intervals. It is, of course, to be understood, that the transitions from glacial to interglacial stages and conversely were not abrupt. The great mantle of ice, once in possession of the country, surrendered the territory only slowly and reluctantly. For a long time the climate remained cold and inhospitable. The surface once covered by ice was doubtless wet, swampy and capable of supporting only such vegetation as is now found on the tundras of Alaska and Siberia. Only the hardiest boreal animals could exist there. As the climate ameliorated, those plants and animals that had, by the rigorous climate, been driven far to the south returned to take possession of the land that had been inhabited by their ancestors of preceding milleniums. There are reasons for believing that during some of these interglacial stages, the climate was as mild as it is today in the same regions, and in some cases probably milder. In interglacial deposits found at Toronto, Canada, there have been discovered, among other trees, the osage orange, the redbud, and the pawpaw, species which at present flourish only considerably farther south.

After a long continuance of favorable conditions there came about another gradual change. Ice began to accumulate in the north and to flow southward. The living things, plants and animals, again moved southward or utterly perished. In due time, that is, after indeterminable ages, Canada and our northern states were again in the fetters of glacial ice. And these changes were repeated several times.

The Aftonian Stage.—This is the period of time that intervened between the disappearance of the Nebraskan ice-sheet and the Kansan, and the same name is applied to its deposits. The type locality is at Afton Junction, Union county, Iowa. Here are found more than 30 feet of water-laid gravel which lies upon Nebraskan drift of a dark blue, almost black color. Over this gravel there lies a thick deposit of Kansan drift. Near the same locality old peat beds are found at the same geological level. Peat beds have been reported from various

counties of the state; and the same is true regarding the Aftonian deposits of sand and gravel. In that part of the state which is covered with Kansan drift any old soil or peat bed found between two till deposits is pretty certainly Aftonian. Shimek found that along Big Sioux river the Aftonian is represented by silts (usually gray), sand, gravel, and bowlders. The coarser materials are usually cross-bedded. J. A. Udden (Iowa Geol. Surv., XI, p. 104) recognized Aftonian sands and gravels in Louisa county. Beyer (Iowa Geol. Surv., VII, p. 231) reported Aftonian in a section about ten miles northwest of Marshalltown. It is possible, of course, that there may be accumulations of gravel and sand within any of the drift sheets; but in that case the drift above would probably resemble quite closely that below. In the Kansan drift region it is possible that an old soil or peat bed might be found overlying the Kansan and covered with loess. Such a deposit would belong to some later interglacial time. In Decatur county, near Lamoni, there was found, according to Bain (Iowa Geol. Survey, VIII, p. 289), in a well at a depth of eighty-five feet an old forest. Beneath this was 100 feet of drift. The latter was probably Nebraskan, while the forest belonged to the Aftonian.

Aftonian deposits are quite certainly present at Davenport. Pratt (Proc. Davenport Acad. Sci., Vol. I, 1876, p. 96, pl. XXXII) reported the discovery of mammoth bones, which had been found in a railroad cut just west of the city. He described the following section:

		FEET.
1.	Recent soil	1
2.	Yellow clay	20
3.	Bluish gray clay	3 to 5
4.	Peat beds	1
5.	Ancient soil	2
6.	Drift with bowlders.	

Shimek (Iowa Geol. Survey, Vol. XX, p. 376) interprets No. 6 as being possibly Nebraskan drift. Numbers 4 and 5 and probably part or the whole of 6 are regarded as Aftonian, while 3 is identified as post-Kansan loess. This is overlain by number 2, a yellow loess of later time. The bones were in the blue loess or at the junction of this and the yellow loess. Possibly this junction represents the Illinoian stage.

Most of the exposures of Aftonian deposits are known from those counties which border on Missouri river. The writer has prepared a map (Pl. I) and a list which are intended to include and describe the position of the principal exposures of interglacial deposits that have been reported from the state. This list is quite certainly not complete; but it may serve to suggest where other exposures may be looked for. The numbers on the map correspond to those in the list. In this list such details are presented as appear important and justified by our knowledge.

In some of the cases mentioned it has not been possible to determine with certainty the interglacial stage to which an old soil or a peat bed, or a gravel bed, belongs. All of those in the counties along Missouri river are pretty certainly Aftonian.

The Aftonian is, for our purpose, the most important of the interglacial stages, because of the considerable number of vertebrated animals that have been discovered in its deposits and because we are able to determine quite exactly their geological position. These remains, a list of which is given below, have been collected mostly by the members of the Iowa Geological Survey and especially by Prof. B. Shimek, during his investigations on the loess, and were studied and described by the late Dr. Samuel Calvin. These fossils seem to indicate that the Aftonian interglacial stage corresponds to what on the Plains have been called the Equus beds; at least, to that part of the latter which contains remains of camels.

Besides the remains of *Vertebrata,* these Aftonian deposits have furnished a considerable number of species of freshwater mollusks. Lists of these, as well as of the *Vertebrata,* are given by Professor Shimek (Bull. Geol. Soc. Amer., XXI, pp. 126-138).

As regards the vertebrate remains, they are usually more or less imperfect, consisting often of single teeth or bones, but occasionally a quite complete set of teeth, or teeth and jaws, has been found.

The plants that have been found consist of a few mosses and remains of a few coniferous trees.

LIST OF REMAINS OF VERTEBRATA DISCOVERED IN THE AFTONIAN.

Megalonyx leidyi?	Extinct sloth
Mylodon harlani?	Extinct sloth
Neohipparion gratum?	Three-toed horse
Equus complicatus	Extinct horse
E. laurentius	Extinct horse
E. niobrarensis	Extinct horse
Camelops kansanus?	Extinct camel
Camelus? sp	Extinct camel
Mylohyus? temerarius	Extinct peccary
Alces shimeki	Extinct moose
Aftonius calvini	Extinct goat
Bison sp	Extinct bison
Mammut americanum	American mastodon
M. progenium	Long-jawed mastodon
Rhabdobunus mirificus	Fluted-toothed mastodon
Elephas primigenius	Mammoth
Elephas columbi	Columbian elephant
Elephas imperator	Emperor elephant
Castoroides ohioensis	Giant beaver
Castor canadensis	Canadian beaver
Ursus americanus	American black bear

For purpose of comparison there is presented the following list of mammals found in the Equus beds at Hay Springs, Nebraska. This is taken from Dr. W. D. Matthew.

Mylodon sp	Extinct sloth
Equus complicatus	Extinct horse
Equus fraternus	Extinct horse
Equus scotti	Extinct horse
Platygonus vetus	Extinct peccary
Platygonus compressus	Extinct peccary
Leptochœrus sp	Extinct hoglike beast
Camelops kansanus	Extinct camel
Camelops vitakerianus	Extinct camel
Camelus americanus	Extinct camel
Antilocapra americana	Pronghorned antelope
Capromeryx furcifer	Extinct deer-antelope
Elephas columbi	Columbian elephant
Castoroides sp	Giant beaver
Microtus amphibius?	Field mouse
Fiber zibethicus	Musk-rat
Cynomys ludovicianus?	Prairie-dog
Thomomys sp	Pocket-gopher
Canis latrans?	Coyote
Dinocyon?	Extinct carnivore
Felis?	Extinct cat

It may be added that in a list of fossils found somewhere in the Oregon desert, Matthew records a similar group of animals, and among them are two species of moose, *Alces,* and a species of *Oreamnus.*

It will be observed that so far as the Aftonian is represented in the collections made, it furnishes a list not greatly different from the more western localities. Such differences as appear may be due to lack of adequate collections. In both lists are mylodons, horses, camels, mastodons, elephants, goatlike species, and moose.

The Yarmouth Stage.—This is the interglacial interval between the Kansan and the Illinoian glacial stages. The deposits, of course, bear the same name. The type locality is found near the village of Yarmouth, in Des Moines county. Probably everywhere in Iowa, within the area covered by the Illinoian drift-sheet, there are deposits of one kind or another that belong to the Yarmouth epoch. Possibly corresponding deposits occur elsewhere in the state overlying the Kansan and covered by some of the loess deposits; but at present it might be hard to distinguish such from those of the Sangamon and Peorian. Moreover, the surface of the Kansan underwent a good deal of erosion before the great body of the loess was laid down and has undergone not a little since. Indeed, Leverett estimates that of the original surface of the Kansan only from ten to thirty per cent remains at the present time. The result of this erosion would be the prevention of deposition during the Yarmouth time except in favored localities. Leverett has furnished a section from a well which several years ago was sunken near Yarmouth. It is as follows in the descending order:

		FEET.
7.	Soil and loam (Iowan loess)	4
6.	Brownish yellow till (Illinoian)	20
5.	Gray till (Illinoian)	10
4.	Peat bed with twigs and bones (Yarmouth)	15
3.	Gray or ashy sandy clay, containing wood (Yarmouth)	12
2.	Fine sand (Yarmouth)	16
1.	Yellow sandy till with few pebbles (Kansan)	33
	Total depth	110

It will be observed that the total thickness of the Yarmouth in this section is forty-three feet and that it is overlain by thirty feet of Illinoian.

Leverett states that similar peat beds are found all over that portion of southeastern Iowa that is covered by Illinoian till; but that they are more prevalent near the border of this drift. The peat is usually associated with sandy beds.

The upper surface of the Kansan is found to have been extensively weathered, a fact which implies that a long lapse of time intervened between the disappearance of the Kansan ice and the deposit of the beds of sand and the growth of the peat. The Yarmouth is therefore regarded as representing a very long period of time.

The plants found in the peat deposits have not been thoroughly studied but they appear to be conifers and largely red cedar. In the well at Yarmouth were found some bones which have been identified by Dr. F. W. True as those of the cottontail rabbit and the skunk. Leverett has told us that specimens of the wood were so well preserved that they took fire as readily as recent wood; also that the marrow of the bones was yet preserved.

Leverett states (Mon. XXXVIII, U. S. Geol. Surv., p. 46) that he has observed several exposures of an old soil and weathered zone in western Scott and eastern Muscatine counties, between what he regarded as Kansan and Illinoian drifts. These exposures are especially conspicuous north and south of Blue Grass in Scott county. Here the Yarmouth soil and weathered zone are represented by a gummy black or gray clay, changing below to a reddish brown till. At the same localities is found a Sangamon soil above the Illinoian till. Yarmouth soils have been reported at Davenport. Here would belong also the bluish gray loess found in a railroad cut west of Davenport (Shimek, Iowa Geol. Surv., Vol. XX, p. 376). According to Leverett there are at Muscatine, beds of sand and silt between the Kansan and the Illinoian, and these may represent the Yarmouth; but there appear to be some differences of opinion as to the age of some of the Pleistocene deposits there. In a ravine about a mile northeast of West Point Leverett found an exposure which furnished a section which he interpreted as follows:

		FEET.
5.	Yellow Iowan loess or silt	6
4.	Sangamon soil	5
3.	Illinoian till, brown and with bowlders	15
2.	Yarmouth, black muck	6
1.	Kansan, brown clay	15

Leverett informs us that in a well made south of New London logs and wood were found at a depth of forty feet.

It appears that in this region covered with Illinoian drift all the Pleistocene stages below this are represented in some form or other. It offers therefore a fine field for the study of the Pleistocene deposits and of the life of the time. It will no doubt be difficult in many cases to determine the level of some of the interglacial beds; but they ought to be searched industriously for animal and plant remains, and accurate records ought to be kept of conditions under which all these occur.

It may be permitted to mention here deposits of loesslike silts, old soils, and mucks of undetermined age, but probably at least as old as the Illinoian drift. which were discovered in the vicinity of Rock Island, Illinois, by J. A. Udden (Leverett, Mon. XXXVIII, p. 114). On pages 47 and 48 of this work Leverett presented a section seen on the bluff of Mississippi river at Muscatine. Near the bottom of this section was found a blue-black till with fragments of wood and underlain by a thin bed of peat. This was supposed to be pre-Kansan and Shimek (Bull. Geol. Soc. Amer., XXI, p. 139) regards it as Aftonian.

The Sangamon Stage.—This interglacial interval and the deposits representing it take their name from old soils and loess which occur along Sangamon river, in central Illinois. In that region are found, overlying the Illinoian drift, a black soil, often thin, but in old basins forming peat beds which are sometimes more than twenty feet thick. Over this there is a loess several feet thick. Leverett states that exposures of Sangamon soil and of the overlying loess beneath Wisconsin drift are found along streams in central and eastern Illinois and across Indiana into southeastern Ohio. In Iowa the Sangamon has been reported from several points, but there is sometimes uncertainty about the determination. Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 143) stated that there were no very satis-

factory exposures of Sangamon in Iowa. Udden (Iowa Geol. Surv., Vol. XI, p. 109) recognized deposits of this stage at many points in Louisa county. At Davenport there is a yellow loess which overlies a bluish gray loess. The latter is by Shimek (Iowa Geol. Surv., Vol. XX, p. 376) identified as a loess laid down during Yarmouth times. The yellow loess probably represents the Sangamon, as suggested to the writer by Shimek.

This author has presented a section found at Des Moines (Bull. Geol. Soc. Amer., Vol. XXIII, p. 710) in which are two sheets of loess. Of these the upper may belong to the Sangamon stage.

Sangamon deposits have been reported from near Montpelier in Scott county. According to Leverett, a Sangamon pebbly black soil three feet thick is found at Muscatine overlying leached brown Illinoian till. It is to be recollected that both Aftonian and Yarmouth have been reported at this place.

At this point mention may be made of a clay, very sticky, varying in color from light gray to nearly black, which occurs in southeastern Iowa, northern Missouri, and southern Illinois, and which has the popular name of gumbo. The black portions resemble swamp mucks. This clay is fine, but contains occasional pebbles, rarely more than one-half inch in diameter. It reposes on the eroded surfaces of the Kansan and the Illinoian drifts and is overlain by "Iowan loess." The origin of this gumbo has not been determined. To the writer it seems best to refer provisionally this deposit to the Sangamon. Tilton has referred gumbo found in southern Iowa to the close of the Kansan stage.

As insufficient as in the case of the Yarmouth is our knowledge of the animal and plant life of the Sangamon. It would seem that the old soils and peat beds that are so widely distributed ought to furnish remains of many small vertebrates, if carefully explored.

It is certain that during practically the whole of the Pleistocene there lived species of megalonyx (sloths), elephants, mastodons, giant beavers, and peccaries. All of these are found abundantly in old pond, river, and marsh deposits which overlie the Wisconsin drift; and all have been found too in the Af-

tonian or equivalent deposits. On the other hand, in post-Wisconsin beds there seem to occur no horses, no tapirs, no extinct bisons, no camels, and no species of Mylodon (sloths). A fossil horse has been found in Illinois in a swamp deposit that overlies Illinoian drift; and hence it probably belonged to the Sangamon stage. Tapirs probably lived during this time and previously. The extinct species of bison are rare in the oldest Pleistocene, so far as known; hence, the numerous remains found of these probably existed during what we may regard as the middle third of the Glacial epoch. During the glacial stages they doubtless inhabited the region south of the great ice-sheets; but during the interglacial stages they occupied nearly the whole of North America. We know of no camels later than the Aftonian. We cannot now determine when the mylodons became extinct. We may, therefore, be pretty certain that during the Yarmouth and Sangamon there roamed over our country two or three kinds of elephants, a species of mastodon, tapirs, several species of peccaries, several species of bisons, one or more species of horse, and one or more species of Megalonyx (sloths). In our swamps were colonies of giant beavers, as well as of the common beaver.

In the Memoirs of the American Museum of Natural History (Vol. XVIII, pp. 157-208, with twelve plates) Mr. Barnum Brown described remains of about sixty species of vertebrates which he collected in a fissure in Newton county, in the northwestern corner of Arkansas.

It is thought worth the trouble to give here a list of the mammals found in that fissure. Those species and subspecies which are preceded by a star are now extinct. Some changes have been made in the nomenclature to conform with that given by Miller (North American Land Mammals, 1911).

LIST OF MAMMALS FOUND IN CONARD FISSURE, NEWTON COUNTY, ARKANSAS.

**Blarina brevicauda ozarkensis*	Short-tailed shrew
Sorex personatus	Common shrew
**Sorex personatus fossidens*	Common shrew, subspecies
Sorex obscurus?	Shrew
Sorex fumeus?	Shrew

**Microsorex minutus*	Shrew
Scalopus aquaticus	Common mole
**Eptesicus fuscus grandis*	Brown bat, subspecies
Myotis subulatus?	Little brown bat
**Mephitis mephitis newtonensis*	Common skunk, subspecies
Spilogale interrupta?	Little striped skunk
**Brachyprotoma pristina*	Extinct skunk
Brachyprotoma spelæa	Extinct skunk
Martes pennanti	Fisher martin
Mustela vison	Mink
**Mustela cicognanii angustidens*	Weasel, subspecies
**Mustela gracilis*	Extinct weasel
Canis occidentalis?	Gray wolf
Vulpes fulva?	Red fox
Urocyon sp.	Gray fox
Procyon lotor	Raccoon
Ursus americanus	Black bear
**Lynx compressus*	Extinct lynx
Lynx ruffus?	Bay lynx
Felis cougar	Puma
**Felis longicrus*	Extinct cat
**Smilodontopsis troglodytes*	Saber-tooth cat
**Smilodontopsis conardi*	Saber-tooth cat
Erethizon dorsatum	Canada porcupine
Marmota monax	Woodchuck
Sciurus hudsonicus	Red squirrel
**Tamias nasutus*	Extinct chipmunk
Citellus 13-lineatus	Striped gopher
**Geomys parvidens*	Extinct pocket gopher
Castor canadensis	Beaver
Peromyscus sp.	White-footed mouse
**Neotoma ozarkensis*	Extinct wood-rat
**Fiber annectens*	Extinct musk-rat
Microtus ochrogaster	Meadow mouse
Lepus floridanus	Cottontail rabbit
Lepus americanus	Varying hare
**Lepus giganteus*	Extinct hare
**Equus scotti?*	Horse
*Mylohyus sp. a	Extinct peccary
*Mylohyus sp. b	Extinct peccary
*Mylohyus sp. c	Extinct peccary
Cervus canadensis	Wapiti
Odocoileus hemionus	Mule deer
Odocoileus virginianus	White-tailed deer
**Symbos australis*	Extinct musk-ox

Besides these mammals there were recognized seven species of birds, three or more species of reptiles and a few species of amphibians. Brown remarks that most of the small burrow-

ing animals are of a boreal type, and that this signifies a crowding southward of northern forms before the advance of one of the great ice-sheets. As instances of boreal forms occurring in the fissure in Arkansas may be noted the shrew, *Sorex personatus*. It lives at present from New England to Alaska and south, in high mountains, to Tennessee and North Carolina. *Sorex obscurus* is now found in British Columbia and on mountains of the western part of the United States. In Gerrit S. Miller's List of North American Mammals this species is said to be restricted to the boreal zone. *Sorex fumeus* is a species belonging to the Canadian and Transition faunas of the Eastern United States, but ranging southward in the Alleghenies.

Erethizon dorsatum, the Canadian porcupine, is a species which is northern in its present distribution; although as Brown remarks, it formerly may have come as far south as Kentucky.

Lepus americanus, the varying hare, is at present known only from Canada, Alaska, the more northern of the United States, and from the mountains of Virginia and West Virginia.

Several other species have a general range farther north than northern Arkansas, but may, even within historical times, have extended south as far as the region just mentioned. Hence, their occurrence in the fissure does not necessarily imply a colder climate than now prevails there. The presence of species of Symbos, the musk-ox, if such it was, is another indication that this collection of animals existed at a time when the climate of the region was colder than at present.

Certain genera and species which one might expect to find here are wanting. Such are the elephants, mastodons, tapirs, bisons, moose, giant beaver (Castoroides), and megalonyx; but, at whatever stage of the Pleistocene we shall reasonably place this assemblage, these animals were undoubtedly living not far away. Doubtless this absence is due simply to the chances attending on their getting into such a fissure.

Taking into consideration the percentage of extinct species, about forty per cent, the nature of the extinct and living species represented and the kind of climate indicated, the writer is disposed to believe that this fauna lived during the Illinoian

stage. It cannot be doubted that practically the same fauna, plus some or all of the forms mentioned above, inhabited the same general region during the preceding stage, the Yarmouth, and the succeeding one, the Sangamon.

The following species are referred, with some reservations, to the Sangamon stage in Iowa:

Mammut americanum.....Mastodon
Elephas primigenius.....Mammoth
Rangifer muscatinensis.....Caribou
Cervalces roosevelti.....Moose
Bison occidentalis.....Bison

The assignment of Rangifer to this stage is uncertain and is based on the statement by Professor Witter, that the type of the species was found in the loess at Muscatine. This statement is questioned by Shimek, who has furnished me with the following statement:

In connection with Witter's Rangifer I wish to note that Professor Witter pointed out to me the exact spot from which the bones and teeth were taken. The lower part of the exposure shows a heavy, close-grained deposit not unlike the Loveland in appearance and probably bearing the same relation to the Illinoian which the Loveland bears to the Kansan. Above this is a deposit of true yellow loess. At this point the two are not sharply separated (probably because of local wash and redeposition) and the bones in question were found in this intermediate portion. It is the only place (and case) where there seems to be a suggestion offered that at the close of (or immediately following) a glacial stage there were Arctic mammals in Iowa. These bones are not associated with ordinary loess fossils, for the latter are restricted to the upper part of the deposit,—that which is manifestly loess. Neither are they in Illinoian drift, but in a deposit evidently closely following it, and *preceding* the deposition of the loess proper.

At Toronto, Canada, a fragment of an antler of a caribou has been found in deposits corresponding probably to the Sangamon. At Correctionville, Woodbury county, have been found fragments of antlers of a caribou possibly *Rangifer muscatinensis*. Here, too, have been found remains of *Elephas primigenius* and of a bison, *Bison occidentalis*. If all were found in the same deposit the writer would regard them as older than the Wisconsin drift.

It appears probable that the scapula of a mastodon found at Wilton, Muscatine county (Iowa Geol. Surv., Vol. IX, p. 352), was found in Sangamon soils. It seems not improbable that some of the mastodon teeth and mammoth teeth found at Des Moines and described on another page belonged to the Sangamon.

It is not improbable that a horn-core sent to the National Museum, from Webster City, Hamilton county, by Charles Aldrich, and mentioned on a succeeding page, was derived from some Sangamon interglacial deposit at that place.

The Peorian Stage.—This name is applied to the interval between the Iowan and Wisconsin stages, as well as to whatever deposits may have been laid down during that interval. This stage is sometimes revealed simply by erosion or weathering of the surface of the drift, or of the loess that was exposed to the action of the elements. The type locality is found east of Peoria, Illinois. Here, beneath the earliest Wisconsin drift, is found a fossiliferous loess that has been regarded as representing the Iowan glacial stage. The upper portion of this loess is leached and stained a dark brown, as if it had once been a plant-supporting soil. The loess itself, six feet thick, is underlain by from three to five feet of peat, which is regarded as belonging to the Sangamon. Unfortunately no Iowan drift is present here, and no locality is known where both drifts are present with evidences of the Peorian stage between them. While the loess in the region about Peoria probably belongs mostly or altogether to the Sangamon stage, it seems to the writer that it may have been formed partly at a later time. Or the erosion may have occurred during the Iowan stage, and the leaching and the plant growth during the Peorian stage. Calvin at one time expressed the opinion that the "Iowan" loess at Peoria might belong to the early Peorian stage. This idea appears to conform with the results of more recent studies.

As has been stated already, some authors, among them Leverett, have questioned the existence of a distinct Iowan drift-sheet. If the idea is correct that the Iowan drift is to some extent the equivalent of the Illinoian, it will be necessary to regard the so-called Peorian stage and its products as really be-

longing to the Sangamon. It is to be desired that the Iowan sheet, as displayed in Iowa itself, be thoroughly studied and, if possible, established, and that the interglacial deposits between it and the overlying Wisconsin be sought for. In one of his papers (Bull. Geol. Soc. Amer., Vol. XX, 1909, pp. 148-149) Calvin has mentioned two localities in Iowa which he supposed to present deposits of Peorian time; but in neither case is this Peorian underlain by Iowan drift. The following section was observed at Des Moines:

3. Wisconsin, with bowlders 3 to 4 feet diameter.
2. Loess, containing terrestrial mollusks.
1. Kansan drift, profoundly weathered.

The other section was at Carroll and is thus presented by Shimek (Iowa Geol. Surv., Vol. XX, p. 390):

		FEET.
6.	Wisconsin drift	1 to 5
5.	Yellow loess (post-Iowan?)	10
4.	Bluish gray loess (post-Kansan)	5 to 6
3.	Black, mucky, soil-like band	1
2.	Heavy, reddish, joint-clay (Loveland)	1
1.	Kansan drift.	

In this section there is nothing to prove that the yellow loess has not been laid down before the Iowan drift. In a note to the writer Shimek says that the yellow loess may correspond in part at least with the Sangamon. In the following section taken at West Amana, the yellow loess overlies the Iowan drift:

		FEET.
4.	Yellow loess	10
3.	Iowan drift	4
2.	Kansan drift	4
1.	Carboniferous sandstone.	

Number 4 must be regarded as a deposit of the Peorian stage, unless it shall be shown that the Iowan is equivalent to the Illinoian. In this case the loess would belong to the Sangamon.

It would appear that favorable localities for finding Peorian soils would be found along the eastern border of the Wisconsin lobe, in Worth, Cerro Gordo, Franklin, and Hardin counties, where the Wisconsin is believed to overlap the Iowan. In this region railroad cuts, the banks of streams, and wells along the Wisconsin moraine might furnish some trace of the under-

lying Iowan with a soil above it. However the Iowan was so thin when laid down that both it and the Peorian soil would, in all but the most favorable positions, have been plowed up by the Wisconsin glacial ice. In Beyer's report on Hardin county it is stated that in section 6, township 86 north, range 20 west (Providence township), loess is found in a railway cut and that this is overlain by twenty feet of Wisconsin drift. This loess itself overlies oxidized Kansan drift; but is supposed to be of post-Iowan, that is, Peorian, age. We are told, too, that well-drillers' records show a zone containing wood and that this zone is believed to lie near the base of the Wisconsin drift.

It may be said that we know little or nothing regarding the vertebrate animals that lived during the Peorian stage, except what we may infer from our knowledge of those that lived previously and those which lived after the Wisconsin glacial stage. We have reason to believe that immediately before the Wisconsin or during that stage many animals became extinct, as the horses, probably the tapir, and various species of bisons. None of these forms, except the common bison, are found in deposits overlying the Wisconsin drift.

The Wabash Stage.—This cannot be called exactly an interglacial stage; unless, indeed, as has been suggested by some geologists, our region is fated some ages hence to be overwhelmed by another sheet of ice comparable to those which have already passed over it. The name Wabash has been given by the author to beds found in Indiana resting on the Wisconsin and containing the remains of such extinct animals as the hairy mammoth, the Columbian mammoth, the mastodon, the giant beaver, peccaries, musk-oxen, etc. They are regarded as having been laid down in the interval between the disappearance of the Wisconsin ice and the beginning of the Recent period. Without a doubt, deposition in lakes, ponds, and marshes went on without interruption during the two periods and the only distinction between the two deposits will be that the earlier contains a number of extinct species, while the later contains only species that are now living. Exact limitation cannot be made and we are not required to perform the impossible.

To this stage are assigned provisionally the list of mammals which have been found in the lead region. Some of these were collected in Iowa, near Dubuque, others in Wisconsin, others in Illinois, in the neighborhood of Galena. In the case of some of the species it is not known in which of the three states they were found. Apparently seven of the species are extinct. These are marked by a star.

**Megalonyx jeffersonii*	Extinct sloth
**Platygonus compressus*	Extinct peccary
**Tayassu lenis*	Extinct peccary
Odocoileus virginianus	Virginia deer
**Odocoileus whitneyi*	Extinct deer
Cervus canadensis	Wapiti, or elk
Antilocapra americana	Pronghorned antelope
Bison bison?	American bison
**Mammut americanum*	American mastodon
Marmota monax	Woodchuck
Microtus sp.	Field mouse
Geomys bursarius	Pocket-gopher
Lepus floridanus?	Cottontail rabbit
**Anomodon snyderi*	Extinct insectivore?
**Procyon priscus*	Extinct raccoon
Canis occidentalis	Gray wolf
Canis latrans	Coyote

The Loess.

On the preceding pages mention has frequently been made of the occurrence of beds which bear the name of loess. It is thought that these should be more particularly described.

The term loess has been applied to deposits found in widely removed parts of the world, and which differ more or less in composition, appearance, and probably in origin; but which have in common certain conspicuous qualities. The material is usually soft, though cohesive; so that where it has undergone erosion, it often presents nearly perpendicular faces; it is fine-grained, and of a light color, yellowish, sometimes bluish, and it is usually rather porous. The various deposits agree also in having been laid down at some time during the Quaternary.

The term was first applied to deposits which occur along the Rhine; but similar deposits are now known to exist over large

portions of France, Germany and Russia. In Mongolia and China are vast accumulations of this loess, the thickness rising to 1500 or 2000 feet. In Europe and America the thickness of the deposits is far less. In the United States the loess occurs principally in the Mississippi Valley, extending from near the mouth of the Mississippi to near Red Wing, Minnesota; up the Missouri to about Yankton; along Illinois river to the region about La Salle; up the Wabash to about Terre Haute; up White river to Indianapolis, and along the Ohio as far as West Virginia. It is thus associated with the rivers of this region, the amount of the deposit being greater immediately along the streams and thinning out on the uplands between them. It also loses its importance as we pass eastward from the Missouri. The great plains west of the Missouri are enveloped by loess, but its character has not been investigated.

Although the loess extends far toward the mouth of Mississippi river, it shows by its general distribution and its composition that in its origin it was connected in some way with the glacial deposits of the northern states. The loess covers large portions of these glacial sheets, and it often extends some distance beyond their borders.

In Iowa the loess may, in general, be said to occupy the whole area of the state, except that part which is covered by the Des Moines lobe of the Wisconsin drift and some counties along the southern border. Only rarely is it found to overlie any part of the Wisconsin drift. On the west side of the lobe in Dallas county, Bain (Iowa Geol. Surv., Vol. IX, p. 91) found the loess overlapping the border of the Wisconsin drift; while Macbride (op. cit. Vol. XI, p. 483) discovered the loess overlying the Wisconsin drift in O'Brien and Osceola counties. It is usually thin, but sometimes several feet thick. In Wisconsin Salisbury (Jour. Geol., Vol. IV, pp. 929-937) found what appears to be true loess on the top of the same drift. Shimek (Bull. Lab. Nat. Hist., Iowa Univ., V, p. 367) reported a thin loess on Wisconsin drift near Carroll, Iowa. Such occurrences are, however, rather rare.

Within the area of the Iowan drift the loess is distributed in a rather patchy manner. It usually occupies the summits of

hills and bluffs, while it is missing lower down. Nevertheless, Calvin found, in Mitchell county, a considerable area of moderately undulating country which was covered by loess. This was only a foot or less in thickness and it appears to overlie Iowan drift. Usually within and for some distance back of the border of the area in question, the Iowan drift is thin and does not occupy the summits of the hills; and the loess, therefore, covers the Kansan drift and seldom the Iowan.

The Driftless area, lying in the northeastern part of the state, and occupying also parts of Illinois, Wisconsin, and Minnesota, is furnished with a mantle of loess, except where it has been removed by erosion.

The thickness of the loess is extremely variable. Shimek states that along Missouri river, in western Iowa, it seldom reaches as much as ninety feet; while west of the river mentioned it does not exceed thirty-five feet. The greatest thickness in Iowa observed by Shimek (Iowa Geol. Surv., Vol. XX, p. 377) was about 100 feet. Along the borders of the Iowan drift sheet, it may reach a thickness of forty or fifty feet. Along Mississippi river it may be from twenty-five to thirty feet thick. The same author found it to be about thirty feet thick at Natchez, Mississippi. Away from the border of the Iowan drift-sheet and from the larger streams it thins out greatly; so that it may be a few feet, five to ten, in thickness, or, it may thin out to a sort of top dressing to the underlying soil.

A few additional words may be said regarding the physical appearance and characteristics of the loess of Iowa. In color it varies from ash-gray through yellowish to buff-brown. Occasionally it has a bluish tint, especially some distance below the surface. In some of the states farther east, as in southern Indiana, it is compact and very pale in color, and is known as white clay. On the other hand, it may now and then be stained so as to be rather brown or red. In respect to grain, the loess is nearly always very fine, standing between very fine sand and smooth plastic clay. According to researches made by Chamberlin and Salisbury (Sixth Ann. Rep. U. S. Geol. Surv., pp. 278-285) and referred to by Leverett (Monogr.

XXXVIII, p. 159) more than ninety-five per cent of the loess consists of grains that have a diameter not greater than 0.005 mm.; that is 1-5000 of an inch. The largest particles were little more than 1-250 of an inch in diameter. All the particles are angular, not rounded as in the case of sand that has been much rolled in water.

As to its mineral constitution, it has been found, especially by the investigators just mentioned, that the loess consists principally of quartz, feldspar, mica, hornblende, augite, magnetite, dolomite, and calcite. In this respect it agrees with the composition of the materials of the drift and may well have been derived from the fine flour that was borne away from the glaciers by streams.

Occasionally the loess, especially in its lower parts, becomes coarser and may grade into sand and the underlying till; but in such cases there may have occurred comminglings of materials of different origins. Often the loess contains nodules composed mostly of carbonate of lime, but these were developed after the laying down of the finer materials. The loess is porous and permits the percolation downward of rainwater. This is likely to dissolve some of the contained carbonate of lime, which, at a lower level, may be redeposited in nodules.

As the loess breaks down, along bluffs and roadsides, it shows a sort of columnar structure. In virtue of this and its cohesive tendency, the loess, in such places as mentioned, is likely to present nearly vertical faces. Such abrupt walls may be seen at many places along Missouri and Mississippi rivers. It is only in rare cases that the loess shows any distinct signs of stratification, although a sort of lamination is frequently observed.

As regards the chemical constitution of the loess the reader may consult the authorities named above. As may be inferred, however, from the mineralogical composition, it consists mostly of silica, but to some extent of compounds of alumina and of lime. Its usually high percentage of silica prevents it from offering a notable degree of plasticity.

It is important to consider the fossils that are to be found in the loess, because from these we may judge under what conditions and at what geological periods the materials were deposited. In some parts of Europe many bones are found and these are of such animals that the conclusion is reached that the loess there was deposited during some cold and arid stage. In America vertebrate remains are rare in the loess and even questionable. The animals represented are mostly gasteropod mollusks, that is, snails of one kind and another. They are often abundant and they have been collected in widely removed localities. Nobody else in America has given as much attention to these mollusks as Professor B. Shimek, of the University of Iowa. For lists of these animals collected at many places and for discussions of their significance, the reader is referred to this author's papers cited on a succeeding page. Especially to be recommended is his paper on the loesses of Iowa in the Twentieth volume of the reports of the Iowa Geological Survey, pages 376 to 407. Suffice it here to say that this investigator has found that the great majority of these mollusks are strictly terrestrial forms; that they belong almost wholly to yet existing species; and that these species are to be found today in the same general localities in which the fossils are found. The few aquatic and amphibious species found in the loess are likewise yet living in the same regions. The fossil terrestrial snails are more abundant in the loess along the streams and that is where Professor Shimek has found the living representatives to abound.

Up to the present time not many vertebrates have been discovered in the loess of this country. Only four or five species have so far been reported from the loess of Iowa and too often there exist doubts regarding their actual occurrence in the loess.

In 1887 McGee (Amer. Jour. Sci., Vol. XXXIV, p. 217) reported the discovery of a part of a skull, with some other parts, of the extinct musk-ox *Symbos cavifrons,* at Council Bluffs. He stated that these were found in the loess at a depth of twelve feet and at a height of 130 feet above the river. In this case there would appear to exist little doubt regarding the po-

sition of the remains. The animal, in all probability, lived at the time when the Wisconsin ice-sheet occupied a part of the state of Iowa; and we must suppose that the twelve feet of loess above the bones had accumulated since that time. On the other hand Shimek, in a note to the writer, regards it as very doubtful that the Symbos was found in loess. He thinks that it was possibly in the Loveland, a deposit made in slack water. This matter is further discussed under the description of this species. An objection to be made to Shimek's theory is that there is no other evidence that this genus existed at so early a time.

J. A. Udden (Iowa Geol. Surv., Vol. XI, p. 160) reported that a pair of horn cores of a bison had been found in the loess in Pottawattamie county. They were met with at a depth of fourteen feet. The species was probably *Bison occidentalis,* and it is further described on a more advanced page.

Leidy (Proc. Acad. Nat. Sci. Phila., 1879, p. 32) announced that Professor Witter, of Muscatine, had found a large part of the skeleton of a reindeer in the loess at Muscatine. This animal will be described in the proper place as *Rangifer muscatinensis.* Shimek doubts that it was found in the loess, as already noted on page 34.

J. E. Todd (Proc. Iowa Acad. Sci., 1875-1880, p. 14) furnished the information that tusks, teeth, jaws, a humerus, and some other bones of a young elephant had been found between Glenwood and Pacific Junction; and that these remains occurred either in the base of the loess or in the top of the drift. There are the same doubts about this as in the case of the finding of the Symbos.

J. A. Udden (Iowa Geol. Surv., Vol. XIII, p. 170) reported that bones of a mammoth had been recovered from the lower part of the loess at Malvern in Mills county.

It is time for us to consider the geological distribution of the loess, especially in Iowa; and, so far as now appears, the loess (and likewise the drifts) may be better studied in Iowa than in any other state. It is evident that all of the loess does not belong to any one of the stages, glacial or interglacial, of the Pleistocene. In the Bulletin of the Laboratory of Natural His-

tory of the University of Iowa, volume V, page 368, Professor Shimek presented a section which he regarded as representing the history of the Pleistocene since the beginning of the Kansan stage. It is as follows, taken in order of deposition:

16. Post-Wisconsin loess.
15. Wisconsin residual sands and gravels.
14. Wisconsin drift.
13. Post-Iowan loess.
12. Black soil.
11. Iowan residual sands and gravels (Peorian).
10. Iowan drift.
9. Post-Illinoian loess.
8. Black soil (Sangamon).
7. Illinoian residual sands and gravels.
6. Illinoian drift.
5. Post-Kansan loess.
4. Black soil (Yarmouth).
3. Gumbo.
2. Kansan residual sands and gravels (Buchanan).
1. Kansan drift.

From this table we see that loess was laid down just before the oncoming of the Illinoian drift, again just before the Iowan stage, again just before the Wisconsin, and finally after the Wisconsin. That is, there are four distinct sheets of loess. So far as we know, no loess was formed in the interval between the Nebraskan and the Kansan drifts. Above the Kansan drift there is found in various parts of Iowa a loess which is to be regarded as belonging to the Yarmouth stage. Shimek states that this loess is widely distributed, very compact, of a pale bluish gray color, and frequently contain numerous fossil gasteropod mollusks. The color was probably derived from the Kansan blue clays. Shimek finds this loess in many sections in the region about Iowa City. Here it may be five or six feet thick and rest on Kansan drift, or on the Buchanan gravel, which was formed on the withdrawal of the Kansan ice-sheet; or it may repose on a gumbo about a foot thick. Over this loess there is found another of a yellowish color and this is regarded by Shimek as post-Iowan and therefore of the Peorian stage. In the region about Iowa City it is sometimes fifteen feet thick. Shimek also finds the bluish Yarmouth loess at Muscatine, where it is placed between the Kansan and the Illinoian drifts and where it is fossiliferous. It is recognized at Davenport

and here it is overlain by a yellowish loess which probably belongs to the Sangamon. The same post-Kansan loess is found at Des Moines. At Carroll, Carroll county, on the western border of the Wisconsin lobe, there is said to be a foot of black soil, overlain by six feet of bluish fossiliferous loess. This again is overlain by probably post-Iowan (Peorian) loess which is yellow and fossiliferous. On the top of the latter is from one to five feet of Wisconsin drift. Professor Shimek (Bull. Geol. Soc. Amer., XXIII, p. 125) found loess of this stage in the northwestern corner of the state, where there occurs likewise a more recent loess. The two taken together are not more than ten feet in thickness. On page 148 Shimek states that he has found the post-Kansan bluish loess in several hundred sections in Indiana, Illinois, Wisconsin, Missouri, Iowa, Nebraska, South Dakota, and Minnesota. Hence, wherever the Kansan drift is overlain by loess, we may suspect that this, or at least its lower portions, belongs to the Yarmouth stage. Its tint of blue will help to confirm the determination. Any loess separated from this by other materials, or having a yellow color will probably be found to belong to a later stage, as the Sangamon or Peorian. Both the bluish loess and the yellowish are widely distributed in Iowa. Shimek (Iowa Geol. Surv., Vol. XX, pp. 376-406) has given us his latest views on the loess. He examined 397 sections showing loess deposits in Harrison and Monona counties. In all cases where the blue loess appeared there was present the yellow; but in nearly one-third of the sections the blue loess was missing. It is usually much thinner than the yellow loess. In the counties mentioned it was not found to exceed fifteen feet; and in the sections published it is usually much thinner than this.

Shimek believes that the yellowish loess itself is composite, consisting of at least two deposits. One of these, the older portion, was probably deposited during the Sangamon stage, the upper and younger portion during the Peorian; although it is not improbable that, outside of the areas which were covered by the Illinoian and Iowan ice-sheets, some loess was laid down during these glacial stages.

In Leverett's work on the Illinois Glacial Lobe (Monogr. XXXVIII, U. S. Geol. Surv., p. 128, pl. XI) are described and

figured sections found east of Peoria, Illinois. In these occurs a deposit of loess which is there recorded as Iowan, supposed, at that time, to represent the Iowan ice-stage. The loess is sometimes from eight to twelve feet thick, and at the top in one place is a thin soil which contained pieces of wood. Later, Leverett regarded this loess as belonging to the Sangamon stage. This author, however, had then abandoned belief in an Iowan ice-stage. If this really existed it may well be that the loess belongs partly to the Sangamon and partly to the Peorian.

Beyer, in his report on Hardin county (Iowa Geol. Surv., Vol. X, pp. 241-306), states that in Providence township, in a railroad cut, loess is seen lying on Kansan drift and overlain by Wisconsin drift. While this is probably Peorian loess (post-Iowan), it may represent Sangamon, or both Peorian and Sangamon.

As already stated, there is a considerable accumulation of loess around the border of the Iowan drift extending thence southeast and far eastward with diminishing thickness. In the counties which lie along the southern border of this state and away from Missouri and Mississippi rivers the loess is thin or wanting.

While a part of the mass of loess around the border of the Iowan drift-sheet may be found to pass beneath the Iowan drift and therefore belong to the Sangamon stage, much of it is probably more recent and a member of the Peorian. As one passes the border and into the area of the Iowan, the loess is found to thin rapidly and, in general, to cover with a thin layer only the tops of hills and the bluffs. Inasmuch, however, as these higher lands are occupied by Kansan drift and not by Iowan, the loess is probably rather pre-Iowan. An examination of the reports of the counties occupied by the Iowan drift shows that loess is found in nearly all of them.

It is not to be supposed from what has been said here that the loess found around the border of the Iowan drift sheet exceeds in thickness that found elsewhere. The thickest deposits in the state are along Missouri river and farther west

there are still greater deposits. Nor is the thickness around the Iowan border greater than at Natchez.

Post-Wisconsin loess likewise occurs in Iowa, but it is usually thin and discontinuous. References to localities have been made on page 39.

Regarding the origin and manner of deposition of the loess, the writer cannot enter into details. An examination of the papers cited on pages 87 to 99 will give the reader a clear insight into the problem in question. Two theories are invoked to explain the presence of the loess, the aqueous theory and the aeolian. The advocates of the former theory believe that the loess was deposited in quiet waters, and that it consists of the finely ground materials that were washed out of the glacial ice-sheets. The acceptance of this theory involves the idea that the regions covered by the loess were at one time, or at various times, depressed so as to be covered with water. Those who hold the aeolian theory believe that the loess consisted of dust which was carried over the country by winds and laid down where we now find it. There are those who combine the two theories. To the writer it seems that at present the aeolian theory has the advantage in the argument.

To illustrate one of the difficulties in the way of accepting the aqueous theory, Shimek has called attention to the fact that almost the whole of the state of Iowa must, on the theory, have been submerged by temporary floods during the deposition of the loess.

The fact that the gasteropod mollusks which occur so abundantly in the loess belong almost wholly to genera and species which live on the land, forms an argument against the aqueous theory that seems to be almost unanswerable. In deposits laid down in water we would expect to find water-breathing and amphibious species almost exclusively. For the facts regarding these mollusks the reader may consult the papers of Professor Shimek. This author's idea is that the materials of the loess were derived from the drift, not while it was being deposited, but later. Rivers coming down from the north gathered up the finer materials and bore it southward, especially during times of flood. Some of this fine sediment was laid down on

the flood plains, and, on the retirement of the waters, this was dried. It was then caught up by the winds and carried over the country. Much of it was deposited on the adjacent bluffs; but much of it was borne farther away. The deposit is thicker on the eastern side of most streams, because of the prevalence of western winds. Naturally the deposit becomes thinner the farther it is away from the source; for the same reason it becomes finer.

The mollusks of the loess of the Rhine have likewise been shown to be principally terrestrial species, and this fact points to a similar origin of that deposit.

Shimek's researches on the mollusks of the loess throw much light on the climate. Fossil terrestrial gasteropods are found in the post-Kansan (Yarmouth) loess; in the post-Illinoian (Sangamon); and the post-Iowan (Peorian). Nearly all the species yet live and they inhabit the regions where their fossil predecessors are found. Hence, the climate at some time during each interglacial stage must have been very similar to that now prevailing.

Doubtless, however, for a long time after the withdrawal of each ice sheet the climate was cold; and likewise for a long time preceding the oncoming of each ice-sheet. In deposits, doubtless not numerous, made during such cold periods, collectors ought, at some time, to find animals and plants that were adapted to rigorous climates.

If the face of the state during these interglacial stages was covered with a vegetation not greatly different from that now existing, it may appear strange that more numerous remains of vertebrate animals were not preserved. There can be no doubt that during these periods, the country was inhabited by elephants, mastodons, bisons of various species, horses, gigantic sloths, wolves, cats, and a host of other and smaller beasts with bony skeletons. As each interglacial stage probably continued some thousands of years, we can hardly doubt that on every foot of ground some animal, probably many of them, had died. Besides these there was one generation after another of animals that burrowed in the ground and died there. If all their bones and teeth had been preserved, the whole sur-

face would have been covered with them and the earth full of them. What became of all these?

We may get an answer from a time much nearer us. On the prairies of Illinois and Iowa, herds of bisons and deer had grazed for doubtless thousands of years, and on dying had left their bones on the surface. And yet when those soils were turned up by the plow, it was the rarest occurrence when a bone or horn was found. These bones and teeth had all decayed and became a part of the soil. Even the hard parts of the animals that had died in burrows had melted into soil. We must conclude, then, that it is only by the most fortunate combination of conditions that a vertebrate animal is preserved. Of the snails that once lived on the loess, it seems certain that only a small per cent have been saved for us. One might suppose further that rain-water, filtering for ages through this porous loess, would have dissolved out every one of these thin and fragile shells.

DIVISIONS OF THE QUATERNARY.

Recent	Champlain	Assumption and maintenance of the present order of things in nature.
Pleistocene	Wabash (Postglacial)	Erosion of surface of Wisconsin drift; filling of lakes and marshes; lowering of levels of the Great Lakes and leaving of old beaches; unimportant accumulations of loess. Gradual amelioration of climate. Continuance and gradual extinction of elephants, mastodons, megalonyx, giant beavers, peccaries, and species of musk-oxen. The modern fauna approaching its meridian.
	Wisconsin (Glacial)	On-coming, culmination, and withdrawal of the Wisconsin ice-sheet, with deposition of its drift. Important changes in drainage lines and deposits of outwash materials along the courses of rivers. Fauna and flora of northern states driven southward. Various, but as yet undetermined species of mammals suffering extinction.
	Peorian (Interglacial)	Geological, faunal, and floral changes not well determined. Formation of peat beds and old soils. Wide distribution of loess.
	Iowan (Glacial)	Spreading of Iowan ice-sheet over parts of Iowa and Minnesota. Condition of country elsewhere not understood. Effect on animal and vegetable life not known.

DIVISIONS OF THE QUATERNARY—Concluded.

	Sangamon (Interglacial)	Gradual amelioration of climate after withdrawal of Illinoian ice-sheet. Erosion of surface of Illinoian drift sheet. Deposition of sediments along river courses. Accumulation of peats, old soils, and loess. Abundance of vegetation and of animal life. Our best knowledge of the vertebrates to be deduced from the collection made in the Conard fissure, Arkansas; although this probably belongs to the Illinoian stage. Horses, elephants, mastodons, bisons, peccaries and tapirs all probably in existence.
	Illinoian (Glacial)	On-set, culmination, and retreat of the Illinoian ice-sheet, with distribution of its drift. Modification of drainage lines. Deposition of loess. Animals and plants driven southward. Vertebrates of the Conard fissure seem to belong here, with about fifty species and subspecies of mammals; forty per cent extinct. Mastodons, mammoths, horses, tapirs, bisons, deer, and saber-tooth cats continuing.
Pleistocene	Yarmouth (Interglacial)	Erosion of Kansan drift-sheet and deposition of gravels and sands. Formation of beds of peat and of old soils. Dispersion of bluish loess. Few remains of plants and animals known. Vertebrates certainly not widely different from those of the Conard fissure (p. 31).
	Kansan (Glacial)	Occupation and possession of the northern states by the Kansan ice-sheet and its withdrawal. Effect on animal and vegetable life only to be surmised. Extirpation of various species of camels and horses.
	Aftonian (Interglacial)	Formation of gravels and sands on the surface of the Nebraskan drift. Occupation of the land by plants and animals, and growth of peat beds. Great abundance of mylodons, megatheres, megalonyx, mastodons, elephants, horses, camels, saber-tooth and other cats, dogs of various species, bears, and rodents. Remains of these found in the Equus beds of the Plains, in the interglacial deposits of western Iowa, and in Port Kennedy cave, Pennsylvania.
	Nebraskan (Glacial)	Occupation of the northern regions by the Nebraskan ice-sheet and the laying down of its drift. Effects on the animal and plant life not well known; but many genera of the Pliocene are missing in the succeeding Aftonian.
	Ozarkian, or Sierran (Preglacial)	Supposed to be a time of high elevation and of great erosion. May belong to Pliocene.

For convenience in referring the Quaternary to its relative position in the geologic time-scale the following table showing the divisions of the Cenozoic, the last great era of geologic time, is here appended:

Era	Period	Epoch
Cenozoic	Quaternary	Recent
		Pleistocene
	Tertiary	Pliocene
		Miocene
		Oligocene
		Eocene

Plate I is intended to represent, in the first place, the distribution of the different sheets of glacial deposits in Iowa. The map is based on Plate III of the Nineteenth and Twentieth Annual Reports of the Geological Survey of Iowa. In the map here presented the Kansan sheet is shown in white; while each of the other sheets is represented in a special way.

In the second place, the map is designed to show the localities where Pleistocene vertebrate fossils have been found; likewise the localities where exposures of interglacial deposits have been demonstrated and where, therefore, such fossils may be expected to occur. The localities are indicated by circular black dots, in the center of each of which is a white number. These numbers refer to corresponding numbers to be found on pages 52 to 87. Under the latter numbers will be found brief descriptions of the respective localities.

Localities in Iowa Where Remains of Pleistocene Vertebrata Have Been Found and Localities Where Exposures of Interglacial Deposits Have Been Demonstrated.

A few pages will be devoted to recording the localities in the state where vertebrate fossils have either been actually discovered, or where, on account of the presence of interglacial mucks, soils, sands, and gravels, remains of these animals may with some confidence be looked for. In connection with these notes reference should be made to the map (Plate I) that the relation of the various discoveries to the different drift sheets may in some measure be elucidated. Each locality has received a number which corresponds to the number of the note here recorded. It has been found necessary sometimes to include two or more localities under one number. It will be observed that the points noted are well scattered over the state; and it is hoped that this map will suggest the search for a multitude of other localities, and that therefrom may result many additions to our knowledge of the geology and the paleontology of the state. It has been found impossible to arrange the notes by counties or in any other systematic manner.

1. *Afton Junction, Union County.*—This is the type locality for the Aftonian interglacial stage. Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 136) states that near here the older (Nebraskan) drift is exposed in the west bank of Grand river, a mile below the railroad station; and that it is there overlain by more than thirty feet of water-laid gravels. Overlying the gravels is a heavy deposit of Kansan till. There is an exposure of gravels at the station also.

2. *Thayer, Union County.*—This locality is four miles east of Afton Junction. Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 136) says that there is here a pit in the Aftonian gravels. In the Proceedings of the Davenport Academy, Vol. X, page 27, he stated that the Aftonian here had been disturbed by the Kansan ice; so that great masses of the Aftonian were, probably in a frozen state, incorporated in the Kansan drift, in the form of "sand bowlders."

The small horselike animal which is described on another page under the name *Neohipparion gratum?* was found near this place (Calvin, Bull. Geol. Soc. Amer., Vol. XX, p. 216). These remains have the number 76 in the records of the collection at the State University of Iowa.

3. *Murray Hill, Harrison County.*—On the southwest quarter of section 8, Little Sioux township (township 81 north, range 44 west), on Murray Hill, are located some exposures which show gravels; and these appear to have been disturbed during the Kansan stage (Shimek, Bull. Geol. Soc. Amer., Vol. XX, pp. 404, 406; Iowa Geol. Surv., Vol. XX, p. 355, pl. XXIX; Calvin, Bull. Geol. Soc. Amer., Vol. XX, p. 343).

A short distance north of this, on the north one-half of section 5, same township, are what Shimek has called the county line exposures. They are less than one-half mile south of the county line.

4. *Loveland, Pottawattamie County.*—Shimek (Bull. Geol. Soc. Amer., Vol. XX, pp. 402, 404, 407, pl. 37, fig. 2) mentions the occurrence of Aftonian sands in the vicinity of Loveland. It does not appear that any vertebrate remains have been discovered here. This is the type locality of the formation called the Loveland (Shimek, Iowa Geol. Surv., Vol. XX, pp. 371-375).

5. *Council Bluffs, Pottawattamie County.*—Shimek (Bull. Geol. Soc. Amer., Vol. XX, p. 402) mentions sands bearing fossil mollusks in this county. One place mentioned is Council Bluffs, but the locality is not more exactly described. Professor Shimek has informed the writer that there is a series of exposures extending on the east side of the river from a mile above Council Bluffs to about four miles above. The sands belong to the Aftonian and in them are likely to occur vertebrate remains.

In the collection in the Iowa State University is the front part of an upper molar, probably the second true molar of the elephant, *Elephas columbi,* which was obtained from the collection of the Council Bluffs High School and which was probably found somewhere about Council Bluffs. It has the catalog number 309. The writer is informed by Professor Shimek

that this tooth was found some miles south or southeast of Council Bluffs, possibly near Henton Station (Locality 111).

It was near Council Bluffs that W J McGee found the skull of a specimen of a musk-ox, *Symbos cavifrons*. This is No. 107 of the State University.

6. *Missouri Valley, Harrison County.*—The Cox pit is situated on the east side of Boyer river, east of the town of Missouri Valley. The more exact location is the northeast quarter of section 24, township 78 north, range 44 west (St. Johns township). About forty feet of Aftonian sands and gravels are exposed here (Shimek, Iowa Geol. Surv., Vol. XX, p. 334).

The following species have been found at this place: Elephants, *Elephas primigenius, Elephas imperator?,* lower jaw; *Elephas columbi;* mastodons, *Mammut americanum, M. progenium;* goat, *Aftonius calvini;* bison, *Bison,* species uncertain; camel, *Camelops?;* horses, *Equus complicatus, E. niobrarensis, E. laurentius, E. excelsus;* beaver, *Castor canadensis;* sloth, *Mylodon harlani;* bear, *Ursus americanus;* moose, *Alces shimeki.*

7. *Logan, Harrison County.*—At this place, on the east side of Boyer river, near the milldam, there are found three sections, called the Peckenpaugh sections. Nine feet of Aftonian sands and gravels are found above the limestone occurring therein. Over the sands and gravels are six feet of Loveland clay; and above these again, twenty feet of loess. The gravels have furnished remains of the elephant, *Elephas columbi* (Pl. LXIII, fig. 3), and of an undetermined horse (Calvin, Bull. Geol. Soc. Amer., Vol. XX, p. 355; Shimek, op. cit., Vol. XX, p. 403; Vol. XXI, p. 137, pl. XXXV, fig. 2; Iowa Geol. Surv., Vol. XX, pp. 335, 336.)

Mr. Charles L. Crow, of Logan, has another elephant tooth which was found in the sand pit at Logan.

8. *Near Rodney, Monona County.*—Professor Shimek (Bull. Geol. Soc. Amer., Vol. XX, pl. 35, fig. 1) has figured an exposure of Kansan drift and Aftonian sand which is found near the north part of this county, on section 7, township 85 north, range 44 west (Grant township), being south of west of Rodney.

9. *Woodbine, Harrison County.*—Shimek (Bull. Geol. Soc. Amer., Vol. XX, pp. 404, 406) mentions a pit about two and one-half miles southwest of Woodbine which shows a tilted layer of Aftonian, with a mass of mingled and folded Nebraskan, Aftonian, and Kansan in front of it, as though the whole Aftonian mass had been moved forward. It is stated also that along the Boyer, below Woodbine, the beds of Aftonian are on the west side of the river.

Leidy (Proc. Acad. Nat. Sci., Phila., 1870, p. 73) stated that there had been shown to him, from the Smithsonian Institution, a part of a lower jaw which he thought might have belonged to the extinct musk-ox, now known as *Symbos cavifrons*. This had been sent to the Smithsonian Institution by Mr. David R. Witter, of Woodbine. He reported that it had been discovered in a well, at a depth of twenty-two feet; this well was situated one mile north of Woodbine and on the second bench along Boyer river.

10. *Mapleton, Monona County.*—Under this number are included the Griffin well and the Hawthorn sand and gravel pit; both being near the town of Mapleton.

The Griffin well is situated on the east side of section 17, Cooper township (township 85 north, range 42 west). At a depth of thirty-five feet a tooth was found which has been referred to the elephant, *Elephas imperator*. It was discovered in Aftonian gravels.

The Hawthorn pit is situated on the northwest quarter of section 14, Maple township (township 85 north, range 43 west). It is stated by Shimek that bones have been found there, but none were saved.

11. *Denison, Crawford County.*—In the southwest corner of Denison is a gravel and sand pit, which has been described by Calvin and Shimek (Calvin, Bull. Geol. Soc. Amer., Vol. XX, p. 343; Shimek, op. cit., Vol. XX, pp. 405, 407; Vol. XXI, p. 137). It was at one time thought that the sands and gravels exposed here are Aftonian, but this is now uncertain. No drift is seen in the section, but above the thirty-five feet of sands and gravels are two beds of loess, separated from each other by five feet of sand. The exact location of the pit is the north-

west corner of section 14, Denison township (township 83 north, range 39 west), and in the bluff of Boyer valley. Another pit southwest of this one has furnished some elephant teeth, but its geological relations are not well determined. Shimek (Bull. Geol. Soc. Amer., Vol. XXII, p. 212, foot note) says that the deposits here form a river terrace without overlying loess or drift, and that no underlying drift was seen.

Here was found the upper second molar of *Elephas primigenius,* described hereafter, and a large last upper molar, No. 294, of the same species, held in a part of the maxilla. Here, too, was found the tooth of a mastodon, *Mammut americanum,* now in the State University. It was at Denison likewise that was found the antler which is the type of the mooselike animal which has been called *Cervalces roosevelti.* Shimek, as elsewhere noted, now has reason to suppose that this antler was found in the pit in the river bottoms where there is no loess over the gravel.

In the State University collection is the scapula of a bison, possibly *Bison occidentalis,* which was found in the Denison sand pit.

Under this number may be mentioned the fact that there is in the National Museum a part of a skull referred to *Bison bison,* which was found at Deloit, about six miles farther up Boyer river. This may be later than the Pleistocene in age.

12. *Pisgah, Harrison County.*—About one mile southwest of Pisgah, on the northeast quarter of section 23, township 81 north, range 44 west (Jackson township), is situated the Peyton sand pit, where Kansan and probably Nebraskan drifts are exposed, having between them Aftonian gravels and sands. In the sands were found remains of mastodon, mammoth, camel, and horse (Calvin, Bull. Geol. Soc. Amer., Vol. XX, p. 343, pl. XVI, fig. 2; Shimek, op. cit. XXI, pp. 133, 134). Here may be mentioned a pit situated on the northwest quarter, section 26, of the same township. The horse found here has the number 262 in the collection at the University of Iowa, and it is identified as *Equus complicatus.* Here was found the lower jaw of the mastodon which was figured by Calvin (Bull. Geol. Soc. Amer., Vol. XX, pl. XXV, fig. 2) and which is here referred provision-

ally to *Mammut progenium.* In the same pit was found the large elephant tooth referred to *Elephas imperator* (Pl. LXVII, fig. 2); also a part of a humerus and the greater part of a femur, which may belong to *Elephas imperator.* A camel is represented by a first phalange (Calvin, pl. xxi, fig. 1). The presence of a horse is shown also by an acetabulum and a part of a metapodial, Nos. 66 and 84 of the University collection.

In the University of Iowa collection there is a supposed upper second molar of an elephant, which has the number 330 and which was collected by Professor Shimek at the Kress sand pit, immediately across a ravine from the Peyton pit. This tooth shows eleven plates present, but a number, perhaps five, are missing from the rear. This tooth is regarded as belonging to *Elephas columbi.*

13. *Near Smithland, Woodbury County.*—On Little Sioux river, near Smithland, there are exposures of the Aftonian; but no particulars are given (Shimek, Bull. Geol. Soc. Amer., XX, p. 407).

14. *Sioux City, Woodbury County.*—Shimek (Bull. Geol. Soc. Amer., Vol. XX, p. 407)refers to Aftonian beds in the vicinity of Sioux City. Later (op. cit., XXI, p. 129) he described an exposure on the southeast quarter of the northwest quarter of section 13, township 89 north, range 48 west (Sioux City township), north of Sioux City. In Aftonian sands here were collected some remains of the sloth, Megalonyx, and the horse, Equus. The beds were seen in the Anderson pit. Todd (Proc. Iowa Acad. Sci., VI, p. 124) states that some vertebræ of a horse and fragments of a small mammal and of a turtle had been found in an old soil at Sioux City. Number 133 of the State University collection is identified as belonging to the horse, *Equus laurentius.* Four injured lower teeth, found near Sioux City, and having the number 181, are described under *E. complicatus.* The conditions at Sioux City are discussed by Shimek in Proceedings of the Iowa Academy of Science, volume XV, page 61.

15. *Burlington, Des Moines County.*—In the collection at the State University of Iowa, is a large last upper molar of the elephant, *Elephas primigenius,* No. 22 of the catalog, which is

recorded as having been found here. It has a length of 255 mm., or ten inches.

