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WITH

ACCOMPANYING PAPERS

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Report of the State Geologist

IOWA GEOLOGICAL SURVEY,
DES MOINES, December 31, 1912.

To Governor B. F. Carroll and Members of the Geological Board:

Gentlemen: I have the honor to report that during the year 1912 the work of the Iowa Geological Survey was carried forward in accordance with the plans approved by you at the beginning of the field season. Some new lines of work of great value to the state were begun, and some important investigations which were commenced in previous years were completed. The work of the Survey for the year 1912 may be summarized as follows:

AREAL GEOLOGY

Detailed areal work and geological mapping was begun in Audubon and Shelby, in Adair and in Lucas counties, and the surveys of Floyd and Clarke counties, upon which considerable work had already been done, were continued. The work in Audubon and Shelby counties was done by Prof. B. Shimek, in Adair county by Prof. J. E. Gow, in Floyd county by Prof. A. O. Thomas, in Clarke county by Prof. John L. Tilton, and in Lucas county by the Director of the Survey.

ROAD AND CONCRETE MATERIALS

Prof. S. W. Beyer and his assistants completed the field work on the road and concrete materials of the state. Some work in the laboratory has yet to be done before this important investigation will be completed. Professor Beyer will submit his manuscript for publication in 1913.

INDUSTRIAL WATERS

During the summer Professor Beyer with one field assistant began the study of the surface waters of Iowa in order to ascertain with definiteness their industrial applicability. Corporations and communities are in need of reliable information regarding the waters which are being used for industrial purposes. Undoubtedly great waste results where waters are used for purposes for which they are by no means adapted.

ARTESIAN WATERS

During the year a most thorough and valuable report on the artesian waters of the state was published by the Iowa Geological Survey in coöperation with the United States Geological Survey. This report is proving to be of great value to city officials, representatives of railways and other corporations, and to private citizens who are seeking information with reference to the water supplies of their respective localities. It is shown in this report that the underground waters of Iowa fall into two groups, namely, shallow or local waters and artesian waters. The former comprise those waters which are available for home, farm and village supply, and which commonly lie less than one hundred feet and rarely more than five hundred feet below the surface. They are usually obtained from bored, drilled, or driven wells and are fed directly by local rainfall, absorbed through the soils above. The artesian waters belong to rock strata below the country rock and circulate through the more permeable layers under greater or less pressure. Wells penetrating to these waters are artesian wells whether they flow at the surface or not.

Furthermore, the report shows that a sufficient knowledge of the attitude and nature of the deeper rocks of Iowa has been gained to permit satisfactory forecasts to be made in nearly all parts of the state relative to the depth at which artesian water may be found, its pressure, quantity, quality and availability for specific uses, and in the report forecasts are given for all towns of the state whose populations indicate that an artesian supply may be needed, and in which the artesian field has not been already fully exploited.

A part of the report deals with the chemical characters of the waters. The inorganic chemical substances have been determined in average and representative well waters in many localities of the state.

For the purposes of this report the state was divided into eight districts as follows: Northeast, East Central, Southeast, South Central, Central, North Central, Southwest and Northwest. Within each of these districts the county is taken as the unit. In connection with each county information is given with regard to the topography, geology, sources and distribution of the water supply, and the city and village supplies. Tables are given containing important facts in connection with the typical wells of the county.

The report was prepared by Prof. W. H. Norton and several collaborators. That part of the report dealing with the chemical characters of the waters was prepared by Professor Hendrixson.

THE DOLOMITES OF THE STATE

There is probably no place in the world where limestones and dolomites offer more interesting problems than in Iowa. The dolomites are the rocks which, near Maquoketa and elsewhere, are being used extensively for lime-making. They are, moreover, the rocks within which the lead and zinc deposits of Dubuque and adjacent areas are found. The Survey has undertaken a thorough study of these dolomites in order to ascertain not only their origin and composition but if possible their influence upon the deposition of metallic salts. The investigation has been undertaken by Francis M. Van Tuyl.

BIBLIOGRAPHY OF IOWA GEOLOGY

In the year 1894 the Iowa Geological Survey issued a bibliography of Iowa geology. The geological literature which has appeared since that date is so extensive that it seemed very desirable that a new bibliography be prepared. The Survey was fortunate in securing to prepare this new bibliography Dr. Charles Keyes, who was the author of the bibliography of 1894.

WATER POWER POSSIBILITIES IN IOWA

Before a safe statement can be made with regard to the water power possibilities in any state it is necessary to ascertain much detailed information as a result of investigations extending over several years. These investigations include:

First, daily stream gaging work at many places on the streams of the state for a period of years in order that the records may cover a cycle of low and high water periods of run-off.

Second, a detailed survey of the chief streams of the state including lakes and reservoir sites, dam sites, etc.

Third, the making of numerous discharge measurements at various times during the year and extending over a series of years at all the stations where gage readings are being made.

This kind of work requires the expenditure of fairly large sums of money. For instance, the State of Minnesota in coöperation with the United States Geological Survey has spent during the past few years about $53,000 in ascertaining the water power possibilities of that state. Last year Illinois spent more than $2,000 in this work and expects to spend an equivalent amount or more during each of several years. Up to the present time it has been possible for the Iowa Geological Survey to spend only a small sum for this important work. Three gaging stations have been maintained and some discharge measurements are being made each year. These stations are at Fort Dodge and Keosauqua on the Des Moines river and at Iowa Falls on the Iowa river. Readings are being made at Cedar Rapids by the Iowa Weather Bureau, and a gaging station is maintained by a private party at Stone City on the Wapsipinicon river. Unless additional appropriations are made available, it will be impossible to do more than is being done at present and it will be many years before complete and authoritative reports can be published.

Although complete data are not available for the State of Iowa, estimates have been made with regard to the water powers of some of the Iowa streams. Mr. M. O. Leighton, in the report of the Iowa State Drainage, Waterways and Conservation Commission, makes the following statements on page 122:

Drainage Systems	Max.H.P.	Min.H.P.
Western tributaries, Mississippi River	33,000	14,000
Northern tributaries, Missouri River	7,000	5,100
Des Moines River	194,000	52,300
Big Sioux River	2,800	1,500
Wapsipinicon River	10,700	4,380
Totals	247,500	77,280

With regard to what ought to be done in the way of legislation to protect the people of any state in connection with the water powers is a question, says Mr. W. G. Hoyt, of the Water Resources Branch of the United States Geological Survey, that is commanding the best thought and consideration of the people of this country. He says:

"The different States and Federal Government, it would seem to me, have been unable as yet to decide upon the best way of handling the whole proposition. In view of the many conflicting ideas on the subject, the safest method for a state to follow, in my mind, is to endeavor to make a detailed study regarding the water resources, in order that when the time comes for final settlement, all the facts of the case will be available."

It seems highly desirable that a detailed study be made of the water powers of Iowa, especially if legislation is introduced with a view to regulating water power as a public utility. If sufficient funds were available the study should include the following:

First. Collection of all existing facts regarding stream flow, river surveys, water power and water storage studies.

Second. The establishment of gaging stations on all the important streams of the state and the maintenance of them for a period of not less than ten years.

Third. The survey of all rivers which have not been surveyed in order that all the developed and undeveloped sites can be surveyed.

Fourth. The survey of possible reservoir sites in order that studies can be made regarding the future regulation of stream flow for power purposes and flood prevention.

Fifth. The publication of such data as are available either as preliminary reports from time to time or waiting a period of from three to five years and publishing one complete final report.

The Survey contemplates publishing as soon as sufficient facts are available a preliminary report on the water power possibilities of Iowa, but it is much to be desired that at an early date sufficient funds be appropriated to enable the Iowa Geological Survey to undertake the study of the streams of Iowa in as thorough a manner as is being done by some of our neighboring states.

CO-OPERATIVE TOPOGRAPHIC MAPPING*

For a number of years the United States Geological Survey, as a part of its work of mapping the area of the United States, has been making topographic maps of portions of Iowa and in recent years the Iowa Geological Survey has coöperated in this work of mapping our state. The areas covered by these maps are called quadrangles and are bounded by meridians of longitude and parallels of latitude rather than by political boundary lines. Hence they may include portions of two or three states, as in the case of the Elk Point sheet, which covers parts of Nebraska, South Dakota and Iowa. These maps, in addition to showing natural features, as rivers and lakes, and cultural features, such as towns, wagon roads and railroads, show by means of contour lines the elevations of the included area. The contour lines pass through all points having the same altitude, hence their closeness or distance indicates the steepness or flatness of the surface. All the topographic maps covering parts of Iowa have a contour interval of twenty feet; that is, the interval between contour lines represents a vertical distance of twenty feet on the ground.

Maps having a scale of 1:62500 cover an area one-fourth degree or fifteen minutes in length and breadth; that is, one-sixteenth of a square degree. The maps whose scale is 1:125000 are one-half degree in dimensions and have an area of one-fourth square degree.

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*Statement and table prepared by James H. Lees.

With a few exceptions, the maps are published on a sheet about 16x20 inches in size. The Omaha and vicinity sheet is 22x32 inches in size. In many cases an explanation of the maps is printed on the back of the sheet.

These maps may be purchased from the Iowa Geological Survey, Des Moines, or from the United States Geological Survey, Washington, D. C.

Name of Map	Counties in Iowa Included	Area in square miles	Scale	Price—cents
Amana[a]	Parts of Linn, Johnson, Iowa, Benton	222.50	1:62500	10
Ames	Parts of Hamilton, Story, Boone	221.65	1:62500	10
Anamosa[b]	Parts of Linn, Jones	221.65	1:62500	10
Baldwin[c]	Parts of Jackson, Clinton, Jones	221.65	1:62500	10
Canton (S. Dak.-Iowa)	Part of Lyon	870.90	1:125000	10
Cedar Rapids[a]	Parts of Linn, Johnson	222.50	1:62500	10
Clinton (Iowa-Ill.)[d]	Part of Clinton	222.50	1:62500	10
Cordova (Iowa-Ill.)[d]	Parts of Clinton, Scott	891.73	1:125000	10
Davenport (Iowa-Ill.)[e]	Part of Scott	223.36	1:62500	10
Decorah	Parts of Allamakee, Clayton, Fayette, Winneshiek	870.90	1:125000	10
Des Moines	Parts of Polk, Warren	223.33	1:62500	10
Dewitt[e]	Parts of Clinton, Scott	222.50	1:62500	10
Durant[e]	Parts of Scott, Muscatine, Cedar	223.36	1:62500	10
Elk Point (S. Dak.-Neb.-Iowa)	Parts of Sioux, Plymouth	877.91	1:125000	10
Elkader (Iowa-Wis.)	Parts of Dubuque, Delaware, Clayton	877.91	1:125000	10
Fairfax[a]	Parts of Linn, Johnson, Iowa, Benton	891.73	1:125000	10
Farley[b]	Parts of Dubuque, Jones, Linn, Delaware	884.85	1:125000	10
Goose Lake (Iowa-Ill.)[d]	Part of Clinton	222.50	1:62500	10
Iowa City[a]	Parts of Johnson, Washington	223.36	1:62500	10
Kahoka (Mo.-Iowa-Ill.)	Part of Lee	911.94	1:125000	10
Knoxville	Part of Marion	224.21	1:62500	10
Lancaster (Wis.-Iowa-Ill.)	Parts of Clayton, Dubuque	877.91	1:125000	10
LeClaire (Iowa-Ill.)[d]	Parts of Clinton, Scott	223.36	1:62500	10
Madrid	Parts of Boone, Polk, Dallas	222.50	1:62500	10
Maquoketa[c]	Parts of Jackson, Clinton	221.65	1:62500	10
Marion[f]	Part of Linn	221.65	1:62500	10
Mechanicsville[g]	Parts of Jones, Cedar, Johnson, Linn	222.50	1:62500	10
Milan	Part of Scott	224.21	1:62500	10
Milo	Parts of Marion, Warren, Polk	224.21	1:62500	10
Monticello[b]	Part of Jones	221.65	1:62500	10
Nebraska City (Neb.-Iowa-Mo.)	Part of Fremont	226.73	1:62500	10
Oelwein	Parts of Clayton, Delaware, Buchanan, Fayette	877.91	1:125000	10
Omaha and vicinity (Neb.-Iowa)	Parts of Pottawattamie, Mills	459.00	1:62500	20
Oxford[a]	Parts of Johnson, Washington, Keokuk, Iowa	223.36	1:62500	10
Pella	Parts of Mahaska, Marion	224.21	1:62500	10
Peosta (Iowa-Ill.)[c]	Parts of Dubuque, Jackson, Clinton, Jones	884.85	1:125000	10
Rock Island (Iowa-Ill.)[e]	Parts of Clinton, Scott, Muscatine, Cedar, Jones	891.73	1:125000	10
Savanna (Iowa-Ill.)	Parts of Jackson, Clinton	221.65	1:62500	10
Shellsburg[f]	Parts of Linn, Benton	221.65	1:62500	10
Slater	Parts of Story, Polk, Boone	222.50	1:62500	10
Stanwood[g]	Parts of Jones, Cedar, Muscatine, Johnson, Linn	891.73	1:125000	10
Tipton[g]	Parts of Jones, Cedar	222.50	1:62500	10
Waukee	Parts of Polk, Warren, Madison, Dallas	223.36	1:62500	10
Waukon (Iowa-Wis.)	Parts of Allamakee, Clayton	870.90	1:125000	10
West Liberty[g]	Parts of Cedar, Muscatine, Johnson	223.36	1:62500	10
Wheatland[e]	Parts of Clinton, Scott, Cedar, Jones	222.50	1:62500	10
Wilton Junction[g]	Parts of Cedar, Muscatine	223.36	1:62500	10
Winthrop[f]	Parts of Delaware, Linn, Benton, Buchanan	884.85	1:125000	10

LIST OF QUADRANGLES IN IOWA IN WHICH TOPOGRAPHIC MAPPING HAS BEEN WHOLLY OR PARTIALLY COMPLETED; MAPS NOT YET PUBLISHED.

Name of Map	Counties of Iowa Included	Area in square miles	Scale	Price—cents
Attica	Parts of Marion, Monroe, Lucas	225.06	1:62500	10
Boone	Parts of Hamilton, Boone, Webster	221.65	1:62500	10
Chariton	Parts of Marion, Lucas, Warren	225.06	1:62500	10

Total area surveyed	11,890
Total area of state	56,147
Percentage of total area of state surveyed	21

Note 1.—The scale of 1:62500 equals approximately one mile per inch. The scale of 1:125000 equals approximately two miles per inch.

Note 2.—A line of precise levels was run in 1905 by the United States Geological Survey along the line of the Chicago, Rock Island and Pacific Railway from Council Bluffs to Des Moines across Adel, Avoca, Casey, Des Moines, Fontanelle, Harlan, Marne, Neola, Panora, Waukee, Wiota, and Omaha and vicinity quadrangles.

Note 3.—Folios have been published by the United States Geological Survey describing the geology of Elk Point and Lancaster quadrangles.

Note 4.—The United States Geological Survey has published a map of Iowa, without contour lines, on a scale of 8 miles per inch. Size of map, 28½x41 inches. Price 20 cents.

[a]Amana, Cedar Rapids, Iowa City, and Oxford sheets, on scale of 1:62500, have been reduced and form Fairfax sheet, on scale of 1:125000.

[b]Anamosa and Monticello sheets, on scale of 1:62500, have been reduced and form parts of Farley sheet, on scale of 1:125000.

[c]Baldwin and Maquoketa sheets, on scale of 1:62500, have been reduced and form parts of Peosta sheet, on scale of 1:125000.

[d]Clinton, Goose Lake and LeClaire sheets, on scale of 1:62500, have been reduced and form parts of Cordova sheet, on scale of 1:125000.

[e]Davenport, Dewitt, Durant and Wheatland sheets, on scale of 1:62500, have been reduced and form Rock Island sheet, on scale of 1:125000.

[f]Marion and Shellsburg sheets, on scale of 1:62500, have been reduced and form parts of Winthrop sheet on scale of 1:125000.

[g]Mechanicsville, Tipton, West Liberty, and Wilton Junction sheets, on scale of 1:62500, have been reduced and form Stanwood sheet, on scale of 1:125000.

COAL INVESTIGATIONS

The Survey has already furnished much valuable information about the coals of the state. Detailed studies have been made in the field but much laboratory investigation of our coals remains to be done. Not only should more accurate information be obtained with respect to the composition of the coals of our state, but also with respect to the conditions which affect the best values of the coal, the effect of washing our coals, the rate of deterioration of coals, etc. The expansion of markets for Iowa coal is a matter of great importance to the coal industry and indirectly to the people of the whole state. It will be necessary in order to promote the expansion to remove certain misapprehensions as to the quality of the coal of Iowa and to point out the best methods of burning the coal to get the greatest efficiency. During the present year Prof. A. W. Hixson has begun some detailed chemical work on the coals of Iowa. When Professor Hixson's report is published it undoubtedly will be of great value to all persons who are interested in the coal industry of the state.

NATURAL HISTORY BULLETINS

Prof. L. H. Pammel is preparing a bulletin on the weeds of Iowa. Each weed will be described in detail, its distribution within the state will be shown, and methods of extermination will be given.

Prof. B. Shimek, who is an authority on the loess, is preparing a bulletin on the Mollusca of Iowa including not only those species that are living today but those that thrived during the time of deposition of the loess.

OIL AND GAS IN IOWA

From time to time for many years statements have appeared in the press with regard to oil and gas having been found in Iowa. Moreover, several thousands of dollars have been spent in prospecting for these minerals in different parts of the state, and numerous letters continue to be received by the officers of the Survey not only from citizens of Iowa but from persons living in other states asking for information as to whether or not oil and gas have been found or are likely to be found in commercial quantities within the state. While developments of recent years have added nothing new to what has been written about oil and gas in previous reports of the Survey, it may be well to review the conditions obtaining in Iowa with reference to this subject.*

*A considerable part of the statement regarding oil and gas was prepared by Mr. James H. Lees, Assistant State Geologist.

SYSTEM	SERIES	FORMATION NAME	COLUMNAR SECTION	THICKNESS IN FEET.	CHARACTER OF ROCKS
QUATERNARY	PLEISTOCENE	Wisconsin		0 - 30 +	BOWLDER CLAY, PALE YELLOW VERY CALCAREOUS.
		Peorian			SOIL BAND
		Iowan		0 - 30 +	BOWLDER CLAY, YELLOW, WITH VERY LARGE BOWLDERS.
		Sangamon			SOIL, PEAT AND FOREST BEDS.
		Illinoian		0 - 100 +	BOWLDER CLAY, YELLOW.
		Yarmouth			SOIL, PEAT AND FOREST BEDS.
		Kansan		0 - 400 +	BOWLDER CLAY, BLUE, JOINTED, WITH INTERCALATED STREAMS AND POCKETS OF SAND AND GRAVEL.
		Aftonian		0 - 40 +	PEAT & FOREST BEDS, SOIL BANDS, AQUEOUS GRAVELS.
		Nebraskan		0 - 30 +	BOWLDER CLAYS, DARK, FRIABLE.
CRETACEOUS	UPPER CRETACEOUS	Colorado		150	SHALES WITH SOFT LIMESTONES, IN PLACES CHALKY.
		Dakota		100	SANDSTONES.
PERMIAN		Fort Dodge		20	RED SHALES AND SANDSTONES.
				20	GYPSUM.
CARBONIFEROUS	PENNSYLVANIAN	Missouri		600	SHALES AND LIMESTONES.
		Des Moines		750	SHALES AND SANDSTONES WITH SOME BEDS OF LIMESTONE.
	MISSISSIPPIAN	St. Louis		100	LIMESTONE, SANDSTONE & MARLY SHALES.
		Osage or Augusta		265	LARGELY CRINOIDAL LIMESTONE, WITH HEAVY BANDS OF CHERT, SOME SHALE.
		Kinderhook		120	SHALE, SANDSTONE AND LIMESTONE, LIMESTONE IN PLACES OOLITIC.
DEVONIAN	UPPER DEVONIAN	State Quarry		(40)	LIMESTONE, MOSTLY BRACHIOPOD COQUINA
		Lime Creek		(120)	MOSTLY SHALES (LOCALLY DEVELOPED FEATURES EACH LYING UNCONFORMABLY ON THE MIDDLE DEVONIAN.)
		Sweetland Creek		(20)	SHALE
	MIDDLE DEVONIAN	Cedar Valley		100	LIMESTONES, SHALY LIMESTONES, SOME DOLOMITE IN THE NORTHERN COUNTIES.
		Wapsipinicon		60 - 75	LIMESTONES, SHALES, AND SHALY LIMESTONES.
SILURIAN	NIAGARAN	Gower		120	DOLOMITE, NOT VERY FOSSILIFEROUS, LE CLAIRE PHASE EXTENSIVELY CROSS-BEDDED.
		Hopkinton		220	DOLOMITE, VERY FOSSILIFEROUS IN PLACES.
ORDOVICIAN	CINCINNATIAN	Maquoketa		200	SHALE, SHALY LIMESTONES, AND, LOCALLY, BEDS OF DOLOMITE.
	MOHAWKIAN	Galena		340	DOLOMITE IN PLACES; IN PLACES UNALTERED LIMESTONES
		Platteville		90	MARLY SHALES AND LIMESTONES.
	CANADIAN	St. Peter		100	SANDSTONE.
		Prairie du Chien: Shakopee		80	DOLOMITE
		Prairie du Chien: New Richmond		20	SANDSTONE.
		Prairie du Chien: Oneota		150	DOLOMITE.
CAMBRIAN	POTSDAMIAN OR SARATOGAN	St. Croix: Jordan		100	COARSE SANDSTONE
		St. Croix: St. Lawrence		50	DOLOMITE MORE OR LESS ARENACEOUS.
		St. Croix: Dresbach		150	SANDSTONE, WITH BANDS OF GLAUCONITE.
ALGONKIAN	HURONIAN	Sioux Quartzite		25	QUARTZITE.

General Geological Section of Iowa.

An inspection of the accompanying geological chart will reveal the succession of the rocks of the Iowa column and their character. The rock at the base of the column—the Sioux Quartzite—is, for the most part, a dense, fine-grained rock built up of grains of sand closely cemented with a siliceous matrix. It is practically impervious to any liquid or gaseous substance which might be found in the earth's crust, and, so far as Iowa is concerned, is of unknown thickness. It was penetrated at Sioux City to a depth of seven hundred and fifty feet.

But even more significant than these facts is the evidence that at the time the sands of this age were being laid down on the sea bottom in Iowa there were practically no forms of life present in the waters. Since oil and gas are generally conceded to be from organic matter, plant and animal, which has suffered decomposition in the rocks, it is evident that in an age when living forms were scanty there could be little, if any, oil or gas formed in the rocks deposited during that time.

Beneath the Algonkian rocks are rocks of Archean age. These are dominantly igneous rocks and only subordinately sedimentary rocks. No form of life ever existed in igneous rock, and, so far as evidence indicates, life was never plentiful in the Archean sedimentary rocks. From these facts it is evident that in Iowa it is useless to seek for oil and gas below the top of the Sioux Quartzite.

Passing up the geological section it may be said that the rocks of the Saint Croix stage are for the most part rather barren of fossils, and that even had life been never so prolific it would have counted for but little since these rocks are largely sandstones and hence would serve as poor conservators of the life forms which might have been present when they were being formed. Sandstones form excellent reservoirs for oil and gas which have been generated from some underlying productive rock. But as has been shown, the underlying rock in this case—the Sioux Quartzite—was devoid of organisms so far as we can learn. Hence the Cambrian rocks in Iowa offer no more fruitful field for research than does the basement upon which they rest.

Overlying the Cambrian sandstones in Iowa come the dolomites of the Prairie du Chien stage and the Saint Peter sandstone, both of which are as barren of life forms as the rocks below them. Hence it may be said with assurance that it is hopeless to look for gas or oil below the top of the Saint Peter sandstone. However reliable this horizon and that of the Saint Croix sandstones may be as producers of artesian water—and they are our chief aquifers—they are equally as certain to bring only failure to the adventurer who pierces their depths with the expectation of getting therefrom commercial quantities of petroleum or natural gas.

To quote here from the discussion of this subject in the administrative report of Dr. Samuel Calvin, included in Volume XI of these reports:

Next in ascending order comes the Platteville (Trenton) limestone, a formation that was laid down on a sea bottom fairly crowded with swarming forms of life. This limestone is impure; it contains a large amount of clay mixed either with the materials forming the layers of stone or laid down as beds of shale between the more stony layers. The Platteville formation was deposited under exceedingly favorable conditions for making it a productive source of gas and oil. It still contains large quantities of bituminous matter which by the slow distillation always going on must yield annually considerable volumes of gaseous or liquid hydrocarbons. At all the exposures of the lower Platteville, from Dubuque northward, the dry shaly partings between the ledges of limestone afford material so rich in bitumen that it is easily lighted with a match; it burns freely and emits a strong oily odor. Bituminous shale, precisely like that seen in the natural exposures, was brought up from the horizon of the Platteville in the deep well at Washington, Iowa; it has been recognized in other deep wells; the same shale, rich in bitumen, probably underlies the greater part of the state.

If then a great amount of bitumen is stored up in the Platteville limestone and is constantly evolving gas and oil by slow distillation, why are not gas and oil wells as common in Iowa as in the productive regions of Ohio and Indiana? Let it be answered that something more than petroleum-bearing rock is needed in order that oil may be obtained in quantities of commercial importance. It has been estimated by Professor Orton that the rocks beneath the surface over a very large part of Ohio contain at least 3,000,000 barrels of oil to the square mile, and yet not one gallon of this can be secured by the drill without the concurrence of at least two other conditions: (1) There must be a porous reservoir—sandstone or porous limestone—in which the oil or gas may accumulate, and this must be covered with shale or other impervious deposit to prevent the hydrocarbons from escaping to the surface and becoming lost as fast as they are generated. But reservoir and cover alone will not insure a supply. So long as the rocks lie flat or have a uniform dip there will be no accumulations of any importance. (2) The reservoir and cover must present a series of folds beneath the arches of which the oil and gas are entrapped and accumulated under high pressure. Three conditions, therefore, must exist conjointly—the source of supply in some form of organic matter, the porous reservoir and impervious cover, and the arched or folded condition of the beds. It is the last of these conditions that is wanting in Iowa. Our stratified rocks are not folded to any noteworthy extent. The compression and crushing which gave rise to the Appalachian mountains produced folds as far west as Indiana, and then the effects fade out. Iowa is too far away from other centers of crustal disturbance, such as the Ozark region of Missouri or the great mountain axes of the west; and so the rocks are without the folds which are so essential to the accumulation of the fluent hydrocarbons.

Above the Platteville rocks there are several other formations in Iowa which represent petroleum-bearing rocks elsewhere in America. The Devonian, for example, is the productive horizon of Pennsylvania, while the lower beds of the Pennsylvanian series have yielded great quantities of both oil and gas in Kansas and Oklahoma. In the Iola and Neodesha fields of southern Kansas, for instance, the petroliferous beds are the basal strata of the Pennsylvanian, known here as the Cherokee shales. They are the equivalent in stratigraphic position and largely in composition of the lower part of the Des Moines stage of Iowa, that part which bears the most numerous, although not the most regular, coal beds. They are also coal-bearing in Kansas, but apparently are not so in the oil field.

These shales in their development in southern Kansas offer an apparent contradiction to the statement made above under the discussion of the necessary conditions for obtaining oil and gas. That is, the sandstones, "sands," which are the productive members, are not folded in synclines and anticlines, but the entire formation is monoclinal, with a dip to the northwest, caused doubtless by the Ozark uplift. The sandstones, however, occur either as lentils shut in by shale or as sandstone masses grading off laterally into shale. In either case they make excellent reservoirs and fulfil all the essential requirements for such purpose.

In Iowa, unfortunately, some of the conditions on which accumulation and recovery depend are absent, and no commercial quantities of oil or gas have been found in these horizons; indeed, no accumulations at all, so far as exploration has gone—and it must be conceded that it has been fairly thorough. Every deep boring, no matter what its primary object, is for the region involved and for the strata penetrated a test hole for oil and gas as much as for water or mineral or what not.

Since, as above stated, the Cherokee shales of the Kansas gas and oil belt extend into Iowa, these shales as developed in southern Iowa offer the best possibilities for finding the materials under discussion. But it must be borne in mind that the rocks of this stage are exposed immediately beneath the drift over a wide belt extending from Fort Dodge southeast into Missouri, and that no traces of these minerals have been found in this great area, and further that to the southwest, where the rocks are buried by later deposits, they have been penetrated by numerous drill holes with equally negative results. Furthermore, in Kansas the oil belt becomes less productive toward the north. All these facts seem to militate against the likelihood of oil or gas being found in this region. However, it is quite possible, especially in southwestern Iowa, that the geological conditions underlying Iola and Neodesha, Kansas, may exist in some limited areas which have not yet been explored by the drill.

There is one geological series in Iowa in which natural gas is known to occur and from which it has been utilized, namely, the Pleistocene, the series embracing the great drift sheets with their intercalated forest beds and other deposits. When the glaciers came down from the great northern snow fields they plowed up and overrode or incorporated into the load of detritus they were already carrying the forests and peat beds and other vegetation living upon the Iowa prairies. The gases evolved from the decomposition and distillation of these masses of vegetable matter in many cases found their way into pockets of sand and gravel buried in the sheets of bowlder clay which the glaciers left upon their disappearance. Some of these pockets have been tapped and usable quantities of gas found and put to use. The best known localities are in the neighborhood of Letts, Louisa county, and of Herndon in Guthrie county. These pockets have continued to yield gas for several years and have kept up the supply and pressure apparently undiminished. But from the nature of these deposits it can be seen that it would be useless to try to increase the supply by going deeper. Where this has been attempted as was done at Herndon about six years ago the outcome has been the only one which could reasonably be expected and which could have been prognosticated had the promotors of the scheme been willing to listen to reasonable arguments.

By way of summarizing what has been said regarding productive horizons, the following table extracted from Volume XII of these reports with slight additions may be inserted to show the geological distribution of oil and gas in the United States and Canada.

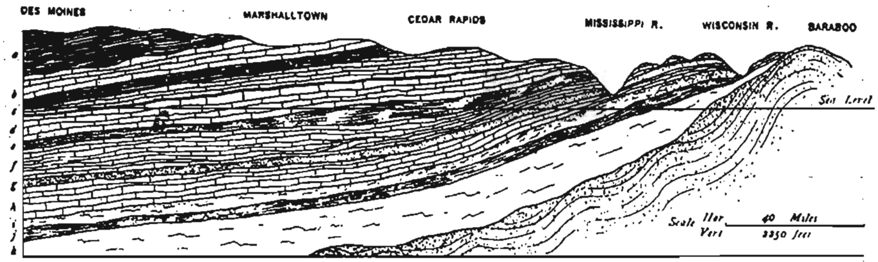
TABLE SHOWING THE GEOLOGICAL DISTRIBUTION OF OIL AND GAS.

Geological Periods.	Localities
Pleistocene or Quaternary	No productive oil wells in deposits of this period. Small reservoirs of gas, in the form of sealed in beds of sand or gravel, occur in the glacial deposits at Letts, Herndon and a few other points in Iowa.
Tertiary	Los Angeles and other oil-producing localities in California; Beaumont, Texas; Jennings, Louisiana; some oil fields in Wyoming; oil fields in Russia and in Peru.
Cretaceous	Florence, Boulder and Pikes Peak, Colorado; San Antonio, Elgin and Corsicana, Texas; some oil horizons in Wyoming and British Columbia.
Jurassic	In one field in Wyoming oil occurs in the Jurassic. No productive wells, however, are yet known to be supplied from reservoirs belonging to this formation.

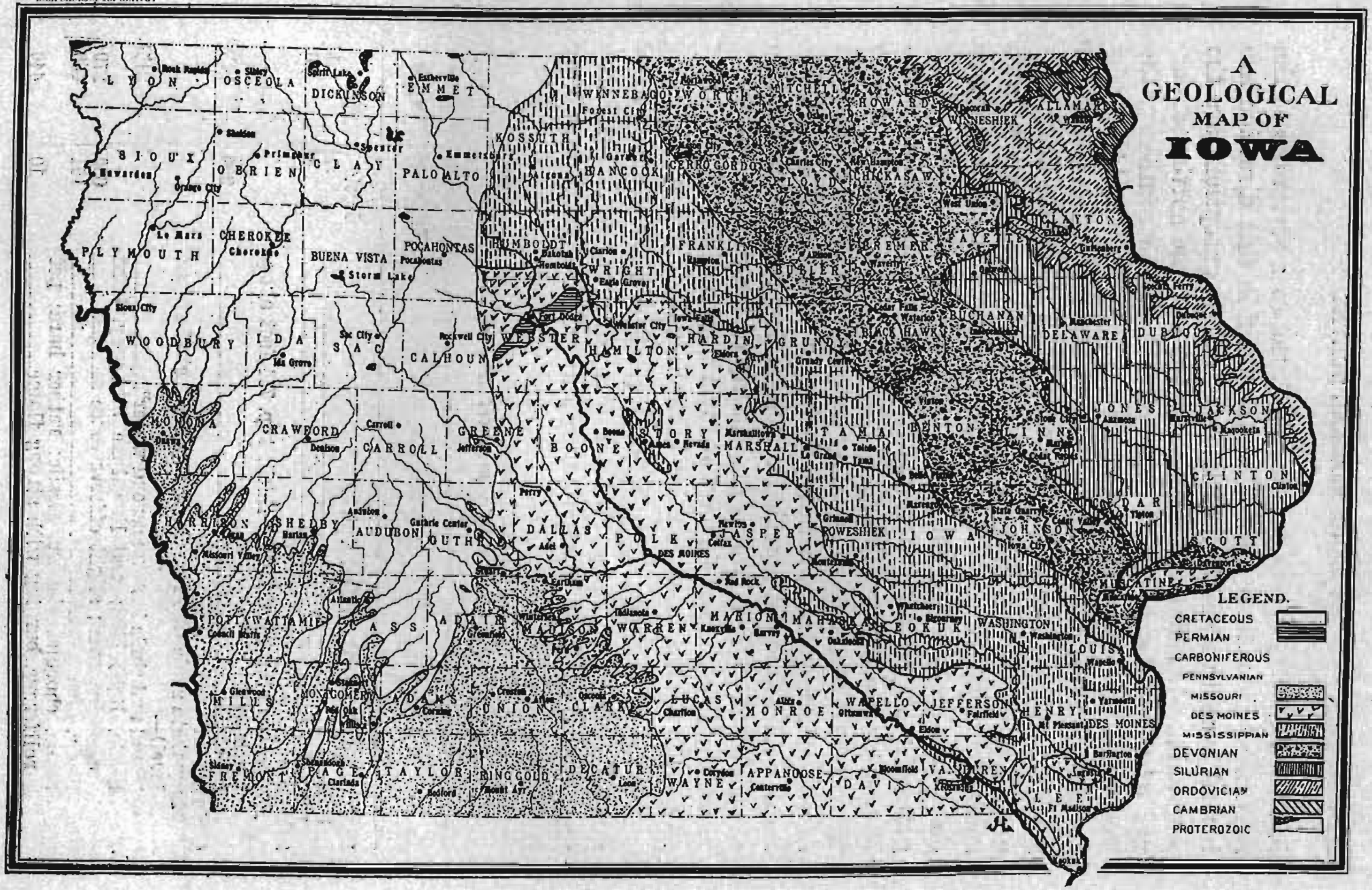
GEOLOGICAL DISTRIBUTION OF OIL AND GAS—Concluded

Geological Periods	Localities
Triassic	No known oil-producing horizons in the Triassic.
Carboniferous	*Upper Carboniferous.* Popo Agie field, Wyoming; field in northern Oklahoma; Neodesha, Chanute, etc., Kansas; in southeastern Illinois. *Lower Carboniferous.* Central Ohio; West Virginia; some in southeastern Illinois.
Devonian	Pennsylvania, western Ontario; some wells in central Ohio.
Silurian	No known productive wells, though oil occurs in the Medina sandstone in Canada, and the Niagara limestones about Chicago are, in places, saturated with oil. Some traces of oil at the same horizon in Cedar county, Iowa.
Ordovician	Oil and gas both abundant in certain localities, in the Trenton limestone, Gaspe, Canada; Lima and many other places in western Ohio; oil and gas fields in Indiana and Kentucky. Some Platteville shales in Iowa are rich in bitumen. In beds of Quebec age, Newfoundland.
Cambrian	No productive wells.
Algonkian	No probability and little possibility of productive wells.
Archean	No possibility of productive wells.

The accompanying sketch map of Iowa together with the geologic section may serve to elucidate the distribution and relations of the various formations discussed in this report. It will



Geological section from Baraboo, Wisconsin, to Des Moines, Iowa, showing the general stratigraphy of the region. The drift is not shown. The chief aquifers are the Saint Peter, the Jordan and the Dresbach sandstones. The line of juncture of the Dresbach sandstone and the Huronian is hypothetical. *a* Des Moines; *b* Mississippian; *c* Devonian; *d* Niagaran; *e* Maquoketa; *f* Galena-Platteville; *g* Saint Peter; *h* Prairie du Chien; *i* Jordan sandstone; *j* Saint Lawrence; *k* Dresbach.


A
GEOLOGICAL
MAP OF
IOWA
LEGEND.
CRETACEOUS
PERMIAN
CARBONIFEROUS
PENNSYLVANIAN
MISSOURI
DES MOINES
MISSISSIPPIAN
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
PROTEROZOIC

be seen that with a few exceptions all the rock series dip to the southwest from their area of outcrop and in this direction are buried beneath sediments of later age. The exceptions are the Algonkian—the Sioux Quartzite—in the extreme northwest corner of the state, whose surface pitches to the southeast, the Permian in Webster county which simply overlies older rocks and is not certainly known to exist elsewhere in Iowa, and the Cretaceous which in all its development in this state lies immediately under the Pleistocene deposits. In northwestern Iowa some of the intermediate formations are absent, and the younger ones overlap directly onto the oldest rocks with a great time gap between, as, for example, at Hull, where Cretaceous sandstones overlie truncated beds of Cambrian age. This is due to the reversal of the dip caused by the presence of the great mass of Algonkian quartzites which formed a shoreline during Cambrian and succeeding periods. These facts are mentioned to show that there is even less probability of the presence of reservoirs of oil or gas in this part of Iowa than to the south and east where the geological succession is much better developed.

A few well sections from different parts of the state may be of value to show the succession and character of the strata. The first well described is of peculiar interest in that it was sunk in the hope of finding oil.

Record of strata in prospect hole at Maquoketa.

	Thickness	Depth
	Feet	Feet
Residual and recent (6 feet thick):		
Soil	1½	1½
Clay, hard, yellow	4½	6
Silurian:		
Niagaran dolomite (209 feet thick; top, 754 feet above sea level)—		
Dolomite	209	215
Ordovician:		
Maquoketa shale (225 feet thick; top, 545 feet above sea level)—		
"Sand and shale in seam second water"	½	215½
Shale, light blue; and limestone blue-gray, hard, close textured; slight effervescence	63½	279
Shale, blue	151	430
Shale, chocolate-brown, fissile; rather hard; petroliferous, burning with strong flame	10	440

Record of strata in prospect hole at Maquoketa.

	Thickness	Depth
	Feet	Feet
Galena dolomite (255 feet thick; top, 320 feet above sea level)—		
Dolomite, porous, subcrystalline, gray; in log called "hard white shale"	46	486
Dolomite, light buff, crystalline; in log, "mixed lime and shale hard"	79	565
Dolomite, light buff, cherty; in angular sand	130	695
Decorah shale (15 feet thick; top, 65 feet above sea level)—		
Shale, bright green, fissile, fossiliferous; with dark gray, fossiliferous, nonmagnesian, pyritiferous limestone; log—"slate and shale"	15	710
Platteville limestone (46 feet thick; top, 50 feet above sea level)—		
Limestone, gray, earthy, compact, nonmagnesian	5	715
Limestone, brown, nonmagnesian, hard; in flaky chips	7	722
Limestone, light gray, soft, earthy	28	750
Shale, blue, plastic, with some chips of brown limestone; in log, "slate soft, blue" (Glenwood shale of Iowa State Survey)	6	756
Saint Peter sandstone (59 feet thick; top, 4 feet above sea level)—		
Sandstone, clean, white; grains well rounded, moderately coarse, many having diameter of 1 millimeter or more	59	815
Continental deposits of time interval between Shakopee and Saint Peter (?) (241 feet thick; top, 55 feet below sea level)—		
Sandstone, fine, brick-red; considerable red argillaceous or ferric admixture; when washed in hot water, drillings remain pink owing to films of ferric oxide on grains of quartz sand; grains rounded, many broken, said by driller to contain seams of red shale; in log, "red sandstone"	241	1,056
Oneota dolomite (54 feet thick; top, 296 feet below sea level)—		
Dolomite, light yellow-gray; with much dark red and dark brown hard fine-grained shale, some light green shale, a fine yellow quartz sand, a fragment of red fine-grained sandstone set with pieces of green shale; all except dolomite probably foreign, at 1056	54	1,110
"Shale, soft gray;" of log; sample supposed to represent this stratum consists of sand grains of Saint Peter facies, but with an occasional grain showing secondary enlargement; rather fine, with considerable foreign red and light green shale and some chert and chips of dolomite		

Record of strata in prospect hole at Maquoketa.

	Thickness	Depth
Cambrian:	Feet	Feet
Jordan sandstone (80 feet thick; 350 feet below sea level)—		
"Sandstone, soft water;" of log; sample said to represent this stratum consists for the most part of angular sand of light gray dolomite with some arenaceous admixture; a sample at 1,125 feet is of sandstone, some grains showing secondary enlargements, along with some chert and dolomite	80	1,190
Saint Lawrence formation (198 feet thick; top, 430 feet below sea level)—		
Dolomite, light yellow-gray	110	1,300
Dolomite, purple-brown	20	1,320
Dolomite, light gray	68	1,388
Dresbach sandstone (208 feet thick; top, 628 feet below sea level)—		
Sandstone, soft, white; grains well rounded, fairly uniform in size, largest 1 millimeter in diameter	208	1,596
Undifferentiated Cambrian strata (120 feet penetrated; top, 836 feet below sea level)—		
Sandstone; in buff sand with the appearance of dolomite to unaided eye, but seen under the microscope to consist of microscopic grains of crystalline quartz with dolomitic cement, along with some fine rounded grains of quartz sand and some glauconite at	----------	1,596
Sandstone as above, with some gray shale	54	1,650
Sandstone of same composition as above; white	45	1,695
Sandstone, fine-grained, light buff; in minute detached grains and in angular chips as above	5	1,700
Sandstone, white, clean, fine; grains imperfectly rounded, most grains from 0.0075 to 0.01 inch in diameter; "quicksand" of log	16	1,716

It may be noted in passing that the boring was carried nine hundred and sixty feet below the base of the Platteville, the lowest oil-bearing horizon in America.

For central Iowa there may be selected from the numerous deep wells of the region that drilled at Greenwood Park, Des Moines, as it goes lower than any of the others. It will be seen that it penetrates far into the Cambrian and so reaches through all productive horizons.

Record of strata in Greenwood Park well at Des Moines.

	Thickness	Depth
Pleistocene (14 feet thick; top, 872 feet above sea level):	Feet	Feet
Till, buff, sandy, with a few pebbles; noncalcareous	14	14
Carboniferous:		
Pennsylvanian—		
Des Moines stage (484 feet thick; top, 858 feet above sea level)—		
Shale, black, brittle, carbonaceous	1	15
Shale, gray, "fossiliferous"	1	16
Shale, black, carbonaceous, calcareous, highly pyritiferous	3	19
Shale, gray	4	23
Shale and limestone, bluish gray, highly fossiliferous	15	38
Shale, varicolored	67	105
Shale, bluish gray, highly and finely arenaceous, hard	10	115
Shale, bluish gray, slightly calcareous	60	175
Shale, dark drab and black, carbonaceous	11	186
Shales, gray, drab, and purplish; practically noncalcareous; 1 foot of grey chert at 284 feet	312	498
Mississippian—		
Saint Louis limestone and Osage stage (200 feet thick; top, 374 feet above sea level)—		
Chert and shale; heavy bed, very hard to drill; most of the sample is an argillo-calcareous powder; the shale is reported as caving in from above, but its calcareous nature indicates that it is in part interstratified with chert and limestone	170	668
Limestone and chert, brownish gray	30	698
Kinderhook stage (160 feet thick; top, 174 feet above sea level)—		
Shale, light blue and gray	40	738
Shale, terra cotta red, highly calcareous	10	748
Shale, light blue-gray	25	773
Shale, light gray, highly calcareous; fine cherty residue	85	858
Devonian (80 feet thick; top, 14 feet above sea level):		
Limestone, light buff; much gray chert	80	938
Silurian (507 feet thick; top, 66 feet below sea level):		
Limestone, light blue-gray, crystalline, saccharoidal; effervescence slow; considerable white gypsum	20	958
Limestone, cherty, crystalline, blue-gray; effervescence moderately rapid	53	1,011
Limestone, cherty, crystalline, saccharoidal, dark blue-gray and buff; effervescence indicates magnesian limestone, but not dolomite	97	1,208
Gypsum and shale; gypsum gray and white, in flakes; shale green, perhaps from above	15	1,223
Limestone, light blue-gray, highly seleniferous; some flakes of gypsum	145	1,368
Limestone, cherty, arenaceous; grains of sand, minute, rounded; much shale in rounded fragments, perhaps from above	22	1,390
Dolomite, buff, crystalline, granular with much chert and some chalcedonic silica; 3 samples	55	1,445

Record of strata in Greenwood Park well at Des Moines.

	Thickness	Depth
Ordovician:	Feet	Feet
Maquoketa shale (33 feet thick; top, 573 feet below sea level)—		
Shales; in large fragments; purplish yellow and green; noncalcareous; finely laminated	33	1,478
Galena dolomite to Platteville limestone (508 feet thick; top, 606 feet below sea level)—		
Dolomite; in yellow-gray powder; cherty	260	1,738
Dolomite, yellow, buff and brown; mostly cherty; residue finely quartzose; 5 samples	200	1,938
Shale, green, very slightly calcareous	8	1,946
Dolomite, brown, arenaceous	30	1,976
Shale, dark green, hard, "fossiliferous"; practically noncalcareous	10	1,986
Saint Peter sandstone (39 feet thick; top, 1,114 feet below sea level)—		
Sandstone, fine, white; grains moderately well rounded	39	2,025
Prairie du Chien stage—		
Shakopee dolomite (124 feet thick; top, 1,153 feet below sea level)—		
Shale; greenish powder of dolomite, chert, fine quartz sand, green shale, and pyrite	7	2,032
Dolomite, arenaceous, cherty	30	2,062
Shale, drab, calcareous; in finest powder; grains of buff, cherty dolomite	23	2,085
Dolomite, gray	5	2,090
Dolomite, gray; minute rounded vesicles resembling matrix of oolite from which grains have been dissolved	5	2,095
Dolomite	5	2,100
Shale; as at 2,085 feet, "exceedingly hard to drill"	40	2,140
New Richmond sandstone (94 feet thick; top, 1,277 feet below sea level)—		
Dolomite, arenaceous, gray; 2 samples	9	2,149
Shale, drab, calcareous	5	2,154
Sandstone, white, fine, calciferous	10	2,164
Dolomite, buff	8	2,172
Sandstone, clean white quartz sand; grains rounded	10	2,182
Dolomite, buff	15	2,197
Sandstone, buff; grains broken, much dolomite	11	2,208
Sandstone, friable, white, fine	2	2,210
Shale, drab, slightly calcareous	4	2,214
Sandstone, white	5	2,219
Dolomite, buff, white; much quartz sand	3	2,222
Shale	2	2,224
Sandstone, gray and buff, calciferous; most of grains broken	14	2,238
Shale, light blue	5	2,243
Oneota dolomite (175 feet thick; top, 1,371 feet below sea level)—		
Dolomite of various tints, many cherty; argillaceous at 2,250, 2,272, 2,333, 2,340 feet; arenaceous at 2,270 and 2,333 feet; at 2,305 feet there is 17 feet of white, blue and green chert; 32 samples	175	2,418

Record of strata in Greenwood Park well at Des Moines.

	Thickness	Depth
	Feet	Feet
Cambrian (582 feet penetrated; top, 1,546 feet below sea level):		
Sandstone, white; fine grains, mostly rough surfaced; some dolomite	12	2,430
Dolomite, brown; in chips	2	2,432
Sandstone	4	2,436
Dolomite, rough, gray and brown	4	2,440
Sandstone, fine, white and reddish; 3 samples	12	2,452
Shale, light blue-gray	2	2,454
Sandstone, calciferous, buff	4	2,458
Dolomite, arenaceous, gray, buff, and brown; 6 samples	30	2,488
Shale, light blue-gray	10	2,498
Dolomite, gray and buff, siliceous	9	2,507
Sandstone, gray, fine, calciferous	27	2,534
Marl, highly quartzose, dolomitic, argillaceous, yellowish powder; 2 samples	19	2,553
Sandstone, calciferous, gray and white; 3 samples	12	2,565
Sandstone; in sand and small chips superficially resembling dolomite; calciferous, glauconitic, close-grained; grains white, gray and buff; 10 samples	145	2,710
Shale and dolomite; shale hard, bright green, slaty; dolomite white, highly siliceous, with much greenish, translucent amorphous silica, 2 samples; over one-half of the second sample soluble in acid	20	2,730
Sandstone, buff; in powder, glauconiferous; rock is termed sandstone although composed chiefly of light colored particles which effervesce freely in acid; fragments of crystalline quartz form but a small proportion of the drillings	20	2,750
Sandstone, saccharoidal; dark with purplish tinge, dark color due to numerous grains of glauconite, purplish tinge to ferruginous stains on quartz sand; sand grains of crystalline silica, rough surfaced, imperfectly rounded, many fractured	130	2,880
Dolomite, dark gray, greenish, macrocrystalline, glauconiferous; sparingly arenaceous	5	2,885
Sandstone, greenish; grains microscopic	5	2,890
Shale, dull gray, fine-grained, and exceedingly finely laminated	5	2,895
Sandstone, glauconiferous, calciferous; grains imperfectly rounded, with hard, dark green slaty shale	15	2,910
Marl; in buff flour; microscopically arenaceous; calciferous; glauconiferous	50	2,960
Marl, pink; calciferous, arenaceous; one-third of drillings by weight insoluble in acid; to bottom of well	40	3,000

In southwestern Iowa there are several wells of considerable depth, but since the dip of the stratified rocks carries these to great depths in this part of the state the lowest formations are not reached. However, the well at Dunlap, Harrison county, 1,535¾ feet deep, reaches the Ordovician. The deep well at the

Institution for Feeble-minded Children at Glenwood, Mills county, 1,910 feet deep, penetrates the Mississipian strata for about 800 feet, and the prospect well at Bedford, Taylor county, 2,400 feet deep, pierces the Silurian rocks for 575 feet. It may be added that at Nebraska City, just over the river from the southwest corner of Iowa, a test hole was drilled to a depth of 2,870 feet, passing through the Saint Peter sandstone and so testing all possible productive zones. Since, as above stated, the productive horizons of the states to the southwest of Iowa lie in the Pennsylvanian series, it will be seen that these horizons have been penetrated in all these wells as well as in numerous other deep wells of the region.

Record of strata of deep well at Bedford.

	Thickness	Depth
	Feet	Feet
Pleistocene:		
Drift, no samples or record	38	38
Carboniferous:		
Pennsylvanian—		
Missouri stage (722 feet thick; top, 1,060 feet above sea level)—		
Limestone, light gray, nonmagnesian, soft; earthy luster; permeated with minute ramifying, smooth-surfaced masses of calcite	6	44
Limestone, argillaceous, light gray, soft; earthy luster; and shale, plastic	6	50
Shale, drab, unctuous, noncalcareous; 8 samples	40	90
Shale, bluish drab, calcareous	5	95
Limestone, earthy, light blue-gray	5	100
Shale, drab, calcareous; 3 samples	15	115
Limestone, light blue-gray, soft, argillaceous; with shale	5	120
Shale, drab, calcareous	5	125
Limestone and shale; limestone, soft, whitish; rapid effervescence; numerous Fusulina; encrinital; 5 samples	25	150
Limestone, light gray, soft, earthy; a little chert	5	155
Shale, greenish drab; some limestone with crinoid stems	10	165
Shale, as above; some black, carbonaceous and a little blue-gray limestone	5	170
Limestone, light brown, white, gray, hard, compact; and greenish shale	5	175
Limestone; light blue-gray, argillaceous; and light yellow-gray with crinoid fragments; greenish shale	5	180
Limestone, yellow, gray, hard	5	185
Shale, dark brick-red, calcareous; 2 samples	10	195
Shale; greenish drab, calcareous, siliceous; and ocher-yellow, hard, siliceous, calcareous; 2 samples	10	205
Shale, hard, greenish drab; so highly siliceous with minute particles of quartz that it might be termed an argillaceous sandstone	5	210

Record of strata of deep well at Bedford—Continued.

	Thickness	Depth
	Feet	Feet
Shale, greenish drab, plastic, pyritiferous; some hard, yellow, fossiliferous limestone	15	225
Shale, blue-drab, soft, laminated; harder siliceous layers	25	250
Shale, drab, laminated; 6 samples	30	280
Shale, drab, with some laminae of black coaly shale	5	285
Shale, green, fossiliferous	5	290
Shale, green, fossiliferous; some drab limestone and chert	5	295
Shale, hard, red; 2 samples	5	300
Limestone, hard, drab, with shale	10	310
Shale, drab, fossiliferous	10	320
Limestone, hard, fine-grained, siliceous	5	325
Limestone, yellow-gray; and white, soft; earthy luster; 3 samples	15	340
Shale, green and black, carbonaceous	5	345
Limestone, soft, yellow, macrocrystalline	10	355
Shale, drab; 5 samples	25	380
Shale, drab; some drab limestone	5	385
Shale, drab; with sand of flinty drab limestone	5	390
Shale, reddish; with dark green-gray argillaceous limestone	5	395
Shale, red; a little brown siliceous limestone	10	405
Shale, drab; 4 samples	15	420
Limestone, light yellow-gray; crystalline in sand; 4 samples	20	440
Shale, greenish drab	10	450
Limestone, light yellow-gray; much shale	5	455
Shale, greenish; some drab limestone, flinty	10	465
Limestone, light yellow-gray	10	475
Shale, drab; 4 samples	20	495
Limestone, white; large fragments of shale	21	516
Shale, drab; some black at 516, with limestone at 525; 4 samples	19	535
Limestone, white and gray	15	550
Shale, black, fissile, combustible; and hard, gray limestone	5	555
Shale, dark drab	10	565
Shale, greenish; with white limestone in concreted powder	5	570
Sandstone, white; microscopic grain; calciferous; with shale	5	575
Limestone, white and light gray	10	585
Shale, dark drab	5	590
Limestone, hard, gray, siliceous; shale	5	595
Shale, dark drab	5	600
Limestone, yellow-gray, rather hard; much shale in large fragments	15	615
Shale, dark drab; nodules and masses of gray chert	15	630
Shale, light brown, calcareous	5	635
Shale, greenish; with gray limestone and chert	5	640
Limestone, gray; much shale	5	645
Shale, drab; black at 645; gritty at 650 and 655; with limestone at 670; sandy at 670, 675, 695, 700; coaly at 705	65	710

Record of strata of deep well at Bedford—Continued.

	Thickness	Depth
	Feet	Feet
Sandstone, fine, gray; 3 samples	15	725
Shale, dark drab; some black; fissile	10	735
Limestone, gray, finely arenaceous	10	745
Shale, drab and reddish brown; 2 samples	10	755
Limestone, light gray	5	760
Des Moines stage (580 feet thick; top, 338 feet above sea level)—		
Shale, varicolored; highly arenaceous at 765 and 770; reddish brown at 785, 790, 940 and 1,065; black at 855, 1,045, 1,055 and 1,060	400	1,160
Sandstone; drillings mostly shale	5	1,165
Shale, black	15	1,180
Sandstone, fine, white; much shale in drillings; 8 samples	40	1,220
Shale	5	1,225
Sandstone	10	1,235
Sandstone, in fine gray meal, the particles of which resemble flint macroscopically but are composed of minute quartzose grains with considerable yellow chert at 1,250, with considerable shale in all drillings; 10 samples	50	1,285
Sandstone, clean, fine, yellow-gray, composed of minute irregular grains	5	1,290
Sandstone, coarser; some grains reaching 1 mm. in diameter	5	1,295
Sandstone, green-gray, fine-grained	5	1,300
Sandstone, yellow-gray, coarser; grains irregular in shape and far from uniform in size	5	1,305
Sandstone, fine, blue-gray; shale in drillings probably from above	35	1,340
Mississippian (355 feet thick; top, 242 feet below sea level)—		
Limestone, gray; rapid effervescence	5	1,345
Limestone, yellow-white, soft; earthy; 4 samples	20	1,365
Limestone, gray, rather hard, conchoidal fracture; lithographic texture	15	1,380
Limestone, soft, gray, earthy, argillaceous	20	1,400
Limestone; as above; and gray, fine-grained sandstone	5	1,405
Limestone, light drab, argillaceous	20	1,425
Limestone and chert; drillings largely chert and chalcedonic silica	10	1,435
Limestone, drab; less chalcedony	5	1,440
Chert, white and gray; in places brown, and limestone, often siliceous; 17 samples	85	1,525
Limestone, soft, gray, earthy; a little chert	5	1,530
Limestone, soft, white and light gray; saccharoidal; some chert	5	1,535
Chert and limestone; limestone nonmagnesian; 14 samples	85	1,620
Limestone, buff; slow effervescence; much gray chert	5	1,625
Limestone, brown; moderate effervescence	5	1,630
Limestone, brown; rapid effervescence, calcite crystals	15	1,645
Limestone, gray, oolitic; rapid effervescence; 4 samples	20	1,665
Shale, blue, fine-grained, gritless, calcareous; in concreted powder; 6 samples (Kinderhook)	30	1,695

Record of strata of deep well at Bedford—Continued.

	Thickness	Depth
	Feet	Feet
Devonian (130 feet thick; top 597 feet below sea level):		
Limestone, light gray; rapid effervescence	10	1,705
Limestone, light blue-gray, compact, fine-grained; in thin flaky chips	10	1,715
Limestone, yellow; in sand; rapid effervescence	15	1,730
Shale, drab, clayey, highly calcareous	5	1,735
Limestone; white and mottled gray at 1,735; gray from 1,740-1,755; buff at 1,755 and 1,760; light gray, subcrystalline, dense at 1,765 and 1,770; all of rapid effervescence	40	1,775
Shale, or highly argillaceous limestone; gray, in nonconcreted powder	10	1,785
Limestone; buff; in fine meal; rapid effervescence	15	1,800
Limestone, gray; in fine meal; rapid effervescence; argillaceous at 1,810; 5 samples	25	1,825
Silurian (575 feet thick; top, 727 feet below sea level):		
Limestone and shale; limestone, gray in meal, rapid effervescence; shale, brick-red, highly pyritiferous, in fine meal, and powder not concreted; some fine ill-rounded quartz grains at 1,830; color of mass of drillings, brick-red	20	1,845
Limestone, yellow; drillings pink from admixture with fine meal and powder of red shale, probably from 1,825; limestone in meal and sand, crystalline; rapid effervescence; some irregular rounded quartz grains in drillings which also may be from above; 14 samples	70	1,915
Dolomite, dark gray; in fine crystalline meal; some calcite	20	1,935
Dolomite, buff	10	1,945
Dolomite, dark gray, argillaceous	5	1,950
Unknown; drillings washed away	20	1,970
Dolomite, light brown; in crystalline meal	7	--------
Marl, in fine white powder, not concreted; calciferous, argillaceous; large amount of anhydrite	4	2,009
Dolomite, as at 1,970; calcite rhombs and a few crystals of anhydrite	6	2,015
Dolomite, light yellow; in finest crystalline meal; numerous crystals of anhydrite	20	2,035
Dolomite, light brown; in floury meal; residue of anhydrite	35	2,070
Dolomite, light greenish gray, argillaceous; much anhydrite and dolomitic marl	5	2,075
Dolomite, light gray, less argillaceous; considerable anhydrite	10	2,085
Dolomite, bright yellow; in meal; considerable anhydrite	15	2,100
Dolomite, brown; in coarser meal	5	2,105
Dolomite, light brown; in much finer meal; anhydrite rather plentiful	--------	2,105
Limestone; somewhat magnesian, judging from effervescence; light yellow and buff; argillaceous; some anhydrite in drillings	15	2,160
Dolomite, buff; in fine crystalline, sparkling meal	8	2,168
Dolomite, light gray, argillaceous; in finest powder, not concreted	2	2,170
Dolomite; in fine brown or yellow meal, not concreted; some anhydrite	35	2,205

Record of strata of deep well at Bedford—Concluded.

	Thickness	Depth
	Feet	Feet
Anhydrite marl; in light cream-colored or whitish powder; 10 samples	55	2,260
Anhydrite marl; in bright buff powder; dolomite	20	2,280
Anhydrite marl, cream-colored; 9 samples	45	2,325
Dolomite and anhydrite; in fine buff meal	15	2,340
Anhydrite marl, argillaceous; in yellow powder	10	2,350
Shale, slightly calcareous and gypseous; in gray powder	5	2,355
Dolomite, light buff; in fine meal	5	2,360
Shale, calcareous; in gray powder	5	2,365
Dolomite; in fine buff meal	5	2,370
Limestone, magnesian, or dolomite; in gray powder and meal; residue argillaceous and cherty and with considerable anhydrite	15	2,385
Dolomite, buff; in angular sand	10	2,395
Shale, calcareous; considerable anhydrite	5	2,400

In southeastern Iowa there is evidence of upwarps of the nature of low domes in which the older terranes are much nearer to the surface than they would have been if the dome structure were absent. This dome or anticlinal structure is, as has been already stated, one of the favorable conditions for the accumulation of oil and gas. Yet in none of the several artesian wells that have been sunk in southeastern Iowa has any oil or gas been found. Whether or not oil or gas will be found in low anticlines which may exist between points already penetrated by deep wells, remains to be proved.

The section of the deep well in Crapo Park at Burlington will serve to show the character of the rock strata in this part of the state.

Record of strata in Crapo Park well at Burlington.

	Thickness	Depth
	Feet	Feet
Pleistocene:		
Loess and drift	18	18
Carboniferous:		
Mississippian (422 feet thick; top, 667 feet above sea level)—		
Limestone, buff; effervescence rather slow; some chert in small chips	23	41
Limestone, buff and white, granular; rapid effervescence	37	78
Limestone, light yellow; in fine meal; rapid effervescence; some chert	19	97

Record of strata in Crapo Park well at Burlington.

	Thickness	Depth
	Feet	Feet
Limestone, buff; in fine meal and flour; rapid effervescence; some chert	13	110
Limestone, magnesian or dolomite, blue-gray, crystalline	39	149
Shale, blue and drab (Kinderhook)	291	440
Devonian and Silurian (140 feet thick; top, 245 feet above sea level)		
Limestone; in light gray, highly argillaceous powder; rapid effervescence	140	580
Ordovician:		
Maquoketa shale (108 feet thick; top, 105 feet above sea level):		
Shale, light gray, highly calcareous; in powder	38	618
Shale, drab	70	688
Galena dolomite and Platteville limestone (257 feet thick; top, 3 feet below sea level)—		
Dolomite, light buff, crystalline-granular; with hard brown bituminous shale at 868 feet; 5 samples	207	895
Limestone, buff, finely granular; rapid effervescence	31	926
Dolomite, light yellow; in sand and powder	19	945
Saint Peter sandstone (120 feet thick; top, 260 feet below sea level)—		
Sandstone, fine-grained, white; some limestone; grains of considerable range in size, moderately well rounded	10	955
Sandstone, clean, white; somewhat coarser than above	45	1,000
Sandstone; as above; much hard, green shale like the basal shale of the Platteville limestone	40	1,040
Sandstone, clean, white; largest grains reach 0.7 millimeter in diameter	10	1,050
Sandstone; as above; largest grains slightly exceed 1 millimeter in diameter	15	1,065
Prairie du Chien stage (565 feet thick; top, 380 feet below sea level)—		
Dolomite, light gray; some chert	35	1,100
Marl, white and pink, highly dolomitic; large residue of fine quartz sand and argillaceous material and flakes of chert; 3 samples	235	1,335
Dolomite; in fine, light yellow, crystalline meal	15	1,350
Sandstone and pink oolitic chert	10	1,360
Dolomite, arenaceous, or sandstone, calcareous, all in fine, yellow sand	20	1,380
Dolomite, light yellow, highly arenaceous; angular grains of pure dolomite and rounded grains of quartz sand	20	1,400
Marl, white; residue minutely quartzose	10	1,410
Chert and dolomite	9	1,419
Dolomite, buff and light gray; in fine sand; cherty; 4 samples	56	1,475
Unknown; drillings washed away	44	1,519
Dolomite and chert	6	1,525
Chert and dolomite, gray	20	1,545
Dolomite, gray, cherty, and arenaceous	25	1,570
Dolomite, light brown, cherty	15	1,585
Dolomite, gray, cherty	45	1,630

Record of strata in Crapo Park well at Burlington.

	Thickness	Depth
	Feet	Feet
Cambrian:		
Jordan sandstone, Saint Lawrence formation, and underlying Cambrian strata (800 feet penetrated; top, 945 feet below sea level)—		
Unknown, drillings washed away	40	1,670
Sandstone, clean; grains well rounded; largest reaching 1 millimeter in diameter	20	1,690
Sandstone, calcareous, or dolomite, arenaceous, buff; dolomite in angular particles with rounded quartz grains	35	1,725
Unknown; drillings washed away	275	2,000
Sandstone, light gray, in fine angular meal; minute grains of quartz and of glauconite with dolomitic cement or matrix; 4 samples	95	2,095
Dolomite, gray; in fine chips, minutely quartzose, 3 samples	35	2,130
Sandstone; as from 2,000-2,095 feet; brownish, highly glauconiferous	95	2,225
Sandstone; fine grains of clear quartz, some pink, some with secondary enlargements	10	2,235
Sandstone, gray, glauconiferous, calciferous; grains varying in size, some being large and well rounded	35	2,270
Sandstone; as from 2,000 to 2,095 feet	5	2,275
Sandstone; in loose grains of clear quartz, largest, diameter of 1 millimeter	85	2,360
Unknown; drillings washed away	40	2,400
Sandstone, dark brown, glauconiferous; in rounded grains and minute siliceous particles; chips of drillings have rough surfaces (due to projecting granules) and not the smooth fractures of quartzite Sandstone, yellow; in chips of minute grains of quartz and glauconite and some rounded quartz grains, embedded in dolomitic matrix or cement; chips crumble easily after digestion in acid; drillings contain considerable hard green shale	5	2,400 2,405
Sandstone, buff, calciferous, glauconiferous; much hard green shale	5	2,410
Sandstone, buff, calciferous, glauconiferous; much green and reddish shale	10	2,420
Shale, hard, dark green and reddish, fissile; and sandstone, calciferous and glauconiferous; in angular chips; grains minute and angular	10	2,430

By way of summary it may be stated that oil in commercial quantities has never been found in Iowa. Gas has been found and no doubt will continue to be found in various parts of the state in small quantities in sands and gravels of Pleistocene age. At no time has the Survey made the statement that oil and gas will never be found in commercial quantities in the indurated rocks of Iowa. But the Survey has asserted and continues to assert that all the evidence that has been gained from a study of the geology of the state, especially in connection with the many deep wells that have been drilled in efforts to get supplies of water, points consistently to the conclusion that it would be a waste of money and effort to drill deep wells with the sole purpose of obtaining commercial quantities of either oil or gas. It is an erroneous notion held by some people that it is necessary only to bore deep enough to get supplies of petroleum and natural gas in any desired quantities and in any locality.

It is the function of the Survey to encourage the development of the resources of the state. But it is also the function of the Survey to furnish such information to the people of the state as will discourage them from investing large sums of money in enterprises which are not even speculations but which from their very nature are doomed to failure.

PLEISTOCENE MAMMALS OF IOWA

For many years, parts of the skeletons of extinct mammals have been found in the Pleistocene deposits of Iowa. But it has been chiefly within the last ten years that many of the most interesting discoveries have been made. Among these are included many well preserved fossils of mastodons, mammoths, horses, camels, sloths, bear and other animals that were found in the Aftonian gravels of western Iowa, and which have been discussed at considerable length by Professor Shimek in the report of the geology of Harrison and Monona counties, published in Volume XX of the publications of the Survey. Moreover, the Aftonian remains have been described somewhat fully by Dr. Samuel Calvin in two papers published in volume twenty and volume twenty-two of the Bulletin of the Geological Society of America. In other papers, also, reference has been made to this most interesting fauna. But my predecessor, Doctor Calvin, recognized the need of a more comprehensive report than any that had been published, a report in which not only the fauna of the Aftonian deposits but also the remains from other horizons of the Pleistocene might be fully described and illustrated, and, furthermore, a report in which the interrelations of the various kinds of life might be considered not alone from the standpoint of their distribution and association in Iowa, but in connection with the Pleistocene of the whole North American continent.

For such a task the Survey is to be congratulated in having had the services of Dr. O. P. Hay of the National Museum, Washington, D. C., an authority on the vertebrate paleontology of the Pleistocene period.

I take pleasure in submitting to you the paper of Doctor Hay, entitled, "The Pleistocene Mammals of Iowa," and recommend that it be published as Volume XXIII, which is the Twenty-first Annual Report of the Iowa Geological Survey.

Respectfully submitted,

George F. Kay.

THE PLEISTOCENE MAMMALS OF IOWA

BY

OLIVER P. HAY

Research Associate of the Carnegie Institution of Washington

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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,
Washington, D. C., February 11, 1914.

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 Missouri; 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 contained 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 satisfactory 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 Aftonian 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 burrowing 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

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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 belonging 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 underlying 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 position 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 History 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 surface 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.
	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.
Pleistocene	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.

Pleistocene	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.
	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, ant-eaters, 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 groundsloths, 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 moraine 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-

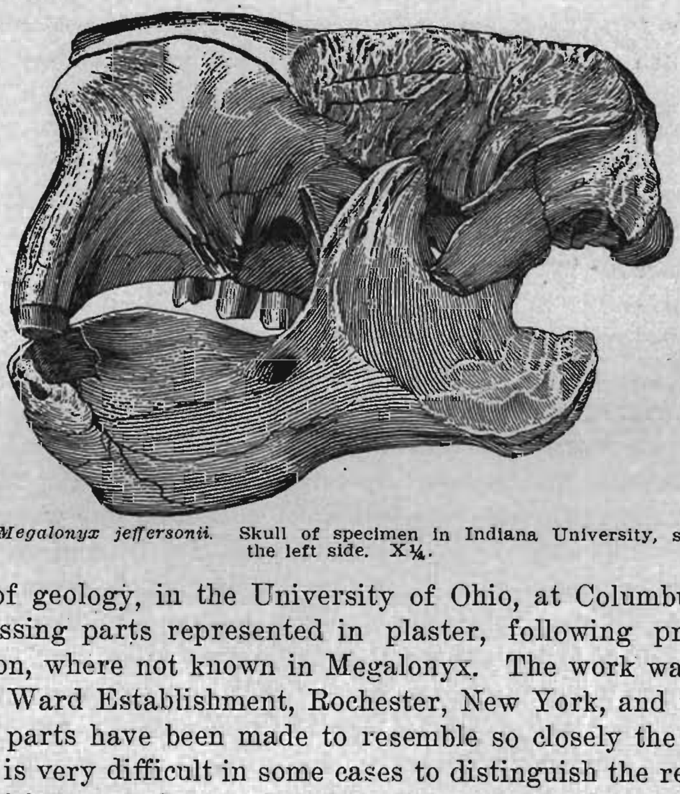


Fig. 2. *Megalonyx jeffersonii.* Skull of specimen in Indiana University, seen from the left side. X¼.

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 representing 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

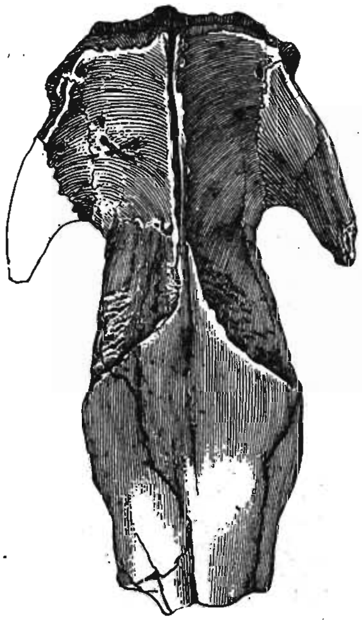


Fig. 3

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-

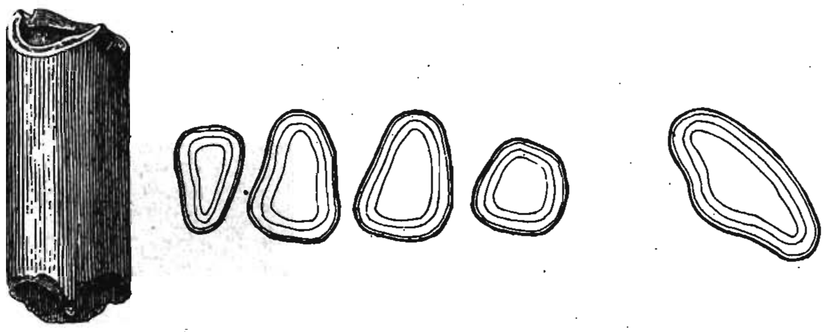


Fig. 5 Fig. 6

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

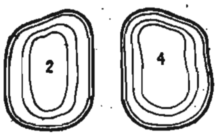


Fig. 8

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.

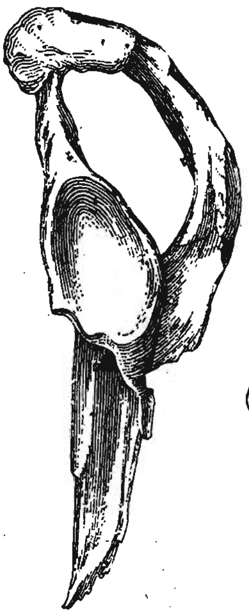


Fig. 9

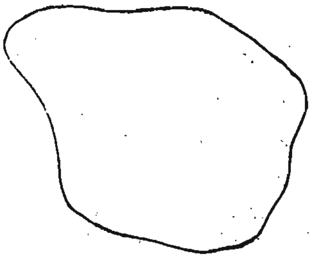


Fig. 11

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.

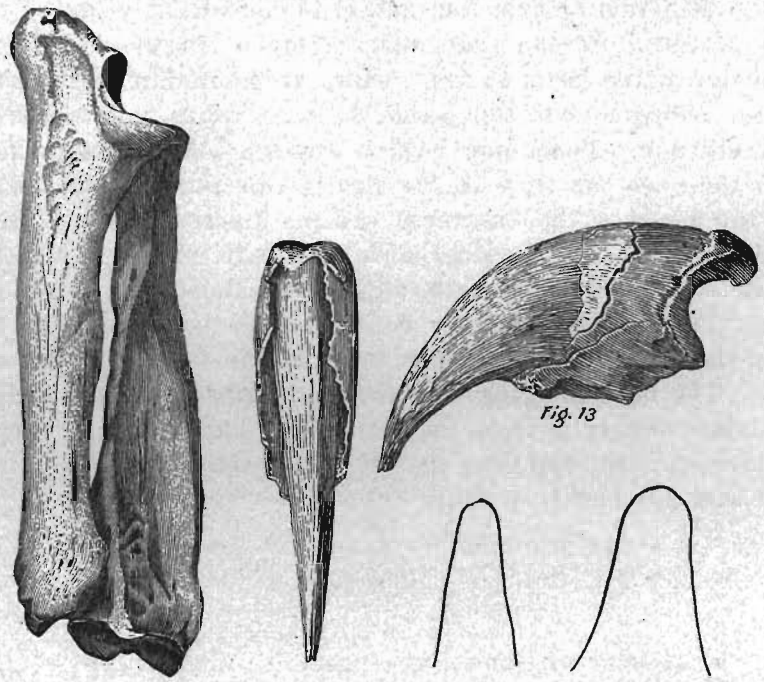


Fig. 12 Fig. 14 Fig. 16 Fig. 15

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.

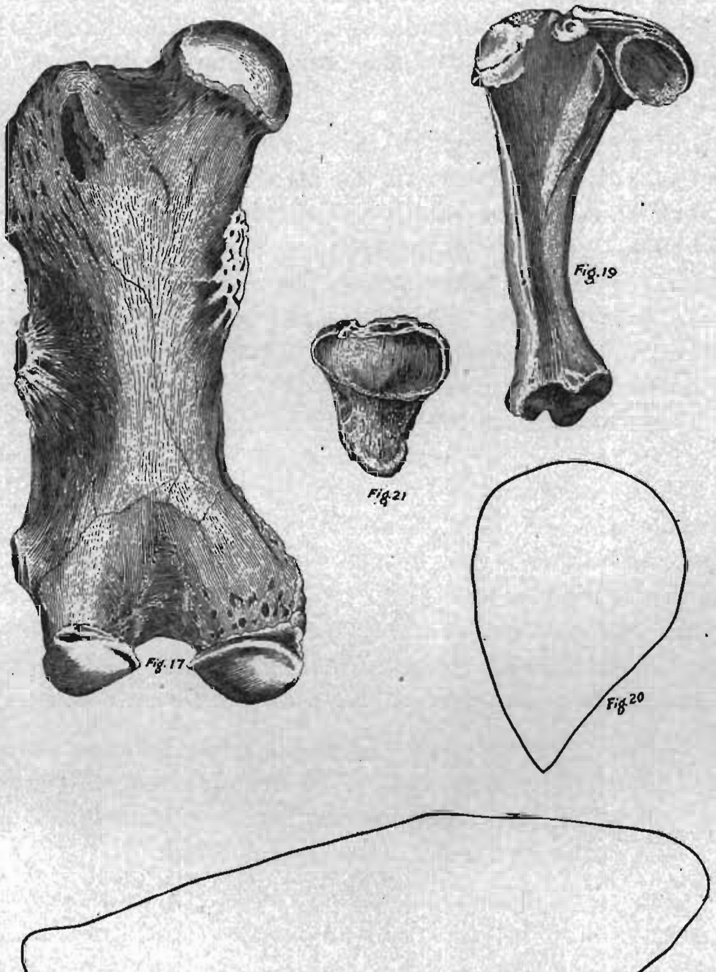
The core for the claw is, toward the base, obtuse on the upper border, but, farther forward, it becomes rather acute. Figure 15 represents a section of the claw-process of the third digit, taken at the middle of its length; while Figure 16 is a section taken at the same place in the second digit. Further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

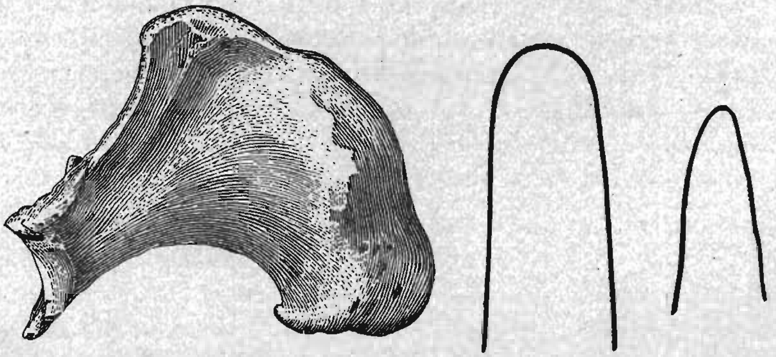


Fig. 22 Fig. 23 Fig. 24

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-

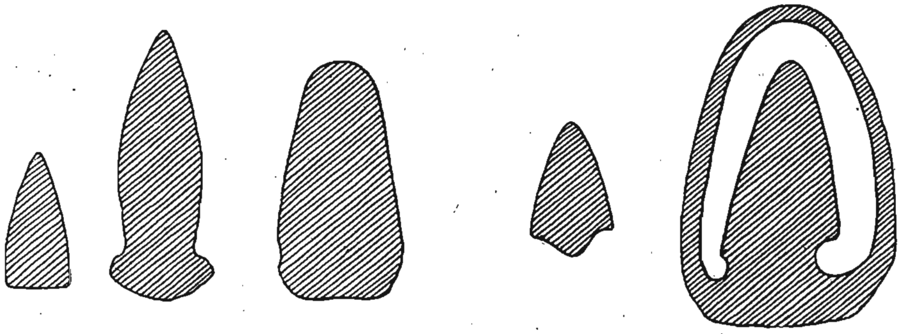


Fig. 27 Fig. 26 Fig. 25 Fig. 29 Fig. 28

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 taken 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.

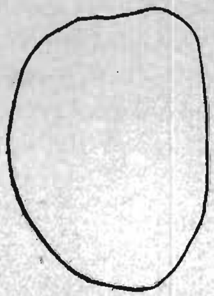


Fig. 30. Megalonyx? Section across right tibia at middle of the length X½. Specimen found at Missouri Valley.

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 $\frac{5}{4}$; 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.

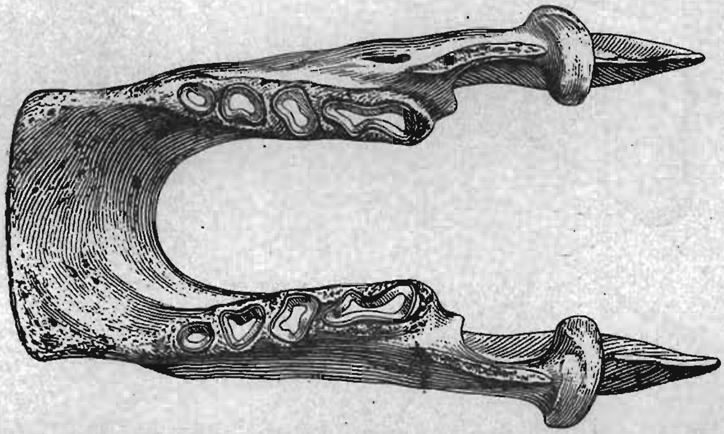


Fig. 31. *Mylodon robustus.* Lower jaw seen from above. X about ¼. From Owen.

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

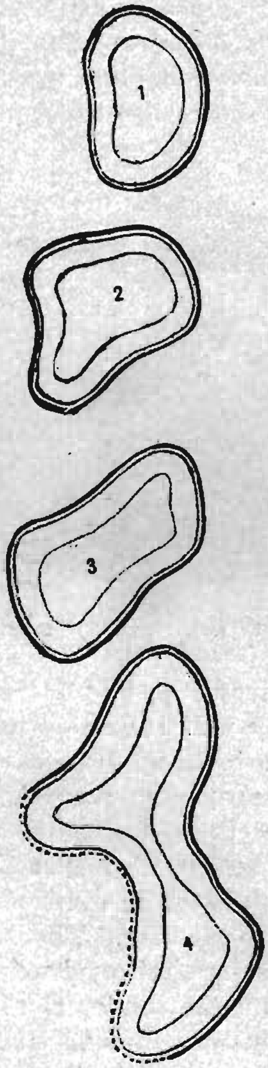


Fig. 32

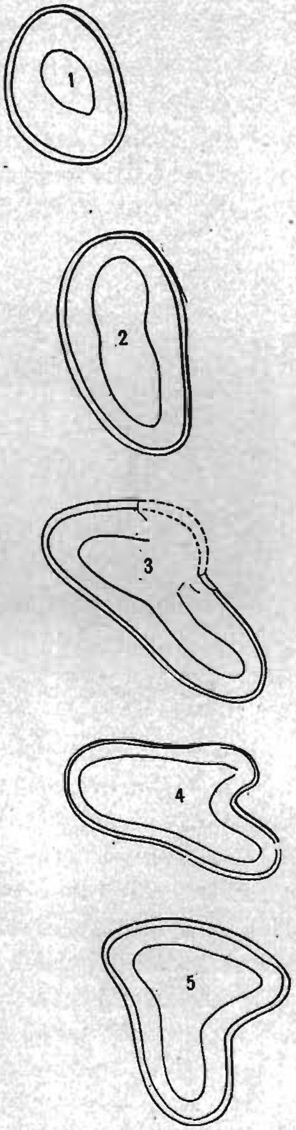


Fig. 33

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

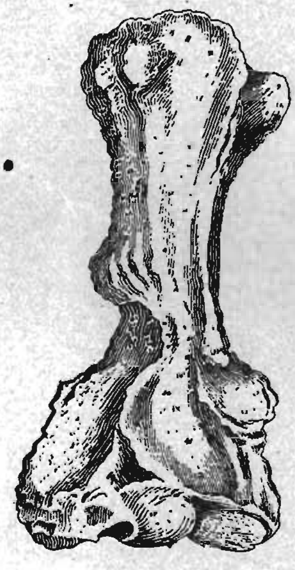


Fig. 35

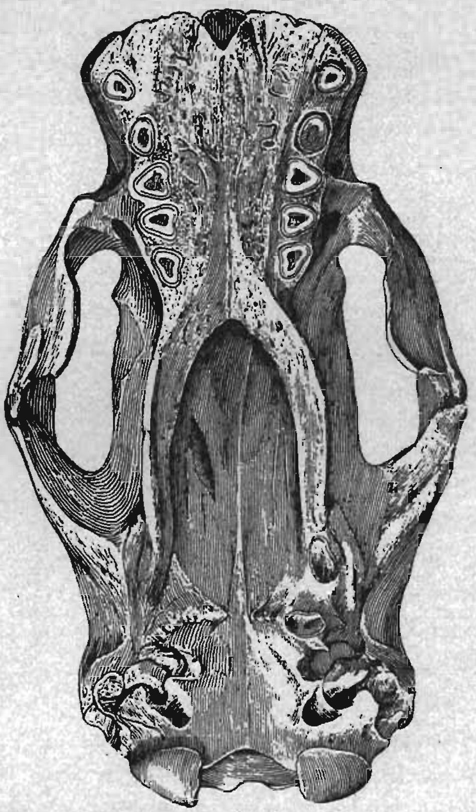


Fig. 34

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

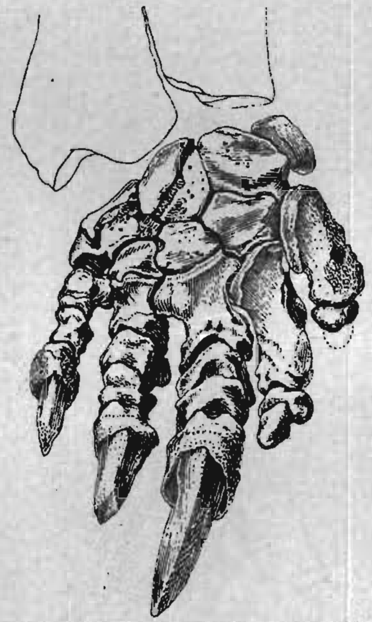


Fig. 36. *Mylodon robustus*. Left forefoot, seen from above. X 3/16. From Owen.

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-

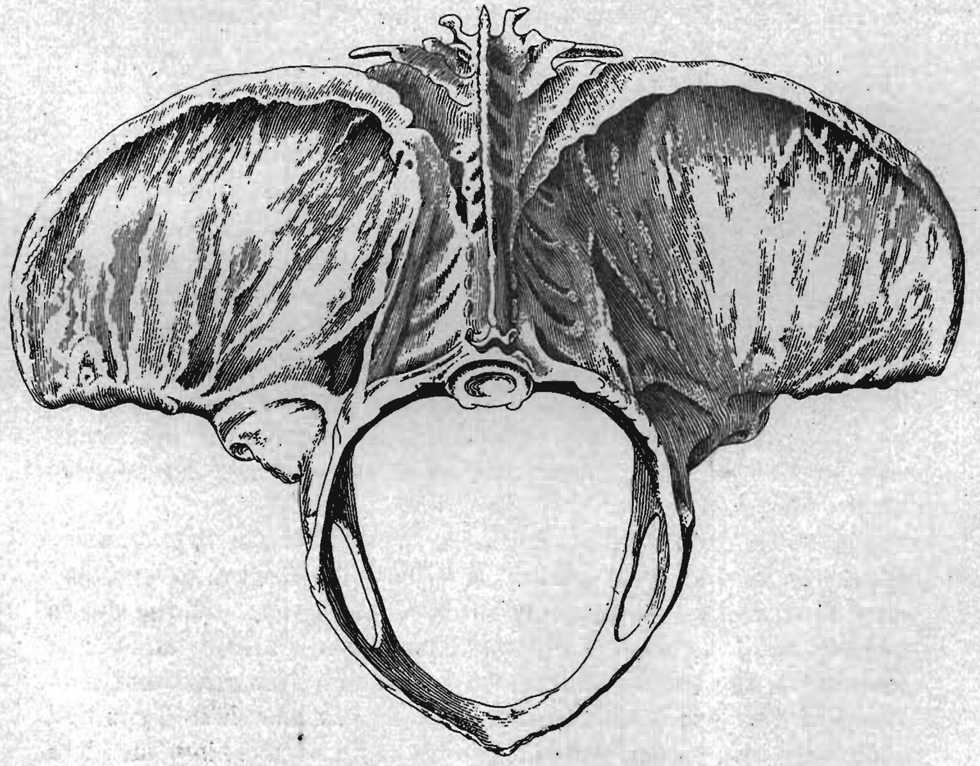


Fig. 37. *Mylodon robustus*. Pelvis, seen from behind. X⅛. From Owen

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

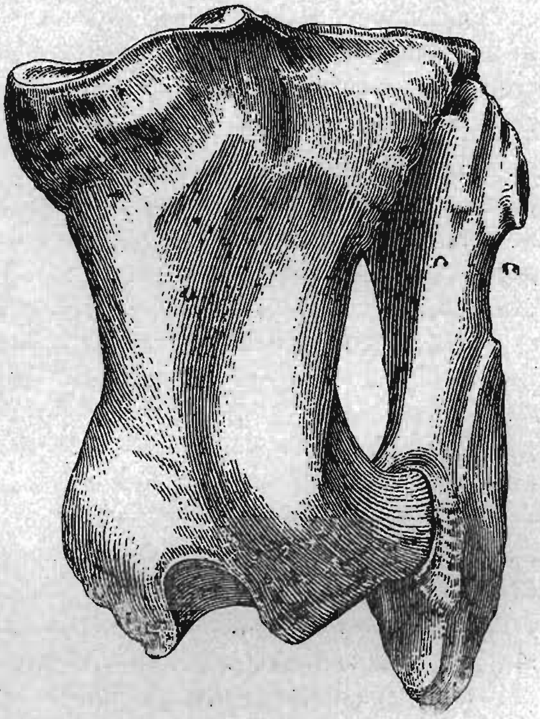


Fig. 38

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

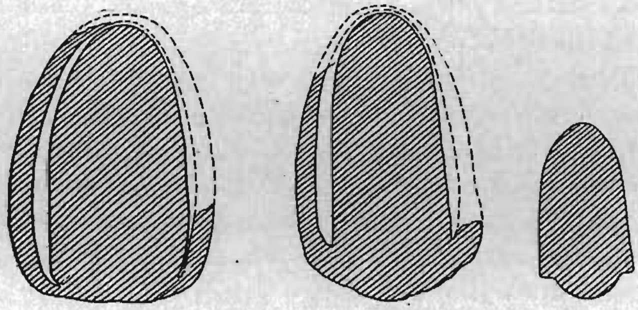


Fig. 40 Fig. 41 Fig. 42

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.