In the High School at Burlington is a part of a tusk, of probably a mastodon, which as stated by Mr. Charles Buetner, who has taken much interest in natural history, was found in making an excavation at the southwest corner of Fourth and Washington streets. The fragment is about four feet long. In the same High School is one of the innominate bones of a proboscidean. This, Mr. Buetner said, was found in Skunk river southwest of Burlington in digging for the support of the bridge of the Chicago, Burlington and Quincy railroad. The bone was found at a depth of twenty feet below the bed of the river.

In the collection at the Iowa Wesleyan College, at Mount Pleasant, is a tooth of an elephant which, as Mr. Charles Buetner informs the writer, was found near Burlington in Flint creek. The tooth has been restored somewhat. It shows twelve or thirteen ridge plates and appears to be a very large first upper molar of *Elephas columbi.*

J. D. Whitney (Geol. Surv., Wisconsin, Vol. I, 1862, p. 135) stated that remains of the extinct peccary had been found at Burlington. It was probably *Platygonus compressus.*

16. *Lyons Township, Mills County.*—The Gladwin section was described by Calvin (Bull. Geol. Soc. Amer., XX, p. 344) and a figure was presented of the teeth of a horse found here. The location is on the east one-half, section 35, Lyons township (township 71 north, range 43 west), as given by Shimek (Bull. Geol. Soc. Amer., XXI, p. 138). This is in the southwestern corner of Mills county. The remains of the horse are here described under *Equus complicatus.* The teeth have the catalog numbers 219 and 220.

17. *Akron, Plymouth County.*—Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 355) described the finding of two molars of the mastodon, *Mammut mirificum,* with portions of the tusks and fragments of cranial bones in a well sunken to the Aftonian, near Akron. The well, more fully described by Shimek (Bull. Geol. Soc. Amer., XXI, p. 126) has a depth of twenty-four feet, reaching down probably to the Nebraskan. Two sloth

bones also were found here. The mastodon remains are described on a future page as *Rhabdobunus mirificus*. The sloth remains consisted of the ankylosed first and second phalanges of the third digit of the hind foot of a ground sloth, probably a species of Megalonyx.

18. *Rodney, Monona County.*—In Grant township (township 85 north, range 44 west), are three exposures of Aftonian, but none have yet afforded vertebrate fossils. A sand pit, the Woodward, is found in the southwest quarter of section 9, about two miles southwest of Rodney (Shimek, Bull. Geol. Soc. Amer., XXI, p. 128; Iowa Geol. Surv., XX, p. 344). An exposure occurs on the northwest quarter of section 7 (Shimek, Iowa Geol. Surv., XX, p. 341, pl. XXVII, fig. 1); also on the southwest quarter of section 17 (Shimek, Bull. Geol. Soc. Amer., XXI, p. 128).

19. *Turin, Monona County.*—In the northeastern part of Turin is located the Elliott gravel pit, which has furnished a considerable number of vertebrate fossils, elephants, mastodon, camel, horses, etc. It was referred to by Calvin (Bull. Geol. Soc. Amer., XX, pp. 344, 345) and has been more particularly described by Shimek (Bull. Geol. Soc. Amer., XXI, p. 129; Iowa Geol. Surv., XX, p. 340), with lists of fossils.

Three species of horses seem to be represented in the remains found in this pit. No. 283 *b* of the collection at Iowa City is referred to *Equus excelsus;* Nos. 122 *a,* 136, 227, 282, 283 *a,* and 284, to *Equus niobrarensis;* and Nos. 261, 184, 242 *a,* 242 *b,* and 285 to *Equus complicatus.* Here was found the fine radius of the sloth Megalonyx represented on plate V, fig. 3. The elephants *Elephas imperator* and *Elephas columbi* were both reported from this locality by Calvin. In the collection at the State University is a last upper molar of the mastodon *Mammut americanum* from the Elliott pit. In the same collection is a part of an incisor of the giant beaver *Castoroides ohioensis.*

20. *Castana, Monona County.*—The Ordway pit is located on the right bank of Maple river, opposite Castana. It is described as being on the southeast quarter of section 13, Kennebec township (township 84 north, range 44 west) (Shimek,

Bull. Geol. Soc. Amer., XXI, p. 130). The Aftonian, eight to twelve feet thick, rises about forty feet above the Maple bottom lands. In the pit are found many heavy-shelled unios and smaller mollusks. About one-eighth of a mile distant, in an old pit, there was found some years ago, by Mr. J. B. P. Day, a large scapula, now No. 91 of the Iowa University collection. Shimek (Iowa Geol. Surv., XX, p. 357) mentions a sand pit on the southeast quarter of section 35 of this same township.

In the collection of the State Historical Department, at Des Moines, is a large tusk, No. 5534, which is labeled as having been found in a well at Castana. It is not known whether it belonged to one of the elephants or to one of the mastodons. It was found by Mr. J. B. P. Day.

21. *River Junction, Johnson County.*—At this place, in section 12, township 77 north, range 6 west (Fremont township), on a river sand-bar, there was collected by Professor Shimek the tip of a proboscidean tusk. It has the catalog number 158 in the collection of the State University of Iowa.

22. *Marble Rock, Floyd County.*—Here was found in the southwest quarter of section 16, Union township (township 94 north, range 17 west), a fine tooth of the mammoth *Elephas primigenius* which is in the collection of the State University, and has the number 381. It was found by Mr. G. W. Ritter and secured for the collection by Mr. A. O. Thomas, in some gravels, which are valley trains formed by the melting of the Wisconsin ice-sheet. The pit where the tooth was found is known as the Chicago, Rock Island and Pacific gravel pit. This tooth is referred to on another page. Number 299 of the same collection is a fragment of a much worn molar from Marble Rock. It is credited to Mr. Mitchell. Number 17 of the same collection appears to be a second true molar of *Elephas columbi.* There are ten plates present, but some are missing from the rear. The enamel is thick. Some years ago a fine tusk was uncovered here; but it crumbled soon after exhumation and none of it was saved. It belonged probably to *Mammut americanum,* the mastodon.

23. *Robinson pit, Harrison County.*—Shimek (Bull. Geol. Soc. Amer., XXI, p. 134; Iowa Geol. Surv., XX, pp. 336, 337)

describes the Robinson pit found on the southeast quarter of section 16, Raglan township (township 80 north, range 44 west). He presents a list of the fossils, but no vertebrates had been found there up to that time.

24. *South Omaha, Nebraska.*—Professor Shimek (Bull. Geol. Soc. Amer., XXI, p. 138) described a section found in the Offerman pit at South Omaha. From this had been obtained remains of the horse Equus and of an elephant supposed to be *Elephas imperator.*

25. *Muscatine, Muscatine County.*—At Muscatine there are afforded sections of Pleistocene deposits. McGee (11th Ann. Rep., U. S. Geol. Surv., pp. 491-493, pl. L) described one of these and presented an illustration. Leverett (Monogr. U. S. Geol. Surv., XXXVIII, p. 47) states that the section has an extent of from 165 to 200 feet. He seems to find here Nebraskan till, Aftonian peaty soil, Kansan till, silts and fine sands that appear to have the position of the Yarmouth, Illinoian drift, Sangamon black soil, and loess referred to the Iowan. Calvin (Bull. Geol. Soc. Amer., XX, p. 143) speaks of probable Sangamon here. Shimek (Bull. Geol. Soc. Amer., XXI, p. 139) has examined the Aftonian at this point. He states that Prof. F. M. Witter at one time found in a layer of gravel at the top of this Aftonian, a part of a molar of the mammoth, *Elephas primigenius.* The same writer (Proc. Iowa Acad. Sci., Vol. XIV, p. 239) described an exposure facing Hershey street, near Green street, which showed three feet of bluish gray fossiliferous loess on Kansan drift and covered by Illinoian drift. See also J. A. Udden in Iowa Geol. Surv., IX, pp. 328-362. A section is to be seen at the brickyard east of Mud creek. At the State University of Iowa the writer has seen a molar tooth (Cat. No. 357), probably the second upper true molar, which had been found in a public road cut along Mud creek at Muscatine. The finder of the tooth was Mr. F. M. Van Tuyl. In a note to the writer Shimek states that the Nebraskan is here well developed, as at other points below Muscatine. In what was supposed to be loess Prof. F. M. Witter found remains of a caribou described on a succeeding page as *Rangifer muscatinensis.*

26. *Toledo, Tama County.*—Near the town of Toledo, on the southwest corner, section 19, Toledo township (township 83 north, range 15 west), is a geological section which was described by Doctor Calvin (Bull. Geol. Soc. Amer., XX, p. 136, pl. I, fig. 2). He says that the two drifts (Kansan and Nebraskan) are separated by a mere thin soil band. The lower drift is compact but plastic, and left the imprint of the steam shovel, while the upper, or Kansan, broke into angular fragments. Professor Savage probably referred to the same section (Iowa Geol. Surv., XIII, p. 230, fig. 28). According to him the old soil is eighteen inches or two feet thick, with fragments of wood, bits of roots, etc. This would be Aftonian.

27. *Oelwein, Fayette County.*—Calvin (Bull. Geol. Soc. Amer., XX, pp. 139, 140, pl. II, fig. 2) tells of an old tamarack swamp here, three feet thick, with great quantities of compressed moss, "almost as fresh as when it grew," underlain by dark Nebraskan and covered by twenty feet of Kansan and Iowan till.

W J McGee (11th Ann. Rep., U. S. Geol. Surv., p. 489) mentions an exposure, probably the same, one mile north of Oelwein. See also Macbride in Proc. Iowa Acad. Sci., IV, p. 63.

28. *Yarmouth, Des Moines County.*—On the border of the village of Yarmouth, on the property of William Stelter, was made a well which furnished Professor F. Leverett the section published here on page 27. At a depth of about thirty-four feet were struck deposits amounting to about forty-three feet which take their name Yarmouth from this village. For further information consult Leverett (Monogr. XXXVIII, pp. 41, 120; Proc. Iowa Acad. Sci., V, p. 82). From the well mentioned there was obtained a portion of the pelvis and part of a femur of a rabbit, *Lepus sylvaticus,* and the scapula of a skunk, *Mephitis mephitica.* The identifications were made by Dr. F. W. True, of the U. S. National Museum. It is very probable that more complete skeletons of these animals would indicate different, possibly extinct, species.

29. *Davenport, Scott County.*—The geology of the vicinity of Davenport has been discussed by many writers. McGee (11th Ann. Rep. U. S. Geol. Surv., p. 491, fig. 77) describes a

section. In Monograph XXXVIII of the U. S. Geological Survey, on pages 45, 128, and 167, Leverett presents and discusses three sections here. From these we learn that there are seen in this city, at the top, what Leverett then called Iowan loess; then, at one point at least, an old soil about one foot deep which lies on Illinoian till, and is to be regarded as Sangamon; below the Illinoian till, at one point, a clay that appears to represent the Yarmouth interglacial stage; and below this from 25 to 40 feet of Kansan. At the junction of the Iowan loess and a blue clay, apparently regarded as Illinoian drift, in a railroad cut, were found remains believed to belong to *Elephas primigenius,* the elephant. Besides the papers cited the reader may consult Leverett (Zeitschrift Gletscherkunde, Vol. VI, p. 296); Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 143); Shimek (Bull. Lab. Nat. Hist., Iowa Univ., Vol. V, p. 361; Iowa Geol. Surv., Vol. XX, p. 376); Norton (Iowa Geol. Surv., Vol. IX, p. 471); McGee (11th Ann. Rep. U. S. Geol. Surv., p. 491, fig. 77).

Professor Shimek informs the writer that his footnote (Iowa Geol. Surv., Vol. XX, p. 376) was, with respect to the Aftonian, perhaps too positive. He had chiefly in mind the presence of two loesses and the reference of these is quite definite and positive. The same general region presents both Aftonian and Nebraskan.

W. H. Pratt (Davenport Acad. Sci., Vol. I, 1876, p. 96) gives an account of an examination of a section exposed by the Chicago, Rock Island and Pacific railroad, west of Davenport. Among other things a tusk, several molars and some bones of a mammoth were found. These are said to have been placed in Griswold College, but they appear to have been transferred to the Davenport Academy of Sciences. These are the elephant remains referred to by Leverett as above cited. Shimek (Iowa Geol. Surv., Vol. XX, p. 376) gave a different interpretation to the section described by Pratt. Shimek regards the "bluish gray clay," Pratt's No. 3, as being the post-Kansan loess; the peat and the ancient soil as being Aftonian instead of Sangamon. According to this interpretation the Kansan drift is missing at that point, as well as the Illinoian. Possibly the elephant bones represent the Illinoian stage.

In the Davenport Academy collection is a large molar of an elephant which was found on the farm of Mr. Sullivan, near Buffalo, Scott county. H. W. Parker (Science, series I, Vol. IV, 1884, p. 46) mentions elephant remains which had been found near Davenport. J. A. Udden (Geol. Surv. Iowa, Vol. IX, 1899, p. 356) states that mastodon remains have been found in the western part of Davenport, from Sangamon soil, resting on Illinoian till. Leverett (Monogr., U. S. Geol. Surv., XXXVIII, p. 167) discusses the geological position of this specimen and thinks that it may have been derived from the Sangamon soil and redeposited in the loess.

30. *Montpelier, Muscatine County.*—Calvin (Bull. Geol. Soc. Amer., XX, p. 143) mentions this as one locality near the village of Montpelier which seems to present Sangamon deposits.

Here may be recorded the elephant remains reported by Doctor Udden from near center of the southwest quarter of section 12, township 77 north, range 1 west (Sweetland township). They are said to have been found in a peat deposit which contained large pieces of gymnospermous wood. The bones are reported to have been placed in Mr. Charles Weir's museum in Muscatine. The peat is regarded as belonging to the Sangamon. As explained in a note on the elephants of Muscatine county, on a succeeding page, the name just mentioned should be James M. Wier and the bones are now in the Muscatine Library.

31. *Des Moines, Polk County.*—Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 148) mentions sections here, in which are shown, (1) Kansan drift; (2) fossiliferous loess, containing terrestrial mollusks; (3) Wisconsin drift. In the collection of the State Historical Department, at Des Moines, the writer examined an upper last molar of the mastodon, *Mammut americanum,* which had been found somewhere about Des Moines. In the same collection are some teeth of the mammoth, *Elephas primigenius,* found in the city; likewise others belonging to *Elephas columbi.* It is unfortunate that no exact record has been kept regarding the levels where these teeth occurred. For mention of these see under notes on Elephants which have been found in Iowa. In the National Museum there is a thor-

oughly petrified tooth of some species of bison which was sent from Des Moines many years ago by Claude D. Brown. It is mentioned further under *Bison antiquus*.

Here may be mentioned some bones which are reported by Prof. J. L. Tilton (Pleistocene deposits of Warren county, Iowa, p. 26) as having been found in a gravel pit at Avon, Polk county. Among these bones were some large ones and a tusk which were supposed to belong to a mastodon. Later other bones were found, one of which the writer has examined. It belongs to a caribou (*Rangifer muscatinensis*). The exact age of this deposit is not known, but the caribou indicates at least a pre-Wisconsin stage.

32. *Carroll, Carroll County.*—Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 149) refers to Shimek's studies here, which show, from below upwards, (1) typical Kansas drift, oxidized and weathered; (2) an old blue fossiliferous loess, with a weather-stained band at the top; (3) a much younger, unaltered, yellow, post-Iowan loess and (4) Wisconsin drift. Only a single fossil has been secured. In the collection of the State University of Iowa is the distal end of the left tibia of an elephant or mastodon, No. 10 of the catalog. The fragment is about one foot long and the articular face is perfectly preserved. This bone was found by Mr. Henry Aitkin. Shimek (Bull. Lab. Nat. Hist., Univ. Iowa, Vol. V, p. 367) reports here a gumbo and a black mucky soil overlying Kansan drift. This might belong to the Yarmouth. See Shimek on various exposures near Carroll (Proc. Iowa Acad. Sci., Vol. XIV, pp. 239-240). In a later publication (Iowa Geol. Surv., Vol. XX, p. 390) Shimek gives the following section found northeast of Carroll:

		FEET.
6.	Wisconsin drift	1–5
5.	Yellow loess (post-Iowan?) about	10
4.	Bluish gray loess (post-Kansan)	5–6
3.	Black, mucky, soil-like band	1
2.	Heavy, reddish joint-clay (Loveland)	1
1.	Kansan drift.	

33. *Near New Boston, Lee County, in an exposure along the Santa Fe railroad.*—Leverett (Monogr. XXXVIII, U. S. Geol. Surv., p. 31) mentions the occurrence of a sheet of loess

underlain by a black gummy clay (gumbo). In this was found and examined some coniferous wood, probably spruce, according to F. H. Knowlton.

In Netta C. Anderson's list Mr. Justus M. T. Myers reported having found, on Lost creek, in this county, a leg bone, a short rib, and piece of tusk; and, on Sugar creek, a molar. These may have belonged to either a mastodon or a mammoth.

34. *Near Blue Grass, Scott County.*—Leverett (Monogr. U. S. Geol. Surv., XXXVIII, p. 46) found, both north and south of this place, evidences of what are probably Sangamon and Yarmouth soils and weathered zones.

35. *West Point, Lee County.*—Leverett (Monogr. U. S. Geol. Surv., XXXVIII, p. 53) presents a section observed in a ravine, about one mile northeast of West Point, which shows what he then regarded as follows:

	FEET.
Yellow silt or loess (Iowan)	6
Soil (Sangamon)	5
Brown till, with bowlders (Illinoian)	15
Black muck (Yarmouth)	6
Brown clay (Kansan)	15
Total	47

See also Leverett in Proceedings of the Iowa Academy of Science, Vol. V, pages 79, 83.

36. *Near Fayette, Fayette County.*—On the southwest quarter of the northeast quarter of section 3, Smithfield township (township 92 north, range 8 west), two miles south of Fayette, McGee (11th Ann. Rep., U. S. Geol. Surv., p. 488, fig. 74) found a section in a railroad cut, where was seen an old forest bed with fragments of wood.

37. *Near Maynard, Fayette County.*—McGee (11th Ann. Rep. U. S. Geol. Surv., p. 489, fig. 75) found one foot of an ancient soil, with some wood, identified as cedar and ash. Three sections of a partly silicified tree trunk, seven inches in diameter, were seen. Above the soil there was eight feet of drift with bowlders, and below the soil a compact blue clay. The locality is in a railroad cut, one mile south of Maynard.

38. *Near Iowa City, Johnson County.*—On the southeast quarter of the southwest quarter of section 11, Union township

(township 79 north, range 7 west), McGee (11th Ann. Rep. U. S. Geol. Surv., p. 490) discovered a geological section which showed six inches of peat beneath five feet of loess. A similar section, with eighteen inches of peaty clay, was seen in the southwest quarter of the northwest quarter of section 10, township 78 north, range 7 west (Sharon township). For fossils of this locality see Shimek in Bull. Lab. Nat. Hist., Iowa Univ., Vol. V, p. 365.

This author, as cited, describes sections in township 79 north, ranges 6 and 7 west, which present post-Kansan and post-Iowan loesses. The lower is pale bluish gray; the upper, yellow. The lower is often underlain by gumbo. Each loess may be from four to six feet thick; the gumbo, one foot.

See also page 366 of the paper just cited, where exposures in the north part of Johnson county are mentioned.

In Madison township (township 80 north, range 7 west) Shimek (Proc. Iowa Acad. Sci., Vol. XV, p. 60, pl. VI, fig. 1) found sections in which the loess is banded with layers of sand.

In section 27, township 79 north, range 6 west, there was discovered some years ago, at a time of low water, in the bed of Iowa river, a nearly perfect tusk belonging probably to *Elephas primigenius* (Pl. LVII, fig. 1). The catalog number in the collection of the State University of Iowa is 115. In 1913 there was found at nearly the same place a nearly perfect first lower molar. This is yet in the possession of the finder.

39. *Albia, Monroe County.*—McGee (11th Ann. Rep. U. S. Geol. Surv., p. 493, fig. 78) describes an exposure of loess, "upper till," a forest bed with grasses, stems of indigenous plants, cones, rootlets, etc. The locality is just north of the town of Albia.

40. *Sol Smith Lake, Harrison County.*—Shimek (Iowa Geol. Surv., Vol. XX, p. 337) describes the Wallace pit, found in the northwest quarter of section 31, Little Sioux township (township 81 north, range 45 west). The pit is just north of Sol Smith Lake. Aftonian deposits are found here. See Shimek also in Bull. Geol. Soc. Amer., Vol. XX, p. 405 and Vol. XXI, p. 134.

41. *Wilkenson well, Monona County.*—Shimek (Iowa Geol. Surv., Vol. XX, p. 343) described a well in the northwest quarter of section 6, Cooper township (township 85 north, range 42 west), which is known as the Wilkenson well. At a depth of from thirty-five to forty feet, in loose sand and gravel, a molar, a part of a tusk (Pl. XLIX, fig. 1) eight feet long on outer curve, and fragments of cranial bones of a mastodon were found. These were regarded as occurring in the Aftonian deposits. In the collection at the State University of Iowa the tusk has the catalog number 234; the cranial bones, the numbers 204-211; and the upper end of an ulna, the number 203.

Under this number may be mentioned the Pinckney pit, in the southwest quarter of section 30, Cooper township (township 85 north, range 42 west) (Shimek, op. cit., p. 357).

42. *McCleary pit, Monona County.*—Shimek (Iowa Geol. Surv., XX, p. 344) describes the McCleary pit on the southwest quarter of section 1, Saint Clair township (township 84 north, range 42 west). No vertebrate remains were found, but some Unio shells were discovered.

43. *McGavern pit, Harrison County.*—What is known as the McGavern pit is located on the southeast quarter of section 27, St. Johns township (township 78 north, range 44 west). Consult Calvin (Bull. Geol. Soc. Amer., XX, p. 140, pl. III, fig. 2) and Shimek (Bull. Geol. Soc. Amer., XX, p. 406, pl. XXXVI, figs. 1, 2). Shimek (Iowa Geol. Surv., XX, p. 351) describes the pit accurately. No vertebrate fossils were found. Displaced and disturbed Aftonian was observed.

44. *Persia, Harrison County.*—Shimek (Iowa Geol. Surv., Vol. XX, p. 352) describes a section observed in a pit on Mosquito creek, near the town of Persia.

45. *Mefferd pit, Harrison County.*—Shimek (Iowa Geol. Surv., Vol. XX, p. 332) describes a geological section found in the southeast quarter of section 31, township 80 north, range 41 west (Douglas township). Aftonian deposits occur in the section, but no fossils were found.

46. *Near Grand View, Louisa County.*—J. A. Udden (Geol. Surv. Iowa, Vol. XI, p. 109) reported from the southwest quar-

ter of the southwest quarter of section 11, Grand View township (township 75 north, range 3 west), near Grand View, a soil intervening between the loess and the upper till; said to be black and peaty. An elephant's tooth of unknown species was once found in digging a shallow well in section 28 of the same township. Aftonian sands and gravels are reported by Udden to have been observed on the southeast quarter of section 2.

The soils and the elephant tooth would belong probably to the Sangamon.

47. *Pottawattamie County.*—J. A. Udden (Iowa Geol. Surv., Vol. XI, p. 260) reported that a bison skull had been dug out of a well at a depth of fourteen feet, in the loess. The locality is near the middle of the east line of section 28, James township (township 76 north, range 40 west). This bison belonged probably to *Bison occidentalis,* or it may have been *B. antiquus.*

Near the same locality a stone ax is said to have been found in the loess at a depth of thirty feet. It is unfortunate that such finds cannot be verified.

48. *Oneida Township, Delaware County.*—Calvin (Iowa Geol. Surv., VIII, p. 165) tells of a forest bed being found below Kansan in trenches dug along a roadside in Oneida township. This would be Aftonian, if the drift called Kansan is really such. The locality is on the southwest quarter of section 6, township 89 north, range 4 west.

49. *Near Leon, Decatur County.*—Bain (Iowa Geol. Surv., Vol. VIII, pp. 287-8) reported an exposure showing a black "gumbo" soil which contained some roots. It is located on the southwest quarter of section 29, Center township (township 69 north, range 25 west). This would probably belong to the Aftonian.

50. *Near Dalton, Plymouth County.*—Bain (Iowa Geol. Surv., Vol. VIII, p. 336) reported an old soil in an exposure seen on the southeast quarter of section 11, township 92 north, range 46 west (Washington township). This is near Dalton, and west of Le Mars.

51. *Le Mars, Plymouth County.*—Bain (Iowa Geol. Surv., Vol. VIII, p. 336) reported an exposure of an interglacial de-

posit here. The loess rests on stratified gravels and is about three and one-half feet thick. Here was found an imperfect innominate bone, No. 259 of the collection at the State University of Iowa, which may have belonged to the mastodon *Mammut americanum* or to *Rhabdobunus mirificus*. Recently in a gravel pit at this place Prof. G. F. Kay obtained a large fragment of a limb bone of some proboscidean, No. 379 of the collection.

52. *Near Mouth of Broken Kettle Creek, Plymouth County.*—Bain (Geol. Surv. Iowa, Vol. VIII, p. 348) tells of a terrace forty-five feet above low water of Sioux river at this place which contains many unios. These, as the writer is informed by Professor Shimek, are connected in large part, if not wholly, with the work of the aboriginal inhabitants. Possibly some of those near the level of the river plain are a part of an alluvial deposit. Those higher up seem to be connected with refuse heaps.

On section 11, township 90 north, range 48 west (Hancock township) was seen a bit of old soil on the slope of a hill, in a wagon road cut, just west of Dalton. This old soil was from twelve to eighteen inches thick and lay between Kansan drift and the loess.

53. *Near Albion, Marshall County.*—Beyer (Iowa Geol. Surv., Vol. VII, p. 231) reported an exposure of probable Aftonian near this place in or near sections 1 or 2, township 84 north, range 19 west. There are gravels and sands about ten feet thick, underlain by a blue till supposed to be Nebraskan. In Nettie C. Anderson's list, Professor Norton reported that a large molar of a mammoth, in a perfect state of preservation, had been found in Iowa river, near Albion. It is in Cornell College, Mt. Vernon, Iowa.

54. *Near Wapello, Louisa County.*—J. A. Udden has reported (Geol. Surv. Iowa, Vol. XI, p. 109) that old soils occur near the center of section 23, township 74 north, range 3 west (Port Louisa township). Below peat Udden observed dark curving cylinders resembling animal burrows going down into the underlying deposit. A soil was observed in the northwest quarter of the northwest quarter of section 15 of the same township. East of the north and south railroad bridge the peat

is replaced by a thick tangle of decayed gymnospermous plants. These soils and peats belong to the Sangamon.

Under this number may be mentioned a tooth of the elephant, *Elephas primigenius,* No. 61, of the State University collection, which is labeled as having been found near Wapello. It is much worn. Its geological age is unknown.

Udden, as cited, page 110, reported that Mr. George Gresham had found in what was regarded as Sangamon soil, in the northwest quarter of section 14, township 74 north, range 3 west (Port Louisa township), the antler of a deer. Mr. Gresham has informed the writer that he still has a part of this antler. It is not probable that this belonged to any living species of deer.

55. *Near Fort Dodge, Webster County.*—F. A. Wilder (Iowa Geol. Surv., XII, pp. 130-131) reports Aftonian sandstone and gravel in a pit of the Ft. Dodge Brick and Tile Company.

56. *Denmark, Lee County.*—Leverett (Proc. Iowa Acad. Sci., Vol. V, pp. 79, 83) discusses the presence of old soils, Yarmouth and Sangamon, in Lee county. Various exposures along the roadside were observed between West Point (see locality No. 35) and Denmark and between Denmark and Ft. Madison. In all such exposures search should be made for remains of organized beings.

Here may be recorded fossil remains found not far from Ft. Madison and which are further described under Notes on the Mastodons which have been found in Iowa.

57. *Malvern, Mills County.*—J. A. Udden (Iowa Geol. Surv., Vol. XIII, p. 170) reported the discovery of mammoth remains at Malvern. These had been found in 1879, at the crossing of First avenue and Railway street, in grading the Chicago, Burlington and Quincy railway. Three teeth, a part of a tusk and two long horns are reported to have been found. These remains are now preserved at Tabor College and have been examined by the writer. They are described in their proper place under Notes on remains of Elephants which have been found in Iowa.

58. *Washington Township, Pottawattamie County.*—J. A. Udden (Iowa Geol. Surv., Vol. XI, p. 260) reported that the bones of an elephant had been found in section 34, township 75 north, range 41 west. Apparently they occurred in the loess. Where these bones now are and to what species they belonged is not known to the writer.

59. *Near Morning Sun, Louisa County.*—J. A. Udden (Iowa Geol. Surv., Vol. XI, p. 106) mentions old soils which belong to the Yarmouth stage as occurring in a ravine in the southwest quarter of the southwest quarter of section 32, township 73 north, range 3 west (Morning Sun township), and again near the northwest corner of section 33.

60. *Lyon County.*—Shimek (Bull. Geol. Soc. Amer., Vol. XXIII, 1912, p. 137) gives the following section found in the southwest quarter of section 33, Centennial township (township 99 north, range 48 west): *(1)* Nebraskan, typical blue-black till, with large numbers of bowlders, 60 feet; *(2)* Aftonian, chiefly sand, with a few lines of pebbles, capped by about 2 feet of silt containing shells, 10 feet; *(3)* Kansan, 15 feet exposed, but with Kansan bowlders on hillside to height of 85 feet above the section. "Finest exposures of Nebraskan yet discovered, and the exposure is clear for fully 60 feet."

61. *Lyon County.*—On the northwest corner, section 21, Centennial township (township 99 north, range 48 west) Shimek (Bull. Geol. Soc. Amer., XXIII, p. 138) obtained the following section:

		FEET.
3.	Kansan, typical	15
2.	Aftonian—Loose sand and gravel	24
	Conglomerate forming a ledge	5½
	White, calcareous, marly stratum, probably Aftonian	5
1.	Nebraskan, typical, to creek	15

Shimek publishes another exposure in the same section and two others seen in the next township west, number 49.

62. *Union County, South Dakota.*—From Otis Mill, Union county, southwest quarter of section 29, township 94 north, range 48 west, Todd (Elk Point folio, No. 156, U. S. Geol. Surv., p. 4) reported that a lower jaw of a horse had been found.

Shimek (Bull. Geol. Soc. Amer., Vol. XXIII, p. 140) reported the deposit as Aftonian, being a bed of fossiliferous silt resting on Cretaceous. Shimek informs the writer that the fossiliferous stratum has been referred to the loess, but that the molluscan fauna is distinctly of the alluvial type. Above the silt is a stratum of gravel, and on this a thick bed of Kansan drift, which in turn is covered with loess.

In Sioux County, Iowa, about two miles north of Chatsworth, Shimek (Bull. Geol. Soc. Amer., XXI, p. 127) found Aftonian sand and gravel in a cut along the Chicago, Milwaukee and St. Paul railroad. No fossils are reported.

63. *Fairview, Lincoln County, South Dakota.*—Shimek (Bull. Geol. Soc. Amer., Vol. XXIII, 1912, p. 144) reports exposures one mile south of Fairview along the Chicago, Milwaukee and St. Paul railroad:

2. 30 feet gravel, Aftonian?
1. Nebraskan, typical blue-black.

Between the two is a silt band, tough, reddish, and laminated.

64. *Granite, Lyon County.*—About one mile west of Granite Shimek found the following section:

	FEET.
3. A gravelly yellowish stratum of uncertain age	3–6
2. Bed of sand and gravel	3–5
1. Weathered grayish drift, probably Kansan, exposed	5

"A worn fragment of the molar of a horse was found in the gravel bed." (Shimek, Bull. Geol. Soc. Amer., Vol. XXIII, pp. 145, 151.) The tooth may have been derived from some older deposit, but probably not.

65. *Near Morning Sun, Louisa County.*—In the bank of Otter creek, on the northwest quarter of section 25, Morning Sun township (township 73 north, range 4 west), were found some years ago some remains of an elephant, consisting of a lower jaw, with a tooth, part of the pelvis, ribs, and piece of tusk. Here the bank of the creek consists of materials resembling a Sangamon soil (Udden, Geol. Surv. Iowa, XI, p. 110).

66. *Grinnell, Poweshiek County.*—J. A. Udden (Augustana Lib. Publ., No. 5, p. 53) reported mastodon remains from this place. Details are not given.

Barbour (Science, ser. 1, Vol. XVI, 1890, p. 263) gave an account of the discovery of remains of two elephants at Grinnell. Tusks, teeth and other parts are reported. See an earlier report by H. W. Parker (Science, Vol. IV, 1884, p. 46). Some of these remains are in Grinnell College, and these have been examined by the writer. The tusk and teeth found in Grinnell belong to *Elephas primigenius*. These remains are further discussed in the part of this paper devoted to the elephants found in Iowa.

67. *Marengo, Iowa County.*—No. 324 of the collection at the Iowa State University is a first lower true molar which was found by Mr. Wm. Walker along Bear creek, in the northwest quarter of the northwest quarter of section 25, Marengo township (township 81 north, range 11 west). This tooth belongs to *Elephas primigenius* (Pl. LV. fig. 3). From the alluvial deposits along Iowa river, at Marengo, was obtained a nearly complete lower jaw of an Elephas (Calvin, Bull. Geol. Soc. Amer., Vol. XX, pl. XXV, fig. 3). Calvin regarded it as *Elephas columbi,* but the great number of plates, nine, in a 100 mm. line, the relatively small size of the teeth and the thinness of the enamel indicate *Elephas primigenius.*

68. *Monona County.*—Shimek (Bull. Geol. Soc. Amer., XXI, p. 129; Iowa Geol. Surv., Vol. XX, p. 347) described the Weniger pit, situated on the east one-half of section 18, Kennebec township (township 84 north, range 44 west). The Aftonian here rises to about forty feet above the Missouri river bottoms. Above it is typical Kansan drift. No vertebrate fossils have yet been found at this place.

69. *Correctionville, Woodbury County.*—In the collection at the Iowa State University is a much worn tooth of *Elephas primigenius,* possibly the last milk molar. This was found in the Gilleas pit and is numbered 355. In the same collection are a horn-core, No. 350, and the base of a skull of a bison, both probably of the same individual, and belonging to *Bison occidentalis.* They were found in the Welch pit. There is also the scapula of a bison from this locality, No. 354. It may have belonged to the species named above, but of this one cannot be certain. Here, too, were found two portions of antlers of some

species of caribou. These are Nos. 352 and 351 of the collection at the State University of Iowa. They will be described and figured in their proper place. The caribou antlers, together with the bison remains, were found in the Welch pit and the writer regards them as older than the Wisconsin stage.

70. *Waterloo, Black Hawk County.*—In the Iowa State Historical Department's collection, at Des Moines, are two large last upper molars, right and left, considerably worn, Nos. 4527 and 4532, and another much worn tooth, No. 4525. They were found in a sand pit, seven feet from the surface. They are referred to *Elephas primigenius.*

This region is covered by Iowan drift underlain by Kansan, but what are the relations of the sands of this pit to the two drift sheets the facts at hand do not enable the writer to determine.

71. *Clear Lake, Cerro Gordo County.*—In the Iowa State Historical Department's collection is a lower jaw, with right and left last molars, of an Elephas, which the writer refers to *E. primigenius.* It was found in 1898 by Mr. H. I. Smith and has the catalog number 4521. There are eight plates in a 100 mm. line. The thick and somewhat crimped enamel resembles somewhat that of *Elephas columbi.* This locality is on the border of the Wisconsin drift, and the age of the jaw may be post-Wisconsin, or late Wisconsin, for the hairy mammoth might have lingered around the borders of the glaciers.

72. *Clinton, Clinton County.*—In the collection of the Davenport Academy of Science is a lower tooth which is referred to *Elephas columbi.* This was found somewhere about Clinton by Mr. Thos. J. Fraser.

In the Chicago Academy of Science there is a tooth and a tusk of Elephas which were found at Clinton and reported in Nettie C. Anderson's list by F. C. Baker.

73. *Big Rock, Scott County.*—In the collection of the Davenport Academy is a part of a tooth of an Elephas which the writer refers with some doubt to *E. columbi.* It was found at Big Rock by Mr. A. W. Manchester.

75. *Cherokee, Cherokee County.*—To *Elephas columbi* is referred a tooth, No. 325, of the Iowa State University collection. It was found in the Turner pit, three miles north of Cherokee, in what is called Cherokee sands.

Mr. Richard Herrmann, of Dubuque, has informed the writer that, about 1875, a tusk of an elephant or of a mastodon was found in a gravel pit of the Illinois Central Railroad, at Cherokee. The pit was on the east side of the river. This tusk was nine feet five inches long and was broken into two pieces. The larger piece was put in a saloon in Fort Dodge. A piece three feet long was placed in the office of the Railroad in Dubuque.

76. *Postville, Allamakee County.*—In 1904 Mr. Thos. French found four teeth, the lower jaw, and some vertebræ of a species of Elephas, which were sticking out of the bank of Yellow river, at a place four miles north of Postville. The remains are in an excellent state of preservation. Mr. French still owns these remains. This county lies wholly in the driftless region.

77. *Lake View, Sac County.*—From this locality there was obtained for the collection at the State University of Iowa the articular end of a large scapula. From the proximity of the spine to the anterior edge of the scapula, the writer is inclined to refer the bone to some species of Elephas. It was found in a gravel pit south of Lake View by Mr. John A. Spurrell. It is catalog number 226.

78. *Polk City, Polk County.*—Beyer (Iowa Geol. Surv., Vol. IX, p. 21) reported that a perfectly preserved molar of *Elephas primigenius* was found, in 1898, by an employe of the Chicago and North Western Railway Company. No details were given and it is not known where the tooth now is. It is also probable that Beyer did not attempt to distinguish between *E. primigenius* and *E. columbi.*

79. *Walnut Township, Jefferson County.*—J. A. Udden (Iowa Geol. Surv., Vol. XII, p. 428) reported that the lower jaw of an Elephas had been found in the bed of Walnut creek, in the northwest quarter of section 28. The writer has received a letter from the finder, Mr. Josia Bales, who says that he still owns the specimen.

Whether this belonged to *E. columbi* or to *E. primigenius* the writer does not know. Nor is it known to what stage of the Pleistocene it belonged.

80. *Montrose, Lee County.*—Number 71 of the collection at the State University belongs to the tooth of a horse which was found near Montrose, at a depth of twenty-five feet. At this depth it seems probable that Aftonian deposits had been reached.

In Nettie C. Anderson's list, p. 28, Mr. Justus M. T. Myers, of Fort Madison, reported having found a tooth of *Elephas primigenius* in a creek below Montrose; also a molar of an extinct elephant in Sugar creek; but the exact locations are not given; nor is it known where the specimens now are.

81. *Near Buffalo, Scott County.*—There is in the collection of the Davenport Academy of Science a large upper molar of Elephas from Sullivan's farm, near Buffalo.

82. *Springfield Township, Cedar County.*—W. H. Norton (Iowa Geol. Surv., Vol. XI, p. 377) reported that some teeth of a mammoth had been found in a washout, on the farm of A. T. Whitnell, in the southeast quarter of the southeast quarter of section 6, township 81 north, range 1 west. Two of these teeth are now in Cornell College. This area is covered with Kansan drift, but the relation of the teeth to this drift is not known.

83. *Rock Rapids, Lyon County.*—In the Bulletin of the Geological Society of America, Vol. XXII, p. 215, Professor Calvin mentioned a large atlas found here and supposed to be that of a mastodon. It seems rather to have belonged to *Elephas primigenius.* This bone is described on another page among the Notes on remains of Elephants which have been found in Iowa. Other proboscidean vertebræ found in the same pit are there mentioned and the conditions in which they were discovered are stated.

84. *Glenwood, Mills County.*—J. E. Todd (Proc. Iowa Acad. Sci., 1875-1880, p. 14) stated that there were found, between Glenwood and Pacific Junction, tusks, teeth, jaws, humerus, and other bones of a young *Elephas americanus.* Professor Todd has stated (Bull. U. S. Geol. Surv., 158, p. 90) that these

bones were in the base of the loess or in the top of the till. The locality is near Keg creek. They were at the east end of the railroad cut at that point; and from forty to fifty feet of drift is seen there. These bones are in Tabor College.

85. *Clarinda, Page County.*—C. A. White (Iowa Geol. Surv., Vol. I, p. 353) reported that in the valley of Nodaway river, near Clarinda, some teeth of the mastodon had been found.

86. *Blanchard, Page County.*—Calvin (Iowa Geol. Surv., Vol. XI, p. 413) stated that large bones which, from the description given, must have belonged to a mammoth or a mastodon, had been brought up from a depth of from ninety to ninety-five feet with pieces of bark and wood. These seem to have been lying in an old preglacial valley. It is unfortunate that such remains should be lost.

87. *Rippey, Greene County.*—Here was found a right scapula, which the writer has examined and which he regards as belonging probably to the mastodon *Mammut americanum.* It is in the collection of the State Historical Department at Des Moines. It probably belonged to the same animal as the humerus which bears the number 4514.

88. *Boone County.*—In the collection of the Iowa State Historical Department, at Des Moines, are various remains of *Mammut americanum.* The exact locality is not given and no details regarding depth and kind of matrix. On the map the number is placed arbitrarily.

89. *Near Adel, Dallas County.*—Calvin (Bull. Geol. Soc. Amer., Vol. XXII, p. 215) records the fact that in 1876 a complete skeleton of *Mammut americanum* was found here. It lay in a peat deposit that partly filled a "kettle" in the surface of the Wisconsin drift. It is not known what has become of this valuable specimen.

90. *New Virginia, Warren County.*—A. R. Fulton (Howe's Annals of Iowa, Vol. II, 1883, p. 102) described, under the name of *Elephas americanus,* the tooth of a mastodon which had been found on Limestone creek one and one-half miles west of New Virginia.

91. *Ottumwa, Wapello County.*—It is stated (Kansas City Rev. Sci. and Indust., Vol. III, 1879, p. 242) that a Mr. Houbler

had discovered, about six miles south of Ottumwa, the tusk of a mastodon. This was two feet two inches long. It is impossible to say whether this really belonged to a mastodon.

In the American Museum of Natural History, New York, there is a part of the rear of the skull of a species of a musk-ox, Ovibos, probably *O. moschatus,* which is credited to E. L. Lathrop, of Ottumwa. No details are known respecting the exact locality where found.

In the Iowa Wesleyan College, at Mt. Pleasant, are the nearly complete innominate bones of a proboscidean which are labeled as having been found in Des Moines river in Wapello county in 1859. There are also two ribs which are labeled as having been found near Ottumwa and presented by the Rev. E. C. Brooks. These ribs probably belong with the pelvis and are those of the Mastodon, *Mammut americanum.*

92. *Mahaska County.*—In the collection of the State Historical Department, at Des Moines, there is an upper last molar of *Mammut americanum* which is said to have been found in this county. Nothing more definite is stated. The collector was J. D. Davis, Des Moines. On the map the number is placed arbitrarily.

In the collection of the Iowa State University is the right os innominatum of a proboscidean which was found in Skunk river in Mahaska county. The bone will be described on another page and referred provisionally to *Elephas primigenius.*

Dr. Mark F. Boyd, of Oskaloosa, informs the author that the locality is about one and a quarter miles east of the bridge of the Minneapolis and St. Louis railroad. This would probably be in the southeast quarter of section 30, township 76 north, range 15 west (Spring Creek township).

93. *Wilton, Muscatine County.*—One-half mile south of this place, on Mud creek, were found remains of a proboscidean which Calvin examined. From a photograph of the scapula (Pl. LII, fig. 1) which has been preserved, the writer refers the remains to the mastodon *Mammut americanum.* (Udden, Iowa Geol. Surv., Vol. IX, p. 352). It was probably buried in Sangamon deposits.

94. *Shellsburg, Benton County.*—A rib and a tooth of *Mammut americanum* were found in alluvium along Bear creek, as reported in Nettie C. Anderson's list, on page 25.

95. *Springville, Linn County.*—In Nettie C. Anderson's list, on page 29, W. H. Norton reported the discovery of two mastodon teeth, in or on Iowan drift, near this place. These teeth are now in Cornell College.

96. *Cedar Rapids, Linn County.*—From Mr. B. L. Wick, of Cedar Rapids, the writer has received photographs and description of a tooth of *Elephas primigenius,* which was pumped up from the bed of Cedar river. The age of the deposit from which it was originally derived cannot be determined.

97. *Maquoketa, Jackson County.*—In Nettie C. Anderson's list, on page 27, W. H. Norton reported the discovery of an atlas and two vertebræ of an extinct proboscidean near the town named. These are in the collection of Cornell College.

98. *Bryant, Clinton County.*—Mr. Louis Rockrohr, of Bryant, has sent the writer a photograph of a last molar tooth of a mastodon, *Mammut americanum,* which he found while loading some gravel. It was buried at a depth of eight feet from the surface.

99. *Milton, Van Buren County.*—In the collection of the State University of Iowa there is a last lower molar, of a mastodon, *Mammut americanum,* which was found in Chequest creek, near Milton, about 1890, by W. B. Bell. The catalog number is 382.

100. *Lost Creek, Lee County.*—In Nettie C. Anderson's list, on page 28, Justus M. T. Myers reported having found, in Lost creek, a leg bone, piece of tusk, and a short rib of a mastodon. These may have belonged to either a mammoth or a mastodon. The exact locality along Lost creek is not known.

Mr. Myers reported likewise that with these remains were associated one human leg bone and one flint arrow head. However, the association of such remains in a creek bed is not usually of much significance.

101. *Mount Pleasant, Henry County.*—In Nettie C. Anderson's list, on page 27, T. E. Savage reported that several teeth

and bones of a mastodon had been found in a well near this place. They were in, or immediately below, Kansan drift. These remains are in the Iowa Wesleyan College, at Mount Pleasant.

102. *Salem, Henry County.*—In the list published by Nettie C. Anderson, page 27, Frank Leverett reported that some mastodon teeth and possibly one of a mammoth had been found, in 1884, in the valley of Big Cedar creek, Salem township, section 8. The creek had made encroachment on an old bog. Leverett did not see these teeth, and they may have belonged to either mastodon or mammoth.

In the same publication Dr. J. M. Shaffer, of Keokuk, reported that he had seen two mastodon teeth which were said to have been dug up near the bank of Skunk river, in Henry county; but no more exact locality was given.

103. *Selma, Van Buren County.*—In the collection of the Iowa State Historical Department, is a right humerus from this place, presented by Mr. A. B. Adams. It has the catalog number 4524. It lacks the proximal end. On account of its relative stoutness, the writer regards it as belonging to the mastodon, *Mammut americanum.* No details are furnished respecting locality or kind of deposit.

104. *Floris, Davis County.*—In the list of Nettie C. Anderson, on page 26, Justus M. T. Myers reported having found in Des Moines river, near Floris, two mastodon teeth, one weighing fourteen pounds, the other four pounds. This great weight indicates that the larger tooth, at least, belonged to one of the elephants.

105. *Near Clermont, Fayette County.*—In Nettie C. Anderson's list, page 26, Prof. T. E. Savage reported a proboscidean tooth from this region, stating that it was in the possession of Mr. C. E. Allen, of West Union. Mr. Allen has sent a description and a drawing of the tooth, and therefrom the writer concludes that the tooth belonged to the elephant *Elephas primigenius.* The tooth was found in a car-load of gravel, which had been obtained at a depth of about twenty feet, at a place between Elgin and Clermont. The description seems to indi-

cate that the locality is along the railroad in section 11, township 94 north, range 7 west (Pleasant Valley township).

In the same township, in section 35, was found a part of the skull of a musk-ox, *Ovibos moschatus.* It was in a clay at a depth of about twenty-six feet. The occurrence of these two boreal species here and at about the same depth seems to indicate that the animals were living there during the time of the Wisconsin ice-sheet.

106. *Webster City, Hamilton County.*—Here was found a left horn-core of *Bison occidentalis,* No. 2349 of the National Museum. It was sent, in 1878, by Charles Aldrich. It was found by him sticking out of one of the gravel bars in Boone river, at Webster City. Although this region is covered by Wisconsin drift, it is probable that the bone was derived from an older deposit. It is figured on plate XL, figure 3.

107. *Near Oakland, Pottawattamie County.*—In the collection at the State University, is a large part of an incisor tooth of the giant beaver, *Castoroides ohioensis.* It has the catalog number 106, and it is described here in its proper place. It was regarded by Calvin as being derived from Aftonian deposits.

108. *Near Dubuque, Dubuque County.*—In lead crevices somewhere about this place, Whitney collected remains of a peccary identified by Leidy as *Platygonus compressus.* These remains are referred to on a succeeding page.

At Horse Shoe Bluffs, three miles below Dubuque, there was once found a large mammoth tooth, as the writer is informed by Mr. Richard Herrmann, of Dubuque, who has been much interested in such matters. This tooth was for a long time in a saloon in the city mentioned.

Under this number may be included mention of a tooth of *Elephas primigenius* which was found in 1896 by Mr. David Dawson near the eleven mile post of the Illinois Central railroad, west of Dubuque. This tooth is now in the Herrmann Museum. It is further mentioned under Notes on remains of Elephants which have been found in Iowa.

109. *Washington Township, Story County.*—M. Stalker, of Ames, Iowa, (Iowa Geol. Surv., Vol IX, 1899, p. 210) gave an

account of the finding of some "mammoth" remains, vertebræ, part of a left femur, one end of the tibia, but no teeth. The township is 83 north, range 24 west. The bones are said to be in the State Agricultural College at Ames.

110. *Clayton County.*—Here may be recorded information received from Rev. J. Gass, formerly of Davenport. In a letter, dated October 20, 1911, from Postville, Allamakee county, he informs the writer that mammoth teeth had been found in sections 5, 16 and 23 of Wagner township (township 94 north, range 5 west). No details were furnished.

111. *Henton Station, Mills County.*—This is a railroad station situated about nine miles south of Council Bluffs and close to Missouri river. Here were found two teeth of elephants, Nos. 300 and 301 of the collection at the State University of Iowa. The present writer regards these as belonging to *Elephas columbi.* Here was found the distal end of a large humerus, No. 305, which belonged to an undetermined species of camel; and Calvin (Bull. Geol. Soc. Amer., Vol. XXII, p. 211) has reported from here a proximal phalange of another camel. Here, too, were collected teeth of horses sent to the writer by Prof. J. E. Marshall of Council Bluffs. They belonged to *Equus complicatus* and *E. laurentius.*

112. *Doon, Lyon County.*—In 1910, according to a letter written by the Henry Kahl Company, and another by Fred C. Smith, of the Sioux City Academy of Science, there were unearthed by a steam shovel operating on the line of the Great Northern Railroad, at Doon, two large tusks. These were much broken and besides soon crumbled. One of these appears to have been about ten feet long. These tusks were found in gravel at a depth of about twenty-five feet below the surface. The gravels probably belong to the Aftonian interglacial stage. It is impossible to determine whether the tusks were those of an elephant or one of the mastodons.

Fragments of one of these tusks belong to the collection at the State University of Iowa, but the writer has not seen them.

113. *Bertram, Linn County.*—In Nettie C. Anderson's list, page 28, F. C. Baker, of the Chicago Academy of Science, reported that there was in the collection of the academy a tusk,

supposed to be of a mastodon, which was found in a gravel pit at Bertram.

114. *Columbus Junction, Louisa County.*—Near this place have been found some lower teeth of *Elephas primigenius.* Photographs and measurements of the teeth have been sent to the writer by Mr. E. B. Tucker, of the town mentioned. The finder was Mr. W. A. Devore. The exact locality has been given as the northeast quarter of the southwest quarter of section 34, Union township (township 76 north, range 5 west). The teeth had been washed out of the earth and were found in a gully. The larger tooth appears to be the lower second molar, $m._2$; the others, the lower first molars, $m._1$, right and left.

115. *Indianola, Warren County.*—In Nettie C. Anderson's list, page 38, Prof. John L. Tilton, of Simpson College, reported that a lot of large bones had been found six feet below the bottom of a ravine, by workmen engaged in laying a cement foundation for a bridge on the Chicago, Burlington and Quincy railroad. This was one and one-half miles east of Indianola. In his dissertation, The Pleistocene Deposits in Warren County, Iowa (University of Chicago Press, 1911, p. 27), Professor Tilton refers to these bones and regards them as belonging to the Aftonian. The large lumbar vertebra whose measurements he gives has been examined by the writer. From the elongated cordate form of the centrum it is judged to belong quite certainly to an elephant.

116. *Near Hampton, Franklin County.*—Here was found an upper second molar of *Elephas primigenius,* in a sand pit in section 19, township 92, range 20 west (Mott township). The tooth was met with at a depth of six feet. The locality is close to the border of the Wisconsin drift, and the animal probably lived there about the time the glacial front was there or not far away.

117. *Near La Porte City, Black Hawk County.*—In the collection at Princeton University, New Jersey, are two cervical and three dorsal vertebræ of a bison which are labeled as having been taken from the bank of Cedar river at this place. From what is at present known one cannot determine to which species of Bison these ought to be assigned nor the stage of the

Pleistocene to which they belonged. It is possible that the bones are those of the yet existing bison.

118. *Bear Grove, Guthrie County.*—From this place there was sent to the National Museum, in 1892, by V. D. Merrill, a lower molar of an undetermined species of bison. No details have been furnished. It is quite probable that the tooth belonged to the yet living bison. From Mr. G. W. Merrill, a relative of V. D. Merrill, writing from Guthrie Center, the author learns that the tooth was found in a gulch about ten feet deep in the northeast quarter of the southeast quarter of section 23, township 79 north, range 33 west (Bear Grove township).

119. *Floyd, Floyd County.*—Near this place, close to the top of a twenty-five foot section along Cedar river, at the bottom of fifteen inches of light brown loam, W J McGee (11th Ann. Rep. U. S. Geol. Surv., p. 431) found some cranial bones and teeth of a bison. These probably belonged to the now existing species, *Bison bison.*

120. *Mason City, Cerro Gordo County.*—Prof. A. O. Thomas informs the writer that the Gabler gravel pit, east of Mason City, in section 11, Mason township (township 76 north, range 20 west) has furnished some Pleistocene remains worthy of note. The gravel is post-Wisconsin in age and is a part of the same valley train that is found lower down at Marble Rock, Floyd county. The foreman of the pit possesses a fine Elephas tooth which has a length of 278 mm., a height of 155 mm., and a width of 77 mm. It is worn back a distance of 120 mm. There are between nine and ten ridge plates in a line 100 mm. long. This appears to the writer to indicate *Elephas primigenius,* and the tooth is probably the last upper molar.

121. *Winthrop, Buchanan County.*—Near the east line of this county, about five miles east of Winthrop, the head of the femur of a proboscidean was found many years ago in a peaty layer, by Doctor Calvin. It has the catalog number 373 in the collection of the State University.

122. *Dale, Guthrie County.*—Number 222 of the catalog of vertebrate fossils in the collection at the State University of Iowa belongs to some fragments of a tusk of a mastodon or elephant which was found some years ago by Dr. J. Lonsdale.

A foot or more of this tusk was observed to protrude from the bank of South Raccoon river. Notice was sent to the Geological Survey of Iowa, but before the locality could be visited a freshet had washed the specimen out and all was lost except the fragments mentioned above.

123. *Eldon, Wapello County.*—In the collection at the Iowa State Teachers College, at Cedar Falls, is the greater part of the left femur of a proboscidean which, according to Prof. M. F. Arey, by a private letter, was found in the gravels along Des Moines river, near Eldon. The present writer has seen a photograph of this and he judges from the stout proportions of the bone that it belongs to the mastodon *Mammut americanum.* The head of the bone is missing.

124. *Clarksville, Butler County.*—Prof. M. F. Arey of the State Teachers College, at Cedar Falls, has informed Prof. A. O. Thomas that there are in the collection of the State Teachers College some fragments of a large tusk which had been found in a gravel pit at Clarksville. The workmen who found this tusk broke it into pieces in order to satisfy their misdirected curiosity. Whether the tusk was that of a mastodon or of an elephant it is impossible to state.

125. *Ida Grove, Ida County.*—In the collection of the Iowa Historical Department, at Des Moines, is a tooth of a proboscidean, which was found at Ida Grove by Mr. Henry Crane of the town just mentioned. It has the catalog number B140. This tusk is between four and five feet in length, and is about four inches in diameter. It is rather slender and considerably curved. It appears to be quite probably the tusk of an elephant.

126. *Red Oak, Montgomery County.*—In the collection of the Iowa Historical Department is a lower right second true molar, No. B264, which is labeled as having been found in the vicinity of Red Oak and presented by William Boll and Son. It is much worn and probably belongs to *Elephas columbi.*

127. *Near Hartford, Warren County.*—Prof. John L. Tilton, of Simpson College, reports (Pleistocene Deposits in Warren County, Iowa, 1911, p. 26) that a bone of some mammal had been found in digging a well in section 20, township 77

north, range 22 west (Richland township). With it were sticks which seem to have been burnt and partly converted into charcoal.

128. *Near Liberty Center, Warren County.*—In the publication just mentioned, page 27, Professor Tilton states that in section 19, township 74 north, range 23 west (Liberty township) Mr. George Leeper had, in digging a well, come across a thigh bone three feet or more in length and a rib. These were in the Aftonian and belonged quite certainly to some species of proboscidean.

List of the Scientific Publications Consulted in the Preparation of the Preceding Pages.

Arey, Melvin F. 1906. Geology of Black Hawk County. Iowa Geol. Survey, Vol. XVI, pp. 407-452, with figures and a map.

Arey, Melvin F. 1910. Geology of Davis County. Iowa Geol. Surv., Vol. XX, pp. 487-524, with figures and a map.

Bain, H. F. 1896. Geology of Woodbury County. Iowa Geol. Surv., Vol. V, pp. 243-299, with maps and figures.

Deposits now regarded as belonging to the Aftonian were described as lacustrine and others as gravelly drift.

Bain, H. F. 1897. Geology of Polk County. Iowa Geol. Survey, Vol. VII, pp. 265-412, with maps and plates.

Bain, H. F. 1897. Geology of Guthrie County. Iowa Geol. Surv., Vol. VII, pp. 415-487, with maps and figures.

Bain, H. F. 1898. Geology of Decatur County. Iowa Geol. Surv., Vol. VIII, pp. 257-309, with map and plates.

Bain, H. F. 1898. Geology of Plymouth County. Iowa Geol. Surv., Vol. VIII, pp. 317-366, with map and plates.

Discusses the age of the drift of the county. Mentions on p. 338 "stratified gravels" which are now regarded as Aftonian deposits.

Bain, H. F. 1898. The Aftonian and Pre-Kansan deposits in southwestern Iowa. Proc. Iowa Acad. Sci., Vol. V, pp. 81-101.

Bain, H. F. 1899. Geology of Carroll County. Iowa Geol. Surv., Vol. IX, pp. 51-107, with figures and a map.

Bain, H. F. 1903. Physiography and Geology [of Iowa]. Iowa Geol. Surv., Supplementary Report, 1903. The grasses of Iowa, pt. ii, pp. 359-373, with map of drift sheets of Iowa.

Gives a brief account of the drift sheets of Iowa. See also Calvin and Bain.

Beyer, S. W. 1897. Geology of Marshall County. Iowa Geol. Surv., Vol. VII, pp. 199-262, with maps and plates.

Describes Kansan, Iowan, and Wisconsin drifts, and the loess.

Beyer, S. W. 1899. Geology of Story County. Iowa Geol. Surv., Vol. IX, pp. 155-237, with figures and maps.

Beyer, S. W., and Young, L. E. 1903. Geology of Monroe County. Iowa Geol. Survey, Vol. XIII, pp. 353-433, with figures and a map.

Call, R. Ellsworth. 1881. Fossils of the Iowa loess. Amer. Naturalist, Vol. XV, pp. 585-586.

Call, R. E. 1881. The loess in Central Iowa. Amer. Naturalist, Vol. XV, pp. 782-784, with 1 figure.

Contains list of fossil mollusks.

Call, R. E. 1882. The loess of North America. Amer. Naturalist, Vol. XVI, pp. 369-381; 542-549, with pl. v.

Ends with a list of papers on the subject.

Calvin, S. 1896. Geology of Jones County. Iowa Geol. Surv., Vol. V, pp. 35-112, with map and figures.

Pleistocene deposits described on pp. 63-70.

Calvin, S. 1897. Geology of Johnson County. Iowa Geol. Surv., Vol. VII, pp. 35-116, with maps and plates.

Calvin, S. 1897. Geology of Cerro Gordo County. Iowa Geol. Surv., Vol. VII, pp. 119-195, with maps and plates.

Describes Buchanan gravels and the Iowan and Wisconsin drifts; also discusses the presence of Kansan drift and of postglacial deposits.

Calvin, S. 1898. Geology of Delaware County. Iowa Geol. Surv., Vol. VIII, pp. 121-192, with map and plates.

Discusses the Pleistocene, especially the Buchanan gravels and Iowan drift.

Calvin, S. 1898. Geology of Buchanan County. Iowa Geol. Surv., Vol. VIII, pp. 203-253, with map and plates.

Under the Pleistocene Calvin describes here the Kansan drift, the Buchanan gravels, the Iowan drift, the loess and postglacial deposits.

Calvin, S. 1901. Geology of Page County. Iowa Geol. Surv., Vol. XI, pp. 399-460, with map and text figures.

Calvin, S. 1905. The Aftonian gravels and their relation to the drift sheets in the region about Afton Junction and Thayer. Proc. Davenport Acad. Sci., Vol. X, pp. 18-31, with pls. i-vii.

Calvin, S. 1906. Geology of Winneshiek County. Iowa Geol. Surv., Vol. XVI, pp. 37-146, with maps and figures.

Treats of the Kansan drift, Buchanan gravels, the older loess, the Iowan drift, and the Iowan loess.

Calvin, S. 1909. Present phase of the Pleistocene problem in Iowa. Bull. Geol. Soc. Amer., Vol. XX, pp. 133-152, pls. i-v.

Calvin, S. 1909. Aftonian mammalian fauna. Bull. Geol. Soc. Amer., Vol. XX, pp. 341-356, pls. xvi-xxvii.

Calvin, S. 1910. The Aftonian age of the Aftonian mammalian fauna. Proc. Iowa Acad. Sci., Vol. XVII, pp. 177-180.

Shows, especially from their unworn condition, that the fossils could not have been redeposited from preglacial beds. Also in many cases considerable parts of the skeleton are associated.

Calvin, S. 1911. Aftonian mammalian fauna II. Bull. Geol. Soc. Amer., Vol. XXII, pp. 207-216.

Calvin, S. 1911. The Iowan drift. Jour. Geology, XIX, pp. 577-602, with 12 figures.

1. The Iowan drift is. 2. The Iowan drift is young when compared with the Kansan. 3. The Iowan drift is not a

phase of the Kansan. 4. The Iowan drift has very intimate relations to certain bodies of loess. 5. The Iowan drift is not related to the Illinoian.

Calvin, S., and Bain, H. F. 1900. Geology of Dubuque County. Iowa Geol. Surv., Vol. X, pp. 379-622, with figures and maps.

Carman, J. E. 1913. Notes on the Nebraskan Drift of the Little Sioux Valley in Cherokee County [Iowa]. (Proc. Iowa Acad. Sci., Vol. XX, pp. 231-235, with map.

Carman, J. E. 1913. The Wisconsin Drift-plain in the Region about Sioux Falls [South Dakota]. Proc. Iowa Acad. Sci., Vol. XX, pp. 237-250, with maps.

Chamberlin, T. C. 1894. Geikie's Great Ice Age, ed. 3, pp. 724-774, with map.

Seems to be first mention, according to Shimek (Bull. Geol. Soc. Amer., XX, p. 399), of the term Aftonian. See Calvin, Jour. Geology, XIX, p. 578, where it is stated that here was first used the name East Iowan.

Chamberlin, T. C. 1895. The classification of the American glacial deposits. Jour. Geology, Vol. III, pp. 270-277.

On p. 270 the terms East Iowan and East Wisconsin are changed to Iowan and Wisconsin at suggestion of Mr. Upham. The Toronto formation is recognized.

Chamberlin, T. C. 1896. Editorial [on glacial and interglacial formations]. Jour. Geol., Vol. IV, pp. 873-874.

The Aftonian is here regarded as being below the Kansan.

Chamberlin, T. C. 1897. Supplementary hypothesis respecting the origin of the loess of the Mississippi Valley. Jour. Geol. Vol. V, pp. 795-802.

Chamberlin, Thos. C., and Salisbury, Rollin D. 1885. Preliminary paper on the driftless area of the upper Mississippi Valley. Sixth Ann. Rep. U. S. Geol. Surv., pp. 199-322, with pls. xxiii-xxix and 23 text figures.

Chamberlin, Thos. C., and Salisbury, Rollin D. 1906. Geology The Pleistocene, or Glacial period. Vol. III, pp. 327-516, figs. 469-576. The Human, or Present period, pp. 517-543.

Fitzpatrick, T. J. 1898. The drift section and the glacial striae in the vicinity of Lamoni, Iowa. Proc. Iowa Acad. Sci., Vol. V, pp. 105-106, with pl. viii.

Geikie, James. 1895. The classification of European glacial deposits. Jour. Geology, Vol. III, pp. 241-269.

Gow, J. E. 1913. Preliminary note on so-called "loess" of southwest Iowa. Proc. Iowa Acad. Sci., Vol. XX, pp. 221-230.

Hay, O. P. 1902. Bibliography and Catalogue of the fossil Vertebrata of North America. Bull. U. S. Geol. Surv. No. 179, pp. 1-868.

Hilgard, E. W. 1879. The loess of the Mississippi Valley and the æolian hypothesis. Amer. Jour. Sci. (3) xviii, pp. 106-112.

Defends the aqueous theory of deposition of the loess.

Keyes, Charles. 1893. Bibliography of Iowa Geology. Iowa Geol. Surv., Vol. I, pp. 209-464.

Keyes, Charles. 1895. Geology of Lee County. Iowa Geol. Surv., Vol. III, pp. 305-407, with figures and a map.

Keyes, Charles. 1895. Geology of Des Moines County. Iowa Geol. Surv., Vol. III, pp. 409-492, with figures and a map.

Leighton, M. M. 1913. Additional evidences of post-Kansan glaciation in Johnson county, Iowa. Proc. Iowa Acad. Sci., Vol. XX, pp. 251-256.

Leonard, A. G. 1898. Geology of Dallas County. Iowa Geol. Surv., VIII, pp. 51-118, with figures and maps.

Leonard, A. G. 1902. Geology of Wapello County. Iowa Geol. Surv., Vol. XII, pp. 439-499, with figures and a map.

Leonard, A. G. 1906. Geology of Clayton County. Iowa Geol. Surv., Vol. XVI, pp. 215-307, with maps and figures.

Leverett, F. 1898. The weathered zone (Sangamon) between the Iowan loess and the Illinoian till sheet. Proc. Iowa Acad. Sci., Vol. V, pp. 71-80, with pl. iv.

Leverett, Frank. 1898. The weathered zone (Yarmouth) between the Illinoian and Kansan till sheets. Proc. Iowa Acad. Sci., Vol. V, pp. 81-88.

Leverett, F. 1899. The lower rapids of the Mississippi River. Proc. Iowa Acad. Sci., Vol. VI, pp. 74-93, with map.

Leverett, F. 1899. The Illinois glacial lobe. Monographs of the U. S. Geol. Survey, Vol. XXXVIII, pp. i-xxi; 1-817, with pls. i-xxiv, figs. 1-9.

Leverett, F. 1902. Glacial formations and drainage features of the Erie and Ohio basins. Monographs of the U. S. Geol. Survey, Vol. XLI, pp. 1-802, with pls. i-xxvi, figs. 1-8.

Leverett, F. 1904. The loess and its distribution. American Geologist, Vol. XXXIII, pp. 56-57.

Leverett, F. 1910. Comparison of North American and European glacial deposits. Zeitschrift für Gletscherkunde, Bd. VI, pp. 241-316, with pls. i-iii.

Macbride, Thomas H. 1897. A pre-Kansan peat bed. Proc. Iowa Acad. Sci., Vol. IV, pp. 63-66.

Macbride, T. H. 1901. Geology of Clay and O'Brien Counties. Iowa Geol. Surv., Vol. XI, pp. 463-508, with maps and figures.

Macbride, T. H. 1902. Geology of Cherokee and Buena Vista Counties, with notes on the limits of the Wisconsin drift as seen in northwestern Iowa. Iowa Geol. Surv., Vol. XII, pp. 303-353, with figures and maps.

Macbride, T. H. 1906. Geology of Sac and Ida Counties. Iowa Geol. Surv., Vol. XVI, pp. 509-562, with figures and maps.

McGee, W J 1878. Relative position of forest beds and associated drift formations in northeastern Iowa. Am. Jour. Sci., (3), Vol. XV, pp. 339-341.

McGee, W J 1879. Notes on the surface geology of a part of the Mississippi Valley. Geol. Mag., Vol. VI, pp. 353-361.

McGee W J 1891. The Pleistocene history of northeastern Iowa. 11th Ann. Report, U. S. Geol. Survey, pt. i, pp. 189-577, with pls. i-lxi; and text figures, 1-120.

McGee, W J 1891. The Lafayette formation. 12th Ann. Report, U. S. Geol. Survey, pp. 347-421, with pls. xxxii-xli; and text figs. 28-72.

See this especially for the Columbia formation, beginning on page 344.

Norton, W. H. 1899. Geology of Scott County. Iowa Geol. Surv., Vol. IX, pp. 391-519, with maps and figures.

Norton, W. H. 1901. Geology of Cedar County. Iowa Geol. Surv., Vol. XI, pp. 281-396, with maps and figures.

Discusses especially the Kansan drift, the Buchanan gravels, the Iowan drift, and pahas.

Norton, W. H. 1906. Geology of Bremer County. Iowa Geol. Surv., Vol. XVI, pp. 319-405, with maps and figures.

Discusses especially the loess and the paha.

Norton, W. H. 1911. Glaciated rock surfaces near Linn and near Quarry, Iowa, with a table of the bearings of glacial striæ. Proc. Iowa Acad. Sci., Vol. XVIII, pp. 79-83.

Orr, Ellison. 1907. Exposures of Iowan and Kansan (?) drift, east of the usually accepted west boundary line of the driftless area. Proc. Iowa Acad. Sci., Vol. XIV, pp. 231-236, with map.

Discusses the northeastern corner of the state; counties considered: Winneshiek, Allamakee, Clayton.

Osborn, Henry F. 1910. The Age of Mammals. In Europe, Asia, and North America. 8vo. Pp. i-xvii; 1-635, with 220 figures. New York. The Macmillan Company.

Owen, Luella A. 1904. The loess at St. Joseph [Missouri]. Amer. Geologist, Vol. XXXIII, pp. 223-228, with pls. ix, x.

Owen, Luella A. 1905. Evidence on the deposition of loess. Amer. Geologist, Vol. XXXV, pp. 291-300, with pl. xx.

This author advocated the aqueous theory to account for loess.

Pratt, W. H. 1876. Report on a geological examination of the section of the bluffs recently exposed by the C., R. I. & P. R. R. [Chicago, Rock Island & Pacific Railroad.] Proc. Davenport Acad. Sci., Vol. I, pp. 96-99, with pl. xxxii.

Pumpelly, Raphael. 1879. The relation of secular rock-disintegration to loess, glacial drift and rock basins. Amer. Jour. Sci. (3), Vol. XVII, pp. 133-144.

Argues for the aeolian theory of deposition of loess.

Salisbury, R. D. 1896. Loess in the Wisconsin Drift formation. Jour. Geol., Vol. IV, pp. 929-937.

Salisbury, R. D. See also Chamberlin and Salisbury.

Savage, T. E. 1902. Geology of Henry County. Iowa Geol. Surv., Vol. XII, pp. 237-302, with figures and a map.

Savage, T. E. 1903. Geology of Tama County. Iowa Geol. Surv., Vol. XIII, pp. 187-253, with map and figures.

Savage, T. E. 1905. Geology of Benton County. Iowa Geol. Surv., Vol. XV, pp. 127-225, with map and figures.

Aftonian noted. Also Nebraskan, Kansan and Iowan drifts.

Savage, T. E. 1905. Geology of Fayette County. Iowa Geol. Surv., Vol. XV, pp. 433-546, with figures and maps.

Shimek, B. 1890. The loess and its fossils. Bull. Lab. Nat. Hist. State Univ. Iowa, Vol. I, pp. 200-214; II, pp. 89-98.

Describes the mollusks found in the loess of Iowa and a part of Nebraska.

Shimek, B. 1897. Additional observations on the surface deposits in Iowa. Proc. Iowa Acad. Sci., Vol. IV, pp. 68-72.

Shimek, B. 1898. The distribution of loess fossils. Proc. Iowa Acad. Sci., Vol. VI, pp. 98-113.

Shimek, B. 1898. Is the loess of aqueous origin? Proc. Iowa Acad. Sci., V, pp. 32-45.

The author thinks that the loess is not of aqueous origin. The paper contains a large list of authorities cited.

Shimek, B. 1899. [Notes on mollusks of the loess]. Monogr., U. S. Geol. Survey, Vol. XXXVIII, pp. 171-176.

Shimek, B. 1899. Distribution of loess fossils. Jour. Geology, Vol. VII, pp. 122-136, with a map. Also in Proc. Iowa Acad. Sci., VI, pp. 98-113, with map.

Shimek, B. 1901. The loess of Iowa City and vicinity. Bull. Lab. Nat. Hist. Univ. Iowa, Vol. V, pp. 195-212.

Notes the species and concludes that they point to a comparatively dry upland, terrestrial condition such as now exists in Iowa.

Shimek, B. 1902. The loess of Natchez, Mississippi. Amer. Geologist, Vol. XXX, pp. 279-298, with pls. x-xv.

Shimek, B. 1904. The loess of Natchez, Mississippi. Bull. Lab. Nat. Hist. Univ. of Iowa, Vol. V, pp. 299-326, with map and pls. ii-vii.

"The Natchez fossils bear out the writer's oft repeated statement that the loess fossils of any given region are practically identical with the modern molluscan fauna of the same region" (p. 313). The writer favors the æolian theory.

Shimek, B. 1904. The loess and the Lansing man. Bull. Lab. Nat. Hist., Univ. Iowa, Vol. V, pp. 327-352, pls. viii-xi, fig. i.

Shimek, B. 1904. Loess and the Iowan drift. Bull. Lab. Nat. Hist., Vol. V, pp. 352-368, pls. xi, xii.

Shimek, B. 1904. Evidences (?) of water-deposition of loess. Bull. Lab. Nat. Hist., Univ. Iowa, Vol. V, pp. 368-381, with pls. xiii, xiv.

Shimek, B. 1907. The loess of the Missouri River. Proc. Iowa Acad. Sci., Vol. XIV, pp. 237-256, with 6 figures.

Reply to Prof. J. E. Todd's objections against the æolian theory of the loess.

Shimek, B. 1908. The genesis of loess, a problem in plant ecology. Proc. Iowa Acad. Sci., Vol. XV, pp. 57-64, pls. iii-vii.

Shimek, B. 1909. Aftonian sands and gravels in western Iowa. Bull. Geol. Soc. Amer., Vol. XX, pp. 399-408, pls. xxxiii-xxxvii.

Shimek, B. 1910. Evidence that the fossiliferous gravel and sand beds of Iowa and Nebraska are Aftonian. Bull. Geol. Soc. Amer., Vol. XXI, pp. 119-140, with pl. ii.

Shimek, B. 1910. Geology of Harrison and Monona counties. Iowa Geol. Survey, Vol. XX, pp. 273-485, with maps and text figures.

To the student of the Pleistocene this is a most important paper.

Shimek, B. 1912. Pleistocene of Sioux Falls, South Dakota, and vicinity. Bull. Geol. Soc. Amer., Vol. XXIII, pp. 125-154, with pls. vii-x.

Stookey, S. W. 1910. Geology of Iowa County. Iowa Geol. Surv., Vol. XX, pp. 151-198, with figures and maps.

Stookey, S. W. Geology of Poweshiek County. Iowa Geol. Surv., Vol. XX, pp. 237-269, with figures and a map.

Tilton, J. L. 1896. Geology of Warren County. Iowa Geol. Surv., Vol. V, pp. 301-359, with map, plates and text-figures.

Tilton, J. L. 1911. The Pleistocene deposits in Warren County, Iowa. University of Chicago Press, pp. i-iv; 1-42.

Tilton, J. L. 1913. A new section south from Des Moines, Iowa. Science, N. S., Vol. XXXVIII, pp. 133-135.

Tilton, J. L. 1913. A Pleistocene section from Des Moines to Allerton [Iowa]. Proc. Iowa Acad. Sci., Vol. XX, pp. 213-220.

Todd, J. E. 1879. Richthofen's theory of the loess, in the light of the deposits of the Missouri. Proc. Amer. Assoc. Adv. Sci., Vol. XXVII, pp. 231-239.

Regarded the theory as inadequate to explain the formation.

Todd, J. E. 1880. On the relation of loess to drift in southwestern Iowa. Proc. Iowa Acad. Sci., 1875-1880, p. 19.

Todd, J. E. 1889. Evidence that Lake Cheyenne continued until the Ice Age. Proc. Amer. Assoc. Adv. Sci., Vol. XXXVII, pp. 202-203.

Todd, J. E. 1894. The Quaternary or Pleistocene formations [of S. Dakota]. Bull. 1, South Dakota Geol. Survey, pp. 112-126.

Todd, J. E. 1896. Formation of the Quaternary deposits [of Missouri]. Geol. Surv. Missouri, X, 113-217, pls. xii-xxii.

Todd, J. E. 1898. Degradation of loess. Proc. Iowa Acad. Sci., Vol. V, pp. 46-51.

The author holds the aqueous theory.

Todd, J. E. 1899. New light on the drift in South Dakota. Proc. Iowa Acad. Sci., Vol. VI, pp. 122-130, with pl. v.

Todd, J. E. 1899. The moraines of southeastern South Dakota and their attendant deposits. Bull. U. S. Geol. Survey, No. 158. Pp. 1-171, with pls. i-xxvii and 31 text-figures.

Todd, J. E. 1903. Olivet folio, South Dakota. U. S. Geol. Surv. Geol. Atlas of U. S. folio No. 96.

Todd, J. E. 1906. More light on the origin of the Missouri River loess. Proc. Iowa Acad. Sci., Vol. XIII, pp. 187-194.

Contends that much of the loess, especially along Missouri river, is of aqueous origin.

See for reply B. Shimek, Proc. Iowa Acad. Sci., XIV, 1907, pp. 237-256.

Todd, J. E. 1906. Some variant conclusions in Iowa Geology. Proc. Iowa Acad. Sci., Vol. XIII, pp. 183-186.

Describes (p. 185) exposure at old site of Otis's mill on the Dakota side of the Big Sioux below Hawarden. Here in one stratum was found jaw of fossil horse. He sees no sufficient reason for considering it very ancient, p. 186. Same view presented in U. S. G. S. folio No. 156, p. 4. See Shimek, Proc. Iowa Acad. Sci., XIV, p. 238.

Todd, J. E. 1907. Recent alluvial changes in southwestern Iowa, Proc. Iowa Acad. Sci., Vol. XIV, pp. 257-266, 3 figs.

Todd, J. E. 1908. Description of the Elk Point quadrangle, S. D.-Neb.-Iowa. U. S. Geol. Surv., Geol. Atlas folio No. 56, 8 pp., 6 figs., 3 maps.

Here Todd recognizes two sheets of glacial drift. The first one has not been found in the Nebraska part of the quadrangle. He states (p. 3) that it is usually regarded as of Kansan age, but he thinks it may really be Iowan; it resembles strongly the Wisconsin.

Thinks that the Missouri, James, and Vermillion rivers began cutting their valleys after recession of Wisconsin ice.

Same view advocated in Proc. Iowa Acad. Sci., XIII, pp. 185-6.

On p. 4 Todd mentions finding of lower jaw of horse with three molars—*E. complicatus*. He seems to think that the deposit is rather recent. It is overlain by till; but this he thinks has caved down on the fossiliferous layer from an overhanging cliff.

Todd, J. E. 1909. Drainage of the Kansan ice sheet. Trans. Kan. Acad. Sci., Vol. XXII, pp. 107-112.

The Kansas ice-sheet is thought to have descended through the Des Moines valley, rather than through James

and Missouri rivers. Western limit of Kansan ice was probably not west of Coteaux des Prairies, in eastern South Dakota. Thence the border extended south to pass Lincoln, Nebraska; on the west and south to Kansas river.

Kansas river worn in its channel since beginning of Kansan—not preglacial. Elsewhere Todd holds same view regarding Missouri river below Niobrara, South Dakota.

Todd, J. E. 1909. Description of the Aberdeen-Redfield District, South Dakota. U. S. Geol. Surv., Geol. Atlas, U. S. Aberdeen-Redfield folio (No. 165), library edition, 13 pp.; full edition 99 pp., 12 pls. (maps) and 14 figs.

Todd, J. E. 1911. Pre-Wisconsin channels in southeast South Dakota and northwest Nebraska. Bull. Geol. Soc. Amer., Vol. XXIII, pp. 463-470.

Todd, J. E. 1914. The Pleistocene History of the Missouri river. Science, N. S., Vol. 39, pp. 263-274. Map.

The vice-presidential address delivered before Section E of the American Association for the Advancement of Science at the Atlanta meeting.

Udden, J. A. 1894. Erosion, transportation and sedimentation performed by the atmosphere. Jour. Geol. Vol II, pp. 318-331.

Udden, J. A. 1896. Some preglacial soils. Proc. Iowa Acad. Sci., Vol. V, pp. 102-104.

Udden, J. A. 1897. Loess as a land deposit. Bull. Geol. Soc. Amer., Vol. IX, pp. 6-9.

Udden, J. A. 1898. The mechanical composition of wind deposits. Augustana Library Publications. No. 1. Lutheran Augustana Book Concern, Rock Island, Ill.

Udden, J. A. 1899. Geology of Muscatine County. Iowa Geol. Surv., Vol. IX, pp. 249-380, with maps and figures.

Udden, J. A. 1901. Geology of Louisa County. Iowa Geol. Surv., Vol. XI, pp. 57-126, with maps and figures.

Discusses the Pre-Kansan (Nebraskan), the Aftonian, the Illinoian, the Sangamon, and the loess.

Udden, J. A. 1901. Geology of Pottawattamie County. Iowa Geol. Surv., Vol. XI, pp. 201-277, with maps and figures.

Discusses the drift and the loess.

Lists of loess fossils identified by Professor Shimek.

Udden, J. A. 1902. Geology of Jefferson County. Iowa Geol. Surv., Vol. XII, pp. 355-437, with figures and a map.

Udden, J. A. 1903. Geology of Mills and Fremont counties. Iowa Geol. Surv., Vol. XIII, pp. 123-183, with maps and plates.

Has lists of fossils as determined by Prof. B. Shimek.

Udden, J. A. 1905. Geology of Clinton County. Iowa Geol. Surv., Vol. XV, pp. 369-431, with figure and maps.

White, Charles A. 1870. The Bluff system. Report of the Geol. Surv. Iowa, Vol. I, pp. 103-117, with 2 plates.

On these pages are treated the phenomena of the loess.

Whitney, J. D. 1858. Allamakee County. Geol. Surv. Iowa, Vol. I, pt. I, pp. 317-323.

Wilder, Frank A. 1900. Geology of Lyon and Sioux Counties. Iowa Geol. Surv., Vol. X, pp. 84-155, with maps and figures.

Wilder, Frank A. 1902. Geology of Webster County. Iowa Geol. Surv., Vol. XII, pp. 63-235, with figures and map.

Gravel and sand beds belonging to Aftonian noted at Fort Dodge.

Williams, Ira A. 1906. Geology of Franklin County. Iowa Geol. Surv., Vol. XVI, pp. 453-507, with figures and maps.

Winchell, Newton Horace. 1903. Was man in America in the glacial period? Bull. Geol. Soc. Amer., Vol. XIV, pp. 133-152.

Annual address of President Winchell. Discussed the loess, the various ice-sheets, the Lansing man, and the existence of man during the Iowan epoch.

Witter, F. M. 1890. Some additional observations on the loess in and about Muscatine [Iowa]. Proc. Iowa Acad. Sci., Vol. I, p. 45.

Wright, G. F. 1904. Evidence of the agency of water in the distribution of the loess in the Missouri Valley. Amer. Geologist, Vol. XXXIII, pp. 205-222, with pls. vii, viii.

Wright, G. F. 1905. Prof. Shimek's criticism of the aqueous origin of loess. Amer. Geologist, Vol. XXXV, p. 236-240.

THE MAMMALS OF THE PLEISTOCENE

The Pleistocene vertebrates known to have lived in Iowa belong almost wholly to the class known as Mammalia. There were living within the limits of Iowa, without doubt, during the whole of Pleistocene times, also numerous freshwater fishes, amphibians, reptiles, and birds. The hard parts of many of these, we may be sure, were covered up in the deposits laid down during interglacial times here and there over the state and even during glacial times in deposits left in lakes and rivers; but, for many reasons they are not collected. The bones of the smaller animals do not attract as much attention as do those of elephants, mastodons, horses, and bisons. The earth in which the bones are buried, not being consolidated into a firm rock, crumbles in being disturbed and permits the skeleton to fall apart. The bones themselves are often not well mineralized and break up readily. When, on the other hand, a fish skeleton, for example, is enclosed in a hard rock, the latter is likely to split in such a way as to reveal the skeleton with all its bones firmly retained in the position which they had when buried.

Nevertheless, we may expect in time to secure specimens even of the fishes, amphibians, reptiles, and birds. Some of the Pleistocene clays are compact and stratified, so that they will split into layers; and in such clays there will yet be found, no doubt, remains of the skeletons of many animals. Inasmuch as such delicate objects as the shells of snails occur in abundance in the loess, there appears to be no reason why the skeletons of snakes and lizards, and land-inhabiting tortoises also should not have been preserved there. In old filled-up ponds and small lakes that existed on the surfaces of the various sheets of drift and in ancient lagoons along buried river channels, there ought to be found the bones of many yet existing species of vertebrates and of others that have become extinct.

From an old dried-up lake in Oregon Dr. R. W. Shufeldt has described the remains of many species of water-birds. Remarkably few such things have up to the present been discovered in Iowa. In some of the regions in Iowa where limestone occurs there may yet be found caves in which the bones of various vertebrates may occur. Prof. J. E. Todd mentions in one of his papers (Proc. Iowa Acad. Sci., Vol. VI, p. 124) the fact that the bones of a tortoise of some kind were once found at Sioux City; and Prof. B. Shimek states (Bull. Geol. Soc. Amer., Vol. XXI, 1909, p. 131) that a vertebra of a small fish was collected from fine sand in the Elliott pit at Turin, Monona county.

Class **MAMMALIA.**

The Mammals.

The Mammalia get their name from the fact that the females of all the species possess organs for the production of milk for the nourishment of the young. The mammals may be recognized from the fact that they, and they only, possess a more or less complete covering of hair. There are many other features which characterize the group, but it is unnecessary to enumerate them here.

The Mammalia are divided into a few groups called Superorders and these again into Orders. Only a few of these orders are represented by remains which have up to this time been found in Iowa. An order which is represented in the existing fauna, but no species of which have yet been discovered in Pleistocene deposits in Iowa, is that known as the Marsupialia and which contains such animals as the Kangaroos and Opossums. The opossums belong to the family Didelphidæ. This family is represented in the present fauna of Iowa by the small animal known as the Virginia Opossum. We cannot doubt that this species was present during at least some part of the Pleistocene period. Many years ago a fragment of the lower jaw of this opossum was found near Charleston, South Carolina, and described by Joseph Leidy. During Oligocene times there existed in North America several species of this genus; but none have yet been found in the Miocene or Pliocene formations.

It may be expected that cave deposits will yet yield evidences of Iowa Pleistocene opossums.

The opossum may be recognized by the fact that the jaws, the parts most likely to be found, contain a greater number of incisor teeth than any other mammal likely to occur within the limits of the state. In other mammals there are not more than three incisors on each side of each jaw; that is, there may be six in each jaw. In the opossum there are five on each side of the upper jaw, ten in all, and four on each side of the lower jaw, eight in all. The dental formula* of the opossums is:

$$i\ \tfrac{5}{4},\ c\ \tfrac{1}{1},\ pm\ \tfrac{3}{3},\ m\ \tfrac{4}{4}.$$

Standing higher in the scale among the Vertebrata than the Marsupialia is the superorder of Edentata,—toothless animals. These animals were represented in Iowa during the Pleistocene, but no member of it is known to have existed there during the Recent epoch.

Superorder **EDENTATA.**

The Slothlike and the Armadillo-like Mammals.

For this superorder the name Edentata is more commonly employed, but the term Bruta is sometimes used. In the fauna of the present world the order is represented by the sloths, anteaters, and armadillos of South America. Some species of armadillos extend their range as far north as Texas. In Asia and Africa are other genera which differ so much from the New World forms that they are by many authors regarded as representing a separate group, the Pholidota. We need not here trouble ourselves about them. To the New World division there is often given also the name Xenarthra.

The Edentata may be defined as claw-bearing animals, with the body covered with hair or horny scales or bony plates, and having the teeth either missing entirely or few in number and in a low stage of development. The teeth are, when present, column-like in form and without roots; and they continue to in-

*Perhaps it may be well, at the beginning of the descriptions, to explain the meaning of the above dental formula. The letter i, in this and all succeeding tooth formulas, means incisor tooth, and, similarly, c means canine tooth, pm means premolar tooth, m means molar tooth. The figures following each letter show the number of teeth of that kind on each side of the upper and lower jaws. Thus i 5/4 means that there are five incisors on each side of the upper jaw and four on each side of the lower jaw.

crease in length at the base as they are worn away at the summit, having a persistent pulp. These teeth have no enamel, but are composed principally of dentine, although often there is a layer of cement. The dentine of the interior is less dense and softer and wears away more rapidly than the very hard outer layer, so that the borders of the worn surface present something like cutting edges.

As to their mode of life, the living New World forms vary greatly. The sloths live among the branches of trees, hanging by means of their great claws with the back downward, and devouring the foliage. The armadillos are burrowing animals that live on roots, worms, insects, and carrion. The ant-eaters of the New World include some terrestrial and some arboreal species, and they all nourish themselves on insects.

During Tertiary times there existed in South America an enormous number of genera of this group Edentata, or Xenarthra. During the Pliocene and Pleistocene epochs some of these migrated into North America and spread over the larger part of the United States. It must be said, however, that representatives of the Edentata appear to have existed in North America as far back as the middle Eocene and probably yet in the Middle Miocene. To this group Prof. H. F. Osborn refers the genus Metacheiromys, of the Bridger beds of Wyoming. It is probable that the group became extinct in North America before the invasion on the part of South American forms, in Pleistocene times.

The New World Edentata have been divided into what may be regarded as two orders, the Pilosa, or hairy Edentates, and the Loricata, or armored Edentates. Inasmuch as none of the latter are known to have occurred within or near the limits of Iowa, it will not be necessary to consider further the differences between the two orders. It suffices to say that the Loricata include the armadillos and the extinct glyptodons, while the Pilosa include the sloths and ant-eaters. These are again sub-divided into two divisions, which may be regarded as superfamilies, the Gravigrada, the extinct ground-sloths, and the Tardigrada, the tree-sloths. We must deal with the Gravigrada only, for the Tardigrada probably never existed within the limits of Iowa.

The map shown as Plate II indicates the localities in the United States where fossil remains of Edentata have been found. It also shows the distribution of the various drift sheets. It will be observed that nearly all the localities lie southward of the border of the Wisconsin drift sheet. Only three specimens have been found in deposits overlying the Wisconsin drift and these three belong to Megalonyx, probably *M. jeffersonii*. Two of these localities are in Ohio, one in Illinois.

Superfamily GRAVIGRADA.

The Ground-sloths.

The Gravigrada may be defined as Edentata having usually a heavily built skeleton and a relatively small skull; size small to medium in early Tertiary forms, large in those of the Pleistocene; the number of presacral vertebræ varying from twenty-six to thirty-two; the posterior dorsals and the lumbars furnished with pairs of articular processes in addition to those of the anterior vertebræ; the skull elongated and low, nearly cylindrical, with the part in front of the orbits short; the zygomatic arches sometimes complete, sometimes with a gap between the jugal and the squamosal; the jugal usually with a strong descending process; the lower jaw with broad ascending and horizontal rami; the upper teeth five or four on each side, lower teeth four or three on each side, ($\frac{5}{4}$ or $\frac{4}{3}$); the radius and ulna not coössified, tibia and fibula sometimes coössified at the extremities; the digits five in each foot in front and behind, or only four behind, clawed; the tail usually large; the habits herbivorous.

Under the superfamily Gravigrada are included three families, the Megalonychidæ, the Megatheriidæ, and the Mylodontidæ. So far, no remains representing the second of these families have been found in Iowa, although some bones of the Megatherium were once reported by Richard Harlan from Pleistocene deposits, in Benton county, Missouri. They are said to have been mingled with bones of Mylodon, ox, deer, and elk. It is possible, therefore, that remains of this animal will yet be discovered in Iowa.

Family Megalonychidae.

Ground-sloths of small to large size; with a long and cylindrical skull, more or less constricted behind the orbits. Teeth, five above, four below ($\frac{5}{4}$). In section the teeth are four-sided or elliptical, sometimes slightly triangular; never lobate in section, that is, with none of the sides concave; the anterior upper one on each side more or less distant from the second; hinder one not differing greatly from the others in size. Fore and usually hind feet with five digits, the median ones most strongly developed, all furnished with claws.

Genera belonging to this family are known from the Santa Cruz beds of the older Tertiary, of South America. Descriptions and numerous illustrations of these may be found in Prof. W. B. Scott's Mammalia of the Santa Cruz beds. In North America the family is represented by Megalonyx and Morotherium. Some scanty remains belonging apparently to *Megalonyx jeffersonii* have been discovered in Iowa, and doubtless others will be found hereafter. For this reason this species is here described with some detail.

Genus MEGALONYX Thomas Jefferson.

Large North American Pliocene and Pleistocene ground-sloths, with teeth $\frac{5}{4}$ on each side, the anterior of both the upper and the lower jaws considerably in front of the succeeding one, and much larger. The four hinder molars roughly quadrate or triangular in section, with rounded angles and straight or convex sides, not fluted.

This genus was proposed by President Thomas Jefferson in 1799, on parts of a skeleton including some claws that had been found in a cave in Greenbrier county, West Virginia. From the form of the claws he concluded the animal was carnivorous. This idea was abandoned, however, when the close relationships of the animal to the tree-sloths, of South America, became established.

Of this genus, nine species have been described from the Pleistocene and one from the Pliocene. In a cave near Port

Kennedy, Pennsylvania, four species have been found, represented by parts of at least ninety-five individuals.

As will be observed from a study of the map (Pl. II) the genus Megalonyx had a wide distribution during the Pleistocene. It is represented in the following states: Pennsylvania (17, 41); West Virginia (1); Virginia (15); Florida (19); Alabama (6); Mississippi (5); Tennessee (2, 4); Kentucky (7, 3); Ohio (14, 57); Indiana (39); Illinois (18, 47); Iowa (21, 25, 51, 52, 56); Missouri (54); Texas (12, 46); Kansas (16, 22); Nebraska (49); South Dakota (50); California (33, 34, 44, 55?).

Megalonyx jeffersonii Desmarest.

Jefferson's Megalonyx.

Although Jefferson gave the generic name to this animal, he did not bestow the specific name. This was done in 1822 by Desmarest, who assigned the fossil remains to the genus Megatherium and, in honor of President Jefferson, named it *Megatherium jeffersonii.*

Jefferson had in his possession only a part of a femur, a radius, an ulna, three claws and a few other foot bones. Since his time portions of the animal have been found in various parts of the country, from Big Bone Cave, Van Buren county, Tennessee; Memphis, Tennessee; Big Bone Lick and Henderson, Kentucky; Natchez, Mississippi; Tuscumbia, Alabama; Wythe county, Virginia; Peace creek, Florida; Holmes county, Ohio; Evansville, Indiana; Galena and Urbana, Illinois; Dubuque and Mills county, Iowa; McPherson and Clark (or Meade) counties, Kansas; Huerfano county, Colorado; Iberia Parish, Louisiana; and Hardin county, Texas. Inasmuch as the finds have often consisted of meager remains, a single tooth or claw, or little more, it may be that some of them belong to some of the other species of the genus.

Our knowledge of this animal depends principally on specimens found near Henderson, Kentucky, and in Holmes county, Ohio. Neither of these lots of bones furnishes a complete skeleton, but, to a considerable degree they supplement each other and between them furnish us with the greater part of the framework. Bones and teeth found in other localities, either

singly or a few together have contributed toward an understanding of the animal.

Henderson is situated on the Kentucky side of Ohio river about 14 miles in a direct line south of Evansville, Indiana. The Kentucky side of the valley is undoubtedly filled with glacial deposits like those on the Indiana side, and the bone bed is, as stated by D. D. Owen in a letter to Leidy (Smithson. Contrib. Knowl., VII, art. V, p. 7), only about five or six feet below the ordinary low stage of water.

Some remains of this species were collected long ago by Mr. Francis A. Linke, in the banks of Ohio river, near the mouth of Pigeon creek, a mile or two below Evansville, Indiana. The materials were reported by Dr. Joseph Leidy, in the Proceedings of the Academy of Natural Sciences, in 1854, page 199. They consisted of the shafts of two tibiæ of a young individual, an axis, a piece of a calcaneum, one metacarpal, one metatarsal and one claw phalanx. In the same deposits were found what were regarded as parts of possibly American bison (*Bison bison*); the white-tailed deer (*Odocoileus virginianus*); an extinct horse (*Equus complicatus*); the extinct tapir (*Tapirus haysii*); and a wolf (*Canis dirus*).

An examination of the map of this region given by Leverett (Monog. XXXVIII, U. S. Geol. Surv., pls. vi and viii) will show that the Ohio valley at this point is occupied by glacial terraces that are older than the Wisconsin glacial stage. This seems to be confirmed by the occurrence there of the fossil horse, the tapir, and the wolf. The bison may belong to some extinct species, rather than the living species, *Bison bison*.

From the bone bed at Henderson Owen collected many horns and bones of the deer. All these remains found at both places may be regarded provisionally as belonging to the Sangamon interglacial stage.

The partial skeleton found in Holmes county, Ohio, was discovered on the farm of Mr. Drushell, about six miles east and a little north of Millersburg. According to Claypole, who described these remains, they were lying on a layer of shell marl and this was overlain by six feet of peat. The terminal mo-

raine of the Wisconsin drift-sheet runs through the county in an east by northeast direction, and it had led to the formation of a small lake north of it, which finally became a swamp filled up with peat. By some means the megalonyx had left his remains in the lake after the formation of the shell marl and before the growth of the peat. It is evident therefore that this sloth existed after the retirement of the Wisconsin drift-sheet, and long enough after it for the climate to become warm enough to permit this animal to wander into Ohio. This post-Wisconsin existence of the megalonyx is, in a measure, confirmed by the finding of a claw near Urbana, Illinois, on early Wisconsin drift. Quite recently many bones of this species have been secured in a tamarack swamp in Huron county, Ohio. This swamp overlies Wisconsin drift.

That the megalonyx existed during late Pleistocene times or even within the Recent period appears to be demonstrated by the discovery of its bones in a dry cave in Van Buren county, Tennessee, to which bones there were yet attached remnants of articular cartilage; and even the horny sheath of a claw yet remained.

The partial skeleton discovered at Henderson, Kentucky, is now in the collection of the State University, at Bloomington, Indiana, where the writer has examined it. It was studied and described by Joseph Leidy in 1855, as cited above. Leidy's treatise took into consideration all the materials known to him, and was beautifully illustrated with sixteen finely engraved plates. From these plates some of the illustrations here used have been prepared. It is not certain that the bones found at Henderson all belong to the same individual, for they were picked at various times and from year to year. Leidy thus enumerates the bones:

> A nearly entire skull and lower jaw; the atlas, axis, and 3 other cervical vertebræ; 2 dorsals, one sacral, and 2 caudal vertebræ; both clavicles; the glenoid articulation of the right scapula; the left humerus; the articular extremities of the right ulna and those of both radii; 5 carpal bones; 4 metacarpals; 11 phalanges of the fore feet; fragments of several ribs; one sternal bone; both thighs, broken; both patellæ; both tibiæ; 7 tarsal bones; 5 metatarsals; and 5 phalanges of the hind feet.

The Millersburg, Ohio, specimen was described by Prof. E. W. Claypole (Amer. Geologist, Vol. VII, pp. 122-132; 149-153), but no figures were given. He gave the following list of bones secured:

> 3 teeth, 1 hyoid, 3 lumbar vertebræ, 1 caudal, probably 1 broken cervical; 3 ribs and some pieces; 1 clavicle; 1 radius, both femora, 1 tibia, both fibulæ, both patellæ, both calcanea, 22 carpals and tarsals, 5 metacarpals and metatarsals, 20 phalanges, including 11 claws.

Fig. 1. *Megalonyx jeffersonii.* Based mostly on a specimen in the State University of Ohio and another in the State University of Indiana. X 1/25.

A comparison of the two lists shows that many bones are represented in neither of these skeletons or only partially represented. Many vertebræ are missing, including the sacrum; few ribs have been secured; the pelvis is present in neither and besides is quite unknown, except that Harlan, in 1835, described an ilium from a cave in Tennessee. Neither of the two specimens mentioned offers a complete scapula; the humerus is represented in the Henderson specimen by a bone without the epiphyses.

The Henderson specimen is mounted without restoration of missing parts. The Millersburg specimen, now in the depart-

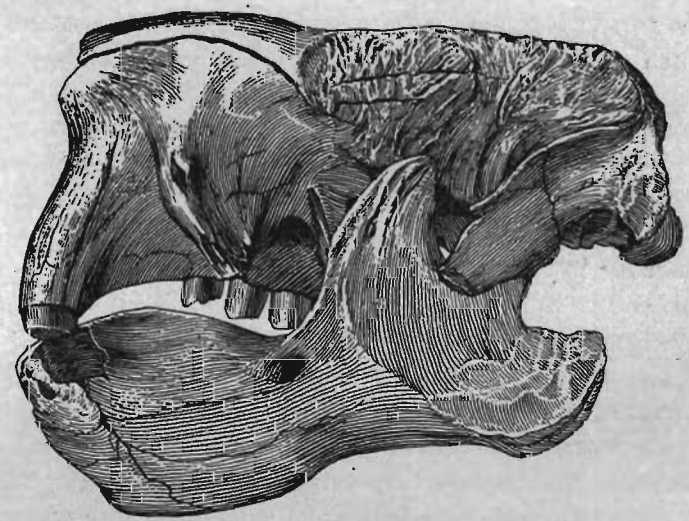


Fig. 2. *Megalonyx jeffersonii.* Skull of specimen in Indiana University, seen from the left side. X¼.

ment of geology, in the University of Ohio, at Columbus, has the missing parts represented in plaster, following probably Mylodon, where not known in Megalonyx. The work was done by the Ward Establishment, Rochester, New York, and the artificial parts have been made to resemble so closely the bones, that it is very difficult in some cases to distinguish the real and the fictitious. A figure of the specimen was published by Osborn in his Age of Mammals, page 465. A line drawing of the animal is here presented (Fig. 1), based on a photograph taken by the writer. It is impracticable to indicate the parts that are restored artificially, and the drawing may be taken as repre-

senting the general form of the animal, and, for the most part, of its elements, as determined from all known materials.

The total length of the specimen as mounted, in the University of Ohio, is 3510 mm.* (eleven feet, six inches). The height of the sacral region, from the floor, is 1500 mm. (four feet, eleven inches); and this is likewise the length of the fore and of the hinder limbs, following the front of the bones. The description of the more important portions of the skeleton will be taken from both skeletons and from other known materials.

Figures are presented of the skull of the Henderson specimen, prepared from those made for Leidy. Figure 2 shows the skull from the left side. It is nearly complete, but the malar bones are gone and likewise the pterygoid processes. The lower jaw is mostly present. The teeth of the upper jaw are all present, except the second of the left side and the fifth one of the right side. As will be seen from figures 2-4, the skull is long, low, and, leaving out of view the zygomatic arches, narrow. The anterior region is higher than the brain-case. The upper border is nearly straight. The rear forms nearly a semicircle whose center is just below the upper border of the foramen magnum. The length from front of the first tooth to the rear of the occipital condyles, is 355 mm.; from the hard palate to the highest part of the snout, is 152 mm.; breadth at the rear of the orbits, 125 mm. The orbits are shallow and are indicated above and in front by a high ridge ascending from the root of the malar process, behind by a slight ridge which separates it from the rough temporal fossa. In front of the malar process on each side is a groove which extends downward on the sides of the upper jaw between the first and second teeth. It will be observed that the part of the face in front of the orbit is extremely short, and it narrows towards the nasal openings. The anterior nares (Pl. III, fig. 2) form a very large opening, about 75 mm. in diameter.

In front of the hinder roots of the zygomatic arches the skull is constricted. The rear of the skull slopes downward to the occipital condyles. There is a low but well-defined sagittal

*The letters mm. in this work are the abbreviations for millimeters. One millimeter=0.0394 inch, or nearly one-twenty-fifth inch.

crest; whereas, in Mylodon there is a broad smooth surface between the two temporal fossæ.

As shown by the skull of another species, *Megalonyx leidyi*, found in Kansas, and described by Dr. Josua Lindahl (Trans. Amer. Philos. Soc., Vol. XVII, pp. 1-10, pls. i-v), (Pl. III, fig. 1), the zygomatic arch was complete. In the living sloths and in Mylodon there is a gap about its middle. In *M. leidyi* there runs downward and backward from the anterior root a long process which would reach quite to the lower border of the

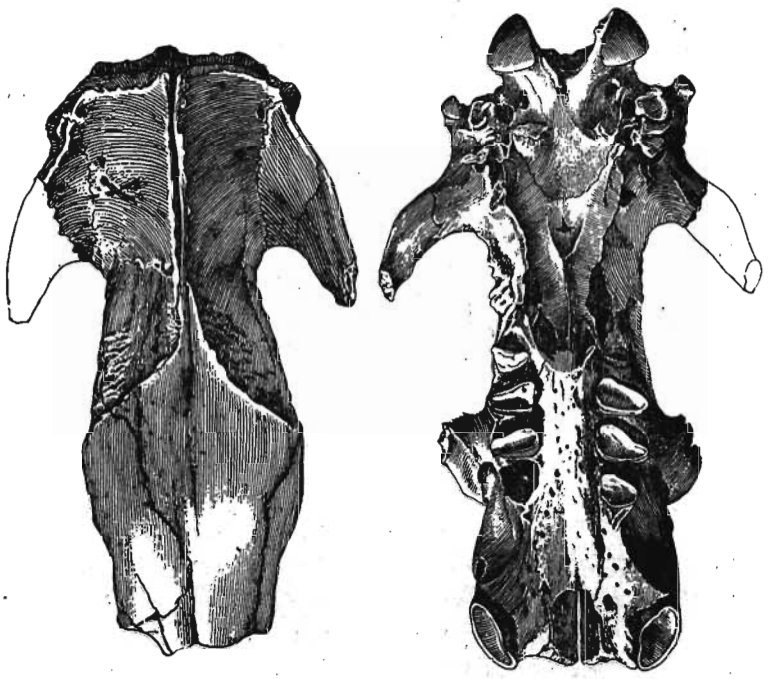


Fig. 3 Fig. 4

Figs. 3, 4. *Megalonyx jeffersonii.* Skull of specimen in Indiana University. X¼.
3. Skull seen from above.
4. Palatal view of skull.

lower jaw at the middle of the latter. From the middle of the arch another shorter process extends upward and backward. These processes offered an extensive attachment for the muscles which moved the lower jaw.

On the lower surface of the skull (Fig. 4) there are to be seen, behind, the occipital condyles, various openings for nerves and bloodvessels, processes for muscles, the auditory processes, and

at the root of each zygomatic arch the articulation for the lower jaw. This is about 28 mm. long and 50 mm. wide, the long diameter being directed outward and forward. The hard palate begins at the hinder border of the last molars. Here it is about 33 mm. wide and is still narrower between the third molars. Between the three hinder pairs of molars it is convex and has the middle of its width about on a level with the worn surfaces of the teeth. Further forward it rises, flattens, and widens to about 100 mm. just behind the anterior teeth. Between the teeth just mentioned is a large anterior palatine foramen.

Five teeth are found in each row above. Those of the anterior pair are considerably larger than the others and some-

Fig. 5

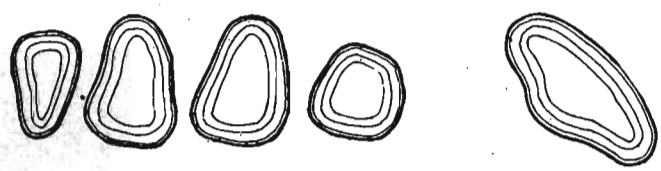


Fig. 6

Figs. 5, 6. *Megalonyx jeffersonii*. X⅔. After Leidy.
5. Lower right last molar.
6. Sections of the teeth of the right side of the upper jaw, with the front tooth at the right hand.

what canine-like. They extend high up in the jaw to the root of the malar process, having a length of 125 mm. and being strongly curved backward as they ascend. The section is elliptical, with a swelling on the inner face. The diameters are 38 mm. and 19 mm. Between the teeth of this pair is a distance of 60 mm.; while between them and the second molars there is a space nearly as great. Figure 3, Pl. III, presents a view of one of these teeth, together with its grinding surface. This tooth was found near Natchez, Mississippi. The hinder four molars of each side are separated by only slight spaces. These teeth are like somewhat flattened pegs and have the same diameters at all levels. Figure 5 taken from Leidy, presents a side view of the hinder tooth, while figure 6, of two-thirds the natural size, shows the sections and positions of these teeth. The

length of the row of four hinder teeth is 80 mm. From the front of the first tooth to the rear of the fifth, is 172 mm. The triturating surface of each is worn so as to present a concavity surrounded by a border of harder dentine. It is much worn towards its hinder border.

The premaxillaries (Pl. III, fig. 2) are consolidated with the maxilla, but not with each other on the midline. They measure about 19 mm. in width and 50 mm. in height.

The lower jaw (Figs. 2, 7) is high in front, much lower at the middle of its length; and it is provided behind with three processes. The length from front to extreme rear is 317 mm. The height of the symphysis is 105 mm., and this symphysis is directed strongly downward and somewhat backward. The height of the bone a little behind the anterior tooth is 100 mm.; at the third tooth, 90 mm.; at the coronoid process, 158 mm.; at the condyle, 105 mm. The outer face of the body of the bone

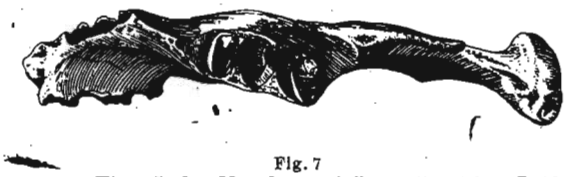


Fig. 7

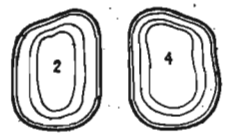


Fig. 8

Figs. 7, 8. *Megalonyx jeffersonii.* After Leidy.
7. Lower jaw seen from above. X¼.
8. Sections of second and fourth lower molars. X⅔.

is convex, the inner face, flat. In the upper border were placed the four peglike teeth, of which only the second and fourth are present. Between the first and the second is a space of 42 mm. At the rear of the jaw is the strong angular process. The condyles for articulation with the skull, are about 50 mm. from side to side. The alveolus for the first tooth has a depth of about 88 mm. and its diameter shows that this tooth was of a size fully as large as the corresponding upper tooth. It was directed upward, forward, and outward. The last three teeth formed a row about 75 mm. long. The second and fourth teeth measured in cross sections 18 mm. from front to back, 24 mm. from side to side (Fig. 8). These sections are quadrate with rounded angles and somewhat convex sides. The worn face of each is concave, surrounded by a sharp border, which bounds a valley running somewhat obliquely across the tooth.

The hyoid bone is described and figured by Leidy. It is not present in either of the two skeletons here described. It is a V-shaped bone, which articulated to the skull by its apex. The length of each arm is about 65 mm.

The cervical vertebræ, except the seventh, may be known from the fact that they are pierced on each side by an opening for the vertebral artery. The atlas is present in the Henderson skeleton and was figured by Leidy in two positions. The greatest width is 170 mm.; the width of the lower arch, 32 mm.; the width of the spinal canal, 43 mm. There is on each side a very tortuous canal for the vertebral artery.

Leidy figured the axis. The body of the bone, with the odontoid process, is 88 mm. long. On the lower surface of the short and obtuse odontoid is a surface for union with the atlas. Behind the anterior zygapophysis is seen the opening of the canal for the vertebral artery.

There are in the Henderson specimen three other cervical vertebræ; being, as Leidy thought, the third, the fifth, and the seventh. The fifth, measured from the lower surface of the body to the tip of the spine, is about 140 mm.; the seventh, about 175 mm. An anterior vertebra has the hinder end of the body transversely elliptical and with diameters of 38 and 50 mm. A posterior dorsal has the hinder end of the body 75 mm. high and 88 mm. wide.

Leidy described a part of a sacrum to which he had access. In the Henderson specimen there is present the last of the five sacrals. The body measures from side to side, 85 mm.; up and down, over 50 mm.; from the extremity of one lateral process to that of the other, is 260 mm. These processes extend outward and backward, and are rough on their front border for union with the processes of the preceding sacral. There are two caudals present.

In the skeleton at Columbus the writer recognized one actual rib, but Claypole stated that there were three of them. A rib in the Henderson specimen has a width of 46 mm. and a thickness of 26 mm. Harlan described what he regarded as one of the anterior false ribs, and this had a length of twenty-nine

inches. It is remarkable that a greater number of such thick and strong ribs has not been preserved.

Neither scapula is present in the Millersburg, Ohio, specimen; and in the Henderson specimen there is present only the region about the glenoid cavity of one scapula. Leidy figures the articular region of a scapula that was found in the vicinity of Natchez, Mississippi. This figure, reproduced here (Fig. 9), shows the glenoid cavity, which measured 83 mm. in length and 60 mm. in width. It shows also that there was an arch of bone that connected the acromion process with the coracoid process of the scapula. Furthermore, the anterior border of the scapula sent forward a process that joined the coracoid process so as to form a foramen in the front portion of the bone. These structures are found in some of the now living sloths.

Richard Harlan figured a scapula of Megalonyx which had been found in a cave in Tennessee (Med. and Phys. Res., pl.

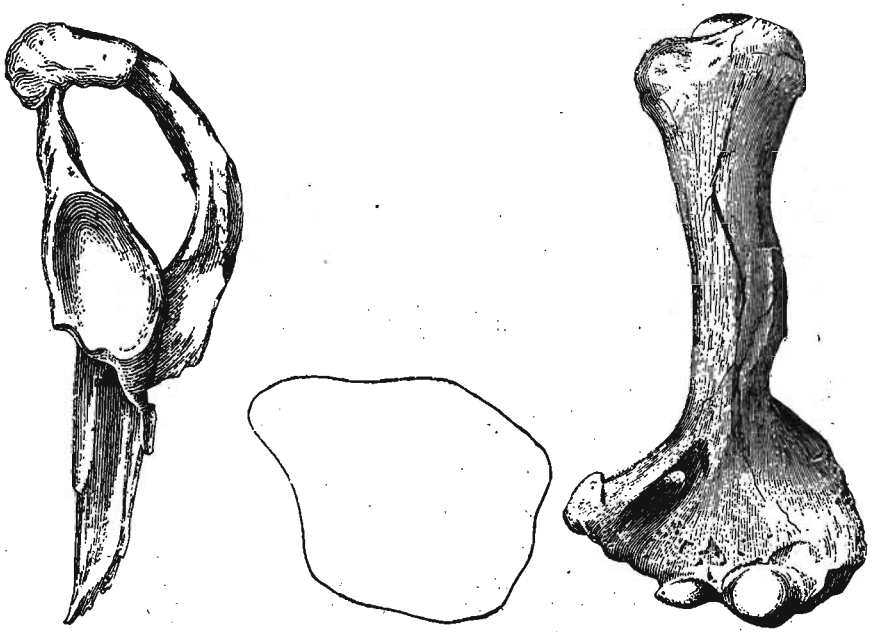


Fig. 9 Fig. 11 Fig. 10

Figs. 9, 10, 11. *Megalonyx jeffersonii.*
9. Articular end of left scapula. X¼. After Leidy.
10. Left humerus from front. X 1/6. After Leidy.
11. Section across left humerus at middle of length. X½. The front of this bone is above; the radial border, toward the left.

xiii, fig. 12). In this bone the acromion had no connection with the coracoid, but this was probably due to the youth of the animal. The distance from the glenoid cavity to the middle of the suprascapular border was about 310 mm.

Both clavicles are present in the Henderson specimen; only one in that from Millersburg. This bone in the former specimen has a length of 220 mm. and a width of 70 mm. It is a compressed bone, with one surface convex lengthwise; the other, concave. The end that joined the sternum is larger and presents an articular head.

Both humeri are lacking in the Ohio specimen and the right one in that from Henderson. The left one of this specimen was figured by Leidy, and his figure has furnished the one presented here (Fig. 10). The bone is large, with a nearly cylindrical shaft and a greatly expanded lower end. The total length is 520 mm.; the greatest diameter of the head, fore and aft, 100 mm.; the other diameter, 85 mm. The two tuberosities are of about the same size and are placed one on each side of the front of the head. The bicipital groove is shallow. The shaft is slightly flattened in front. At the middle of the length of the bone the diameter, from side to side, is 85 mm.; from front to rear, 62 mm. Figure 11 gives a section at this part. The expanded lower end of the bone measures 258 mm. across the epicondyles. The inner epicondyle projects farther beyond the corresponding trochlea, than does the outer epicondyle beyond the trochlear surface for the radius. At the upper part of its base is the entepicondylar foramen. The border which ascends from the outer epicondyle is convex. The hinder face of this lower end is slightly concave, and there is a shallow depression for the anconeal process of the ulna. The articular surface for the radius is much larger than that for the ulna.

Figure 12, after Leidy, represents a front view of the left radius and ulna. The figure is based on bones that were in the collection made by Jefferson. The extreme length of the ulna in a straight line is given as 20 inches, 500 mm. The breadth of the bone, from the summit of the coronoid process to the opposite side, was 100 mm.; the breadth, at the middle of the shaft, 75 mm.; that at the distal end, 75 mm. At the upper

end are concave articular surfaces for the humerus and the radius. The distal end articulated at the side with the radius, and at the extremity with the cuneiform. Neither ulna was present in the Millersburg specimen. The radius which Leidy described and figured was 17.56 inches (445 mm.) long; the greatest breadth at the distal end was 89 mm.; at the middle of the shaft, 81 mm. This bone is present in the right arm of the Millersburg skeleton, and it is considerably larger than that of the Jefferson specimen, having a length of 520 mm.; diameter of the head, 65 mm.; width at the middle of the shaft, 87 mm.; thickness at this point, 35 mm.; width, near the distal end, 112 mm. The upper end is cup-shaped for articulation with the humerus, and on the rim of this is a smooth surface for the notch in the humerus. At the distal end the bone articulated with the scaphoid and the lunar. The palmar face of the bone is concave on the upper half, flat on the lower portion. The opposite face is convex, there being a ridge that runs the whole length of the bone, at the middle of the surface. The border which was directed toward the ulna is thin; the outer border is thick and rounded. The skeleton found at Henderson furnished only the articular extremities of the right ulna and those of both radii.

For the description of the bones of the wrist, the reader may consult Dr. Leidy's monograph which has already been cited.

In the Henderson specimen there were present the metacarpals of the second and third digits of the left arm, and the third and fourth of the right. None of his specimens furnished the first metacarpal. This is represented on the right arm of the restoration of the Millersburg skeleton and appears to be actual bone. Its length and its breadth are equal, each being 46 mm. The second metacarpal in the Henderson skeleton is 95 mm. long and 44 mm. wide. Its distal end has a prominent vertical median ridge which fitted into a corresponding groove on the proximal end of the first phalange. The third metacarpal has a length of 100 mm., and the shaft is 38 mm. wide. The distal end has a vertical articular ridge like that of the second digit.

The fourth metacarpal is the largest of all, having a length of 125 mm. Its distal end has the usual vertical ridge. The fifth metacarpal is not present in the Henderson specimen, but it is found in the Millersburg skeleton. It has a length of 120 mm. and a with of 26 mm. at the middle of the shaft. Leidy gives a figure of one of these bones which was in the Jefferson collection. The distal end presents an obtuse vertical ridge.

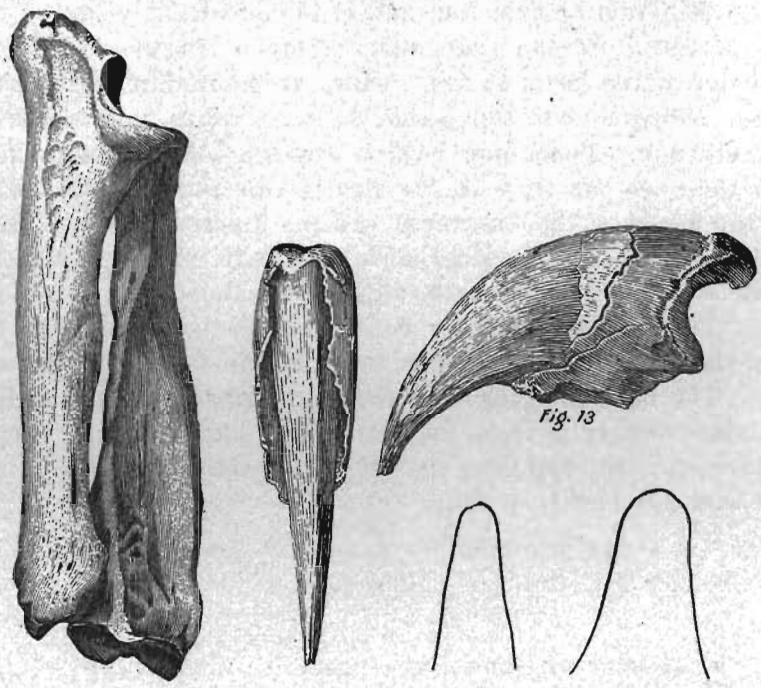


Fig. 12 Fig. 14 Fig. 16 Fig. 15

Figs. 12-16. *Megalonyx jeffersonii.*
12. Left radius and ulna seen from in front. X 1/6. After Leidy.
13. Terminal phalange of third digit at middle of length, seen from the side. X½. From Leidy.
14. Same phalange seen from above. X½. From Leidy.
15. Section across terminal phalange of third digit at middle of the length. X½.
16. Section across terminal phalange of second digit at middle of length. X½.

The phalanges of the first row, so far as known, are short thick bones, varying in length from 39 mm. in the second digit, to about 41 mm. in the fourth. As mounted, all the first phalanges are present in the right hand of the Millersburg specimen.

In the Henderson specimen there were present the second phalanges of the second, third, and fourth digits. Those of digits three and four are present in the right hand of the

Millersburg specimen. The figures of the third digit here shown will give an idea of these phalanges. That of the second digit has a length of 58 mm.; that of the third digit 62 mm.; that of digit four, 67 mm. The terminal phalanges are each modified to support a horny claw. In the Henderson specimen all these phalanges were present, except that of the thumb; but a few are apparently now missing. Leidy figures a thumb ungual phalange that belonged to the Jefferson collection. It was small in comparison with the others, being 88 mm. long. Leidy's figure appears to be only two-fifths the natural size. Each terminal phalange consists of a compressed claw-core, with an upper convex border and a concave lower face. From the tuberosity which occupies the hinder half or more of the lower face of the bone, there rises and surrounds the hinder half of the claw-core a bony sheath which enclosed and protected the base of the horny claw. This sheath is also attached to the base of the bone on the sides and above. The base of the phalange is occupied by an articular surface which consists of two vertical grooves separated by a prominent ridge. Each groove forms a vertical semicircle. The tuberosity on the under side of the bone is pierced near its middle by a pair of foramina for bloodvessels. Figures 13 and 14, prepared from Leidy's drawings, present views of the terminal phalange of the third digit. The greater part of the sheath of the claw had been broken away. Figures 5 and 6 of Plate III show the appearance of a nearly perfect third ungual phalange which was found near Champaign, Illinois, and is now in the collection of the Illinois State University. The length of the ungual phalange of the second digit is given by Leidy as 150 mm.; its depth, 62 mm. The ungual phalange of the third digit is 178 mm. long; 81 mm. deep. The fourth ungual phalange, 144 mm. long; 62 mm. deep. In the case of this phalange in the fifth digit the length is 62 mm.; the height, 37 mm. The length of the one found at Champaign was very close to 145 mm.; the greatest depth, 65 mm.; the width, 41 mm.

The core for the claw is, toward the base, obtuse on the upper border, but, farther forward, it becomes rather acute. Figure 15 represents a section of the claw-process of the third digit, taken at the middle of its length; while Figure 16 is a

section taken at the same place in the second digit. Further forward in each the upper border becomes acute.

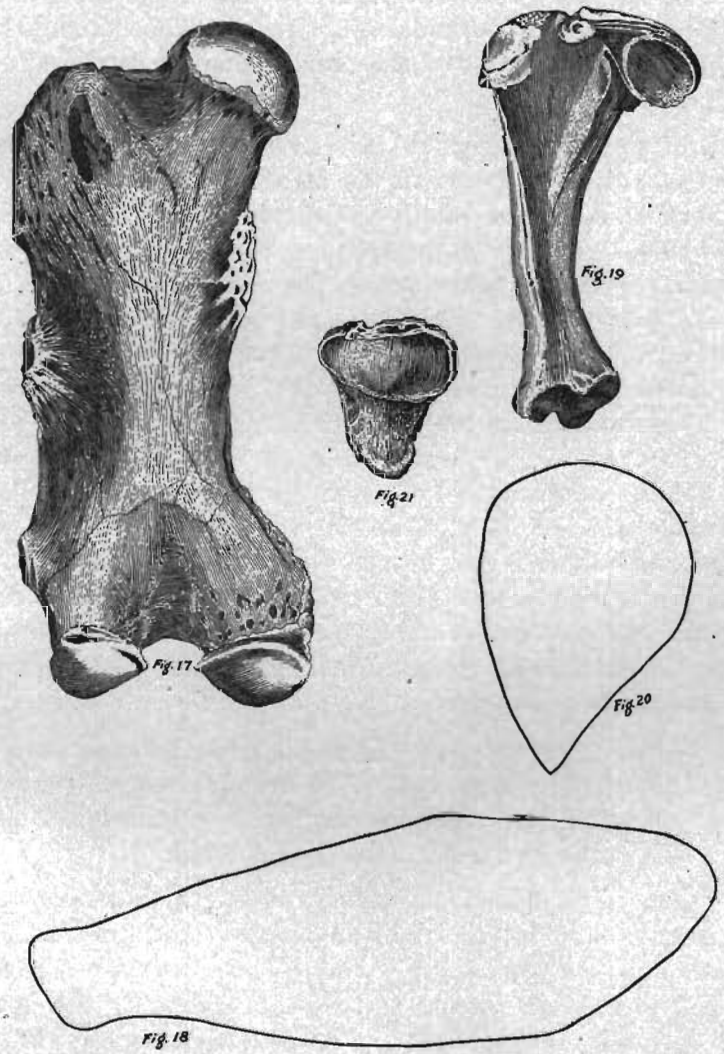
The fore foot had a length of nearly 300 mm. The horny claws would doubtless have made the length fully that much or more.