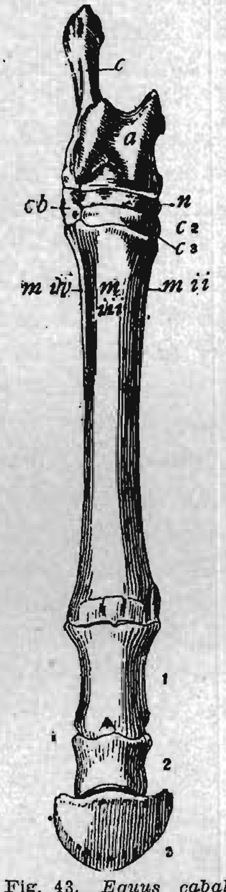


Fig. 43. *Equus caballus.* Right hind foot seen from in front. *a*, astragalus; *c*, calcaneum; *cb*, cuboid; *c1*, *c2* mesocuneiform; *c3*, ectocuneiform; *mii*, second metatarsal; *miii*, third metatarsal; *miv*, fourth metatarsal; 1, 2, 3, first, second and third phalanges, or upper and lower pasterns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

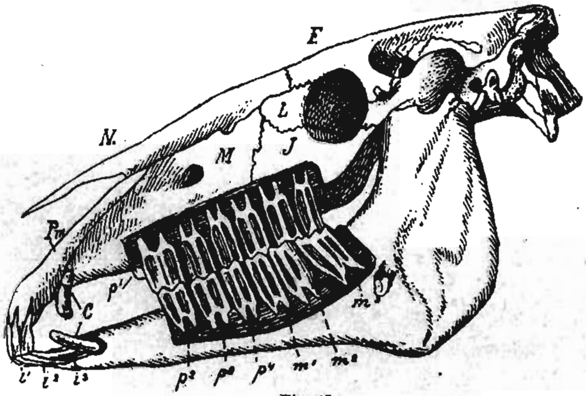


Fig. 45

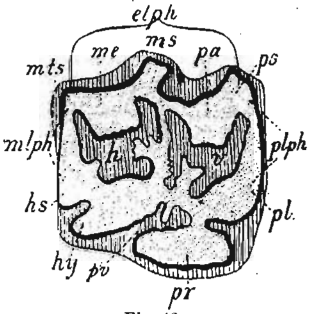


Fig. 46

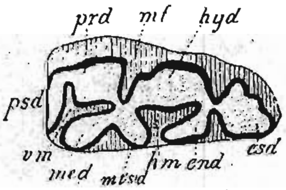


Fig. 47

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

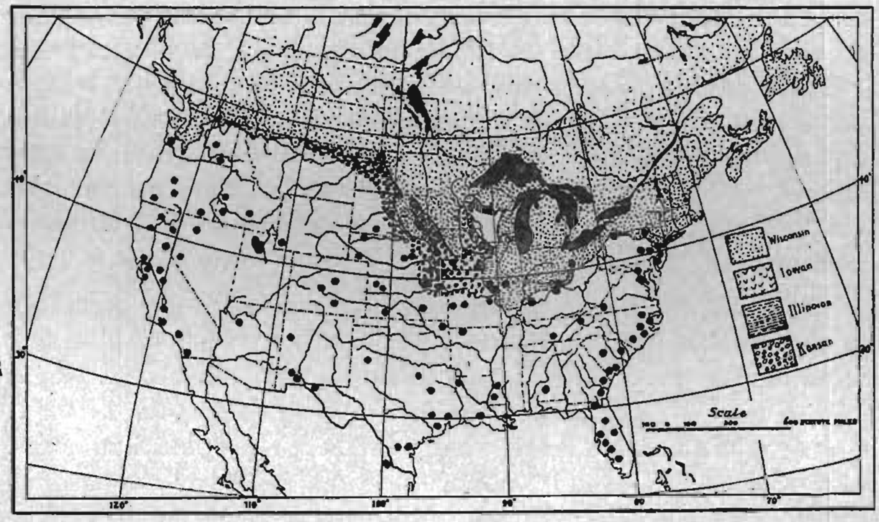


Fig. 48. Map showing localities where remains of fossil horses have been found in the United States and the relations of these localities to the various drift-sheets.

(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).

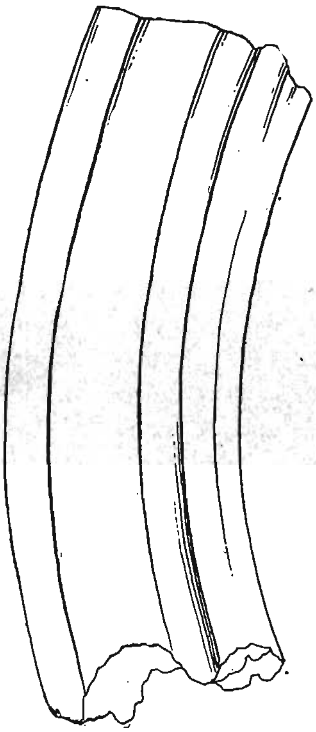


Fig. 50

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 Ansė 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.

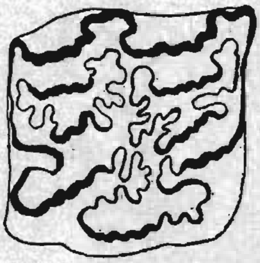


Fig. 51. *Equus complicatus.* Premolar from Petite Anse, Louisiana. X1. After Leidy.

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.

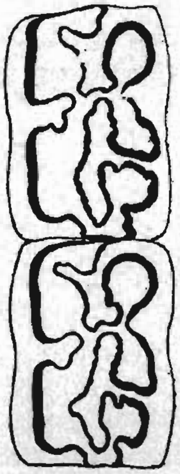


Fig. 52

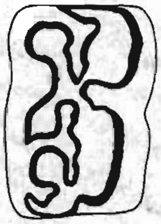


Fig. 53

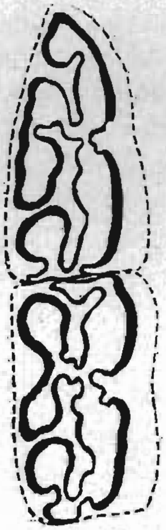


Fig. 54

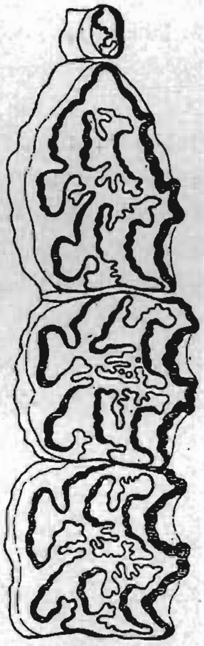


Fig. 55

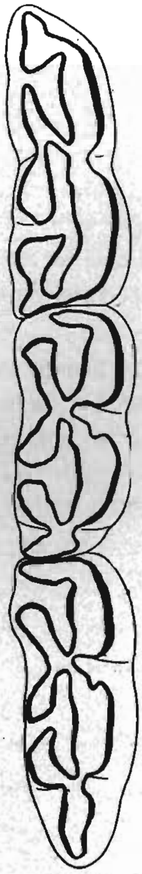


Fig. 56

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.

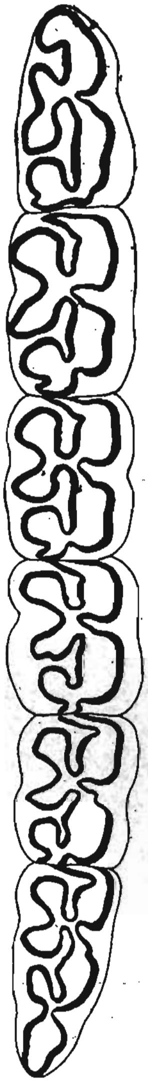
No. 723, U. S. National Museum, from Petite Anse, presents the bone surrounding the acetabulum. The long diameter of this cavity is 72 mm. The bone does not permit a section being taken in front of the acetabulum, but the upper border of the bone is more rounded than in the Arabian horse. From the upper 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



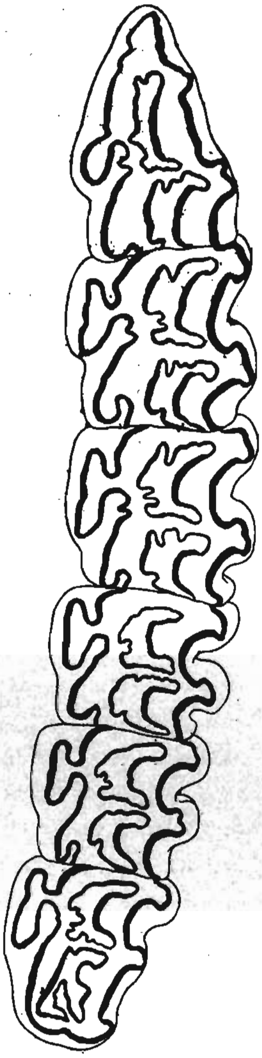


Fig. 57

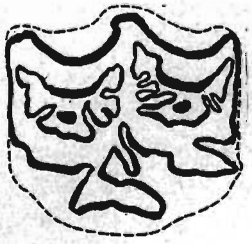


Fig. 58

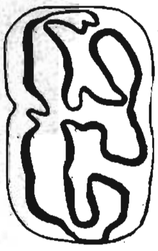


Fig. 61 Fig. 60 Fig. 59

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.

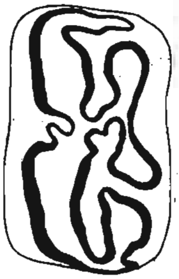


Fig. 62

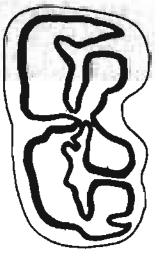


Fig. 63

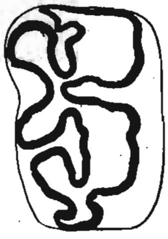


Fig. 64

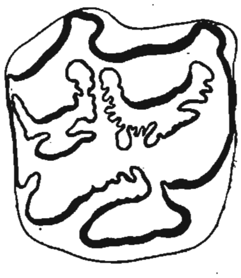


Fig. 65

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,

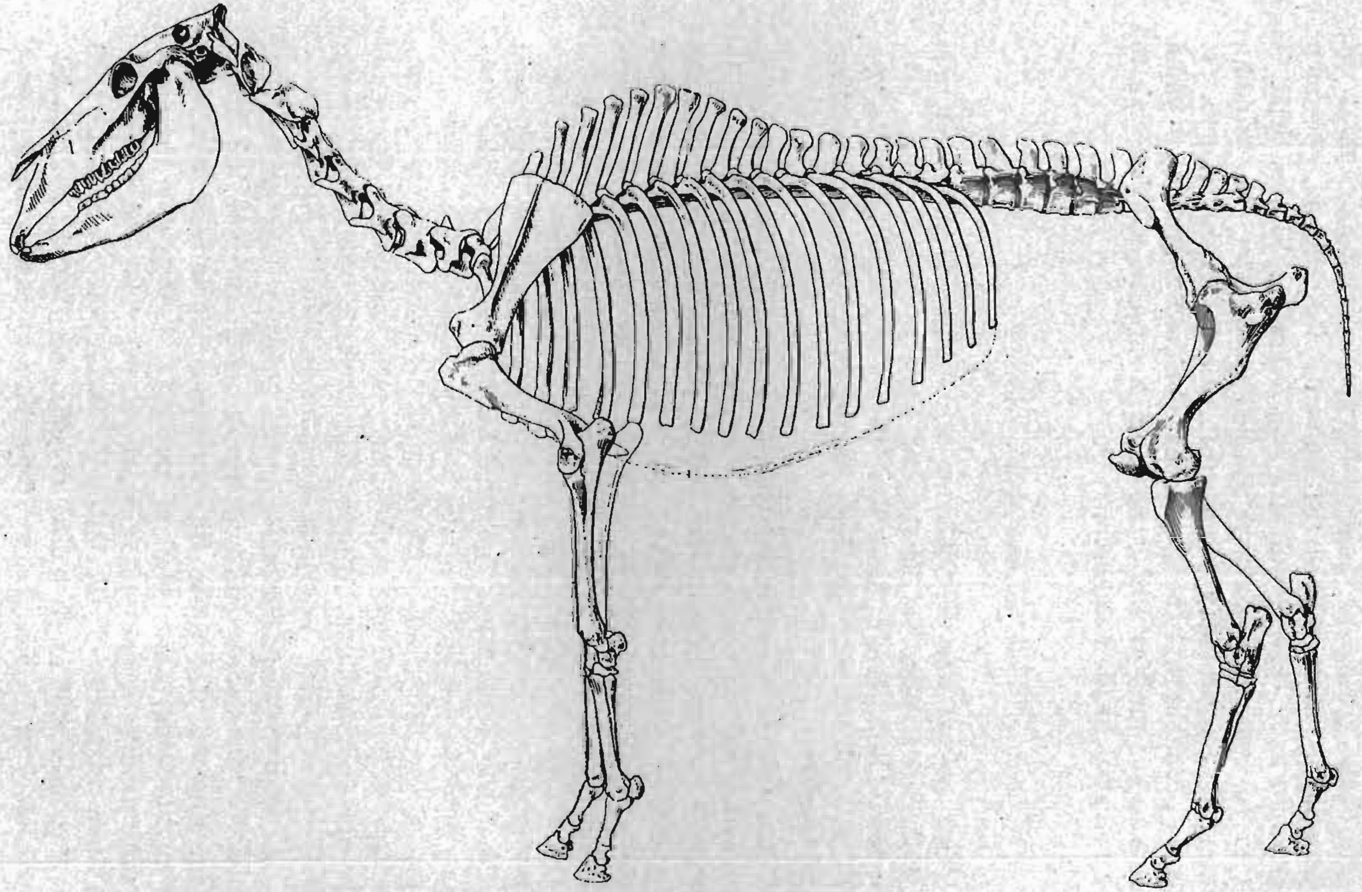


Fig. 66. *Equus scotti.* From skeleton mounted in American Museum of Natural History. Drawing made by Bruce Horsfall.

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.

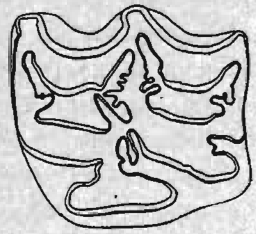


Fig. 67. *Equus scotti.* Grinding face of first left molar of type. X1.

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 i³ and pm.²	55	51
Distance between i³ 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.

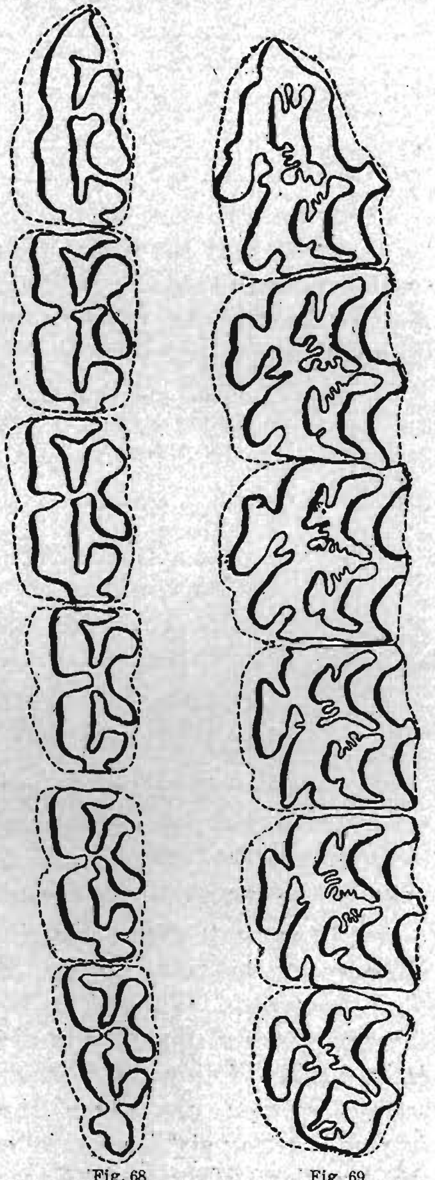


Fig. 68 Fig. 69

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, approximately 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.

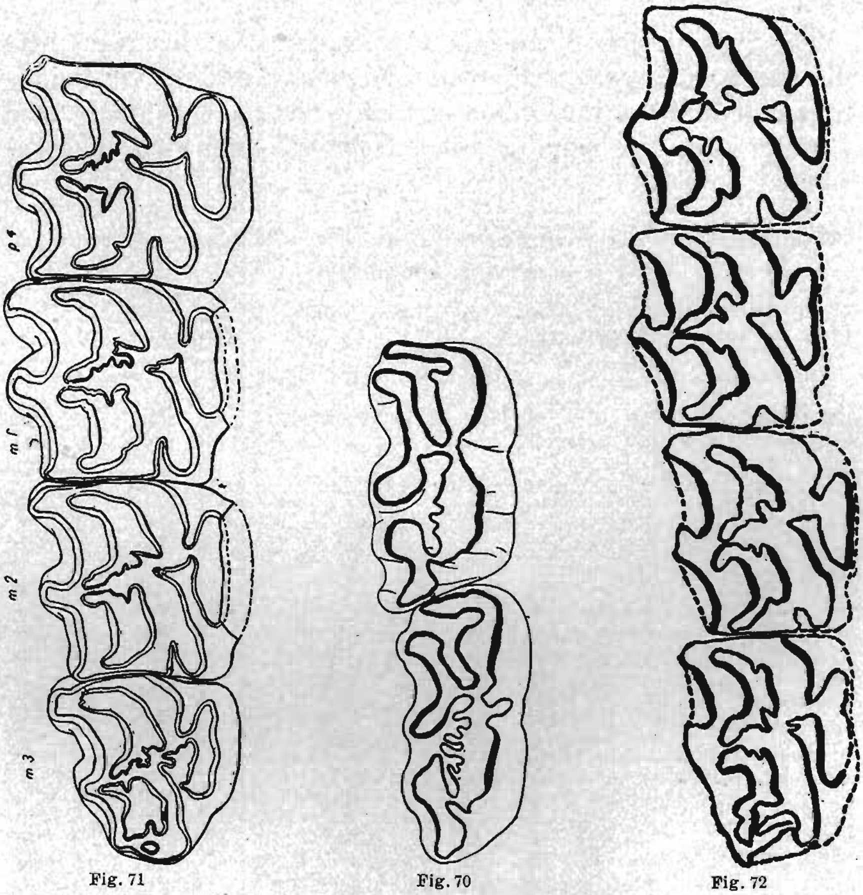


Fig. 71 Fig. 70 Fig. 72

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 region 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

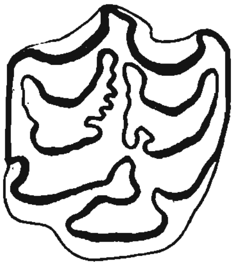


Fig. 73

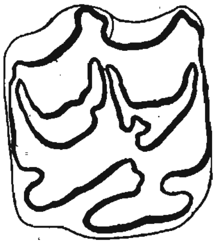


Fig. 74

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

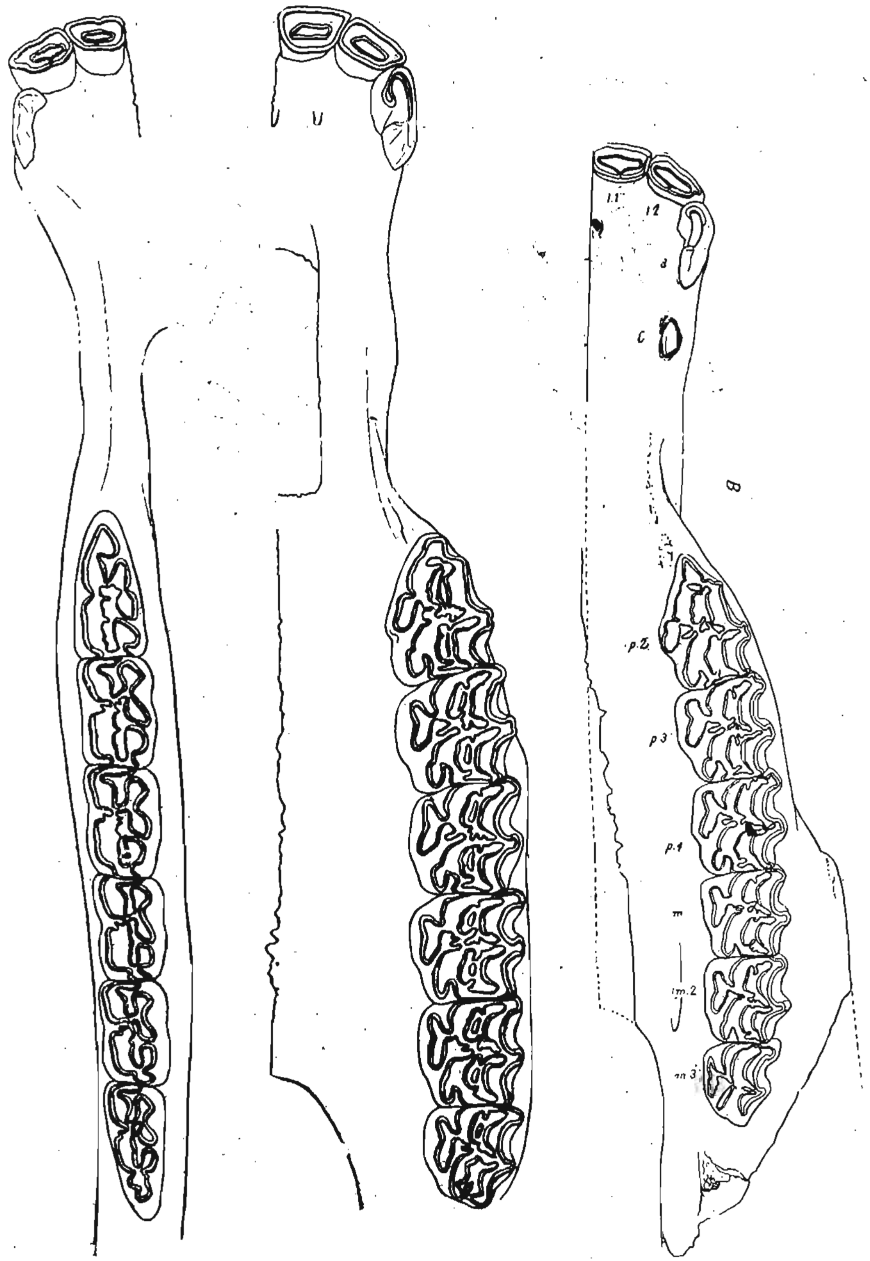


Fig. 77 Fig. 76 Fig. 75

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

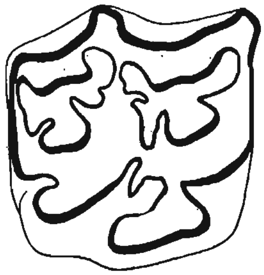


Fig. 78

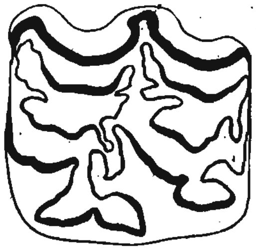


Fig. 79

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 figures 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.

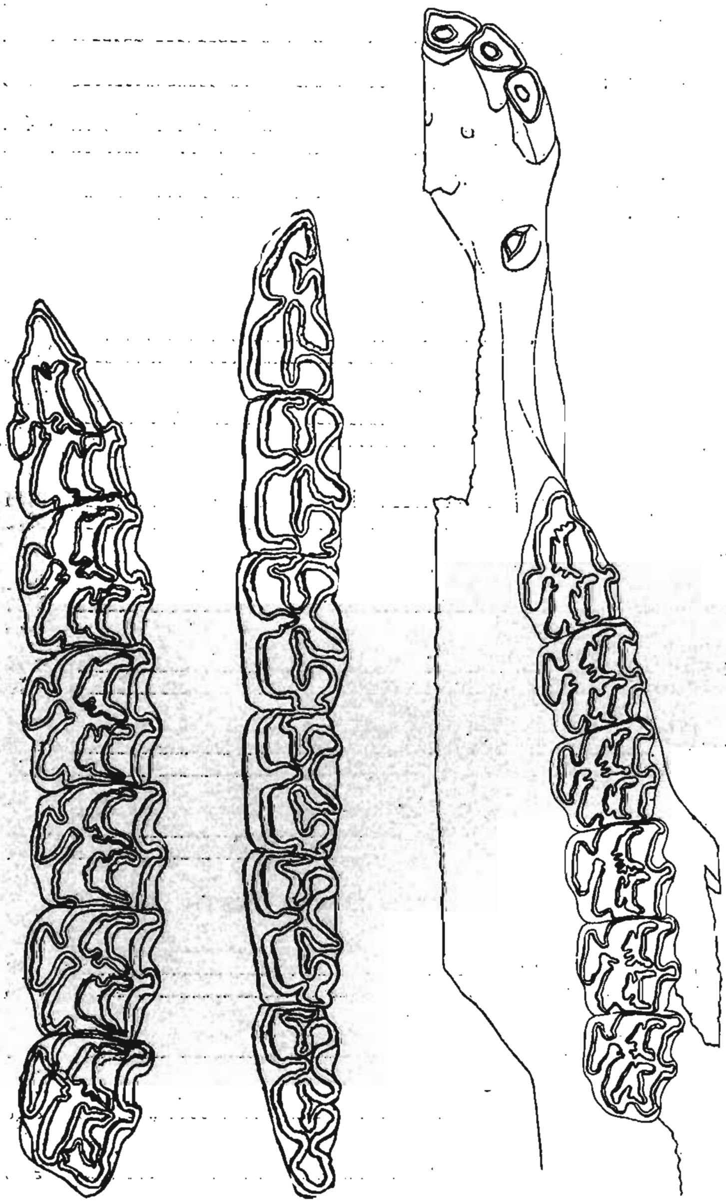


Fig. 80 Fig. 81 Fig. 82

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.

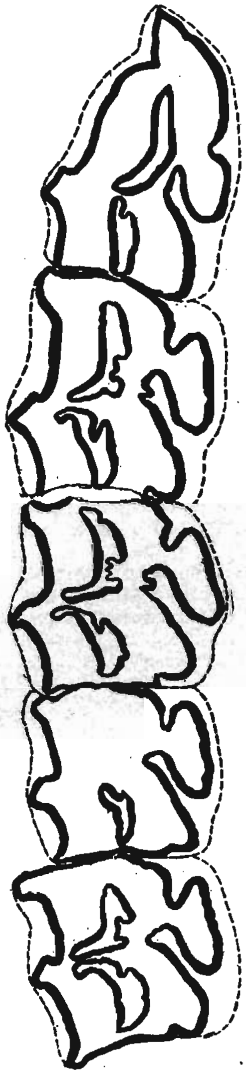


Fig. 83. *Equus laurentius*. Cheek-teeth of right side. X1. No. 133 State University of Iowa.

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 millimeters. 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-

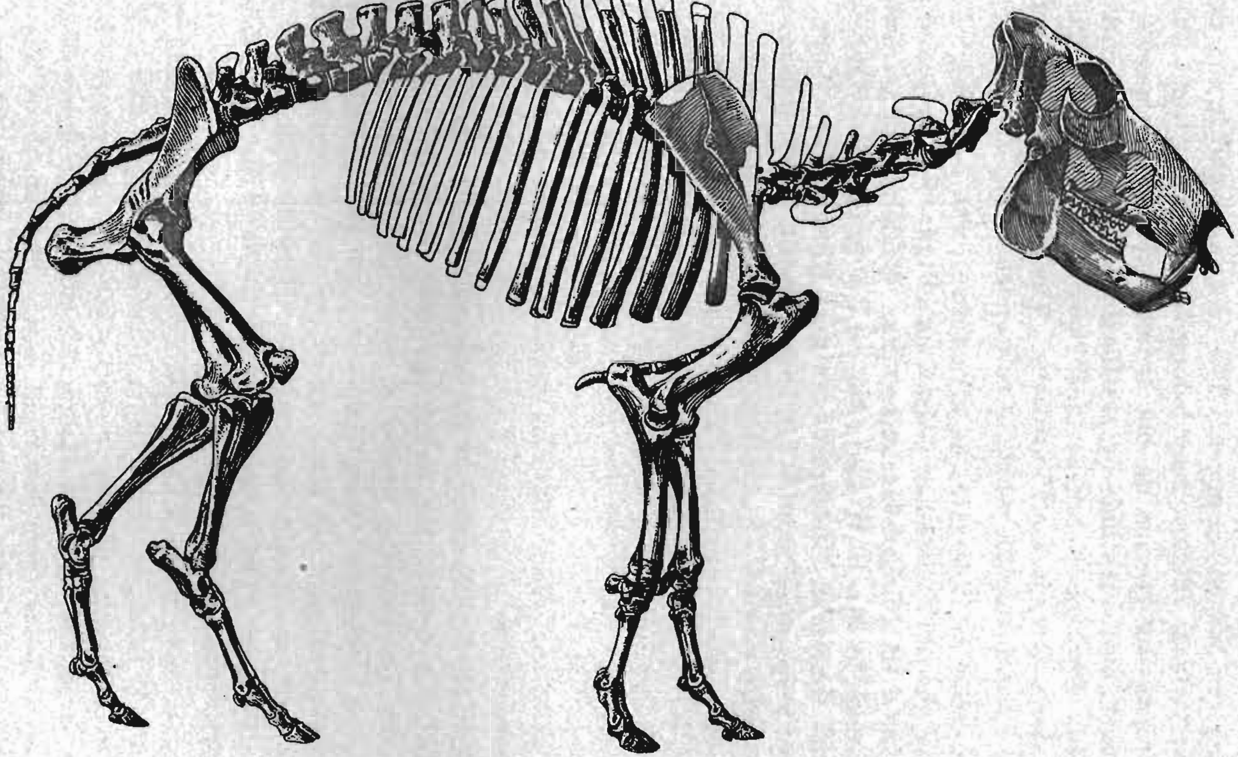


Fig. 84. *Platygonus leptorhinus.* Skeleton of specimen in American Museum Natural History. Found in Kansas.

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.: . $\frac{3}{3}$ 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 species 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 antero-posteriorly. 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.

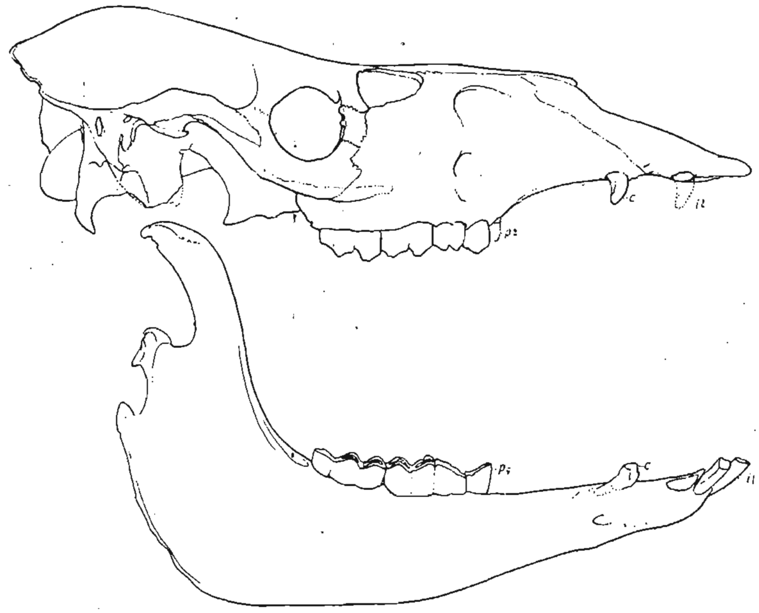


Fig. 85. *Camelops hesternus?* X 1/6. From Merriam. Side view of skull and lower jaw.

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-

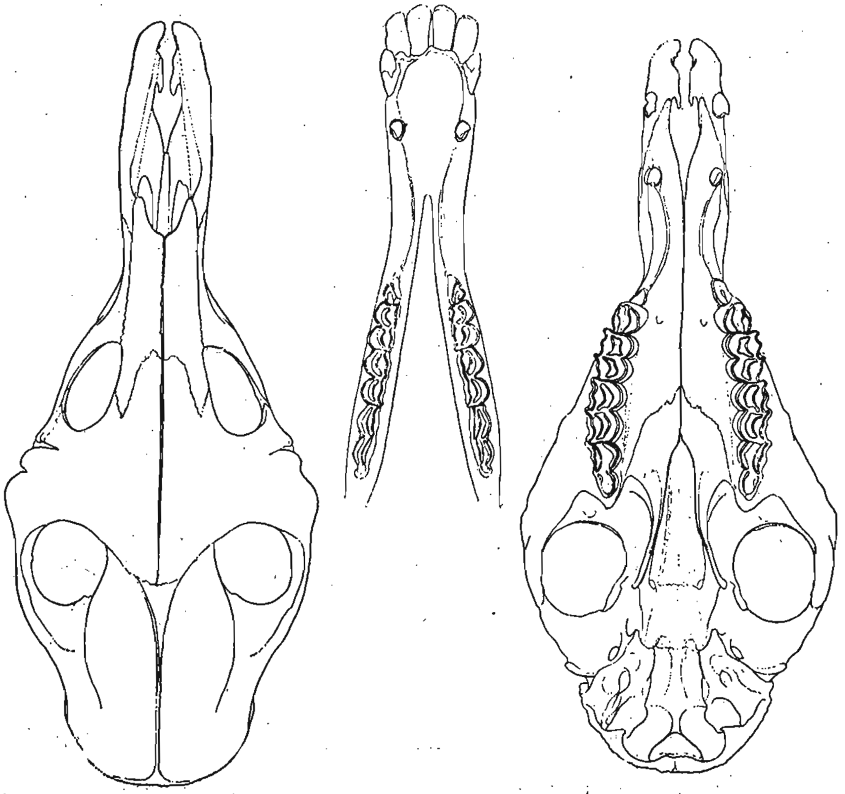


Fig. 86 Fig. 88. Fig. 87

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 cf 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 another 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.

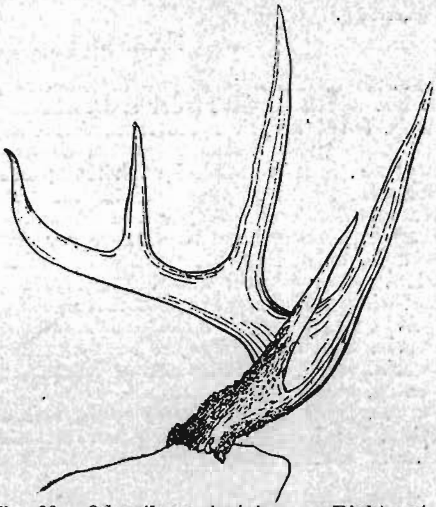


Fig. 89. *Odocoileus virginianus.* Right antler seen from the left side. The nose is toward the left hand. Much reduced. From Baird.

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.

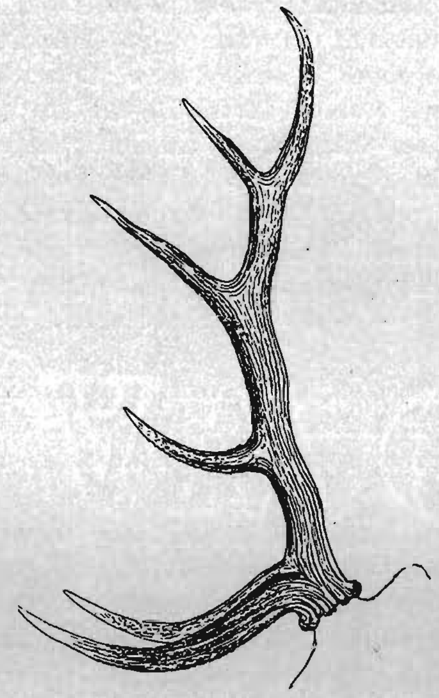


Fig. 90. *Cervus canadensis.* Right antler seen from the left side. Much reduced. The nose is toward the left hand. From Baird.

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

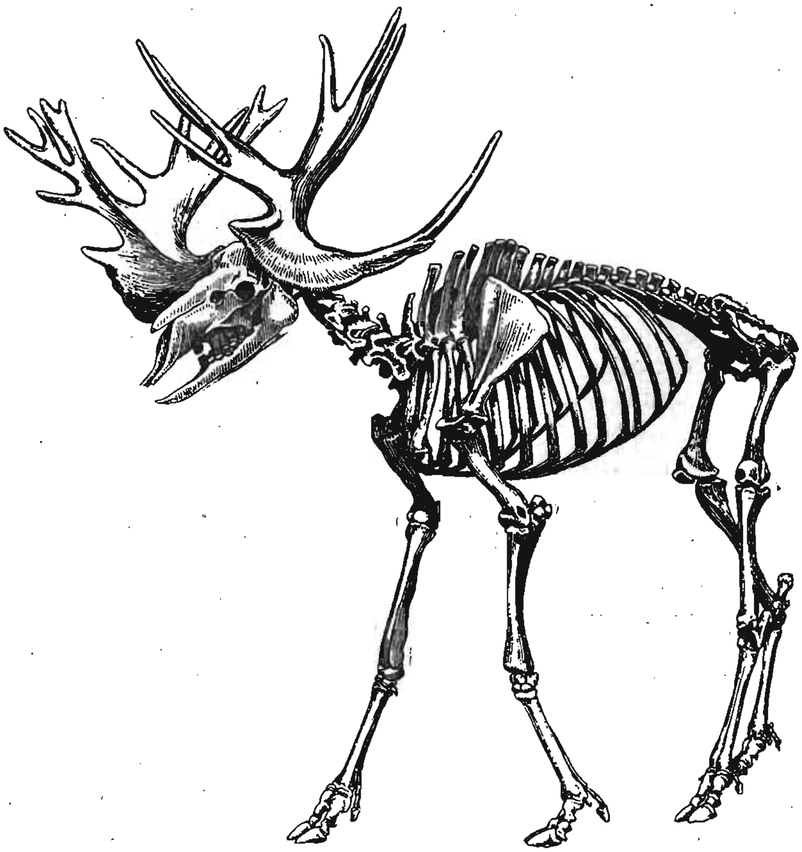


Fig. 91. *Cervalces scotti*. Skeleton of specimen in Princeton University. After Scott.

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.

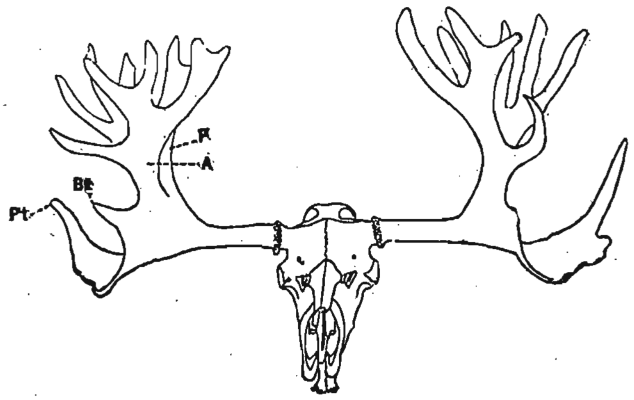


Fig. 92. *Cervalces scotti.* Skull and antlers, seen from in front. From Scott. *A*, anterior division of palmation; *P*, posterior division; *Bz*, beztine; *Pt*, posterior tine.

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 directed 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.

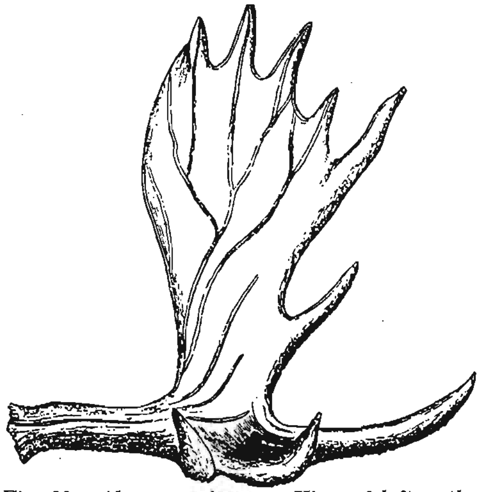


Fig. 93. *Alces americanus.* View of left antler from front. After Baird.

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

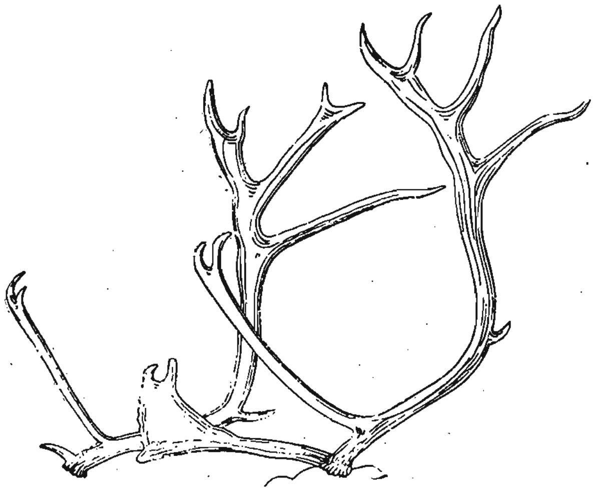


Fig. 94. *Rangifer arcticus.* Two antlers, seen from the side. The near one that of a male; the other probably of the female. The nose is directed toward the left.

belonged to a male and presents the palmated brow tine; the other, supposed to have belonged to a female, has the brow tine ver~ 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 relatively 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 perceptible burr there was given off a tine and at a distance of 125 mm. above the burr a second tine was directed forward. Between the two tines the fore and aft diameter is 34 mm.; the transverse, 28 mm. At the distal end of the fragment the diameters are 38 mm. and 30 mm.

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

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

Family Bovidae.

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

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

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

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

Subfamily ANTILOCAPRINAE.

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

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

Genus ANTILOCAPRA Ord.

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

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

Antilocapra americana Ord.

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

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

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

MEASUREMENTS OF THE SKULL OF PRONGHORN.

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

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

MEASUREMENTS OF THE TEETH.

Upper Teeth.		Lower Teeth.	
Length, premolar-molar series	67 mm.	Length, premolar-molar series	71 mm.
Length, premolar series	26 mm.	Length, premolar series	27 mm.
Length, molar series	42 mm.	Length, molar series	46 mm.
Pm.^{2}, length	7 mm.	Pm.$_2$, length	7.5mm.
width	5 mm.	width	4 mm.
Pm.^{3}, length	7.5mm.	Pm.$_3$, length	9 mm.
width	6 mm.	width	5 mm.
Pm.^{4}, length	8 mm.	Pm.$_4$, length	10 mm.
width	7 mm.	width	5 mm.
M.^{1}, length	12 mm.	M.$_1$, length	11 mm.
width	8.5mm.	width	6 mm.
M.^{2}, length	13 mm.	M.$_2$, length	13 mm.
width	9.5mm.	width	7 mm.
M.^{3}, length	17 mm.	M.$_3$, length	21.5mm.
width	9.5mm.	width	7.5mm.

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

MEASUREMENTS OF SKELETON.

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

Subfamily **CAPRINAE.**

The Sheep and Goats.

Genus **AFTONIUS** Hay.

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

Aftonius calvini Hay.

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

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

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

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

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

The following measurements have been taken:

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

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

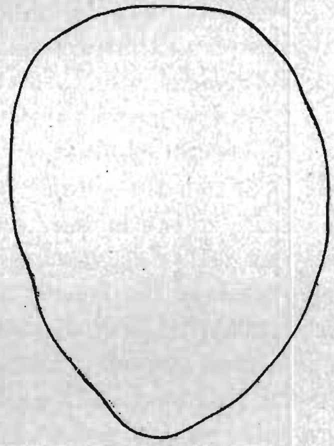


Fig. 95. *Aftonius calvini.* Section of horn-core at its base. X¾. The front of the core is below, the outer face toward the right.

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

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

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

MEASUREMENTS OF BONES.

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

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

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

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

Subfamily OVIBOVINAE.

The Musk-oxen.

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

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

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

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

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

MEASUREMENTS OF SKULL.