In order to illustrate still further the structure of the fore foot of Megalonyx, there is presented here a figure (Pl. IV, fig. 1) of the fore foot of *Hapalops longiceps,* a species found in the Santa Cruz Miocene beds of Patagonia. The figure is reduced from that presented by Prof. W. B. Scott (Mammalia of the Santa Cruz Beds, pl. xxxiii, fig. 2). It will be observed that in this figure the metacarpal and the first phalange of the first digit are missing. Professor Scott regards the genus Hapalops as being closely related to Megalonyx.

The pelvis of this animal is not yet well known. The last sacral bone has been mentioned above. Doctor Leidy seems to have had no part of the innominate bones for study. The pelvis was wholly lacking in the Henderson specimen and likewise in that found at Millersburg. Harlan (Med. and Phys. Res., p. 336, pl. xvi) mentions and figures an ilium that had been found in Big Bone Cave, Tennessee; but he gave little description of it and no measurements. The pelvis in the restoration of the Millersburg specimen has been modeled probably after that of Mylodon, as figured by Owen. In this animal (Fig. 37) the ilium stands out at nearly right angles with the vertebral column, like that of an elephant, thus making the basin very shallow. In the species described by Owen, *Mylodon robustus,* an animal about the size of Jefferson's megalonyx, the greatest breadth of the pelvis was three feet, five inches (1031 mm.). As in the elephants, the acetabulum, for articulation with the head of the femur, looked nearly directly downward.

The femur of *Megalonyx jeffersonii,* as that of other great ground-sloths, is a powerful bone. It is broad and flat, with the head directed nearly upward. Both of the femora were rescued in the Henderson specimen, and both in that found at Millersburg. Figure 17 is taken from the illustration furnished by Leidy. He gives the length as 21.5 inches, 546 mm. The head of the bone has a diameter of 120 mm.; the breadth

across the middle of the shaft, is 180 mm.; and here the thickness is 62 mm. Figure 18 represents a section at this place. The breadth of the lower end, across the articular surface, is 260 mm.



Figs. 17-21. *Megalonyx jeffersonii.* Femur.
17. Left femur from behind. X 1/6. After Leidy.
18. Section across left femur at middle of length. X½.
19. Left tibia, outer view. X 1/6. After Leidy.
20. Section of left tibia of Henderson specimen. X½. The front of the bone is toward the left, the outer border is below.
21. Patella seen from behind. X 1/6. After Leidy.

The greater trochanter does not rise as high as the head. On the hinder face of this is a deep slitlike pit. The lesser trochanter is on the inner border of the bone, about 75 mm. below the head. On the outer border there is a tuberosity which represents the third trochanter. At the lower end there are two smooth surfaces for articulation with the tibia; and between these, more on the front of the bone, a smooth surface for the patella.

Both of the tibiæ (Fig. 19) are preserved in the Henderson specimen, and the left one in the Millersburg specimen. They are short bones, with relatively slender shaft and much expanded ends. Figure 20 presents a section of a tibia of the Henderson specimen, taken across the bone at the middle of the length. The length of the bone is 310 mm., taken along the inner border; but the greatest length, taken obliquely, is 370 mm.; the greatest breadth at the upper end is 205 mm.; the greatest breadth at the lower end, 150 mm. At the upper end are articulatory surfaces for the femur, and on the hinder face of the outer extension of the bone, a surface for the fibula. At the distal end there is a surface 88 mm. wide for union with the astragalus; and adjoining it on the other side, an oblique surface for the lower end of the fibula. The tibia of the Millersburg specimen is 40 mm. longer along the inner border than the same bone in the Henderson megalonyx. The lower end is likewise wider, being about 180 mm.

The patella (Fig. 21) is a triangular bone, 125 mm. long and 100 mm. wide at the upper end. The broader end, on the hinder face, is occupied by a smooth surface for movement on the femur. The anterior face is convex and rough.

The fibula is a relatively slender bone, articulating above with the tibia, and below with both the tibia and the astragalus. The bone is not present in the Henderson specimen, but both the right and the left are in the Millersburg skeleton. The bone in the middle of its length, stands out so as to leave a wide space between it and the tibia; but its enlarged lower end is bent inward so as to join the tibia by a surface looking upward and inward, and the astragalus by a large surface which looks inward. The bone is 350 mm. long; 87 mm. wide, fore and aft, at

the upper end; 67 mm. traversely. Where slenderest the two diameters of the shaft measure 31 mm. At the lower end the fore and aft diameter is 87 mm.

Neither of the tarsi of the Henderson specimen is complete; the right foot presents the astragalus, the calcaneum, the external cuneiform, and the cuboid; the left foot furnished the astragalus, the calcaneum, and the navicular. Of the metatarsals there remain the second of the left foot, and the fourth and fifth of both feet. Of the phalanges there are preserved the first and second of the third digit consolidated into a single bone, the claw phalange of the same toe, the claw phalanges of either the second or fourth toe of both feet; and the first phalange of the last toe.

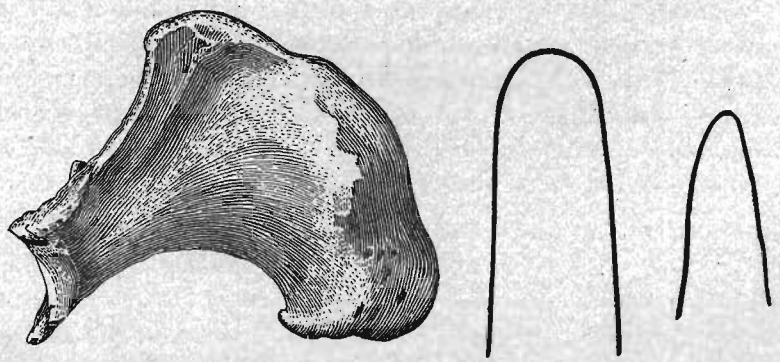


Fig. 22 Fig. 23 Fig. 24

Figs. 22-24. *Megalonyx jeffersonii.*
22. Left heel-bone, outer view. X½. After Leidy.
23. Section across ungual phalange of third digit at middle of length. X⅔.
24. A similar section across the second digit. X⅔.

It will be impossible here to describe all these bones. The reader will have to consult Leidy's monograph.

Neither are all the bones of the ankle and feet present in the Millersburg specimen. Both calcanea are represented, one astragalus, both naviculars, all four of the bones of the distal row of tarsals in the right foot, four metacarpals, and three ungual phalanges. On account of the manner of restoration of lost bones and parts of them, it is sometimes difficult to decide between the real and the artificial.

The extreme length of the hind foot, as shown in the Millersburg specimen, is 670 mm., nearly twenty-seven inches. The

presence of the internal cuneiform bone seems to indicate that the foot has been correctly restored with five digits.

The most remarkable bone of the foot is the heel-bone, the calcaneum. Figure 22, taken from Leidy, gives a view of the one of the left side seen from the outside. The broad end is directed backward in the position represented. This part is relatively thin. The anterior end of the bone is thickened, and is furnished with two smooth surfaces, for articulation with the astragalus and a smaller one for union with the cuboid.

The fifth metatarsal has a process standing directly out from its outer edge, and this process, more than half as long as the body of the bone, is also broader than the rest of the bone. It is possible that the fifth digit had only two phalanges. The first was described by Leidy as a four-sided nodule which had a smooth surface for the second phalange. This phalange was not preserved. From a specimen found in a cave in northern Alabama Leidy figured all the metatarsals, except the first (Trans. Amer. Philos. Soc., Vol. XI, pl. vi, fig. 1). His figures are reproduced on plate IV, figure 3.

The claw phalanges seem to have resembled closely those of the fore feet. Leidy figures the one of the third, or median, digit. The tip is missing. The length is given as eight and one-fourth inches (210 mm.); the greatest depth, four and one-half inches (109 mm.). The phalange is therefore 35 mm. longer than the corresponding one of the fore foot and proportionally somewhat deeper. This phalange in the Millersburg specimen is 230 mm. long, along the upper curve, and the sheath at the base occupies nearly one-half of the length of the bone, being 108 mm. long above. It is likewise 105 mm. high and 60 mm. thick, from side to side. Where the core of the claw emerges from the sheath, it is 70 mm. high and 25 mm. thick below. The upper border is obtuse posteriorly, but becomes more acute towards the distal end. Figure 23 represents a section taken across the ungual phalange of the third digit at the middle of its length; while figure 24 shows a section of the same phalange of the second digit.

In order to elucidate more fully the structure of the hind foot of megalonyx, there is shown here (Pl. IV, fig. 2) a figure of

the same member of the species *Hapalops longiceps,* a species from the Santa Cruz beds of Patagonia. This figure also is taken from Scott's work on Santa Cruz Mammalia. See page 122. In this specimen the internal cuneiform was missing; also the second and third phalanges of the fourth digit, and all of those of the fifth, and the outstanding process in the fifth metatarsal.

As to the habits of these animals, it is certain that, like the modern sloths, they devoured vegetable matter, probably the foliage of trees; but their more powerful teeth doubtless enabled them to crush and eat likewise the smaller branches. Their weight made it impossible for them to climb trees, but they were probably able to pull down trees of considerable size and possibly, in case of need, to uproot them.

PLACES IN IOWA WHERE THE GROUND-SLOTH, MEGALONYX, HAS BEEN FOUND.

Scanty remains belonging to this genus have been found in a number of places in Iowa.

In 1862 Prof. J. D. Whitney (Geol. Surv. Wisconsin, Vol. I, p. 135) reported having found bones and teeth of Megalonyx associated with a peccary in a flat crevice in the Galena limestone at a depth of ten feet, near Dubuque. He again referred to this discovery in 1866 (Geol. Surv. Illinois, Vol. I, p. 162). The determination of these remains was made by Dr. Jeffries Wyman. The materials on which the determination was made are probably in the Museum of Comparative Zoology at Cambridge, Massachusetts; but the present writer has not seen them. Doctor Wyman (Whitney's Report, Geol. Surv. Wisconsin, Vol. I, 1862, p. 422) stated that in Professor Hall's collection made in the lead region, there were fragments of bones and several teeth, the latter belonging to *Megalonyx jeffersonii.* Two or three individuals were represented. Unfortunately Doctor Wyman did not indicate whether these remains were found in Iowa or Wisconsin.

In 1889 (Proc. Amer. Assoc. Adv. Sci., XXXVII, p. 202) Prof. J. E. Todd reported the discovery of a claw phalange in Mills county, Iowa, in sand below the drift. The identification

of the object was made by Dr. Joseph Leidy. Doctor Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 353) stated that this sand is interglacial, belonging to the Aftonian.

The remains above mentioned may be referred provisionally to *M. jeffersonii;* but it is not at all unlikely that they belong to *M. leidyi,* especially those bones and teeth which occur in the Aftonian. The type locality of the latter, McPherson county, Kansas, is much nearer to western Iowa than those localities where authentic specimens of *M. jeffersonii* have been found. Furthermore, there is as yet no certain evidence that the latter existed as early as the Aftonian. The specimen found at Henderson, Kentucky, may belong to the Sangamon; those found in Ohio belonged to post-Wisconsin times. *M. jeffersonii* was not found in the Port Kennedy cave, an early Pleistocene deposit.

The Aftonian deposits at Sioux City have furnished various remains of Megalonyx. In the collection at the University of Iowa is an ungual phalange which had been secured by Prof. B. Shimek in the Anderson pit, at North Riverside, near Sioux City. The catalog number is 174. This phalange has the terminal portion broken off a short distance in front of the tuberosity for the tendon, and the whole of the basal sheath is gone likewise. Figures 1, 2, plate V, give a side view and a view from below of this phalange; while figures 25, 26, and 27 pre-

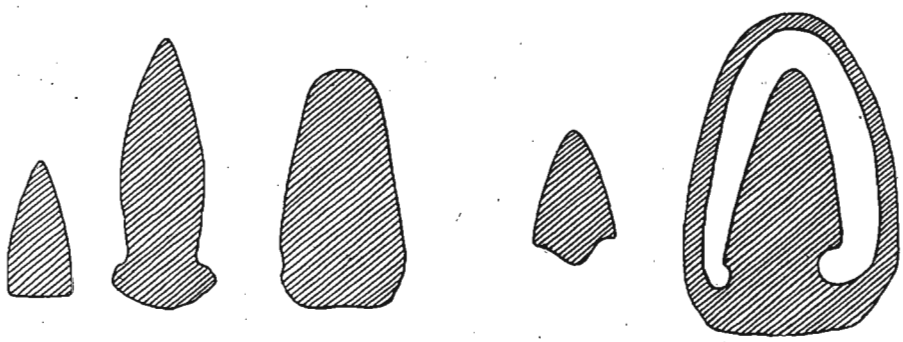


Fig. 27 Fig. 26 Fig. 25 Fig. 29 Fig. 28

Figs. 25-29. *Megalonyx jeffersonii.* Sections of ungual phalanges. Numbers 25, 26, 27, a phalange from Sioux City; Nos. 28, 29, one from Champaign, Illinois. X⅔.

25. Section taken just in front of the hinder end.
26. Section taker. at middle of the tuberosity for the tendon.
27. Section in front of the tuberosity.
28. Section taken through tuberosity. Shows also the sheath.
29. Section taken in front of tuberosity.

sent sections taken just in front of the articulation with the preceding phalange, at the middle of the tuberosity for the tendon, and in front of this tuberosity, respectively. It will be seen that the bone is high and compressed, and that in the front half it comes to an acute border above. The length of the fragment is 105 mm.; the height at the rear end, 46 mm.; at the tuberosity, 57 mm.; at a point on the upper edge where broken, 27 mm. The thickness where the sections are taken are respectively 25 mm., 25 mm. (tuberosity), and 12 mm. At the rear is the articulation for the second phalange, consisting of two grooves separated by a prominent ridge. Figures 28 and 29 represent sections of a claw from Champaign, Illinois, (see also figs. 5 and 6 of plate III) which correspond to figures 26 and 27. It will be seen that the Sioux City claw core is considerably more compressed, hence it possibly belongs to another species.

From the same pit there is a supposed patella, now in the collection at Iowa City, and having the number 175. So far as its form is concerned, it may be referred to either Megalonyx or Mylodon. It is probably that of a small or half-grown animal. The patella of *Megalonyx jeffersonii* described by Doctor Leidy had a length of 5 inches and a width of 4 inches. The present bone has a length of only 55 mm., a width of 43 mm., and a thickness of 36 mm. It is more constricted about the middle of the length than was the bone figured by Leidy, and likewise more than that of Mylodon figured by Owen (Extinct gigantic Sloth, pl. xvii, fig. 2). What corresponds to the articular face of the patella is about as rough as the remainder of the bone. It seems possible that the bone belongs elsewhere.

Here was found also one of the second phalanges of probably Megalonyx. It has the catalog number 221. At Turin, in Monona county, there was found a very complete right radius, which is now in the collection at Iowa City and which has the number 275. Doctor Calvin's figures are here reproduced (Pl. V, figs. 3, 4), showing a front view of the bone and a view of the border which was turned toward the ulna. The bone differs in form but little from the one figured by Leidy, and which belonged to *Megalonyx jeffersonii*. The length is 424 mm. (sixteen and five-eighths inches). The diameters of the head are 53

mm. and 61 mm.; those of the middle of the shaft, 32 mm. and 80 mm.; those of the distal end 89 mm. and 63 mm. The bone described by Leidy was 453 mm. long; 90 mm. wide at the middle; and 82 mm. at the distal end. It will be seen that the bone of the Henderson specimen is longer than the Turin bone, but narrower at the distal end.

From the Aftonian deposits of the Cox pit, at Missouri Valley, Doctor Calvin reported a damaged right tibia which he identified as that of *Megalonyx jeffersonii*. It has the catalog number 31. Both the upper and the lower ends are damaged, but the shaft is complete. The writer has seen this bone and taken a photograph and measurements of it. It appears to be necessary to refer it to Megalonyx, but it probably is not that of *M. jeffersonii*. The total length of the bone is 345 mm.; the greater diameter at the middle of the length 75 mm.; the shorter diameter, 50 mm. The articulation shown in the photograph looks upward. One face, supposed to be the outer one, is straight and nearly flat; the opposite one is, on the lower half of the bone, convex from side to side, while in the upper half there is a broad groove which descends from the upper end. A transverse section taken at the middle of the length is shown here (Fig. 30) and is to be compared with a corresponding section of the tibia of the Henderson specimen of *M. jeffersonii*. It will be seen that they are quite different. In the Henderson specimen the fibular border of the bone is acute. This bone cannot belong to Mylodon, for the tibia of that animal is relatively much shorter and thicker.

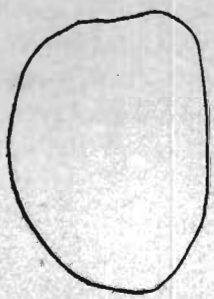


Fig. 30. Megalonyx? Section across right tibia at middle of the length X½. Specimen found at Missouri Valley.

From this gravel pit there was obtained by Professor Shimek a lumbar vertebra, of which two views are here presented (Pl. VI, figs. 1, 2). It seems certain that it belonged to a species of Megalonyx. The catalog number in the collection at Iowa University is 19. The centrum measures at one end 100 mm. from side to side, 76 mm. vertically. The sides of the centrum are slightly concave. On the lower face there is a pair of large

foramina opening into the interior of the bone, each measuring from side to side 17 mm.; fore and aft, 22 mm. The spinal canal is 55 mm. high, 60 mm. from side to side. A great neural spine passes upward and backward from the neural arches, rising 125 mm. above the roof of the neural canal. Near the upper end this spine measures 87 mm. from front to rear and is 34 mm. thick.

From the Jensen well, near Akron, Plymouth county, there was obtained the coalesced first and second phalanges of the third digit of the hind foot of a species of ground-sloth, but to what species it belonged is unknown (Shimek, Bull. Geol. Soc. Amer., Vol. XXI, p. 127). It was most probably a Megalonyx.

Family **Mylodontidae.**

The Mylodons.

Ground-sloths with teeth i $\frac{0}{0}$, c $\frac{0}{0}$, m $\frac{4}{4}$; the teeth of the upper jaw, especially the hinder ones, more or less triangular in section, with some of the sides concave from side to side; the front tooth of each side usually planted near the second; the front one in the jaw considerably behind the front of the snout; the hinder tooth of the lower jaw larger than the others, and with one or more wide grooves along its inner face, making the section lobate; humerus with or without foramen above the inner epicondyle; hinder feet with four digits.

Under this family are arranged, besides Mylodon, about fifteen genera which have left their remains in the Tertiary and Pleistocene deposits of South America. Still another genus, Paramylodon, closely related to Mylodon, occurs in North America, but so far as yet known, not in Iowa. Since it is known from Nebraska, it is entirely probable that its remains may yet be discovered in Iowa also.

Genus **MYLODON** Owen.

Skull rather elongated; snout longer and broader than in Megalonyx. Zygomatic arch interrupted. Front upper tooth not larger than the second. Hindermost lower tooth bilobate; the hinder three upper teeth with a broad groove on the inner face. Humerus without foramen above the internal epicondyle. Fore foot with five digits; hind foot with four.

Species belonging to this genus have been found in the Pleistocene of both South and North America. From this epoch in North America there have been described four species. All of these are known from teeth and portions only of the skeleton. The type of the genus is *Mylodon harlani* Owen.

Mylodon harlani Owen.

This species is not well known, for only scanty remains of its skeleton have up to this time been found. It was based on part of the right side of a lower jaw which was found before 1831, at Big Bone Lick, Kentucky. The specimen is now probably at the American Museum of Natural History, having been a part of the collection of the Lyceum of Natural History of New York. Other meager portions of this animal have been found in various parts of the country. Among these are parts of the skeleton of a half-grown animal that were discovered near Natchez, Mississippi; a tooth found near Charleston, South Carolina; some bones and teeth found in Benton county, Missouri; a humerus and a tooth from Oregon, which, however, may belong to another species. Two other closely related species have been described from the Pleistocene of Louisiana, and a third from the same epoch in Oregon.

Figures 3 and 4 of plate VI present views of the fragment of a jaw found at Big Bone Lick. In figure 3 the jaw is seen from above, so that the forms of the crowns of the teeth are represented; in figure 4 it is seen from the outside. Figure 3 is two-thirds of the natural size; figure 4 a little more than one-half the size of nature. The length of the fragment is 210 mm.; the height, at the front of the hinder tooth, 84 mm.; the thickness, 37 mm. The figures indicate that the jaw from front to rear of the tooth-line was somewhat concave on the outside. There were originally, as in Megalonyx, four teeth in the jaw, but the front one was lost from its socket.

Inasmuch as the scanty remains of the North American species give us no correct idea of the form and anatomy of the mylodons, it is thought best to reproduce a number of figures of a South American species, *Mylodon robustus*. Plate VII is prepared from a photograph of one of a group of mylodons in

the American Museum of Natural History in New York. The liberality of the authorities of this museum makes it possible to publish this view. The other illustrations are taken from Richard Owen's monograph entitled "Description of the Skeleton of the Giant Sloth *Mylodon robustus* Owen."

Figure 31 represents the lower jaw of *M. robustus* viewed from above. It will be observed that the teeth resemble closely those of the North American species, but that there were nevertheless some differences. The figure shows also the spoutlike form of the front of the jaw.

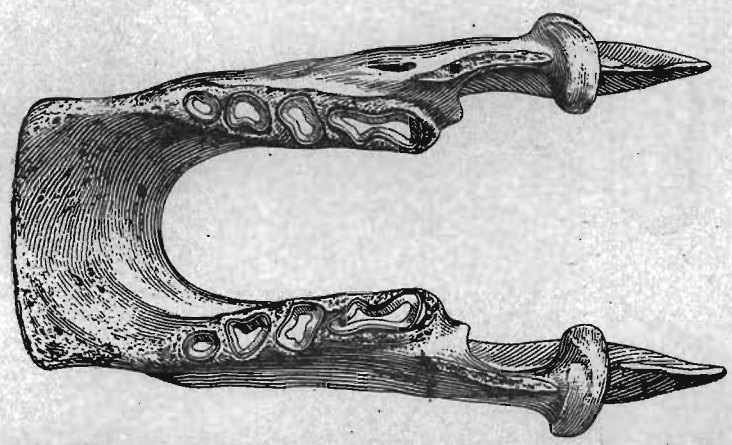


Fig. 31. *Mylodon robustus*. Lower jaw seen from above. X about ¼. From Owen.

The size and form of the first, or front, lower tooth of *M. harlani* has been determined sufficiently well from the form of the socket and from a fragment of the tooth in the socket. A section of this and of the other teeth is shown in figure 32, taken from Leidy's Memoirs of the Extinct Sloth Tribe of North America, the work referred to under Megalonyx. The section is somewhat kidney-shaped. The long diameter is directed fore and aft, and is 25 mm.; the transverse, 16 mm. The second has a section more irregular in form, somewhat quadrate, with rounded angles, and with the outer and the hinder sides concave. The long axis, oblique to the jaw, measures 29 mm.; the one at right angles to this, 20 mm. The third tooth also has its long axis oblique to the jaw, and measures 33 mm. The axis at right angles to the middle of the long axis measures 16

mm. The fourth tooth is much the largest of the teeth, having a length of 56 mm. Its section is constricted in the middle, indicating a broad groove on the inner side, and another on the

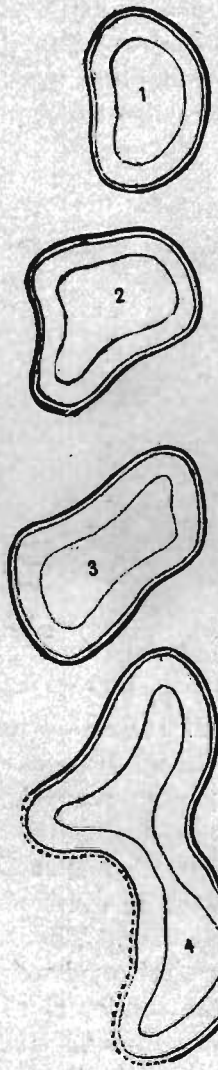


Fig. 32

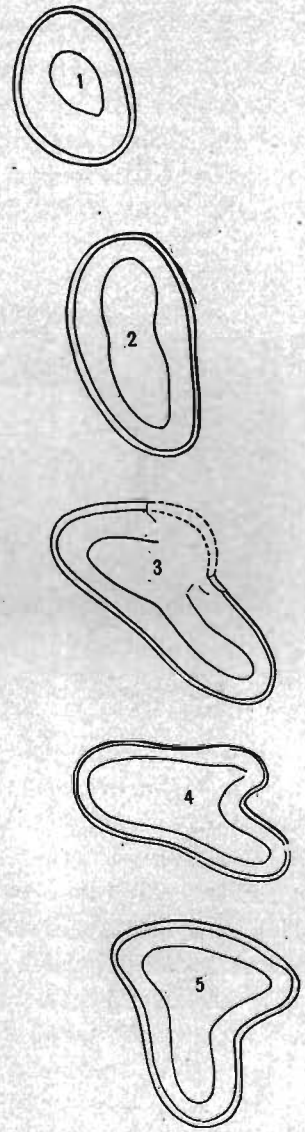


Fig. 33

Fig. 32. *Mylodon harlani.* Sections of lower teeth. X1. From Leidy. They are numbered from in front.

Fig. 33. *Mylodon harlani.* Sections of upper teeth of right side. From Cope. X1. They are numbered from in front.

outer side running the length of the tooth. This tooth is very characteristic of Mylodon. As to the other teeth it will be observed that they are likely to have some of the sides more concave than those of Megalonyx.

The upper teeth have not yet all been found in their places in the jaw. From Benton county, Missouri, Harlan had fragments of the upper jaw which contained two teeth. From New Iberia, Louisiana, Professor Cope described what he regarded as the upper teeth of *Mylodon harlani.* From his figures there have been prepared the sections of these teeth as here shown (Fig. 33). These teeth were not found in the bone, however.

Figure 34 represents a palatal view of the skull of *Mylodon robustus,* and a comparison of this with the same view of Megalonyx will show important differences. In Megalonyx the rows

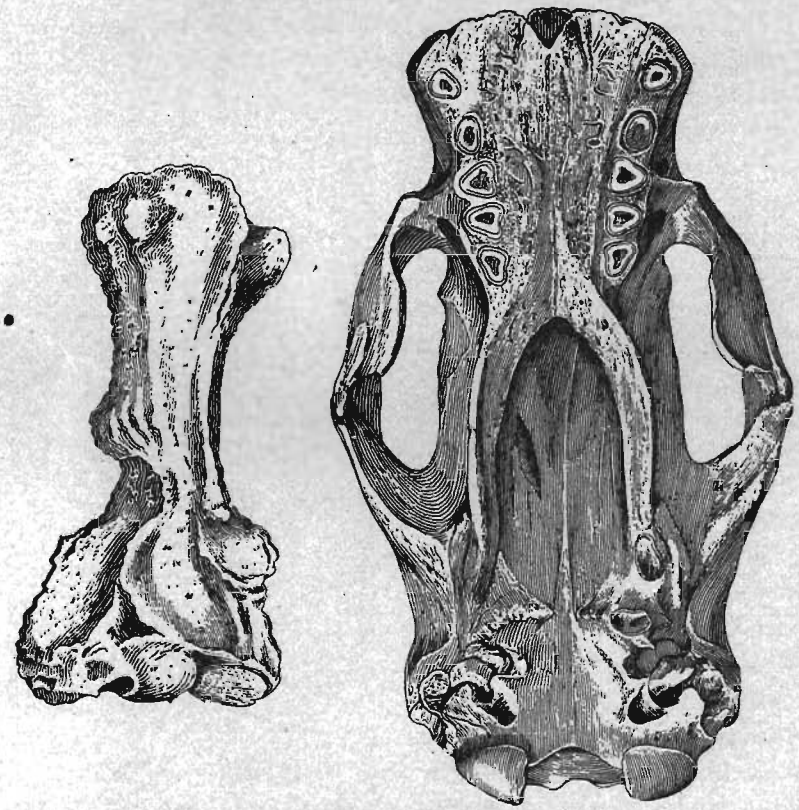


Fig. 35 Fig. 34

Fig. 34. *Mylodon robustus.* Palatal view of skull. X¼. From Owen.
Fig. 35. *Mylodon harlani?* Humerus. X 1/7. From Harlan.

of teeth are nearly parallel with each other; in Mylodon, they converge backward. In Megalonyx the front tooth is the largest and is placed far in front of the next one; while in Mylodon the front one is small and not far removed from the second, and the hinder one is the largest. In Megalonyx, the hinder tooth is near the middle of the length of the skull; in Mylodon, near the hinder end of the front third.

In 1843 Harlan described some parts of the skeleton of *Mylodon harlani* under the name of *Orycterotherium missouriense* (Amer. Jour. Sci., Vol XLIV, p. 69, pls. i-iii). These had been found in Benton county, Missouri, by Albert Koch. Among these remains was one humerus. A copy of this drawing, furnished by Harlan, is here presented (Fig. 35). The bone had exactly the length of that of the megalonyx described and figured by Leidy, twenty inches (508 mm.). In the megalonyx, the diameter across the epicondyles is ten and one-half inches; in the mylodon, it is eleven inches. In the megalonyx the shaft is much more slender than in the mylodon; the diameter of the former, at the middle, being three and one-fourth inches (82.6 mm.); in the latter, five inches (128 mm.). Another humerus was figured by H. C. Perkins from a specimen found in Oregon (Amer. Jour. Sci., Vol. XLII, p. 136, figs. 2-4). The humerus of Mylodon has no foramen just above the inner condyle, while that of Megalonyx does have the foramen. Another large bone of Mylodon described by Harlan is the ulna. Compared with that of Megalonyx, it is shorter and a stouter bone. Its total length was 16 inches (406 mm.). According to Harlan's figure and his measurements, the distance from the coronoid process to the hinder end of the bone was a

Fig. 36. *Mylodon robustus*. Left forefoot, seen from above. X 3/16. From Owen.

little more than four-tenths the whole length of the bone; while in Megalonyx this distance is only about three-tenths the length.

The structure of the fore foot is not known from the North American species. Therefore, a copy of Owen's figure of that of *Mylodon robustus* is presented (Fig. 36) which shows this member of one-fourth the natural size. This foot is stated to be one foot and two inches long and eight and one-third inches broad. It will be seen that there are five digits, of which the three first bore horny claws, and that at the base these were protected by bony sheaths, as in Megalonyx. It is evident from Owen's figures, that the claw cores were not as compressed as in Megalonyx and did not have such an acute upper border. In the fourth and fifth digits the phalanges were much reduced, and possibly the third one in each was not developed. These fingers were probably either wholly buried in a pad of connec-

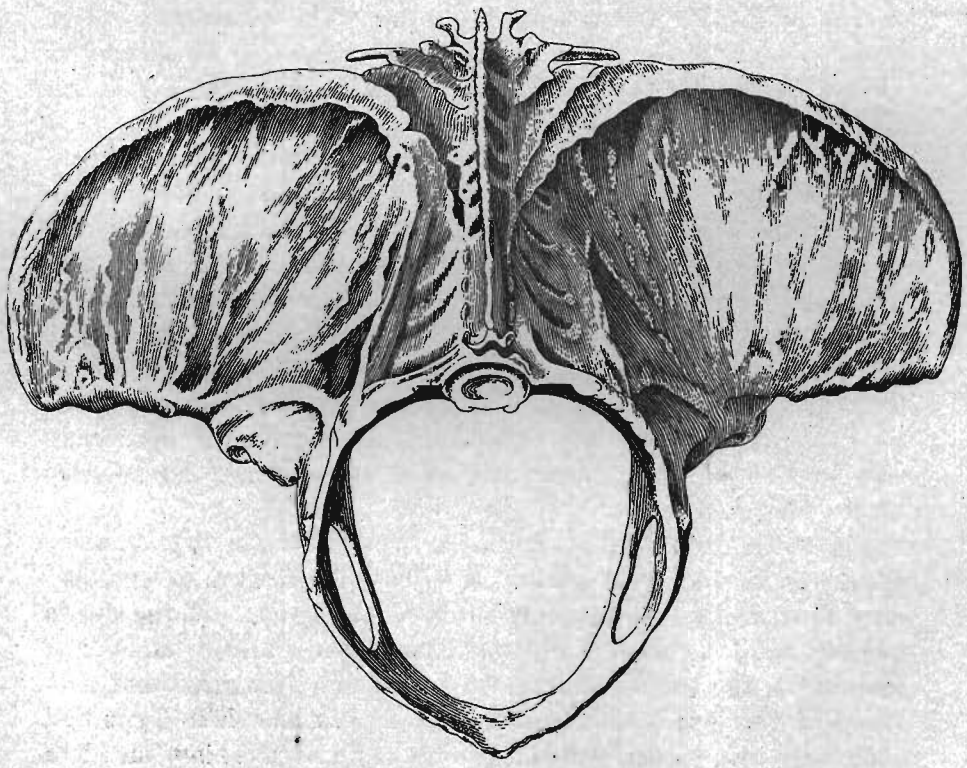


Fig. 37. *Mylodon robustus.* Pelvis, seen from behind. X⅛. From Owen

tive and fatty tissues and hard skin, or, they may have ended in rudimentary nails. According to Owen, the last bone of the middle finger was five and a quarter inches long. This length was considerably increased by the presence of the horny claw.

Figure 37 represents the pelvis of *Mylodon robustus.* This striking portion of the skeleton resembles greatly that of the elephant, being much extended laterally and shortened from front to rear. Its entire breadth is three feet and five inches. The acetabula, those cavities which received the head of the femurs, look downward. The appearance presented by the pelvis in Mylodon and Megalonyx may be seen also from the figure of *Megalonyx jeffersonii* (Fig. 1).

The femur of *Mylodon robustus* resembled considerably that of *Megalonyx jeffersonii.* However, a comparison shows that, while in *Mylodon robustus* the upper end of the bone is considerably wider than the lower, in *Megalonyx jeffersonii* the lower end is somewhat wider than the upper. The tuberosity on the inner border of the bone, the third trochanter, is considerably above the middle of the bone in the Mylodon, while in Megalonyx it is at the middle.

Harlan had also two tibias of *Mylodon harlani,* and these contrast strongly with the same bone in Megalonyx, being much shorter and thicker. The tibia agrees in form closely with that of the South American *Mylodon robustus,* whose tibia and fibula are here shown (Fig. 38). The larger tibia described by Harlan, had a length of ten and one-half inches (255 mm.); while the diameter at the middle of the shaft, was thirty hundredths that of the length. In Megalonyx, the tibia described by Leidy is fifteen inches (380 mm.) in total length; the diameter at the middle of the shaft is about twenty-three hundredths of the length.

Figure 39 from Owen shows the hinder foot of *Mylodon robustus* as viewed from above. It will be observed that there are only four digits, the first one being wholly gone. Of the digits present only the second and third possessed the full number of phalanges, the third phalange of each being elongated and provided in life with a horny claw. The fourth and fifth digits had each only two much reduced phalanges and possibly the fifth had only one. It will be seen that the form of the heel bone is

greatly different from that of Megalonyx. The structure of this foot shows that the sole was turned somewhat inward and that the animal rested more or less on the outer edge of the foot. The last phalange of the middle digit was five and one-third inches (136 mm.) long; one and five-sixths inches (46 mm.) high at the middle; and one and three-fourths inches (44 mm.) wide at the middle. Here, as in the fore foot, the upper border

Fig. 39

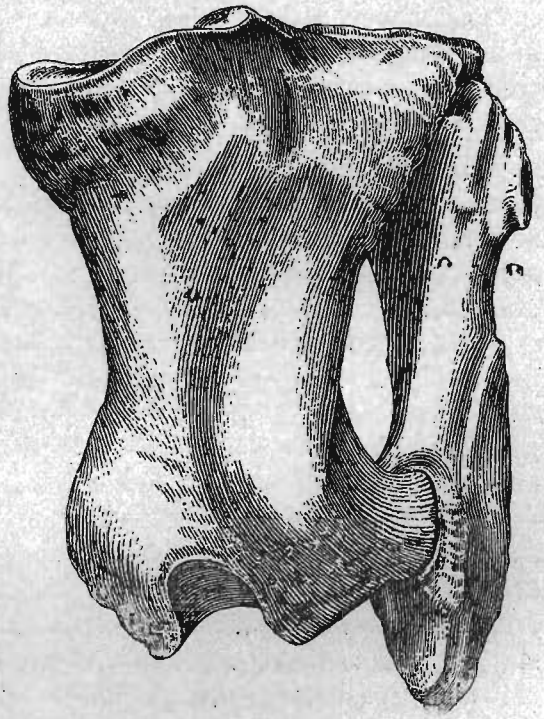


Fig. 38

Figs. 38, 39. *Mylodon robustus.*
38. Left tibia and fibula, seen from front. X 2/5. After Owen.
39. Left hind foot. X 3/16. After Owen.

of the claw-core was less acute than in the claw-cores of Megalonyx. It seems evident, too, that the bony sheath at the base of these ungual phalanges of the fore and the hind feet was shorter than in the Megalonyx. The core, too, seems to have been straighter.

There were four claw-cores in the collection of remains of *M. harlani* examined by Harlan, but his figures do not give one a clear idea of their details.

As regards the habits of the mylodons it is evident that, like their far smaller modern relatives, the tree-inhabiting sloths, they were devourers of vegetation. We are forbidden by their great size to suppose that such animals could climb about among the branches of trees. They might, indeed, have consumed the foliage and tender branches of shrubs and of herbaceous plants. Professor Owen, in his monograph, expresses the opinion that the enormously strong bones, especially those of the hinder part of the body, indicate that these animals were fitted to uproot trees of considerable size and thus to bring the foliage within their reach.

Within recent years some light has been cast on the structures and habits of the giant sloths. In 1897 there was found in a cavern in Patagonia, near the line between Chile and Argentina, a large piece of the dried skin of an animal unknown to the natives of that region. It was later ascertained to belong to some sort of Edentate, and was then supposed to have belonged to some species of Mylodon. A piece of this skin, about twenty-two inches long and eighteen inches wide, came under the observation of Dr. A. S. Woodward, of the British Museum of Natural History. He furnished a description of this which is to be found in H. H. Pritchard's "Through the Heart of Patagonia." The piece of skin is there illustrated by two figures. The outside is thickly covered with hair varying from two inches to nearly three in length. In the deeper part of the skin are numerous closely crowded nodules of bone, the largest of which measures 15 mm., in length. The piece was supposed to belong in the region about the head and neck. It was impossible to prove that the skin had belonged to a mylodon; for the known dermal bones of the latter belonged to the lumbar region and lay nearer the surface of the skin, being immediately covered with horny epidermis.

At a later time further excavations brought to light another piece of skin, and various broken bones of more than one individual of this animal. There were present remains of other animals, some extinct, besides evidences of human occupation, and, among other things, some remains of cut hay. The conclusion was reached that at some time men had kept these huge

edentates impounded there for some purpose. A study of the remains has shown that the animal belonged to a genus, Grypotherium, related to Mylodon and already known from parts of the skeleton.

With the other remains of this animal there was found in the cave examined some of its excrement. A study of this by botanists indicated apparently that the animal had lived in large part on grasses and some other plants. This suggests that not improbably the North American species of Mylodon were not wholly addicted to pulling down and destroying trees. As to the time when this grypotherium had lived nothing certain has been determined. It was at first thought that the species might yet be in existence in the mountains of that region. The skin seemed to have been but recently taken from the animal, and there was yet on it dried serum. Some of the vertebræ and limb-bones retained yet portions of cartilage and traces of muscles and ligaments.

These facts seem to indicate very recent existence. Dr. Woodward, however, concludes that the animal formed part of a fauna that is now mostly extinct, but that nevertheless the grypotherium was probably actually kept and fed by an early race of men. The mere existence of a large part of the skin of one of these mylodons appears to indicate plainly that men had captured and killed the animal.

In North America Mylodon remains have been found in many places; and apparently at very different levels. One ungual phalange was found in Port Kennedy cave, but Professor Cope was not certain that it belonged to *Mylodon harlani.*

A claw-core of Mylodon has been found in the Aftonian of Iowa, and another at Tecumseh, Nebraska, but in the absence of associated skulls, and even of teeth, we cannot be wholly certain that the species is *Mylodon harlani,* whatever the probability may be. The actual age of the type specimen found at Big Bone Lick, Kentucky, cannot be determined. It seems probable that the deposits of bones made there may range from the Sangamon stage to the Recent. It is to be taken into account that no Mylodon remains have yet been found in deposits overlying Wisconsin drift. We may therefore suppose for the present

that *Mylodon harlani* flourished from the Aftonian to the Sangamon stage.

In his first paper on Aftonian Mammalian Fauna already quoted, Dr. Calvin described and figured (plate XXVI, figs. 1-3) a part of a large ungual phalange which he referred to Mylodon, without venturing to name the species. This phalange was found in the Cox gravel pit, at Missouri Valley, and has the catalog number 162. One of Calvin's figures, the one illustrating the bone as seen from above is here reproduced (Pl. VIII, fig. 2). Another figure on the same plate shows the left side of the claw. The anterior part of the bone is broken off and lost. The greater part of the bony sheath which protected the base of the horny claw is likewise missing, especially on the left side. The length of the bone as found is 113 mm.; but originally it

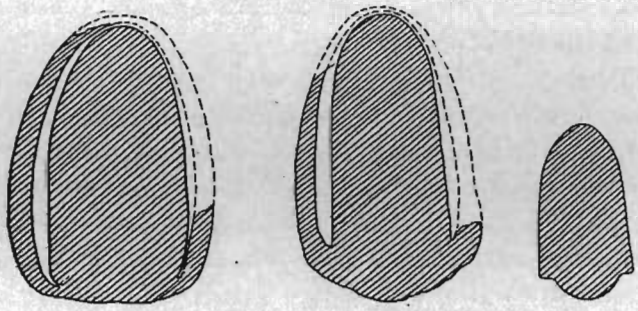


Fig. 40 Fig. 41 Fig. 42

Figs. 40-42. *Mylodon harlani?* Sections of claw found at Missouri Valley. X⅔.
40. Section taken near the base.
41. Section taken at middle of inferior tuberosity.
42. Section taken in front of tuberosity.

cannot have been far from 160 mm. The height at the front of the articulation with the second phalange is 52 mm.; at the rear of the tuberosity for the tendon, 58 mm., allowing nothing for the missing sheath; at the place of fracture, 32 mm. The breadth at the articulation is 39 mm.; at the place where the second section is taken, allowing something for the missing part of the sheath, about 40 mm.; at the broken end, 18 mm. The bone is more convex on the right side, showing that it was bent slightly towards the left. The upper border of the claw-core

is broadly rounded; thus differing from the same part in Megalonyx, in which this border comes to an acute edge in the distal half of its course. Sections are here furnished which are to be compared with similar ones of Megalonyx. Just behind the tuberosity in the lower border of the bone is a pair of large foramina for bloodvessels. Figure 40 represents a section of this claw taken just in front of the articulation with the second phalange; figure 41 another section taken at the middle of the tuberosity on the lower border; while figure 42 represents a section at the broken end of the specimen. These sections are to be compared with figures 25-29 on page 128.

The phalange mentioned as being found at Tecumseh, Johnson county, Nebraska, is in the State collection, at the University of Nebraska. It is a somewhat larger claw than the one found at Missouri Valley. The height at the front of the articulating surface, is 60 mm.; that at the tuberosity, 67 mm.

Recently Glover M. Allen has published (Mem. Mus. Comp. Zool. Harv. Coll., Vol. XI, pp. 317-346, pls. 1-4) a description of a new species of Mylodon, *M. garmani,* the type of which was found many years ago somewhere not far from Hay Springs, Nebraska. This species has a much narrower skull than *Mylodon robustus,* and there are important differences in the teeth. The lower teeth resemble rather closely those of *M. harlani,* but are yet different. The upper teeth are still more different. It is not improbable that the specimens found in the Aftonian of Iowa belong to this species rather than to *M. harlani.*

Allen regards his species as having been a browsing rather than a grazing animal.

Superorder **UNGULATA.**

Suborder **PERISSODACTYLA.**

Tapirs, Horses, Rhinoceroses, Titanotheres, Etc.

Ungulata which have the middle, or third, digit of all the feet most strongly developed; astragalus with the distal end flat; fibula usually not articulating with the heel-bone; femur with a third trochanter; presacral vertebræ 20 or 30.

This group, or suborder, of hoofed animals is represented today by only the horses, the tapirs, and the rhinoceroses; but during Tertiary times there existed a host of related forms. Many of these have been discovered in North America; others in South America, Europe, Asia, and Africa. One family that existed in our country, the Titanotheres, contained species that were as large as elephants. Because of the relatively few species now existing, the suborder may be looked on as a vanishing one.

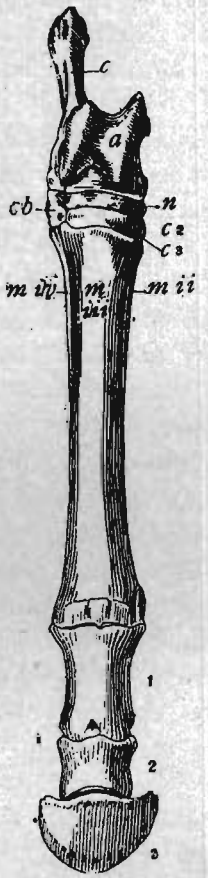


Fig. 43. *Equus caballus.* Right hind foot seen from in front. *a*, astragalus; *c*, calcaneum; *cb*, cuboid; *c1*, *c2* mesocuneiform; *c3*, ectocuneiform; *mii*, second metatarsal; *miii*, third metatarsal; *miv*, fourth metatarsal; 1, 2, 3, first, second and third phalanges, or upper and lower pasterns and coffin bone.

The character which especially distinguishes the animals of this suborder from other Ungulata is the relatively large size of the third or middle toe. In all species of the group, fossil or living, the first, or inner, toe is either wholly missing, or represented in the forefoot by only a slender vestigial element; in nearly all, the fifth also is wanting. Among living genera the tapirs have the fifth present in the forefoot, but it is much reduced in size; the middle toe is, however, much larger than any of the others. In the living and in the Pleistocene horses, the middle digit alone is complete and functional, but remnants of the second and fourth toes exist in the form of splint-bones (Figure 43).

In all the perissodactyles the femur has an outstanding process, the third trochanter, on the outer side of the bone. That ankle bone on which the shin-bone rests, the astragalus, is semi-cylindrical and pulley-like at the upper end, with a deep furrow, while the lower end is cut off squarely, differing thus much from the corresponding bone in the artiodactyles.

Superfamily **EQUOIDEA.**

Hyracotheres, Palaeotheres, Anchitheres, Protohippines, and Horses.

Skull elongated; teeth in full number, forty-four or sometimes with canines and first premolars missing. Orbits in hinder half of the skull. Never any horns. Nasal bones long and pointed. Feet elongated.

All the animals included in this group are extinct, except the true horses; and it is mostly these which continued on into the Pleistocene.

Family **Equidae.**

The Horses, Asses, and Zebras.

Skull elongated and with the orbits well behind the middle of the length. Limbs fitted for great speed. Feet with three functional digits in many of the extinct genera; with only one in Equus. Teeth $i\frac{3}{3}$, $c\frac{1}{1}$, $pm\frac{4-3}{4-3}$, $m\frac{3}{3}$; cheek-teeth in the older forms low-crowned, in the most recent high-crowned; the upper molars showing on the unworn grinding surface two outer, two inner, and two intermediate cusps, each inner cusp joined to the corresponding intermediate by an oblique ridge. The worn molars showing an internal column (protocone) and two inner crescents separated from two outer crescents by two "lakes" of cement; lower molars with two outer crescents, two inner cusps, and an inner median column (mesostylid). The premolars of the higher genera, except the first, becoming molariform. Incisors, chisel-like, the canine and first premolars often wanting, especially in the females.

The numerous relatives of the domestic horse which belonged to other genera than Equus and Neohipparion need not be described here. It suffices only to say that as we go further and further backward in Tertiary times, the species and genera lose gradually the distinctive characteristics of our horses. The feet come to have three or four functional toes, and the whole foot becomes larger as compared with the rest of the leg. The teeth come to have shorter and shorter crowns, the grinding

surface is furnished with rounded cusps covered with enamel, and the premolar teeth resemble less and less the true molars. The animals have no longer the great size of our horses; and the earliest forms were no larger than a small fox. The earliest known species belong to the Eocene of North America and Europe. Eohippus had four toes on the fore feet and three on the hinder. The crowns of the teeth were extremely low and resembled those of monkeys more than those of our horses.

Of this family there have been found in the Tertiary deposits of North America a dozen or more genera and many species; but of these only Equus and Neohipparion, so far as we now know, came into the Pleistocene. Many of the genera were common to Europe and North America. Equus existed in all the continents, except Australia, during the Pleistocene, probably also during a part of the Pliocene.

It may be said that good reasons may be proposed for removing from the family Equidæ many of the earlier and more primitive genera. On this question consult the recently published work by R. Lydekker, "The Horse and Its Relatives."

In a paper published in 1907 (Bull. Amer. Mus. Nat. Hist. Vol. XXIII), Mr. J. W. Gidley accepted the family in its wider sense and divided it into four subfamilies, as follows:

I. Hyracotheriinæ.
II. Anchitheriinæ.
III. Protohippinæ.
IV. Equinæ.

In Iowa there have been discovered representatives of only the last two families. Of these the Protohippinæ contain about five genera most of which flourished during the Miocene and Pliocene; but one genus, Neohipparion, appears to have continued on into the Aftonian. The Protohippinæ may be defined as follows:

Subfamily **PROTOHIPPINAE.**

Cheek-teeth high-crowned and furnished with abundant cement, the lakes well-developed. Three toes furnished with hoofs on all the feet, the median one much the largest.

Genus **NEOHIPPARION** Gidley.

The New World Hipparions.

Cheek-teeth high-crowned and prismatic; the hinder three premolars like the molars; the first upper premolar present, but reduced in size; inner anterior column (protocone) of upper cheek-teeth not connected with the anterior crescent (protoconule), on the worn surface appearing as an enamel-surrounded island of oval or elliptical form; canines present in both sexes; incisors with cups more or less well-developed. Feet each with three toes furnished with hoofs; the metacarpals and the metatarsals without keel at distal end.

This genus, which comprehends the New World hipparions, differs from the genus Hipparion, in which are placed the hipparions of the Old World, in having the internal anterior column of the upper teeth (as it appears on the worn face of the tooth) more or less elongated fore and aft, instead of circular. Also on the outer face of the tooth the spaces between the prominent ribs or styles are concave, as in the common horse, instead of being flat. It is thought also, that its lateral toes are more reduced than in Hipparion. However, the two genera are closely related.

About twenty species of this genus have been described as former inhabitants of our country; some of these will, however, probably be assigned to the genus Merychippus. This latter genus differs especially in having shorter-crowned teeth. Most of the species of Neohipparion belong to the upper Miocene, most of them coming from the regions of the Great Plains. Two species have been described from the Pliocene, and it is quite certain that the genus continued on into the early Pleistocene. *Neohipparion venustum* was described by Dr. Leidy in 1860 on specimens found in Pleistocene deposits near the mouth of Ashley river, in South Carolina; and Dr. Calvin reported from the Aftonian at Rockport, Missouri, a tooth which is described below as probably *Neohipparion gratum.*

As in the case of the true horses, most of the species of Neohipparion are known from teeth only or in one or two cases from jaws. However, Professor Cope received from the upper Mio-

cene of northern Kansas a nearly complete skull of the species *N. speciosum,* which was associated with various vertebræ, one-half of the pelvis, and parts of a foreleg. The skull was figured by him in 1887 (Amer. Naturalist, Vol. XXI, fig. 38), and a description of the remains was given in 1889 (Proc. Amer. Philos. Soc., Vol XXVI, p. 436). In order that the student may get some idea of the form of the skull of this genus, or at least a genus closely related to it, a figure is here reproduced of the skull mentioned (Pl. VIII, fig. 3). It is not improbable, however, that this species will be found to belong to Merychippus. The figure is from an unpublished plate prepared for Professor Cope. Its reproduction here is due to the courtesy of the United States Geological Survey.

It will be seen that it is very horselike. In size it differs much from the skull of the domestic horse, being only about one foot long (315 mm.). This includes the occipital condyles and probably the incisor teeth. The greatest width, at the zygomatic arches, is 130 mm.; that between the third incisors is 37 mm. The horizontal diameter of the orbit is 48 mm.; the orbit is therefore relatively considerably larger than in the domestic horse. The forehead is more prominent than even in the Arabian horse, if we may judge from Cope's figure; and the height of the skull at the occipital condyles and at the temporal fossæ is greater than in the Arabian horse. In the hipparion the height indicated enters into the length of the skull four times; in the Arabian horse nearly five times.

Cope described the various vertebræ which he had, but it is not practicable to do so here. The metacarpal bone had a length of 164 mm.; that of an Arabian horse fourteen and one-half hands high is 250 mm. long. On each side the metacarpal of the hipparion is beveled for union with the lateral metcarpals, showing that the animal had three toes. Cope stated that this species had a size about equal to that of the pronghorn antelope, but that the neck was shorter and the limbs more robust.

Neohipparion gratum? Leidy.

In the collection belonging to the University of Iowa is a single tooth which is to be assigned to the genus Neohipparion and which was discovered in the Whitman gravel pit a few miles south of Rockport, Atchison county, Missouri. This pit is located in section 22, township 64 north, range 41 west, and was regarded by Doctor Calvin as being excavated in Aftonian deposits. Besides this tooth, this pit has furnished teeth and a metatarsal of the horse, Equus, a tooth of a camel, and a tooth and part of a tusk of the elephant *Elephas columbi.* The tooth of the Neohipparion was reported by Doctor Calvin in the Bulletin of the Geological Society of America, volume xxii, page 211, and was figured on plate xix, figure 5. The figures are here reproduced (Pl. IX, figs. 1, 2). A pen drawing showing the grinding face is also presented (Fig. 44).

Fig. 44. *Neohipparion gratum?* Grinding surface of a molar tooth. X1.

The tooth has suffered the injury of having the external wall of enamel split off, but otherwise shows no evidence of post-mortem violence. It is rather strongly curved, so as to be convex on the outer face, concave on the inner. The coat of cement was well developed and is preserved, except on the outer face. The height of the tooth, measured on the outer face, in a straight line, is 34 mm.; on the inner face, 27 mm. The length of the grinding face is 17 mm.; its width cannot be determined. However, from the inner side of the protocone to the hinder extremity of the anterior lake, is 14 mm. The protocone is oval and has a fore and aft diameter of 3.5 mm. The postprotoconal valley, which in this genus opens out in front of the protocone, as well behind it, has a deep notch opposite the latter. There is a deep inlet in the hinder border of the tooth, cutting off partially the hinder inner column (hypocone). The enamel surrounding the lakes has a very simple arrangement, but hardly more simple than in some species of true horses, Equus. The anterior lake has no notch in the front border, but a very deep loop near the hinder end of the inner border, and another in the hinder border. Beyond this are two small loops. The posterior

lake has a deep loop in its front border and another in the hinder one.

The type of the species *Neohipparion gratum* was found somewhere along Niobrara river, in Nebraska, and is assigned to the Upper Miocene. Other specimens have been found since that time in Kansas, in Upper Miocene deposits. It seems somewhat improbable that the same species continued on through this epoch, through the Pliocene, and into the Aftonian. One has the choice, therefore, between the conclusion that the tooth described above is an undescribed species, and the conclusion that the tooth had been redeposited in the Aftonian from some Upper Miocene bed. It seems best to await further discoveries.

The tooth here under discussion appears to agree in all essential respects with the type tooth figured by Leidy, and those later described by Cope (Proc. Amer. Philos. Soc., Vol. XXVI, p. 415, figs. 16, 17).

The probability that Neohipparion existed during the Aftonian is increased by the fact that some remains of a small horse-like animal have been discovered in the Aftonian beds at the typical locality near Thayer, Union county. These remains consist of an astragalus, a large part of a right metatarsal, a proximal phalange and one or two unerupted teeth. These materials were first referred to by Dr. Calvin in 1910 (Bull. Geol. Soc. Amer., Vol. XX, p. 139) where he stated that the animal was less than half the height of the domestic horse. In a later paper (ibid. Vol. XXII, p. 210, pl. xix, figs. 1-4) further mention was made of these teeth and bones in connection with the tooth above described as *Neohipparion gratum?;* and figures were presented of all. Calvin's figures of the foot-bones are here reproduced (Pl. IX, figs. 3, 4, 7). The catalog number is 76. The metatarsal has a part of the lower end missing. The length of the fragment is 100 mm.; the front-to-rear diameter of the upper end, 26 mm.; the side-to-side diameter, about 28 mm.

At a distance of 75 mm. from the upper end the fore-and-aft diameter is 19 mm.; the transverse diameter, 18 mm. A part of the border of the upper articulation is abraded, so that the

measurements there taken are not wholly exact. In case this bone had the proportions that are found in the corresponding bone of another species of the genus, its length was close to 200 mm. The bone was therefore a relatively slenderer bone than that of the domestic horse. It differs from the metatarsal of the horse likewise in having the fore-and-aft diameter greater than the transverse. A section of the fragment, taken at any point below the head would be U shaped. The rear of the bone is nearly flat or slightly concave from side to side. On each side of the hinder face is a rough line, along which were attached the metatarsals of the second and fourth digits respectively. That border along which was attached the fourth metatarsal stands backward a little more prominently than that of the second.

The phalangeal bone is the first one of the digit. It belonged to a smaller animal than that which possessed the metatarsal; perhaps it belonged to another species. It is 36 mm. long. The fore-and-aft and the transverse diameters of the upper end are respectively 19.5 mm. and 11.5 mm., the latter taken at the midline of the articulation; at the middle of the length, 10.5 mm. and 13.5 mm.; at the lower end, 9 mm. and 16 mm.

Subfamily EQUINAE.

One-Toed Horses.

Cheek-teeth high-crowned and provided with abundant cement; the lakes well developed. Only one functional digit in each foot; the lateral digits, second and fourth, appearing as splint bones.

Genus EQUUS Linn

The True Horses.

Cheek-teeth high-crowned and prismatic; premolars, except the much reduced and often absent first one, like the molars; in the upper jaw the inner column (protocone) attached by a slender neck to the anterior inner crescent. Incisor teeth usually with well-developed cups. Feet each with only one digit.

Of the genus Equus, about a dozen species are known from the Pleistocene of North America, north of Mexico. At some time during the Pleistocene, horses occupied our country from the Atlantic ocean to the Pacific, and from the Great Lakes to the Gulf of Mexico and far down to into Mexico. Even in Alaska their remains are not uncommon. Unfortunately, many of the species are known to us from their teeth only; and, in many cases, the teeth of different species resemble one another so closely that it is difficult to distinguish these species from one another and from the dometic horse, The finding of bones of fossil horses, especially skulls and whole skeletons, or large parts of them is greatly desired.

Figure 45 represents a side view of the skull of a horse. In this the bone has been cut away, so that the cheek-teeth may be seen in their full length. Of these great teeth there are six on each side of each jaw. All except the one in front and the one behind are long and nearly square prisms. A small first pre-

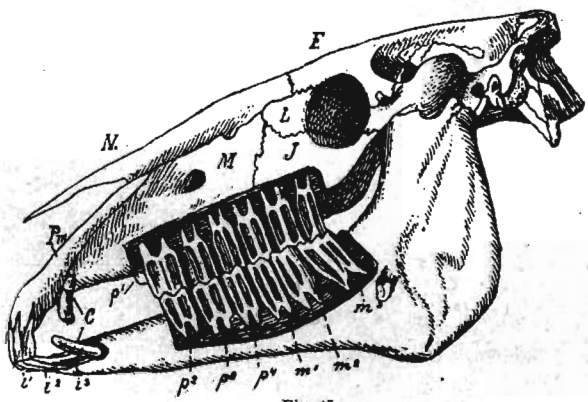


Fig. 45

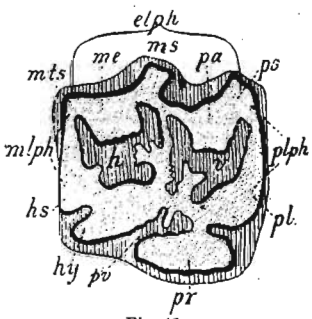


Fig. 46

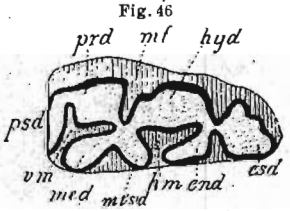


Fig. 47

Figs. 45-47. *Equus caballus.*

45. Side view of skull, dissected to show the teeth.

46. Section of right upper molar. From Max Weber. X1. The enamel is shown by the heavy black lines, the dentine by stippling, the cement by parallel lines. *elph,* ectoloph; *h,* posterior lake; *hs,* hypostyle; *hy,* hypocone; *me,* metacone; *mlph,* metaloph; *ms,* mesostyle; *mts,* metastyle; *pa,* paracone; *pl,* protoconule; *plph,* protoloph; *pr,* protocone; *ps,* protostyle; *v,* anterior lake.

47. Section of right lower molar. X1. From Max Weber. *end,* entoconid; *esd,* entostylid; *hm,* posterior inner fold, or valley; *hyd,* hypoconid; *med,* metaconid; *mf,* median fold, or outer valley; *mts,* metastyle; *prd,* protoconid; *psd,* parastylid; *vm,* inner anterior fold or valley.

molar is represented in this figure as present in the upper jaw, but it is often absent.

Figures 45, 46 and 47, reproduced from Weber's Säugetiere, page 595, show the appearance of the grinding face of the upper and of the lower molar and premolar teeth of a horse. These and other figures here presented show how complicated is the pattern assumed by the enamel of the teeth in horses, and the relatively small differences seen among the various species. In these figures the dentine, which constitutes the largest part of the tooth, is indicated by stippling; the heavy black lines represent the enamel; the cement is shown by parallel lines. Figure 46 is lettered to show the various regions of the teeth, as seen on the worn face. The front of the tooth is directed toward the right. The regions marked *pr., pa., me., hy.,* and *pl.,* were, before the teeth began to wear down, projecting cusps. The space *h* below *me.,* surrounded by the irregular wall of enamel in the worn tooth, forms a "lake" of cement; that below *pa.,* lettered *v.,* forms another. In the figure of the lower tooth the constituent elements are indicated as they are in the upper. In this figure (Fig. 47) the front of the tooth is toward the left hand. Before the tooth began to wear the areas marked *prd, hyd, med,* and *end,* stood above the general surface of the tooth as enamel-covered cusps.