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

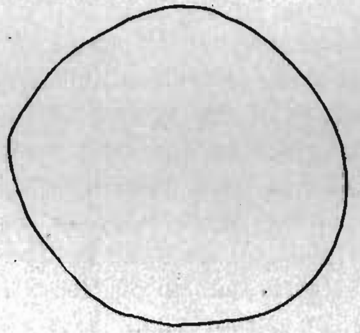


Fig. 96

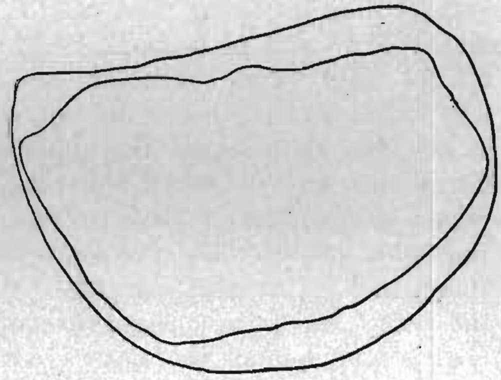


Fig. 97

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

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

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

Genus **OVIBOS** Blainville.

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

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

Ovibos moschatus (Zimm.)

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

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

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

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

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

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

MEASUREMENTS OF SKULL.

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

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

MEASUREMENTS OF TEETH.

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

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

MEASUREMENTS OF SKELETON.

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

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

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

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

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

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

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

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

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

Genus SYMBOS Osgood.

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

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

Symbos cavifrons (Leidy).

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

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

MEASUREMENTS.

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

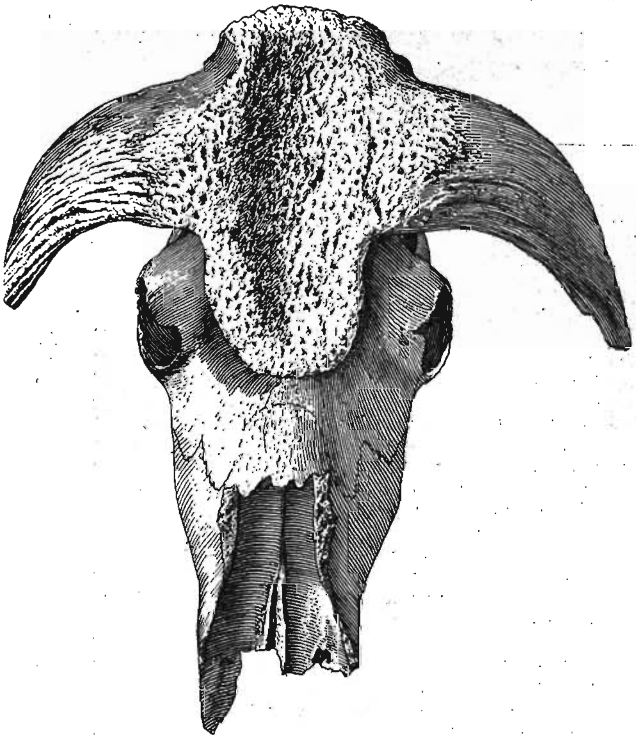


Fig. 98. *Symbos cavifrons.* Front view of skull found at Hebron, Indiana. X 1/6.

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

MEASUREMENTS.

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

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

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

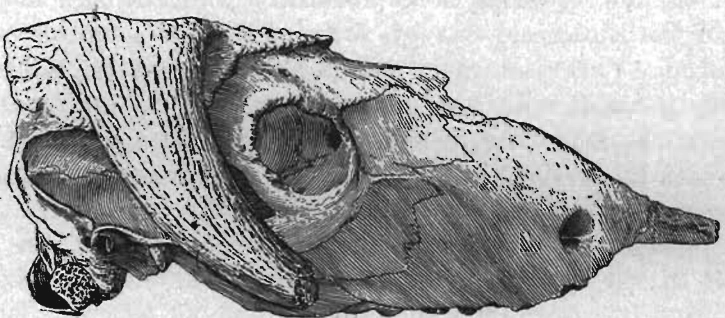


Fig. 99. *Symbos cavifrons.* Side view of skull found at Hebron, Indiana. X 1/6.

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

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

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

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

MEASUREMENTS.

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

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

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

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

MEASUREMENTS OF THE TEETH.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Subfamily BOVINAE.

The Bisons, Buffaloes and Oxen.

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

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

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

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

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

Genus BISON H. Smith.

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

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

ANALYSIS OF SPECIES OF BISON.

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

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

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

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

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

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

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

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

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

Bison bison (Linnæus).

The American Bison; American Buffalo.

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

MEASUREMENTS OF SKELETON OF THE AMERICAN BISON.

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

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

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

MEASUREMENTS OF SERIES OF TEETH.

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

INDIVIDUAL TEETH.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Bison antiquus Leidy.

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

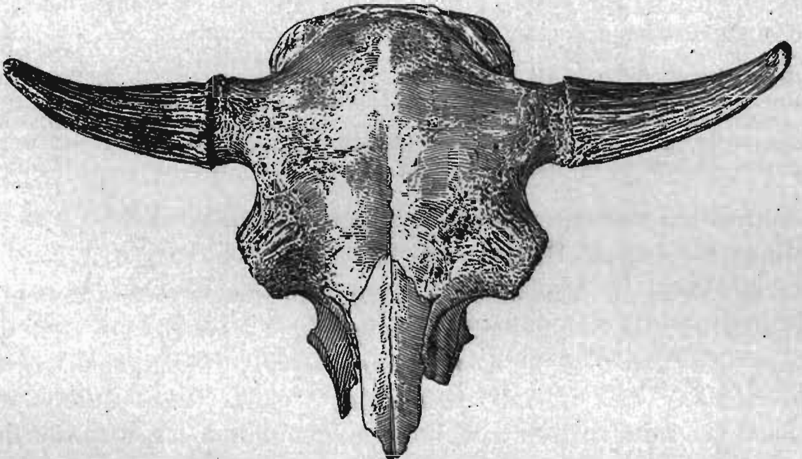


Fig. 100

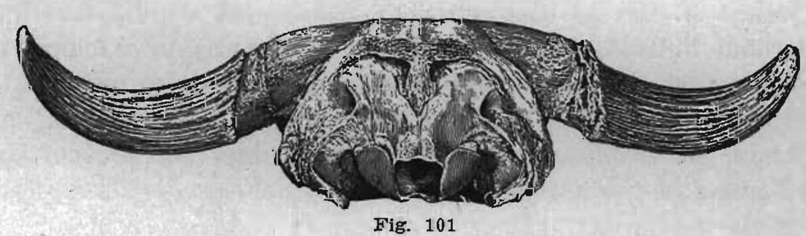


Fig. 101

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

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

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

MEASUREMENTS ON SKULL OF *BISON ANTIQUUS*.

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

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

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

Bison occidentalis Lucas.

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

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

MEASUREMENTS TAKEN ON SKULLS OF *BISON OCCIDENTALIS*.

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

MEASUREMENTS OF SKULLS OF *BISON OCCIDENTALIS*—Concluded.

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

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

MEASUREMENTS OF MOLAR TEETH.

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

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

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

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

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

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

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

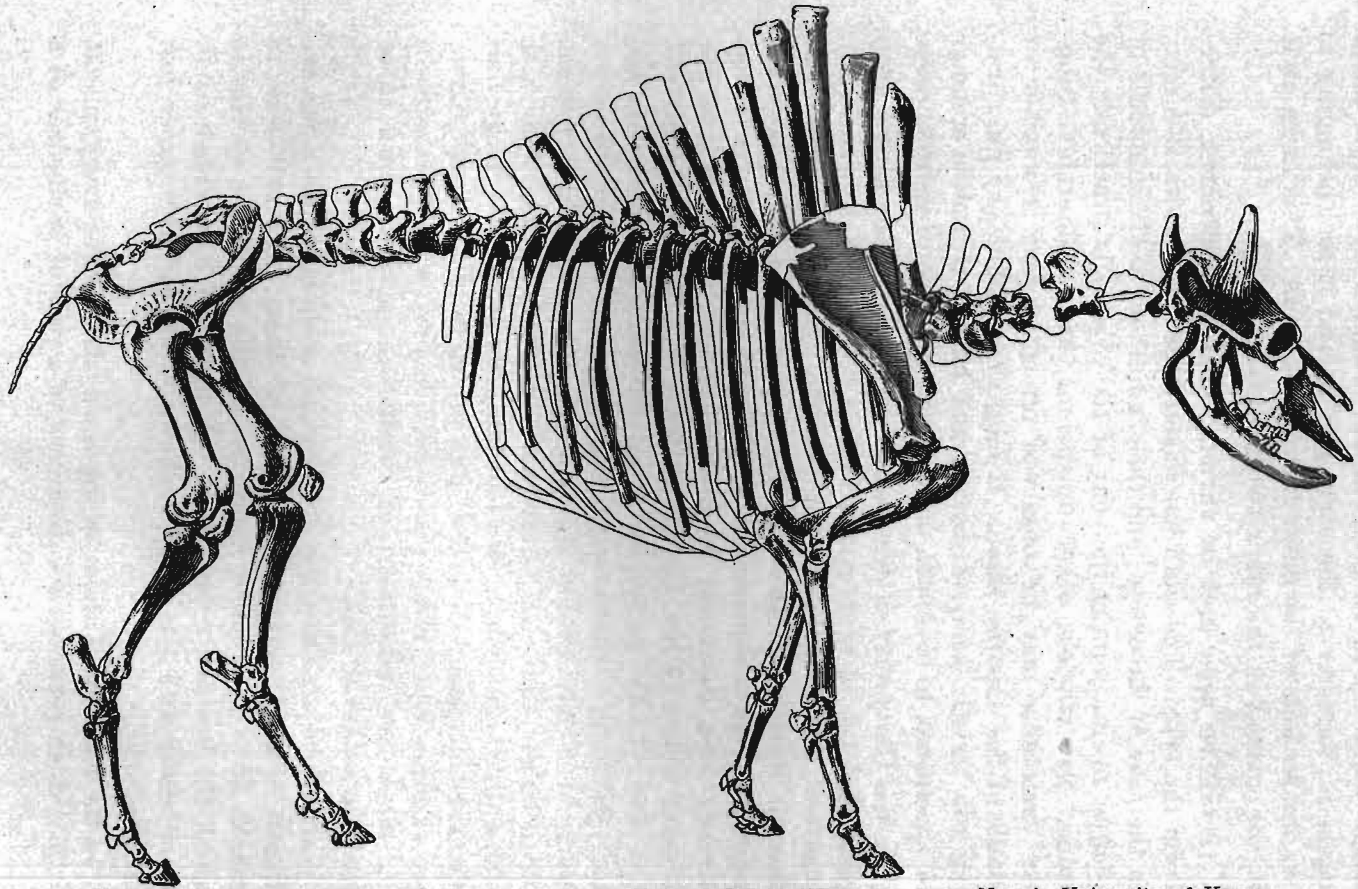


Fig. 102. *Bison occidentalis.* Skeleton of specimen found in Logan county, Kansas. Now in University of Kansas.

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

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

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

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

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

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

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

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

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

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

MEASUREMENTS OF HORN-CORE NO. 350.

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

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

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

MEASUREMENTS OF SCAPULA.

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

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

Bison alleni Marsh.

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

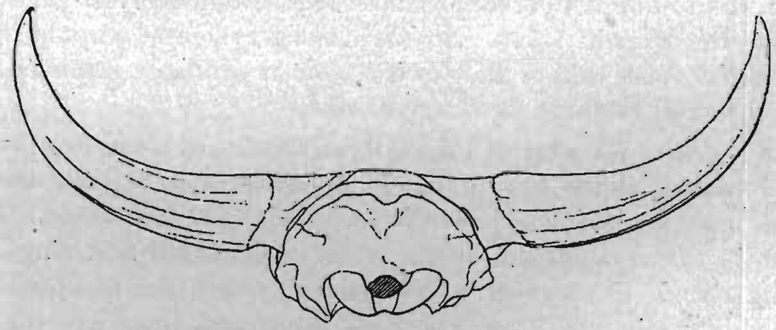


Fig. 103. *Bison alleni.* View of skull from behind, showing curvature of the horn-cores. x .18. From Alaska.

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

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

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

Bison latifrons Leidy.

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

Bison regius Hay.

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

Order **Proboscidea.**

The Elephants and Their Kindred.

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

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

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

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

Family **Elephantidae.**

The Mastodons and Elephants.

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

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

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

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

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

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

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

Genus MAMMUT Blumenbach.

The Mastodons.

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

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

Mammut americanum (Kerr).

The American Mastodon.

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

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

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

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

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

MEASUREMENTS OF MASTODON AND ELEPHANT.

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

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

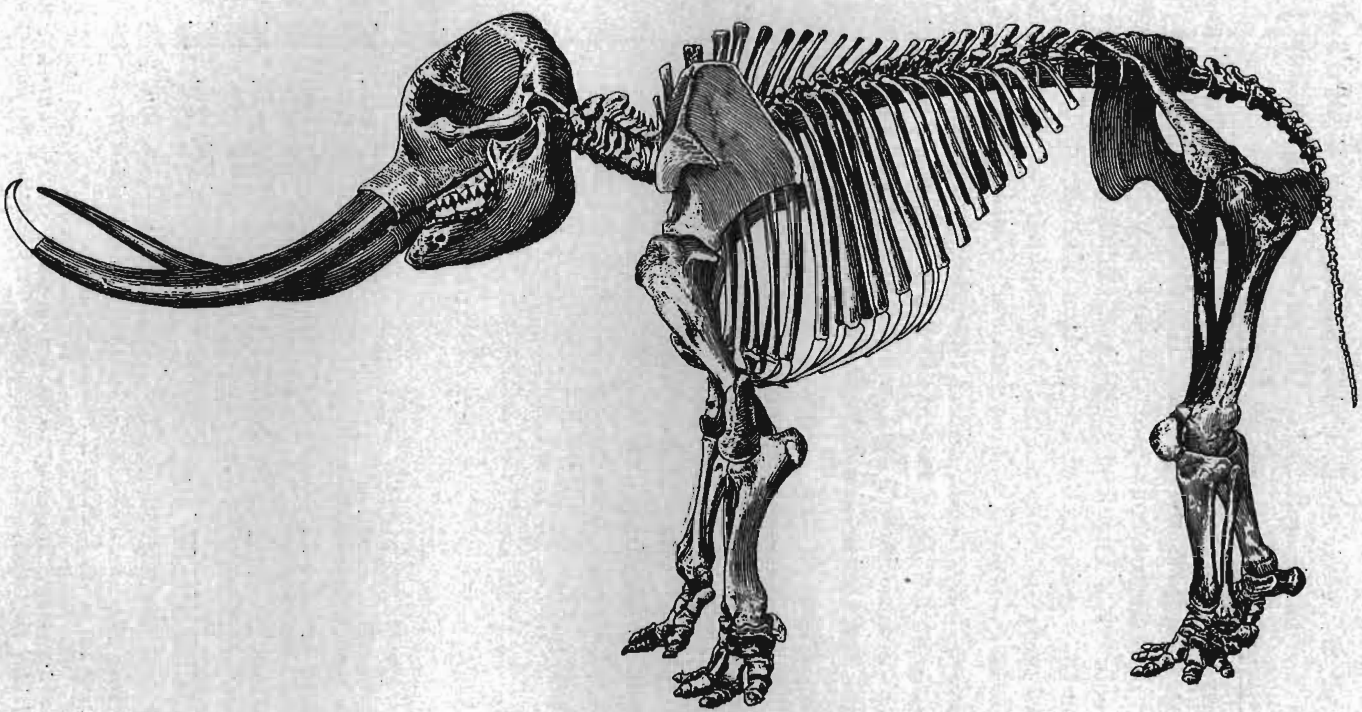


Fig. 104. *Mammut americanum.* Skeleton of a specimen found in Miami county, Indiana. Now in Public Museum, Milwaukee.

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

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

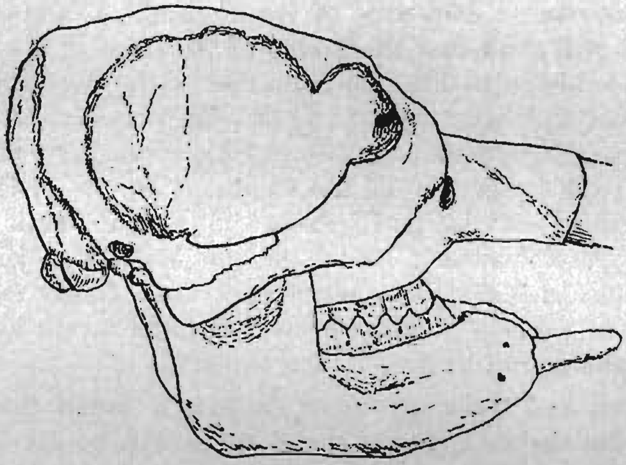


Fig. 105. *Mammut americanum.* Side view of skull of specimen having a small tusk on the left side of the lower jaw. After Falconer and Cautley.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

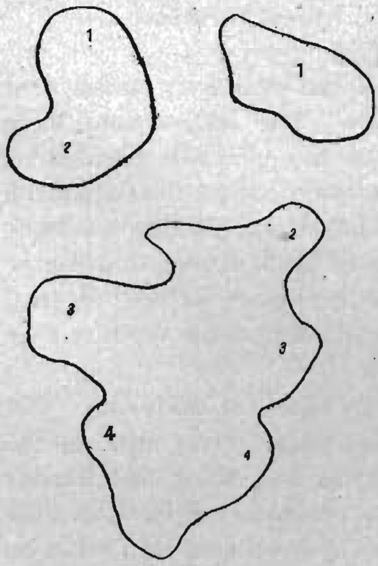


Fig. 106

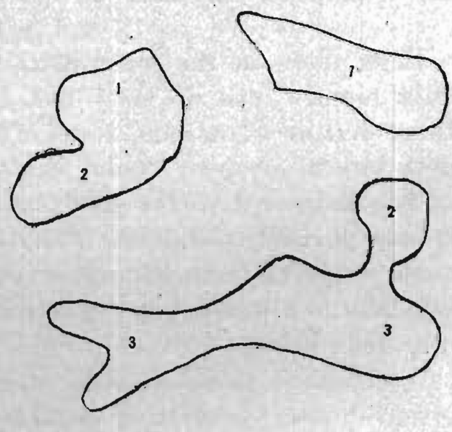


Fig. 107

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

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

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

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

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

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

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

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

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

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

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

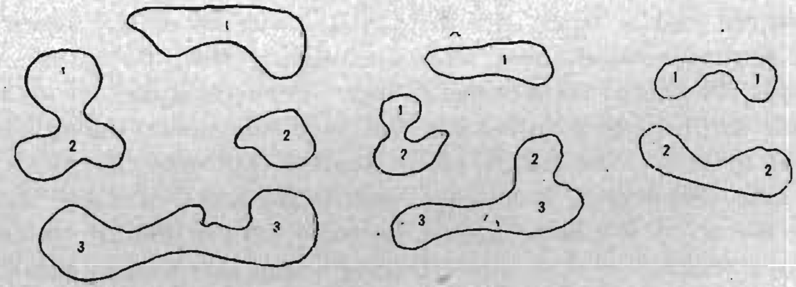


Fig. 108 Fig. 109 Fig. 110

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

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

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

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

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

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

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

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

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

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

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

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

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

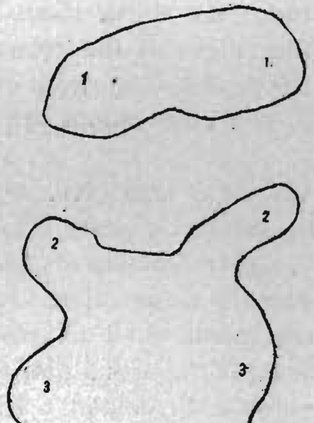


Fig. 111

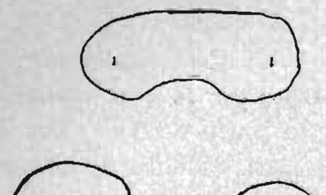


Fig. 112

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

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

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

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

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

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

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

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

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

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

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

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

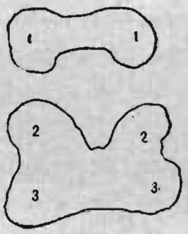


Fig. 113

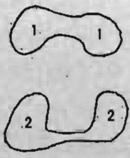


Fig. 114

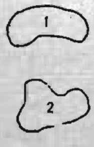


Fig 115

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

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

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

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

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

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

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

ANALYSIS OF THE TEETH OF *MAMMUT AMERICANUM.*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

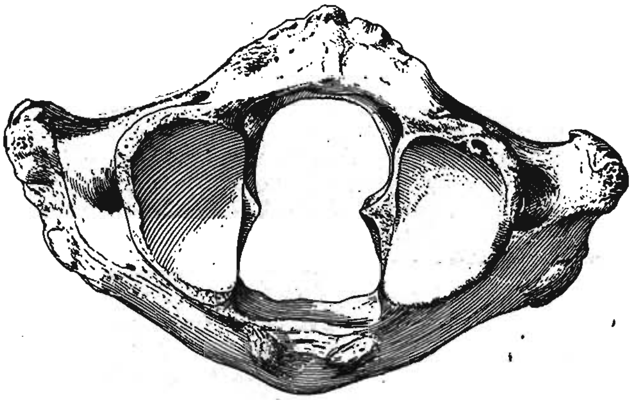


Fig. 116. *Mammut americanum.* Atlas of specimen in National Museum. From Church, Michigan. Seen from front. x ½.

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

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

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

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

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

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

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

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

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

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

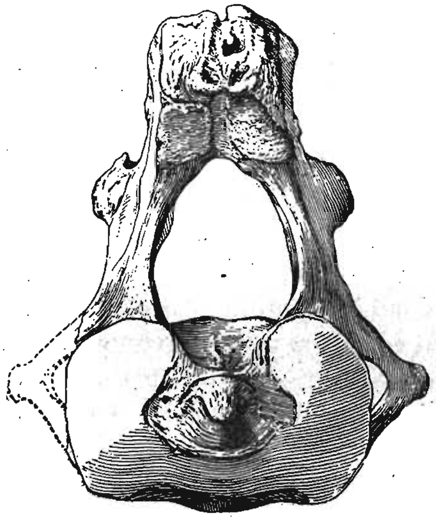


Fig. 117

Fig. 118

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

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

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

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

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

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

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

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

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

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

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

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

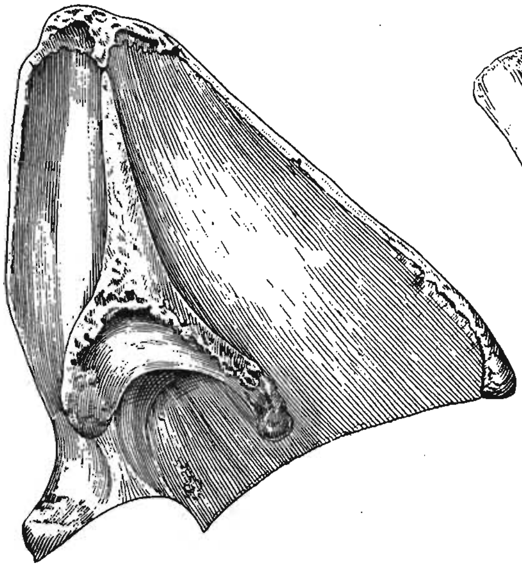


Fig. 119

Fig. 120

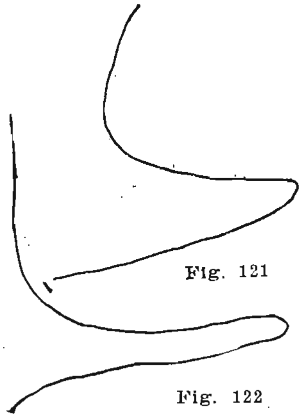
Fig. 119. *Mammut americanum.* Left scapula of the Warren mastodon; in American Museum Natural History.
Fig. 120. *Elephas primigenius.* Left scapula of Siberian mammoth. After Salensky.

MEASUREMENTS AND INDICES.

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

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

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



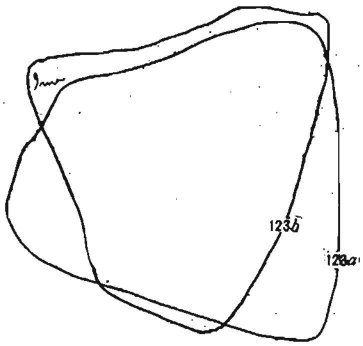


Fig. 121. *Mammut americanum*. Section across front of scapula.
Fig. 122. *Elephas primigenius*. Section across front of scapula.
Fig. 123. Sections across the ulna at the middle of the length. The front of the bones is above, the outer face toward the right.
123a. *Mammut americanum*. From Hillsdale,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

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

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

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

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

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

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

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

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

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

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

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

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

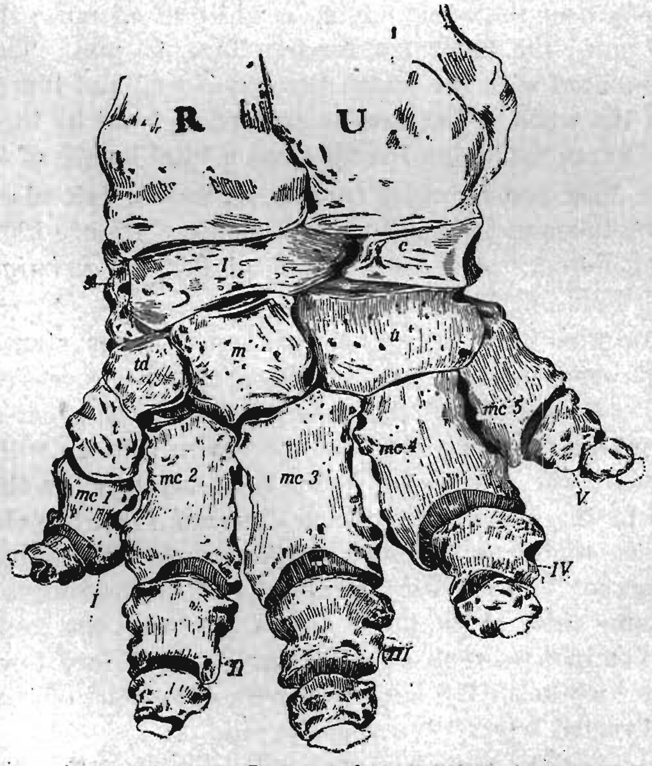


Fig. 124. *Mammut americanum*. Left fore foot seen from in front. *R*, radius; *U*, ulna; *I*, inner digit; *V*, outer digit; *c*, cuneiform bone; *l*, lunar; *s*, scaphoid; *td*, trapezoid; *m*, magnum; *u*, unciform; *mc 1* to *mc 5*, the metacarpals.

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

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

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

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

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

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

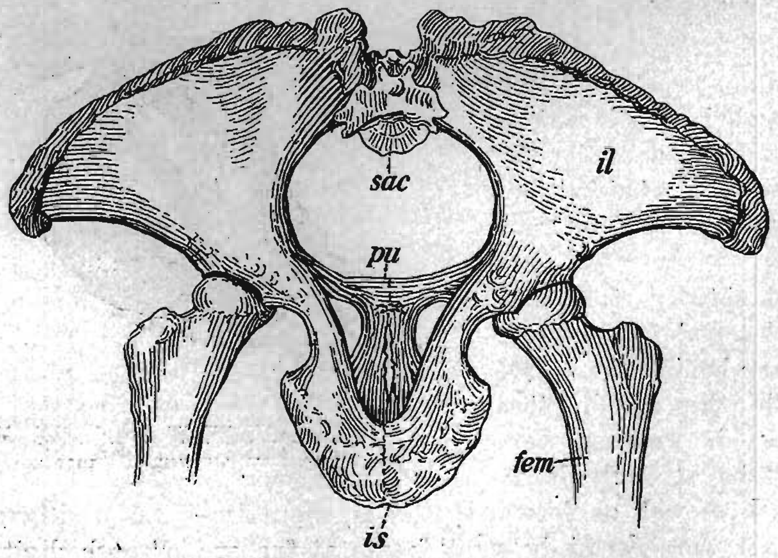


Fig. 126. *Mammut americanum.* Pelvis as seen from behind. After Warren. *fem.* femur; *il,* ilium; *is,* ischium; *pu,* pubis; *sac,* sacrum.

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

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

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

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

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

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

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

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

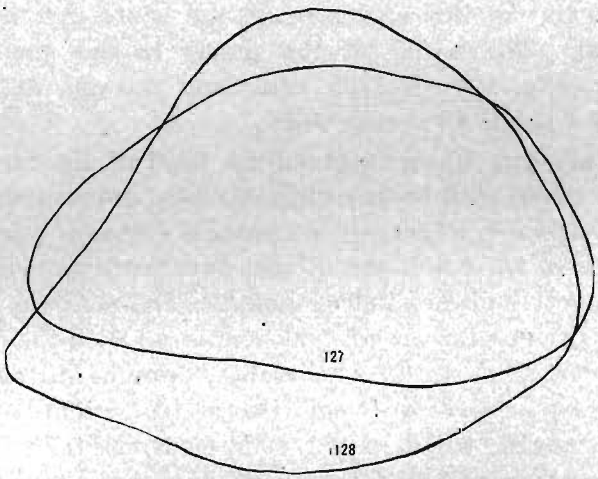


Fig. 127 *Mammut americanum.* Section of left femur, taken one-third the length of the bone above the lower end. x ½.
Fig. 128. *Elephas primigenius.* A section taken as in figure 127. x ½. In these figures the front of the bones is above; the outer border toward the left.

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

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

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

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

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

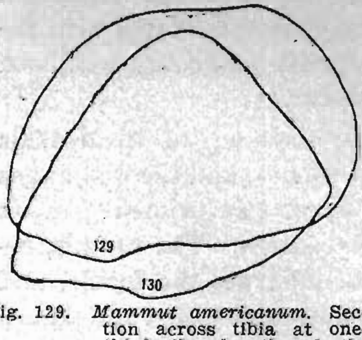


Fig. 129. *Mammut americanum.* Section across tibia at one-third the length of the bone above the lower end. x ½.

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

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

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

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

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

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

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

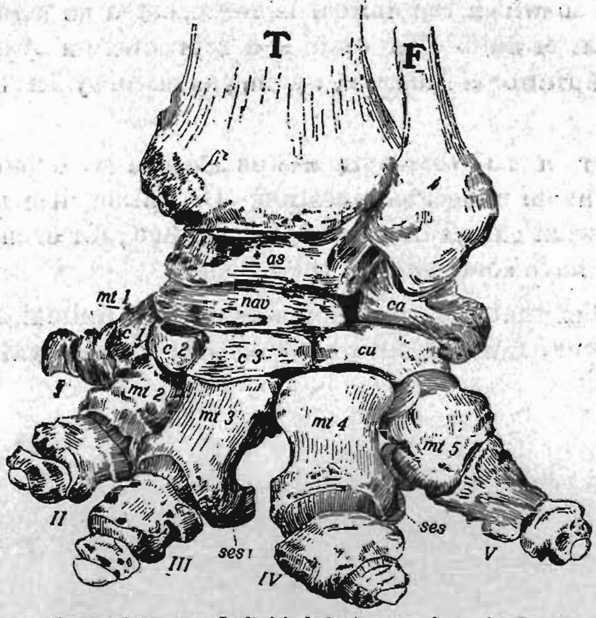


Fig. 131. *Mammut americanum.* Left hind foot, seen from in front. After Warren. *T*, the tibia; *F*, the fibula; *I*, inner digit; *V*, the outer digit; *mt 1* to *mt 5*, the metatarsals; *as*, astragalus; *ca*, calcaneum; *nav*, navicular; *cu*, cuboid; *c1*, *c2*, *c3*, the internal, middle, and external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

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

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

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

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

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

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

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

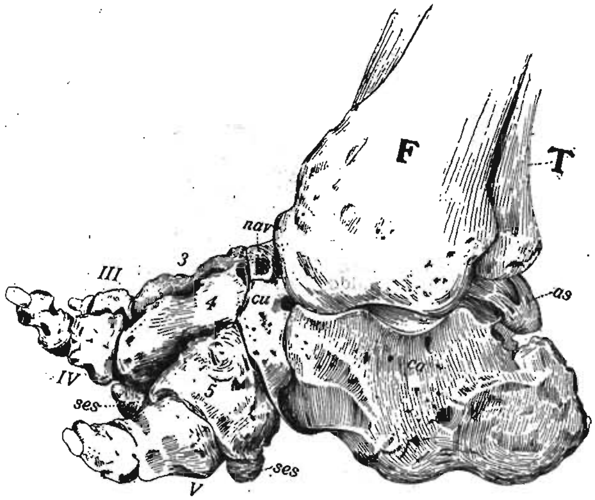


Fig. 132. *Mammut americanum.* Left hind foot, seen from the left or outer side. Explanatory letters as in figure 131.

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

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

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

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

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

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

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

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

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

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

Mammut progenium, new species.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Genus **RHABDOBUNUS** Hay.

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

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

Rhabdobunus mirificus (Leidy).

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

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

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

MEASUREMENTS OF TYPE OF *RHABDOBUNUS MIRIFICUS.*

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

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

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

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

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

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

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

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

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

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

NOTES ON THE MASTODONS WHICH HAVE BEEN FOUND IN IOWA.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Genus ELEPHAS Linnaeus.

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

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

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

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

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

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

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

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

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

Elephas primigenius Blumenbach.

The Hairy Mammoth.

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

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

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

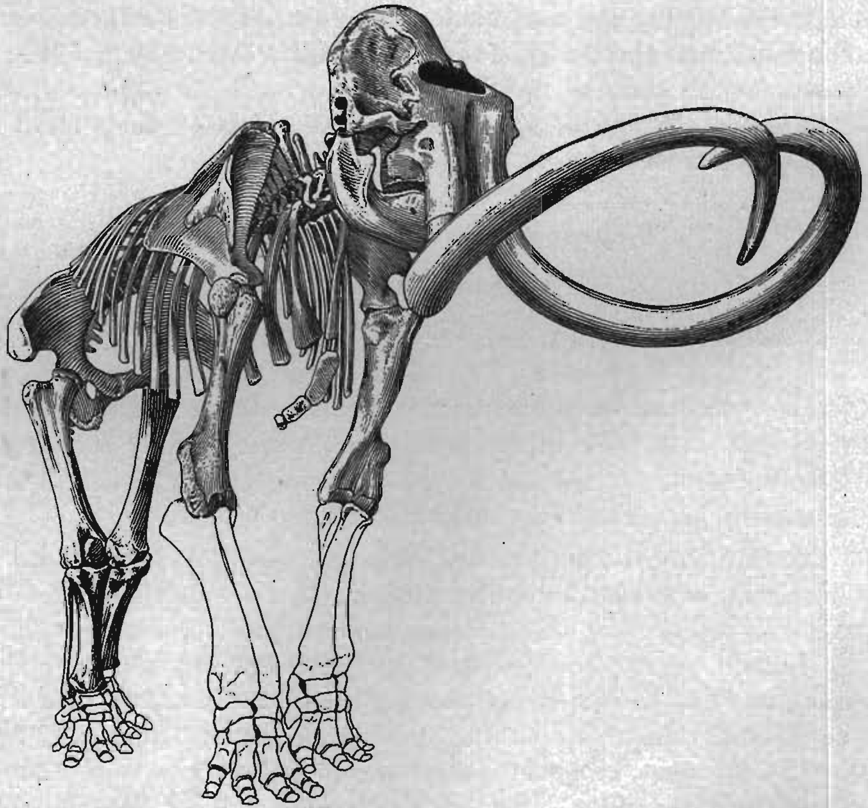


Fig. 133. *Elephas primigenius*. Skeleton found in Grant county, Indiana, and now in American Museum Natural History, New York. Oblique view.

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

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

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

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

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

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

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

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

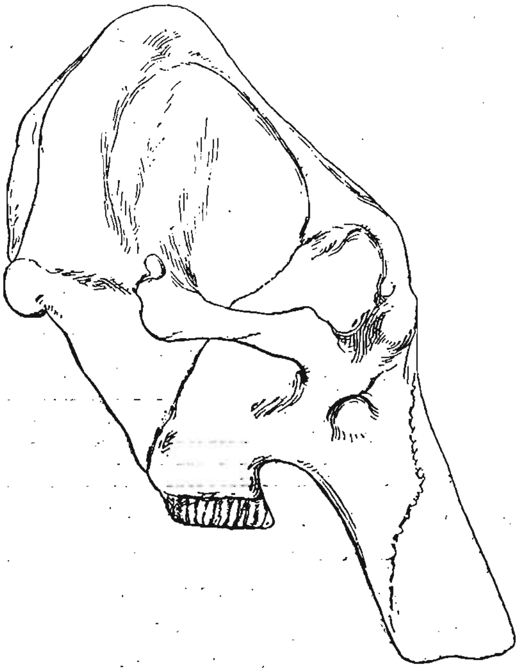


Fig. 134. *Elephas primigenius.* Side view of skull of Siberian specimen. From Falconer.

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

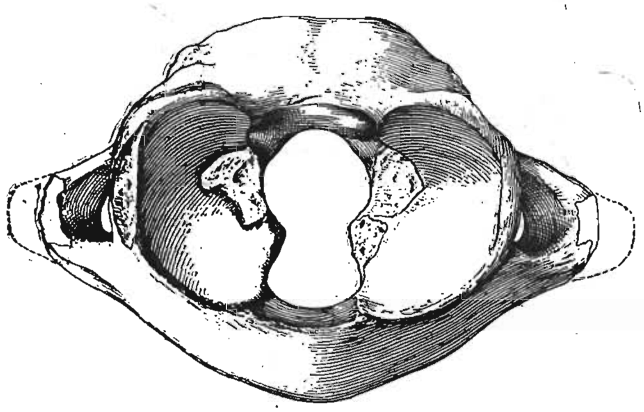


Fig. 135. *Elephas primigenius*. Atlas found on Old Crow river, Alaska. x ¼.

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

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

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

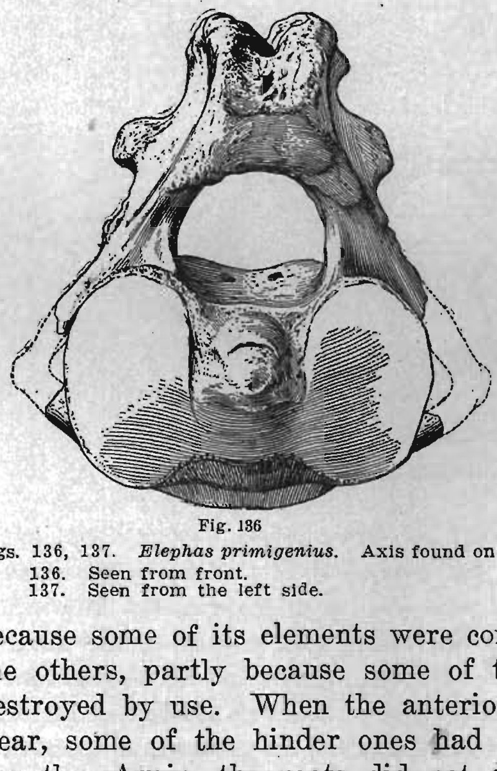


Fig. 136

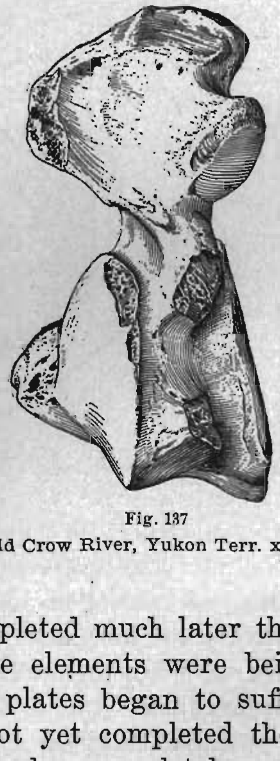


Fig. 137

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Elephas columbi Falconer.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Elephas imperator Leidy.

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

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

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

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

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

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

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

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

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

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

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

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

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

The following measurements have been secured from these limbs:

MEASUREMENTS OF FORE-LIMBS.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

MEASUREMENTS.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Order **Rodentia.**

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

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

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

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

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

Suborder **SIMPLICIDENTATA.**

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

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

Superfamily **SCIUROMORPHA.**

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

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

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

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

Family **Castoridae.**

The Beavers.

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

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

Genus CASTOR Linnæus.

The Beavers.

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

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

Castor canadensis Kuhl.

The American Beaver.

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

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

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

MEASUREMENTS.

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

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

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

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

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

MEASUREMENTS.

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

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

Family **Castoroididae.**

The Giant Beavers.

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

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

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

Genus **CASTOROIDES** Foster.

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

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

Castoroides ohioensis Foster.

The Giant Beaver.

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

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

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

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

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

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

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

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

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

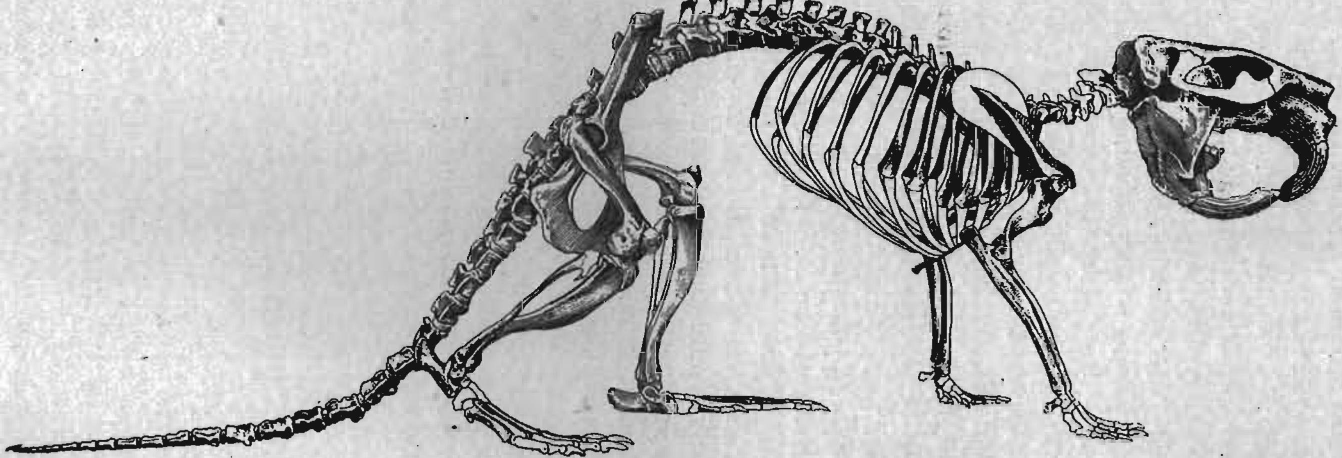


Fig. 138. *Castoroides ohioensis.* Skeleton in Earlham College, Richmond, Indiana.

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

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

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

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

MEASUREMENTS OF UPPER PREMOLARS AND MOLARS.

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

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

MEASUREMENTS OF LOWER PREMOLAR AND MOLARS.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Suborder DUPLICIDENTATA.

(Lagomorpha.)

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

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

The Leporidæ may be defined as follows:

Family Leporidae.

The Hares and Rabbits.

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

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

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

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

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

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

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

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

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

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

Genus **SYLVILAGUS** Gray.

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

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

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

Sylvilagus floridanus (Allen).

The Cottontail Rabbit.

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

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

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

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

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

MEASUREMENTS OF SKELETONS OF RABBITS.

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

Order **Ferae.**

(Carnivora).

The Flesh-eating Mammals.

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

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

Suborder **FISSIPEDIA.**

The Bears, Hyenas, Dogs, Cats, etc.

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

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

Family **Ursidae.**

The Bears.

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

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

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

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

Genus URSUS Linn.

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

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

Ursus americanus Pallas.

The Brown Bear of the Eastern United States.

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

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

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

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

MEASUREMENTS OF BEARS' SKULLS.

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

MEASUREMENTS OF BEARS' SKULLS—Concluded.

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

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

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

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

MEASUREMENTS OF BEARS' SKELETONS.

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

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

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

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

Family **Mustelidae.**

The Otters, Badgers, Skunks, Weasels, Etc.

Carnivora with reduced dentition, the tooth formula being i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{3-4}{3-4}$, m. $\frac{1}{2-1}$. The sectorial upper premolar and the sectorial lower molar well differentiated from the succeeding tooth. Body usually elongated and the limbs short.

The Mustelidæ are widely distributed over the world, but they are missing from Australia. In Europe they date from the Upper Eocene; in America, from the Oligocene. In the Pleistocene, they became abundant.

This family is divided into three subfamilies, the Lutrinæ (land-otters and sea-otters), the Melinæ (the skunks, badgers, etc.), and the Mustelinæ (the martens, minks, and weasels). Of the first and the last subfamilies no remains have yet been reported from Iowa. The Melinæ are represented by one skunk.

Subfamily MELINAE.

The Skunks and Badgers.

Limbs are more elongated than in the otters and weasels; the feet longer. Upper sectorial triangular and usually smaller than the very broad molar present. Lower sectorial elongated, with large basin-like heel.

Genus MEPHITIS Geoffroy and Cuvier.

Heavily built mustelids with tooth formula i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{3}{3}$, m. $\frac{1}{2}$. The upper sectorial considerably smaller than the molar. Heel of the lower sectorial nearly as long as the rest of the tooth. Palate ending behind nearly on a line with the hinder borders of the molars. Postorbital processes small or nearly wanting. Auditory bullæ little inflated.

The skunks of this genus inhabit the greater part of North America. Nine species are now recognized. The genus was revised in 1901 by Arthur H. Howell, of the Biological Survey (N. Amer. Fauna, No. 20, pp. 1-62, with pls. i-viii), the name Chincha being adopted. Gerrit S. Miller (Bull. 79, U. S. Nat. Mus., pp. 107-111) gives a list of the existing species.

From the Pleistocene there have been described seven species of this genus, most of them from the Port Kennedy cave, in Pennsylvania. From the Conard fissure in northern Arkansas, Barnum Brown described a form which he regarded as belonging to *Mephitis mephitis*. This species has been reported from the Port Kennedy cave, but Cope, in his last paper on the fauna of this cave did not recognize *M. mephitis,* but three other species, all extinct. True identified *M. mephitis* from Yarmouth peat, at Yarmouth, Iowa. At the time the latter identification was made, about 1881, the name *Mephitis mephitis,* or *mephitica,* was applied to most of the skunks of the eastern half of North America. It is now restricted to a large skunk which inhabits the region extending from Nova Scotia into the province of Keewatin. The skunk of this genus which now inhabits Iowa is known as *Mephitis mesomelas.* While probably all or most of the recognized existing species are tenable, they are closely related and their skulls vary comparatively little, and their skeletons probably still less. It would, therefore, probably be impossible to determine, with certainty, to which of the known species a single bone, as a scapula, belonged. It is, indeed, possible that, when the Yarmouth peat was being deposited, the boreal species *Mephitis mephitica* inhabited Iowa; but until materials have been found which are more characteristic, we cannot speak with assurance. The remains found at Yarmouth are, therefore, referred only provisionally to *M. mephitis.*

It is quite certain that species of this genus existed in this country at all times during the Pleistocene.

Mephitis mephitis (Schreber).

The circumstances attending the discovery of remains of skunk in the Yarmouth peat, at Yarmouth, Iowa, have already been mentioned in the discussion of *Sylvilagus floridanus,* on page 472. A single bone, a scapula, was found; and this, Dr. F. W. True was not able to distinguish from that of the most abundant skunk known to inhabit the eastern part of the United States. This, at that time, went under the name given above, but it is now known as *Mephitis putida.* This is not known to extend, at present, so far west as Iowa.

Inasmuch as fossil remains of skunks are liable to be found in the state of Iowa, it is thought proper to furnish illustrations (Pl. LXXIV, figs. 1-6) and measurements of the skull and measurements of some of the bones of the skeleton. There are first given measurements of the skull of a specimen of *Mephitis mephitis,* No. 110191, of the Biological Survey, found at Oxford House, Keewatin; in the second column those of the skull of *Mephitis putida,* No. 3523, of the National Museum, secured in Massachusetts:

MEASUREMENTS OF THE SKULLS OF *MEPHITIS MEPHITIS* AND *MEPHITIS PUTIDA.*

	Mephitis mephitis. Biological Survey	Mephitis putida National Museum
From front of premaxillae to rear of condyle	79 mm.	70 mm.
From front of premaxillae to lower border of foramen magnum	71 mm.	65 mm.

MEASUREMENTS OF SKULLS—Concluded.

	Mephitis mephitis Biological Survey	Mephitis putida National Museum
From front of permaxillae to rear of occipital crest, at midline	80 mm.	71 mm.
From front of premaxillae to line joining postorbital processes	38 mm.	35 mm.
From front of premaxillae to rear of hard palate	32 mm.	29 mm.
From rear of hard palate to foramen magnum	39 mm.	36 mm.
Width across occipital condyles	21 mm.	17 mm.
Width across mastoid region	44 mm.	38 mm.
Greatest width across the zygomatic arches	48 mm.	43 mm.
Width of snout at roots of canines	21 mm.	19 mm.
Least width just behind postorbital processes	20 mm.	19.5mm.
Width across postorbital processes	23.5mm.	22 mm.
Interorbital width	23 mm.	20.5mm.
Width across hinder molars, at base, in front	31.5mm.	27 mm.
Width across the incisors	11.5mm.	10 mm.
Canine, height	11 mm.	12 mm.
Canine, length of base	5 mm.	4 mm.
Canine, width of base	3.5mm.	3 mm.
Fourth premolar, length	8 mm.	7.5mm.
Fourth premolar, width	6 mm.	5 mm.
First molar, length	7.5mm.	6.5mm.
First molar, width	9.5mm.	8 mm.
From front of symphysis to middle of line joining condyles	50 mm.	45 mm.
Height of coronoid process	27 mm.	22 mm.
Width across the condyles	44 mm.	42 mm.
Length of first molar (sectorial)	11.5mm.	9.5mm.
Width of sectorial at rear	5 mm.	3.5mm.

The following measurements have been taken from a skeleton of *Mephitis putida*, No. 3523, of the National Museum, the skull of which is measured above:

MEASUREMENTS.

Scapula, length parallel with spine	40 mm.
Scapula, width near upper end	23 mm.
Humerus, total length	54 mm.
Humerus, width of upper end through head and greater tuberosity	13 mm.
Humerus, fore-and-aft diameter at middle of length	7 mm.
Humerus, side-to-side diameter at middle of length	4.5mm.
Humerus, greatest width at lower end	17 mm.
Ulna, total length	54 mm.
Ulna, greatest diameter at middle of length	4.5mm.
Radius, total length	43 mm.
Radius, greatest diameter at middle of length	4 mm.
Radius, greatest diameter at distal end	9.5mm.

Pelvis, greatest length	60 mm.
Pelvis, from front of ilium to center of acetabulum	37 mm.
Pelvis, width at front of ilia	37 mm.
Pelvis, width across upper borders of acetabula	30 mm.
Pelvis, width at rear of ischia	41 mm.
Femur, total length	61 mm.
Femur, width through head and greater trochanter	16 mm.
Femur, fore-and-aft diameter at middle of length	5 mm.
Femur, side-to-side diameter at middle of length	5.5mm.
Femur, greatest width across condyles	14 mm.
Tibia, total length	64 mm.
Tibia, diameter of upper end	15 mm.
Tibia, fore-and-aft diameter at middle of length	5 mm.
Tibia, side-to-side diameter at middle of length	4 mm.
Tibia, transverse diameter of lower end	10 mm.
Fibula, total length	55 mm.
Fibula, diameter at middle of length	2.5mm.

The measurements of the skulls show that *Mephitis mephitis* is a larger animal than *Mephitis putida.* There are other characters, derived from the living animals, which distinguish them.

Family Canidae.

The Dogs, Wolves, and Foxes.

Skull rather elongated. Auditory bullæ inflated. Tooth formula, i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{4}$, m. $\frac{2-3}{3}$; the sectorial tooth strongly developed, the lower one with cutting edge, the upper one transversely extended. Second upper molar broader than long. Premolars increasing in size backward. Feet digitigrade; first digit of fore foot very short; that of the hind foot vestigial. Digits with moderate, non-retractible claws.

The Canidæ have at present a world-wide distribution. In Europe numerous genera existed from the time of the Upper Eocene; and in North America from the time of the Oligocene. Several species existed in our country during the Pleistocene, but it is not certain that any remains have been found within the limits of Iowa. In 1862 (Geol. Surv. Wis., p. 422) Wyman announced wolf remains from Blue Mounds, Wisconsin, which he could not distinguish from the common gray wolf, *Canis occidentalis.* He also stated that the skull and most of the teeth of another wolf, not distinguishable from the coyote. *Canis latrans,* had been discovered in the lead region, but the state is not mentioned. It was from the collections made by James Hall, and may have been found by him in Iowa during his occupancy of the office of State Geologist of Iowa.

Genus CANIS Linn.

Dogs having the tooth formula, i.$_3$, c. $\frac{1}{1}$, pm. $\frac{4}{4}$, m. $\frac{2}{3}$. Upper molars wider than long, the hindermost one small. Last two molars of lower jaw small. Heel of lower sectorial usually narrower than the body of the tooth. Postorbital processes inflated and their upper surfaces turned strongly downward toward the extremity of the processes.

In the foxes the heel of the lower sectorial is as wide as, or wider than, the body of the tooth; the postorbital process has on its upper surface a depression, and this surface is not turned downward toward the tip of the process.

Canis mississippiensis Allen.

In 1876 J. A. Allen (Amer. Jour. Sci., ser. 3, Vol. XI, p. 49) described some remains of a wolf which had been found by Prof. J. D. Whitney in the lead region of Iowa, Wisconsin, and Illinois. Allen stated that the remains consisted of a femur, two tibia, and a humerus; and he indicates that possibly these formed a part of the wolf bones which were mentioned by Jeffries Wyman as having been found at Blue Mounds, Wisconsin. Allen concluded, however, that Wyman could not, because of the large size of the bones, have mistaken them for those of the gray wolf. Accordingly he described them under the name given above. It was not known in which of the three states named the bones were found.

Allen mentions the fact that Leidy had, in 1854, described a large wolf from a part of an upper jaw which had been found along Ohio river, in Indiana, and to which is now applied the name *Canis dirus*. Inasmuch as there were no teeth or jaws associated with the lead region specimen, Allen concluded that it would be better to describe it under a provisional name, awaiting the discovery of additional materials.

In 1873 Leidy described a lower jaw of a wolf which had been found in California, and this he referred to the same species as that based on the Indiana jaw. Recently J. C. Merriam (Mem. Univ. Calif., Vol. I, No. 2, pp. 217-246, pls. xxv-xxviii, text figs. 1-26) has referred to *Canis dirus* a large part of the abundant wolf materials which had been recovered from the asphalt beds of Rancho La Brea, near Los Angeles, California. Merriam's materials include practically every part of the skeleton. In making his identification he had the benefit of the type specimen of *Canis dirus,* which belongs to the collection of the Philadelphia Academy.

The following table is in part copied from Allen's paper; but there is added a third column in which are given corresponding measurements taken from bones of *Canis dirus,* secured at Rancho La Brea. These measurements have been sent the writer by Doctor Merriam. Those of the humerus are taken on No. 19793 of the collection at the University of California; those of the femur from No. 19795; those of the tibia from No. 19794.

COMPARATIVE MEASUREMENTS OF BONES OF *CANIS MISSISSIPPIENSIS, CANIS LUPUS* AND *CANIS DIRUS.*

	Canis mississippiensis	Canis lupus	Canis dirus
Humerus. total length	223 mm.	176 mm.	240 mm.
Humerus, greatest diameter of proximal end	55 mm.	44 mm.	62 mm.
Humerus, antero-posterior diameter of head	41 mm.	34 mm.	47.7mm.
Humerus, greatest transverse diameter of distal end	46 mm.	37 mm.	55.1mm.
Humerus, greatest antero-posterior diameter of inner condyle	36 mm.	28 mm.	43 mm.
Humerus, least circumference of shaft	62 mm.	50 mm.	70.3mm.
Femur, total length	-----------	193 mm.	260 mm.
Femur, transverse diameter of axis and great trochanter	-----------	45 mm.	66.4mm.
Femur, transverse diameter of condyles	43 mm.	35 mm.	54.5mm.
Femur, antero-posterior diameter of inner condyles	53 mm.	39 mm.	62.7mm.
Femur, least circumference	56 mm.	44 mm.	73.4mm.
Femur, length of corresponding parts (distal two-thirds)	155 mm.	123 mm.	-----------
Tibia, total length	244 mm.	200 mm.	237 mm.
Tibia, transverse diameter of head	47 mm.	38 mm.	55.4mm.
Tibia, antero-posterior diameter at most elevated point of the tuberosity	43 mm.	35 mm.	57.3mm.
Tibia, transverse diameter of distal end	31 mm.	24 mm.	38.2mm.
Tibia, least circumference of shaft	52 mm.	43 mm.	69.6mm.

A comparison of the lengths of the humerus and tibia of the two individuals measured above shows that Allen's species was taller by one-fifth than the gray wolf. Allen regarded his species as being nearly twice the size of the gray wolf, but in that he evidently referred to the relative bulks; and this would be true.

Allen's *Canis mississippiensis* has sometimes been referred to Leidy's *C. dirus*. It would, therefore, be interesting if a direct comparison of the bones described by Allen could be made with the corresponding bones of *Canis dirus;* but this at present, is impracticable. Merriam has, in his paper on *Canis dirus,* given only the lengths of the humerus, femur, and tibia. He has, however, as already stated, very obligingly sent the writer measurements corresponding to those taken by Allen; and these are presented in the third column of the table given above. These measurements show that the wolf from the lead region had nearly the same size as that which lived at La Brea, the humerus measured by Merriam being slightly longer, the tibia slightly shorter. As indicated by such measurements as could be taken on both femora, that of the La Brea wolf was much larger. It must not be forgotten, however, that all three bones measured belonged to as many individuals.

PERCENTAGES OF DIAMETERS AND LEAST CIRCUMFERENCES OF HUMERI AND TIBIÆ TO THEIR LENGTHS.

Dimensions Considered	Canis mississippiensis	Canis lupus	Canis dirus
Humerus total length, taken as unity	100	100	100
Greatest diameter of proximal end	22.9	24.6	25
Antero-posterior diameter of head	19.9	18.3	18.9
Greatest transverse diameter of distal end	22.9	20.6	21
Greatest antero-posterior diameter of inner condyle	17.0	16.1	15.9
Least circumference of shaft	29.0	27.8	28.4
Tibia, total length, taken as unity	100	100	100
Transverse diameter of head	23.3	19.2	19
Antero-posterior diameter at most elevated point of tuberosity	24.2	17.6	17.5
Transverse diameter of distal end	16.1	12.6	12
Least circumference of shaft	28.9	21.3	21.5

It will be observed that the corresponding ratios found in the last two columns are remarkably close to each other, showing that these two animals, although of very different dimensions, were built much alike. When we compare the corresponding ratios in the first and the second columns we find that they are farther apart. This is shown especially in the comparisons of the tibiæ of the three species. *Canis mississippiensis* appears to have been an animal with relatively much heavier limbs than either the living wolf (called above *C. lupus*) or *C. dirus,* as represented by the bones found at La Brea.

As regards the geological age of *Canis mississippiensis,* nothing can be affirmed. The writer sees no good reason for believ-

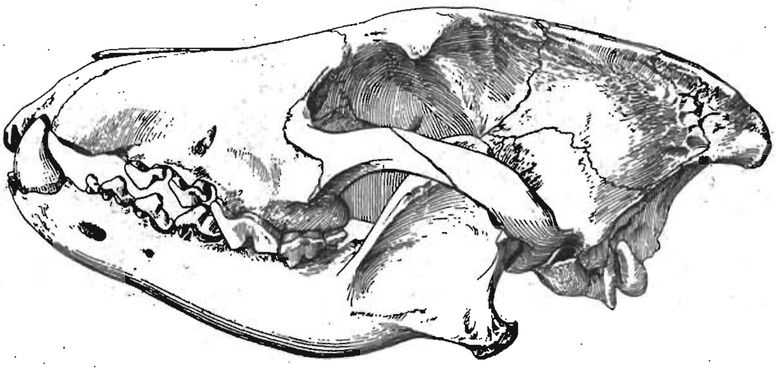


Fig. 139. *Canis dirus.* Skull and lower jaw seen from the side. x 1-3. From La Brea, California.

ing that they antedate the close of the Wisconsin stage. Many of the other mammals which have been found in the lead crevices belong to extinct species, several of them to extinct genera. There have been discovered there, Mammut, Megalonyx, Platygonus, Bison, Cervus, Odocoileus, Antilocapra, Canis, Procyon, Anomodon, Arctomys, Geomys, Sylvilagus and Arvicola. Of the extinct genera it is certain that all were yet in existence after the disappearance of the Wisconsin ice-sheet; unless it be Anomodon, about which we know practically nothing. As to the bison found in the crevices, Allen stated that it was an extinct species; but he does not give his reasons for his conclusions. So far as the writer knows there were found only limb bones, mostly broken; and Wyman stated that they were all of the size of the same parts of the buffalo and closely resembled them. *Canis mississippiensis* may, therefore, be post-Wisconsin in age.

We cannot be certain regarding the age of the type of *Canis dirus*. It was found associated with *Megalonyx jeffersonii,* a tapir, a horse, an Odocoileus which was supposed to be the

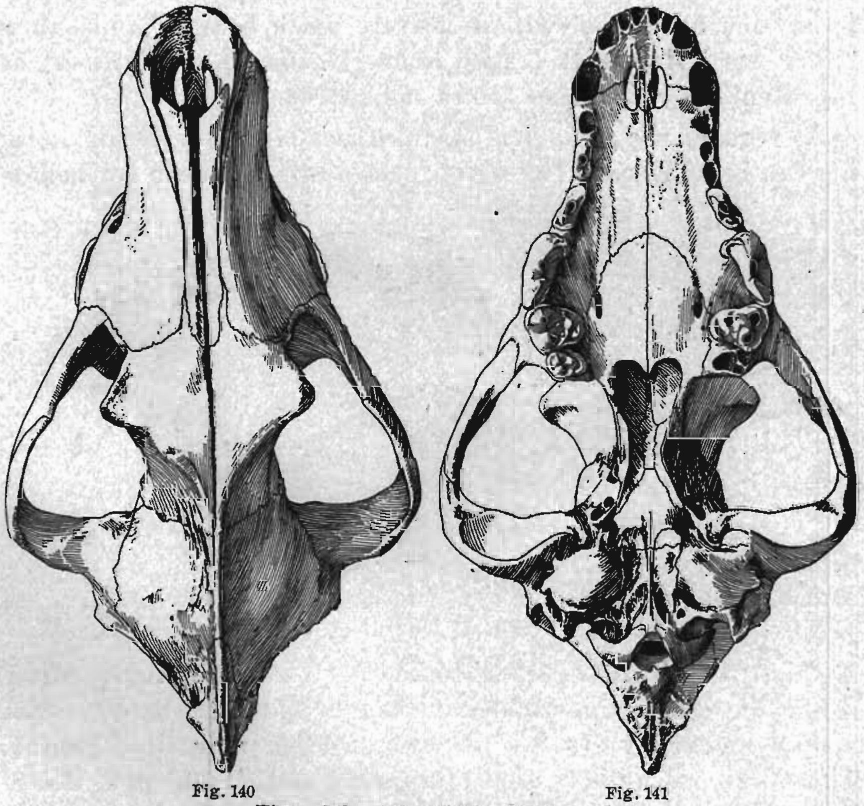


Fig. 140 Fig. 141
Figs. 140, 141. *Canis dirus.* x 1-3.
140. Skull seen from above.
141. Palatal view of skull.

Virginia deer, and a Bison supposed to be the yet existing buffalo, but which is more probably an extinct species. No horse or tapir remains have yet, so far as the writer can learn, been found in post-Wisconsin deposits; and, it is therefore probable that the wolf remains belong to pre-Wisconsin times. There appear to be no reasons for believing that the animals mentioned in this paragraph, likewise those found at Big Bone Lick, Kentucky, are as old as the Aftonian, during which time lived numerous horses and camels. The writer is inclined to assign these all to the Sangamon stage, that immediately following the Illinoian stage. The position of the bones in the deposits forming the banks of Ohio river seems to confirm this conclusion.

As to the age of the California specimens which have been referred to *Canis dirus*, there can be no doubt that they belong to the early Pleistocene.

The question then arises: Did *Canis dirus* continue to exist from the beginning, or near the beginning, of the Pleistocene to its close? The writer has so much doubt as to the probability of this that, fortified by the differences which appear to exist between the bones of the California specimens and those of Allen's *C. mississippiensis*, he prefers to retain the name just mentioned for the remains found in the lead region.

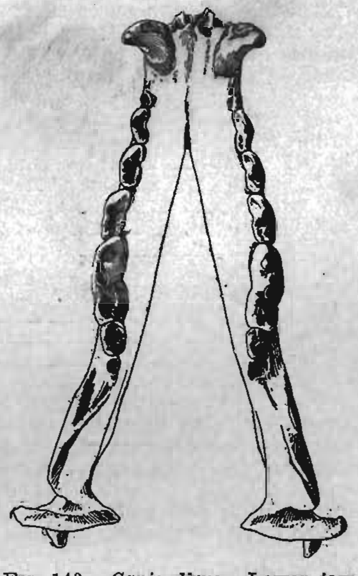


FIG. 142. *Canis dirus.* Lower jaw seen from above. x 1-3.

Inasmuch as skulls, teeth, and other parts of the skeleton of wolves are likely to be found in Pleistocene deposits of Iowa, it is thought well to present views (Figs. 139-142) of the skull of *Canis dirus*, as represented by a California specimen and to give measurements of its skull and of the teeth. Furthermore, to aid in distinguishing wolves of the size of the gray wolf from the larger ones, such as *C. mississipiensis*, and from the smaller ones, as the coyote, measurements are given of various bones of a specimen of the gray wolf. The latter measurements are placed in the second column of the table of measurements of *C. latrans*, on page 493. The measurements here given of the skull of *Canis occidentalis* are taken from a skull coming from Texas.

MEASUREMENTS OF THE SKULLS OF *CANIS DIRUS* AND OF *CANIS OCCIDENTALIS.*

	Canis dirus	Canis occidentalis
Front of premaxillae to hinder end of occipital crest	300 mm.	253 mm.
Front of premaxillae to hinder end of occipital condyles	260 mm.	235 mm.
Width of skull across zygomatic arches	170 mm.	128 mm.
Width of skull at rear of pm.^{4}	100 mm.	78 mm.
Width of skull at rear of pm.^{1}	53 mm.	44 mm.
Width at interorbital space, least	62 mm.	41 mm.
Width across postorbital processes	85 mm.	54 mm.
Width at constriction behind postorbital processes	50 mm.	43 mm.
Fore-and-aft diameter of orbit	45 mm.	37 mm.
Distance from m.^{2} to front of articulation for lower jaw	55 mm.	50 mm.
Width of posterior nares	30 mm.	21 mm.
Long diameter of auditory bulla	29 mm.	29 mm.
Outside of one bulla to that of the other	75 mm.	65 mm.
Front of premaxillae to posterior nares	138 mm.	123 mm.
Front of canine to rear of m.^{2}	123 mm.	101 mm.
Canine, diameter fore-and-aft	18 mm.	15 mm.
Canine, width	13 mm.	9 mm.
Pm.^{2}, length	16 mm.	15 mm.
Pm.^{2}, width	8 mm.	7 mm.
Pm.^{3}, length	19 mm.	16 mm.
Pm.^{3}, width	9 mm.	7 mm.
Pm.^{4}, length	32 mm.	25 mm.
Pm.^{4}, width behind the claw	13 mm.	12 mm.
M.^{1}, length	19 mm.	16 mm.
M.^{1}, width	25 mm.	22 mm.
M.^{2}, length	11 mm.	9 mm.
M.^{2}, width	16 mm.	13 mm.
Lower jaw from front to rear of condyle	212 mm.	185 mm.
Height of jaw between pm.$_2$ and pm.$_3$	33 mm.	26 mm.
Height of jaw between m.$_1$ and m.$_2$	40 mm.	32 mm.
Canine tooth, fore-and-aft diameter	18 mm.	15 mm.
Canine tooth, transverse diameter	13 mm.	10 mm.
Pm.$_1$, length	6 mm.	6 mm.
Pm.$_1$, width	5 mm.	5 mm.
Pm.$_2$, length	16 mm.	14 mm.
Pm.$_2$, width	7 mm.	6.5 mm.
Pm.$_3$, length	16.5 mm.	14.5 mm.
Pm.$_3$, width	8 mm.	6.5 mm.
Pm.$_4$, length	20 mm.	16 mm.
Pm.$_4$, width	10 mm.	9 mm.
M.$_1$, length	35 mm.	29 mm.
M.$_1$, width	13 mm.	12 mm.
M.$_2$, length	13 mm.	12.5 mm.
M.$_2$, width	10 mm.	9 mm.
M.$_3$, length	10 mm.	----------
M.$_3$, width	15 mm.	----------

Canis latrans Say.

The Coyote; the Prairie Wolf.

In J. D. Whitney's report on the lead region already referred to, Wyman stated that in Professor James Hall's collection there were some wolf remains which he could not distinguish from the corresponding parts of the prairie wolf, *Canis latrans*. These parts consisted of a portion of the skull which contained nearly the whole series of upper teeth, excepting the incisors, the first premolar on both sides, and the last molar on the right. Here again we are uncertain in which of the three states which share the lead region the skull was found; but the probability is that it was in Iowa. Where this skull now is, if yet in existence, the writer does not know.

The coyote belongs among the smaller species of wolves. Its present range is from northwestern Indiana to Missouri and thence northwest to the Rocky mountains and Alberta. Geologically the species appears to have existed since the early part of the Pleistocene, having been found in Oregon and Nebraska in company with horses and camels. However, the reference to this species of remains found in Oregon may prove to be erroneous.

Should any bones be found which are suspected to belong to a wolf, it would be well to compare them with the corresponding parts of the domestic dog. These may usually be obtained without great difficulty. Should the relationships to the wolves be proved, recourse may be had to measurements. In order to make this possible the following measurements are furnished. Those of the skull are taken from No. 12893, of the National Museum. For measurements of the skull of *Canis occidentalis*, see the second column on page 490.

Plate LXXV offers views of the skull, lower jaw, and teeth of this species. The figures are from a skull in the National Museum, which was obtained at old Fort Kearney, Nebraska.

MEASUREMENTS OF THE SKULL OF THE COYOTE.

Front of premaxillae to end of occipital crest	190 mm.
Front of premaxillae to end of occipital condyles	178 mm.
Width of skull at ear-openings	55 mm.
Width of skull across zygomatic arches	93 mm.
Width of skull at pm.^{4}	58 mm.
Width of skull at pm.^{1}	28 mm.
Width of skull at interorbital space, least	30 mm.
Width of skull across postorbital processes	44 mm.
Width of skull behind postorbital processes	32 mm.
Diameter of orbit, fore-and-aft	28 mm.
Distance from m.^{2} to front of articulation for lower jaw	28 mm.
Width of posterior nares	16 mm.
Long diameter of auditory bulla	21 mm.
Front of premaxillae to rear of hard palate	92 mm.
Front of canine to rear of m.^{2}	89 mm.
Canine, upper, diameter, fore-and-aft	13 mm.
Canine, upper, diameter, side-to-side	6.5mm.
Canine, lower, diameter, fore-and-aft	9 mm.
Canine, lower, diameter, side-to-side	6 mm.

Pm.^{2}, length	11 mm.	Pm.$_2$, length	11 mm.
width	4 mm.	width	4 mm.
Pm.^{3}, length	12.5mm.	Pm.$_3$, length	12 mm.
width	4.4mm.	width	5 mm.
Pm.^{4}, length	20 mm.	Pm.$_4$, length	13 mm.
width, behind claw	7.5mm.	width	6 mm.
M.^{1}, length	13 mm.	M.$_1$, length	23 mm.
width	17 mm.	width	8 mm.
M.^{2}, length	7 mm.	M.$_2$, length	10 mm.
width	11 mm.	width	6 mm.
		M.$_3$, length	4.5mm.
		width	3.3mm.

The following measurements of parts of the skeleton are taken from a specimen in the National Museum, No. 1011, the skull of which had a length to the condyles, of 165 mm. Therefore the skeleton may be slightly undersized. In the second column are given corresponding measurements of the gray wolf, *Canis occidentalis,* taken from a specimen captured at Fort Kearney, Nebraska. It has the number 6508 in the National Museum. The length from the front of the premaxillæ to the rear of the condyles is 241 mm., only 6 mm. greater than the skull measured on page 490.

MEASUREMENTS OF PARTS OF THE SKELETONS OF *CANIS LATRANS* AND OF *CANIS OCCIDENTALIS.*

	Canis latrans	Canis occidentalis
Scapula—		
Length, parallel with the spine	105 mm.	174 mm.
Breadth near the upper end	52 mm.	90 mm.
Breadth of the neck	17 mm.	41 mm.
Humerus—		
Total length	153 mm.	212 mm.
Greatest length through the head and greater tuberosity	35 mm.	51 mm .
Fore-and-aft diameter at middle of length	11 mm.	22 mm.
Side to-side diameter at middle of length	9 mm.	16 mm.
Greatest width at the distal end	26 mm.	52 mm.
Ulna—		
Extreme length	185 mm.	241 mm.
Greatest diameter at middle of length	7 mm.	11.5mm.
Radius—		
Extreme length	161 mm.	204 mm.
Width of proximal end	15 mm.	23 mm.
Greatest diameter at middle of length	10 mm.	16.5mm.
Shortest diameter at middle of length	6 mm.	11.5mm.
Greatest width at lower end	19 mm.	31 mm.
Pelvis—		
Extreme length	113 mm.	182 mm.
Width between upper borders of acetabula	58 mm.	90 mm.
Greatest width at front of ilia	63 mm.	113 mm.
Greatest width across ischia	86 mm.	127 mm.
Height of front of ilium	35 mm.	66 mm.
Least width of ilium in front of acetabulum	15 mm.	26 mm.
Femur—		
Extreme length	161 mm.	216 mm.
Distance through head to outside of great trochanter	31 mm.	46 mm.
Fore-and-aft diameter at middle of length	10.5mm.	15 mm.
Side-to-side diameter at middle of length	9.5mm.	16 mm.
Greatest width across condyles	24.5mm.	39 mm.
Tibia—		
Extreme length	182 mm.	221 mm.
Side-to-side width of upper end	28 mm.	43 mm.
From front of tuberosity to rear of inner articulation	31 mm.	49 mm.
Fore-and-aft diameter at middle of length	10 mm.	16 mm.
Side-to-side diameter at middle of length	10 mm.	17 mm.
Greatest width across lower end	17 mm.	28 mm.
Fibula—		
Extreme length	169 mm.	206 mm.
Greatest diameter at middle of length	2 mm.	5.5mm.

In the effort to determine whether a particular canine skull belonged to the coyote, to some other species of wolf, or to some breed of common dog, one must take into account first, the size of the skull and then its general form. The skull of the coyote is long, relatively narrow, with elongated narrow snout. The canine teeth of the coyote are relatively longer and thinner than those of the domestic dogs. In fact, all of the teeth are larger in proportion to the skull than in the domestic dogs; and the cusps and ridges are more prominent, as seen in the little worn teeth.

As to the geological age of the remains of the coyote reported from the lead region, the reader is referred to remarks under *Canis mississippiensis,* on page 487.

GLOSSARY.

Acetabulum. That cavity of the hip bone which received the head of the femur.

Astralagus. The bone of the ankle on which the tibia rests. See figure 43, page 144; figure 131, page 365.

Atlas. The first vertebra of the neck. See page 399, figure 135.

Auditory bulla. An inflated part of one of the bones of the ear; seen one on each side of the base of the skull of some animals, as the rodents, the cats, etc.

Axis. The second vertebra of the neck. See figures 136, 137, page 400.

Basilar length. Distance from the front of the premaxillæ to the lower border of the foramen magnum; basal length.

Calcaneum. The heel-bone. See figure 43, on page 144; figure 131, page 365.

Canine teeth. Those teeth in the upper and lower jaws which correspond to the prominent holding teeth of a cat and dog.

Cannon-bone. In the even-toed hoofed animals the bone immediately below the wrist bones and the ankle bones.

Carpal bones. The bones of the wrist. See figure 124, page 358.

Champlain stage. See page 10.

Cingulum. A ridge or fold of enamel at the base of the crown of teeth, especially the cheek-teeth of some mammals.

Clavicle. The bone of an animal which corresponds to the collar bone of man. Many mammals do not have these bones.

Condyle. Rounded articular surfaces, as those by which the head is joined to the neck, and the articular surface at the lower end of the humerus.

Cuboid. A bone of the ankle. See figure 131, page 365.

Cuneiform. A bone of the wrist. See figure 124, page 358; also applied to three bones of the ankle. See figure 131, page 365.

Dental formula. See page 103.

Entepicondylar foramen. A hole at the inner side of the lower end of the humerus.

Entoconid. See page 152, figure 47.

Entostylid. See page 152, figure 47.

Epicondyle. The prominence on each side of the lower end of the humerus.

Femur. The bone of the upper part of the hind leg and articulating above with the hip bone. Plural, femora. See figure 126, page 360.

Fibula. The bone of the lower leg which is the smaller and which is found on the outer side. See figure 131, page 365.

Foramen magnum. The opening at the base of the skull by which the spinal cord enters the brain-cavity.

Glenoid fossa. The smooth surface on the skull at which the lower jaw is attached.

Hyoid. The bone at the base of the tongue.

Hypocone. See page 152, figure 46.

Hypoconoid. See page 152, figure 47.

Hypostyle. See page 152, figure 46.

Humerus. The bone of the upper part of the arm.

Ilium. That part of the innominate bone which forms the hip. See page 360, figure 126.

Incisor teeth. The front, or gnawing, teeth of mammals.

Innominate bone. That bone formed by the permanent union of the ilium, the ischium, and the pubic bones, of each side. See figure 126, page 360.

Ischium (plural Ischia). In a mammal that part of the innominate bone on which the animal rests when in a sitting position. See figure 126, page 360.

Jugal bone. The bone in an animal which corresponds to the cheek-bone in man; called also malar.

Lake. In tooth of horse. See page 152, figure 46. Corresponding structures are found in many hoofed animals.

Loess. See pages 15, 38.

Lunar bone. A bone of the wrist. See figure 124, page 358.

Magnum. A bone of the wrist. See figure 124, page 358.

Malar bone. See Jugal bone.

Mammals, Mammalia. Animals which nourish their young on milk; nearly all have a covering of hair. See pages 101, 102.

Mark. In a horse's tooth the same as "lake."

Mesostyle. See page 152, figure 46.

Metacone. See page 152, figure 46.

Metaconid. See page 152, figure 47.

Metapodials. A term including the metacarpals and the metatarsals.

Metacarpals. The bones of the fore leg which are immediately below the wrist bones. In man and some animals there are five of these, and they form the palm. They are numbered from the inner or thumb side.

Metatarsals. The bones of the hind leg which are immediately below the ankle bones. In man and some animals they are five in number, and they form the instep. See page 144, figure 43; page 365, figure 131. They are numbered from the inner or great toe side.

Metastyle. See page 152, figure 46.

Millimeter. A unit of length in the metrical system. Twenty-five millimeters (mm.) may for practical purposes be taken as equal to 1 inch. One hundred mm. are slightly less than 4 inches; 305 mm. equal 12 inches.

Molar teeth. Those teeth, three or fewer in numbers, which are farthest behind in the upper and lower jaws. They are not preceded by milk teeth.

Moraines. See page 12.

Navicular. A bone of the ankle. See figure 131, page 365.

Occipital condyles. The smooth articular surface by means of which the skull joins the first bone of the neck.

Ossa innominata. See Innominate bones.

Paracone. See page 152, figure 46.

Parastylid. See page 152, figure 47.

Patella. The knee-cap.

Pelvis. The basinlike structure formed by the innominate bones and the sacrum. See figure 126, page 360.

Phalanx, phalange, phalanges. Terms applied to the bones of the fingers and toes, excepting the metapodials. The first phalanges are the upper ones. See figure 43, page 144; figure 124, page 358; figure 131, page 365.

Pisiform. A bone of the wrist. See figure 125, page 359.

Pleistocene epoch. See page 10.

Postprotoconal valley. That deep inlet of the enamel which is found on the inner side of the grinding surface of the upper cheek-teeth of a horse. See page 152, figure 46, *pv*.

Premolar teeth. Those grinding, or cutting, teeth, usually three or four in number, which occupy the front part of the upper and lower jaws behind the canines; they take the place of the milk teeth when these are shed.

Protocone. See page 152, figure 46.

Protoconid. See page 152, figure 47.

Protoconule. See page 152, figure 46.

Protostyle. See page 152, figure 46.

Pubis. That bone which forms the front part of the outlet of the pelvis.

Quaternary. That division of geological time which includes the Pleistocene and the Recent. See page 49.

Radius. That one of the two bones of the lower arm which joins the wrist on the thumb side. See figure 124, page 358.

Ridge-plate. A constituent of a tooth of an elephant consisting of a thin plate of dentine surrounded by enamel. See page 393.

Sacrum. Those bones of the vertebral column to which the hip bones are joined. See figure 126, page 360.

Scaphoid. A bone of the wrist. See figure 124, page 358.

Scapula. The shoulder blade.

Sectorial tooth. A tooth, the fourth premolar above and the first molar below, which in Carnivora is more or less blade-like and fitted for cutting.

Sesamoid bones. Small bones found in the tendons of the feet. See figure 125, page 359; figure 131, page 365.

Squamosal. A bone of the skull in the region of the ear and sending forward the zygomatic process. Same as temporal bone.

Sternum. The breast bone of an animal.

Style. In speaking of a tooth this means a prominent fold of enamel on the outer, or in the inner, face of a tooth.

Symphysis. The union of two bones of opposite sides of the body, as the two halves of the lower jaw and of the two pubic bones.

Tarsal bones. The bones of the ankle. See figure 131, page 365.

Temporal bone. See squamosal bone.

Temporal fossa. The space between the zygomatic arch and the wall of the brain-case.

Tibia. That bone of the lower part of the hind leg which is on the inner side; the shin-bone. See figure 131, page 365.

Trapezium. A bone of the wrist. See page 358, figure 124, t.

Trapezoid. A bone of the wrist. See figure 124, page 358.

Trochanter. Each of the two processes of bone at the upper end of the femur. A process called the third trochanter is situated on the outer side of the shaft of the femur in some animals, as the horse. See page 144.

Trochlea. The pulley-like end of the humerus which fits against the ulna.

Ulna. That one of the two bones of the lower arm which joins the wrist on the side of the little finger. See figure 124, page 358.

Unciform. A bone of the wrist. See figure 124, page 358.

Ungual phalange. That bone of a digit which bears a nail or a claw or a hoof.

Vertebrata. Animals which, with rare exceptions, possess a back-bone; as fishes, reptiles, birds, mammals. For common names of most of the species dealt with in this work see pages 32, 34, 38.

Zygoma; zygomatic arch. The arch of bone on each side of the skull below and behind the orbit.

EXPLANATION OF PLATES

Plate I.

Map showing localities in Iowa where vertebrate fossils have been found; also localities where have been observed exposures of interglacial deposits, except of loess. See pages 52-87.

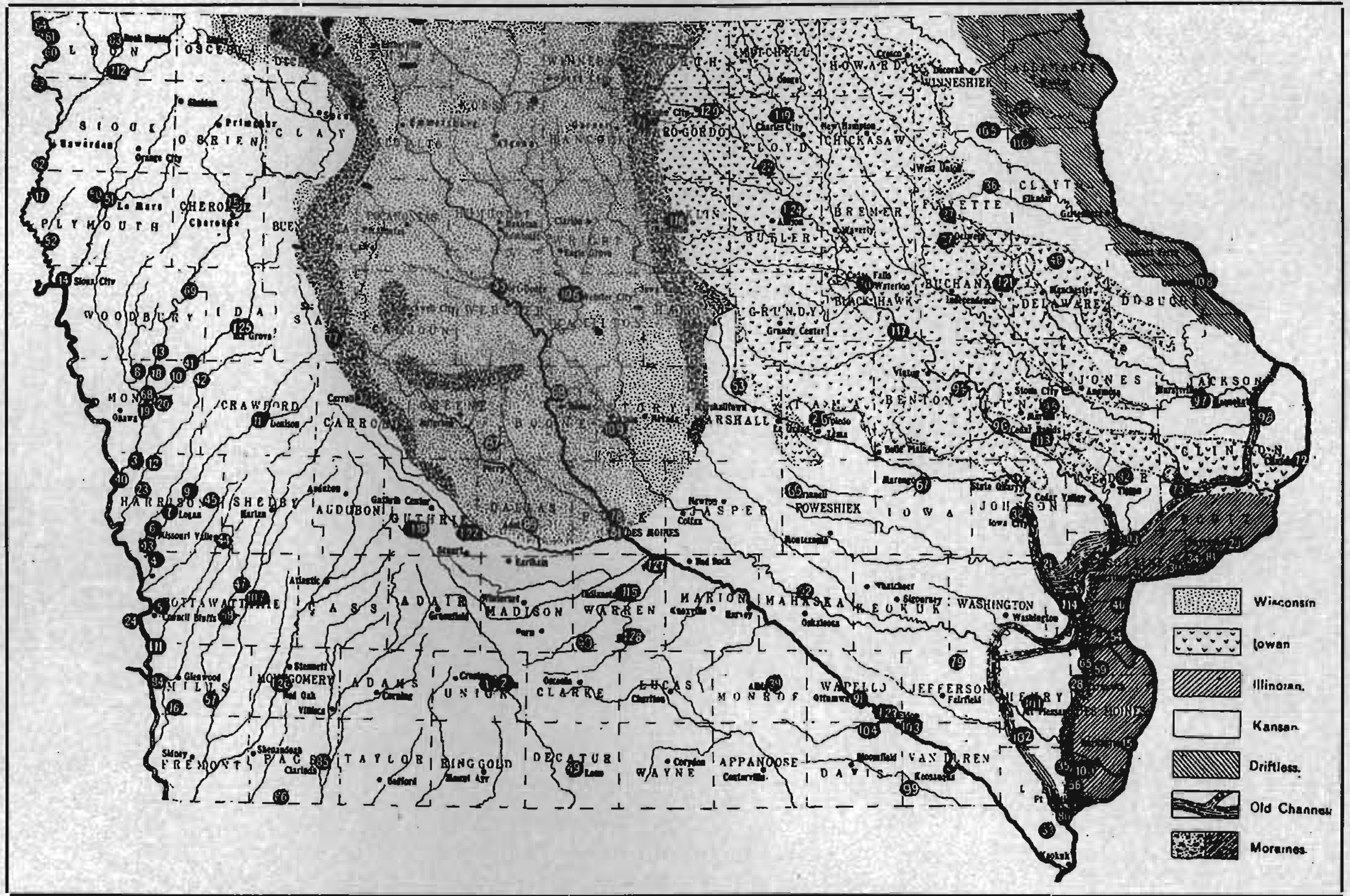

Wisconsin
Iowan
Illinoian.
Kansan.
Driftless.
Old Channels
Moraines.

Plate II.

This map is intended to show the localities where remains of extinct Edentata have been found in Pleistocene deposits. The numbers given correspond to those within the black circles of the map. Only generic names are given.

1. Megalonyx; Greenbrier county, West Virginia. 2. Megalonyx; Memphis, Tennessee. 3. Megalonyx and Mylodon; Big Bone Lick, Boone county, Kentucky. 4. Megalonyx; White county, Tennessee. 5. Megalonyx, Mylodon and Ereptodon; Natchez, Mississippi. 6. Megalonyx; Tuscumbia, Alabama. 7. Megalonyx; Henderson, Kentucky. 8. Mylodon and Megatherium; Charleston, South Carolina. 9. Mylodon; Lane county, Oregon. 10. Mylodon and Megatherium?; Benton county, Missouri. 11. Megatherium; Brunswick, Georgia. 12. Megalonyx; Hardin county, Texas. 13. Megatherium; 50 miles above mouth of Brazos river, Texas. 14. Megalonyx; Holmes county, Ohio. 15. Megalonyx; Wythe county, Virginia. 16. Megalonyx; McPherson county, Kansas. 17. Megalonyx and Mylodon; Port Kennedy cave, Montgomery county, Pennsylvania. 18. Megalonyx; Galena, Illinois. 19. Megalonyx, Glyptodon, and Chlamytherium; Peace creek, Florida. 20. Mylodon; New Iberia, Louisiana. 21. Megalonyx; Dubuque, Iowa. 22. Megalonyx; Clark or Meade county, Kansas. 23. Mylodon; Seneca, Nemaha county, Nebraska. 24. Mylodon and Paramylodon; Sheridan county, Nebraska. 25. Megalonyx; Mills county, Iowa. 26. Mylodon; Harrison county, Iowa. 27. Mylodon; Huerfano county, Colorado. 28. Mylodon; Fossil Lake, Oregon. 29. Morotherium; Owyhee county, Idaho. 30. Megatherium; Archer county, Florida. 31. Glyptodon; Nueces county, Texas. 32. Mylodon; Washtucna Lake, Washington State. 33. Megalonyx; Calaveras county, California. 34. Megalonyx; Shasta county, California. 35. Morotherium; Contra Costa county, California. 36. Morotherium; Marin county, California. 37. Mylodon?; Austin county, Texas. 38.

Mylodon; Lookout Mountain, Tennessee. 39. Megalonyx; Evansville, Indiana. 40. Morotherium; Almeda county, California. 41. Megalonyx; Blair county, Pennsylvania. 42. Mylodon; Savannah, Georgia. 43. Mylodon; Yamhill county, Oregon. 44. Megalonyx, Paramylodon, and Nothrotherium; Los Angeles county, California. 45. Megatherium; Brazos county, Texas. 46. Megalonyx; Hidalgo Falls, Brazos county, Texas. 47. Megalonyx; Champaign county, Illinois. 48. Mylodon; Tecumseh, Nebraska. 49. Megalonyx; Otoe county, Nebraska. 50. Megalonyx; Stanley county, South Dakota. 51. Megalonyx; Sioux City, Iowa. 52. Megalonyx; Monona county, Iowa. 53. Mylodon; Blue Lick Springs, Kentucky. 54. Megalonyx; Kimmswick, Missouri. 55. Megalonyx; Douglas City, California. 56. Megalonyx; Plymouth county, Iowa. 57. Megalonyx; Huron county, Ohio.