The three hinder premolars have, in the horses, assumed the form and structure of the true molars so thoroughly that they are almost indistinguishable from them. They are slightly larger than the molars and the column at the outer anterior angle is a little broader and is somewhat channeled the whole length of the tooth. The third true molar is larger than the others and its hinder border is not so squarely cut off as in the cases of the other teeth (Fig. 60). The second premolar is the largest tooth, and the front end of its grinding face is pointed (Fig. 68). In front of this tooth there may sometimes be found a very small first premolar (Fig. 45). It is the "wolf tooth" of veterinarians.

Far in front of the premolars are located the incisors, six in number in each jaw (Fig. 45). When somewhat worn they display on the grinding face an outer and an inner ring of

enamel. Within the inner ring is a cavity, or cup, the "mark" of veterinarians. In old horses the cup disappears. At some distance on each side behind the incisors a canine tooth (Fig. 45, c) is found in the stallion, but is missing, usually at least, in the mare.

The inferior molars are much narrower than are the upper ones, nearly twice as long, fore and aft, as wide. The lower premolars also have the form and structure of the true molars, but are usually slightly larger. The hinder true molar is pointed behind, the second premolar is pointed in front. The first premolar is usually missing. There are six incisors and a pair of canines, the latter sometimes not developed.

The three hinder premolars, both above and below, are preceded by milk teeth, which have the general structure of the permanent teeth, but have a smaller transverse diameter. The fore-and-aft diameter may, however, be even greater than in the adult horse.

It may be desirable sometimes to identify the teeth of horses and to determine their positions in the mouth. They may be known from the teeth of other animals by their size, their form and the peculiar arrangement of the enamel walls. If the teeth have the grinding face nearly square, they belong to the upper jaw; if they are nearly twice as long on the worn face as broad, they are to be assigned to the lower jaw. The crown may be very high or it may have been worn down nearly to the small roots. In case the tooth has suffered little or no wear and is nevertheless short-crowned, it is to be taken as a milk tooth.

In the upper jaw the outer border of the tooth has a continuous wall of enamel; but this bends inwards somewhat at two points and leaves two prominent ridges, or styles, running up and down on the tooth (Fig. 46 *ps. ms.*). The enamel of the inner border of each upper tooth bends inward to the very center of the tooth, producing a valley directed forward, the post-protoconal valley (Fig. 46 *pv.*), so called here because it starts behind the protocone.

In each lower tooth there is, on the outer face, one inlet of the enamel, situated about the middle of the length (Fig. 47 *mf.*). On the inner border there are two deep inlets (Fig. 47

vm. hm.), one near the front of the tooth, the other just behind the middle of the length. Between the two, are two loops of enamel (metaconid and mesostylid). Behind the second inlet is another loop of enamel, representing a ridge running up and down on the inner face of the tooth, the entoconid. At the extreme rear of the tooth is the more or less developed entostylid. Observations of these features will lead to the placing of the teeth in the proper jaw, on the proper side, and with the right end forward.

In the upper jaw the second premolar may be distinguished by its large size and pointed front end; the hinder true molar by its small size and its narrower hinder end. The other four teeth are more difficult to locate, and it is not usually necessary to do so. These same observations apply to the lower teeth.

There appear to be pretty well established at least ten species of the genus Equus which were inhabitants of the United States during the Pleistocene; although a number of others have been named. Much better materials of nearly all the species must yet be found and studied before our knowledge will be satisfactory.

There is need, not only of a better knowledge of the structure of the various species, but of their relation to the species that lived during the Pliocene, and therefore of the place of origin of the genus Equus, and what was the genus from which it sprang. We need to learn what was the geographical range of each species; but of more importance is it to learn what was the range of each species in time. It seems quite certain that true horses were present in America soon after the opening of the Pleistocene, and probably during some part of the later Pliocene. In Europe species of the genus existed during the upper Pliocene. In India the genus occurs in the upper Miocene. Therefore, the genus Equus appears to have had its origin in Asia, notwithstanding the fact that the genera that are most closely related to it seem to have lived in America. It seems probable that the horselike animals that gave origin to the genus Equus passed by some land bridge into Asia and that later some species of Equus returned to America over perhaps the

same land bridge, located perhaps somewhere in the region of Bering strait.

Another important and interesting question is that regarding the time when our native horses became extinct. It has been supposed that some species continued on until late in the Pleistocene. It has even been argued that in Mexico and South America native horses existed when white men arrived in the New World. No sufficient proof has been produced in favor of such statements. Inasmuch, on the other hand, as no authentic specimens of fosssil horse remains have been reported from any deposits overlying the latest sheet of drift, the Wisconsin

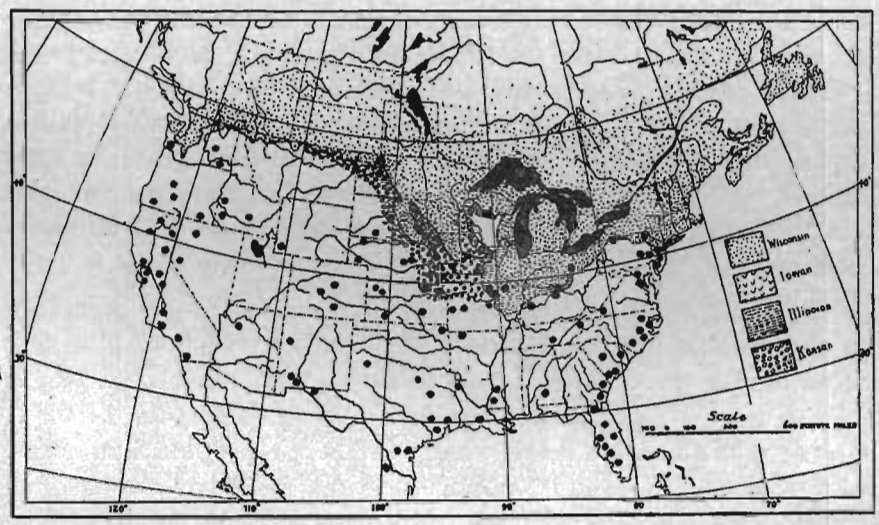


Fig. 48. Map showing localities where remains of fossil horses have been found in the United States and the relations of these localities to the various drift-sheets.

(Fig. 48), the writer believes that at least in the glaciated region, so well fitted for the mammoths, the mastodons, and the giant beaver, there existed no species of horse. It, further, seems extremely doubtful whether any remains of a fossil horse have been found in any late Pleistocene deposit in the region outside of that occupied by Wisconsin drift. However, future investigations must settle this question.

Inasmuch as remains of fossil horses have been found at many localities in Iowa, especially along the western border and

are likely to be found anywhere except where the state is covered with Wisconsin drift, it might appear proper here to describe and figure the principal parts of the skeleton. This is, however, less necessary because not only the teeth but also bones of all fossil horses resemble closely the corresponding parts of our domestic horses. Almost anywhere in the state, with a little trouble, one may find the skeleton of some domestic horse and with these one may compare any fossil teeth or bones that may be suspected to belong to a horse. Teeth of fossil horses are most likely to be found; and it is hoped that the many figures of these presented in this treatise may enable the finder to determine whether or not what he shall find belonged to a horse. One may easily judge whether any bones found are of a size befitting those of a horse and one may then proceed to make a comparison.

On page 180 will be found a figure of a skeleton of a fossil horse which was found in Texas. It will be sufficient to show the general form of most of the bones. It will be seen that the lower jaw is quite characteristic. The humerus may be distinguished from that of any oxlike animal by the fact that there are two deep grooves at the upper end in front for the passage of tendons instead of one. The nearly cylindrical metacarpals and metatarsals are quite different from those of any ruminant animal. The femur differs from that of any other large animal likely to be found in Iowa in having a prominent process on the outer side about one-third the length of the bone from the upper end. The form of the astragalus will be seen in figure 43, page 144. The hoof-bones may be recognized by anybody.

The following species of horses have been found either within the limits of Iowa or so near them as to make them of interest and they are therefore described.

Equus complicatus Leidy.

In 1847 Dr. Joseph Leidy based a species of fossil horse, called *Equus americanus,* on twelve specimens of teeth which had been sent him from Natchez, Mississippi (Proc. Phila. Acad. Nat. Sci., Vol. III, p. 265, pl. ii). Later, having learned that the name *americanus* had been applied to a fossil horse from South

America, he adopted for his species the name *complicatus*. In 1869, however, he abandoned this name and accepted a name, *Equus major*, which had been proposed in 1842, by J. E. DeKay, for a fossil horse. The latter name had, however, never been defined and had no nomenclatorial standing. Dr. Leidy, nevertheless, continued to use it ever afterwards.

In 1901 Mr. Gidley selected as type specimen of *Equus complicatus* the tooth which Leidy had figured in 1847 (Figs. 49, 50).

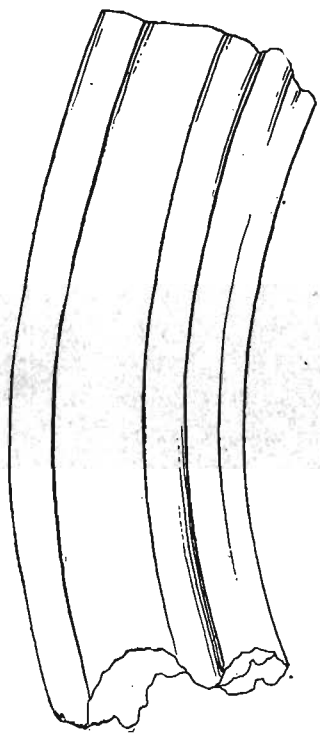


Fig. 50

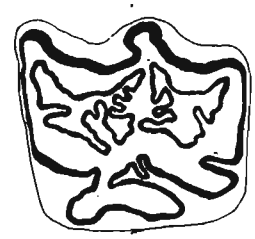


Fig. 49

Figs. 49, 50. *Equus complicatus*. Views of the type, of an upper left molar. Slightly less than natural size.

49. Grinding surface of the tooth.
50. Side view of the tooth.

Leidy and others at various times assigned to this species remains, some of which undoubtedly belong to other species, while it is probable that some specimens that have been identified as *E. fraternus* belong really to *E. complicatus*. Indeed, it is probable, as concluded by Gidley, that the type of *Equus fraternus*, chosen by Cope, belongs really to *Equus complicatus*. It is

evident that in the region of the South Atlantic and Gulf states there existed at fewest three species of horse, one of large, one of intermediate, and one of small size. Unfortunately these species are at present known to us almost wholly by their teeth; and as the teeth of all the species varied somewhat in size in different parts of the jaw and in different individuals, it is not possible in all cases to determine with certainty to which species some teeth belong. It happens, too, that the enamel in both the large and the small teeth, had assumed a rather complicated and similar pattern.

Under the circumstances it has seemed proper for the present to refer to *Equus fraternus* the large teeth found on the Atlantic slope, while other names are to be applied to the horses of middling and small sizes. *Equus complicatus* is then to be used for certain horses of the Mississippi valley. It is greatly to be desired that more satisfactory remains of the large horse that roamed on the Atlantic slope shall be discovered, so that we may determine its relation to *Equus complicatus*. In 1870, Professor Cope (Trans. Amer. Philos. Soc., XIV, p. 250) mentioned a skull that had been found at Pea Shore, near Camden, New Jersey, but this skull has apparently been lost. The writer agrees with Mr. Gidley that Cope's *Equus intermedius* (Proc. Amer. Philos. Soc., Vol. XXXIV, p. 463, pl. xi, fig. 8), found at New Iberia, Louisiana, is the same as *Equus complicatus*. There are no essential differences and the types of both are from places near each other. Therefore, the fragment of upper jaw with the two hinder premolars and all three of the molars which served as Cope's type of *E. intermedius* may be used in defining *E. complicatus*. The enamel of *E. intermedius* is not so much crimped as is that of the type of *E. complicatus;* but that is probably due to the fact, as Gidley has remarked, that Cope's type belonged to an older individual and was worn down nearer the roots.

In the type of *E. complicatus* (Figs. 49, 50) the grinding face is 32 mm., fore and aft, and 27.5 mm., transversely, neglecting the cement. The internal column (protocone) equals sixty per cent of the transverse width of the tooth. The height of the crown is nearly 100 mm., and it is considerably curved.

The following are the dimensions of the teeth of the type of *E. intermedius,* as determined from Cope's figure. Cope gives the length along the crowns of the teeth 143 mm., but this seems to have been taken on the outer border. The measurements here given are taken about the middle of the face. Cope's illustration of his *E. intermedius* is here reproduced (Pl. IX, fig. 6).

MEASUREMENTS OF UPPER TEETH.

From front of pm.^{3} to rear of m^3	141mm.
From front of m.^{1} to rear of m^3	84mm.
Pm.^{3}, length	29mm.
width	31mm.
protocone	15mm.
Pm.^{4} length	29mm.
width	29mm.
protocone	18mm.
M.^{1}, length	25mm.
width	28mm.
protocone	16mm.
M.^{2}, length	27mm.
width	25mm.
protocone	15mm.
M.^{3}, length	31mm.
width	22mm.
protocone	16mm.

The maxilla itself does not furnish any valuable character for distinguishing the species. The postpalatine foramen is opposite the front end of the last molar.

Cope described and figured the front end of the lower jaw with all the incisors present, and his figure is here reproduced (Pl. IX, fig. 5). The outer incisor has no posterior wall for its cup, while in the other incisors the cups are completed. The teeth are larger than the corresponding ones of the common horse, the first one having a transverse diameter of 21 mm.

The lower jaw is remarkably narrow at or just behind the middle of the symphysis, being here only 34 mm. wide, while at the base of the outer incisor the width is 63 mm. In an Arabian horse belonging to the U. S. National Museum the width at the narrowest part of the symphysis is 37 mm.; at the base of the outer incisors, 60 mm.

Dr. Joseph Leidy, in 1889 (Trans. Wagner Inst., Vol. II, p. 37) described some teeth of a horse which had been found at Petite Anse near New Iberia, Lousiana. One of Leidy's figures is here reproduced (Fig. 51). It agrees in all essential respects with the tooth which stands as the type of the species.

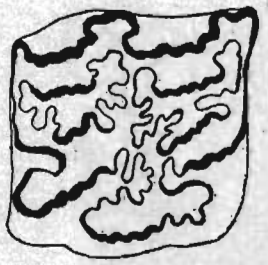


Fig. 51. *Equus complicatus.* Premolar from Petite Anse, Louisiana. X1. After Leidy.

The tooth is evidently a premolar. Its height is given as 70 mm.; the length of the grinding face, 31.5 mm.; the width, 31 mm.

The five lower cheek-teeth found at Petite Anse, Louisiana, mentioned by Leidy (Trans. Wagner Inst., Vol. II, p. 38) are in the U. S. National Museum, No. 707. These appear to belong to three individuals; $pm._3$, and $pm._4$, of the left side of one (Fig. 52), a right $m._1$, of another, and $m._1$ (Fig. 53) and $m._2$, of the right side of a third. Two other teeth, numbered 705, are the second and third right premolars (Fig. 54).

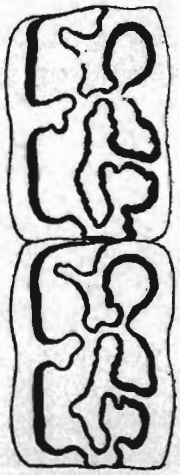
The following measurements of these teeth are taken, the cement coating being neglected:

MEASUREMENTS OF TEETH.

Tooth	Fore and aft mm.	Transverse mm.
$Pm._3$	34	18
$Pm._4$	31.5	18
$M._1$	28	16
$M._2$	28	16

It will be seen that in size these teeth agree with the upper ones of *E. complicatus.* Compared with those of a domestic horse, they are somewhat longer fore and aft. The premolars are a little wider than those of the domestic horse, while the

molars are slightly narrower; but individual differences may be concerned here.



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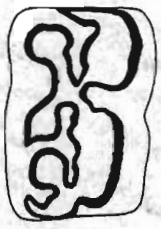

Fig. 53

Fig. 56

Fig. f4

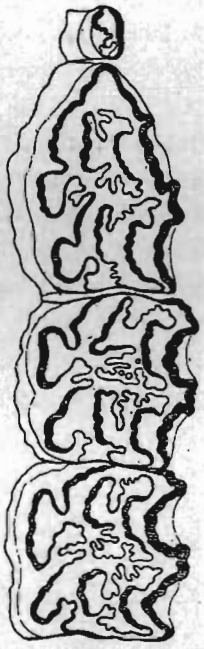

Fig. 55

Figs. 52-56. *Equus complicatus.*

52. *Equus complicatus.* Third and fourth lower premolars of left side. X1.

53. *Equus complicatus.* First lower molar of right side. Slightly less than natural size.

54. *Equus complicatus.* Second and third lower premolars of right side. Slightly less than natural size.

55. *Equus complicatus.* Upper left premolars 1 to 4 and molar 1. From Illinois. Slightly less than natural size. After Leidy.

56. *Equus complicatus?* Lower milk molars of right side. No. 10059 American Museum Natural History. Slightly less than natural size.

In none of these teeth does the outer valley get in between the ends of the two longitudinal valleys. It will be observed that this outer valley sends backward a little loop, the so-called protostylid. This is found also in the domestic horse. The enamel ridges are somewhat more crimped than in the domestic horse. The inner boundary of the hinder longitudinal valley is not straight, but is pushed outward about the middle. Whether or not these features are of specific value, we cannot yet be certain.

In 1889 Dr. Leidy (Trans. Wagner Inst., Vol. II, p. 39) described a specimen consisting of a part of the left upper jaw containing all four premolar teeth, and supposed by him to belong to *Equus major,* his later name for *Equus complicatus.* This had been discovered many years before in a bog on the boundary line between Bond and Fayette counties, Illinois; but the exact locality and the depth where found were not given. This specimen is now in the collection at Springfield, Illinois, and the writer, through the kindness of Dr. A. R. Crook, has been permitted to examine it. The complication of the enamel appears to be greater than in the common horse and to be like that of the type of *E. complicatus.* In giving his measurements Dr. Leidy included the cement. These measurements are here corrected so as to exclude the cement. Leidy's figure of the teeth is here reproduced (Fig. 53):

MEASUREMENTS OF TEETH.

Tooth	Height mm.	Length mm.	Width mm.
Pm.[1]	----------	8.5	5
Pm.[2]	----------	41	27
Pm.[3]	68	31.5	30
Pm.[4]	86	31	28.5

Although the first premolar was present in this specimen, there was no trace of the canine at a distance of three and one-fourth inches in front of the premolar. In a large specimen of the domestic horse the canine is only two and three-fourths inches in front of the premolar. Possibly the canine had not been present.

Nothing certain is known about the milk teeth of this species. Figure 56 shows the lower milk molars of the right side which were found by Mr. J. W. Gidley in Tule canyon, Briscoe county, Texas, within three miles of the locality where the type of *Equus scotti* was discovered. It might be supposed that these teeth belonged to a colt of *E. scotti*, but they differ considerably from the corresponding teeth of one of the five specimens of the latter species found with the type, as may be seen by comparing the figures shown here with figures on page 187. They are therefore referred provisionally to *Equus complicatus*. To what extent such teeth may vary within the same species we do not yet know. Figure 56 is from No. 10591 of the American Museum of Natural History.

Up to the present the skull of this species is known only from fragments. In the U. S. National Museum is a fragment, No. 709, which presents most of the zygomatic arch and the hinder boundary of the orbit. The specimen is from Petite Anse, near New Iberia, Louisiana. The zygomatic arch, where narrowest, just in front of the articulation for the lower jaw, is 32 mm. wide, just equalling that of a specimen of *E. caballus*. The postorbital bar, where narrowest, is 28 mm. wide; that of the domestic horse is 35 mm. wide.

In the U. S. National Museum, No. 711, from Petite Anse, Louisiana, is the symphysis of the upper jaw, with the alveoli of the incisor teeth. Immediately behind the last incisors the width of the jaw is 70 mm.; that of a domestic horse (No. 843, U. S. National Museum) being 74 mm. The premaxillary suture extends backward 58 mm.; in the domestic horse, 44 mm. The bone near the hinder end of the symphysis is 28 mm. thick, in the domestic horse only 22 mm.

No. 710, U. S. National Museum, from Petite Anse, furnishes the articulation of the under jaw and the hinder border of the jaw for about 150 mm. below the articulation. A feature to be remarked is the thickness of this hinder border. When compared with the jaw of a domestic horse of the same size, it is found that in the latter, 100 mm. below the articulation, the

bone is 10 mm. thick; in the fossil, it is 22 mm. thick. At 150 mm. below the articulation the bone in the domestic horse is 15 mm. thick; in the fossil, 29 mm. Doubtless in all these structures there is great variation within the species and not too much reliance must be placed at present on these characters in identifying remains. It may be said that nothing is known which indicates with certainty differences between the skull of *Equus complicatus* and our domestic horse unless it be the very narrow mandibular symphysis. Little is known regarding the form and proportion of the remains of the skeleton.

From Petite Anse, Louisiana, there is in the U. S. National Museum, No. 703, the distal end of a right humerus. It appears to differ in no way from that of the Arabian horse, except that it is slightly larger, measuring 85 mm. across the articular surface at the lower end, the Arabian measuring 81 mm. No other skeleton of *E. caballus* is at hand for comparison. It is observed that the outer ridge bounding the cavity for receiving the olecranon maintains an equal width, 23 mm., from the lower to the upper end; whereas, in the Arabian horse this ridge is 33 mm. wide below and only 18 mm. above. On the inner face of the bone, at the lower end, the greatest width, fore and aft, is 93 mm.

No. 702 includes the right radius, lacking a few inches of the middle of the shaft. The upper end fits the humerus, No. 703, so accurately that both bones were probably parts of the same individual. The extreme width of this upper end of the bone is 95 mm.; in the Arabian horse. 80 mm. The greatest diameter of the shaft, 125 mm. below the head, is 49 mm.; the shortest diameter, 32 mm. In the Arabian horse these dimensions are respectively, 41 mm. and 31 mm. The shaft of the fossil is thus seen to be somewhat flatter than in the Arabian horse. The surface for the outer condyle of the humerus is narrower fore and aft than in the Arabian horse, measuring, at the middle of the length in the fossil, 25 mm.; in the Arabian horse, 28 mm. The distal end of the radius has an extreme width of 83 mm.; in the Arabian horse, 79 mm. On the anterior surface of this lower end the external groove for a tendon is placed nearer the outer border of the bone than it is in the domestic

horse; and a prominence, which in the latter is near the middle of the anterior surface, is, in the fossil, much nearer the outer border.

No. 723, U. S. National Museum, from Petite Anse, presents the bone surrounding the acetabulum. The long diameter of this cavity is 72 mm. The bone does not permit a section being taken in front of the acetabulum, but the upper border of the bone is more rounded than in the Arabian horse. From the upper edge of the acetabulum to the upper border of the ilium is 54 mm., while in the Arabian horse, a smaller animal evidently, the distance is 57 mm. The pubic bone is much thinner in front of the obturator foramen than in the Arabian horse, being, in the former, 17 mm. wide, in the latter, 23 mm. Measured 25 mm. behind the acetabulum, the ischium is 43 mm. high, while in the Arabian horse, the bone is only 36 mm. high.

In the U. S. National Museum is the lower end of the left tibia from Petite Anse, No. 704. It measures from side to side 85 mm.; from front to back on the inner side 51 mm. In the Arabian horse these dimensions are respectively 81 mm. and 48 mm. No other differences are observed in this part of the tibia of the two animals.

TEETH OF *EQUUS COMPLICATUS* FOUND IN IOWA.

To this species I refer certain teeth that have been discovered in Iowa. One of these (No. 116) was described by Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 345, pl. xviii, figs. 1, 3). It was found in the Cox pit, near Missouri valley, Harrison county. Calvin's figures are here reproduced (Pl. X, figs. 1, 3) and a pen drawing (Fig. 57) is furnished which shows more distinctly the arrangement of the enamel. This is an upper left premolar, either the third or fourth, and has the following dimensions: Height of crown, 88 mm.; length, 31.5 mm.; width, 32 mm.; length of protocone, 17 mm. It is about as much curved as the type tooth (Fig. 50), probably just a little less. The anterior and posterior pillars are broken off near the summit of the tooth. In the drawing (Fig. 57) this is restored from a lower level of the tooth.

Figure 58 represents the grinding face of an upper left true molar (No. 122b), either the first or the second. It was found in an Aftonian gravel pit at Turin, Monona county. It has

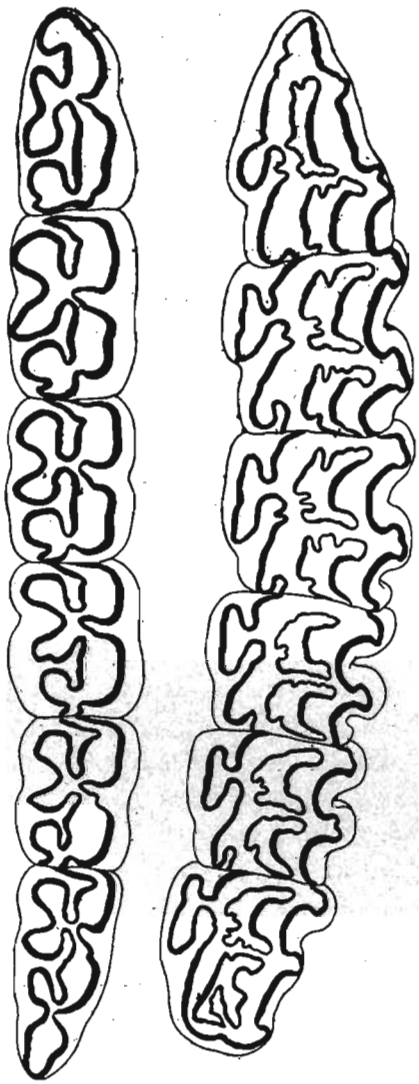

Fig. 61

Fig. 60

Fig. 57

Fig. 58

Fig. 59

Figs. 57-61. *Equus complicatus.*

57. Grinding surface of left upper premolar. X1. No. 116 State University of Iowa.
58. Upper left molar. X1. No. 122b State University of Iowa.
59. Lower left molar or premolar. Slightly less than natural size. No. 261 State University of Iowa.
60. Upper left cheek-teeth. X .726. No. 220 State University of Iowa.
61. Lower right cheek-teeth. X .726. No. 219 State University of Iowa.

the following dimensions: Height, 83 mm.; length, 30.2 mm.; width, 28 mm.; protocone, 13 mm. The tooth appears to be slightly more curved than the type tooth. If the arrangement of the enamel of these two teeth be compared with that in the type tooth, it will be seen that no important differences exist. Nevertheless, the pattern in all three resembles closely that found in the upper teeth of *E. scotti*.

Figure 59 represents the grinding face of a left lower tooth (No. 261), probably a premolar. It was found in the Cox gravel pit at Missouri Valley, Harrison county. It is little worn down and shows the following dimensions: Height of crown, 80 mm.; length, 33 mm.; width, 17 mm. This tooth appears to agree closely with the lower teeth from Louisiana here represented (Figs. 52, 53, 54) and believed to belong to *E. complicatus*.

In the collection of the Iowa University, with the catalog numbers 219 and 220, is a specimen consisting of the left upper and right lower cheek-teeth. The number 219 is assigned to the lower teeth, 220 to the upper. The lower teeth are in place in a part of the lower jaw. These teeth were described and figured by Professor Calvin in his paper entitled Aftonian Mammalian Fauna (Bull. Geol. Soc. Amer., Vol. XX, 1908, p. 344, pl. xvii, figs. 1, 2). The animal was identified by him as *Equus scotti*. We are told in that communication that these teeth were found by Mr. E. L. Gladwin while grading a road in section 35, Lyons township, Mills county. Prof. B. Shimek (Bull. Geol. Soc. Amer., Vol. XXI, p. 138) informs us that the locality is in the east one-half of section 35, township 71 north, range 43 west. It is stated by Calvin that a considerable part of the skeleton was present, but the bones were too soft for preservation. The matrix was a fine blue clay, a bed of silt; and this bed is regarded as belonging to the Aftonian. The presence of this skeleton with all these teeth and so many bones associated furnishes evidence that the animal was in its original place of burial and had not been redeposited from some older formation. Calvin speaks of this specimen as the "Gladwin horse."

The present writer prefers to refer this specimen to *Equus complicatus* rather than to *E. scotti,* because he knows of no means of distinguishing the teeth of the two forms and is inclined to believe that both belong to the same species. Later studies may show that they are distinct. Inasmuch as the present specimen presents some peculiarities it is described and figured with some detail (Pl. XI, figs. 1, 2; text figs. 60, 61).

The following measurements are taken from the teeth of this specimen. It must be stated that the horse was rather old and that the teeth are worn down to about one-half their original lengths.

MEASUREMENTS OF TEETH OF GLADWIN HORSE.

Upper Teeth.

Length of premolar-molar series		190 mm.
Length of premolar series		104 mm.
Length of molar series		86 mm.
Pm.^{2},	height	45 mm.
	length	42.5mm.
	width	27 mm.
	protocone	10 mm.
Pm.^{3},	height	48 mm.
	length	31 mm.
	width	30.5mm.
	protocone	14 mm.
Pm.^{4},	height	53 mm.
	length	29.5mm.
	width	31.5mm.
	protocone	16.8mm.
M.^{1},	height	39 mm.
	length	26 mm.
	width	30 mm.
	protocone	14 mm.
M.^{2},	height	43 mm.
	length	27 mm.
	width	27.5mm.
	protocone	14 mm.
M.^{3},	height	53 mm.
	length	32 mm.
	width	26 mm.
	protocone	15.5mm.

Lower Teeth.

Length of premolar-molar series	194 mm.
Length of premolar series	98 mm.
Length of molar series	96 mm.

Pm.$_2$,	height	29 mm.
	length	37 mm.
	width	18 mm.
Pm.$_3$,	height	39 mm.
	length	31 mm.
	width	18 mm.
Pm.$_4$,	height	--
	length	30 mm.
	width	20.5mm.
M.$_1$,	height	44 mm.
	length	28 mm.
	width	18 mm.
M.$_2$,	height	--
	length	28 mm.
	width	16.5mm.
M.$_3$,	height	--
	length	37 mm.
	width	14 mm.

The teeth of this horse are remarkable on account of the great thickness of the coat of cement. This is especially thick on the external columns of the upper teeth; and as a consequence the grooves between these cement-covered columns are deep and narrow. In the type of *Equus niobrarensis* the cement adds 2 mm. to the width of the last upper premolar, while in this specimen it adds 3 mm. The enamel, too, is very heavy, being thicker than in specimens of the domestic horse, nearly twice as thick as in the type of *E. excelsus,* and thicker than in other specimens of *E. complicatus* at hand.

As to the disposition of the enamel on the grinding face of the teeth, it may be said that the pattern is rather simple. There is an unusual difference in the arrangement of the enamel around the lakes of the premolars and those of the molars. In the premolars the arrangement is very similar to that seen in *E. niobrarensis,* but there is rather less folding of the enamel around the anterior lake. In both the lakes of each premolar there is a front and a hinder notch. In the molars the pattern of the lakes resembles a good deal that of *E. excelsus.* The anterior lake has no notch in its front border, and the posterior has only a minute notch in its hinder border.

Notwithstanding the great differences which these teeth present when compared with undoubted specimens of *Equus complicatus,* the writer proposes to refer it to that species. It may

be regarded as probably furnishing the extreme limit in variation in the direction of simplicity of arrangement of the enamel. This simplicity is due probably to some extent to the approach of the grinding surface to the bases of the teeth. On account of this simplicity in the enamel, its great thickness, and the great breadth and prominence of the styles of the upper teeth and the great thickness of the cement on all the teeth, there is a temptation to regard the specimen as belonging to an undescribed species. On the whole, however, this course does not seem to be advisable.

A tooth bearing the catalog number 262 is a large lower left premolar, probably the third (Fig. 62). It was discovered near Pisgah, Harrison county, in the Peyton gravel pit. The tooth is only moderately worn and is in good condition. The height is 80 mm.; the length, 34 mm.; the width, 19 mm. The size of the tooth and the arrangement of the enamel agree so closely with a corresponding premolar of *Equus complicatus* found at New Iberia, Louisiana, (Fig. 52) that there is nothing else to do than to refer it to the same species.

There is a second tooth in the collection which has the number 262 and which was found likewise in the Peyton pit. Not improbably it appertained to the same individual. It belonged to the left side of the lower jaw and seems to be either the first or second molar. The height is 56 mm.; the length, 29 mm.; the width, 16.5 mm. The arrangement of the enamel is essentially the same as in No. 127, but its thickness is not so great.

The tooth bearing the number 132 was found in the Cox gravel pit at Missouri Valley. It belonged to the left side of the lower jaw and is probably a second molar. It was mentioned by Calvin in his paper on Aftonian Mammals (Bull. Geol. Soc. Amer., Vol. XX, p. 348, pl. xix, figs. 1, 3). Calvin's figures are here reproduced (Pl. XII; figs. 1, 3) and a pen drawing is presented (Fig. 63). This author regarded it as belonging to the same species as the Gladwin horse, *E. scotti*. The present writer is disposed to refer both these specimens to *E. complicatus*. The tooth had only begun to wear. Its height, not including the roots, is 85 mm.; the length, 31 mm.; the width, 16 mm. However, the width would on further wear soon

have been somewhat greater. The enamel is arranged very much like that of the tooth of our figure 52, and like the tooth numbered 262. It will be observed from Calvin's illustration that the tooth was diseased on the inner face.

The tooth which has the catalog number 134 is a lower left last molar. It was secured in the Cox pit, at Missouri Valley, Harrison county. It is only moderately worn and is in fine condition of preservation. The tooth is curved backward. The height is 75 mm.; the length, 36 mm.; the width, in front, 15 mm. The outer inlet is broad and furnished with a loop, the so-called protostylid, in its hinder border. The inlet does not push itself between the two longitudinal valleys. The heel is thin and prolonged backward. The tooth is referred to *Equus complicatus*. Figures are here presented showing both faces of the tooth. Some of the cement is still retained (Pl. XIII, figs. 1, 2).

A tooth which bears the catalog number 131 was found in the Cox gravel pit, at Missouri Valley. It was described and figured by Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 349, pl. xix, figs. 2, 4). He referred it to *Equus complicatus* and the present writer is content to agree with the determination. The tooth is a true molar, probably the second, of the left side of the lower jaw. It is only moderately worn down and is in good preservation, except that a portion of the hinder part of the base is split off. The height is 80 mm.; the length, 29 mm.; the width, 17.5 mm. The disposition of the enamel resembles much that of the second molar of No. 127 (Fig. 64), but the lines of enamel are not so heavy. As in No. 127 the outer inlet pushes in between the ends of the longitudinal valleys. Calvin's figures are here reproduced (Pl. XII, figs. 2, 4).

The number 127 has been given to a fragment of the right ramus of the lower jaw with the last two molars (Pl. XII, fig. 6). The specimen was discovered in the Cox gravel pit, at Missouri Valley, and was described by Professor Calvin (Bull. Geol. Soc. Amer., Vol. XX, pl. xix, fig. 6). He referred it to *Equus complicatus,* and the present writer believes that his assignment of it is correct. The animal was an old one and the teeth are worn down to half their original height.

The following are the measurements:

MEASUREMENTS OF TEETH OF SPECIMEN 127.

Tooth	Height mm.	Length mm.	Width mm.
M_2	50	28	17
M_3	40	37	15

These teeth, the second molar of which is here figured (Fig. 64), differ in one respect, perhaps important; this is, that the outer inlet of enamel pushes itself inward beyond the midline of the tooth and between the adjacent ends of the two longitudinal valleys. There are at hand six lower teeth that can be assigned with considerable certainty to *Equus complicatus*. These are from New Iberia, Louisiana, and one of them is here figured (Fig. 53). In none of these does the outer inlet reach so far inward. Whether it may have done so in some individuals cannot now be determined. In the length of this inlet, the specimen, No. 127, resembles the domestic horse, in the true molars of which the inlet in question is interposed between the longitudinal valleys. The second molar of a large gelding in the U. S. National Museum has the same length as that of the specimen here described, but the width is only 15 mm. Also the outer inlet is considerably nearer the middle of the length of the tooth than in No. 127.

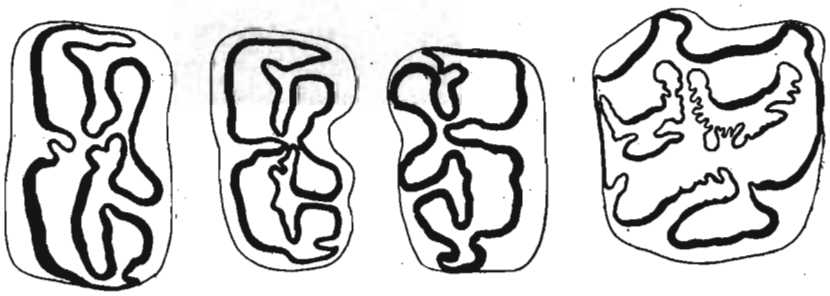

Fig. 62 Fig. 63 Fig. 64 Fig. 65

Figs. 62-65. *Equus complicatus*. X1.
62. Lower left premolar. No. 262 State University of Iowa.
63. Lower left tooth, probably second molar. No. 132 State University of Iowa.
64. Lower right second molar. No. 127 State University of Iowa.
65. Upper right tooth, fourth premolar? No. 118 State University of Iowa.

Number 328 of the collection at the State University of Iowa is a left lower molar which appears to belong to *Equus complicatus*. It, too, was collected in the Cox pit, by Shimek.

In the collection is found a large second lower premolar of the right side which had not yet come into use; so that what in a worn tooth appear as dentine areas are here rounded cusps covered with enamel and a little cement. The specimen was discovered in the Cox pit, at Missouri Valley. It has the catalogue number 120. Views are here presented of both faces of the tooth (Pl. XIV, figs. 1, 2). The height of the tooth is 68 mm.; the length, 41 mm.; the width, 15 mm. The tooth had probably not reached its full height. Naturally, in the unworn condition of the tooth the details of the foldings of the enamel cannot be made out. Nevertheless, the size of the tooth indicates that it belongs to none of the known extinct horses, unless it be *Equus complicatus* or possibly *Equus scotti*.

Tooth No. 118, from Cox pit, Missouri Valley, is a right upper tooth, perhaps the fourth premolar, of an old horse. It was referred by Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 345, pl. xviii, fig. 6) to *Equus scotti*. The height of the tooth was given as 38 mm.; the length of the grinding face, 32 mm.; the width as the same. As in other cases, Calvin included the cement and measured on the extreme outer border. As determined by the present writer, the dimensions are: Height, 38 mm.; length, 29.8 mm.; width, 32 mm.; protocone, 15.5 mm. (Pl. X, fig. 6).

The most remarkable feature about the tooth is the excessive folding of the enamel. This affects not only the lakes but likewise to some extent the walls of the post-protoconal valley. The foldings of the enamel can best be understood from the drawing (Fig. 65). One is reminded of the teeth of Cope's *Equus fraternus pectinatus* (Jour. Acad. Nat. Sci. Phila., Ser. 2, Vol. XI, pp. 255, 257) found in Port Kennedy cave, Pennsylvania. A figure of the type specimen has been given by Gidley (Bull. Amer. Mus. Nat. Hist., Vol. XIV, p. 135, fig. 23), who recognized it as a distinct species. The present tooth differs from it in having a much broader protocone; although this character may not be distinctive. For the present the writer

prefers to regard the tooth as having belonged to an individual of *Equus complicatus* which possessed teeth with unusually strongly crimped enamel.

The specimen bearing the number 282 presents the outer half of the crown of an upper true molar of the left side. It was found in the Elliott pit, Turin, Monona county. The tooth had only just begun to be worn. The height is 90 mm.; the length, 32 mm. at the summit; 29 mm. at half the height. The lakes are both preserved. There is a good deal of folding in the enamel around the lakes. There appears to be no reason for refusing to refer the tooth to *Equus complicatus.*

In the collection are three teeth which were found in the Whitman pit about five miles south of Rockport, Atchison county, Missouri. The locality is in section 22, township 64, range 41. It seems to be on Nishnabotna river.

No. 364 *a* is a right lower molar or premolar, probably the former, which had not yet been cut. The height is 80 mm.; the length, 34 mm.; the width, 18 mm. On account of its size it is referred to *Equus complicatus,* admitting, however, that it may belong to *Equus scotti,* if this should be found to be a distinct species.

A second tooth in the collection is numbered 364 *b.* It belonged to the right side of the lower jaw and is probably a premolar, the third or the fourth, probably the third. It was relatively little worn during life, but it has been rolled and polished after death. The height of the tooth is 98 mm.; the length, 34 mm.; the width, 16 mm. The adjacent ends of the two longitudinal valleys almost touch and of course exclude the outer inlet.

In lack of evidence to the contrary the tooth is referred to *Equus complicatus.*

A third tooth, bearing the number 364 *c,* is the last true molar of the left side of the lower jaw. The crown is curved so that the front border is convex, the hinder concave. The tooth had not been greatly worn. The height is 77 mm.; the length, 36 mm.; the width, in front, 14 mm. The outer inlet does not press itself between the longitudinal valleys. It is broad and

has a loop in its hinder border. The heel of the tooth, or the entostylid, is unusually thick and truncated behind, the thickness being 9 mm. In this respect it is quite different from the next tooth. It is referred to *Equus complicatus.*

No. 364 *d* is another lower left last molar, but more worn than the one just described. The height is 55 mm.; the length, 39 mm.; the width, 16 mm. The "heel" is thinner (6 mm.) than in the tooth just described and is more prolonged backward. The tooth is supposed to belong to *Equus complicatus.*

No. 227, of the Iowa University collection, is a much worn lower left molar or premolar. It was found at Turin, Monona county, in the Elliott pit. The crown has a height of only about 30 mm., but there were two strong roots developed, an anterior and a posterior. The latter is still present and with it the tooth has a height of 69 mm. The length of the grinding surface is 30 mm.; the width is 18 mm. The external inlet does not get in between the longitudinal valleys. The tooth is referred to *Equus complicatus.*

A tooth bearing the catalog number 242 *b* is an upper right third milk molar. It was found in the Elliott gravel pit near Turin, Monona county. It is worn so that the enamel is presented and this is of a simple character. The tooth is referred provisionally to *Equus complicatus.* In size it agrees closely with the corresponding tooth of a specimen in the American Museum of Natural History, found at Hay Springs, Nebraska, and having the field number 81. The height of the tooth numbered 242 is 30 mm.; the length, 35 mm.; the width, 26.5 mm.; the protocone, 11 mm.

From the same pit was obtained a lower right fourth milk molar to which has been given the catalog number 242 *a.* Its height is 30 mm.; the length, 39 mm.; the width, 13 mm. This tooth so closely resembles the corresponding tooth of the specimen from Tule Canyon, Texas (Fig. 56) and referred here to *Equus complicatus,* that the present tooth is regarded as belonging to this species. It will be seen that it is quite different from the last milk molar represented by figure 70 and which belonged to one of the five horses of *Equus scotti* found originally by Mr. Gidley. It is possible that these variations occur within the limits of one species, but this is yet to be determined.

Another tooth, No. 184, found in the Elliott pit is referred provisionally to *Equus complicatus*. It likewise is an upper right third milk molar; but it had not yet come into use. The height is 40 mm.; the length, taken along the middle of the tooth, 37 mm.; the width, 25 mm.; the protocone, 14 mm. In its unworn condition it is impossible to determine the arrangement of the enamel.

Under the number 181 there are in the collection parts of two lower teeth; both of the right side. They were found at North Riverside, near Sioux City, in the Anderson pit. One of these, 181 *a*, shows the external inlet pushed in between the adjacent ends of the two longitudinal valleys. It is a tooth slightly smaller than $m._2$, of No. 127 (Fig. 64), but it is here assigned provisionally to *Equus complicatus*.

The second specimen has a portion on the outer side of the hinder end broken away. This tooth is somewhat abnormal in having the protoconid reduced and not separated from the metaconid by an anterior inner inlet. The tooth appears to be a premolar. Another tooth with the hinder third of the crown missing has the outer inlet between the longitudinal valley. In its condition it is impracticable to determine the species.

A tooth numbered 119, from the Cox pit, at Missouri Valley, belonged to the right side of the upper jaw and is probably the first true molar. It is much worn. The height is about 45 mm.; the length, 30.2 mm.; the width, 31 mm.; the protocone, 16 mm. The enamel of the lakes shows little complication, a condition probably due to the nearness to the base of the crown. The pattern resembles closely that of the molars of the specimen numbered 220 (Fig. 60) and described on page 168. The tooth is referred provisionally to *Equus complicatus*.

From Prof. J. E. Marshall, of the Council Bluffs High School, the writer has received for examination some fossil horse teeth which had been found at Henton Station, Mills county, Iowa. One specimen is an upper left true molar, probably the second. It is pretty well worn down. The height is 55 mm.; the length, 29 mm.; the width, 30 mm. The enamel around the lakes is considerably folded. There appears to be no reason why this tooth should not be referred to *Equus complicatus*.

Another specimen is a part of the left ramus of the lower jaw, containing the second, third, and fourth premolars. These are worn down almost to the roots, and the enamel in the central parts of the teeth is much modified. The cement is very thick. The teeth are referred, with slight doubt, to *Equus complicatus*. Accompanying these teeth is a molar which belongs to *Equus laurentius* and it is mentioned more particularly under that species.

In 1891 (Eleventh Annual Rep. U. S. Geological Survey, p. 495) the late Dr. W J McGee reported the discovery of the tooth of a fossil horse which he regarded as *Equus complicatus*, in Delaware county, Iowa. On inquiry Doctor McGee informed the writer that the tooth was found lying on a knoll of Niagaran limestone, on which were only meager remains of drift materials. According to the latest map showing the distribution of drift sheets (Iowa Geol. Surv., Vol. XXI, pl. iii) this vicinity is covered with Iowan drift; but as both Iowan and Kansan had been mostly removed, the tooth may have been placed there before either sheet was laid down.

A left lower milk molar, the third in the series, including the one in front that is seldom developed, has the number 135. It was found in the Cox pit, at Missouri Valley. The length is 33 mm., the width 14 mm., the height only 15 mm. There appears to be no reason why it should not be referred to *Equus complicatus*.

Beyond the limits of Iowa, remains of this species have been found at Natchez, Mississippi; at Petite Anse, near New Iberia, in southern Louisiana; at Big Bone Lick, Kentucky; in Bond county, Illinois; and apparently at Hay Springs, Nebraska.

Remains, especially teeth, have been reported from many other localities, but for various reasons there is doubt about the identifications. Teeth found east of the Alleghany Mountains and resembling those of *Equus complicatus* are here referred somewhat arbitrarily to *Equus fraternus*. So far as our knowledge enables us to judge, *Equus complicatus* ranged from the western slopes of the Alleghanies to the region of the Great Plains.

As to the geological range of the species knowledge is as yet incomplete. Inasmuch as the Bond county, Illinois, specimen seems to have been found in a bog overlying Illinois drift, it is to be concluded that the species lived after the Illinoian stage. It is probably to be referred to the Sangamon. It seems probable that the specimens of *Equus complicatus* which have been found at Big Bone Lick, Kentucky, are likewise to be referred to the Sangamon.

Equus scotti Gidley.

This species was described by Mr. James W. Gidley in 1900 (Bull. Amer. Mus. Nat. Hist., Vol. XIII, pp. 111-116, figs. 1-5). In 1901 (Bull. Amer. Mus. Nat. Hist., Vol. XIV, pp. 103, 104, 134, 137, pl. xx, text-figs. 5, 6, 25, 26) it was further described and illustrated.

This species is better known, as regards its osteology, than any other of our fossil horses. At the head of Rock creek, in Briscoe county, Texas, Mr. Gidley discovered, in a compact deposit of Pleistocene sand, five skulls and numerous other bones, so that practically all parts of the skeleton are represented. Five of the skeletons belonged to young horses, but one skull, found at a later time, is that of an older individual. The specimens are in the American Museum of Natural History, in New York. This horse is stated by Mr. Gidley to differ from the domestic horse in having a skull larger relatively to the size of the body, the neck shorter, the body longer, the ribs of the belly region less curved near their heads, and the limbs shorter and slenderer. Figure 66 represents this horse, shown as mounted in the American Museum of Natural History.

Mr. Gidley compared the bones and teeth of this species with those of various skeletons of the domestic horse in the American Museum of Natural History, among them that of a large draught horse. The skull of the latter had nearly the same length as that of the type of *Equus scotti*. The series of dorso-lumbar vertebræ of the draught horse was about one inch longer than that of *E. scotti;* nevertheless, the neck of the latter was four inches shorter than that of the draught horse,

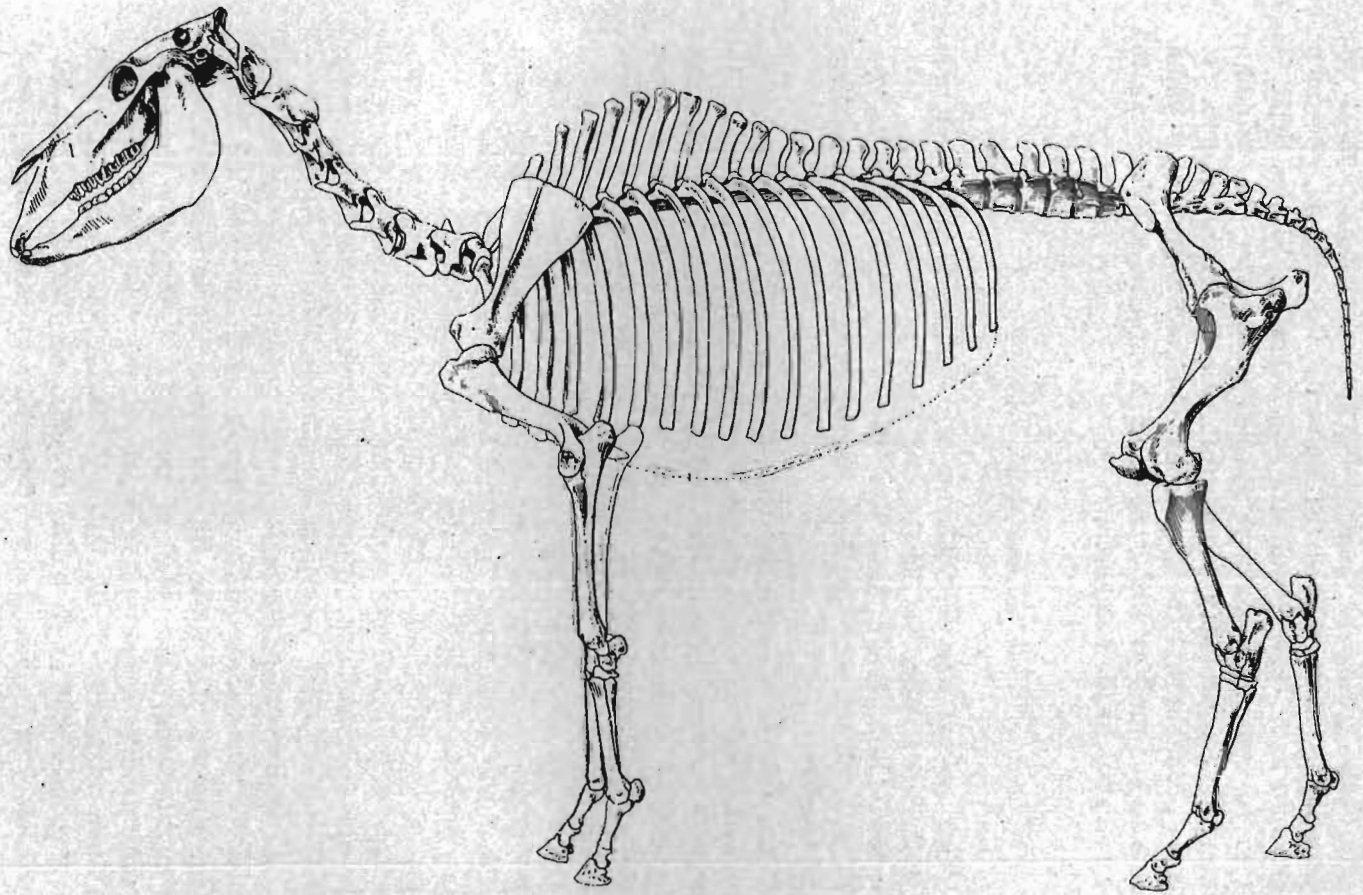

Fig. 66. *Equus scotti.* From skeleton mounted in American Museum of Natural History. Drawing made by Bruce Horsfall.

while the fore leg was about six inches shorter than that of the draught horse.

As may be seen from figure 67 the enamel of the teeth of the type of this species is, when compared with that of the domestic horse, hardly different in any essential respect. That surrounding the lakes appears to be somewhat less plicated than that of some domestic horses and more plicated than that of others. On the other hand, accurate measurements show that the teeth of *Equus scotti* are considerably larger than those of the domestic horse, larger than those of the large draught horse mentioned.

Fig. 67. *Equus scotti.* Grinding face of first left molar of type. X1.

The following measurements were made by Gidley on the type specimen of this species, No. 10606, of the American Museum of Natural History, and on the large draught horse, No. 528, of the same museum:

MEASUREMENTS OF TEETH.

	Equus scotti	Equus caballus
I^1 greater diameter	23mm.	18mm.
$Pm.^3$, length of grinding face	33mm.	29mm.
width of grinding face	31mm.	27mm.
$M.^1$ length of grinding face	32mm.	25mm.
width of grinding face	30mm.	25.5mm.

The length of the premolar-molar series in the type of *E. scotti* is 190 mm.; in the large draught horse, 172 mm.

In further comparison with the domestic horse, Gidley found that the orbit of *E. scotti* is relatively nearer the hinder borders of the occipital condyles; the maxillary ridge extends further forward, reaching a point over the last premolar; the face is deeper over the anterior premolars; the occiput projects further backward, and is of a different shape; the basioccipital bone is not so compressed, and the fossa included between the paroccipital process and the condyle is much deeper; the posterior region of the skull, and the posterior nares and the palate are narrower; the lower jaw is much deeper and more massive in the dental region; and the symphysis is heavier and longer, than in *Equus caballus*.

Through the liberality of the American Museum of Natural History, the writer has been able to examine a considerable amount of the materials collected by Mr. Gidley. As a contribution to the knowledge of this species, the following measurements and notes are given regarding the more mature individual found by Mr. Gidley. The region about the occipital condyles is somewhat injured, so that the length of the skull cannot be exactly determined, and there are slight distortions at the orbits and in the palate, making the diameter of the orbit a little inexact; also the width at the orbits and the width of the palate at pm.^{2}, and the width of the nose. In the second column are measurements of the skull of No. 10609, being one of the five younger specimens. Mr. Gidley (Bull. Amer. Mus. Nat. Hist., Vol. XIV, p. 136, pl. xviii, fig. A) presented measurements of the upper teeth of No. 10628 and a figure of them.

MEASUREMENTS OF THE SKULL.

Dimensions Taken	No. 10628 mm.	No. 10609 mm.
From front of premaxillae to front of foramen magnum	570	545
From front of premaxillae to rear of glenoid fossa	508	---
From front of premaxillae to front of posterior nares	320	308
From front of premaxillae to front of pm.^{2}	167	166
From front of premaxillae to front of orbit	380	370
Width across mastoid processes	---	125
Width across hinder nares	45	50
Width across glenoid fossae	232	224
Width from outside to outside last molars	134	138
Width from outside to outside of outer incisors	85	85
Width between fronts of orbits, about	158±	173
Width of palate at last molars	75	82
Width of palate at pm.^{2}, about	52±	63
Distance across premaxillae at middle of nasal opening	83	71
Least width of space between i^3 and pm.^{2}	55	51
Distance between i^3 and pm.^{2}	117	109
Diameter of orbit fore and aft, about	70±	72
From front of lower jaw to rear of ascending ramus, about	455±	462
Length of symphysis of lower jaw	107	108
Height of lower jaw at front of m.$_1$	105	103
Height of lower jaw at front of pm.$_2$	75	72
Width of lower jaw at symphysis, least	---	50

The teeth are to be considered. All the incisors have deep cups. That of the outer incisor has a broad notch on the lingual, or inner, wall. The cups of the others are complete. The incisors are of large size. The following are the measurements taken. Of course, the diameters would vary according to the age of the animal.

MEASUREMENTS OF INCISORS.

Width of i.^{1}	20mm.	diameter at right angles to this	14mm.
Width of i.^{2}	21mm.	diameter at right angles to this	13mm.
Width of i.^{3}	23mm.	diameter at right angles to this	12mm.
Width of i.$_1$	20mm.	diameter at right angles to this	20mm.
Width of i.$_2$	20mm.	diameter at right angles to this	12mm.
Width of i.$_3$	24mm.	diameter at right angles to this	12mm.

Figures 68 and 69 represent as accurately as possible the grinding teeth of the upper and of the lower jaws. It is recommended that the structure of these be compared with corresponding teeth that have been referred to *Equus complicatus,* especially with the type of the latter. The following are the dimensions of the upper and the lower rows of teeth and of the separate teeth:

MEASUREMENTS OF TEETH OF *EQUUS SCOTTI.*

Upper Teeth.

Length of premolar-molar series	202	mm.
Length of premolar series	111	mm.
Pm.^{2}, length	42	mm.
width	31	mm.
Pm.^{3}, length	35	mm.
width	33	mm.
protocone	14	mm.
Pm.^{4}, length	33	mm.
width	33	mm.
protocone	15	mm.
M.^{1}, length	30	mm.
width	30	mm.
protocone	14.5	mm.
M.^{2}, length	31	mm.
width	29	mm.
protocone	15	mm.
M.^{3}, length	30	mm.
width	25	mm.
protocone	16	mm.

Lower Teeth.

Length of premolar-molar series	203	mm.
Length of premolar series	106	mm.
Length of molar series	97	mm.

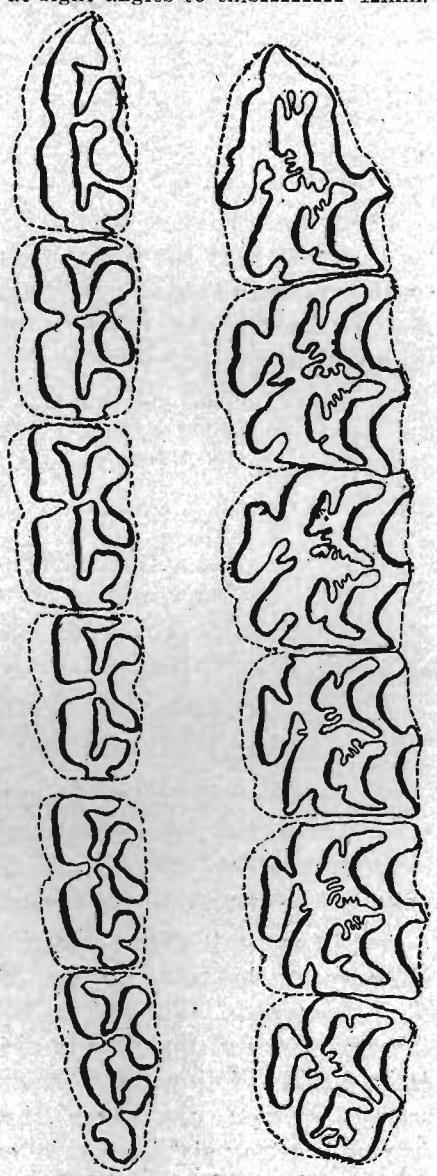

Fig. 68 Fig. 69

Figs. 68, 69. *Equus scotti.* Grinding faces of upper and lower cheek-teeth. X .733. No. 10628 American Museum Natural History.
68. View of the upper teeth.
69. View of the lower teeth.

$Pm._2$,	length	37 mm.
	width	18 mm.
$Pm._3$,	length	33 mm.
	width	17.5mm.
$Pm._4$,	length	33 mm.
	width	18 mm.
$M._1$,	length	29.5mm.
	width	17 mm.
$M._2$,	length	31 mm.
	width	15 mm.
$M._3$,	length	34 mm.
	width	15 mm.

As to the structure of the enamel of the upper teeth, it will be observed that the opposed borders of the two lakes in each tooth are much folded. In the anterior lake there is usually an M opposite the end of the post-protoconal valley. The latter does not lie wholly in the inner half of the tooth.

From No. 10608 of the American Museum of Natural History, one of the five horses originally found, the writer has secured the following description and figure (Fig. 70) of the third and fourth lower milk-molars of the right side:

MEASUREMENTS OF MILK TEETH.

Tooth	Length	Width
$Dm._3$	36.5mm.	16 mm.
$Dm._4$	35 mm.	14 mm.

The figures will show the arrangement of the enamel, and it will be seen that this is much more folded than that of the milk teeth of another horse found not far away (Fig. 56) and supposed to belong to *Equus complicatus* (p. 162).

With the skull above described, No. 10628, in the American Museum of Natural History, Mr. Gidley found the two hinder limbs complete. To add to the knowledge of the skeleton of this species, and possibly to aid in distinguishing other species from it, the following measurements are presented. In the second column are given the corresponding measurements from a trotting stallion in the collection of Mr. S. H. Chubb, of the American Museum of Natural History.

MEASUREMENTS OF SKELETON.

Bones Measured	Equus scotti No. 10628	E. caballus No. 74
Femur of left side—		
Total length	412 mm.	444 mm.
From top of head to inner condyle	375 mm.	390 mm.
From inner surface of head to outer face of bone	129 mm.	123 mm.
Fore-and-aft diameter at middle of length	51 mm.	54 mm.
Transverse diameter at middle of length	53 mm.	45 mm.
Fore-and-aft diameter at lower end	128 mm.	141 mm.
Width across articular surfaces at lower end	94 mm.	95 mm.
Tibia of left side—		
Total length of bone	370 mm.	392 mm.
Greatest width of upper end	107 mm.	108 mm.
Fore-and-aft diameter at middle of length	40 mm.	37 mm.
Transverse diameter at middle of length	49 mm.	43 mm.
Greatest width at lower end	93 mm.	86 mm.
Fore-and-aft thickness at middle of width of lower end	46 mm.	47 mm.
Tarsal bones—		
Total length of calcaneum	123 mm.	131 mm.
Depth of hinder process (tuber calcis)	49 mm.	46 mm.
Thickness of bone at front of the inner process	55 mm.	56 mm.
Greatest length of astragalus	67 mm.	70 mm.
Width of astragalar articulation for navicular	57 mm.	60 mm.
Metatarsal, median—		
Total length	285 mm.	290 mm.
Fore-and-aft diameter of upper end	46 mm.	47 mm.
Side-to-side diameter of upper end	58 mm.	53 mm.
Fore-and-aft diameter of lower end	35 mm.	44 mm.
Side-to-side diameter of lower end	40 mm.	55 mm.
Phalanges—		
Total length of first phalange	88 mm.	94 mm.
Greatest width of first phalange at upper end	63 mm.	62 mm.
Total length of second phalange	54 mm.	51 mm.
Greatest width of upper end of second phalange	86 mm.	78 mm.
Length of ungual phalange on front slope	64 mm.	60 mm.
Greatest width of ungual phalange	86 mm.	60 mm.