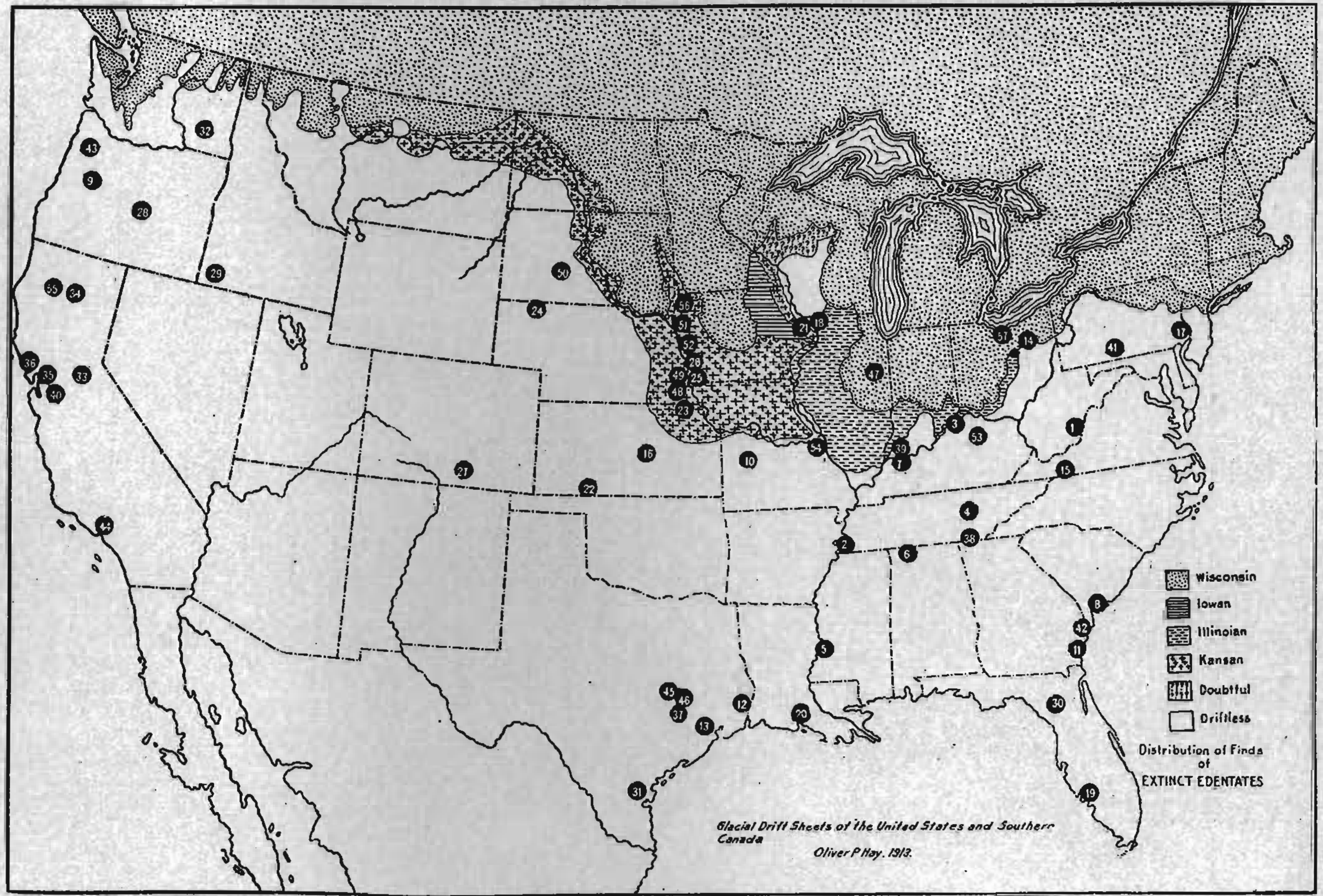

Wisconsin
Iowan
Illinoian
Kansan
Doubtful
Driftless
Distribution of Finds of EXTINCT EDENTATES
Glacial Drift Sheets of the United States and Southern Canada
Oliver P Hay. 1913.

Plate III.

Fig. 1. *Megalonyx leidyi.* Skull, seen from the right side. x 1/5. After Lindahl . . . . p. 113

Figs. 2-7. *Megalonyx jeffersonii.* Various parts.

2. Skull, seen from front. x 1/3. After Leidy . . . p. 115
3. Canine tooth. x .7. After Leidy . . . . p. 114
4. Same tooth, grinding surface. x .7. After Leidy . . . . p. 114
5. Claw found near Champaign, Illinois. x 3/5 . . . p. 129
6. Same claw seen from above. x 3/5 . . . . p. 129
7. Tibia and calcaneum, from behind. x about 1/12. From photograph of Henderson specimen . . . . pp. 124, 126

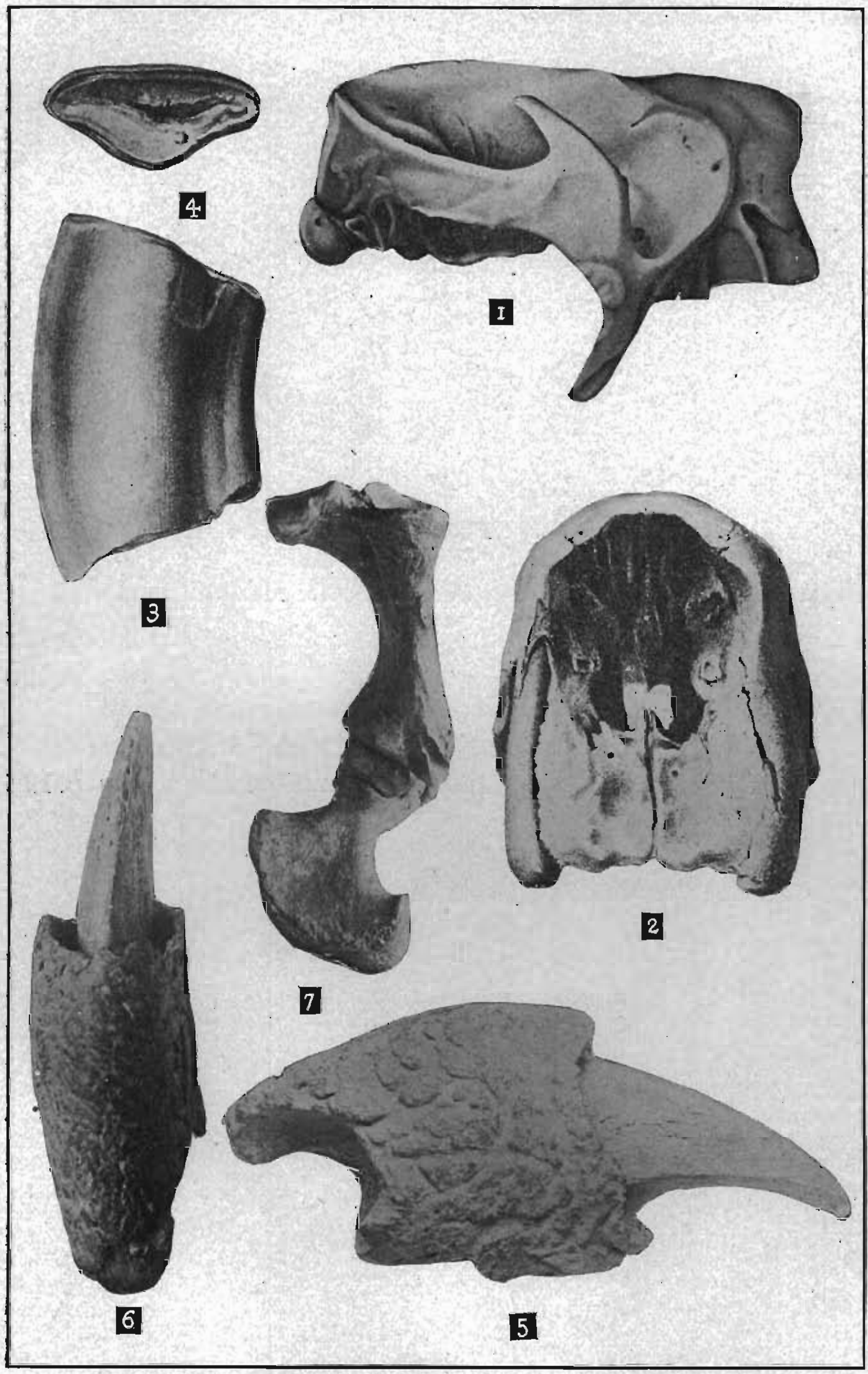

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Plate IV.

Figs. 1,2. Hapalops. After W. B. Scott. Much reduced.

1. Fore foot .... p. 122
2. Hind foot .... p. 126

Fig. 3. *Megalonyx jeffersonii.* Metatarsals. x .35. After Leidy. Numerals 2 and 5 over this figure indicate the second and the fifth digits . p. 126

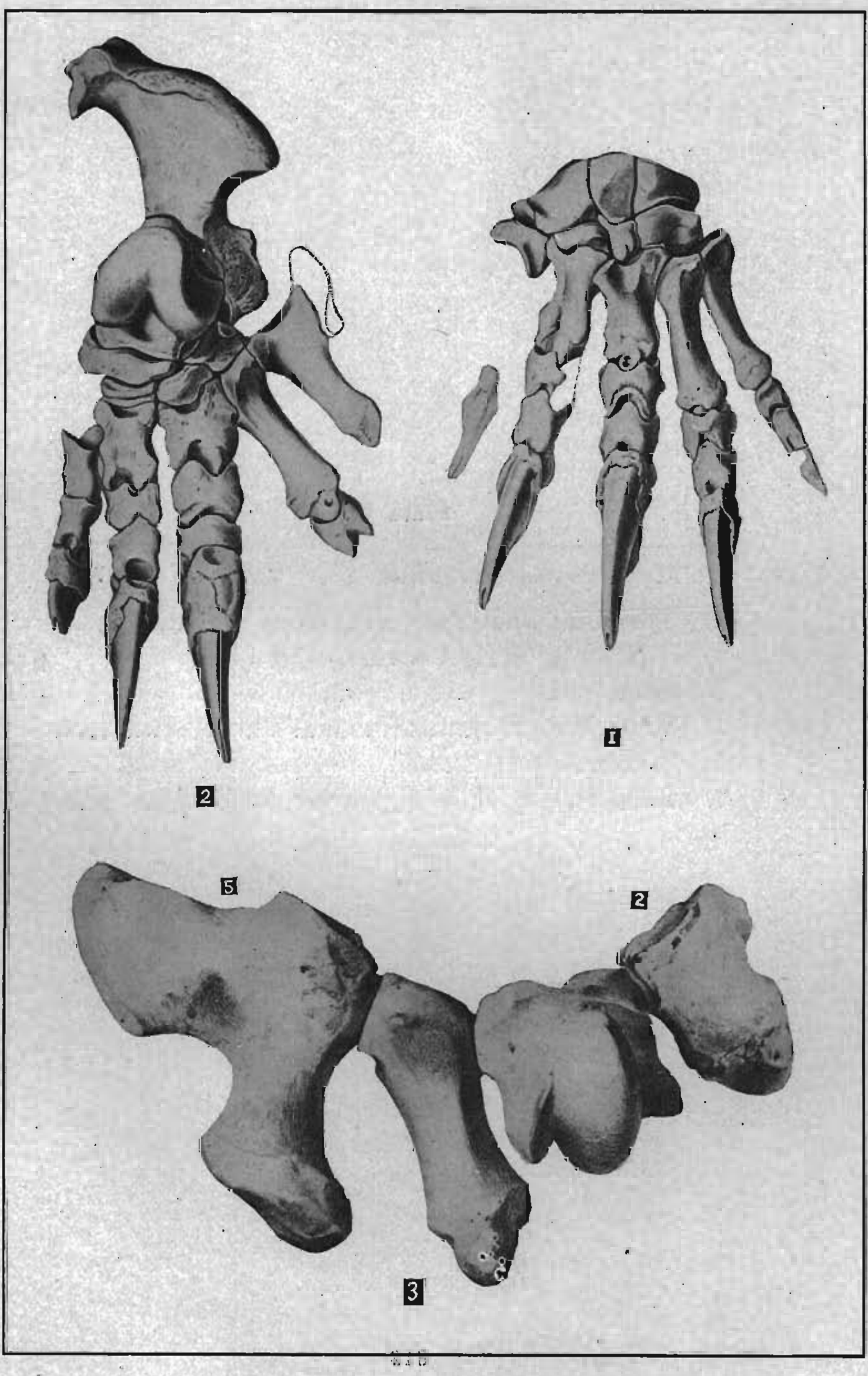
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Plate V.

Figs. 1-4. *Megalonyx jeffersonii?*

1. Terminal phalange, seen from the side. x .8. No. 174, State University of Iowa..........p. 128
2. Same phalange, seen from below. x .8........p. 128
3. View of right radius found at Turin, Iowa, seen from front. x .3..........................p. 129
4. Same radius, showing border next to ulna. x .3. p. 129

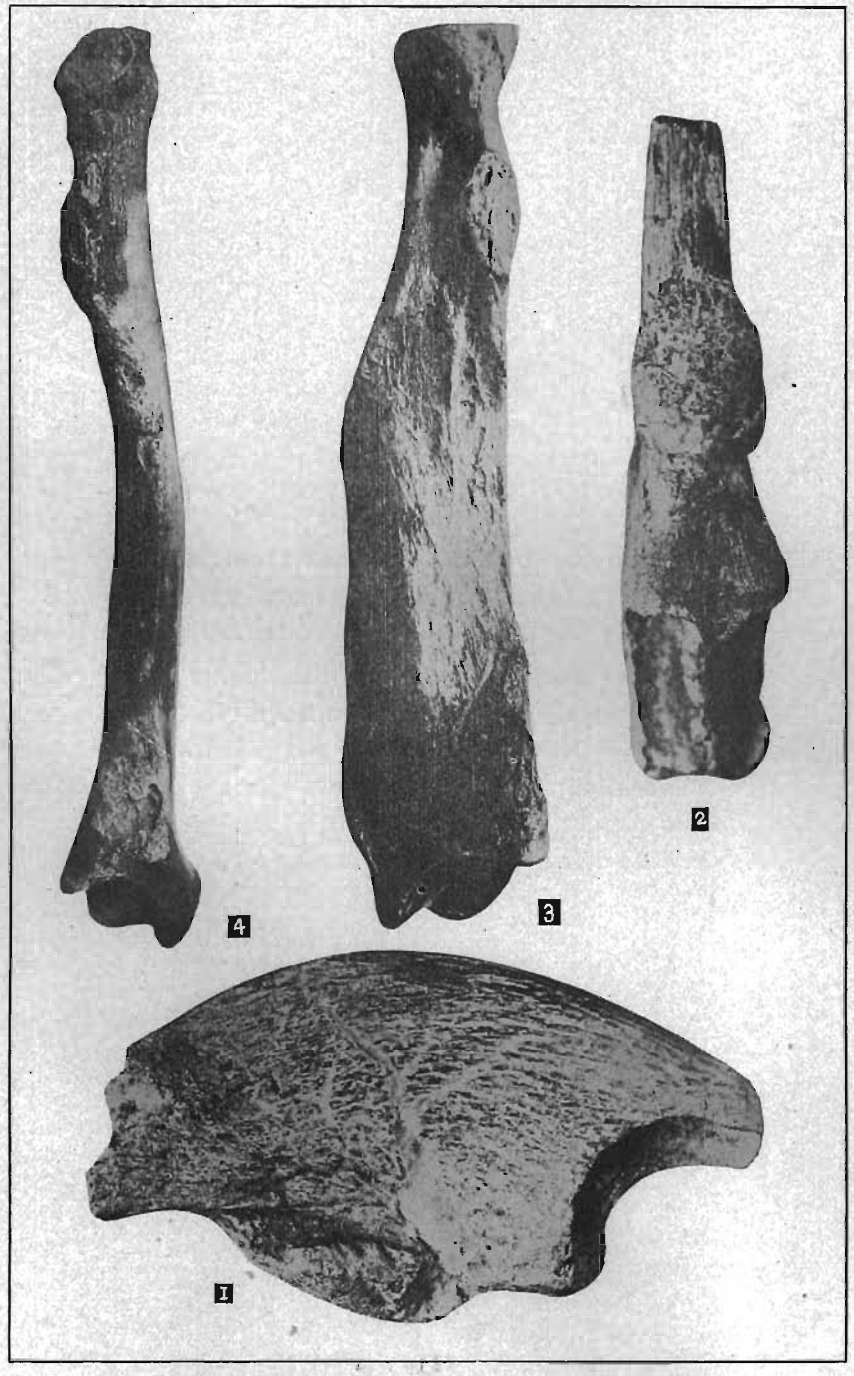
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Plate VI.

Figs. 1,2. Megalonyx. Lumbar vertebra from Missouri Valley, Iowa. x .3. Inverted by the engraver . . . . p. 130

1. Vertebra seen from behind.
2. Same vertebra seen from the right side.

Figs. 3,4. *Mylodon harlani.* Lower jaw of the type specimen . . . . p. 132

3. Jaw seen from above. x .66.
4. Jaw seen from right side. x .56.

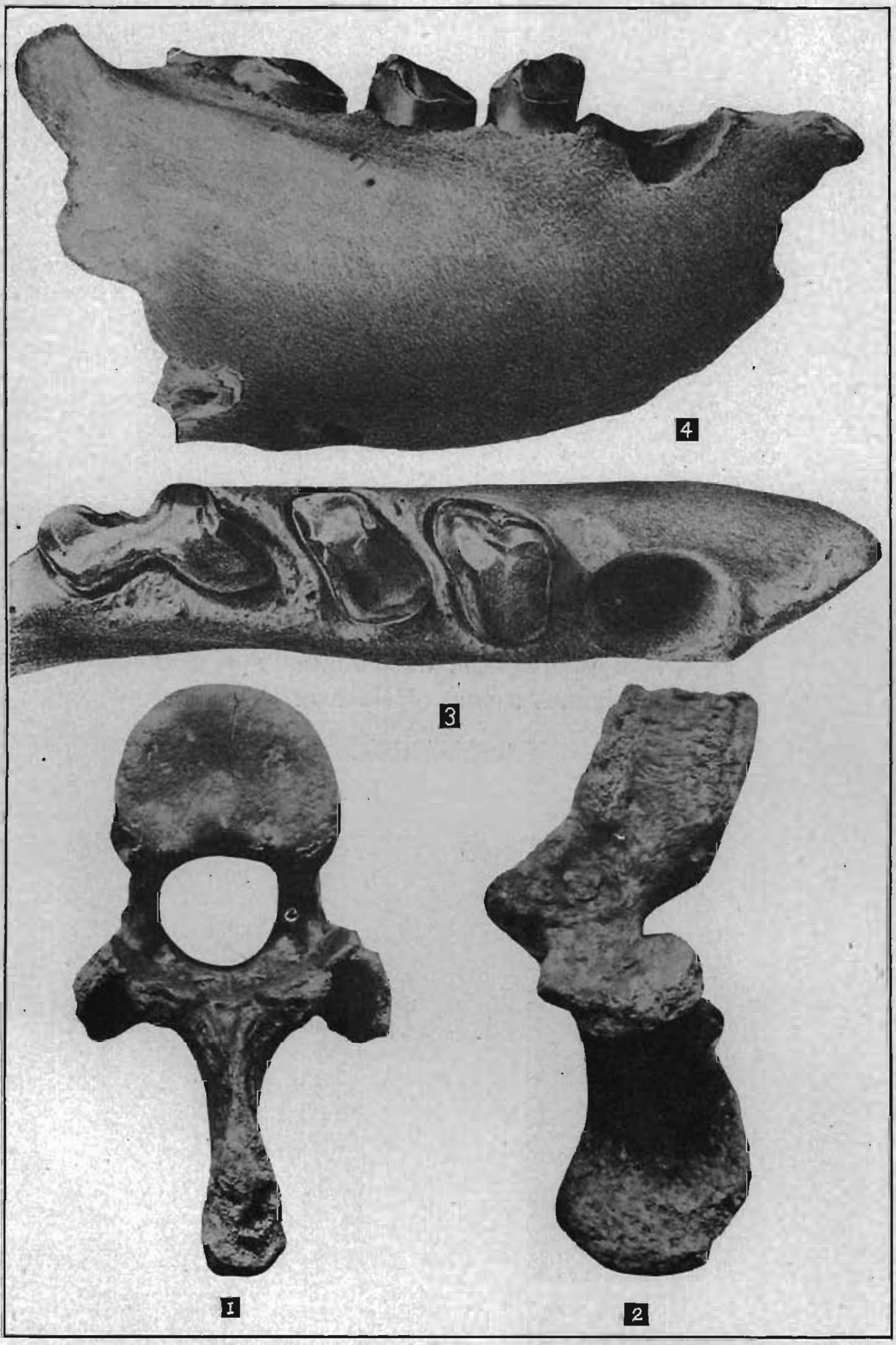
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Plate VII.

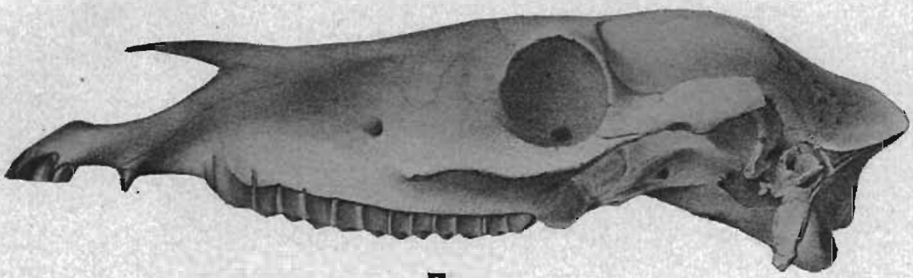
Mylodon robustus. Found in South America. From photograph of mounted specimen in American Museum of Natural History, New York .... p. 132

Plate VIII.

Figs. 1, 2. *Mylodon harlani?* Claw of third digit. x 1. . . . p. 142

1. Claw seen from the side.
2. Claw seen from above.

Fig. 3. *Neohipparion speciosum.* Skull seen from the side. x .35. . . . . p. 148



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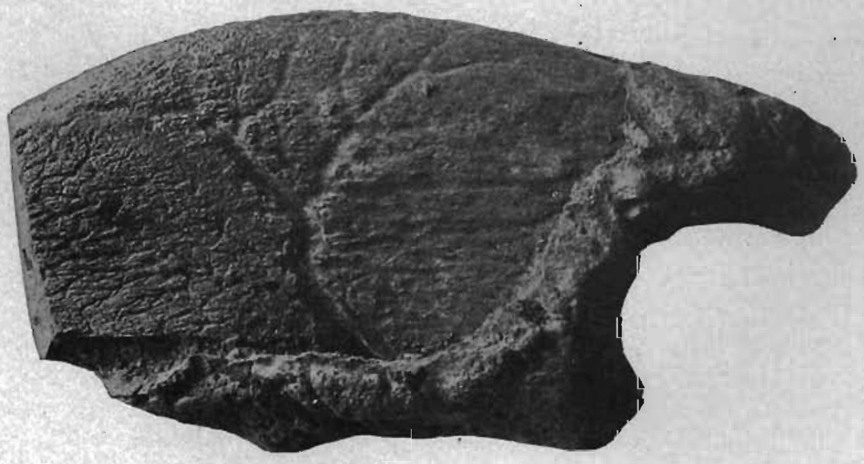

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Plate IX.

Figs. 1,2. *Neohipparion gratum?* Upper premolar or molar of the right side. x 1. From Thayer, Iowa . . . . p. 149

1. Tooth seen from the front.
2. Tooth showing grinding surface.

Figs. 3,4. *Neohipparion gratum?* Foot bones. x 1. . . . . . p. 150

3. Metatarsal; proximal portion, seen from rear.
4. Proximal phalange, seen from rear.

Fig. 5. *Equus complicatus.* Front of lower jaw, with incisor teeth. x 3/4. From Cope. . . . . p. 160

Fig. 6. *Equus complicatus.* Premolars and molars. x 4/5. From Cope . . . . pp. 159, 160

Fig. 7. *Neohipparion gratum?* Metatarsal, seen from front. x 1 . . . . p. 150

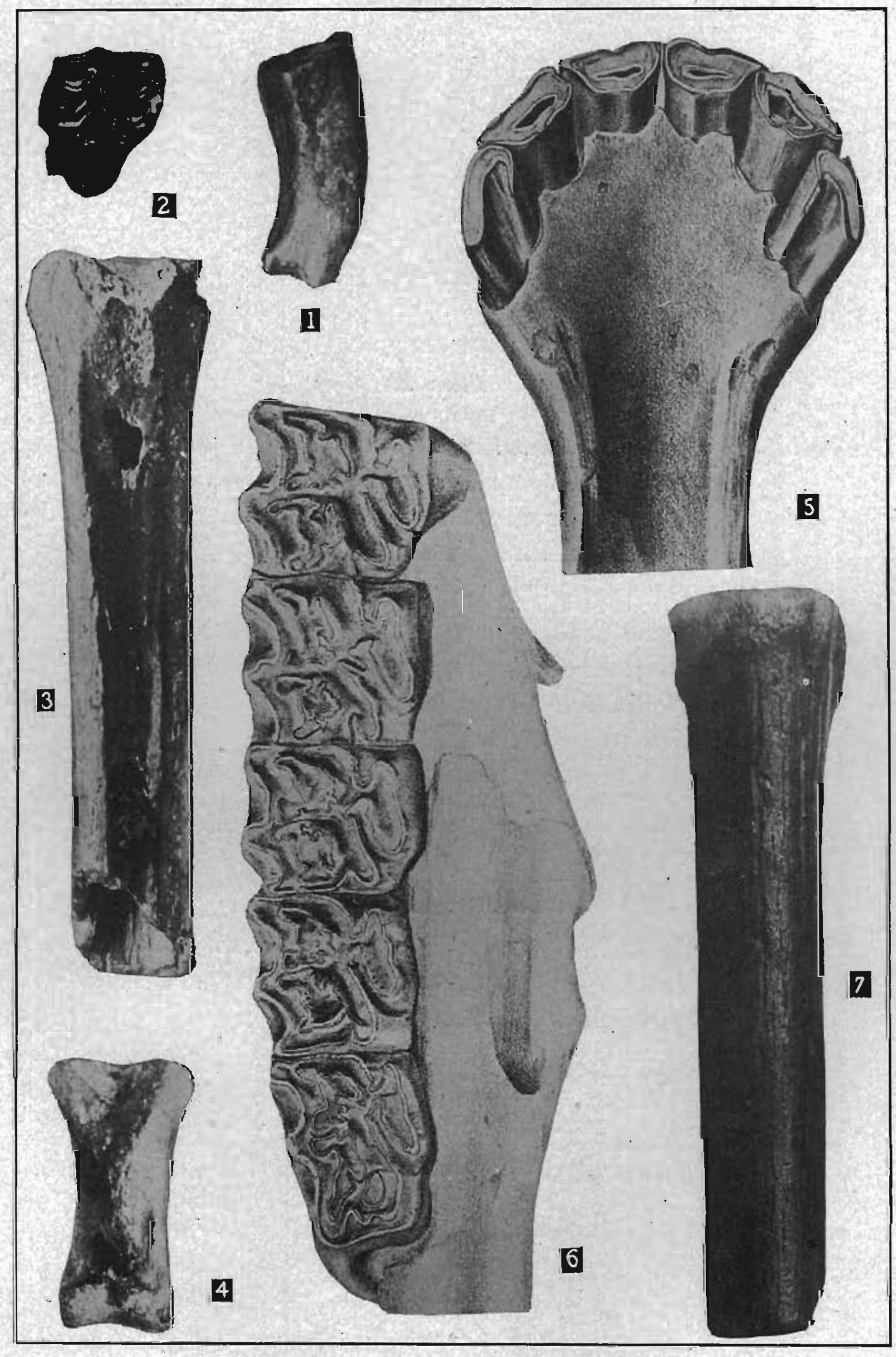
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Plate X.

Figs. 1, 3. *Equus complicatus.* Two views of a left upper premolar. x 1. No. 116, State University of Iowa. From Missouri Valley . . . . p. 166

1. View of grinding surface.
3. View of outer face of tooth.

Figs. 2, 4. *Equus niobrarensis.* Two views of supposed upper fourth premolar. x 1. No. 117, State University of Iowa . . . . p. 199

2. View of grinding face.
4. View of outer face.

Fig. 5. *Equus complicatus.* View of grinding surface. x 1. No. 119, State University of Iowa. Cox pit, Missouri Valley . . . . p. 177

Fig. 6. *Equus complicatus.* View of grinding surface of upper tooth, fourth premolar? x 1. No. 118, State University of Iowa . . . . p. 174

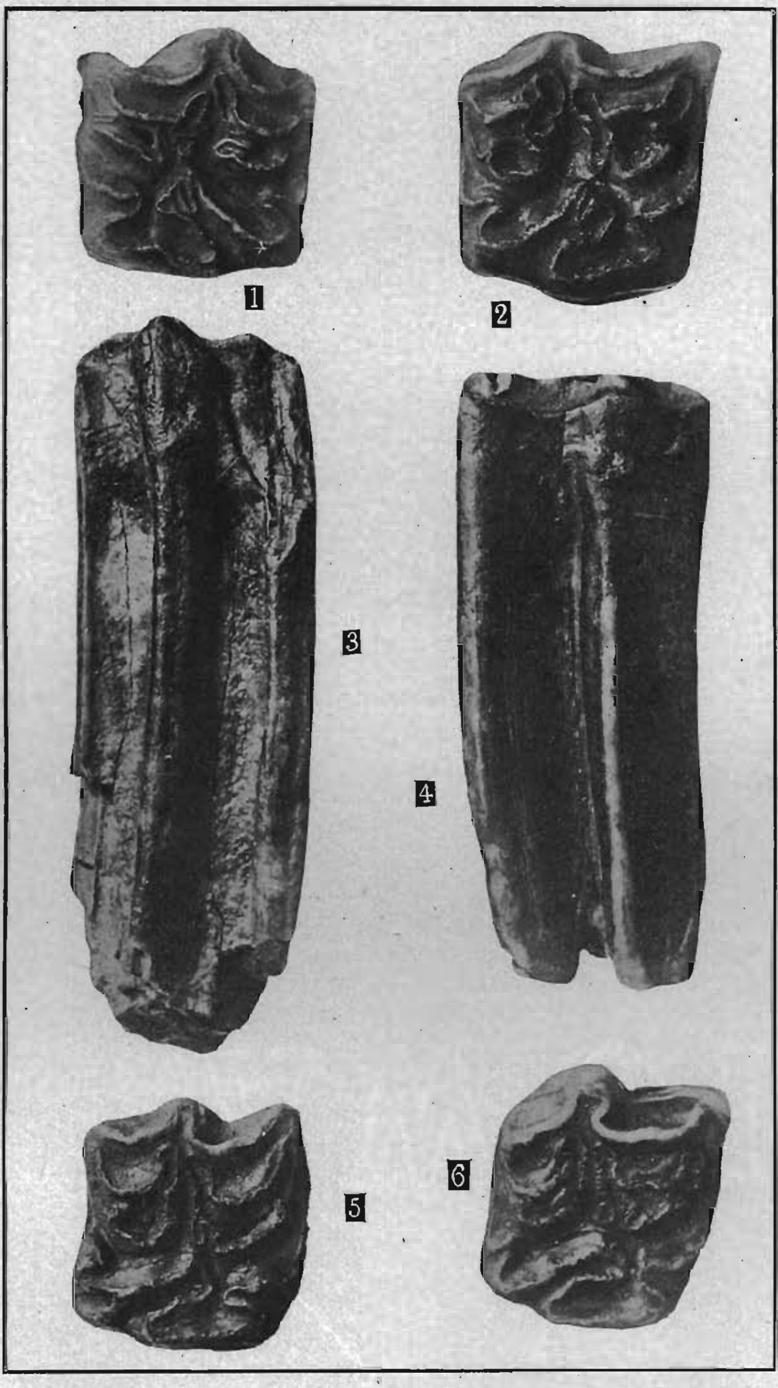
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Plate XI.

Equus complicatus. Upper and lower cheek-teeth. x 1.
Nos. 219, 220, State University of Iowa. . . . . p. 169

Fig. 1. Left upper teeth.
Fig. 2. Right lower teeth.

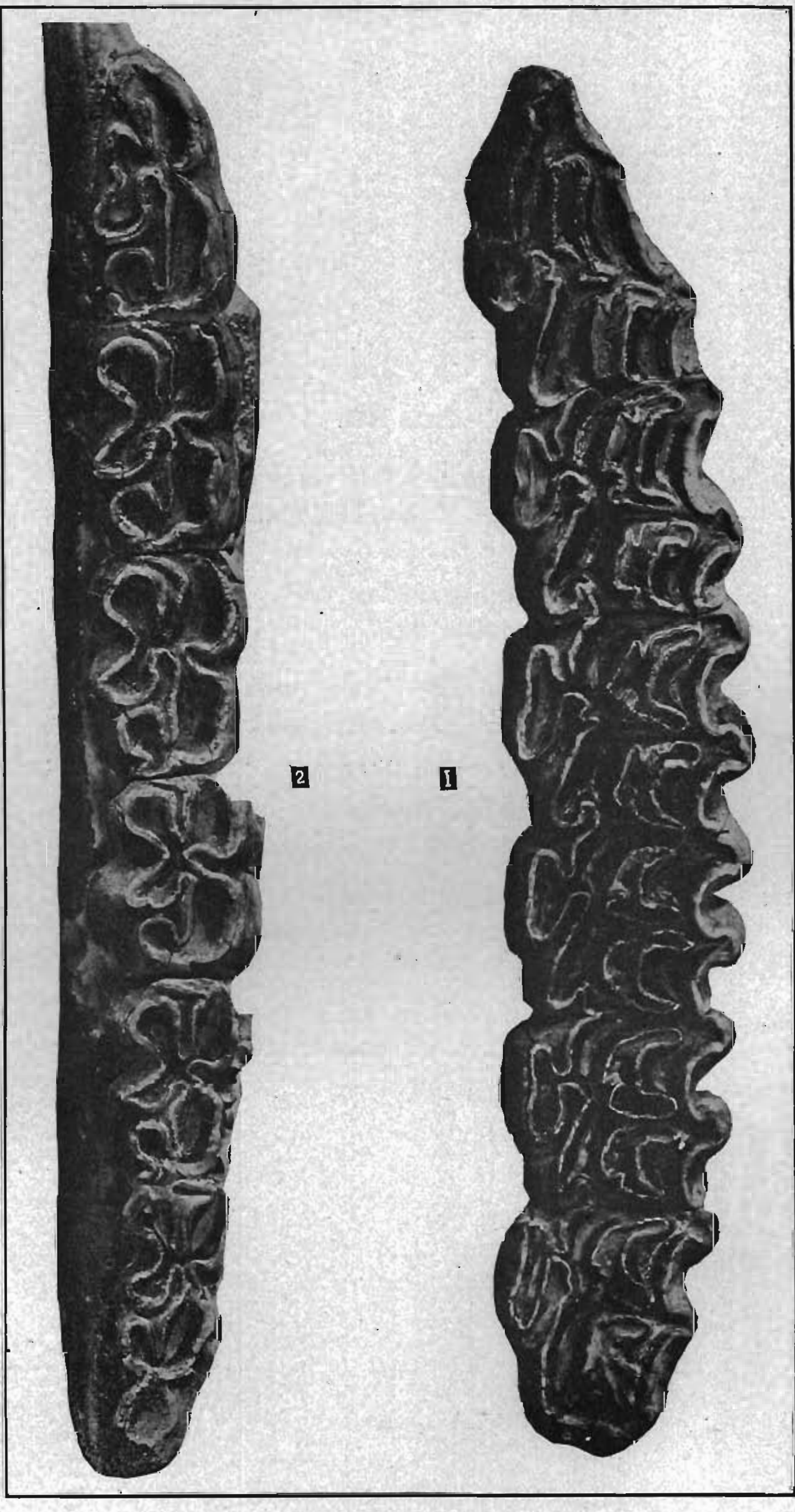
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Plate XII.

Figs. 1, 3. *Equus complicatus.* Two views of second lower left molar. x 1. No. 132, State University of Iowa . . . . p. 171

1. View of grinding surface.
3. View of the inner face.

Figs. 2, 4. *Equus complicatus.* Two views of lower left molar. x 1. No. 131, State University of Iowa . . . . p. 172

2. View of grinding surface.
4. View of outer face.

Fig. 5. *Equus complicatus.* Left lower tooth, probably a molar. x 1. No. 119, State University of Iowa . . . . p. 177

Fig. 6. *Equus complicatus.* Part of the right ramus of lower jaw with two hinder molars. x 1. No. 127, State University of Iowa . . . . p. 172

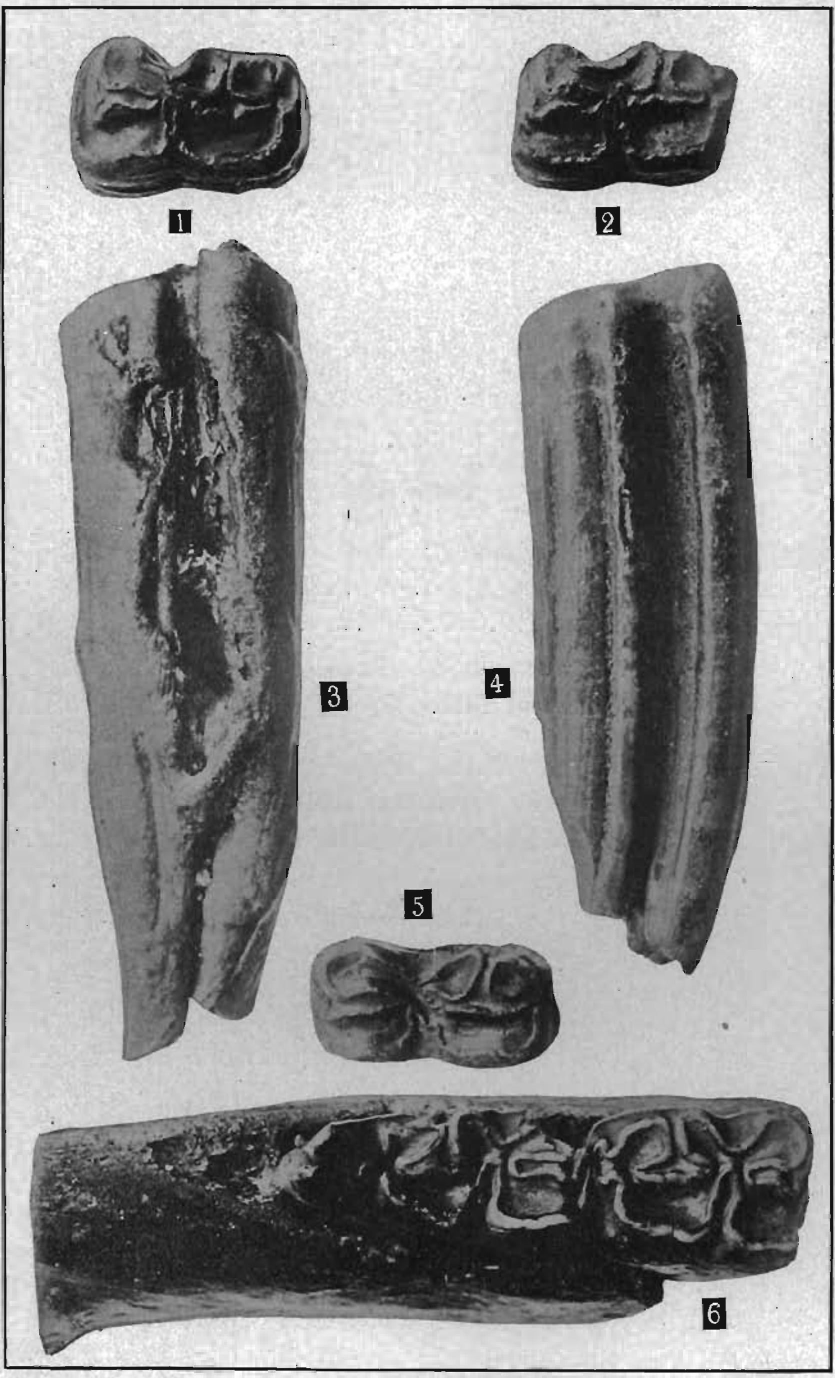
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Plate XIII.

Figs. 1, 2. *Equus complicatus.* Two views of lower left last molar. x 3/4. No. 134, State University of Iowa .... p. 172

1. View of outer face.
2. View of inner face.

Fig. 3. *Equus laurentius.* Part of right upper jaw with three premolars and two molars. x 1. No. 133, State University of Iowa .... p. 207

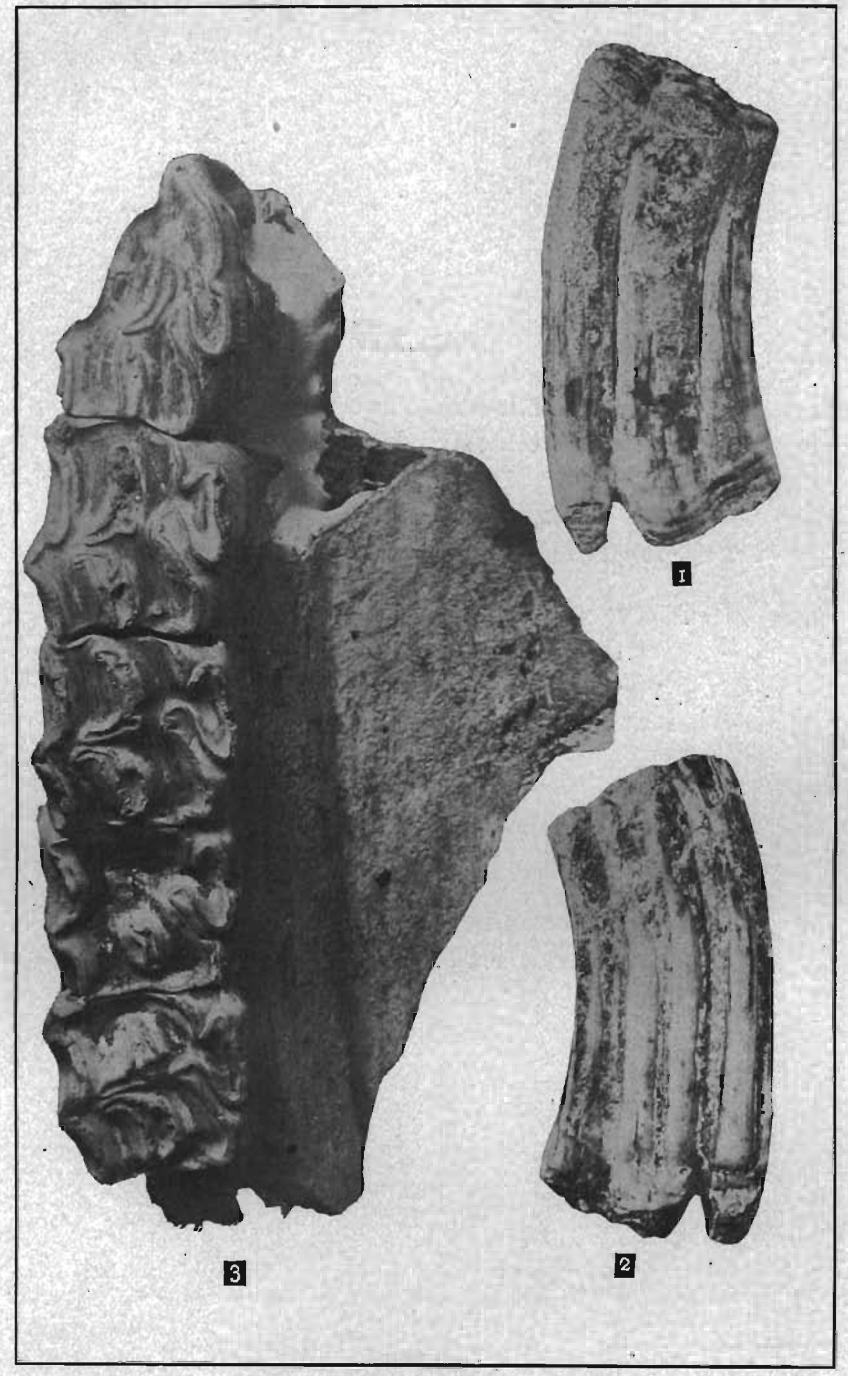

Plate XIV.