Measurements of the fore limbs of one of the younger individuals, No. 10609, of the American Museum of Natural History are here presented. The corresponding measurements of the trotting stallion already mentioned, are also given.

MEASUREMENTS OF SKELETON—Continued.

Bones Measured	Equus scotti No. 10609	Equus caballus No. 74
Scapula—		
Length along the spine	318 mm.	365 mm.
From rear of glenoid cavity to front of coracoid process	105 mm.	107 mm.
Diameter of neck, where least	66 mm.	68 mm.
Humerus—		
Total length	296 mm.	318 mm.
From top of head to inner condyle	286 mm.	310 mm.
Diameter, fore-and-aft, through head and greater tuberosity	110 mm.	117 mm.
Diameter side-to-side, through head and greater tuberosity	98 mm.	100 mm.
Fore-and-aft diameter of bone at middle of length	50 mm.	51 mm.
Side-to-side diameter of bone at middle of length	35 mm.	40 mm.
Fore-and-aft diameter of bone at inner side of lower end	95 mm.	97 mm.
Width of lower articulation	93 mm.	87 mm.
Radius—		
Total length	342 mm.	372 mm.
Side-to-side diameter near upper end	92 mm.	96 mm.
Fore-and-aft diameter near upper end	48 mm.	50 mm.
Fore-and-aft diameter at middle of length	30 mm.	31 mm.
Side-to-side diameter at middle of length	45 mm.	40 mm.
Greatest diameter near lower end	87 mm.	83 mm.
Side-to-side diameter of lower articulation	70 mm.	71 mm.
Metacarpal, median—		
Total length	236 mm.	252 mm.
Fore-and-aft diameter of upper articulation	35 mm.	34 mm.
Side-to-side diameter of upper articulation	57 mm.	55 mm.
Fore-and-aft diameter at middle of length	29 mm.	27 mm.
Side-to-side diameter at middle of length	38 mm.	36 mm.
Fore-and-aft diameter of lower end	40 mm.	42 mm.
Side-to-side diameter of lower end	54 mm.	53 mm.
Phalanges—		
Total length of first phalange	94 mm.	96 mm.
Width of upper end of first phalange	60 mm.	60 mm.
Width of upper end of second phalange	55 mm.	57 mm.
Width of lower end of second phalange	55 mm.	54 mm.

Equus excelsus Leidy.

This species is one of the horses that inhabited the region of the Great Plains, and it seems to have extended its range as far east as Iowa. For this reason it is here described as exactly as can be done in the present state of our knowledge of it. The type specimen, which is now in the U. S. National Museum, was found somewhere along Loup river, approxi-

mately at the center of the present state of Nebraska. The exact locality is not known; nor are the circumstances known under which it was found. The specimen was first briefly defined by Leidy in 1858 (Proc. Acad. Nat. Sci. Phila., p. 26); but it was not fully described and figured until 1869 (Jour. Acad.

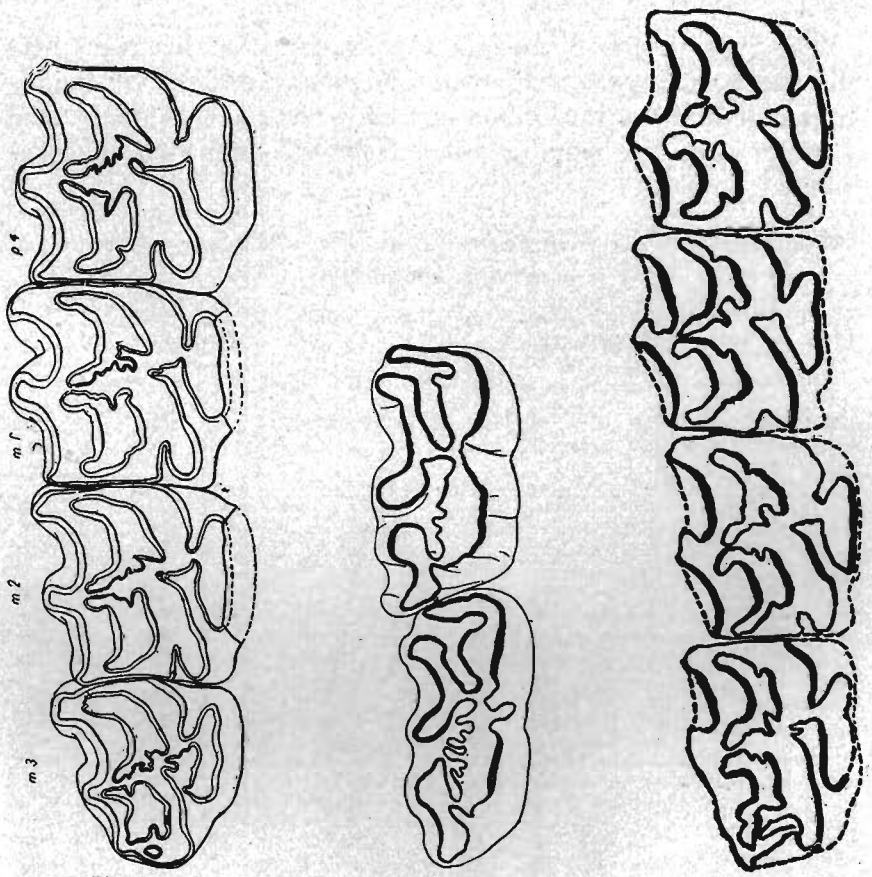

Fig. 71 Fig. 70 Fig. 72

Fig. 70. *Equus scotti.* Right third and fourth lower milk molars. Slightly less than natural size. No. 10608 American Museum Natural History.

Fig. 71. *Equus excelsus.* Last premolar and the three molars of the type. X1.

Fig. 72. *Equus excelsus.* Last premolar and the three molars of specimen 112 in American Museum Natural History. X1.

Nat. Sci. Phila., ser. 2, Vol. VII, p. 266, pl. xx, fig. 39; pl. xxi, fig. 31). However, the second and third true molars, represented by figure 39, of Leidy's plate XX, may in reality belong to some one of the other species which certainly inhabited that same re-

gion in Pleistocene times. Gidley (Bull. Amer. Mus. Nat. Hist., XIV, p. 114, fig. 9) presented a view of the grinding surface of the teeth which shows the details somewhat better than Leidy's figure, but the engraver has made the figure 4 mm. too short. There is presented here (Fig. 71) a reproduction of Gidley's figure brought to the size of nature.

The type specimen consists of a fragment of the right maxilla and a small part of the palatine bone, together with the last premolar and the three true molars. The teeth are only moderately worn, as may be seen from the following measurements.

MEASUREMENTS OF THE TYPE OF *EQUUS EXCELSUS*, AND OF ANOTHER SPECIMEN.

Parts Measured	Type	No. 112
Length of the molar series and the last premolar	107 mm.	113 mm.
Length of the molar series	78 mm.	84 mm.
$Pm.^4$. height	78 mm.	55 mm.
length	28 mm.	29 mm.
width	28 mm.	27.5mm.
protocone	16 mm.	12.5mm.
$M.^1$, height	66 mm.	58 mm.
length	26 mm.	27 mm.
width	28 mm.	26 mm.
protocone	14.2mm.	13.5mm.
$M.^2$, height	77 mm.	53 mm.
length	26 mm.	27 mm.
width	25 mm.	25 mm.
protocone	15.5mm.	13 mm.
$M.^3$, height	79 mm.	55 mm.
length	28 mm.	29 mm.
width	22 mm.	23 mm.
protocone	14 mm.	15 mm.

These teeth are somewhat curved, so as to be convex on the outer face and concave on the inner, but somewhat less so than in the type of *Equus complicatus*. They are also slightly curved backward, so as to be convex on the anterior face. The anterior and median pillars of the outer faces are very prominent, so that between them is a very deep groove extending up and down on the tooth.

An examination of the enamel surrounding the lakes shows that it has a simple arrangement. The front border of each of the anterior lakes is without a notch, and the same is true of the hinder border of the posterior lakes, except there is a slight notch in that of the premolar and in that of the last molar. In the hinder border of the anterior lake of each tooth there is a deep notch opposite the head of the post-protoconal valley, followed further outward by some minute loops.

In the front face of the posterior lakes is a shallow notch. The post-protoconal valley is narrow, without a deep notch at its head, and, except for a prolongation at the head of the valley of the premolar, the valley is confined to the inner half of the tooth. It will be observed that the protocone is broad, occupying about six-tenths of the length of the grinding face.

As regards the characters shown by the bone present, it is seen that the maxillary ridge, running along on the outside above the lower edge of the jaw, extends forward about to the middle of the last premolar; slightly further than in the domestic and in the Arabian horse at hand. The post-palatine foramen is opposite the front half of the inner face of the second true molar, instead of being opposite the last molar, as seen in the domestic horse and the Arabian. The palatine bone in front of this foramen is about twice as thick as on the other horses mentioned.

Such are the characters presented by the type specimen. To what extent these will vary in different individuals can be determined with certainty only after much additional materials shall have been collected and studied.

In the American Museum of Natural History is a fragment of a right upper maxilla, which contains the same teeth as Leidy's type, the last premolar and the three molars. This specimen was found at Hay Springs, Nebraska, in 1893, by a party consisting of Messrs. Wortman, Peterson and Gidley. It bears the field number 112. The measurements of these teeth are given in the second column on page 188. Figure 72 represents the grinding surface of these teeth. It must be observed that these teeth, as shown by the reduced height, are more worn than those of the type. Hence, each one originally had

the grinding surface possibly slightly longer than it now is. In no case does the length or the breadth differ from the type by more than one millimeter. The protocones are, except in the case of the last molar, shorter than in the type. Two of the post-protoconal valleys have a little reëntrant fold at the head, and they are confined to the inner half of the tooth. The enamel which surrounds the various lakes is nearly as simple in its pattern as in the teeth of the type. The notch in the front border of the anterior lake of each is present, but very small; that in the hinder border of the posterior lake is absent or small. The lakes are not so broad as in the type and the front border does not sweep inward and backward with the same bold curve.

Notwithstanding these differences, the writer refers this specimen provisionally to *Equus excelsus,* and believes that additional materials will yet be found showing intermediate conditions. However, in referring specimens of teeth to this species one must take care not to depart far from the original. It is to be hoped that more complete skull materials will soon reveal to us the essential characters of the species.

No lower teeth are yet known which can with confidence be referred to this species.

TEETH FOUND IN IOWA AND REFERRED TO *EQUUS EXCELSUS.*

A tooth, numbered 125, (Fig. 73) from Missouri Valley, is here referred to *Equus excelsus.*

This tooth, apparently the first true molar of the right side, was found in the Cox pit at Missouri Valley. It was not figured by Calvin; but he gave its dimensions (Bull. Geol. Soc. Amer., Vol. XX, p. 345). In his measurements he included the enamel. The following measurements exclude this: Height, not including the root, 58 mm.; length, 30 mm.; width, 30 mm.; protocone, 15 mm. Calvin referred the specimen to *Equus scotti.* To the present writer it seems to belong rather to *Equus excelsus.* The dimensions are somewhat greater than of the corresponding tooth of the type. Excepting that the enamel on the hinder border of the anterior lake is slightly less folded than in the type, the pattern is the same.

The tooth having the catalog number 283 *b* (Fig. 74) was found at Turin, Monona county, in the Elliott pit. It belonged to the right side of the upper jaw and is apparently the first true molar. It was that of an old horse, the height of the crown

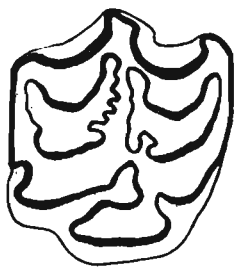

Fig. 73

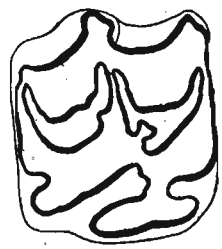

Fig. 74

Figs. 73, 74. *Equus excelsus.* Upper molars. Slightly less than natural size.
73. Grinding surface of probably first upper right molar. No. 125 State University of Iowa.
74. Grinding surface of probably first upper right molar. No. 283 State University of Iowa.

being only 30 mm. The length of the grinding surface is 27 mm.; the width, 30 mm.; the protocone, 15 mm. In dimensions this tooth agrees closely with the first molar of *Equus excelsus,* and there appears to be nothing in the pattern of the enamel to exclude it from this species.

Equus niobrarensis Hay.

This species was described by the present writer in the Proceedings of the U. S. National Museum, Vol. XLIV, 1913, pp. 576-584, and illustrated on plates lxix-lxxi and by text figures 19-23. It is another of those horses which inhabited, during a part of Pleistocene times, the regions of the Great Plains. The type specimen is a nearly complete skull which is in the U. S. National Museum and which was found along Niobrara river, near Hay Springs, Nebraska, in 1886, by Prof. J. B. Hatcher. When found, this skull was in a broken condition, but it was afterwards reconstructed. The specimen has the catalog number 4999. Certain parts, indicated in the illustrations here presented (Plates XV, XVI) by lines ruled parallel, are missing, but the structure of the skull can be determined quite accurately. Other remains of the same horse have been collected at Hay Springs and the neighboring region for the United

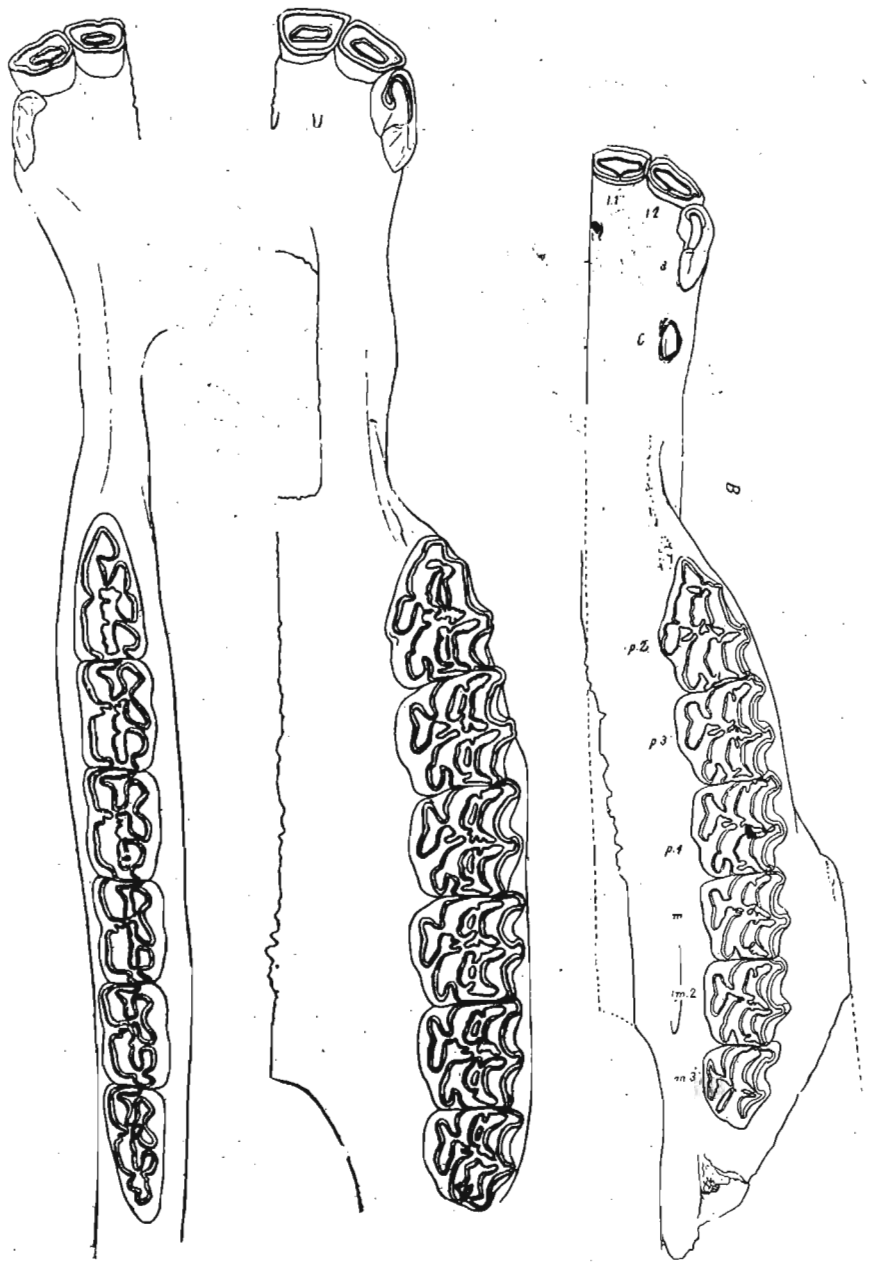

Fig. 77 Fig. 76 Fig. 75

Figs. 75-77. *Equus niobrarensis*. Jaws and teeth.
75. Maxilla, premaxilla and teeth of left side. X 2/5. No. 2725 American Museum of Natural History.
76. Left side of upper jaw of type, showing the teeth. X .49.
77. Left side of lower jaw of type, showing the teeth. X .49.

States National Museum, for Princeton University and for the American Museum of Natural History. Some of these materials were identified by Mr. Gidley (Bull. Amer. Mus. Nat. Hist., XIV, p. 132) as *Equus complicatus,* and the left side of the upper jaw of one specimen was figured (op. cit., pl. xviii, fig. B) under this name. Gidley's figure is here reproduced, but of only two-fifths the natural size (Fig. 75). In the same paper (p. 132, text-fig. 22) this writer figured and identified as *E. complicatus,* the left upper cheek-teeth of a specimen which he had found in the canyon of Tule creek, Swisher county, Texas. This specimen likewise seems to belong to *E. niobrarensis,* and it shows the range of the species in that direction.

While many bones of the skeleton belonging to two or three species of horses have been collected about Hay Springs, these have not been found, or at least recorded as being found, in such immediate association with teeth that they can be referred to their proper species. This is much to be regretted.

Below follow measurements taken from the type skull. In the second column are presented corresponding measurements taken on the skull of a domestic horse, No. 843, of the U. S. National Museum. The age of the latter seems to have been about six years, while the Niobrara horse appears to have been approximately a year younger. Inasmuch as No. 843 lacks the lower jaw, measurements of this bone have been supplied from No. 174960 of the U. S. National Museum, a large gelding, whose skull has a length of 610 mm. The upper row of cheek-teeth measure, however, the same as in No. 843.

MEASUREMENTS OF SKULLS.

Dimensions Taken	E. niobrarensis	E. caballus
From front of premaxillae to front of occipital foramen	530 mm.	550 mm.
From front of premaxillae to front of posterior nares	290 mm.	300 mm.
From front of premaxillae to rear of notch between nasal and premaxillae	200 mm.	196 mm.
From front of premaxillae to rear of occipital crest	582 mm.	602 mm.
From front of premaxillae to front of pm.[2]	133 mm.	143 mm.
From front of premaxillae to front of orbit	340 mm.	362 mm.
Width across mastoid processes	110 mm.	129 mm.
Width across hinder nares	47 mm.	55 mm.

MEASUREMENTS OF SKULLS—Concluded

Dimensions Taken	E. niobrarensis	E. caballus
Width across articulation for lower jaw	217 mm.	213 mm.
Width from outside to outside of last molars	123 mm.	127 mm.
Width from outside to outside of outer incisors	78 mm.	75 mm.
Width of skull on maxillary ridge at maxillo-malar suture	187 mm.	188 mm.
Distance between the rear of the orbits	240 mm.	220 mm.
Distance between the fronts of orbits	158 mm.	153 mm.
Width of palate at last molars	70 mm.	77 mm.
Width of palate at pm.^{2}	50 mm.	53 mm.
Distance across premaxillae at middle of nasal opening	75 mm.	67 mm.
Least width of space between i.^{3} and pm.^{2}	45 mm.	45 mm.
Distance between i.^{3} and pm.^{2}	105 mm.	110 mm.
Diameter of orbit, fore-and-aft	84 mm.	70 mm.
From front of lower jaw to rear of ascending ramus	467 mm.	--
Length of symphysis of lower jaw	90 mm.	--
Height of jaw at front of m.$_1$	96 mm.	--
Rear of i.$_3$ to front of pm$_2$	93 mm.	--

MEASUREMENTS OF THE TEETH.

Teeth	Upper Teeth		Lower Teeth	
	E. niobrarensis	E. caballus	E. niobrarensis	E. caballus
	mm.	mm.	mm.	mm.
Length molar-premolar series	179	185	180	187
Length premolar series	98	98.5	94	97
Length molar series	81	86	84	90
Height of crown of m.^{2}	75	—		
Pm.^{2}, length	38	40	35	36
width	27	27	15	16
protocone	10	10		
Pm.^{3}, length	30	30	28	30
width	28	29	16	17.5
protocone	13.5	14		
Pm.^{4}, length	29	29	30	30
width	27	30	16	17
protocone	14	15		
M.^{1}, length	27	27	27.5	27
width	28	29	14	15
protocone	13	15		
M.^{2}, length	27	28	27	28
width	25	28	13.5	15
protocone	14	16		
M.^{3}, length	26	31	30	34
width	23	25	13	14
protocone	14	16.5		
I.^{1}, diameter, side to side	19	16	17	16
diameter, fore and aft	13	11.5	11	11
I.^{2}, diameter, side to side	20	18	17	19
diameter, fore and aft	12	11	11	11
I.^{3}, diameter, side to side	21	20	17	17
diameter, fore and aft	11	11	11	13

Having compared many of the measurements of the skulls, as given above, with the length, it is found that the ratios in the two species are not greatly different. However, it appears that the nose of *E. niobrarensis* is slightly longer than that of the domestic horse, the part of the skull in front of the premolars being eighty per cent of the length of the tooth-line, while in the domestic horse it is only seventy-seven per cent. Here again, no doubt, there will be found to exist some variations. In fact, the specimen, No. 2725, of the American Museum of Natural History, New York, has the nose about as in the domestic horse. It will be seen that the teeth agree closely in their dimensions. It appears, therefore, necessary to find most of the specific differences in the structure of the teeth. In general, the arrangement of the enamel of the cheek-teeth is simpler than in the domestic horse, as seen on the hinder border of the anterior and the front border of the posterior lakes (Fig. 76). Here the enamel band has merely one or two short loops; whereas, in the domestic horse, it is almost always considerably crinkled. The valley which enters the face of the tooth from the lingual side, the post-protoconal valley, appears usually to extend further outward than in the domestic horse. In the latter, the distance from the inner wall of the protocone to the anterior and outer extremity of the post-protoconal valley is equal to or less than the distance from the latter point to the enamel wall in front of the median ridge, or style, on the outer face of the tooth. In *E. niobrarensis* the valley is usually extended somewhat farther toward the outward face. Here, as in other characters, deviations from the rule are to be expected.

In the lower cheek-teeth, both premolars and molars (Fig. 77), the loop of the enamel which enters the crown at the middle of the outer face is short, not being permitted to push itself in between the adjacent ends of the two longitudinal loops of enamel. In the domestic horse the outer valley insinuates itself between the two longitudinal loops of the true molars.

The first and second upper incisors have deep cups (Figs. 76, 77; plate XIV, fig. 3). If there was originally a notch on the hinder, or lingual, lip of the cup of the first incisors, all traces

of it have been worn away. There seems to have been a very shallow notch on the lingual lip of the second incisor. The third incisors had just begun to suffer wear. Each has a cup about 20 mm. deep, but the lip on the lingual side is notched nearly to the bottom of the cup. The hinder part of this lip rounds into the opposite, or buccal, lip, between the middle and hinder thirds of the latter.

There was evidently a shallow notch in the lingual lip of the second lower incisor (Plate XIV, fig. 4). The cup of the third incisor is very incomplete. Its lingual lip is notched broadly and nearly to the bottom of the cup. This lip is represented by a descending ridge in front and a tubercle about the middle of the lingual face of the tooth. The remainder of this face is concave transversely.

In the American Museum of Natural History is a mandibular symphysis which the writer regards as belonging to *Equus niobrarensis*. It bears the collector's number 24. It presents all the permanent incisors, of which the first and second are somewhat worn (Plate XIV, fig. 5). The third on each side had made its way through the bone, but not yet through the gum. Just outside of the front border of each is seen the root of the milk incisor just about to be displaced. The cup of the third permanent incisor has a low lingual lip, not well shown in the figure, but the bottom of the cup extends 25 mm. below it. This tooth is thus quite different from the corresponding one of the type. Here, again, as in other characters there is a good deal of variation. Even in the domestic horse there is considerable variation in the completeness of the cup of the third incisor. Mr. Gidley (Bull. Amer. Mus. Nat. Hist., Vol. XIV, p. 103, fig. 5) has referred to this variation and published three figures. Nevertheless, in the domestic horse, the absence of the cup is a rare occurrence; and we may expect to find in *E. niobrarensis* some condition that prevails. Possibly this tooth in the type is less completely developed than usual; or it is possible that the piece of jaw numbered 24 belongs really to some other species. The condition of the incisor in the type is not advanced really beyond that of the same tooth in a specimen supposed to belong to *Equus excelsus* (plate XIV, fig. 6).

In the American Museum of Natural History, New York, is a specimen, No. 2725, already referred to on page 195, from Hay Springs, which presents the upper jaw with all the teeth and a part of the lower jaw with the cheek-teeth (Fig. 75). To show the variations presented by the teeth the measurements are here given:

MEASUREMENTS OF THE TEETH OF NO. 2725, AMER. MUS. NAT. HIST. EQUUS NIOBRARENSIS.

Upper Teeth

Length of the upper premolar-molar series	190	mm.
Length of the upper premolar series	107	mm.
Length of the upper molar series	83	mm.
Pm.^{2}, length	42	mm.
width	30	mm.
protocone	12	mm.
Pm.^{3}, length	32	mm.
width	30	mm.
protocone	17	mm.
Pm.^{4}, length	31	mm.
width	30	mm.
protocone	16	mm.
M.^{1}, length	30	mm.
width	27	mm.
protocone	14	mm.
M.^{2}, length	30	mm.
width	25	mm.
protocone	15	mm.
M.^{3}, length	25	mm.
width	20	mm.
protocone	15	mm.

Lower Teeth

Length of premolar-molar series	200	mm.
Length of premolar series	110	mm.
Length of molar series	90	mm.
Pm.$_2$, length	38	mm.
width	17	mm.
Pm.$_3$, length	33	mm.
width	19	mm.
Pm.$_4$, length	32	mm.
width	18	mm.
M.$_1$, length	30	mm.
width	16	mm.
M.$_2$, length	32	mm.
width	15	mm.
M.$_3$, length	31	mm.
width	11	mm.

It will be seen on comparison of these measurements with those of the type skull, that the teeth of No. 2725 are, in nearly all cases, distinctly larger. As already stated, the nose is shorter than in the type specimen. We can hardly doubt, however, that the two specimens belong to the same species.

TEETH OF *EQUUS NIOBRARENSIS* FOUND IN IOWA.

The following teeth, found in Iowa, are referred to this species:

Two teeth numbered 124 and 121 were described and figured by Dr. Calvin in his paper on Aftonian Mammalia (Bull. Geol. Soc. Amer., Vol. XX, p. 347, pl. xxi, figs. 3, 4). They had been found in the Cox gravel pit at Missouri Valley, Harrison county. Both of these teeth are sawn across at the upper end, so as to show the arrangement of the enamel bands. In both teeth this resembles so closely that of the type of *Equus niobrarensis,* that they are referred without hesitation to that species. On account of the missing part of the crowns, the exact height cannot be determined.

The following are the other dimensions:

Tooth	Length	Width	Protocone
124	29 mm.	28 mm.	13 mm.
121	29 mm.	29 mm.	16 mm.

The tooth which bears the number 283 *a,* is one that has been rolled and water-worn. It was found in the Elliott pit, at Turin, Monona county. It is a left upper molar, the first or the second. The height of the crown is 55 mm.; the length, 29.5 mm.; the width, 29.5 mm.; the protocone, 14 mm. The dimensions of the tooth and the pattern of the enamel indicate distinctly that the tooth belonged to *Equus niobrarensis.*

A tooth, numbered 117 and which seems quite certainly to be a right upper premolar, probably the fourth, was described and figured by Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 345, pl. xviii, figs. 2, 4), who referred the tooth to *Equus scotti.* The

specimen was found in the Cox gravel pit at Missouri Valley. Professor Calvin gave as the height ("length") of the tooth 82 mm.; as the length ("antero-posterior diameter"), 35 mm.; and as the width ("transverse diameter"), 33.5 mm. In obtaining the last two dimensions that author included the cement; which for various reasons it is not well to include. The measurements obtained by the present writer are as follows: Height, 82 mm.; length, 33 mm.; width, 33 mm.; protocone, 15 mm. An accurate pen drawing is here presented showing the arrangement of the enamel on the grinding face (Fig. 78). Dr. Calvin's figures also are reproduced (Pl. X, figs. 2, 4). It will be observed that there is no great amount of folding around the lakes. Both of these are deeply notched in the front border, and

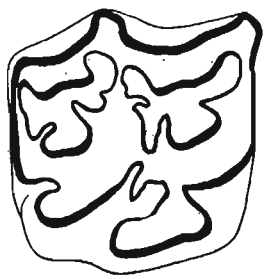

Fig. 78

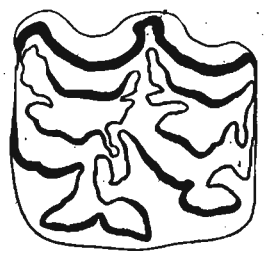

Fig. 79

Figs. 78, 79. *Equus niobrarensis.* Premolars. X1.
78. Grinding surface of supposed right upper fourth premolar. No. 117 State University of Iowa.
79. Grinding surface of supposed third premolar of left side of upper jaw. No. 185 State University of Iowa.

the anterior lake shows a deep inlet opposite the head of the post-protoconal valley. There is no such crimping of the adjacent faces of the lakes as usually appears in *Equus complicatus* and *E. scotti.* The lakes are very wide. The post-protoconal valley is wide and deeply notched at its head. The tooth is a very large one. In size it agrees with the fourth premolar of *E. scotti,* but is considerably larger than the molars of the latter. The arrangement of the enamel is much simpler than in the ordinary specimen of *E. scotti;* even simpler than in the first true molar of the type of the species, as figured by Gidley. The arrangement of the enamel resembles so strongly that in the type of *Equus niobrarensis,* that the tooth is referred to that species, notwithstanding that it is considerably larger than

the teeth of the type. It is possible, nevertheless, that it belongs to *E. complicatus.*

A left upper molar, No. 327, from the Cox pit, was collected by Shimek and is to be referred to *E. niobrarensis.* Here, too, belongs No. 123, collected by Shimek from the Cox pit. It is the left second premolar.

It can hardly be doubted that a tooth, numbered 185, belongs to the same species as No. 117, above mentioned. It was found at Missouri Valley, Harrison county, in the Cox pit. The height is 88 mm.; the length of the grinding face, 33 mm.; the width, 29 mm.; protocone, 15 mm. The anterior outer pillar is very flat and the tooth is certainly a left upper premolar, probably $pm.^3$. The lakes of No. 185 (Fig. 79) are not so wide as those of No. 117. The enamel of the adjacent border is very slightly more crimped than in No. 117. The post-protoconal valley is broad and it presents the peculiarity of sending far outward the hinder branch at its head, so as almost to touch the anterior lake. A loop of the latter enters the notch in the post-protoconal valley. These relations are doubtless due to the fact that the tooth had undergone but little wear. The tooth is referred to *Equus niobrarensis* with some doubt.

The portion of a tooth, bearing the number 122 *a,* was found in the Elliott gravel pit, at Turin, Monona county. It presents a little more than the hinder half of the crown of an upper left molar or possibly premolar. It was mentioned by Calvin (Bull. Geol. Soc. Amer., Vol. XX, p. 347), who referred it to *Equus complicatus.* In thus identifying the species Doctor Calvin followed Gidley who then referred to *E. complicatus* the horse here called *E. niobrarensis.* The tooth at hand appears to have just begun to wear, inasmuch as the two lakes are not completely separated. The tooth has a height of 70 mm.; and a width of 28 mm. The enamel has the arrangement seen in *E. niobrarensis.*

Number 136 of the catalog of the State University of Iowa collection is a fine large upper premolar of the right side. It was collected by Shimek in the Aftonian sands at Turin, Iowa. From the same locality is another premolar, still larger, credited to Mr. Babcock and found in the Aftonian gravels. It belonged on the left side. The height of the tooth is about 95 mm.;

the length of the grinding surface, 32 mm.; the width, 30 mm. The tooth has the number 284.

The number 369 has been given to a large upper premolar of the right side, probably the third, which was found in the Cox gravel pit at Missouri Valley, by Mr. Earl Barnum, and secured for the Iowa University collection by Prof. Geo. F. Kay. The tooth is in good condition and was only moderately worn at the death of the animal. The height of the crown is 76 mm.; the length, 33 mm.; the width, 28 mm.; the protocone, 18 mm. The tooth is identified as that of *Equus niobrarensis*, but it must be admitted that it belongs possibly to *Equus complicatus*. It is somewhat larger than the corresponding tooth of the type of *Equus niobrarensis*, but otherwise agrees with it.

In the collection at the Iowa University is a horse's tooth which was found in a well, near Montrose, Lee county, at a depth of twenty-five feet. The catalog number is 71. The grinding surface is covered with a part of what appears to have been a calcareous nodule, and on this account the species has not been determined. At the depth where it was found it seems probable that Aftonian deposits may have been reached.

A much worn upper cheek-tooth of the right side, probably $pm.^3$, which after death had been rolled and waterworn, was found in the Whitman gravel pit, on section 22, township 64 north, range 41 west, about five miles south of Rockport, Atchison county, Missouri. It has the catalog number 361. Its height is about 40 mm.; the length, 31 mm.; the width, 33 mm.; the protocone, 18 mm. The latter is unusually wide. The enamel has a very moderate complication and seems to agree with that of *Equus niobrarensis*.

In the State University of Iowa is a tooth, loaned and without number, which was found in the Collins pit, one mile southeast of Sioux Falls, South Dakota. It appears to belong to the species here described.

Equus laurentius Hay.

Equus laurentius was first described by the present writer in the Proceedings of the U. S. National Museum, Vol. XLIV, 1913, pp. 584-591, and illustrated by plates lxxii, lxxiii and text fig-

ures 25-27. The plates are here reproduced (Pls. XVII, XVIII). For the photographs the writer is indebted to the University of Kansas and for figure 80 to the U. S. National Museum. The type of this species is a nearly complete skull which is preserved in the paleontological department of the University of Kansas. The only part that is missing is the extremities of the nasal bones. The specimen bears the catalog number 347.

This skull was found in 1910, after a period of high water, on a sand bar, on the north side of Kansas river, near North Lawrence. With the skull were found the femur of a carnivore which Prof. Roy L. Moodie has identified as that of Smilodon, and the base of an elk's antler. In 1903 there were secured, about one mile north of the place where the horse skull was found, some skulls of the existing bison, besides the horn-core and hinder part of the skull of a bison which Prof. C. E. McClung has described as *Bison kansensis*. The skulls of the existing bison appear to be less mineralized than the horse skull and the bison described by Professor McClung, and probably were derived from a more recent deposit. It would be interesting to know from what level the elk's antler had been derived. Taking into account all the circumstances the writer believes that Kansas river had attacked some deposit of the Aftonian interglacial stage and likewise some later deposits.

The form and proportions of this skull are illustrated here by several figures. The following measurements were taken from it by the writer during a visit at the Kansas State University. The animal was mature, but not old.

MEASUREMENTS OF SKULL OF *EQUUS LAURENTIUS*.

From middle of incisive border to front of foramen magnum	481	mm.
From middle of incisive border to front of the posterior nares	260	mm.
From middle of incisive border to naso-premaxillary notch	163	mm.
From middle of incisive border to middle of occipital crest	541	mm.
From middle of incisive border to front of pm.[2]	128	mm.
From middle of incisive border to front of orbit	293	mm.
From front of orbit to naso-premaxillary notch	183	mm.
Width across mastoid processes	117	mm.
Width across articulations for lower jaw	197	mm.
Width from outside to outside of last molars	132	mm.
Width from outside to outside of last premolars	127	mm.
Width from outside to outside of canines	61	mm.
Width from outside to outside of outer incisors	65	mm.
Width on maxillary ridge at maxillo-malar suture	177	mm.
Width between the rear of the orbits	207	mm.

Distance between the front of the orbits	153 mm.
Width of palate at last molars	72 mm.
Width of palate at pm.^{2}	68 mm.
Width of palate at diastema, least	45 mm.
Length of orbit	65 mm.
From front of symphysis of lower jaw to rear of ascending ramus	415 mm.
Length of symphysis	82 mm.
Height of jaw at front of m.$_1$	73 mm.
From rear of canine to front of pm.$_2$	68 mm.
From front of canine to rear of i.$_3$	5 mm.

MEASUREMENTS OF THE UPPER TEETH (FIG. 80).

Length of premolar-molar series	160 mm.
Length of premolar series	87 mm.
Length of molar series	73 mm.
Pm.^{2}, length	35 mm.
width	24.5mm.
protocone	8 mm.
Pm.^{3}, length	26 mm.
width	24.5mm.
protocone	9 mm.
Pm.^{4}, length	25 mm.
width	25 mm.
protocone	10 mm.
M.^{1}, length	22 mm.
width	23.5mm.
protocone	10.5mm.
M.^{2}, length	23 mm.
width	23.5mm.
protocone	13 mm.
M.^{3}, length	30 mm.
width	22 mm.
protocone	14 mm.

MEASUREMENTS OF THE LOWER TEETH (FIG. 81).

Length of the premolar-molar series	175 mm.
Length of the premolar series	89 mm.
Length of the molar series	86 mm.
Pm.$_2$, length	32 mm.
width	15 mm.
Pm.$_3$, length	28 mm.
width	16.5mm.
Pm.$_4$, length	29 mm.
width	16 mm.
M.$_1$, length	25 mm.
width	15 mm.
M.$_2$, length	26 mm.
width	14 mm.
M.$_3$, length	30 mm.
width	14 mm.

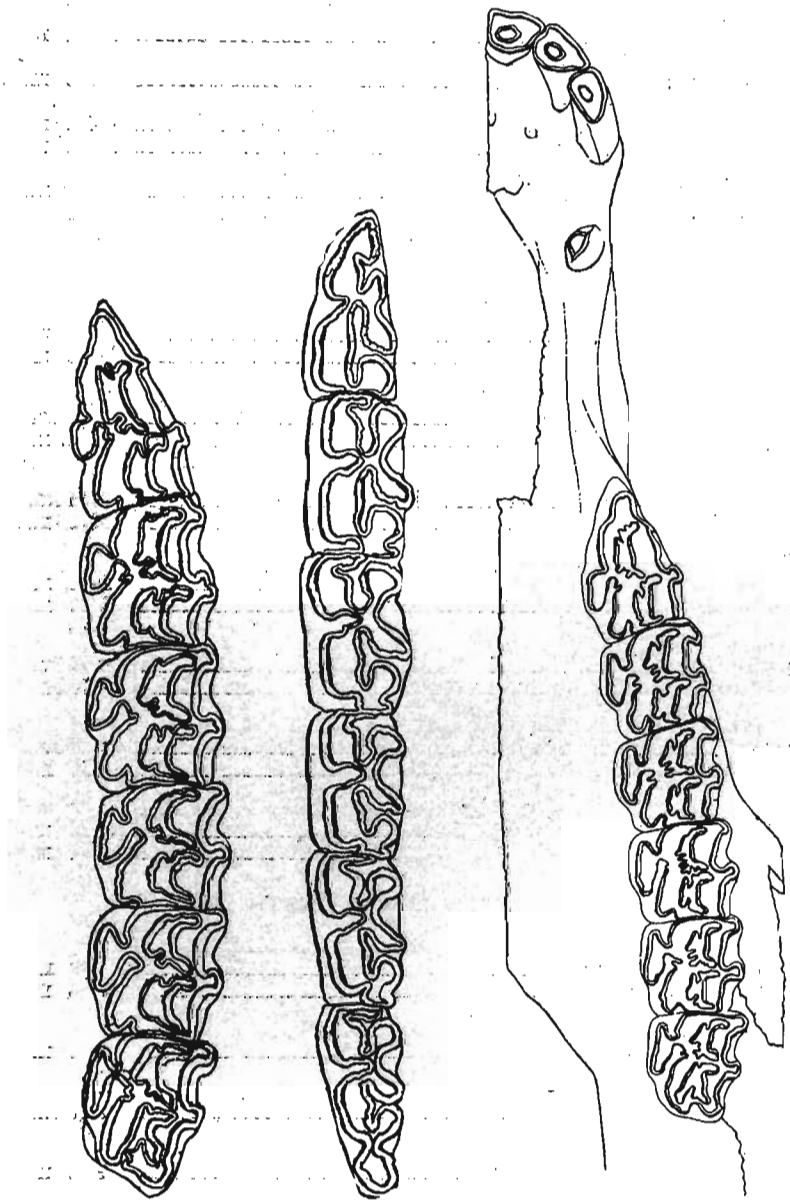

Fig. 80 Fig. 81 Fig. 82

Figs. 80-82. *Equus laurentius*. Jaw and teeth.
80. Upper cheek-teeth of left side of type. X .74.
81. Lower cheek-teeth of left side of type. X .74.
82. Left side of upper jaw, with teeth. X .53. No. 4991 National Museum.

In the U. S. National Museum there is a palate which presents the complete upper dentition of a horse which seems to have belonged to the species here described. Its catalog number is 4991, and the specimen was collected by J. B. Hatcher, in 1886, near Hay Springs, Nebraska. Figure 82 shows the dentition of the right side. The animal was considerably older than the type specimen.

The following measurements are given in order to show what seems to be the essential agreement of the specimen with the type and at the same time some deviations therefrom:

MEASUREMENTS OF SKULL AND TEETH.

From front of incisor to rear of line joining m.^{3} of the two sides	275 mm.
From line joining fronts of pm.^{2} to front of premaxillae	117 mm.
Width of premaxillae at base of i.^{3}	70 mm.
Width of palate between c. and pm.^{2}, narrowest	40 mm.
Width at border of nasal opening just above last	69 mm.
Width of face opposite middle of pm.^{4}	136 mm.
Width of face opposite m.^{2}	180 mm.
Width of posterior nares	51 mm.
Length premolar-molar series	158 mm.
Length premolar series	87 mm.
Length molar series	72 mm.
Pm.^{2}, length	36 mm.
width	23 mm.
protocone	11 mm.
Pm.^{3}, length	25 mm.
width	27 mm.
protocone	14 mm.
Pm.^{4}, length	25 mm.
width	25.4mm.
protocone	15 mm.
M.^{1}, length	23 mm.
width	25 mm.
protocone	14 mm.
M.^{2}, length	23 mm.
width	24 mm.
protocone	13 mm.
M.^{3}, length	27 mm.
width	21.5mm.
protocone	13 mm.
I.^{1}, diameter from side to side	15 mm.
I.^{2}, diameter from side to side	15 mm.
I.^{3}, diameter from side to side	14 mm.

The cheek-teeth are worn down to a height of about 50 mm. It is to be noted here that, while the diameters of the corresponding teeth in the two specimens are practically the same, the length of the protocone in No. 4991 is considerably greater than in the type specimen. It appears, however, in general, that one must not place too much reliance in the size and form of the protocone in identifying species.

Fig. 83. *Equus laurentius*. Cheek-teeth of right side. X1. No. 133 State University of Iowa.

In the Lawrence specimen it will be seen that the axis of the post-protoconal valley in the third and fourth premolars is directed nearly to the anterior outer corner of the tooth. In the molars the axis prolonged strikes the middle of the next tooth in front; or, in the case of the last molar, the front of the next tooth. In the Hay Springs specimen the prolongation of the axis of all the molars reaches the anterior pillar of the next tooth in front or even farther in front. The front border of the anterior lakes is more deeply notched in the Hay Springs specimen than in that from Lawrence, and the same statement is true regarding the hinder border of the posterior lakes. In that border of the anterior lake which is opposite the head of the post-protoconal valley, there is in the Hay Springs horse a double folding of the enamel resembling an M; whereas, in the horse from Lawrence, the fold is usually simple. From the table on page 203 it will be seen that the nose of the Hay Springs horse is slightly wider than in the other horse. Nevertheless, one would hardly be justified in regarding the two specimens as belonging to distinct species.

The writer's studies on the horses seem to indicate that *Equus niobrarensis* possessed a skull which was wider in the rear than

that of the domestic horse but that it narrowed more in front; while *Equus laurentius* had a skull relatively nearly as wide, but with a long nose. These conclusions may, of course, be modified by other specimens.

To this species the writer refers certain teeth which have been found in Iowa, as follows:

In the collection of the University of Iowa is a part of the left maxilla with five teeth. The number is 133. It was found somewhere near Sioux City. The specimen was figured and described by Calvin in his paper on Aftonian Mammalia (Bull. Geol. Soc. Amer., Vol. XX, pp. 347, 348, pl. xx). This plate is here reproduced on plate XIII, figure 3. In order to illustrate more clearly the arrangement of the enamel, a pen drawing is here presented (Fig. 83).

This specimen was identified by Calvin as *Equus scotti*. He regarded as belonging to the latter species the materials collected at Hay Springs and described in the present work as a distinct species, *Equus niobrarensis*. However, the present writer identifies the Sioux City specimen as *Equus laurentius*. The specimen belonged to an old horse and the teeth are not in a good condition for identification. They are worn down to about an inch from the roots; and, as a result, the arrangement of the enamel is much modified. In the first true molar the anterior lake has disappeared and the posterior one is nearly gone. It seems probable that the length of each grinding surface has been shortened somewhat, but this is not necessarily true; and, in the case of the front two premolars, the shortening may be wholly compensated by the obliquity of the worn grinding face.

The following are the measurements secured:

MEASUREMENTS OF TEETH.

Pm.^{2} to M.^{3}, inclusive	137 mm.
Length of the premolars	91 mm.
Pm.^{2}, length	37 mm.
width	24 mm.
protocone	10 mm.
Pm.^{3}, length	28 mm.
width	27.5mm.
protocone	13 mm.

Pm.^{4},	length	25 mm.
	width	28 mm.
	protocone	13 mm.
M.^{1},	length	23 mm.
	width	26 mm.
	protocone	13 mm.
M.^{2},	length	24 mm.
	width	27 mm.
	protocone	13 mm.

In size these teeth exceed somewhat those of the type of *Equus laurentius* and of the specimen referred to it, now in the U. S. National Museum, No. 4991 (Fig. 82). In size they do not differ much from those of the type *Equus niobrarensis;* but there was originally evidently more complication of the enamel around the lakes than in *E. niobrarensis,* and there is no indication that the protoconal valley had the deep re-entering loop at its head or the great prolongation of this to the center of the tooth. Furthermore, the third premolar has almost exactly the same size as that of No. 4991 of the U. S. National Museum.

The specimen here described shows that the posterior palatine foramen opened opposite the last molar, and that the bone of the hinder region of the palate was thin, differing thus from the type of *Equus excelsus.*

In the State University collection, with the number 250, are three lower right molars which are referred to this species. These were secured by Professor Shimek in the second cut along the Illinois Central railroad east of Sioux Falls, South Dakota. They were found in the Aftonian silts. In the same collection, with the number 128, is an upper last molar which Shimek found in the Cox pit at Missouri Valley. It appears to belong to this species. Another, a left lower tooth, No. 126, likewise appears to belong here, and was found in the Cox pit.

From Prof. J. E. Marshall, of Council Bluffs, the writer has received for examination various teeth of horses which had been found at Henton Station, Mills county. A part of these have already been mentioned under *Equus complicatus.* One very fine tooth, a left upper premolar, probably the last, is found to belong to *Equus laurentius.* This had begun to wear only a short time before the death of the animal. The height is 76 mm.; the length of the grinding surface, 26 mm.; the

width, 25 mm. The tooth is considerably curved, so as to be concave on the inner face and on the hinder. The enamel of the lakes is somewhat more folded than in the type, but there can be no hesitation in referring the tooth to *E. laurentius*.

At the close of the descriptions of the horse remains which may, with some certainty, be referred to their proper species may be mentioned two specimens which are in the collection of the State University of Iowa and whose specific relationships are undeterminable.

The first of these is a femur of the left side, No. 320. This was found by Mr. W. E. Babcock, in the Elliott sand pit, at Turin. The following measurements were taken: Length from the upper surface of the head to the distal end, 393 mm.; width across the head to the outer side of the bone, 120 mm.; fore-and-aft diameter at the middle of the length, 47 mm.; transverse diameter at the middle of the length, 54 mm.; fore-and-aft diameter of the outer condyle, 105 mm.; same diameter across inner condyle, 122 mm.

Number 136 of the same collection belongs to a left tibia which was found by Ira A. Williams, in the Cox pit, at Missouri Valley. The proximal end, including about that part belonging to the proximal epiphysis, is missing. The following measurements were taken: Length of fragment, 345 mm.; width of upper end, on hinder face, at the level of the nutritious foramen, 56 mm.; transverse diameter of shaft 100 mm. below the nutritious foramen, 49 mm.; fore-and-aft diameter at the same place, 42 mm.; transverse diameter at the lower end, 75 mm.

From this locality were obtained four cannon-bones, three phalangeal bones, and a left radius.

Superfamily TAPIROIDEA.

The Lophiodonts and Tapirs.

Under this superfamily are arranged the tapirs and their extinct relations, which were so numerous during the Tertiary period. The group is to be regarded as one far less progressive than is that to which the horses belong. The cheek-teeth

are always low-crowned and the upper ones lack the intermediate cusps. Those of both jaws are characterized by having the crown traversed by two prominent crests; those of the upper jaw by having, besides, a prominent wall joining the outer ends of the two crests. Thus there is, between the two cross-crests, a valley which opens on the side of the tooth next the tongue. In the animals of this group the digits are never less than three.

Although tapirs, belonging apparently to two species, continued to exist in North America well into the Pleistocene period, no remains of these have yet, so far as the writer knows, been found in Iowa. A map showing the localities where tapirs' remains have been found in the United States may be found in volume LIX of the Smithsonian Miscellaneous Collection, 1912, No. 20, page 11. None of these fall within the region covered by Wisconsin drift; from which fact the writer believes the conclusion justified that these animals had, by the time of the Wisconsin stage, been driven far to the south in the United States, if not into Central and South America, where three or four species yet exist.

Superfamily **RHINOCEROTOIDEA.**

The Rhinoceroses.

During the Tertiary period the group to which the Rhinoceroses belong was represented in our country by numerous genera and species; but none are known to have lived at any time during the Pleistocene.

Suborder **ARTIODACTYLA.**

The Even-toed Hoofed Mammals.

Ungulata which have the third and fourth digits of each limb equally developed; second and fifth digits more or less reduced, sometimes ending in hoofed phalanges, sometimes wholly wanting; presacral vertebræ always twenty-six; femur without third trochanter; the astragalus with a grooved trochlear surface for the tibia, and another for the navicular

and cuboid; fibula articulating with the calcaneum; teeth variously modified, sometimes in full number, forty-four, sometimes with some of those in front of the second premolar wanting; incisors never furnished with a cup, or pit.

The Artiodactyla include, besides a considerable number of extinct families, the swine, the hippopotami, the camels, the deer, the giraffes, the antelopes, the sheep, the goats, the musk-oxen, and the oxen. Richard Lydekker has recently called attention to the fact that, while there are yet existing less than a score of perissodactyls, there are between one and two hundred species of existing artiodactyls. All the continents have been occupied by members of the group; but Australia only through recent introduction by man. The oldest forms are found in the Lower Eocene. In the Upper Eocene and succeeding epochs the group is represented by increasing numbers.

As to their food habits, all nourish themselves on vegetable material; but some of them, as the swine, readily devour animal matter.

In the Pleistocene of North America the following superfamilies are represented: Suöidea (piglike ungulates), Cameloidea (camels) and Boöidea (deer, sheep, goats, and oxen).

Superfamily SUOIDEA.

The Hogs and Peccaries.

Even-toed ungulates with usually four functional digits in each foot; but these in some cases reduced to three or even to two; tooth formula, i. $\frac{3-2}{2}$, c. $\frac{1}{1}$, pm. $\frac{4-2}{4-3}$, m. $\frac{3}{3}$; the molars furnished with four conical cusps which are connected so as to form two cross-crests, between which may be found few or many accessory tubercles; canines usually large and trenchant.

Although remains of true hogs, Suidæ, have been reported from the Pleistocene deposits of the United States, they have probably in all cases belonged to the introduced domestic swine. On the other hand, the peccaries (Tayassuidæ) are numerously represented.

During the Tertiary period many genera of hoglike animals existed in the United States, some of which reached proportions much exceeding those of the domestic hog.

Family **Tayassuidae.**

The Peccaries.

Hog-like ungulates, with two or four hoofed digits in the fore feet and two or three in the hinder. Tooth formula, i. $\frac{2}{3-2}$, c. $\frac{1}{1}$, pm. $\frac{3}{3}$, m. $\frac{3}{3}$. Lower incisors directed forward, the upper ones downward. Canines large, the upper ones with hinder border sharp; the lower ones with the anterior border subacute. Molars with four principal cones and often with intermediate cuspules and tubercles.

Of this family three genera are recognized as having been represented in our country during the Pleistocene, Tayassu, Platygonus, and Mylohyus.

ANALYSIS OF GENERA HERE DESCRIBED.

1. One premolar or none like the molars; cusps short and conical; diastema between canine and premolar not equal to one-half the length of the premolar-molar series, and less than the width of the palate. Tayassu.
2. No premolars like the molars; cusps high, those of each pair forming a crest across the tooth; diastema equal to about two-thirds the length of the premolar-molar series; the palate here nearly as wide as the length of diastema. Platygonus.
3. Two premolars like the molars; molars and premolars like those of Tayassu, but sometimes at least, with the enamel more rugose; cross-valleys more or less blocked up by accessory cusps; diastema as long as, or nearly as long as the premolar-molar series; width of palate much less than the length of the diastema. Mylohyus.

Genus TAYASSU Frisch.

(The genus Dicotyles of older authors.)

Peccaries with four hoofed digits on front feet; three on hinder; metatarsals three and four coössified in the upper half; snout rather short; teeth, i. $\frac{2}{3}$, c. $\frac{1}{1}$, pm. $\frac{3}{3}$, m. $\frac{3}{3}$; molars with four low cones and weak accessory conules; the cones of each pair separated by a longitudinal valley; lower molars like the upper but longer, the hindermost one with a well developed heel; no premolar or one with two pairs of cross-crests.

The members of this genus have four digits furnished with hoofs in the fore limbs; but the inner one and the outer one (second and fifth) are short and slender, usually not reaching the ground. In the hinder legs the second digit hardly touches the ground, but has the usual number of bones; the fifth digit is represented only by a splint-bone about an inch long and hidden under the skin.

The species of this genus inhabit, at the present day, the region extending from the Red River of Texas, through Central and South America, to Patagonia. Several species have been established, and these have been divided into two genera or subgenera, Tayassu and Olidosus. Certain fossil remains of peccary, found at several localities in the United States, have been assigned to the living species, under the name *Dicotyles torquatus* and *D. tajacu;* but, as Leidy finally concluded, they belonged, probably, to an extinct species. Hence, Leidy's specific name *lenis* is here adopted for it.

Tayassu lenis (Leidy).

This is the peccary recorded in the author's Bibliography and Catalogue of the Fossil Vertebrates of North America, page 659, under the name *Tayassu tajacu.* Of course, some of the literature there cited refers to the living peccary.

Tayassu lenis was based by Leidy (Jour. Phila. Acad., 1869, Vol. VII, p. 384) principally on two teeth that had been found near Charleston, South Carolina, and which he had described and figured in 1860 (Holmes' Post-Pliocene Fossils of South

Carolina, p. 108, plate xvii, figs. 13, 14). One of these teeth is the second, the other, the third, lower molar. Inasmuch as it is not wholly certain that both teeth belonged even to the same species, it seems best to choose as the type of *T. lenis*, the third true molar. Judging from Leidy's figure, this has a length of 18 mm. and a width of 12 mm. This is slightly larger than the same tooth in the Texan species, *T. angulatum;* and some other differences seem to exist.

Other remains of a true peccary resembling some of those now living have been found in the lead region of Wisconsin, and in Iowa, Indiana, Illinois, and West Virginia. Whitney (Rep. Geol. Surv. Upper Mississippi Lead Region, 1862, p. 133) stated that he had obtained some teeth of a peccary, from a crevice near Dubuque. These were submitted to Dr. Jeffries Wyman, who judged them to belong to the existing peccary. They occurred with remains of megalonyx, imbedded in clay, at a depth of ten feet from the surface. Wyman states in his report (op. cit. p. 422) that he examined three teeth, but he did not say exactly where they had been found.

The scanty remains which are referred to this species have not been well described and are not at present accessible. In order that bones and teeth which may be found within the state may be identified properly, it is thought best to give here a description of the skull and teeth of the collared peccary, the animal which inhabits Texas and the region southward and westward. This description is taken from No. 52128 of the U. S. National Museum, a female taken at Fort Bowie, Arizona. However, figures of the skull and teeth of the same species are taken from Baird's Mammals of North America (pl. lxxxvi, figs. 1a, 1d, 1h, 1i).

The figures of the skull (Pl. XIX, figs. 1, 2) show that it resembles considerably that of a common hog, but it differs in several respects. Seen in profile the region between the eyes is convex, instead of being concave, as it is in the hog. It is also convex from side to side between the eyes; whereas, in the hog, it is flat. The front of the orbit is half-way between the rear of the skull and the infraorbital foramen; and the latter is over

the fourth premolar; in the hog the front of the orbit is much nearer the foramen. In the hog there is hardly any space between the canine teeth and the first premolar. In the peccary the first premolar is missing entirely and the second one is far away from the canine. In the hog there is a pair of very long processes in front of the occipital condyles; in the peccary, these are of very moderate size. The molars of the hog are far more tuberculated than are those of the peccary.

In the case of the skull from Arizona, mentioned above, the following measurements have been taken:

MEASUREMENTS OF SKULL.

Distance from front of premaxillae to front of occipital foramen (basilar length)	190 mm.
Distance from front of premaxillae to middle of occipital crest	229 mm.
Distance from front of occipital foramen to line joining the rear of last molars	68 mm.
Distance from front of occipital foramen to line joining rear of the glenoid fossae	30 mm.
Distance from front of premaxillae to front of orbit	126 mm.
Width of skull just above ear openings	86 mm.
Width of skull at front of glenoid fossae	95 mm.
Width of palate, between canine and pm.^{2}	30 mm.
Diastema between incisor and canine	17 mm.
Diastema between canine and pm.^{2}	15 mm.
Distance from front of lower jaw to line joining rear of condyles	152 mm.
Height of condyles above supporting surface	60 mm.
Height of coronoid process above supporting surface	67 mm.
Height of jaw below pm.$_4$	31 mm.
Length of diastema between canine and pm.$_2$	21 mm.

MEASUREMENTS OF TEETH.

Upper Teeth

Length premolar-molar series	64 mm.
Length premolar series	27 mm.
Length molar series	37 mm.
Pm.^{2}, length	9 mm.
width	8.5mm.
Pm.^{3}, length	9 mm.
width	10 mm.
Pm.^{4}, length	10 mm.
width	11 mm.
M.^{1}, length	12 mm.
width	11 mm.
M.^{2}, length	13 mm.
width	12 mm.

$M.^3$,	length	13.5mm.
	width	11 mm.
$I.^1$,	width	10 mm.
$I.^2$,	width	7 mm.
Canine,	height	28 mm.
Canine,	length at base	12 mm.
Canine,	thickness at base	8 mm.

Lower Teeth.

Length premolar-molar series		70 mm.
Length premolar series		28 mm.
Length molar series		42 mm.
$Pm._2$,	length	8 mm.
	width	4.5mm.
$Pm._3$,	length	9.5mm.
	width	6 mm.
$Pm._4$,	length	10.5mm.
	width	9 mm.
$M._1$,	length	12.5mm.
	width	10.5mm.
$M._2$,	length	13.5mm.
	width	12 mm.
$M._3$,	length	16 mm.
	width	11 mm.
$I._1$,	width	6 mm.
$I._2$,	width	6 mm.
$I._3$,	width	5 mm.
Canine,	height	32 mm.
Canine,	length at base	9.5mm.
Canine,	width at base	8 mm.

The first incisor of the upper jaw is a relatively large and thick tooth; the second incisor is much smaller. In the lower jaw the first and second incisors are narrow and prolonged forward; the third incisor is much reduced in size.

The upper canine has a sharp hinder border and a rounded front border, which is worn from whetting against the lower canine. This latter has the anterior border acute; the hinder, flattened and worn against the upper canine.

As will be seen from the figures (Pl. XIX, figs. 4, 5) the upper true molars have four principal cones. In the center of the space occupied by these is a subsidiary conule. One or two still smaller conules may be present. These teeth are surrounded by a narrow shelf, the cingulum.

The hinder premolar (Pl. XIX, figs. 2, 4, 5) has three principal cones and some conules. The next premolar in front, pm.^{3}, has two main cones and one or two strong conules behind them. The front premolar, pm.^{2}, is not much different, but is smaller.

In the lower jaw (Pl. XIX, figs 3, 6), as in the upper, the true molars have each four main cones. Behind each pair of these, and in the longitudinal valley, is a conule which varies in size. The hindermost molar has, in addition, a rather large "heel" at the rear, made up of two or three conules. The hindermost premolar resembles a true molar, but is smaller. The next premolar, pm.$_3$, has a pair of closely compressed cones; and, in front and behind these, conules of considerable size. The anterior premolar resembles the one behind it, except that it is smaller and there is only one cone.

It must be stated that the teeth represented by Baird's illustrations (Pl. XIX, figs. 2, 3, 4) are much more worn than those that belong to the specimen from Arizona (Pl. XIX, figs. 5, 6). It will be seen from the size of the hinder lower molar, that it is smaller than the one described by Leidy from South Carolina. Too much dependence should not be placed on this; for other teeth of the living species, especially of males, will show less difference. When fossil peccary teeth shall have been found which appear to belong to the genus Tayassu, they ought to be carefully compared with the teeth of authentic specimens of the collared peccary, *T. angulatum*.

Prof. J. D. Whitney, in the report referred to, stated that remains of a peccary had been found at Burlington; but whether these belonged to *Tayassu lenis*, or to *Platygonus compressus* or some other species, it is impossible to say.

Genus PLATYGONUS Le Conte.

Peccaries with moderately elongated snout; no premolars with more than one pair of cusps; molars with the four primary cusps strongly developed and confluent in pairs to form high cross-crests; the accessory cusps less developed than in Mylohyus and Tayassu; incisors, two on each side of the upper jaw, three on each side of the lower; all the feet with only two digits each.

The type of the genus is *P. compressus,* the species described below.