Figs. 1, 2. *Equus complicatus.* Two views of lower right second premolar. No. 120, State University of Iowa .... p. 174

1. View of outer face. x 1.
2. View of inner face. x 3/4.

Figs. 3, 4. *Equus niobrarensis.* Upper and lower incisors of the type .... p. 195

3. Upper incisors. x 2/3...................... p. 195
4. Lower incisors. x 1......................... p. 196

Fig. 5. *Equus niobrarensis.* Lower incisors of "No. 24," American Museum of Natural History. x 2/3 .... p. 196

Fig. 6. *Equus excelsus?* Lower incisors. x 2/3. No. 2762, American Museum of Natural History. p. 196

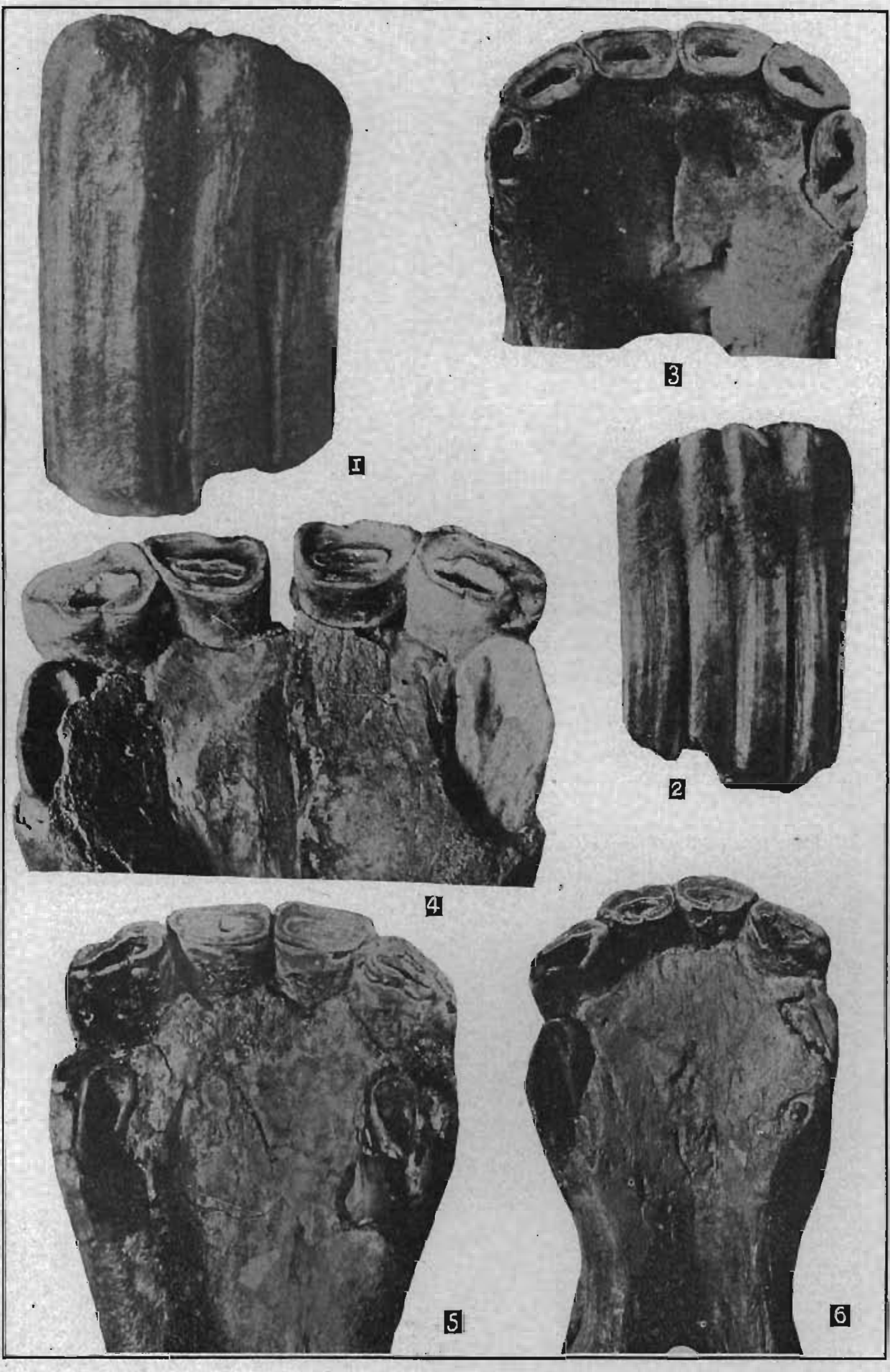

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Plate XV.

Figs. 1,2. *Equus niobrarensis.* Two views of the skull of the type. Slightly less than three-tenths natural size ....p. 191

1. View from below.
2. View from above.

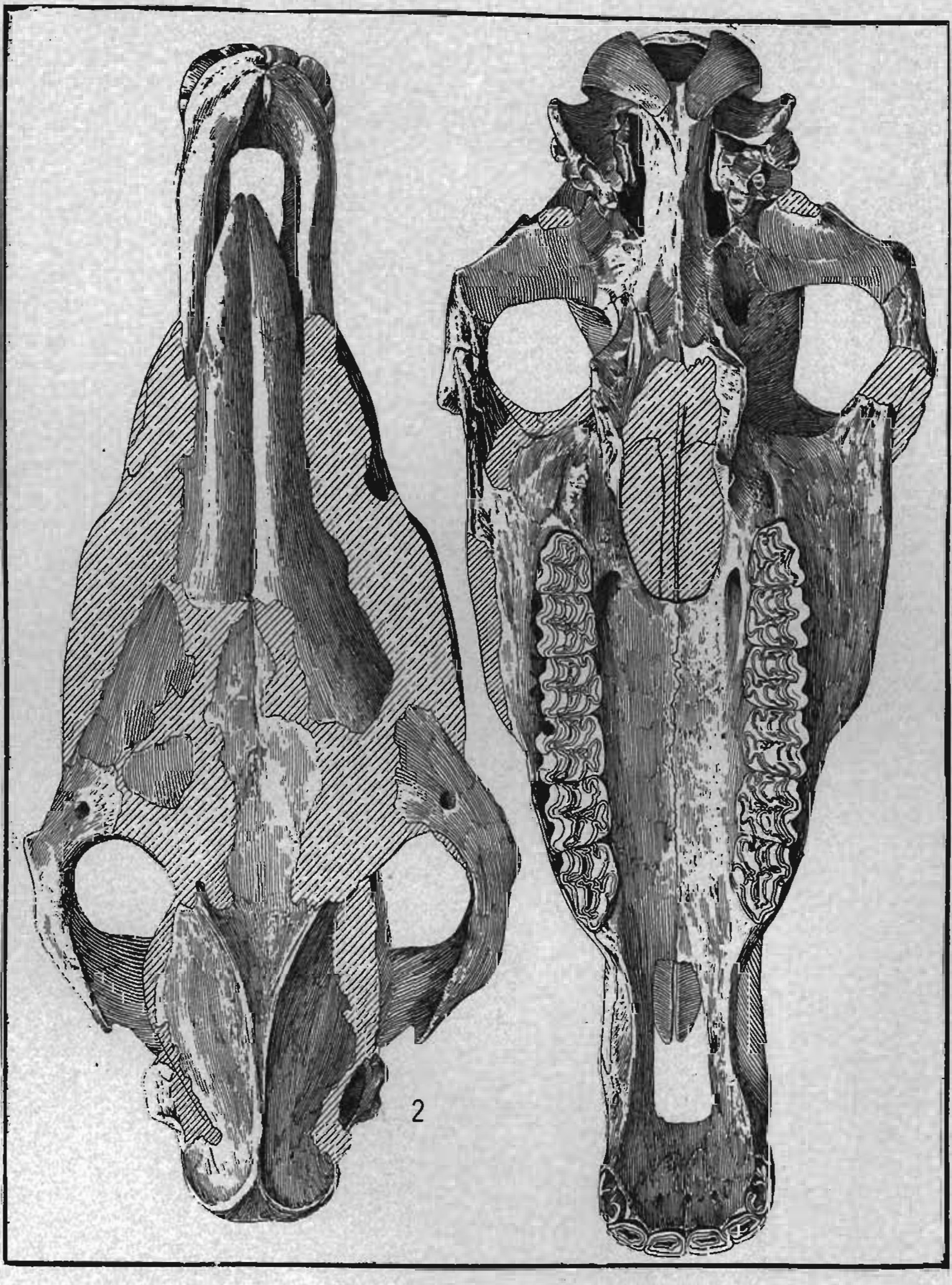
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Plate XVI.

Equus niobrarensis. Side view of the skull of the type. Slightly less than one-fourth natural size..............p. 191

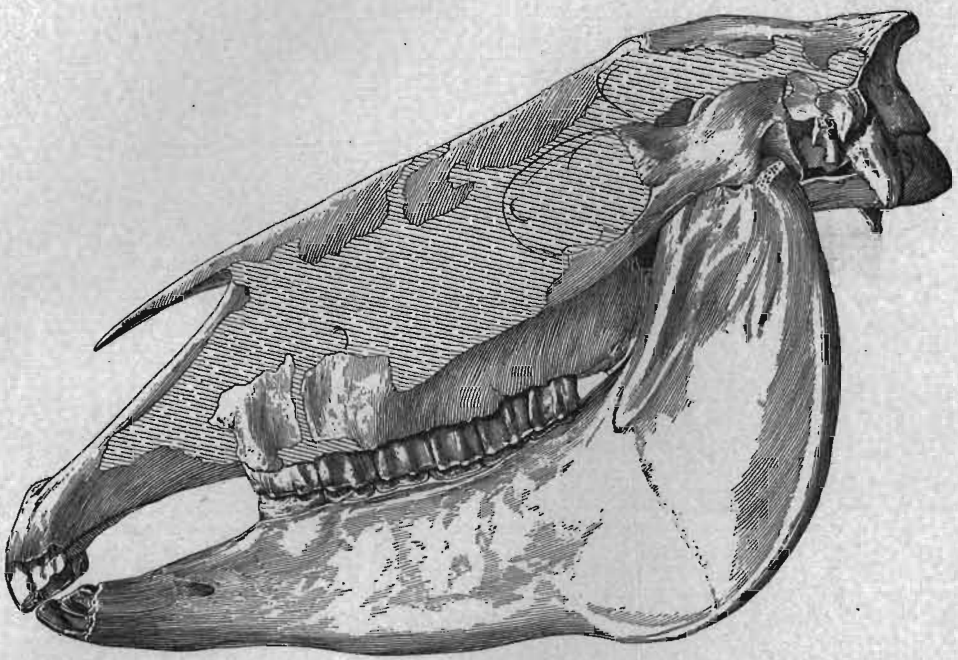


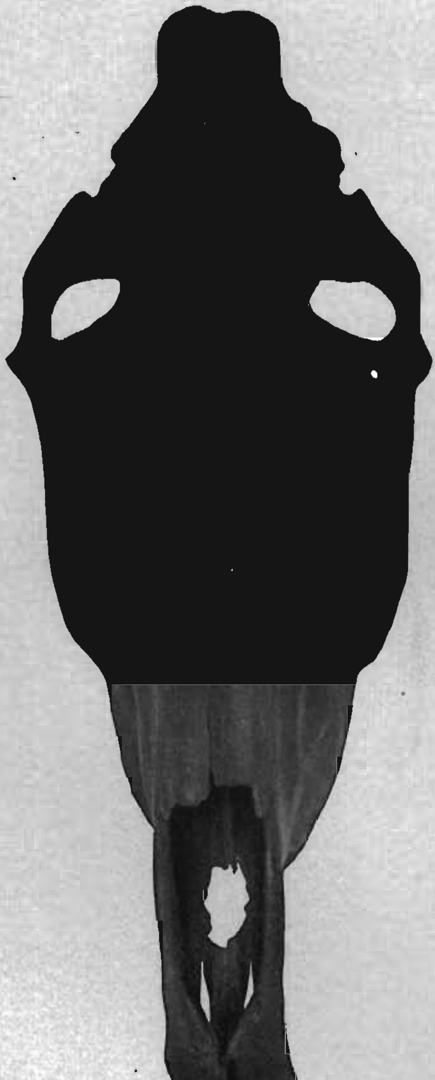
Plate XVII.

Equus laurentius. Side view of the type. x .283 . . . . p. 202

Plate XVIII.

Figs. 1, 2. *Equus laurentius*. Two views of the type. x .28 . . . . p. 202

1. View from above.
2. View from below.



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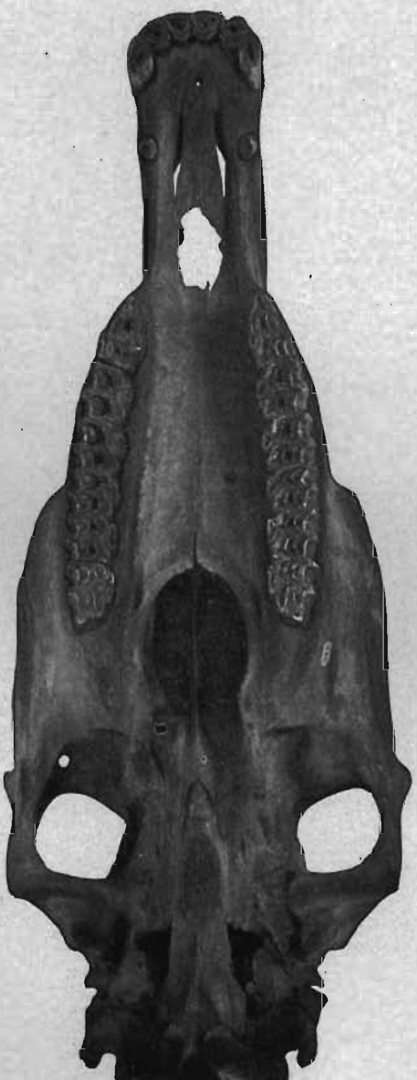

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Plate XIX.

Figs. 1-4. *Tayassu angulatus.* Views of the skull and teeth. From Baird ....p. 214

1. Side view of the skull and lower jaw. x 2/5....p. 214
2. Skull seen from below. x 2/5...........pp. 214, 217
3. Lower teeth of left side. x 1.................p. 217
4. Upper teeth of left side. x 1............pp. 216, 217

Figs. 5,6. *Tayassu angulatus.* Views of upper and lower teeth. Slightly less than natural size. No. 52128, National Museum.

5. Upper teeth of right side...............pp. 216, 217
6. Lower teeth of right side....................p. 217

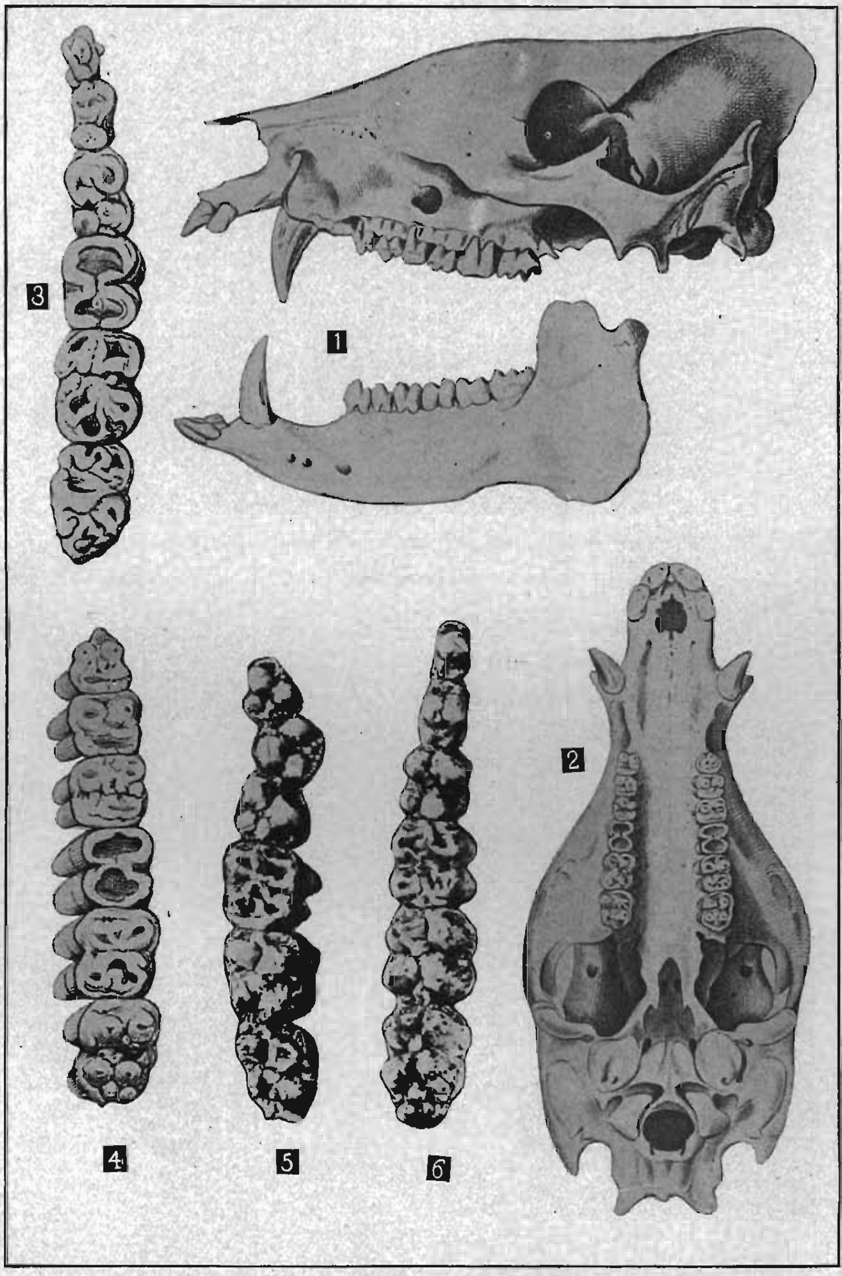
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Plate XX.

Figs. 1-3. *Platygonus compressus.* Three views of the skull. x 1/3. After Leidy............pp. 218, 219

1. Skull seen from the side.
2. Skull seen from above.
3. Skull seen from below.

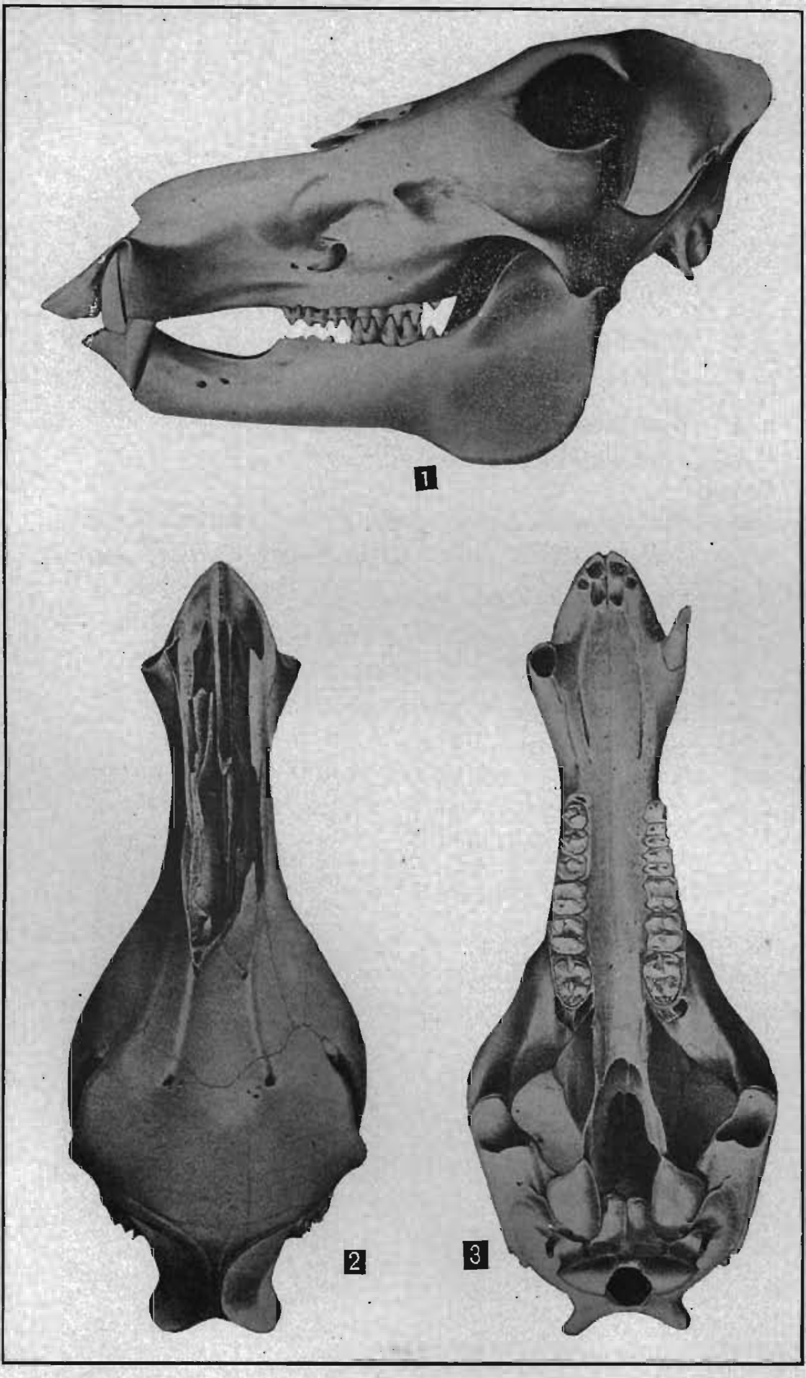
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Plate XXI.

Figs. 1, 2. *Mylohyus? temerarius.* Two views of the left lower canine. Type. x 1..................p. 227

1. Tooth seen from the outer side.
2. Tooth seen from behind.

Figs. 3-6. *Platygonus compressus.* Four views of the cheek-teeth. x 1. After Leidy........pp. 219, 220

3. Upper teeth seen from below.
4. Upper teeth seen from the outer side.
5. Lower teeth seen from above.
6. Lower teeth seen from the outer side.

Figs. 7, 8. *Platygonus compressus.* Figures of teeth found at Burlington. x 1. From Leidy..........p. 225

7. Upper teeth.
8. Lower teeth.

In figures 5 and 6, from error in the original figure, the hindermost premolar has the hinder end wrongly placed in front, thus making the higher cones to appear in front.

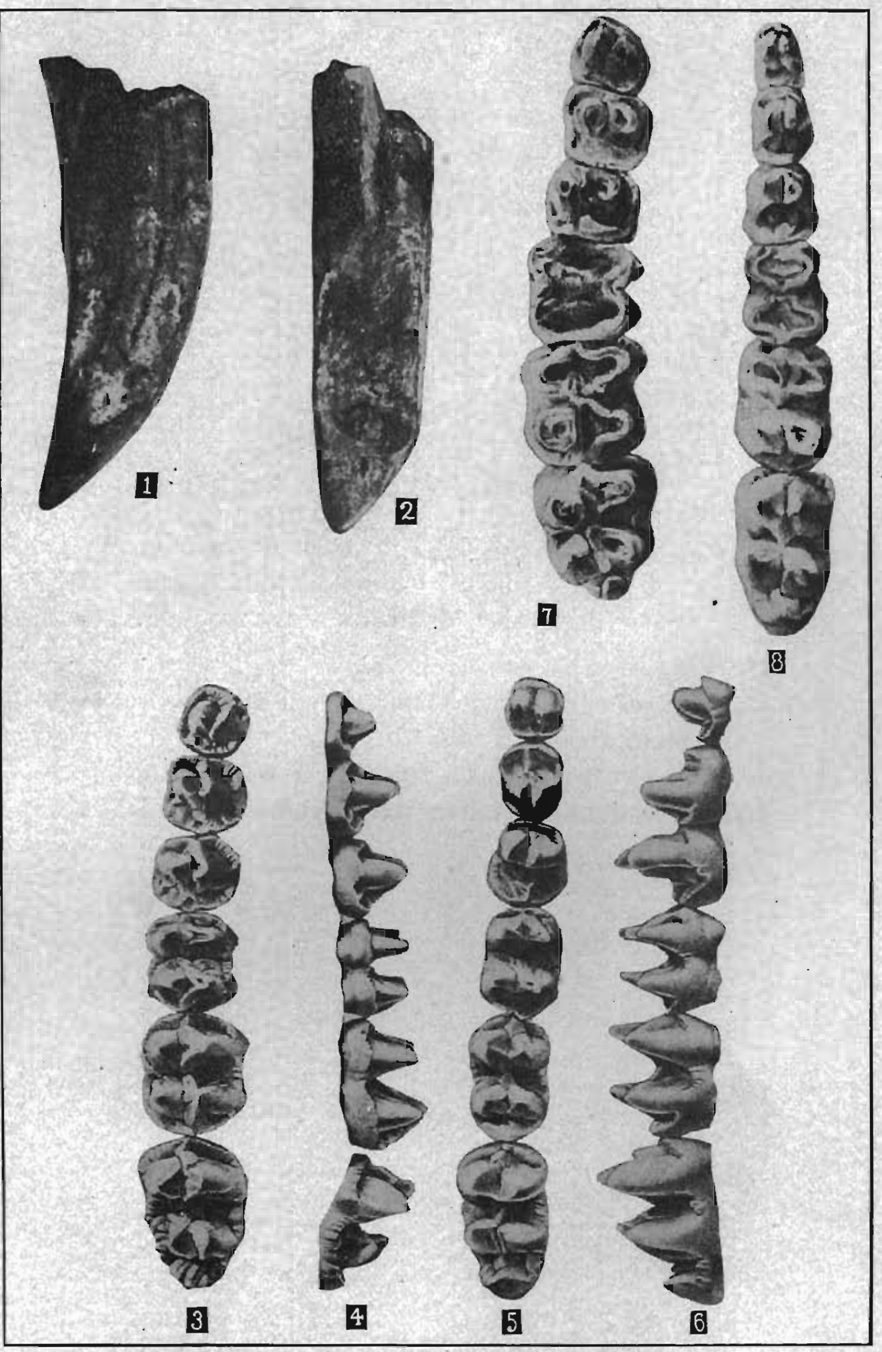
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Plate XXII.

Figs. 1-4. *Platygonus compressus.* Views of vertebræ of specimen found at Columbus, Ohio; now in Yale University Museum.................p. 222

1. View of atlas seen from below. x 1/2.
2. View of cervical vertebræ, except atlas, as seen from above. x .655.
3. Same vertebræ, seen from right side. x .655.
4. Three dorsal vertebræ seen from right side. x 1/2.

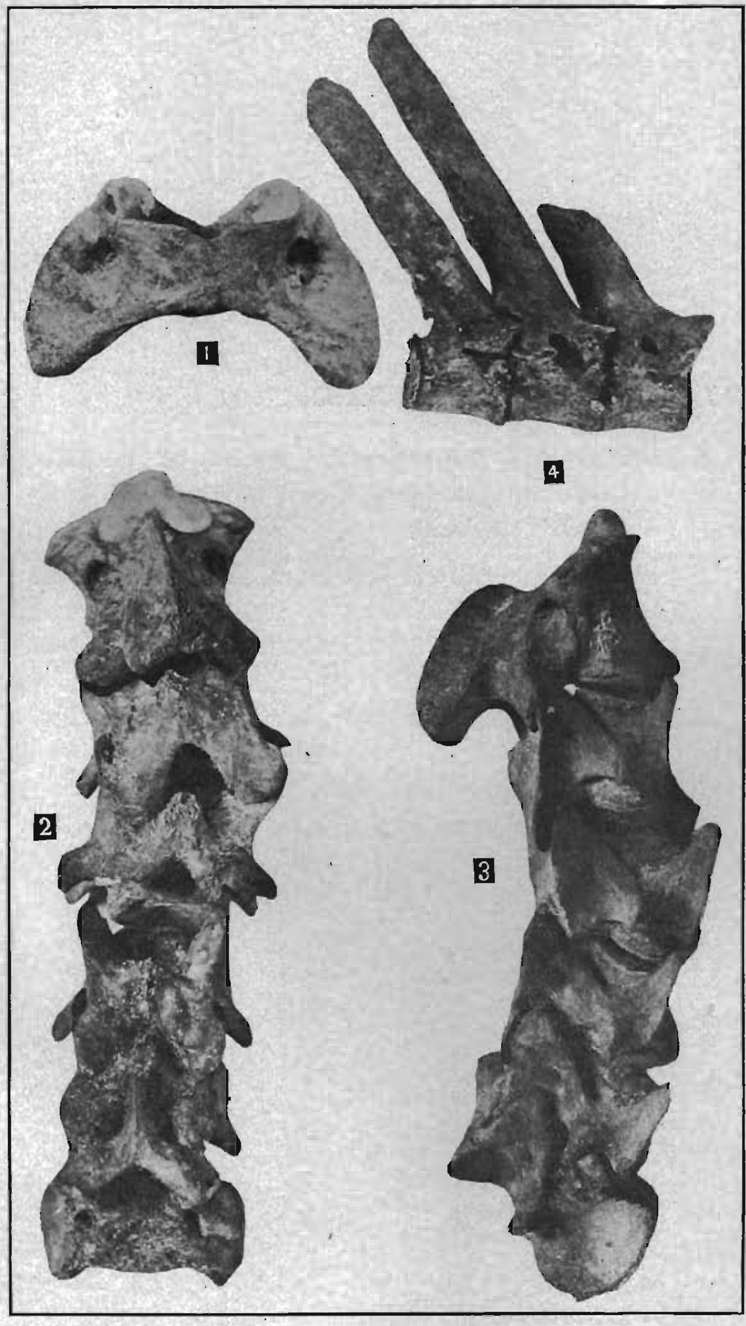
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Plate XXIII.

Figs. 1-5. *Platygonus compressus.* Bones of animals found at Columbus, Ohio; now in Yale University Museum.

1. Sacrum and part of left ilium, seen from below. x 9/16 .... p. 223
2. Hinder portion of left innominate bone, showing acetabulum. x 9/16 .... p. 224
3. Humerus of right side, seen from left side. x 1/2 .... p. 223
4. Same humerus, seen from front. x 1/2 .... p. 223
5. Ulna and radius of left side, seen from front. x 1/2 .... p. 223

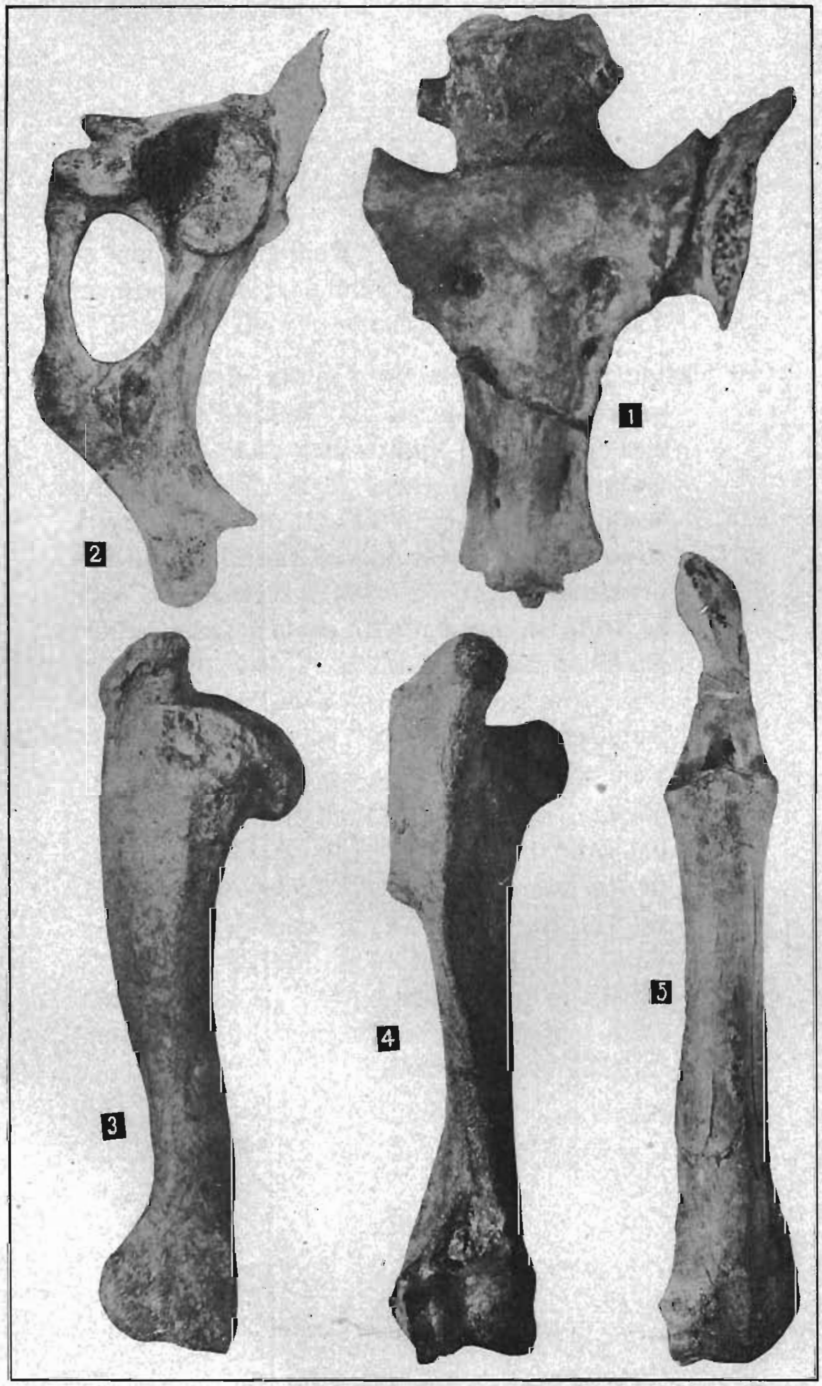
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Plate XXIV.

Figs. 1, 2. *Platygonus compressus.* Folded fore limbs of animal found at Columbus, Ohio; now in Yale University Museum. x .40.

1. Right fore limb. Shows scapula with damaged proximal end; humerus (lacking the proximal epiphysis); radius and ulna; the fourth metacarpal; its three phalanges; and the second phalange of the third metacarpal. Between the distal end of the ulna and the proximal end of the fourth metacarpal may be seen the head of the second metacarpal; while on the side of the upper end of the fourth metacarpal is seen the nodular fifth metacarpal .... pp. 223, 224

2. Left fore limb, seen from in front. Shows humerus, articulated below with the radius; the bones of the wrist; and the two toes, lacking the terminal phalanges. Between and below the digits is seen the proximal end of the ulna. At the right of the upper end of the fourth metacarpal is seen the nodular fifth metacarpal. Just above this and toward the right is the pisiforme.................... p. 224

Fig. 3. *Platygonus compressus (leptorhinus).* Left fore foot, seen from behind. From Williston .... p. 225

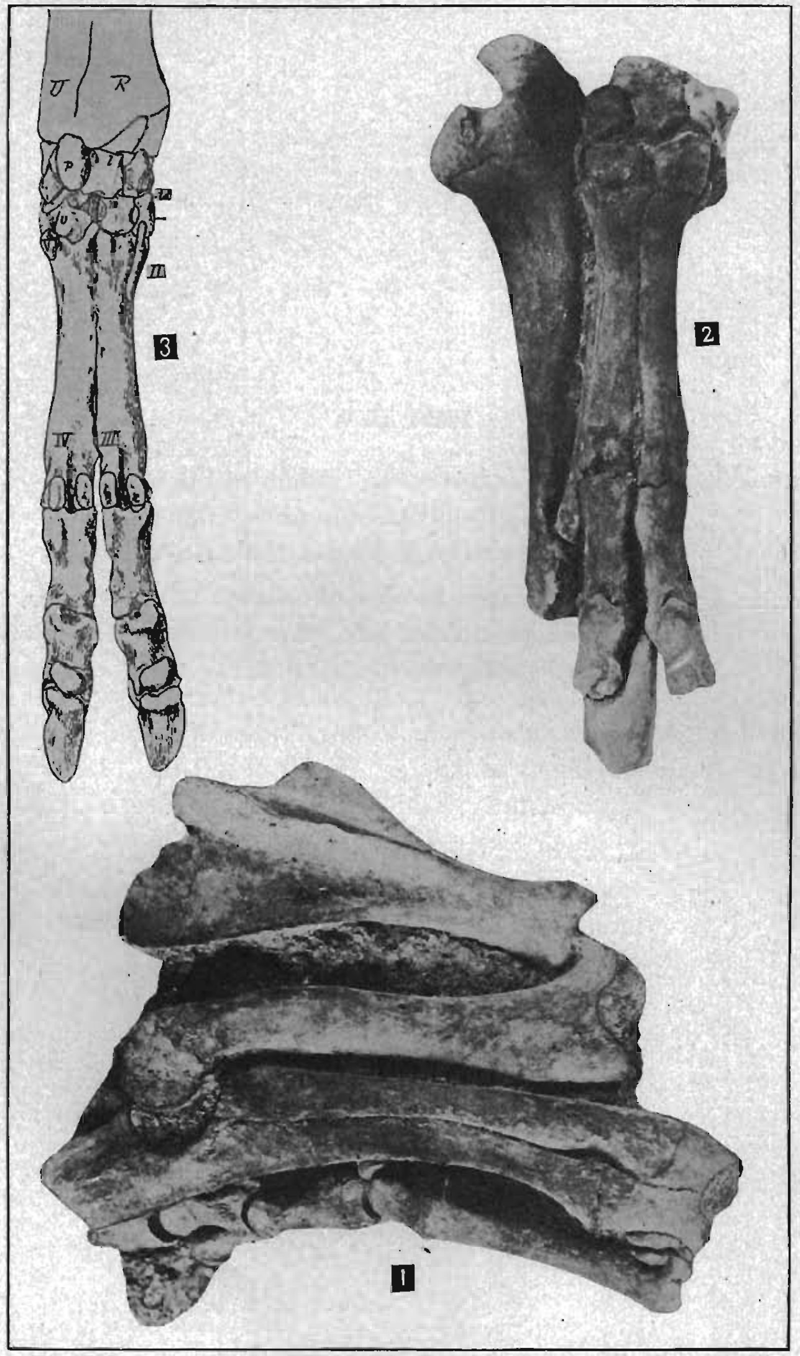
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Plate XXV.

Figs. 1-3. *Platygonus compressus.* Bones of hinder limbs of animals found at Columbus, Ohio; now at Yale University Museum. x .6.

1. Left femur seen from right side............p. 224
2. Left tibia, seen from left, or outer, side......p. 224
3. Left hind foot, seen from front............p. 225

Figs. 4-6. *Mylohyus nasutus?* Three figures of lower jaw and teeth of young animal found in Columbiana county, Ohio.....................p. 226

4. Left lower jaw, inner surface. x 1.
5. Same jaw seen from above, showing three milk molars and uncut molar. x 1.
6. View of the uncut first molar. x 2.

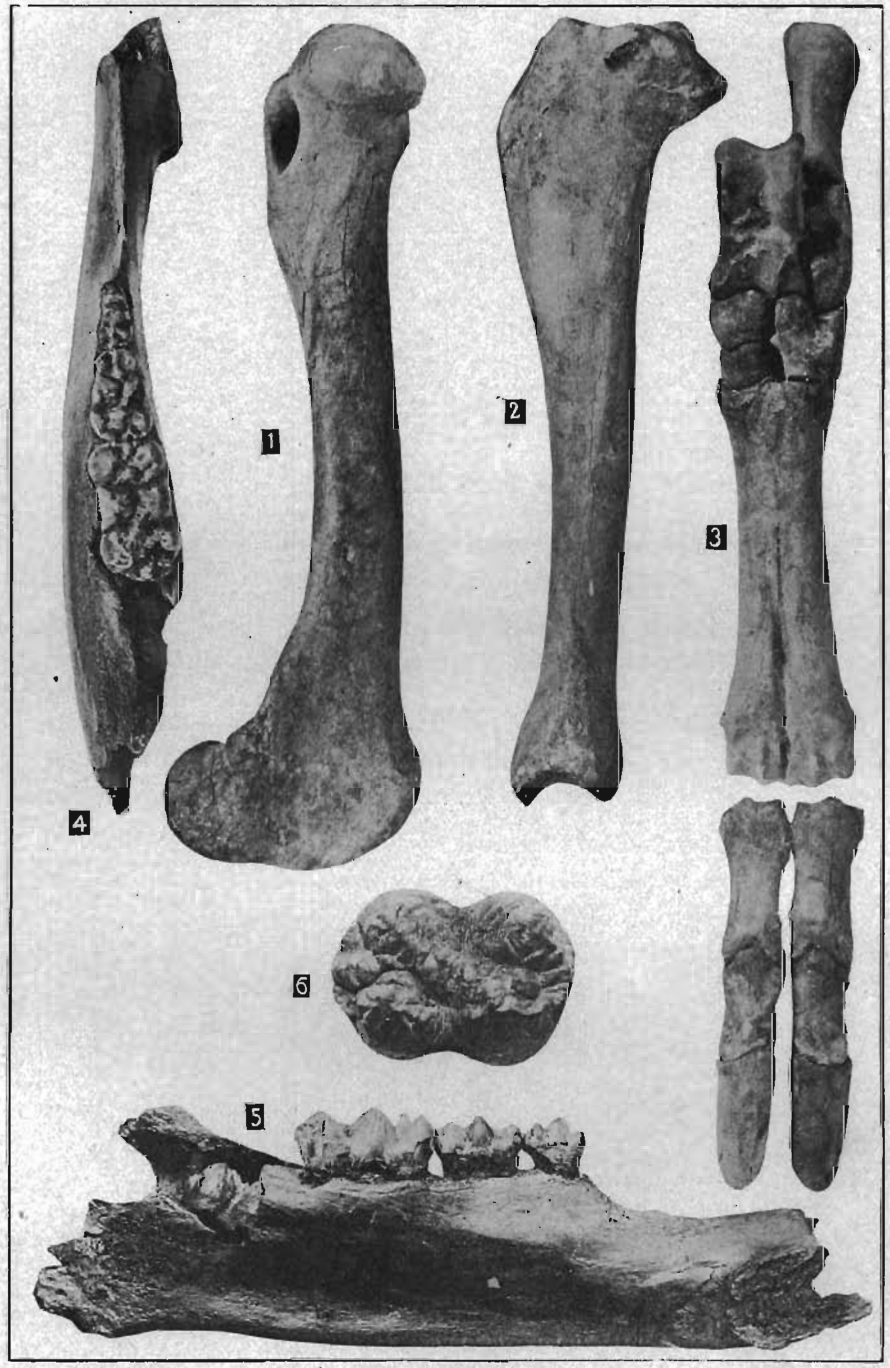
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Plate XXVI.

Figs. 1, 2. *Mylohyus nasutus.* Two views of the snout of the type. x 1. . . . . p. 226

1. Snout seen from below.
2. Same specimen seen from the right side.

Figs. 3-5. Mylohyus sp.? Views of lower jaw and foot from Conard fissure, Arkansas. From Barnum Brown . . . . pp. 226, 227

3. Jaw seen from above. x 1/3.
4. Left side of jaw, inner face. x 1/3.
5. Fore foot, seen from front. x 1/4.

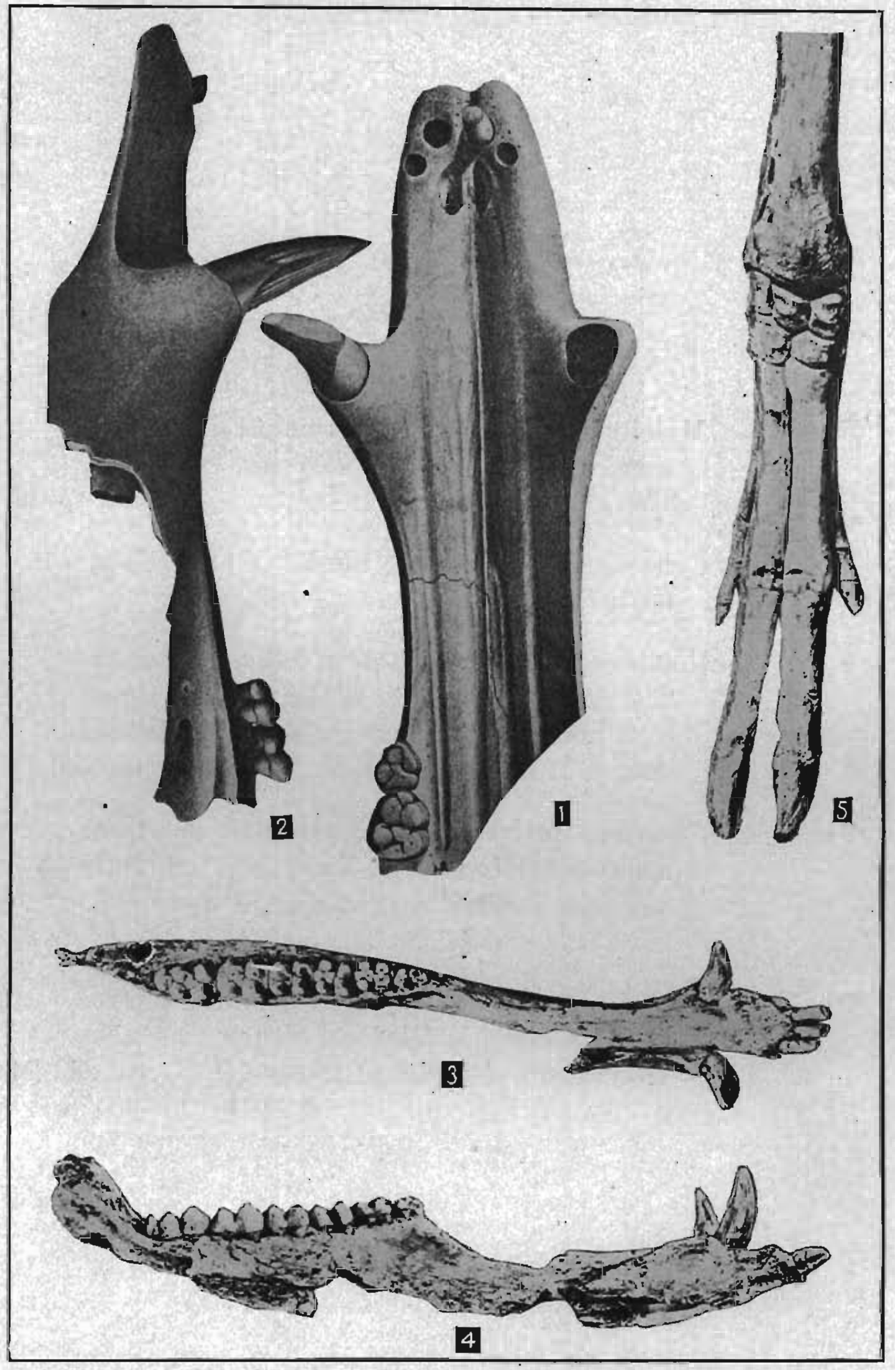
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Plate XXVII.