Platygonus compressus Le Conte.

This is, so far as yet known, the most widely distributed species of extinct peccary. Remains referred to it have been found in Illinois, Indiana, Ohio, Kentucky, New York, Missouri, Iowa, Kansas, and probably in Mexico. At Columbus, Ohio, a collection of twelve individuals was found, six smaller animals in one nest eight feet below the surface and six larger ones about six feet away from the first lot and at a depth of twelve feet. The individuals of each nest were lying side by side and with their snouts pointing, it is said, toward the southeast. These remains have never been adequately described. Most of them are now in the Peabody Museum of Yale University.

This species was described in 1848 by Dr. John L. LeConte. His materials had been found in the lead region, near Galena, Illinois, in a fissure in the limestone, at a depth of fifty feet. The materials consisted of teeth, parts of the upper jaw and front of the skull, a part of a lower jaw, a few vertebræ, part of a pelvis, and some limb bones. To these he gave the name *Platygonus compressus,* and he appears to have regarded the animal more closely related to the tapirs than to the peccaries.

Other teeth and scanty bones he described under the names *Hyops depressifrons* and *Protochœrus prismaticus;* but these were afterwards shown by Leidy to be the same as *Platygonus compressus.*

In 1853 (Trans. Amer. Philos. Soc., Vol. X, pp. 330-341, pls. xxxvi, xxxvii), Leidy described, under the name of *Euchœrus macrops,* a nearly complete skull of a fossil peccary that many years before had been found in a saltpeter cave in central Kentucky. He afterwards concluded that this specimen also belonged to *Platygonus compressus.*

The beautiful figures furnished by Leidy are here reproduced (Pl. XX, figs. 1-3). They show better than any descriptions the form of the skull and of its various parts.

The following measurements of this skull are taken from Leidy's description, his inches and lines being reduced to milli-

meters. Some other measurements are introduced, taken from Leidy's illustrations:

MEASUREMENTS OF SKULL AND TEETH.

Distance from front of occipital foramen to end of premaxillae (basilar length)	286 mm.
Length of head from occipital condyle to end of the snout	296 mm.
Length of frontal bone on midline	53 mm.
Greatest breadth of the forehead	112 mm.
Breadth at front of glenoid fossae	114 mm.
Breadth at second upper molar	51 mm.
Breadth at sockets for canines	60 mm.
Height from between fronts of orbits to palate	87 mm.
Height of rear of skull from occipital foramen	89 mm.
Length of hard palate	197 mm.
Length of upper premolar-molar series	77 mm.
Length space from canines to premolar	46 mm.
Lower jaw from condyle to front	225 mm.
Height of lower jaw at first true molar	37 mm.
Length of symphysis of lower jaw	72 mm.
Length of lower premolar-molar series	84 mm.
Upper premolar 2, length	8.5mm.
Upper premolar 2, breadth	9 mm.
Upper premolar 3, length	10 mm.
Upper premolar 3, breadth	10.3mm.
Upper premolar 4, length	10 mm.
Upper premolar 4, breadth	11 mm.
Upper molar 1, length	13.5mm.
Upper molar 1, breadth	10.5mm.
Upper molar 2, length	16 mm.
Upper molar 2, breadth	14 mm.
Upper molar 3, length	19.5mm.
Upper molar 3, breadth	14 mm.
Lower premolar 2, length	8.5mm.
Lower premolar 2, breadth	7.5mm.
Lower premolar 3, length	10 mm.
Lower premolar 3, breadth	8 mm.
Lower premolar 4, length	11 mm.
Lower premolar 4, breadth	10.5mm.
Lower molar 1, length	14.5mm.
Lower molar 1, breadth	10 mm.
Lower molar 2, length	16 mm.
Lower molar 2, breadth	11 mm.
Lower molar 3, length	20 mm.
Lower molar 3, breadth	12 mm.

Leidy's figures of the teeth of this specimen are here reproduced (Pl. XXI, figs. 3-6). On the left are those of the right upper jaw, presenting their grinding surfaces and a view of the outer faces. On the right are the lower teeth, showing the grinding surfaces and a view of the outer faces. It will be observed that each of the true molars is crossed by two prominent ridges or crests, and that a longitudinal cleft divides each of these into two cones. These crests and cones are much more

prominent than in the living peccaries. Likewise, the transverse valley separating the two crests of each tooth is less obstructed by tubercles than in either Tayassu or Mylohyus.

The hinder upper molar has a considerable projection, heel, or talon, at the rear, and this is composed of tubercles. From the inner cone of each crest, both in front and behind, there descends a buttress to the middle of the width of the tooth. At the base of the cones, especially on the outer border of the tooth and at its anterior end, there is a tuberculated shelf, or cingulum. The two other molars are without the talon, but they have a well developed cingulum and some tubercles in the valley between the two crests.

The premolars have only one cross-crest. They possess each a well defined cingulum and buttresses descending from the main cones.

The lower teeth resemble, in general, the upper ones, but they are narrower. The molars are crossed each by two crests, the premolars by only one each. In the figures of the lower teeth (Pl. XXI, figs. 5, 6) the hinder premolar was accidentally reversed, so that the high cones appear to be placed on the front of the tooth, instead of the rear. The hinder molar has a considerable talon, and the hinder cingulum of the other molars and of the hinder premolar, resembles a talon. The lateral view of the upper and lower teeth illustrates the height of the cones before they have suffered any wear. Later in life these teeth would present a quite different aspect.

Some years ago two well preserved adult specimens of this species were found in a gravel bank, near Rochester, New York. Most of these remains are now in the Philadelphia Academy of Sciences. Leidy (Trans. Wagner Institute, Vol. II, p. 41) described them and figured a complete skull. Many comparative measurements will be found in his paper.

Undoubtedly this species lived with a fauna which took possession of our northern states soon after the withdrawal of the last, or Wisconsin, ice-sheet. The remains, which have been found in Wabash county, Indiana, at Columbus, Ohio, in Kent county, Michigan, and at Rochester, New York, are all within the region occupied by the Wisconsin drift, and there is little proba-

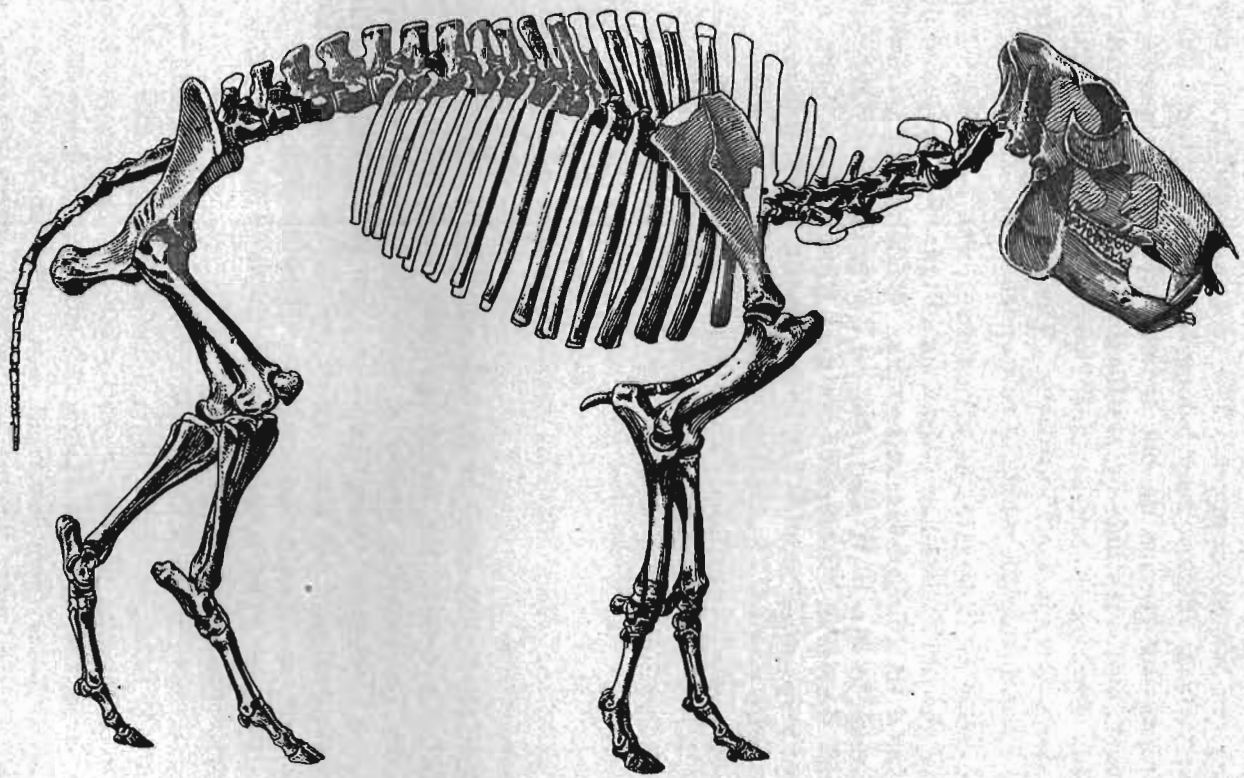

Fig. 81. *Platygonus leptorhinus.* Skeleton of specimen in American Museum Natural History. Found in Kansas.

bility that any of these remains were in deposits laid down preceding the Wisconsin epoch. The remains found in the region about Galena, Illinois, may belong to an earlier time; but the accompanying species do not indicate this. The species has, however, been identified by Matthew among materials collected at Hay Springs, Nebraska, and these deposits were certainly laid down early in the Pleistocene. The species may, therefore, have lived during the whole of this epoch.

In order to illustrate the structure of the peccaries of this genus, the writer has had a drawing (Figure 84) prepared of a specimen of *Platygonus leptorhinus* Williston. The drawing was made by Mr. R. Weber, from a photograph kindly furnished by the American Museum of Natural History, New York, and shows a specimen mounted in that museum. This fine skeleton is one of a number of individuals that were found together near Goodland, Sherman county, Kansas, and which were afterwards described by Williston. It will be observed that the animal has longer legs than the hog has. It seems to have had a height, at the shoulders, of somewhat more than two feet six inches (750 mm.). Comparison of this specimen with other materials has convinced the writer that *Platygonus leptorhinus* is the same as *P. compressus*.

Through the liberality of the officers of the Peabody Museum of Yale University, the writer has been permitted to study the remains representing nearly a dozen individuals which were found at Columbus, Ohio, about the year 1874. Unfortunately the skeletons were not taken up by persons experienced in such work; and, as a result, the bones of different skeletons are mingled together. The writer proposes to describe and illustrate the principal bones of the skeleton.

Figure 1, of plate XXII, gives a view of the atlas seen from below. It belonged to a fully grown individual. The extreme width is 95 mm. Figure 2 of the same plate presents a side view of all the cervicals except the atlas; while figure 3 shows the same bones from the right side. The length of these six vertebræ is 160 mm. They resemble considerably the same vertebræ in the hog. Figure 4 presents a side view of three dorsal vertebræ belonging about the middle of the series. The bodies

of the dorsals vary in length from about 25 mm. to about 35 mm. Those shown here belonged to an animal not wholly grown.

Figure 1 of plate XXIII presents a view of the sacrum. In front of it is the last lumbar vertebra; while on the right side of the figure is seen a part of the left ilium.

The scapula, as may be observed in figure 84, is rather long and narrow. The length of the bone in a grown animal is about 225 mm.; the breadth at the upper end from 90 to somewhat more than 100 mm. The bone resembles that of the domestic hog, but in the latter animal, it is relatively broader, and the spine ascends nearer the anterior border.

The humerus (Pl. XXIII, figs. 3, 4) resembles considerably that of the pig. In the skeleton shown here by figure 84 the bone has a total length of 197 mm.; from the top of the head to the extremity of the outer condyle, 180 mm. At the middle of the shaft, the fore-and-aft diameter is 32 mm.; the transverse, 21 mm. Four or five humeri at Yale have each a total length of 200 mm. In one measured, the length from the upper surface of the head to the outer condyle, is 174 mm.; while the diameters at the middle of the shaft are respectively 28 mm. and 19 mm.; thus showing variation from the Kansas specimen. The radius and the ulna (Pl. XXIII, fig. 5) are closely bound together and appear in adult life to be coössified. They are in this condition in the Kansas specimen at New York; but, in the younger ones at Yale (Pl. XXIV, fig. 1), the union was not yet effected. The total length of the radius in the Kansas specimen is 172 mm.; in one at Yale, the length is only 158 mm. Figure 5, plate XXIII, shows a mature left ulno-radius at Yale, seen from in front. The ulna is a rather strongly bent bone as may be seen from plate XXIV, figure 1. The length of the bone shown on plate XXIII, is 193 mm. in a straight line; but in another specimen it measures 219 mm. In the latter the olecranon process extends 63 mm. behind the cavity for articulation with the humerus.

The wrist bones are the same that are found in the pig. In the figure of that of a left fore limb (Pl. XXIV, fig. 2), these bones are seen little disturbed.

The same figure shows well the metacarpals. The third and fourth only are functional. In the domestic hog there are four functional metacarpals, although the second and fifth are smaller than the third and fourth. The second metacarpal in Platygonus is a splint about 40 mm. long (Pl. XXIV, figs. 1, 3), while the fifth is a nodule of bone about 11 mm. long. The third and fourth metacarpals are each about 90 mm. long. In adult age they become solidly cöossified. They are so coössified in the specimen from Kansas, but not yet so in those from Columbus, Ohio. The metacarpals are followed by three pairs of phalanges, the last pair of which were armed with hoofs. In figure 2 of plate XXIV the usual phalanges are missing; but, in figure 1 one of these is present. The first phalanges are 40 mm. long; the second, 30 mm.; the unguals, 32 mm.

The innominate bones are not complete in any of the specimens seen; but, from the various remains, their form may be quite exactly determined. It appears that in the specimen shown in figure 84 the ilium has been artificially restored in front and made about an inch too long. From the specimen seen at Yale, it is determined that the length from the front of the ilium to the rear of the ischium measured close to 225 mm. Figure 2, plate XXIII, presents a view of the hinder portion of the left innominate bone, seen from the under side. The upper right border of the bone fits on the piece of ilium seen on the right side of figure 1 of the same plate. The center of the acetabulum was nearly equidistant from the front of the ilium and the rear of the ischium. In the existing peccary this center is considerably nearer the rear of the ischium than to the front of the ilium; and this is still more the case with the pig.

The femur is shown by figure 1 of plate XXV, taken from a bone at Yale. It is a view of the inner face of the left femur of a mature specimen. It resembles closely that of a peccary and that of a pig. It measures in total length, 188 mm.; that of the specimen of figure 82 measures 205 mm.

The tibia of the left side is represented by figure 2 of plate XXV, which shows the outer face of the bone. Near the upper end is a surface to which was attached the upper end of the fibula, and at the lower end a rough surface for the lower end

of the fibula. A tibia at Yale (not the one figured) has a length of 182 mm.; a fore-and-aft diameter of 19.5 mm. at the middle of the bone, and a side-to-side diameter of 25 mm. The tibia of the Kansas specimen is slightly larger. The fibula is a slender bone which was applied to the tibia as just mentioned. Its lower end reached below the end of the tibia and articulated with a surface on the outer side and front of the heel bone.

The hind foot is represented by figure 3 of plate XXV, but not all these bones belonged to the same individual. The length of this foot, from the extremity of the heel bone to the extremity of the last phalange, measured close to 280 mm. The figure just cited gives a front view of the foot and no rear view is shown; but here as in the fore foot, the second and the fifth metapodials are reduced to mere vestiges. The second and the third metatarsals are closely united at their upper ends.

Of this species we have only one record in Iowa and that gives no more exact locality. In 1860 Dr. Leidy (Trans. Amer. Philos. Soc., Vol. XI, p. 105, pl. vi, figs. 2, 3) mentioned and illustrated the upper and lower cheek-teeth of a specimen of this species which he stated had been found in Iowa by Doctor Foster. The remains included besides the teeth, the jaws which contained them and fragmentary bones of several individuals. These were in the possession of Dr. Jeffries Wyman. It is not unlikely that these remains had been found in the lead region, but they are possibly the peccary remains which Whitney mentioned as having been found at Burlington (Geol. Lead Region, p. 135). Leidy's figures of the teeth are shown here on plate XXI, figures 7, 8.

Genus MYLOHYUS Cope.

Peccaries with narrow and elongated snout. Molars resembling in structure those of Tayassu; two, probably sometimes all three, premolars molariform; that is, provided each with two pairs of cones; outer pair of incisors wanting, both above and below; space between the canines and premolars about as long as, or longer than, the tooth-row. Fore feet with second and fifth digits present with all their elements, but greatly reduced; hinder feet apparently lacking the second and fifth digits.

The type of this genus is *Mylohyus nasutus,* a species which was based on a part of the upper jaw with one incisor, one canine, and two premolars. This snout was found in Gibson county, Indiana, at a depth of between 30 and 40 feet. To what stage of the Pleistocene it belonged is unknown. Cope described as belonging to *M. nasutus* an upper canine from Port Kennedy cave, in eastern Pennsylvania, the contents of which seem to belong to very early Pleistocene. Mr. Barnum Brown found many remains of more than one undetermined species of Mylohyus in the Conard fissure, in northwestern Arkansas. The present writer is inclined to regard these remains as dating from the Illinoian stage. On the other hand, Leidy found *Mylohyus pennsylvanicus* in a cave in Pennsylvania which contained mostly existing species, and belonging evidently to the post-Wisconsin stage. It seems, therefore, that the genus existed during the whole of the Pleistocene.

So far as the writer is aware no remains of *Mylohyus nasutus* have been discovered in Iowa; nevertheless, in order to illustrate the osteology of the genus, Leidy's figures of the type specimen are here reproduced (Pl. XXVI, figs. 1, 2); also the figures of a lower jaw of an undetermined species of Mylohyus and those of the feet of one or two species of the same genus, all having been found by Mr. Barnum Brown in northwestern Arkansas. These feet were not found in such association with any jaw that they can be regarded as certainly belonging to Mylohyus; although it is extremely probable that they do appertain to some species of the genus.

The writer has been permitted through the kindness of Prof. W. C. Mills, of Columbus, Ohio, to examine the lower jaw of a young peccary which is believed to belong to this species and which was found in Columbiana county, Ohio (Pl. XXV, figs. 4-6). The jaw lacks the greater part of the symphysis and the whole of the ascending portion. It contains the three milk molars, little worn, and the first molar, yet enclosed in the bone. These teeth are all much larger than the corresponding ones of a young Texas peccary; and they are, besides, more complicated in structure and have the enamel more strongly rugose. The milk molars have each three cross-crests, and these are each

composed of two cones. There are in addition various accessory tubercles. The following are the measurements of these teeth. The milk molars are designated by the abbreviation Dm.:

MEASUREMENTS.

Dm.$_2$,	length	9 mm.
	width	5 mm.
Dm.$_3$,	length	12 mm.
	width	8 mm.
Dm.$_4$,	length	19.5mm.
	width	11 mm.
M.$_1$,	length	16.5mm.
	width	12 mm.

In the front of the jaw is the base of the socket for the canine. The rear of the symphysis is situated about 22 mm. in front of the anterior milk molar. The alveolar border of the jaw in front of the front milk-molar is thin, sharp and straight. At the front of the hinder milk molar the jaw is 22 mm. deep.

Those characters which especially distinguish Mylohyus from Tayassu, are the elongation of the upper and lower jaws in front of the premolars and the occurrence of two pairs of cones on at least the two hinder premolars. The fore foot (Pl. XXVI, fig. 5) referred to Mylohyus resembles closely that of the existing peccaries (Tayassu); but, judging from the figure, the hind foot (Pl. XXVII, fig. 1) is very different. It gives no indication of the presence of the second digit, which in Tayassu has a hoof, nor of the fifth, which in Tayassu is represented by a splint.

To Mylohyus is referred provisionally the species next to be described represented by a lower canine only.

Mylohyus? temerarius, new species.

The only remains known at present of this species is the crown of the left lower canine. This was found in the Anderson gravel pit, at North Riverside, near Sioux City, Iowa, and was secured for the Iowa University collection by Prof. B. Shimek. It bears the catalog number 176. Reproductions of photographs of it are here presented (Pl. XXI, figs 1-2). The tooth appears

to have been broken off where it emerged from the jaw. The height of the tooth is 61 mm.; the antero-posterior diameter at the base is 21.5 mm.; the transverse diameter is 15 mm. The anterior border is broadly rounded, presenting no such indications of a keel as is found in the other peccaries. The hinder border, as shown at the base, is broader and more flattened, with a median ascending channel. The inner face is broadly convex, with a median broad and shallow ascending groove. The outer face is more convex than the inner and presents two shallow ascending grooves, which divide the face into three nearly equal parts.

The upper two-thirds of the hinder border of the crown is worn flat through attrition against the upper canine. Also the outer face and front border are whetted off a distance of 20 mm. from the summit of the crown, probably from rubbing against exterior objects, shrubs, roots, and the like.

Cope gave as the dimensions of an upper canine found in the Port Kennedy cave, taken at the base of the tooth, 11 mm. and 9 mm. respectively. The tooth here described has therefore diameters nearly twice as great.

Superfamily CAMELOIDEA.

The Camels, Llamas, and Their Extinct Allies.

Even-toed ungulates with usually only two functional digits in each of the four feet; teeth sometimes in full number, viz.: $\cdot\frac{3}{3}$ c. $\frac{1}{1}$ pm. $\frac{4}{4}$ m. $\frac{3}{3}$, but the later forms with some upper incisors and the first premolar wanting; the true molars of the selenodont type; that is, with the four primitive cusps converted into crescents; the horns of which are directed outward in the upper jaw, inward in the lower. Skull without horns.

In the group just defined there are included not only the existing family of camels, but likewise a number of subfamilies or families which are now extinct. Dr. W. B. Scott has suggested that the oreodonts (Merycoidodon) and related genera known only from North America were primitive members of the same group. Inasmuch as none of these early genera are known from the Pleistocene or are likely to be found in it, we need not consider them further. Only the Camelidæ concern us.

Family Camelidae.

The Camels and Llamas.

The definition of this family will differ but little from that of the superfamily as above given. Those genera that are excluded would be such as the oreodonts and agriocheres, about whose relations to the camels there are as yet differences of opinion.

In the Camelidæ the skull (Pl. XXVII, fig. 2) is short or rather elongated; the rear is broad, the muzzle contracted; the outer upper incisor is present in probably all the genera; likewise, in some genera, the first and second incisors. The canine is usually removed some distance from the incisors and from the premolars. The cervical vertebræ are peculiar in that the vertebrarterial canal pierces the anterior part of the pedicle of the neural arch, instead of the base of the transverse process. The ulna and radius are more or less completely consolidated. The elements of the carpus and tarsus are, for the most part, free from one another. In the more primitive genera there may be four digits; but in most the third and the fourth digits are alone represented; and in these digits the metacarpals and metatarsals are more or less closely united in the upper half or more. In all cases, however, the lower ends are separated for some distance. The articular ends of the phalanges are without guide-ridges and the corresponding grooves, such as are found in most ruminants.

The Camelidæ are represented today by two species of camels, the single-humped Arabian camel of Asia and Africa, and the two-humped Bactrian camel of Asia, and by the llamas, alpacas, etc., of the Andean region of South America.

North America seems to have been the continent in which the camels took their origin, being here traced back into the Middle Eocene. From this continent, they probably crossed by some land bridge into Asia; and having spread over that continent they passed thence into northern Africa. From North America members of the family made their way into South America, arriving there apparently about the beginning of the Pliocene. None of the family, so far as is known, ever reached Europe. In South America, in Asia and Africa, they have maintained

their existence up to the present time. In North America the race seems to have become extinct in the early Pleistocene. Several species have been described from the Equus beds of the region west of Mississippi river, but too often these species have been based on imperfect materials.

In the Smithsonian Miscellaneous Collections, Vol. LX, 1913, p. 1, Mr. J. W. Gidley reported a phalange of a camel which was found during the summer of 1912 on Old Crow river, near the Yukon-Alaska boundary, and thus north of the Arctic Circle. Along the same river have been found remains of the hairy mammoth, an extinct horse, and remains of an extinct bison.

Subfamily CAMELINAE.

Camels with the dentition more or less reduced, the formula being i.$\frac{1}{3}$, c.$\frac{1}{1}$, pm.$\frac{1-3}{1-2}$, m.$\frac{3}{3}$. Ulna and radius consolidated; the fibula represented by only a small bone entering into the tarsus; the two metacarpals of each foot united to near the distal end; metatarsals similarly united.

Genus CAMELOPS Leidy.

Large camels having the tooth formula as in the llamas (Auchenia), viz.: i.$\frac{1}{3}$, c.$\frac{1}{1}$, pm.$\frac{2}{1-2}$, m.$\frac{3}{3}$; m.$_2$ and m.$_3$ with anterior outer style absent or feebly developed; m.^{3} with or without a talon; upper molars with antero-posterior diameter much greater than the transverse. Skull relatively more elongated than in the llamas. Nasals not expanded posteriorly.

The writer follows here J. L. Wortman (Bull. Amer. Mus. Nat. Hist., Vol. X, p. 129) in regarding Leidy's genus Megalomeryx and Cope's genus Holomeniscus as being probably the same as Camelops, proposed by Leidy in 1854. Cragin (Amer. Geologist, Vol. IX, p. 257) showed that the tooth formula of a Pleistocene camel skull, found by Prof. R. C. Hills, in Huerfano county, Colorado, and belonging to the same genus as Leidy's *Auchenia californica* and *A. hesterna,* and Cope's *Holomeniscus vitakerianus* and *H. macrocephalus,* possessed the same tooth-formula as do the llamas. He therefore described the specimen as *Auchenia huerfanensis.* Wortman, however, put all the spe-

cies just mentioned into one genus and retained for this Leidy's name Camelops. He distinguished this from Auchenia on the ground that in the last and the next to the last lower molars of Auchenia there is a very prominent buttress, amounting almost to a lamina, developed at the outer anterior angle of the tooth. This, in the extinct camels mentioned above, is wanting or very inconspicuous. It is evident also that the upper third premolar was a tooth far less reduced than that in the llamas. In the latter the grinding faces of the upper molars are nearly square; in the species of Camelops, they are much elongated anteroposteriorly. This is an indication that in Camelops the skull was much more elongated than it is in the llamas. Complete skulls, belonging to the species *Camelops hesternus,* which have lately been found in California and described by Dr. John C. Merriam, confirm the conclusion that the skulls of Camelops were relatively longer than those of llamas. In the llamas the nasal bones are much expanded at the hinder ends; in Camelops, they are not expanded.

Considering these differences it seems best for the present to retain these extinct camels in a genus distinct from Auchenia; and at present it seems very probable that the type species of that genus is *Camelops kansanus,* the first true camel that was described from North America. It was based on meager materials, but it seems possible to connect it generically, at least, with recently discovered remains.

Camelops kansanus Leidy.

Certain camel remains which have been discovered in the Aftonian deposits of Iowa, are here referred provisionally to *Camelops kansanus.* The principal reason for regarding them as belonging to the species just named, rather than to *C. huerfanensis,* is that the former was found in Kansas, the latter in Huerfano county, Colorado, a locality considerably more distant. The remains found in Iowa do not, in fact, enable us to say positively to what species they belonged.

Camelops kansanus was described by Leidy in 1854 (Proc. Acad. Nat. Sci., Phila., p. 172). It was based on a fragment of the snout and consisted of the front end of the left premaxilla,

containing the root and base of the crown of the third incisor, together with an attached piece of the maxilla, which presented a part of the socket for the canine. These parts were further described in 1856 (Jour. Acad. Nat. Sci., Phila., Vol. III, p. 166, pl. xvii, figs. 8-10). One of these figures is here reproduced (Pl. XXVII, fig. 3). In 1873 Leidy (Cont. Ext. Fauna, West Terrs., p. 225, pl. xxxvii, figs. 1-3) described and figured, under the name of *Auchenia hesterna,* some lower teeth which had been found in California. One of these figures is here reproduced on a smaller scale (Pl. XXVII, fig. 4). In 1883 (4th Ann. Rep. Geol. Surv. Texas, pl. xxi, figs. 3, 4) Cope described and figured a part of a lower jaw which presented the incisors, premolars and molars, and these he called *Holomeniscus hesternus,* believing that it was the same camel as that described by Leidy from California. Cope's figures are here shown, one-fourth of the natural size of the bones (Pl. XXVIII, figs. 4, 5). In the same publication Cope described another species which he called *Holomeniscus sulcatus.* His figures are here shown, reduced to one-fourth the natural size of the objects, on plate XXVIII, figures 2, 3. In 1892 Cragin, as cited, described his *Auchenia huerfanensis,* without illustration. In 1898 Wortman, as cited, united under Leidy's earliest name, *Camelops kansanus,* the Kansan species just named, Leidy's *Megalomeryx niobrarensis* (based on teeth found in Nebraska), Leidy's *Auchenia hesterna,* Cope's *Holomeniscus hesternus* and *H. sulcatus,* and Cragin's *Auchenia huerfanensis.* It appears, however, that recent discoveries do not wholly justify this procedure.

Dr. John C. Merriam has recently discovered, in certain asphalt deposits near Los Angeles, California, a few complete skulls and nearly all parts of the skeleton of a camel which he regards as being identical with that called by Leidy *Auchenia hesterna.* To the present writer, as to Merriam, the species seems to be clearly distinct from *Camelops kansanus,* although it probably belonged to the genus Camelops. Inasmuch as Merriam's figures give a clear idea of the form and structure of the skull of the camels of this genus, they are here reproduced (Figs. 85-88). These skulls belonged to large camels, that represented by figures 86-88 having a length of 573 mm. from the

front of the snout to the rear of the occipital condyles. A skull of the Bactrian camel in the U. S. National Museum has a length of 485 mm. It is estimated that the length of the skull of the camel described by Cragin was 625 mm. The width of the skull of the California specimen, taken at the rear of the orbits, is equal to 251 mm. This width, in the case of the Bactrian camel, is 245 mm. Calculations show that the width in the case of the fossil forms forty-four per cent of the length, while in both the Bactrian camel and the llama the width forms fifty per cent of the length.

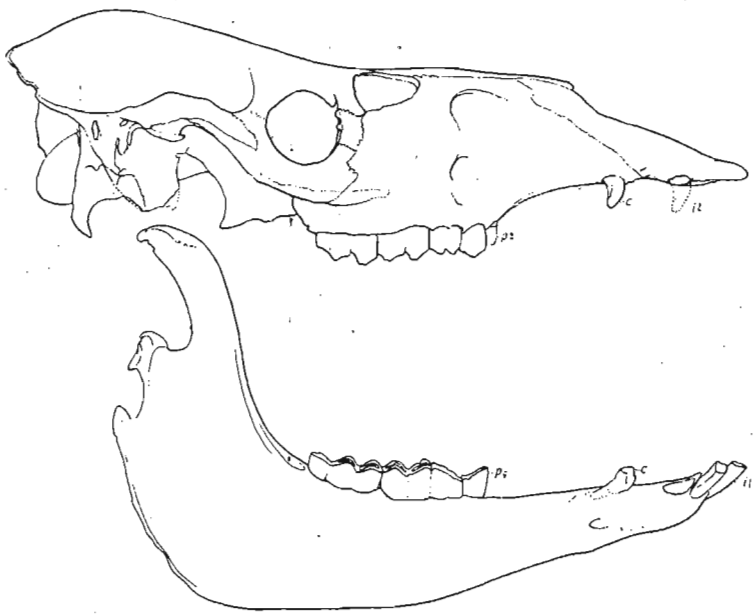

Fig. 85. *Camelops hesternus?* X 1/6. From Merriam. Side view of skull and lower jaw.

A comparison of the illustration showing a side view of the skull of the California specimen (Fig. 85) with Leidy's figure of Camelops, indicates that in the latter the alveolar border of the jaw in front of the socket for the canine was much more sigmoid than in Merriam's specimen. Likewise in Leidy's specimen (Pl. XXVII, fig. 3) the premaxilla continued to widen as far back as it was preserved; while in the California skull, as figured, the premaxilla begins to narrow at the suture with the maxilla. The skulls described by Merriam show that the orbits

were not as large relatively as in the llama, and that they were placed farther backward; the nasal bones were not expanded at the hinder ends; the facial vacuity did not come into contact, or hardly so, with the lachrymal bone; and there was a deep depression on the upper border of the maxilla.

The writer has studied the type of Cragin's Huerfano camel, now in the U. S. National Museum. Fortunately, with the re-

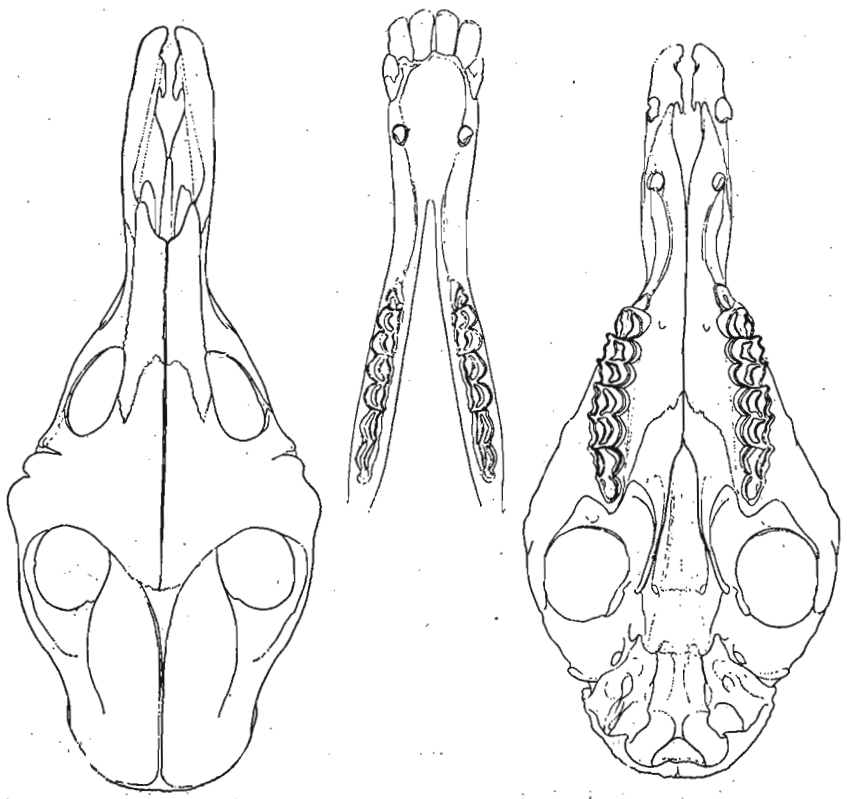

Fig. 86 Fig. 88 Fig. 87

Figs. 86-88. *Camelops hesternus.* Views of skull and lower jaw. X 1/16. From J. C. Merriam.

86. Skull viewed from above.
87. Skull viewed from below.
88. Front of upper jaw viewed from above.

mains there is present the left premaxilla, which permits comparison with Leidy's type of *Camelops kansanus.* However, the part in front of the exit of the third incisor is missing. The canine came out much closer behind the incisor, than it did in

Camelops kansanus. It appears, therefore, that Cragin's camel did not belong to *Camelops kansanus*. Whether or not it is the same as Leidy's *Megalomeryx niobrarensis* must be left for decision to future discoveries.

Inasmuch as the type specimen of *Camelops huerfanensis* presents some important parts of the skull, these will be described with some care and figures will be presented. Considerable parts of the brain-case are present, but they are badly broken up. The rear of the skull is partly preserved, showing a part of the sagittal crest and the lamddoidal crest. Figure 1 of plate XXIX shows this part as seen from behind. Most of the right side of it is missing. On each side of the median ridge is seen a deep pit for the insertion of a muscle. Farther out is a larger pit, in the bottom of which is an opening into the cavities of the bone. The piece does not extend down quite to the foramen magnum. A fragment of the maxilla shows that there was present, as in *C. hesternus*, a deep depression above the infraorbital foramen. The left premaxilla is represented on plate XXIX by figures 2-4. Figure 2 shows the bone from the outside; figure 3 from the inside; while figure 4 presents a view of the edge which was in contact with the maxilla. The size of the third incisor may be judged from that of its socket. This has a depth of more than 40 mm. and a fore-and-aft diameter of 20 mm. On the lower edge of the bone (Pl. XXIX, fig. 4*c*), is seen the smooth surface which formed a part of the front wall of the socket of the canine. This must have been a tooth of considerable size and its front border could have been hardly more than 23 mm. from the incisor.

Plate XXX, figure 1, gives a view of most of the palate of this camel. The fourth premolar and the three molars are preserved on the right side; while on the left there remain only the roots of the third and fourth premolars and of the first and second molars. The following are the measurements of these teeth. The height is the elevation of the crown above the roots; the length is taken along the middle of the grinding face; the width is taken near the base of the tooth, at the widest part. It is to be noted that, usually, as the teeth become worn down nearer to the base, the length of the grinding face decreases. However,

the grinding face of the last molar would increase in length until at about one-third of its present height it would have reached a length of 55 mm.

MEASUREMENTS OF TEETH.

Length of the premolar-molar series, pm.^{3}—m.^{3}, inclusive	175	mm.
Length of the molar series	130	mm.
Pm.^{4}, height	37	mm.
length	25	mm.
width	25	mm.
M.^{1}, height	33	mm.
length	38	mm.
width	29	mm.
M.^{2}, height	57	mm.
length	48	mm.
width	30	mm.
M.^{3}, height	62	mm.
length	46	mm.
width	28	mm.

The third premolar had two roots, an anterior and a posterior. At its base the crown was at least 19 mm. long and 10 mm. wide.

As will be seen from the figure of these upper teeth, all the true molars have prominent anterior and median outer styles. The free edges of these are directed more strongly forward than in the teeth of some llama skulls at hand. The hinder molar has a well developed talon, or third lobe. At the base of the tooth this talon is 13 mm. wide and projects backward from the second lobe a distance of nearly 10 mm. It becomes much reduced as it approaches the summit of the tooth. A broad valley ascends between the second and third lobes on the inner face of the tooth. No such talon is seen in the last molar of the llamas. It seems probable that it is not always present in the fossil species here described.

In the skull from the Huerfano basin the anterior palatine foramina open out opposite the first molar of each side; while in *Camelops hesternus* they are placed opposite the fourth premolars. With the material in hand it is impossible to determine how far the third premolar was removed from the front of the premaxilla. In *Camelops hesternus* this distance is about 200 mm.

The greater part of the symphysis of the lower jaw is missing in the Huerfano camel. Some materials from Minidoka, Idaho, now in the National Museum, present two symphyses, together with the incisors and the canines. From the difference in the sizes of the canines of the two specimens present, it is supposed that one (No. 5315, U. S. Nat. Mus.) belonged to a female, the other (No. 2579) to a male. The former is used for illustration (Pl. XXX, fig. 2). In this jaw the width at the base of the third incisors is 58 mm.; at the symphysis, 50 mm.; the length of the symphysis taken on the upper side, 102 mm. The incisors are not greatly worn, those of the outer pair being only slightly abraded. All these incisors have the usual elongated spatulate form. It is observed that those of the first and the second pairs are less strongly curved than in the llama. The outer one has a length, from root to tip, of 60 mm. The others are apparently still longer. The following are the diameters of these teeth, the width being taken where greatest; that is, toward the free end; the thickness about the middle of the length, where greatest.

$I._1$,	width------	17 mm.	thickness ----	12 mm.
$I._2$,	width------	19 mm.	thickness ----	10 mm.
$I._3$,	width------	14 mm.	thickness ----	8.5mm.

The incisor teeth of the other specimen, the supposed male, are still thicker than those measured above. Figures 4 and 3 of plate XXX show, of the natural size, the second and third incisors of the right side of a camel found near Greeley, Colorado (No. 870, U. S. National Museum). It is not certain to what species it belonged.

The canine of No. 5315 (Pl. XXX, fig. 2) is a small tooth which is placed about 15 mm. behind the outer incisor. Its total length, from apex to root, is 35 mm. The greater diameter of the crown is 8 mm.; the thickness, 6 mm. It is smooth and convex on the outer face; on the inner face there is a groove parallel with the front border and another parallel with the hinder edge; and these cause the front and hinder edges of the tooth to be very thin and sharp, like the blade of a hollow-ground razor. The canine of No. 2579 is a much more powerful tooth, the antero-posterior diameter at the base being 17 mm.; the transverse, 10 mm.

The left mandible of the specimen described by Cragin lacks, as already said, most of the symphysis, there remaining only about an inch of the hinder end of it. It is estimated that the distance from the front of the jaw to the rear of the symphysis was close to 125 mm. If this is correct, the length of the jaw in a straight line, from the incisive border to the rear of the condyle was about 520 mm. At the hinder end of the symphysis the depth of the jaw is 48 mm.; at the front of the last premolar, 58 mm. The left mandible shows that the depth at the front of the last molar is 82 mm.; at the rear of this tooth, 110 mm. At the fractured end of the right mandible there is seen a little of the hinder border of the socket for the canine. This shows that this tooth emerged at a distance of about 90 mm. in front of the fourth premolar. The left mandible shows only the hinder root of this premolar; but this tooth, as well as the first molar, is complete on the right side. By using both sides we may obtain the measurements of these teeth.

MEASUREMENTS OF THE LOWER TEETH.

Length of the premolar-molar series	168	mm.
Length of the molar series	141	mm.
$Pm._4$, height	32	mm.
length	27	mm.
width	15	mm.
$M._1$, height	35	mm.
length	35	mm.
width	22	mm.
$M._2$, height	55	mm.
length	46	mm.
width	24	mm.
$M._3$, height	--	
length	62	mm.
width	23	mm.

It may be noted here that the right mandible of the specimen in the U. S. National Museum, No. 5315, from Minidoka, Idaho, has present a small $pm._3$ (Pl. XXX, fig. 5). Only the base of the crown is seen. This is about 7 mm. in diameter and nearly circular in section. In the front of the next tooth there is a groove which seems to have lodged the crown of this slender tooth.

Some of the ways in which these teeth differ from those of the llamas (Auchenia) have already been mentioned. The grinding face of the fourth premolar forms nearly an isoceles triangle, instead of being trilobate. On the outer anterior angle of the last two molars of Auchenia is a strongly developed style, which is wanting in Camelops. In Auchenia the outer valley between the two lobes is much deeper than in Camelops.

At hand is Leidy's type of his *Megalomeryx niobrarensis,* a much worn $m._2$, of the left side. It seems to present no differences when compared with Cragin's specimen. With it is the other tooth which Leidy described and figured, a very little worn $m._2$, of the left side. It seems to be identical with the Cragin specimen; but, if we had the whole skull, differences might be found.

It is further to be said that the teeth $pm._4$ and $m._3$, found in Iowa and shown by figure 5, plate XXVII; figure 1, plate XXVIII; and figure 7, plate LXXIV, present no differences that can be regarded as specific when compared with the specimen above described from the Huerfano basin. At present there appears to be no reason for supposing that the Idaho specimen does not belong to the same species as that from the Huerfano basin. The individuals represented were, however, both somewhat smaller than the one just mentioned. Two lower right fourth premolars are present, one in the jaw of No. 5315 (Pl. XXX, fig. 5). These are slightly smaller than the corresponding tooth of the Huerfano specimen, and one of them has the anterior portion turned somewhat inward. The first molar has the grinding face short, but this is because it is worn down to near the roots. Two lower right last molars present differ from the same tooth of the Huerfano specimen in being slightly shorter, fore and aft, and in being somewhat thinner than this shortness might indicate. One of them, probably belonging to No. 2579, is interesting in that the inner valley between the first and the second lobes is, in the upper half of the tooth, very shallow. It was especially on the presence of this inner valley that Cope based his *Holomeniscus sulcatus.*

With the remains of the camel described by Cragin there is the distal end of one front cannon-bone, accompanied by one of

the two proximal phalanges. The whole length of the fragment of the cannon-bone is only 120 mm. The distance across the distal end of the bone is 91 mm.; across each articulation, 40 mm.; the antero-posterior diameter of each articulation, 43 mm. The extreme length of the phalange is 116 mm.; the width across the upper articulation, 42 mm.; across the lower, 33 mm.

Wortman, in the place cited, gave the following measurements of some of the bones of the skeleton of the remains identified as *Camelops kansanus* and the measurements of the corresponding bones of the one-humped camel:

MEASUREMENTS OF BONES OF CAMELOPS AND CAMELUS.

	Camelops kansanus	Camelus dromedarius
Length of a posterior cannon-bone	345 mm.	325 mm.
Length of a second posterior cannon-bone	360 mm.	---
Length of a third posterior cannon-bone	365 mm.	---
Length of an anterior cannon-bone	330 mm.	325 mm.
Length of a second anterior cannon-bone	370 mm.	---
Length of ulna and radius	555 mm.	580 mm.
Length of humerus	375 mm.	420 mm.
Length of scapula	415 mm.	460 mm.
Length of phalanges, proximal row, varying from	98 to 124mm.	102 mm.

These figures appear to indicate that the cannon-bones of the limbs of the supposed specimens of *C. kansanus* were relatively longer than in the dromedary. At the same time one might conclude that the ulna, radius, humerus, and scapula of the extinct species were considerably shorter.

Various remains of one or more camels have been found in the Aftonian deposits of western Iowa, and most of the specimens have been reported and some of them figured by Professor Calvin.

In his first paper on Aftonian mammals (Bull. Geol. Soc. Amer., Vol. XX, p. 350, pls. xxi, fig. 1, xxii, fig. 2) Calvin mentioned and figured a phalange of the proximal row which had been found in the Peyton gravel pit, near Pisgah, in Harrison county. This bone belonged probably to the fore leg. Its measurements are given in the table below.

In his second paper on Aftonian mammals (Bull. Geol. Soc. Amer., Vol. XXII, p. 212, pl. xix, fig. 8) Calvin described an-

other proximal phalange which presents different proportions. This specimen was found in Aftonian gravels at Henton Station, near Council Bluffs. Its measurements are given in the following table. Its catalog number is 304. Calvin's figure is reproduced one-half of the natural size (Pl. XXXI, fig. 1). Alongside of it (Fig. 3) is shown the anterior first phalange of the type of *Camelops huerfanensis* Cragin. It will at once be seen that the two bones must have belonged to very different species.

MEASUREMENTS OF PROXIMAL PHALANGES.

	Camelops		Camelus	
	Pisgah	Henton	Hind foot	Fore foot
Total length of the bone	128mm.	123mm.	90mm.	101mm.
Side-to-side diameter at upper end	39mm.	52mm.	35mm.	41mm.
Fore-and-aft diameter at upper end	37mm.	40mm.	27mm.	34mm.
Side to side diameter at middle	21mm.	31mm.	19mm.	22mm.
Fore-and-aft diameter at middle	26mm.	25mm.	18mm.	20mm.
Side-to-side diameter at lower end	32mm.	38mm.	30mm.	34mm.
Fore-and-aft diameter at lower end	26mm.	28mm.	21mm.	22mm.

There can be no doubt that we have here the phalanges of two distinct species, but at present it is impossible to say which, if either, of these two phalanges belonged to *Camelops kansanus*. The measurements of the bone found at Pisgah agree more closely with those of the phalange of *Camelops huerfanensis* than do those of No. 304; the bone was nevertheless a slenderer bone than either of the others. The bones described have been rolled and worn, so that their prominent edges and ridges have been removed; but this in no way affects the length and the diameters at the middle of the length.

On the plate on which the phalange No. 304 was figured Professor Calvin illustrated a phalange of the second row (Calvin, op. cit., pl. xix, fig. 9) which had been found at Turin, Monona county. It is here shown on plate XXXI, figure 2. It may well be supposed to have belonged to the same species as the first phalange figured just above it. Its total length is 68 mm.; the width across the middle 28 mm.; the fore-and-aft diameter, 22 mm. It may be remarked here again that the phalanges of the camels may be distinguished

from those of other even-toed ungulates by the fact that the articular ends are not provided with ridges and grooves directed from front to rear and which fit into corresponding grooves and ridges of the adjoining bones. In his first paper just referred to Calvin figured a large astragalus (Calvin, op. cit., pl. xxii, fig. 1) as that of some large ruminant. This had been found in the Cox pit, at Missouri Valley. It seems almost certain that the bone is that of a camel. The length is 98 mm., the thickness across the middle of the outer face is 49 mm. The corresponding measurements taken from an astragalus of a dromedary are respectively 78 mm. and 35 mm. We can refer the bone only provisionally to *Camelops kansanus*.

In his first paper, page 351, Calvin mentioned two heel-bones. These have been examined by the writer and measurements taken. These were found at Missouri Valley and have the number 67.

MEASUREMENTS OF HEEL-BONES.

	Smaller	Larger
Total length	171 mm.	178 mm.
Extent of bone behind articulation with astragalus	107 mm.	115 mm.
Height of bone at hinder end of articulation with astragalus	59 mm.	80 mm.
Thickness of bone at hinder end of articulation with astragalus	52 mm.	59 mm.
Height of hinder process of bone at its middle	51 mm.	61 mm.
Thickness of hinder process of bone at its middle	29 mm.	30 mm.
Greatest diameter of articulation with the navicular	--	52 mm.
Width of articulation with navicular, above	--	30 mm.
Length of articulation with fibula, in straight line	22 mm.	23 mm.

The considerable differences found here in some of the measurements appear to indicate that two species are involved. The larger of these bones is here figured (Pl. XXVIII, fig. 6).

In the collection at the University of Iowa is the distal end of the left humerus (No. 305) of a large ruminant which was found in Aftonian deposits at Henton Station, near Council Bluffs, and therefore at the same place as the phalange just mentioned. After a careful comparison of the bone with the corresponding one of a number of large animals the conclusion is reached that it belonged to a large camel. The bone has been

rolled and worn so that some prominent borders are gone. The width of the articulatory surface for the ulno-radius had a width of about 112 mm. The fragment includes a length of 170 mm.

In Calvin's second communication referred to above he mentioned and figured (p. 212, pl. xix, fig. 10) a large premolar which had been found in the Whitman pit, near Rockport, Atchison county, Missouri. This figure is here reproduced (Pl. XXXI, fig. 4). The tooth, an upper right fourth premolar, has suffered post-mortem abrasion in a way to injure the root and the base of the crown; the remainder is in good condition. The crown is about 40 mm. high, 22.5 mm. fore-and-aft, and 26 mm. wide at the base. The outer face has a rather prominent pillar behind. In front of this is a channel which disappears as the base is approached. The middle of the outer face is occupied by a broad low ridge. Near the front of the face is a pillar disappearing below, and in front of this a groove which looks forward; while still in front of this, there was evidently a strong pillar or style, but which has been split off. Whether or not this tooth belonged to *Camelops kansanus* it is impossible at present to say, inasmuch as the upper teeth of this species are unknown. In case the tooth does belong there, it is probable from its size and form that there were two upper premolars present. The tooth is quite different from the fourth premolar of *C. huerfanensis* and from that of the living species of Camelus.

From Professor Kay the writer has received for examination two lower teeth of one or two kinds of camels. One of these (Pl. XXVIII, fig. 1) has the catalog number 230 and was found at Turin, Monona county. It is the fourth premolar and belongs to the right side of the lower jaw; and there is nothing in its structure or size which enables it to be distinguished from the same tooth of *C. huerfanensis*. The crown is pretty well worn down, the height being about 25 mm. The length of the tooth is 26 mm.; width, 16 mm., at the hinder end. Anteriorly the tooth is very narrow, so that the worn face is triangular. The parts of the inner and outer faces remain nearly flat.

The other tooth (Plate XXVII, fig. 5; pl. LXXIV, fig. 7) has the number 183 and was found at Missouri Valley, in the Cox

gravel pit. It is the hindermost molar of the left side. The roots have been broken off, as well as the hinder lobe, or talon. The height of the crown is 35 mm.; the length of the two lobes present, is 44 mm.; the thickness of the anterior lobe is 22 mm.; of the second one, 20 mm. The heel would have added possibly 10 mm. to the length. On the anterior inner angle there is a style of moderate size. There is, too, a broad channel running up the tooth between the two lobes.

In the collection at the University of Iowa there is what appears to be the upper end of a cannon-bone of a camel. This has the number 241 and was found in the Elliott pit, at Turin, Iowa. The articular end, somewhat eroded, is divided into two nearly equal articular surfaces. The transverse diameter of the upper end of the bone is 68 mm.; the fore-and-aft diameter, 47 mm. These measurements are almost exactly those of the upper end of the anterior cannon-bone of a dromedary.

In the same collection, with the catalog number 274, is the distal end of a cannon-bone of a camel, which was found in the Cox pit, at Missouri Valley. About half of the bone is present. The width of the lower end is 73 mm. The cleft at the lower end extends upward about 60 mm. At a distance of 100 mm. above the lower end the side-to-side diameter is 45 mm.; the fore-and-aft, 30 mm. These measurements indicate a hinder cannon-bone, but one with a shaft much larger than that of the dromedary. It may be considered in connection with the stout first phalange No. 304 (page 241) and the larger and heavier heel-bone (page 242).

Much additional materials must be collected before the history of the camels of the Aftonian stage can be satisfactorily written.

Superfamily BOOIDEA.

The Deer, Giraffes, Antelopes, Sheep, Musk-oxen, Oxen.

Even-toed ungulates with the third and fourth metapodials of each foot consolidated into one mass, the cannon-bone. The lateral digits greatly reduced or wholly missing. Fibula appearing only as a small bone at the lower end of the tibia. Tooth formula, i. $\frac{0}{3}$, c. $\frac{0 \text{ or } 1}{1}$, pm. $\frac{3}{3}$, m. $\frac{3}{3}$. The lower canines close to and resembling incisors. Cusps of the molars and often of the

premolars wearing into crescents, whose extremities are directed outward in the upper jaw, inward in the lower. Habits herbivorous.

The members of this superfamily occur in all lands from the tropics to the polar regions. In Australia, however, only domestic species are found. In this group are included some of the most useful and most beautiful of herbivorous animals.

The earliest recognized members of this superfamily are found in the Lower Miocene. From that time they appear in increasing numbers.

Family Cervidae.

The Deer.

Second and fifth digits of all the feet usually present, but much reduced. Head sometimes without frontal appendages, but often furnished with antlers, which, with rare exceptions, are found only in the males and which are periodically shed and reproduced. Teeth usually short-crowned and with large roots. Upper canines often absent.

At the present day species of deer are found in North and South America, Europe, Asia, and Africa north of the Sahara. In time they range from the lower Miocene to the present. From the Pleistocene of North America seven or eight extinct species are known, besides remains of several of the species yet living. The genera represented are Odocoileus, Cervus, Cervalces, Alces, and Rangifer. These all belong to the following subfamily.

Subfamily CERVINAE.

Antlers with short pedicel; periodically shed; in all genera, except Rangifer, found only in the males. Upper canines usually wanting or feebly developed. Cheek-teeth usually short-crowned, the enamel more or less wrinkled.

Genus ODOCOILEUS Rafinesque.

Antlers in the males only; with a short pedicel, the bases rising nearly on the plane of the face, turning outward then strongly forward, furnished with a sub-basal snag; the tines arising

from the hinder border of the main stem. No brow tine. Metacarpals two and five having only the distal end preserved. Lateral hoofs developed on all the feet. Canines usually absent. Gland pit of face small. Hinder nares divided into two passages by the vomer.

The deer of this genus inhabit the New World. The type of the genus is the common Virginia, or white-tailed, deer, which occurs also in the Pleistocene. There have been described four extinct species from the Pleistocene: *Odocoileus whitneyi,* from the lead region of Iowa, Illinois, and Wisconsin; *O. dolichopsis,* from Indiana; *O. ensifer,* from Oregon; and *O. lævicornis,* from Pennsylvania. Mr. Barnum Brown found in northwestern Arkansas remains of deer which he referred with some doubt to *O. hemionus,* the mule-deer; while, in a cave in northern California, Prof. W. J. Sinclair found *O. columbianus.*

Odocoileus virginianus Zimmermann.

This is the Virginia, or white-tailed, deer which, at the coming of white men to this continent, inhabited the country from the Atlantic ocean to the Rocky mountains, and from southern Canada to the Gulf of Mexico. To this species some authors apply the specific name *americanus,* instead of *virginianus.*

It has been reported as occurring in Pleistocene deposits from Pennsylvania, New York, West Virginia, Michigan, Illinois, Indiana, Missouri, and elsewhere.

Since the skeleton of recent individuals of this species may be procured and employed in the study of extinct species, some parts will be briefly described.

The face is rather long and narrow. The antlers (Fig. 89) show a main stem which at first proceeds from the skull upward, outward and backward. The stem then turns outward strongly, then forward and upward, ending in well-developed males far in front of the orbits. Besides the backwardly directed sub-basal snag, there may be three or four tines rising from the upper border of the stem. No antlers occur in the females; and the skulls of males may be found without them, but these will present the pedicels. The antlers of young males are smaller and have fewer tines than those of adults. The

length of the skull of a grown individual, from the occipital condyles to the front of premaxillæ, will measure about 285 mm.; the breadth across the rear at the mastoid process, is about 100 mm. The length of the upper premolar-molar series, is 80 mm.; of the premolar series, 36 mm.; of the molar series, 48 mm. The length of the lower premolar-molar series is 85 mm.; of the premolars, 38 mm.; of the molars, 51 mm. These measurements, and the following ones of the individual teeth, are taken from a specimen in the U. S. National Museum, No. 17452. The width is taken at the base of the crown of the tooth.

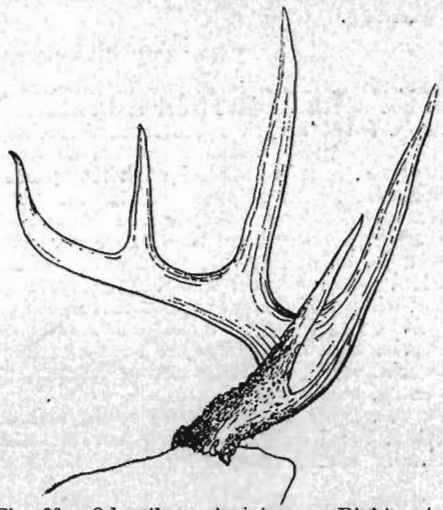

Fig. 89. *Odocoileus virginianus.* Right antler seen from the left side. The nose is toward the left hand. Much reduced. From Baird.

MEASUREMENTS OF TEETH.

Upper Teeth	Length of Crown	Width of Crown	Lower Teeth	Length of Crown	Width of Crown
Pm.^{2}	11 mm.	11 mm.	Pm.$_2$	10 mm.	6 mm.
Pm.^{3}	11 mm.	13 mm.	Pm.$_3$	12 mm.	7 mm.
Pm.^{4}	11.5mm.	14 mm.	Pm.$_4$	12 mm.	9 mm.
M.^{1}	14 mm.	14 mm.	M.$_1$	14 mm.	10 mm.
M.^{2}	16 mm.	15.5mm.	M.$_2$	16 mm.	11 mm.
M.^{3}	16.5mm.	16 mm.	M.$_3$	22 mm.	11 mm.

In the upper molars there is often a small tubercle on the inner face between the two lobes, and a similar one on the outer face of the lower molars between the two lobes.

In the upper jaw the distance from the front premolar to the front of the premaxillæ, is about 95 mm. In the lower jaw the distance from the front of the jaw to the anterior molar, is 85 mm. The height of the lower jaw at the first true molar, is 22 mm.

Measurements are here presented of some of the principal bones of the skeleton. They are taken from a young but mature male, No. 35139, U. S. National Museum. The measurements

are taken in a straight line. It is to be understood, however, that other individuals may be somewhat larger or somewhat smaller.

MEASUREMENTS OF BONES.

Skull, length from condyles to front of premaxillae	245	mm.
Atlas, width across hinder end	73	mm.
Axis, total length	65	mm.
Axis, width of anterior end across articulation	48	mm.
Scapula, length parallel with its spine	170	mm.
Scapula, width of upper end	115	mm.
Humerus, extreme length	187	mm.
Humerus, from head to surface for ulna	173	mm.
Radius, total length	200	mm.
Ulna, total length, about	240	mm.
Anterior cannon-bone	200	mm.
Pelvis, total length	230	mm.
Pelvis, width at acetabula	117	mm.
Pelvis, width at hinder end of ischia	148	mm.
Femur, total length	230	mm.
Femur, from head to outer condyles	215	mm.
Tibia, total length	270	mm.
Hinder cannon-bone	235	mm.

Remains of this deer have been reported from many localities within the area occupied by it within historical times. We cannot always be sure that the identifications have been correct, not always sure that the remains belonged to Pleistocene times. Cope, in 1869, reported that remains of this species were abundant in the cave breccia of West Virginia. He also found in the collection made in Port Kennedy cave, in eastern Pennsylvania, teeth which he could not distinguish from that of the Virginia deer. It is the writer's opinion, at present, that the deposits made in that cave were made early in the Pleistocene. Hildreth (Amer. Jour. Sci., Vol. XXIX, 1835, p. 147) reported the finding of bones of the deer, (probably this species), in cave stalagmite, in Wood county, West Virginia. Leidy found, in Peace Creek beds, Florida, (regarded as early Pleistocene, or even Pliocene) antlers, bones, and teeth of a deer, that he could not distinguish from corresponding parts of the Virginia deer.

The indications are, therefore, that this deer has existed in our country since early in the Pleistocene. Had we, however, more abundant materials, it is possible that we would find that more than one species has been included under this name.

It is, however, not certain that this deer has been found in Pleistocene deposits in Iowa. Jeffries Wyman (Geol. Surv.

Wisc., Vol. I, 1862, p. 421) stated that there were, in Professor Hall's collection made in the lead region, a series of several molars which in form and size corresponded exactly with those of the Virginia deer. We are not informed, however, the conditions under which these were found, whether in the lead-bearing crevices or in superficial accumulations; nor even in which state, Iowa or Wisconsin.

In the collection at the University of Iowa are some remains of this deer; but it is probable that they belong to the Recent epoch. Nevertheless, it is not impossible that the individuals lived in the later Pleistocene. A skull is here illustrated (Pl. XXXI, fig. 5). This was found on Cedar creek, seven miles east of Turin, Monona county. It is apparently thoroughly mineralized with oxide of iron and is of a reddish brown color. The jaws and teeth are all gone; and the bones in advance of the frontals. The extremities of the antlers are likewise missing. The following measurements were secured; and for comparison the corresponding measurements were taken from the skull of a large buck which was collected on Eagle river, Wisconsin, No. 119794, U. S. National Museum.

MEASUREMENTS OF SKULLS OF *ODOCOILEUS VIRGINIANUS*.

	Fossil	Recent No. 119794 U.S.N.M.
From occipital crest to fronto-nasal suture	157 mm.	156 mm.
Width at the mastoid region	100 mm.	103 mm.
Width below the antlers	75 mm.	74 mm.
Height of occipital crest above lower surface of condyles	60 mm.	78 mm.
Width across face between antlers and orbits	102 mm.	107 mm.
Width of face at the rear of the orbits	128 mm.	122 mm.
Width from outside to outside of occipital condyles	52 mm.	59 mm.
Diameter of antler just above the burr	32 mm.	37 mm.
Height of first fork of antler above the burr	125 mm.	113 mm.
Diameter of the beam above 75mm. above first tine	34 mm.	34 mm.

It will be seen that the two skulls have practically the same dimensions. The first tine in both these specimens is given off at a greater height than is usual.

With this skull were found other remains of the deer, besides parts of antlers of the elk (*Cervus canadensis*) and numerous skulls and other bones of the buffalo.

In a letter written early in 1910 Doctor Calvin informed the writer that in Iowa near Missouri river, old river valleys had been graded, beaver dams had been built across them, and buffalo, elk and deer had become mired in the peaty swamps above the dams. These valleys had in some cases been filled to a depth of twenty or thirty feet. Later another change of grade had resulted in reëxcavating the valleys, and the bones of the animals mentioned are now found in the bottoms of these young, narrow, deep gulches. Doctor Calvin thought that the deposits containing the bones might be either late Pleistocene or early Recent. See also Shimek in volume XX of the Iowa Geological Survey, pages 408, 409.

In the Proceedings of the Iowa Academy of Science, for 1890-91, on page 67, Prof. F. M. Witter of Muscatine stated that an antler of a deer had been found in what he regarded as loess in the city of Muscatine. It is not known where the antler now is; and without it, probably even with it, it would be impossible to determine the species to which it belonged.

Odocoileus whitneyi (Allen).

In 1876 J. A. Allen described this species (Amer. Jour. Sci., ser. 3, Vol. XI, p 49) on materials which had been found several years previously by J. D. Whitney, somewhere in the lead region of Wisconsin, Iowa, and Illinois. These materials, together with remains of Mammut, Megalonyx, Platygonus, a supposed extinct species of Bison, and bones apparently of *Cervus canadensis* and of *Antilocapra americana* and some other species had been discovered in the lead-bearing crevices of that region. Whether or not the bones which form the type of *O. whitneyi* had been discovered in Iowa, seems nowhere to have been stated; but in Wyman's account of the vertebrate remains which had been secured in the region (Rep. Geol. Surv. Wisc., Vol. I, p. 421) referred to, he includes some remains of a deer among those which had been found in Iowa and Wisconsin. We cannot therefore be certain to which of these two states to credit the type. We need not doubt, however, that the species at the same time inhabited that whole region.

The remains which Allen referred to *O. whitneyi* were a left humerus, entire except lacking the proximal epiphysis; a left radius, also lacking the distal end; and a right metatarsal,

which had lost its distal portion. None of these parts were figured. They are now probably in the collection at the Museum of Comparative Zoology at Cambridge, Massachusetts.

According to Allen's description, these bones resembled in form closely the corresponding parts of the white-tailed deer and of the mule deer, but they were somewhat larger; the animal being, as he concluded, about one-seventh larger than the mule deer, and about one-fifth larger than the white-tailed deer. He found that in the mule deer, *O. hemionus,* the condyles at the distal end of the humerus were slightly broader than in the other two species here mentioned. The ulna of *O. whitneyi* had been ankylosed solidly to the radius nearly throughout its length; whereas in *O. hemionus* it is ankylosed only at its middle portion, being free at both the proximal and the distal ends and distally not even in contact with the radius. In *O. virginianus,* however, the ankylosis is nearly as complete as in *O. whitneyi.* The metatarsal bone differed in some respects from that of both the other species. It is thought proper to copy here Allen's measurements. It will be noted that the names employed by that author differ somewhat from those here used, all the species being referred to the genus Cervus and the specific name *macrotis* being applied to the mule deer.

COMPARATIVE MEASUREMENTS OF BONES OF *CERVUS WHITNEYI, CERVUS MACROTIS,* AND *CERVUS VIRGINIANUS.*

	Cervus whitneyi	Cervus macrotis	Cervus virginianus
Humerus, total length	--	227 mm.	220 mm.
Length from most proximal part of head to most distal part of inner condyle	--	203 mm.	200 mm.
Breadth of condylar surface	48 mm.	42 mm.	38 mm.
Antero-posterior breadth of inner condyle	51 mm.	42 mm.	42 mm.
Least circumference of shaft	85 mm.	76 mm.	73 mm.
Radius, total length	--	242 mm.	230 mm.
Transverse breadth of proximal end	--	39 mm.	37 mm.
Transverse breadth of distal end	41 mm.	38 mm.	37 mm.
Least transverse diameter of shaft	29 mm.	25 mm.	24 mm.
Least circumference	80 mm.	68 mm.	65 mm.
Metatarsus, total length	--	273 mm.	255 mm.
Transverse breadth of proximal end	33 mm.	29 mm.	28 mm.
Antero-posterior breadth of proximal end	36 mm.	32 mm.	30 mm.
Transverse breadth of distal end	--	35 mm.	33 mm.
Least transverse diameter of shaft	22 mm.	21 mm.	18 mm.
Least circumference of shaft	67 mm.	66 mm.	58 mm.
Length of corresponding portions (proximal five-sixths)	273 mm.	232 mm.	220 mm.

J. A. Udden (Iowa Geol. Surv., Vol. XI, p. 110) reported that an antler of a deer had been found in what was regarded as Sangamon soil near Wapello, Louisa county, Iowa. The exact locality is given as the northwest quarter of section 14, township 74 north, range 3 west. The finder was Mr. George Gresham. This gentleman informs the writer that he still has a part of the antler. It is impossible to determine the species to which the antler belonged.

Genus CERVUS Linn.

Antlers in the male only; with a short pedicel; large and cylindrical; with a brow tine and two other tines on lower half of shaft; the tines arising from the front of the main shaft. Canine teeth present; upper molars rather high-crowned and with an accessory column on the inner side. Antorbital gland pit of moderate size.

The members of this genus inhabit central Europe, central and northern Asia, and central North America. Formerly the American species occupied the United States from the Atlantic to the Rocky mountain region and to northern California, and from Yukon Territory south to Tennessee and probably even western Florida in the eastern region. In Europe and northern Asia species of this genus occur in both the Pliocene and the Pleistocene. From Pleistocene deposits of Oregon Cope described a species, *Cervus fortis,* but it is not certain that it belongs in the genus. No other species is known in North America until the appearance of *C. canadensis* in the latter part of the Pleistocene.

Cervus canadensis Erxleben.

The Wapiti; American Elk.

The American Elk, or Wapiti, is a stately and splendid species of deer which, on the coming of white men to this continent, occupied the more temperate parts of the country from the Atlantic to the Pacific, extending its range north to about 57° latitude and south to North Carolina, Tennessee, Arkansas, Texas, and New Mexico. It is now on the verge of extinction. It is a much larger animal than the Virginia deer, having a length of about eight feet from the nose to the root of the tail, a height of nearly five feet at the shoulders and somewhat more

at the rump. The female is somewhat smaller. The antlers (Fig. 90) are large, reaching four feet six inches in length, measured along the curve; and sometimes probably they were still larger. They extend upward, outward, and somewhat backward. The tines, five to seven in number, project from the front of the main shaft. Other details of the structure are given below.

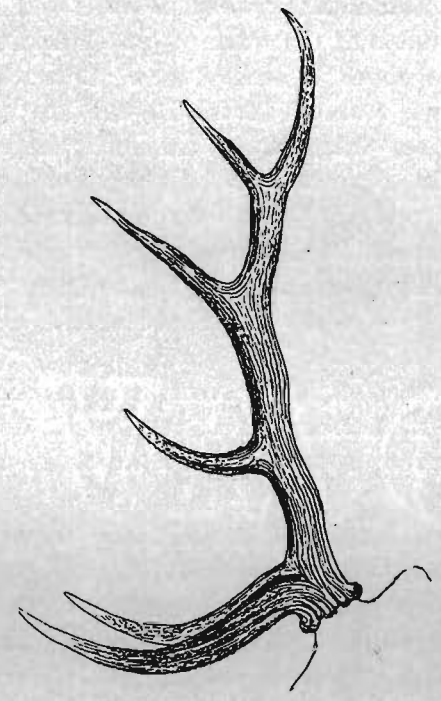

Fig. 90. *Cervus canadensis.* Right antler seen from the left side. Much reduced. The nose is toward the left hand. From Baird.

Remains of the wapiti in a fossilized or semi-fossilized condition have been reported from various parts of the eastern half of the United States, Vermont, New York, New Jersey, Maryland, North Carolina, South Carolina, Kentucky, Indiana, Michigan, Iowa, Wisconsin, and Illinois, and from Ontario, Canada. Certainly some of the remains reported belong to the Recent epoch; others are certainly of Pleistocene times; about others there must remain great doubt. There seem to be no remains that prove the presence of this animal in our country during the earlier part of the Pleistocene, none that seem to be

as ancient as some of the finds of the Virginia deer. Harlan (Amer. Jour. Sci., Vol. XLIII, 1842, p. 143) reported that elk teeth had been found at Newbern, North Carolina, and with them teeth of the mastodon, elephant, deer and horse. Cope (Trans. Amer. Philos. Soc., Vol. XIV, p. 125) stated that fragments of antlers not distinguishable from those of the elk had been found at Talbot Neck, Maryland, in company with bones of an elephant. James Hall (Jour. Boston Soc. Nat. Hist., Vol. V, p. 391) reported that the horn of an elk had been found in a bed of muck at a depth of twelve feet. This was in Allegheny county, New York. Leidy (Ann. Rep. Geol. Surv. Pa., 1887, p. 6) found a large fragment of an antler and pieces of limb bones of the elk in a cave at Stroudsburg, Pennsylvania. In the same cave were remains of the bison, reindeer and the giant beaver (Castoroides). The writer agrees with Osborn that, so far as we can now determine, the wapiti was a late comer to this region; but it was probably here before the extinction of the mastodon. Inasmuch as remains of this animal will certainly be found here and there throughout the state, it is thought best to present measurements of the teeth and of the most characteristic parts of the skeleton in order to aid in their identification.

The following measurements are made from three skulls in the U. S. National Museum, No. 86417, a young adult male from Jackson Hole, Wyoming; a nearly adult female, No. 24217, from Yellowstone Park; and a second larger male, No. 171889, from Jackson Hole, Wyoming:

MEASUREMENTS OF SKULLS OF THE WAPITI.

	Male No. 86417	Female No. 24217	Male No. 171889
Length from condyles to front of premaxillae	408 mm.	380 mm.	455 mm.
Breadth at ear-openings	123 mm.	110 mm.	160 mm.
Breadth across zygomatic arches	177 mm.	156 mm.	187 mm.
Breadth on rim of orbit at fronto-lachrymal suture	132 mm.	125 mm.	150 mm.
Breadth just above antorbital foramen	88 mm.	88 mm.	98 mm.
Breadth at sockets of canines	86 mm.	68 mm.	90 mm.
Distance from front of premaxillae to palatines	192 mm.	192 mm.	215 mm.
Distance from front of premaxillae to hinder nares	255 mm.	245 mm.	283 mm.

MEASUREMENTS OF SKULLS OF THE WAPITI—Concluded

	Male No. 86417	Female No. 24217	Male No. 171889
Distance from front of premaxillae to anterior premolar	126 mm.	--	145 mm.
Width of palate at front premolars	50 mm.	55 mm.	57 mm.
Width of palate at front of hinder molars	70 mm.	70 mm.	78 mm.
Length of lower jaw from incisive border to rear of angle	332 mm.	305 mm.	--
Length of symphysis	52 mm.	44 mm.	--
Height at first true molar	44 mm.	38 mm.	--
Length of upper premolar-molar series	133 mm.	133 mm.	138 mm.
Length of upper premolar series	59 mm.	58 mm.	62 mm.
Length of upper molar series	78 mm.	80 mm.	81 mm.
Length of lower premolar-molar series	144 mm.	140 mm.	--
Length of lower premolar series	57 mm.	55 mm.	--
Length of lower molar series	87 mm.	87 mm.	--
Distance from last incisor to anterior premolar	96 mm.	89 mm.	--
Pm.^{2}, length	21 mm.	--	21 mm.
width	17 mm.	--	18 mm.
Pm.^{3}, length	22 mm.	--	22 mm.
width	19.5mm.	--	21 mm.
Pm.^{4}, length	18 mm.	--	19 mm.
width	20 mm.	--	21.5mm.
M.^{1}, length	23 mm.	24 mm.	23 mm.
width	24 mm.	25 mm.	26 mm.
M.^{2}, length	29 mm.	30 mm.	29 mm.
width	25 mm.	28 mm.	28.5mm.
M.^{3}, length	27 mm.	--	28 mm.
width	23 mm.	--	25 mm.
Pm.$_2$, length	16 mm.	--	--
width	10 mm.	--	--
Pm.$_3$, length	19 mm.	--	--
width	13 mm.	--	--
Pm.$_4$, length	23 mm.	--	--
width	15 mm.	--	--
M.$_1$, length	24 mm.	25 mm.	--
width	16 mm.	17 mm.	--
M.$_2$, length	30 mm.	31 mm.	--
width	18 mm.	19 mm.	--
M.$_3$, length	35 mm.	--	--
width	17 mm.	--	--

In the case of the female skull measured above, the milk teeth, much worn, are yet in position. Although their individual measurements are not given, they are included in the lengths of the series. The lower hinder true molar is not sufficiently extruded

for accurate measurement. In considering the measurements of the teeth of this species, as in the others, it must be taken into account that as they are worn down they become slightly shorter, fore and aft, and the worn face broader. The latter fact does not affect the measurements here given of the breadth, for this is taken at the base of the tooth.

In each of the upper molars of *Cervus canadensis* (Pl. XXXI, fig. 6) there are two parts, or lobes, an anterior and a posterior, and each of these is made up of two crescents, an inner and an outer, the four crescents corresponding to the four cusps of the quadritubercular tooth. The hinder molar lacks a third, or hinder lobe, or heel. Between the inner and the outer crescent of each lobe there is a deep crescentic pit, which remains open, instead of becoming filled with cement, as it does in the buffalo. Neither is there any cement on the other parts of the tooth. On the outer face there are three prominent ridges. One of these, the parastyle, is in front; the second, the mesostyle, is situated at the meeting place of the outer crescents of the anterior and posterior lobes; the third, the metastyle, is at the hinder outer angle of the tooth. The outer face of each lobe is nearly parallel with the axis of the tooth. The anterior face is divided into two equal parts by a prominent ridge which descends from the base of the parastyle. The hinder face is traversed from top to bottom by a broad low ridge. The inner faces of these upper molars have the two lobes separated by a very deep valley. In this valley, at the base of the crown, is a little column which resembles somewhat a diminutive stalactite.

The upper premolars are composed of a pair of crescents, an outer and an inner. The inner face of each is convex. The outer face has a prominent style, or pillar, in front; another behind this, starting near its base; and a third, at the rear of the tooth. In the two hinder premolars there is a very narrow and sharply defined valley between the anterior and the second pillars.

In the lower jaw (Pl. XXXI, fig. 7) the molars are much narrower than the upper, but there are here also two lobes and four crescents. The hinder molar presents, in addition, a smaller lobe, or heel. Here the deep valley which separates the

lobes is on the outer face of the tooth. In this valley, at the base of the crown, is seen a stalactite-like column; while at the front of the anterior lobe is a pillar which is applied to the lobe, but does not rise to its summit. On the inner face of each tooth there are styles, or pillars, similar to those seen on the outer faces of the upper teeth. The ridge rising on the face of each lobe is well developed, being broader and more prominent than the styles themselves.

The lower premolars are more advanced than are those of the upper jaw; that is, they have begun to assume the form of the molars. On the outer face there is, between the middle and hinder thirds, a rather deep valley, cutting off a small hinder lobe; and each of these in the hinder premolar, contains a pit, which is, however, much shallower than those of the molars. In the third premolar the lobes are slightly less well defined, and the front half of the outer face is deeply excavated. The second premolar is of still simpler form.

The lower incisors diminish rapidly in size from the first to the third. In a specimen with these teeth little worn the first is 17 mm. wide; the second, 11 mm.; the third, 9 mm. The hinder face of each is excavated and presents two or three strong ridges, which pass from near the base of the crown to the cutting edge. The canine has a width of 7 mm., is closely appressed against the third incisor, and resembles it closely; but it is a little smaller than the incisor. The enamel of all the teeth is finely wrinkled.

The antlers of the elk (Fig. 90) rise from the pedicels, passing upward, and outward, and having between them an angle of less than 90 degrees. Toward the extremity the main stem turns forward and often a little inward. The tines rise from the front of the main stem, not from the hinder border, as they do in Odocoileus. There is a brow tine and two others in the lower half of the shaft, and two or three others in the upper half. In the specimen at hand, from Wyoming, the main shafts are about four feet long, and the tips of the two antlers are three feet apart.

To assist in identifying bones of the elk that may be found, the following measurements are given. They are taken from a

fully grown male individual in the U. S. National Museum. All measurements are made in a straight line:

SKELETAL MEASUREMENTS OF ELK.

Axis, total length of the centrum	130 mm.
Axis, width across anterior articulation	88 mm.
Scapula, length parallel with the spine	350 mm.
Scapula, width at the upper end	205 mm.
Humerus, total length	345 mm.
Humerus, length from head to distal end	300 mm.
Humerus, fore-and-aft diameter of upper end	110 mm.
Humerus, side-to-side diameter of upper end	97 mm.
Humerus, fore-and-aft diameter at middle of shaft	47 mm.
Humerus, side-to-side diameter at middle of shaft	38 mm.
Humerus, width of lower end	74 mm.
Radius, total length	350 mm.
Radius, greatest width at upper end	73 mm.
Radius, diameter at middle of length, fore and aft	25 mm.
Radius, diameter at middle of length, side to side	43 mm.
Radius, width at the lower end, side to side	67 mm.
Ulna, total length	435 mm.
Ulna, breadth at rear of articulation with humerus	65 mm.
Ulna, greatest diameter at middle of length	20 mm.
Anterior cannon-bone, total length	303 mm.
Anterior cannon-bone, diameter at upper end, fore and aft	36 mm.
Anterior cannon-bone, diameter at upper end, side to side	54 mm.
Anterior cannon-bone, diameter at middle, side to side	33 mm.
Anterior cannon-bone, diameter at lower end, side to side	55 mm.
Pelvis, total length	430 mm.
Pelvis, breadth at acetabula	265 mm.
Pelvis, breadth at hinder end of ischia	310 mm.
Femur, total length	400 mm.
Femur, head to distal end	380 mm.
Femur, greatest width at upper end	110 mm.
Femur, diameter at middle of length	38 mm.
Femur, greatest width at lower end, side to side	95 mm.
Tibia, total length	445 mm.
Tibia, width at upper end, side to side	100 mm.
Tibia, diameter at middle of length, fore and aft	33 mm.
Tibia, diameter at middle of length, side to side	42 mm.
Tibia, diameter at lower end, side to side	67 mm.

In the female which furnished the measurements of the skull and teeth, the bones are considerably shorter. The humerus, from the head to the surface for the ulna, is 260 mm. long; and the total length of the tibia is 385 mm. Allowance must therefore be made for individual variation, for sex and for age. In case the antlers are not found with remains of the elk, it may

be necessary to rely on the teeth for identification; or teeth only may be found.

The size of the teeth of the wapiti will distinguish them easily from those of the Virginia deer. They need to be carefully studied to distinguish them from those of the moose (*Alces americanus*), Scott's moose (*Cervalces scotti*), the musk-oxen, and the various species of bison.

A comparison of the measurements of the teeth of *Cervus canadensis* with those of *Alces americanus* shows at once that those of the latter are larger, being especially broader. The greatest differences are found between the premolars of the two species, those of the moose being both much longer and much broader. In the upper molars of the moose there is no, or a very minute, column between the lobes, on the inner face of the tooth. The outer face of each lobe is directed strongly backward and inward, instead of being parallel with the jaw. The anterior and the median styles (parastyle and mesostyle) are more prominent in the moose than in the wapiti. In the moose the ridge, or the pillar, which descends near the middle of the outer face has its summit directed forward, so as to overhang slightly the excavation in front of it.

The lower molars of the wapiti are easily distinguished from those of the moose by the measurements. In general the molars and premolars of the latter are much wider in proportion to their length.

The teeth of the bisons must be considered. If unworn or little worn upper molar teeth of the bison and of the wapiti are compared, the former may at once be distinguished by the far higher crowns, being perhaps twice as high as those of the wapiti. If the teeth are worn down those of the wapiti will have the inner and the outer face sloping strongly toward each other, while in the bisons they will be nearly parallel. The worn faces of the molar teeth of the bisons are more nearly square than those of the wapiti. Those of the bisons have, on the inner face, instead of a little freely projecting column, like a little stalactite, a large column that adheres to the tooth nearly the whole length and nearly fills the cleft between the two lobes. As to the premolars, the measurements must be applied; or

those of the wapiti may be compared with the same teeth in the skull of the domestic ox. In regard to the lower teeth, comparisons of the measurements of the wapiti teeth with those of the bisons will usually settle the matter. The lower true molars of the bison have, on the outer face, a strong fold of enamel, forming a style or column in the cleft between the two lobes. Finally in the teeth of the bisons there is more or less cement on the surfaces and in the pits between the crescents.

As stated on page 249, in discussing the occurrences of the Virginia deer in Iowa, Calvin reported the finding of elk remains along Cedar creek, east of Turin, Monona county. With these were found many skulls of the American bison. Mr. Henry McCall of Monona county informs the writer that he has picked up elk horns and buffalo heads on his father's farm about seven miles north of Moorhead. This is along Beaver creek. In a letter from Mr. H. C. Lowrey, of Nevada, Story county, Iowa, the author has been informed that Mr. Lowrey has found many elk antlers in ditching and plowing up a large peat marsh on his farm. In ditching, one antler was found at a depth of three feet. Others were found in the process of deep plowing and, of course, not far beneath the surface. One complete skull was found, with the antlers attached. This locality is within the area covered by the Des Moines lobe of the Wisconsin drift and, of course, the peat deposit is more recent than that drift. Nevertheless, a long period may have elapsed since the burial of some of those antlers.

Professor Shimek (Iowa Geol. Surv., Vol. XX, pp. 408-409) states that remains of the elk have been found along Beaver creek in Monona county and along Hog creek, in Harrison county. They are found mingled with many bones of the American bison. It is most probable that all these bones belong to animals that lived during the Recent period; but for all that they are quite old.

J. A. Allen, of the American Museum of Natural History, New York, stated (Amer. Jour. Sci., Vol. XI, 1876, p. 48) that among the bones and teeth collected by J. D. Whitney in the lead region of Iowa, Illinois, and Wisconsin, he had found an imperfect radius that seemed not to differ at all from that of a

young male *Cervus canadensis*. We do not know in which of the three states this bone was found. The age of the remains found in the lead region is not certainly known. Most of the species are yet living. Almost the only reason for supposing that they are pre-Wisconsin is the fact that Dr. Allen regarded the bison remains found there, or at least some of them, as belonging to an extinct species.

Genus CERVALCES Scott.

Antlers palmated, dividing successively into two portions, the shaft much longer than in Alces. Nasals and premaxillæ much less reduced than in the latter genus, and the nasals in contact with the premaxillæ.

This genus appears to differ essentially from Alces, that containing the moose, in having the anterior nares, as shown in the skeleton, much smaller, an indication that the prehensile upper lip was not so greatly developed.

Three species of the genus are now known, all from the Pleistocene. *Cervalces scotti,* Lydekker, has been found at Big Bone Lick, Kentucky, and Mount Hermon, New Jersey; *C. roosevelti* Hay, in Iowa; and *C. borealis* Bensley, at Toronto, Canada. *C. scotti* is represented at Princeton University by a nearly complete skeleton, while the other species are known from only imperfect materials. The former is therefore described here with considerable detail.

Cervalces scotti Lydekker.

Scott's Pleistocene Moose.

This is the species which W. B. Scott (Proc. Phila. Acad., 1885, p. 181, pl. ii) described under the name *Cervalces americanus*. Lydekker, in his "Deer of All Lands," p. 60, pointed out that the specific name was preoccupied, and he therefore named the animal in honor of Professor Scott.

The first known remains of this species were found at Big Bone Lick, Kentucky, and were described and figured by Wistar, in 1818 (Trans. Amer. Phil. Soc., Vol. I, p. 375, pl. x, figs. 4, 5). He mentions it as a "Cervus." Cooper, Smith, and Dekay, in

1831, referred it with doubt to the living species of moose. Harlan, in 1834, gave it the name *Cervus americanus*. The descriptions and figures were based on the hinder part of the skull which bore the bases of the antlers. Leidy (Jour. Phila. Acad., Vol. VII, 1869, p. 378) expresses some doubt regarding the place where the skull was found. With the skull in the Academy of Natural Sciences in Philadelphia Leidy found the bases of the antlers of another specimen and two metacarpals, all in the same friable and abraded condition.

About the year 1884 there was discovered in a shell-marl deposit, under a bog, at Mount Hermon, New Jersey, a nearly complete skeleton of a moose which Scott referred to this species. The only bones missing are five tail bones, two ribs, the

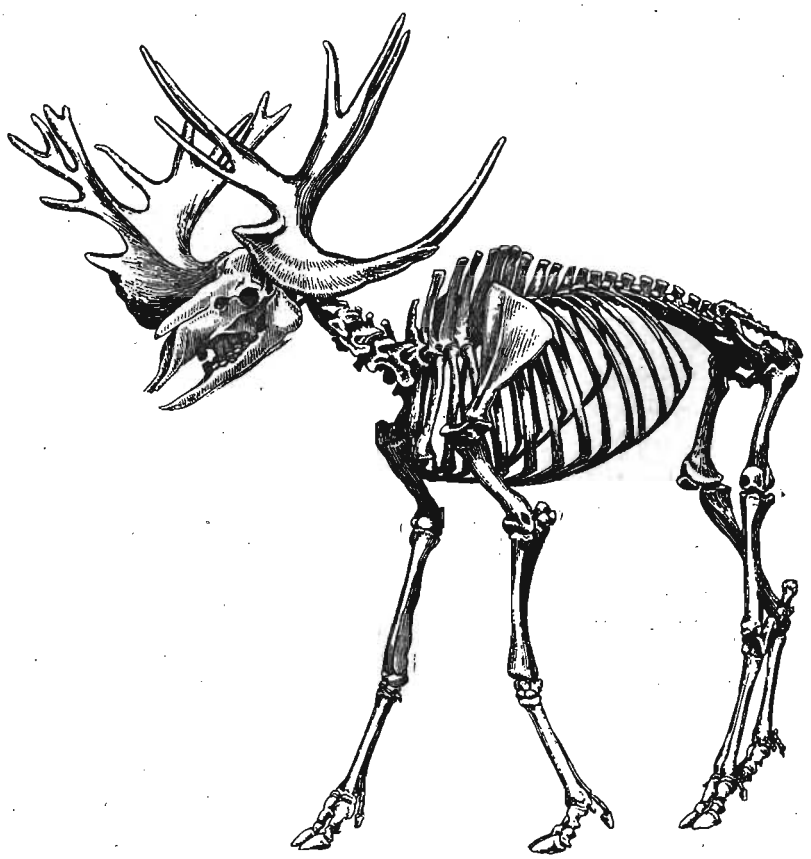

Fig. 91. *Cervalces scotti.* Skeleton of specimen in Princeton University. After Scott.

right scapula, right humerus, and a few foot bones. Excepting the bones of the tail, every bone is represented on one side or the other of the animal. The bones are beautifully preserved and look as if they had been obtained from a recently killed animal. They belonged to an individual which was adult, but not old. They have been mounted, and the skeleton forms one of the attractions of the natural history collection at Princeton University. From Scott's plate (op. cit. pl. ii), representing this skeleton as mounted, has been prepared the line drawing here presented (Fig. 91). The other illustrations also are from Scott's memoir.

The only certain identifications of this moose are those of the materials found at Big Bone Lick and at Mt. Hermon, New Jersey. It has been reported with doubt from Kansas and from the interglacial deposits at Toronto, Canada. The remains found at the latter place have recently been described by Doctor Bensley as *Cervalces borealis*. In the American Museum of Natural History, New York, there is a humerus which has been identified as belonging to this species, and which was found near Brantford, Ontario. It is said that the whole skeleton was present, but no attempt was made to save it. The single bone was rescued by Mr. S. C. Waters, of Poughkeepsie, New York. It seems probable that the deposit containing the skeleton was of post-Wisconsin age. It is impossible to determine with exactness the age of the Big Bone Lick remains. Animals left their remains there probably from the time of the retirement of the Illinois ice-sheet up to the present. There is more certainty about the time when this fine specimen at Princeton University lived. The whole country about Mount Hermon, New Jersey, is, according to Salisbury's map of the glacial deposits of New Jersey (Geol. Surv. N. J., Vol. V), covered with what is called late drift. This is regarded as equivalent to the Wisconsin. The specimen was found in a bog on this drift, and may be regarded therefore as post-Wisconsin in age.

A study of the measurements of this specimen, as presented by Scott, seems to the writer to show that the proportions of the extinct species were almost exactly those of the moose, the legs being little if any longer and the neck rather longer than

shorter, all as compared with the length of the animal. This moose was thought by Scott to have stood higher on its legs than does the living species. He has given comparative measurements of this specimen and of one of the moose. The latter is said to have had a height of 1695 mm. at the withers and 1565 mm. at the sacrum. The extinct species showed 1810 mm. and 1680 mm. as the corresponding measurements. That is, the extinct species had a height of about six feet at the shoulders. Elliott (Synops. Mamm. N. A., etc., p. 38) states that the American moose may attain a height of 2440 mm. at the withers. On the other hand the Mount Hermon specimen of Cervalces may not have been the largest of the species.

In order that it may be possible to recognize remains of this species if found, the following descriptions and measurements are presented, these having been taken from the specimen at Princeton.

The skull has a length of 550 mm. from the condyles to the front of the premaxillæ. The width across the paroccipital processes is 150 mm.; at the hinder borders of the orbits, 252 mm.; at the anterior premolar, 132 mm. From the front of the premaxillæ to the front of the nasals is 185 mm., one-third the length of the skull; in the moose, this is 285 mm., one-half the length of the skull. Along the midline, between the back of the head and the antlers, there is a slight depression; between the antlers a convexity; in front of the antlers, a slope downward.

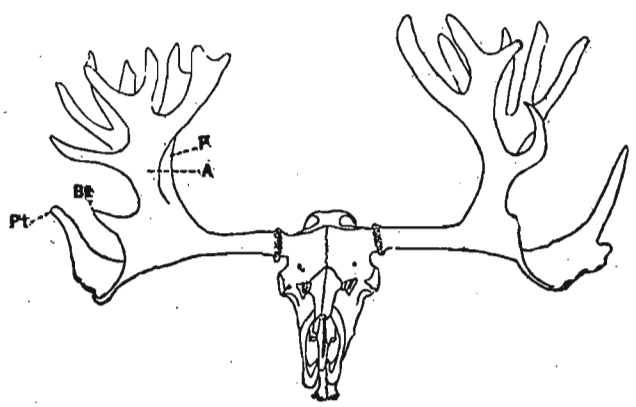

Fig. 92. *Cervalces scotti.* Skull and antlers, seen from in front. From Scott. *A*, anterior division of palmation; *P*, posterior division; *Bz*, bezotine; *Pt*, posterior tine.

In the male of the existing moose there is a high knob of bone between the antlers. The nasal bones of *Cervalces scotti* are 181 mm. long and extend forward in advance of the hinder end of the premaxillæ. In the living moose the nasals are very short and lack much of reaching the premaxillæ.

The antlers (Fig. 92) start out laterally at nearly right angles with the plane of the midline of the skull. At a distance of 100 mm. from the base the diameter of the shaft is 55 mm. At about 170 mm. the shaft begins to flatten and is soon divided into two palmations. One of these may be said to continue the main axis outward, then somewhat upward, ending in the snag Pt. Its hinder border is thickened, and the width of the palmation amounts to as much as 300 mm. The other branch is directed upward and is soon divided into an anterior division, A, and a posterior, P. Each of these divides into two portions and subdivides similarly into terminal snags. The length of the antler, measured on the outside of the curve, is 863 mm.; the distance between the outer extremities of the two antlers is 1620 mm., over five feet.

All the teeth are present except the lower incisors and canines. The following measurements have been taken by the writer:

Length of the upper premolar-molar series, 168 mm.; of the premolar series, 74 mm.; of the molar series, 90 mm.

Length of the lower premolar-molar series, 168 mm.; of the lower premolar series, 75 mm.; of the lower molar series, 97 mm.

MEASUREMENTS OF THE SEPARATE TEETH.

Upper Teeth.		Lower Teeth.	
$Pm.^2$, length	23 mm.	$Pm._2$, length	21 mm.
width	23 mm.	width	14 mm.
$Pm.^3$, length	26 mm.	$Pm._3$, length	23 mm.
width	24 mm.	width	17 mm.
$Pm.^4$, length	26 mm.	$Pm._4$, length	27 mm.
width	27 mm.	width	20 mm.
$M.^1$, length	29 mm.	$M._1$, length	28 mm.
width	27 mm.	width	20 mm.
$M.^2$, length	28 mm.	$M._2$, length	30 mm.
width	29 mm.	width	22 mm.
$M.^3$, length	31 mm.	$M._3$, length	41 mm.
width	27 mm.	width	21 mm.

The width of the molars, upper and lower, except $m._1$, is taken across the anterior lobe.

In the upper molars there may be minute accessory pillars, or columns, at the base of the valley between the two lobes, on the inner side of the tooth. On the outer face of the premolars there are two strong styles, of which the anterior is the broader. Both arise below the anterior root, and the hinder one swings backward to the middle of the face of the tooth. On the outer face of the molars there are three strong styles. Two of these arise below the anterior root and diverge little. The third root arises between the two roots of the tooth. This swings somewhat backward. In front of it is a strong excavation; behind it a shallower one. In the hinder molar there is a fourth style into which the hinder crescent sends an extremity.

In the lower molars there is a rather thick, but short, style on the outer face in the interval between the two lobes. On the inner face the molars are deeply and obliquely notched between the lobes and the notch penetrates the anterior cement lake. The inner face of each lobe has a style, which, however, subsides toward the base of the crown. The hinder molar has a large heel or third lobe. The hindermost premolar resembles a molar, but it has a little external style. The inner face of the two anterior premolars is strongly folded and notched.

The following measurements are given of some of the principal bones of the skeleton; and, in a parallel column are presented the corresponding measurements taken from a specimen of the moose, No. 24219, of the U. S. National Museum:

MEASUREMENTS OF BONES OF CERVALCES AND ALCES.

	Cervalces	Alces
Atlas, distance between the hinder extremities of the wings	180 mm.	140 mm.
Axis, length of centrum along midline below, not including the spout	96 mm.	115 mm.
Axis, extreme height, behind	138 mm.	133 mm.
Scapula, extreme length, parallel with spine	445 mm.	382 mm.
Scapula, width along upper border	255 mm.	240 mm.
Humerus, total length	425 mm.	360 mm.
Humerus, diameter at middle of length, fore and aft	55 mm.	50 mm.
Humerus, diameter at middle of length, side to side	44 mm.	39 mm.
Humerus, width of lower end	85 mm.	70 mm.

MEASUREMENTS OF BONES OF CERVALCES AND ALCES—Concluded

	Cervalces	Alces
Radius, total length	450 mm.	350 mm.
Radius, diameter at middle of length, fore and aft	31 mm.	28 mm.
Radius, diameter at middle of length, side to side	55 mm.	46 mm.
Anterior cannon-bone, total length	355 mm.	306 mm.
Anterior cannon-bone, diameter at middle of length, fore and aft	37 mm.	37 mm.
Anterior cannon-bone, diameter at middle of length, side to side	40 mm.	37 mm.
Pelvis, greatest length	490 mm.	485 mm.
Pelvis, width in front	--	220 mm.
Pelvis, width at front and rear of acetabula	--	205 mm.
Pelvis, width at extreme rear	440 mm.	340 mm.
Femur, length from upper surface of head to internal condyle	--	392 mm.
Femur, diameter at middle of the length, fore and aft	51 mm.	41 mm.
Femur, diameter at middle of the length, side to side	45 mm.	40 mm.
Tibia, total length	512 mm.	466 mm.
Tibia, diameter at middle of the shaft, fore and aft	35 mm.	35 mm.
Tibia, diameter at middle of the shaft, side to side	47 mm.	42 mm.
Hinder cannon-bone, total length	421 mm.	353 mm.
Hinder cannon-bone, diameter at middle of length, fore and aft	38 mm.	33 mm.
Hinder cannon-bone, diameter at middle of length, side to side on inner face	36 mm.	30 mm.

Cervalces roosevelti Hay.

Roosevelt's Pleistocene Moose.

Of this species nothing is known except the right half of the brain-case and a part of the antler borne by it. This was found in a gravel pit at Denison, Crawford county, Iowa. The deposits were at one time supposed to belong to the Aftonian, but this opinion is not now regarded as certain. Professor Shimek informs the writer that he was misinformed regarding the place where the antler was found; and that, instead of coming from a pit beneath two beds of loess, it was obtained in another pit, in a terrace near the river over which no loess is deposited.

The specimen here described was first mentioned by Calvin in 1908 (Bull. Geol. Soc. Amer., Vol. XX, p. 350), who announced it as the antler of a large stag which had relationship with *Cervalces americanus,* the animal just described here as *C. scotti.* The present writer described and named the specimen in 1913 (Proc. Biol. Soc. Washington, Vol. XXVI, p. 5, fig. 1). In the study of this specimen comparison had been made with

the figures and measurements of the corresponding parts of the fine specimen of *Cervalces scotti* which is in the paleontological collection at Princeton University.

The portion of the skull present extends to the midline and along this a distance of 154 mm. It includes a part of the parietal, a part of the right squamosal, and the right frontal as far as the outlet of the olfactory nerve. Nearly one-half of the brain-case is therefore presented.

As will be seen from a photograph sent the writer by Calvin a short time before his death (Pl. XXXII, fig. 1), and another taken by the writer (same pl., fig 2), the antler stood on a pedicel of considerable length, the distance from the midline of the skull to the burr being 105 mm. The face, just in front of the antlers, had a width of 210 mm. The remarkable feature of the antler and that which especially distinguishes it from the antler of *Cervalces scotti,* is the length of the beam. The distance from the burr to the point where the upper border begins to rise is about 300 mm.; in the case of *C. scotti,* this distance is about 180 mm. At the same time the diameter of the beam at a distance of 100 mm. from the burr is slightly less in *Cervalces roosevelti* than in *C. scotti,* 52 mm., instead of 55 mm. The burr itself has a diameter of 65 mm. in the plane of the face, and of 68 mm. at right angles to it.

The beam is directed outward at nearly right angles with the median plane of the skull, rising possibly a little at first and farther out drooping slightly. The lower border continues outward straight to the limit of the specimen, 485 mm. from the midline of the skull, 380 mm. from the burr. How much farther the antler extended one cannot say, but doubtless it ended in a snag. As stated, at a point about 300 mm. from the burr, on the upper border, the ascending branch takes its origin. It is at first directed upward, then turns somewhat inward. From the lower border of the antler to the place where the ascending branch is broken off is a distance of 335 mm. Where the fracture is found the greatest diameter is 55 mm. and this, in a horizontal plane, is directed forward and outward. Above this the ascending branch probably divided and finally ended in snags, as in *C. scotti.* That border of this branch which is di-

rected inward is flattened and, at a height of 150 mm. above the lower border of the antler, is 65 mm. thick. This branch is connected outwardly with the horizontal branch by an expansion whose edge, 13 mm. thick, is broken away. This palmation begins at a point 180 mm. above the lower border of the antler, and its outwardly directed free border seems to have sloped downward and outward. Probably this palmation extended outward and corresponded to the horizontally directed one seen in *C. scotti;* but it must have been quite differently disposed. Just above the upper edge of this expansion, at a distance of 190 mm. above the lower border of the antler, the ascending branch gave off another division which appears to have been directed upward, backward, and outward; but there remains only the base, which has diameters of 60 mm. and 45 mm. This division may have subdivided, as in *C. scotti,* or it may have soon ended in a tine. It is very probable that the various divisions of the antler of this species might be homologized with those of the antler of *C. scotti,* but better materials are needed in order to do this.

Cervalces borealis Bensley is known from only the type specimen. This consists of the shaft of one antler, extending from the burr to just beyond the expansion. The total length of the fragment is 430 mm. The length from the burr to where the antler expanded is about 180 mm., perhaps a little more. The shaft is bent, so that distally the antlers evidently drooped considerably. The diameter of the shaft just beyond the burr is 68 mm., and nearly as much (65 mm.) near the point of expansion.

This specimen was found in the interglacial deposits at Toronto, Canada. These may belong to the Sangamon stage.

Genus ALCES Gray.

Antlers broadly palmated and with a rather short shaft. Nasal bones very short, far removed from the reduced premaxillaries and leaving in the skeleton the anterior nares open a distance equal to one-half the length of the head.

Of this genus there are recognized at present two distinct species. One, *Alces machlis,* inhabits northern Europe and Asia;

the other, *A. americanus,* the region extending from Labrador and Nova Scotia west to the Rocky mountains and north to Great Slave Lake and even Alaska.

Although the moose (*Alces americanus*) has not, so far as the writer knows, been found fossil within the limits of the state of Iowa, there is every reason to suppose that it will yet be discovered there. For this reason, but especially to enable comparison to be made between it and the species of Cervalces, the following remarks are made on it.

The genus Alces differs from Cervalces in having the nasal bones much reduced, so that they do not come into contact with the shortened premaxillæ and so that the nasal opening in the skeleton occupies about one-half of the length of the face. The antlers are broadly palmated, but they do not divide dichotomously, as they do in Cervalces, at least in *C. scotti.* The shaft of the antler of the moose is much shorter than that of Cervalces.

The moose attains a bulk about equal to that of the horse. The height at the shoulders may be as much as 2440 mm. (eight feet); the length, 2190 mm. (seven feet). The size is, however, usually smaller. The skull is long and narrow and the part of the upper jaw in front of the anterior premolar is considerably longer than the series of cheek-teeth. In this respect it resembles Cervalces, but differs from the elk. The length of the skull of a specimen in the U. S. National Museum, No. 111671, from Manitoba, is 560 mm., from the occipital condyles to the front of the premaxillæ. The width at the ear-opening is 165 mm.; at the zygomatic arches, 218 mm.; at the hinder border of the orbits, 232 mm. From the front of the premaxillæ to the front of the nasals is 255 mm.

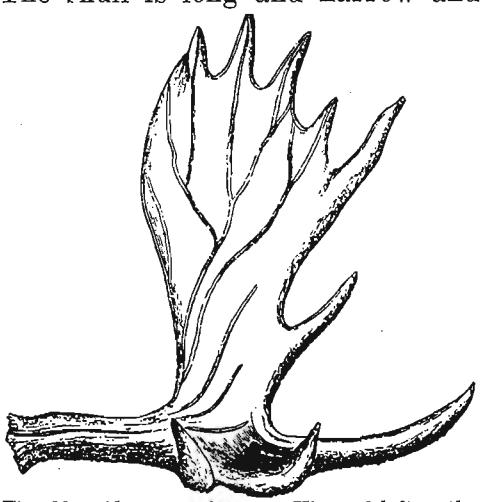

Fig. 93. *Alces americanus.* View of left antler from front. After Baird.

In the grown males the antlers form two enormous expansions, which are furnished on their front borders with numerous tines, or snags (Fig. 93). The shafts are short. The extent of the antlers (from outside to outside) may be more than four feet. The following measurements of the teeth are taken from the specimen mentioned above.

Length of the upper premolar-molar series, 147 mm.; of the upper premolar series, 67 mm.; of the upper molar series, 82 mm.

Length of the lower premolar-molar series, 163 mm.; of the lower premolar series, 67 mm.; of the molar series, 93 mm.

MEASUREMENTS OF THE SEPARATE TEETH.

Upper Teeth.

$Pm.^2$,	length	24 mm.
	width	21 mm.
$Pm.^3$,	length	23 mm.
	width	25 mm.
$Pm.^4$,	length	23 mm.
	width	28 mm.
$M.^1$,	length	26 mm.
	width	27 mm.
$M.^2$,	length	28 mm.
	width	29 mm.
$M.^3$,	length	28 mm.
	width	30 mm.

Lower Teeth.

$Pm._2$,	length	19 mm.
	width	14 mm.
$Pm._3$,	length	23 mm.
	width	17 mm.
$Pm._4$,	length	27 mm.
	width	18 mm.
$M._1$,	length	25 mm.
	width	20 mm.
$M._2$,	length	27 mm.
	width	22 mm.
$M._3$,	length	30 mm.
	width	22 mm.

On page 266, in the second column, there are given measurements of some of the principal bones of the skeleton of the

moose. These were taken from a specimen in the U. S. National Museum, but it is not a large individual and allowances must be made for this. These measurements will not usually enable one to distinguish Cervalces from Alces, but they will help to distinguish both from any other ruminant likely to be found in the region. When examined in detail many of the bones of *Cervalces scotti* differ from the corresponding ones of *Alces americanus,* but these differences cannot be given here.

Alces shimeki, new species.

The type of this species consists of a part of the left ramus of the lower jaw containing three teeth. These are the last premolar and the anterior two molars. The first molar has a part of its inner wall missing, but the other teeth are uninjured and in a medium stage of wear. The specimen was found in the Cox pit at Missouri Valley, Harrison county, and was mentioned by Calvin in his second paper on the Aftonian fauna (Bull. Geol. Soc. Amer., Vol. XXII, p. 211). The specimen bears the catalog number 249. The total length of the fragment is 93 mm. The height of the jaw at the front of $pm._4$ is 38 mm.; the thickness, 20 mm. The height at the rear of $m._2$ is 40 mm.; the thickness, 21 mm. The following are the measurements of the teeth present.

MEASUREMENTS OF TEETH.

Tooth	Length	Width
$Pm._4$,	19 mm.	14 mm.
$M._1$,	18 mm.	15±mm.
$M._2$,	20.5mm.	17 mm.

On comparing these teeth (Pl. XXXI, fig. 8; pl. XXXII, fig. 3) with those of the elk (*Cervus canadensis*) and those of the moose (*Alces americanus*), they are found to resemble more closely those of the latter. It is found on comparing the first and second molars of the elk and of the moose, that in the latter these teeth have the width equal to about eighty per cent

of the length; while in the elk the width of the first molar varies from sixty-seven per cent to seventy-four per cent; that of the second molar, from sixty per cent to sixty-four per cent. In the fossil here described the width of the first molar is about eighty-three per cent of the length; the width of the second molar, eighty per cent of the length. In the elk the plane of the inner cusps, or crescents, is nearly parallel with the axis of the row of teeth; while in the moose the plane of each inner cusp is directed strongly inward and backward. In the fossil it is directed backward and inward, but not so decidedly so as in *Alces americanus*. As a result, the styles in which the two inner cusps terminate posteriorly stand out more prominently from the face of the tooth than in the elk. In the fossil, as in the moose, a stalagmite-like column arises from the base of the tooth in the bottom of the outer valley between the two lobes of the two molars. These are not so well developed in the elk.

If we base an estimate on the relative sizes of the teeth of the two species the fossil moose here described had about three-fourths the height of the American moose.

This species is named in honor of Prof. Bohumil Shimek, of the University of Iowa, who has done so much to increase our knowledge of the loess deposits of the Mississippi valley.

From the Pleistocene of Whitman county, Washington, Professor Cope described (Amer. Naturalist, Vol. XXIII, pp. 162, 163, Feb.) two species of *Alces, A. brevitrabalis* and *A. semipalmatus*. These were based on antlers only, and it is therefore impossible to say what are their relationship to the species here described. In case that the fossil jaw found in Iowa shall be found to belong to one or the other of Cope's species, a result which is not probable, it will be easy to relegate the name *A. shimeki* to synonomy.

Genus RANGIFER Frisch.

Antlers present in both sexes of most species; placed nearer the occipital crest than to the orbits; more or less palmated, and furnished with brow tine; the brow tines of the two sides usually unlike, one large and directed in front of the face. A

bez, or second, tine present. Shaft of antler at middle of length bent forward and ending in a snagged palmation. Lower tines on front of shaft; the upper ones on its hinder border. Canine teeth present. Rather heavily built animals.

Fossil remains of one or more species of caribou have been reported from many parts of North America, usually under the name *Rangifer tarandus* (which name properly belongs only to an Old World species) or the name *R. caribou,* the Barren Ground Caribou of the colder parts of North America. Such remains have been found in Connecticut, New York, Ontario (Canada), New Jersey, Pennsylvania, Kentucky, Iowa, Nevada, Yukon, and Alaska. Inasmuch as the caribous of North America have been shown to belong to about eight species, it is not at all improbable that the fossil remains do not all belong to *R. caribou;* perhaps none of them. Indeed, it is quite certain that the bones and teeth found long ago at Muscatine, Iowa, belong to what is now an extinct species.

As to the age of the caribou remains found in the United States we cannot always be certain. Some of them undoubtedly belonged to Wisconsin or post-Wisconsin times. The scanty remains found at Toronto probably lived at some time between the Illinoian and the Wisconsin glacial stages. The same may be true of the Muscatine jaws and pieces of antlers. Other remains are quite certainly post-Wisconsin in age. It is rather remarkable that more numerous remains of this genus have not been found in the northern portion of the United States. During the Wisconsin stage and after the retreat of its ice-sheet there must have been a long period when the climate was favorable for the existence of these animals. Most frequently, perhaps it is the antlers that have been preserved; and doubtless they have often been mistaken for those of the elk or deer and not regarded as worth saving. Nevertheless, their remains seem not to be so abundant as those of the musk-oxen, the elk, or the giant beaver (Castoroides).

Inasmuch as bones belonging to members of the genus are likely to be found anywhere in the state, it is thought to be advisable to describe somewhat briefly the most important parts of the skeleton of some of the living species, in order that such

bones, teeth, and antlers may be distinguished from those of related animals.

The form usually assumed by the antlers is illustrated by figure 94. This figure, taken from Baird's Mammals of North America, shows two antlers of the right side. The one in front

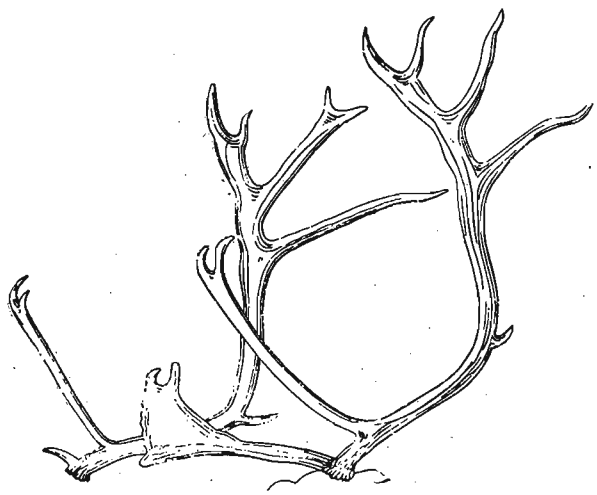

Fig. 94. *Rangifer arcticus.* Two antlers, seen from the side. The near one that of a male; the other probably of the female. The nose is directed toward the left.

belonged to a male and presents the palmated brow tine; the other, supposed to have belonged to a female, has the brow tine very short. There is much variation in the tines according to species, sex, and age.

The following measurements of the skull are taken from a specimen which was secured near Great Slave Lake, Manitoba, and is identified by Mr. N. H. Hollister, as *Rangifer arcticus arcticus*:

MEASUREMENTS OF THE SKULL.

Length of skull from rear of occipital condyles to front of premaxillae	390	mm.
Length of skull from lower border of foramen magnum to front of premaxillae	365	mm.
From front of posterior nares to front of premaxillae	250	mm.
From front of palatine, at midline, to front of premaxillae	183	mm.
From middle of line joining fronts of pm.^{2}, to front of premaxillae	136	mm.
From middle of occipital crest to line joining rear of orbits	120	mm.
From front of premaxillae to line joining rear of orbits	290	mm.
Width of skull, just above ear-openings	138	mm.
Width of skull, at rear of orbits	170	mm.

Width of skull, on maxillary ridge at maxillo-malar suture	117 mm.
Width of skull, at front of the maxillae	77 mm.
From front of nasals, at midline, to front of premaxillae	122 mm.
Length of lower jaw from incisive border to rear of condyles, in straight line	332 mm.
Length of lower jaw from incisive border to front of $pm._2$	125 mm.
Depth of lower jaw at front of $m._1$	36 mm.

The measurements in the first column are from the skull described above; those in the second column are taken from a specimen of *Rangifer caribou sylvestris,* from Manitoba, a larger species.

MEASUREMENTS OF THE TEETH.

Upper Teeth	Rangifer arcticus	R. caribou sylvestris
Length of premolar-molar series	93 mm.	106 mm.
Length of premolar series	43 mm.	49 mm.
Length of molar series	51 mm.	59 mm.
$Pm.^2$, length	13.5mm.	18.5mm.
width	14.5mm.	15.5mm.
$Pm.^3$, length	14 mm.	17 mm.
width	15 mm.	16 mm.
$Pm.^4$, length	14 mm.	17 mm.
width	16 mm.	16 mm.
$M.^1$, length	15 mm.	19 mm.
width	15 mm.	16 mm.
$M.^2$, length	17 mm.	20 mm.
width	17.5mm.	16.5mm.
$M.^3$, length	17 mm.	20 mm.
width	16.5mm.	16 mm.
Lower Teeth		
Length of premolar-molar series	101 mm.	108 mm.
Length of premolar series	44 mm.	45 mm.
Length of molar series	58 mm.	64 mm.
$Pm._2$, length	11.5mm.	11 mm.
width	7 mm.	8 mm.
$Pm._3$, length	15 mm.	18 mm.
width	9 mm.	10 mm.
$Pm._4$, length	16.5mm.	18 mm.
width	10.5mm.	11.5mm.
$M._1$, length	16 mm.	20 mm.
width	10 mm.	11 mm.
$M._2$, length	19 mm.	20 mm.
width	12 mm.	11.5mm.
$M._3$, length	23 mm.	24 mm.
width	11 mm.	12 mm.

The skull of the caribou differs from that of the elk in being considerably smaller, but relatively wider. The widest place at the orbits is not immediately at the rear, but at the suture across the post-orbital bar, which is itself much wider than in the elk. The orbits project more than in the elk. The nasal bones are much more expanded in the hinder half, and the ascending processes of the premaxillæ are much narrower than those of the elk. The latter bones do not come in contact with the nasals, but are separated from them by an accessory bone not found in other deer. The anterior nasal opening in the skull is about equal in length to the nasal bones; whereas, in the elk, it is much shorter than the nasals. The teeth of the caribous are much smaller than those of the elk, as may be seen on comparing the measurements.

The structure of the cheek-teeth, when they become well worn down, may be seen from the illustration of those of *Rangifer muscatinensis* (Pl. XXXIII, figs. 1, 2). The upper true molars are composed of two lobes, an anterior and a posterior; and each of these of two crescents, an outer and an inner. In their early condition each crescent forms a sharp cusp; while between the crescents of each lobe there is a deep unfilled cleft. On the inner face of the tooth there is a valley between the two lobes; on the outer, there are five descending folds of enamel, the styles. One of these is at the anterior outer angle of the tooth; another between the anterior and the posterior outer crescents; another at the hinder outer angle of the tooth. Down the middle of each of the outer cusps there runs a style, of which the hinder one is a little elevated. The premolars are composed of an outer and an inner crescent, or cusp, between which cusps is a deep cleft. The inner faces of these premolars are convex, while the outer faces are furnished with three conspicuous styles.

The lower true molars are thinner and more compressed teeth than the corresponding upper teeth. Each has its two lobes, each with two cusps, or crescents. In addition, the hinder molar has a small hinder third lobe, the talon, or heel. In these teeth the outer face has the valley between the lobes, while the five styles are on the inner face. Unlike the upper premolars,

the lower premolars, especially the two hinder ones, have nearly the same structure as the molars. The hinder lobe is, however, not yet completely developed.

As the teeth become worn down, the cusps become inflated and the crescent structure becomes more conspicuous. The whole surface of the tooth may lie at nearly the same level, the lines of enamel rising a little above the softer dentine.

The bones of the limbs of the reindeer are relatively shorter and thicker than in the other deer. The following measurements have been taken from an imperfect skeleton, No. 4176, in the U. S. National Museum:

MEASUREMENTS OF BONES OF CARIBOU.

Scapula, length parallel with the spine	280	mm.
Scapula, width across the dorsal border	175	mm.
Humerus, total length	256	mm.
Humerus, length from upper surface of the head	236	mm.
Humerus, from rear of head to the front of the bone	71	mm.
Humerus, diameter at middle of length, fore and aft	28	mm.
Humerus, diameter at middle of length, side to side	23	mm.
Humerus, diameter at the lower end, side to side, greatest	51	mm.
Humerus, diameter at the lower end, fore and aft, greatest	52	mm.
Ulna, total length, in a straight line	330	mm.
Ulna, depth of olecranon process	43	mm.
Radius, total length	280	mm.
Radius. width of the upper articulation	47	mm.
Radius, width at the middle of the length	26	mm.
Radius, width of the lower articulation	41	mm.
Femur, total length	300	mm.
Femur, diameter, through head to outer side of the bone	78	mm.
Femur, diameter at middle of length, fore and aft	25	mm.
Femur, diameter at middle of length, side to side	23	mm.
Femur, diameter across condyles, side to side	63	mm.
Femur, diameter across inner condyle, fore and aft	80	mm.
Tibia, total length	325	mm.
Tibia, diameter at upper end, side to side	72	mm.
Tibia, diameter at middle of length, fore and aft	22	mm.
Tibia, diameter at middle of length, side to side	27	mm.

Rangifer muscatinensis Leidy.

The species here described is based on a portion of a left upper jaw containing all the premolars and molars in good condition; a part of a left ramus of the lower jaw with the second premolar, the first molar and third molar represented by little more than the roots, and with the third and fourth premolars

and the second molar in good condition; and an uncharacteristic fragment of bone, probably a metapodial. These were found at some time before 1878, in what was supposed to be loess, in the city of Muscatine, Iowa, by Prof. F. M. Witter. These were sent to Dr. Joseph Leidy, at Philadelphia, who (Proc. Acad. Nat. Sci. Phila., 1879, p. 32) described the bones under the name of *Rangifer caribou*, being advised to do this by Dr. Elliott Coues, of Washington, to whom Doctor Leidy had applied for comparison of the fossil bones with those of the woodland caribou. Doctor Leidy quotes Doctor Coues as follows: "I think you may safely announce *Rangifer caribou* from the loess of Iowa." On May 24, 1878, Professor Witter read, before a meeting of the Iowa Academy, a communication on "Some geological features near Muscatine," in which he stated: "Almost the entire remains of *Rangifer caribou*, as identified by Dr. Joseph Leidy, were taken from the loess." This was not published until some time in 1880 (Proc. Iowa Acad. Sci., 1875-1880, p. 16). In his description of 1880 Leidy mentions other bones which were too much decomposed for preservation.

At the close of the description just mentioned Leidy makes this statement: "The fossil remains of the deer, at first supposed to belong to an extinct species, for which the name *Cervus muscatinensis* was suggested, were discovered in grading a street in the city of Muscatine." It appears quite necessary to believe that the deer here referred to was the one Leidy had just described as *Rangifer caribou;* McGee (Amer. Jour. Sci., Vol. XXXIV, 1887, p. 218) so understood Leidy's use of the name. Leidy did not accept the name himself, nor did he state who had suggested it. It could, however, hardly have been anyone else than Professor Witter himself. Inasmuch, however, as this is not certain, and as the name occurs in Doctor Leidy's paper, it seems necessary to credit it to him.

The jaws forming the type belong quite certainly to one individual and Leidy seems to have regarded them thus. They belonged to an animal, as stated by Leidy, which was past maturity. The grinding surfaces have, therefore, nearly reached the widest part of the tooth. The most obvious character belonging to them is that already noted by Leidy, the rela-

tively great size of the premolars. The following are the measurements which the teeth have furnished the writer. These are to be compared with the measurements furnished on page 276.

MEASUREMENTS OF TEETH.

Upper Teeth.		Lower Teeth.	
Length of premolar-molar series	98 mm.	Length of premolar-molar series, about	104 mm.
Length of premolar series	49 mm.	Length of premolar series	48 mm.
Length of molar series	52 mm.	Length of molar series, about	56 mm.
Pm.^{2}, length	16.5mm.	Pm.$_2$, length, about	13.5mm.
width	17 mm.	width, about	7 mm.
Pm.^{3}, length	16 mm.	Pm.$_3$, length	16.5mm.
width	18 mm.	width	12 mm.
Pm.^{4}, length	16 mm.	Pm.$_4$, length	18 mm.
width	17 mm.	width	13.5mm.
M.^{1}, length	17 mm.	M.$_1$, length	17 mm.
width	17 mm.	width	12.5mm.
M.^{2}, length	18 mm.	M.$_2$, length	20 mm.
width	18 mm.	width	13 mm.
M.^{3}, length	19 mm.	M.$_3$, length	----------
width	17 mm.	width	----------

On comparing the measurements of the teeth of *Rangifer muscatinensis* with those of *Rangifer arcticus*, the barren ground caribou, it will be seen that those of the latter, both upper and lower, are uniformly smaller. Especially are the lower teeth narrower than they are in the fossil. On comparing the teeth of the fossil species with those of *R. caribou sylvestris*, it is observed that the latter, too, has relatively large upper premolars. In these the length of the teeth, in both premolars and molars, exceeds that of *R. muscatinensis*, while the width is less. This gives them a very different form. The same statement is true regarding the lower teeth. The teeth of *R. muscatinensis* may then be said to be characterized, with respect to the living species mentioned, by their relatively great breadth.

Rangifer fortidens, a very large caribou described by Hollister (Smiths. Misc. Coll., Vol. LVI, No. 35, p. 3, pl. i, figs, 1, 1a) from Alberta, British America, has correspondingly large teeth. The premolars measure, however, only 52 mm., while the molars measure 62 mm. The individual upper premolars are hardly longer than those of *R. muscatinensis* and not wider. The molars, on the other hand, are considerably longer, but hardly wider. The hinder outer cusp (hypoconid) of the lower teeth of *R. muscatinensis* does not appear to have been cut off so much from the rest of the tooth as it is in *R. fortidens.*

Rangifer osborni, from British Columbia, has broad premolars, but they are much shorter than those of the fossil here described.

The writer believes that the remains on which the name *R. muscatinensis* is bestowed belonged to a species distinct from any now living; but, of course, it was closely related to them.

The writer has received from Professor J. L. Tilton a first dorsal vertebra and a part of a lower jaw, with the penultimate molar, of this species. It was found in a gravel pit at Avon.

The following, being portions of antlers only, can be referred provisionally to the species just described.

In the possession of Prof. B. Shimek, at the University of Iowa, is a fragment of a caribou antler which had been collected at Muscatine by Prof. F. M. Witter and presented by him to Professor Shimek. This is said to have been found in the loess at Neibert's brickyard, near Woodlawn and Orange streets. Shimek, however, does not think that it was found in the loess. For his statement regarding this see page 34.

This specimen is represented on plate XXXIII, figure 3. The length of the fragment is 135 mm.; from the base to the fork above the tine is 67 mm.; the diameter of the tine is 23 mm.

The number 352 of the collection at the University of Iowa, is given to the base of a caribou antler which was found in post-Kansan deposits at Correctionville, Woodbury county, Iowa. This is illustrated on plate XXXII, figure 4. The length of the fragment is 270 mm. Immediately above the hardly per-