Fig. 1. Mylohyus sp.? Hind foot found in Conard fissure, Arkansas. From Barnum Brown. x 3/8 .... p. 227

Fig. 2. *Camelus dromedarius*. Skull. x 1/7. From Blainville .... p. 229

Fig. 3. *Camelops kansanus*. View of left side of snout. The figure to the right of the numeral shows a palatal view; the one on the left a lateral one. x 1. From Leidy ....pp. 232, 233

Fig. 4. *Camelops hesternus*. Last premolar and three molars of left side of lower jaw. Slightly less than one-half natural size. From Leidy. .... p. 232

Fig. 5. *Camelops kansanus?* View of grinding surface of tooth found at Missouri Valley. x 1. No. 183, State University of Iowa.........pp. 239, 243

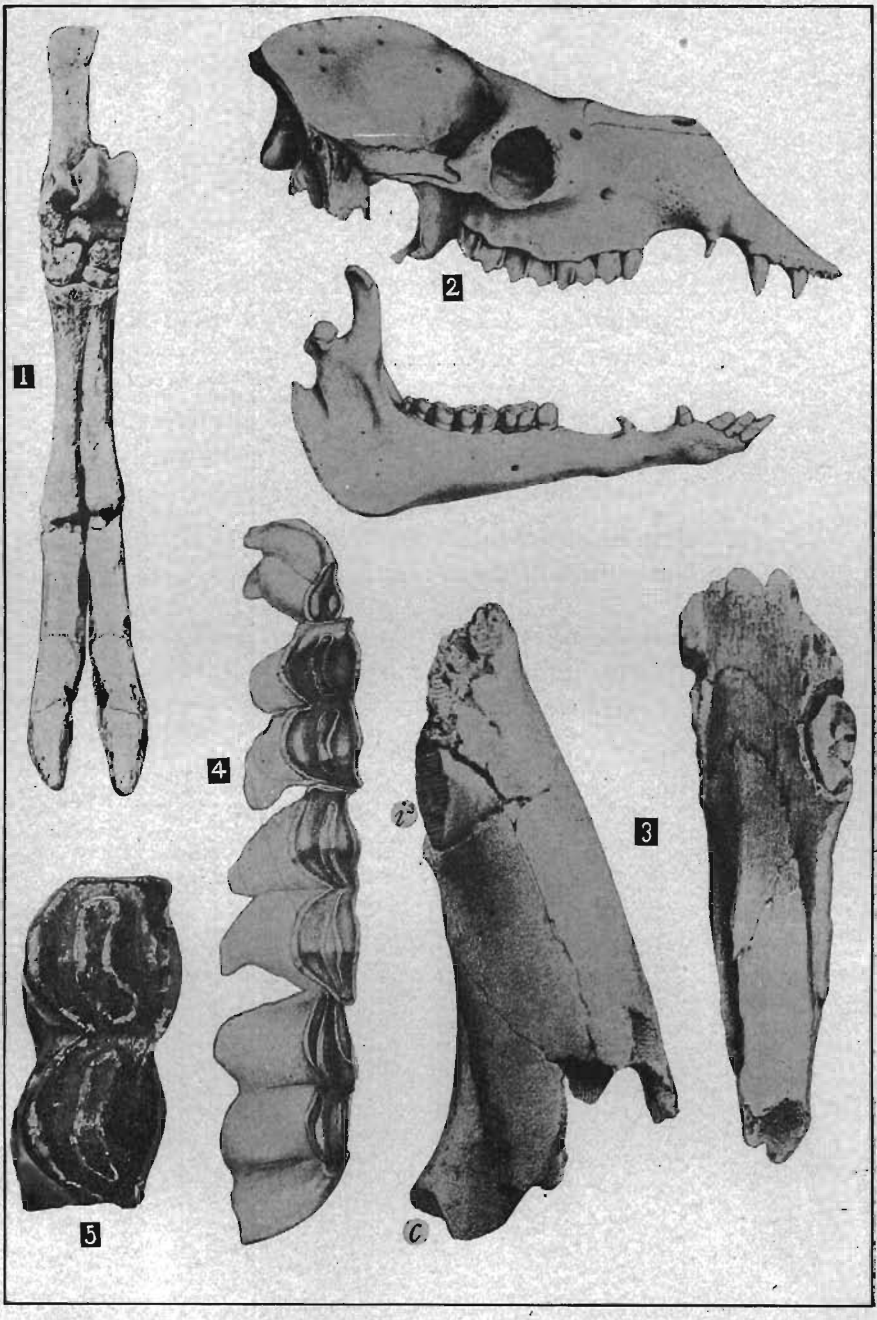

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Plate XXVIII.

Fig. 1. *Camelops huerfanensis?* Lower fourth right premolar. x 1. No. 230, State University of Iowa .... pp. 239, 243

Figs. 2,3. *Camelops sulcatus* (Cope). Last premolar and three molars of type. Slightly less than one-fourth natural size. From Cope...........p. 232

2. Grinding surface of the teeth.
3. Outer face of the teeth.

Figs. 4,5. *Camelops hesternus?* Left lower jaw and teeth. Texas specimens. Slightly less than one-fourth natural size. From Cope...........p. 232

4. Lower jaw seen from above.
5. Same jaw, outer face.

Fig. 6. *Camelops kansanus?* Astragalus found at Missouri Valley. x 2/3. From Calvin........p. 242

Fig. 7. Neohipparion sp.? Section of an upper molar or premolar not yet cut. x 1. Found at Thayer, Iowa ....p. 150

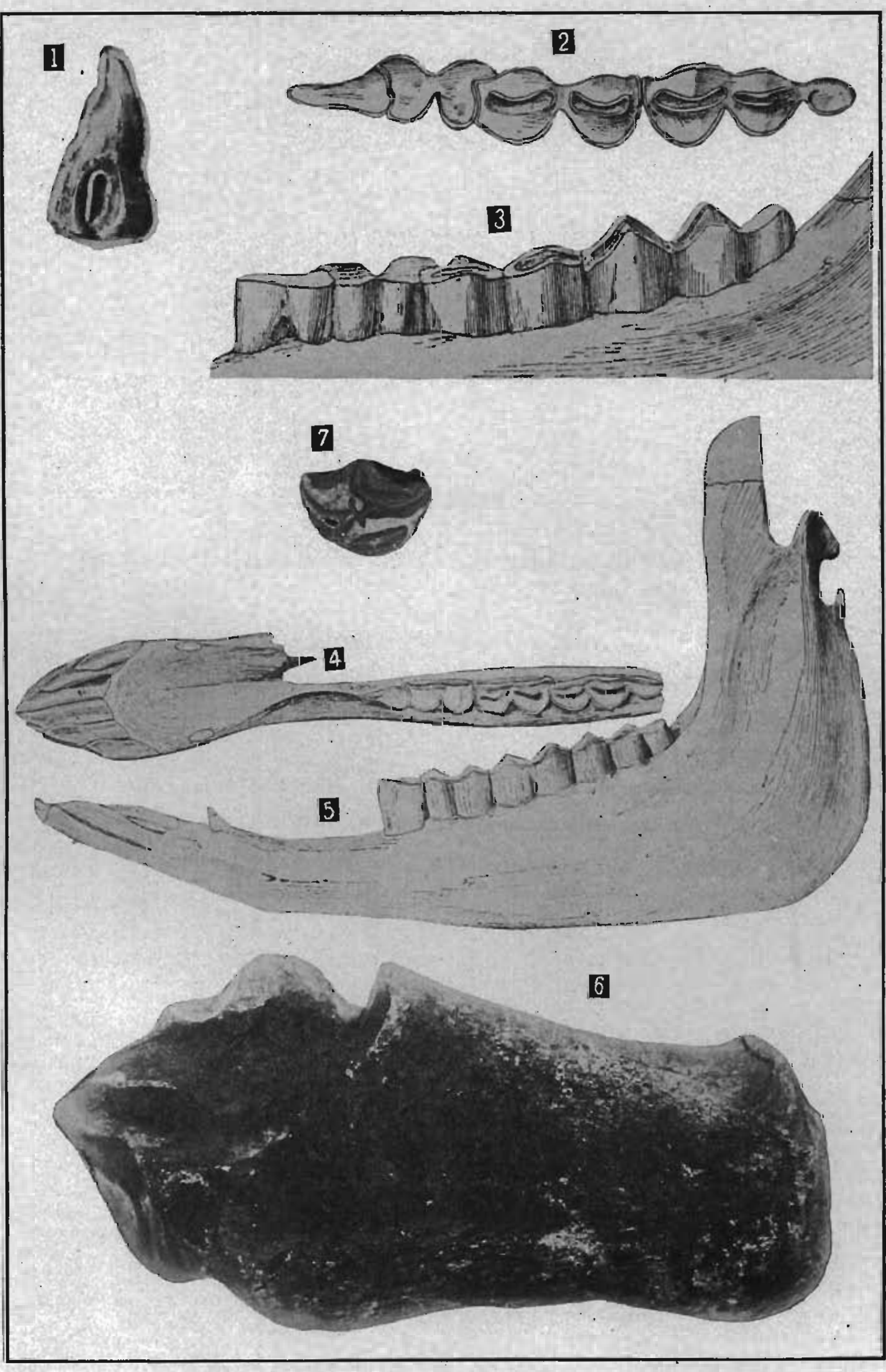

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Plate XXIX.

Figs. 1-4. *Camelops huerfanensis.* Portions of skull of the type .... p. 235

1. Occipital region, from behind; partly missing. x 2/3.
2. Left premaxilla; some missing in front. Outer face. x 1.
3. Same bone, showing inner face. x 1.
4. Same bone, showing lower edge. x 1.

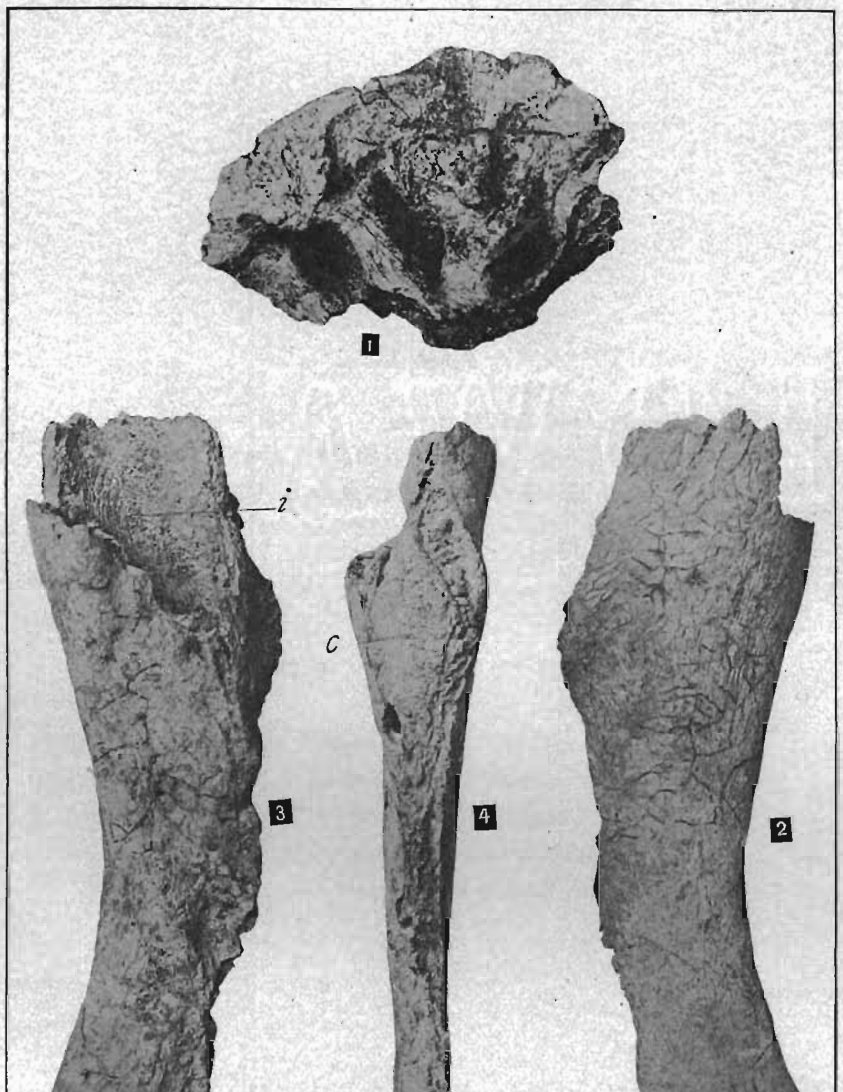
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Plate XXX.

Fig. 1. *Camelops huerfanensis.* Palate of the type, showing the last premolar and the three molars. Teeth of the left side of the jaw injured. x 1/2 .... pp. 235, 237

Figs. 2-5. *Camelops huerfanensis?* Views of jaw and teeth .... pp. 237, 238, 239

2. Symphysis of lower jaw, with canines and incisors. x 1/2 .... p. 237
3. Third incisor. x 1. No. 870, National Museum.
4. Second incisor. x 1. No. 870, National Museum.
5. Part of right side of lower jaw, with two premolars and two molars. x 1/2. No. 5315, National Museum.

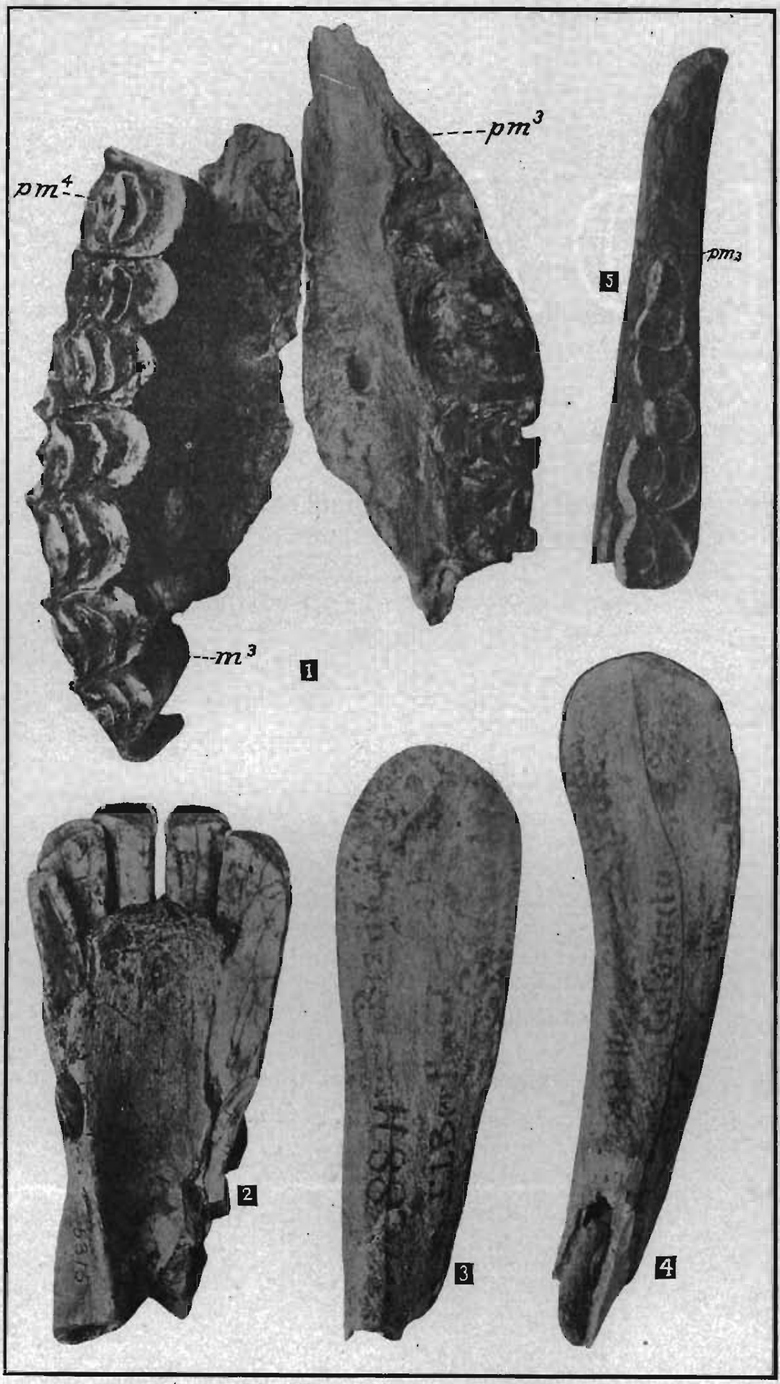

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Plate XXXI.

Figs. 1,2. Camelops? ——— Foot-bones found in Iowa. x 1/2 . . . . pp. 59, 241

1. Proximal phalange, found at Henton Station, near Council Bluffs. No. 304, State University of Iowa.
2. Second phalange, found at Turin, Monona county.

Fig. 3. *Camelops huerfanensis.* Proximal phalange of type; for comparison. x 1/2 . . . . p. 241

Fig. 4. *Camelops kansanus?* Right upper fourth premolar. x 1 . . . . p. 243

Fig. 5. *Odocoileus virginianus.* Part of skull and antlers. Much reduced . . . . p. 249

Figs. 6,7. *Cervus canadensis.* Upper and lower cheek-teeth of left side. x 2/3 . . . . pp. 255, 256

6. Upper teeth.
7. Lower teeth.

Fig. 8. *Alces shimeki.* Teeth of type seen from above. x 1 . . . . p. 272

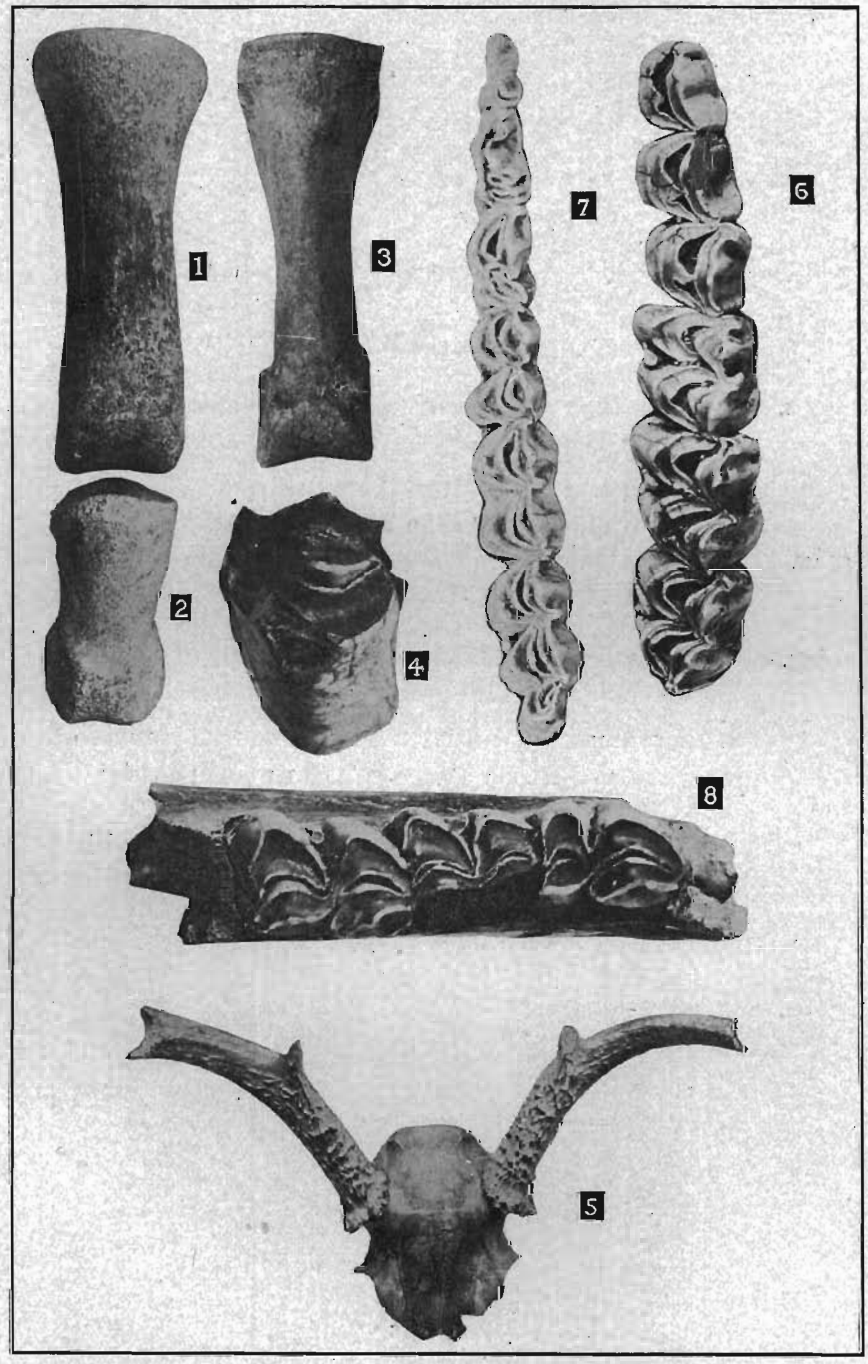
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Plate XXXII.

Figs. 1,2. *Cervalces roosevelti.* Part of skull forming the type. x .185 .... p. 268

1. Skull and antler seen from behind.
2. Skull and antler seen from in front.

Fig. 3. *Alces shimeki.* Type jaw, seen from outside. x 1 .... p. 272

Figs. 4,5. *Rangifer muscatinensis?* Fragments of antlers. .... p. 282

4. Fragment of antler found at Correctionville, Iowa. x 1/4. No. 352, State University of Iowa.
5. Fragment of antler, found at Correctionville, Iowa. x 1/4. No. 351, State University of Iowa.


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Plate XXXIII.

Figs. 1, 2. *Rangifer muscatinensis.* Teeth forming the type. x 1 . . . . pp. 277, 279, 280

1. Upper left premolars and molars.
2. Lower left premolars and molars.

Fig. 3. *Rangifer muscatinensis?* Fragment of antler found at Muscatine. x .58 . . . . p. 281

Fig. 4. *Rangifer muscatinensis?* Fragment of antler. x 1/6. Locality unknown . . . . pp. 281, 282

Figs. 5, 6. *Antilocapra americana.* Upper and lower cheek-teeth of the left side. x 1 . . . . p. 285

5. Upper teeth.
6. Lower teeth.

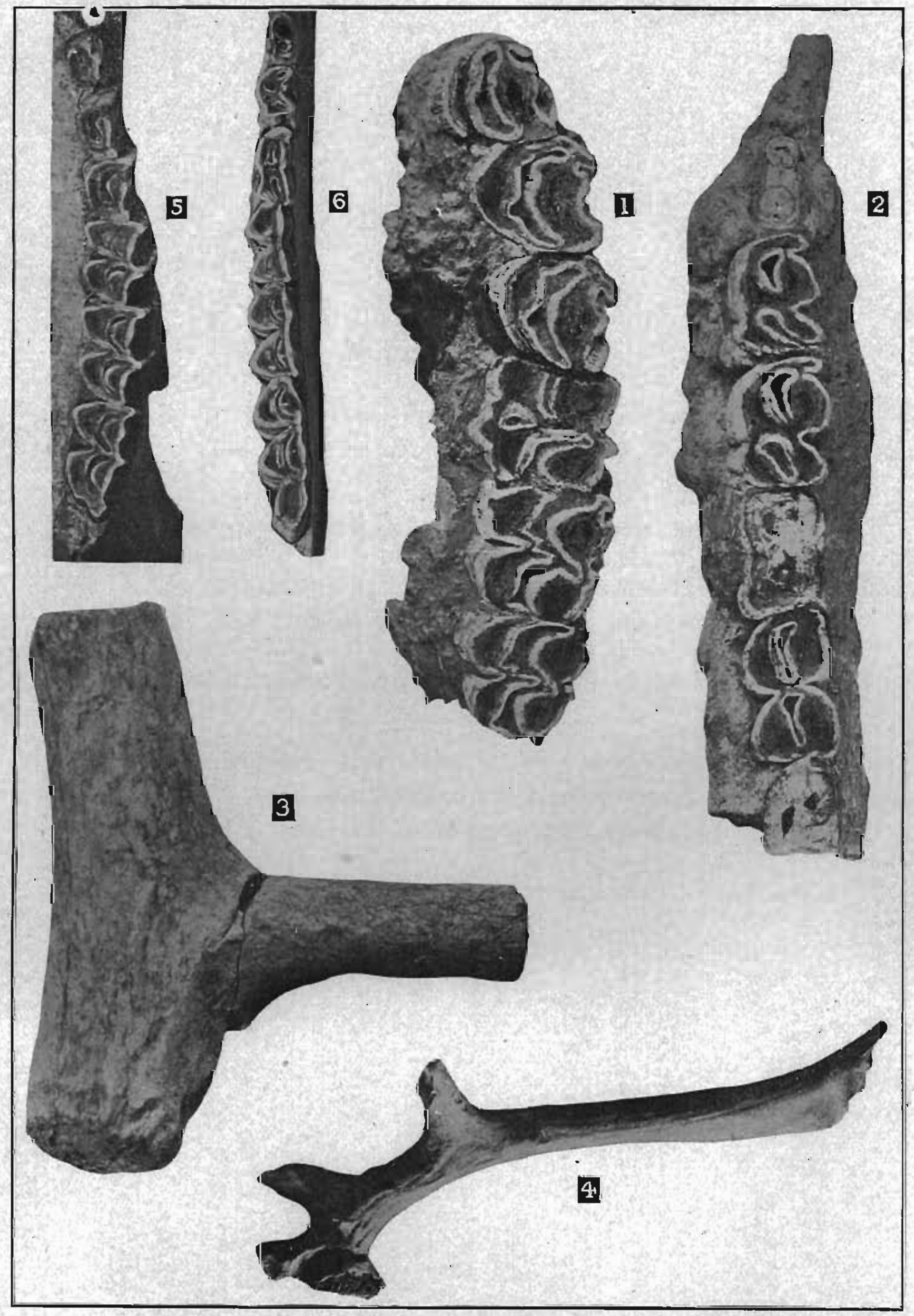
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Plate XXXIV.

Figs. 1,2. *?Aftonius calvini.* Left hinder cannon-bone. x .4 . . . . p. 289

1. Bone seen from the inner side.
2. Bone seen from front. Inverted by engraver.

Fig. 3. *Antilocapra americana.* Upper cheek-teeth of left side, seen from outer side. x 1 . . . . p. 285

Figs. 4,5. *Aftonius calvini.* Horn-cores forming the type. . . . . p. 287

4. Horn-cores seen from in front. Somewhat less than one-half the natural size.
5. Left horn-core, seen from the side. x 1/2.

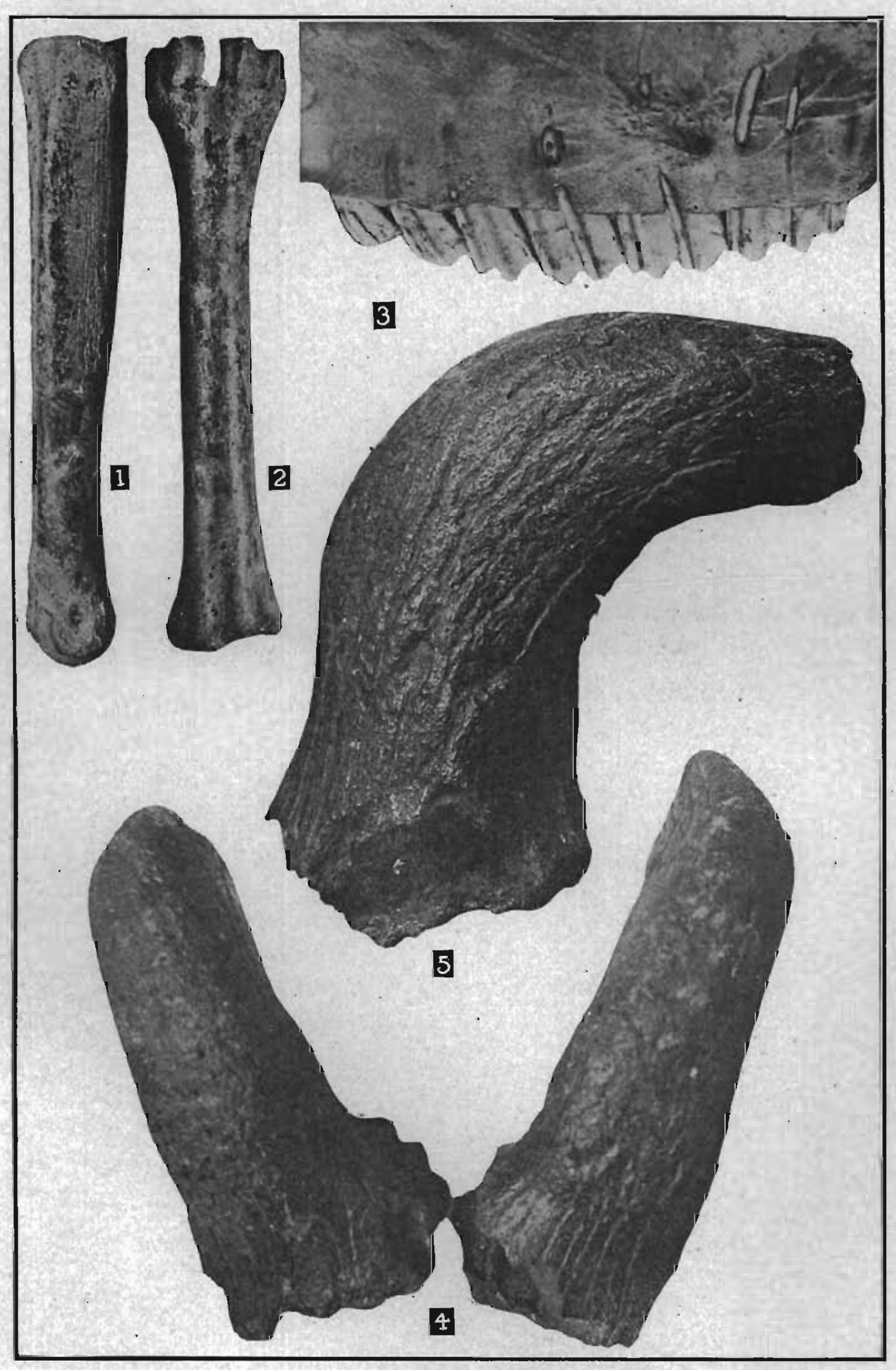
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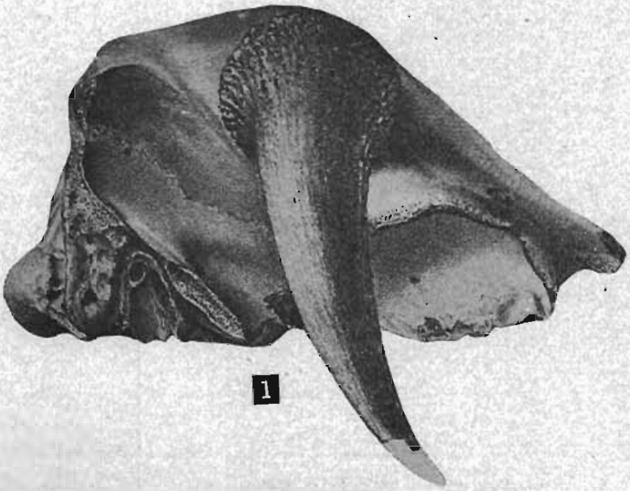
Plate XXXV.

Figs. 1, 2. *Boötherium bombifrons.* Two views of the skull of the type. x about 1/3. . . . . p. 291

1. Skull seen from the right side.
2. Skull seen from above.



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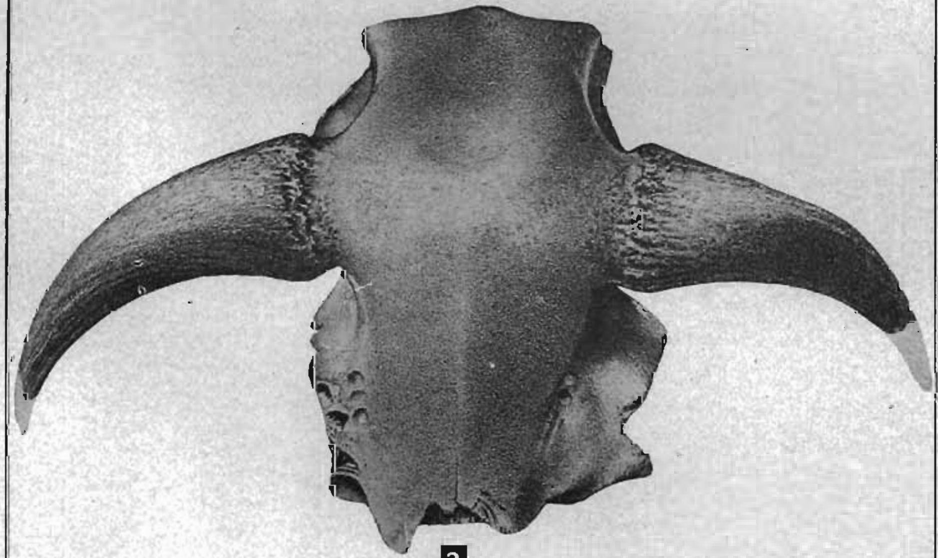

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Plate XXXVI.

Fig. 1. *Ovibos moschatus.* Skull seen from above. x about 1/3. From Osgood.............pp. 294, 297

Figs. 2,3. *Ovibos moschatus.* Two views of skull found in Fayette county, Iowa. x about 1/5..pp. 294, 297

2. Skull seen from above.
3. Skull seen from the left side and above.

Fig. 4. *Symbos cavifrons.* Skull of type seen from the rear. x about .22 .... p. 298

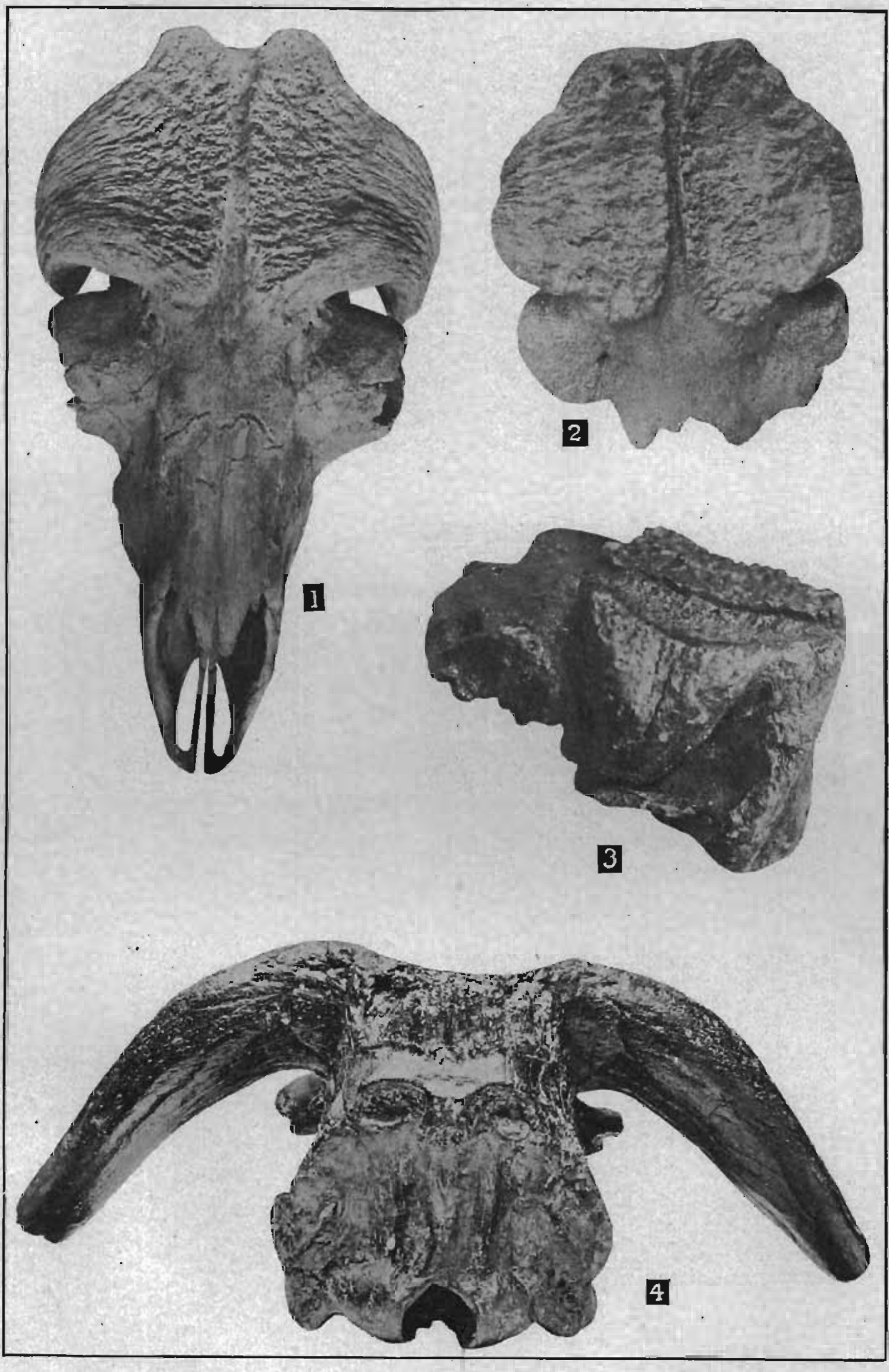
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Plate XXXVII.

Figs. 1, 2. *Symbos tyrrelli.* Two views of the skull forming the type. x about 1/5. . . . . pp. 302-304

1. Skull from above.
2. Skull from below.

Fig. 3. *Symbos cavifrons.* View of forehead and horn-cores of specimen found near Council Bluffs. x about 1/4. . . . . p. 305

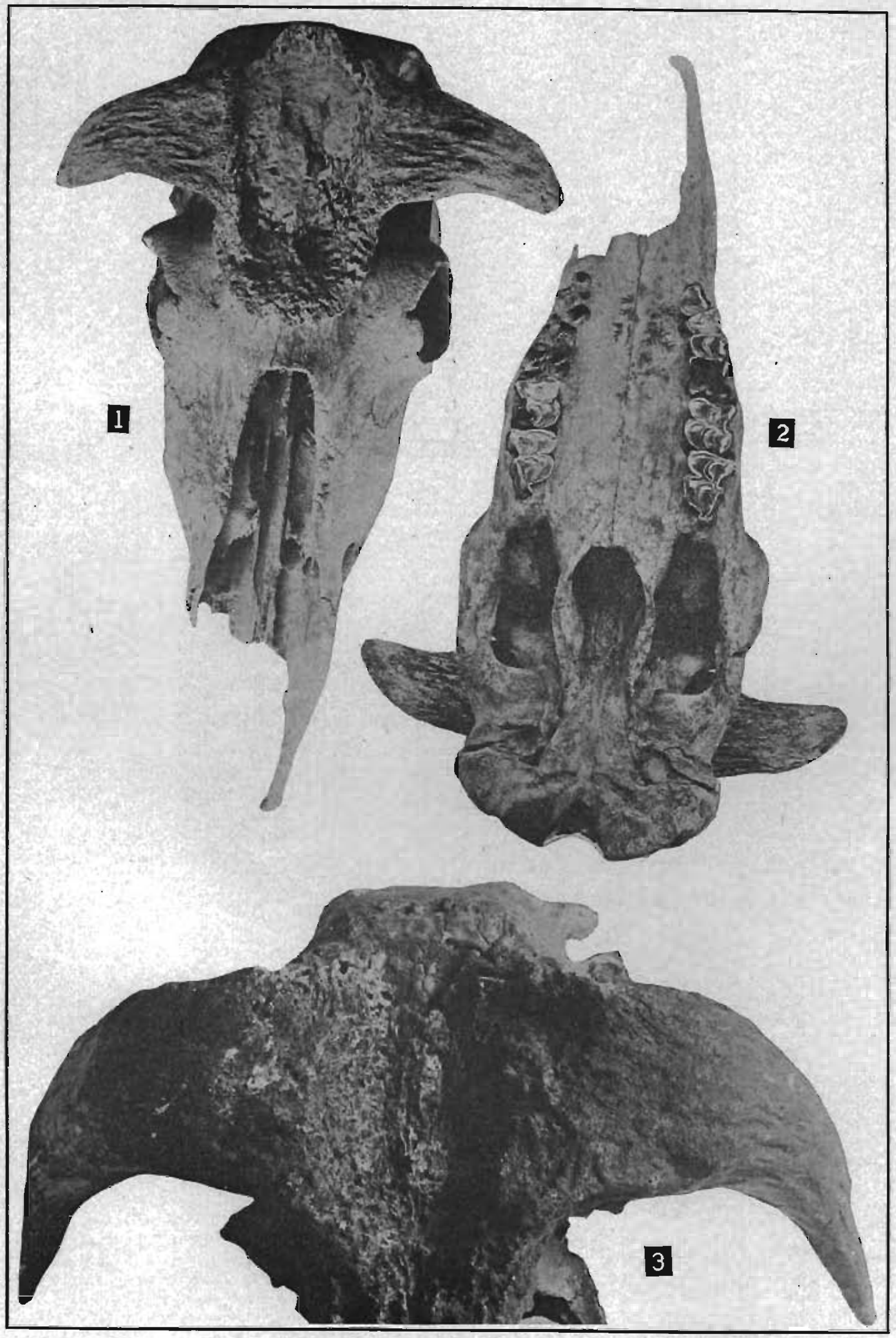
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Plate XXXVIII.

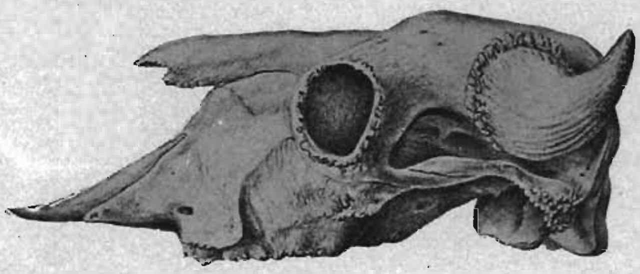
Figs. 1,2. *Bison bison.* Views of skull of an old male. x 1/6 .... p. 313

1. Skull seen from the side.
2. Skull seen from the rear.

Figs. 3,4. *Bison bison.* Views of grinding surface of upper and lower molars and premolars. x 2/3. p. 313

3. Upper teeth of left side.
4. Lower teeth of right side.

All these figures are from Dr. J. A. Allen's Monograph on North American Bisons.



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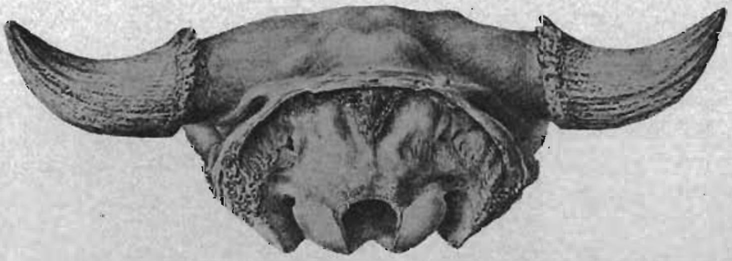

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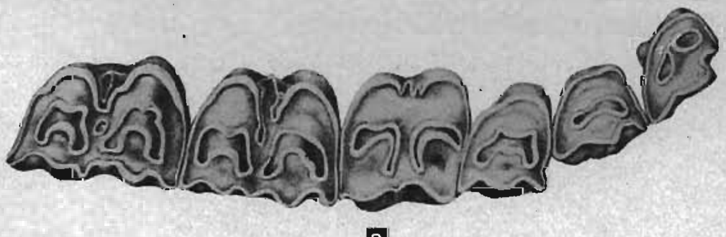

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Plate XXXIX.

Fig. 1. *Bison bison.* Part of skull of a young animal found at Deloit, Crawford county, Iowa. x .22 .... p. 315

Figs. 2, 3. *Bison occidentalis.* Views of the skull forming the type. x 1/7 .... p. 319

2. Skull seen from above.
3. Skull viewed from behind.

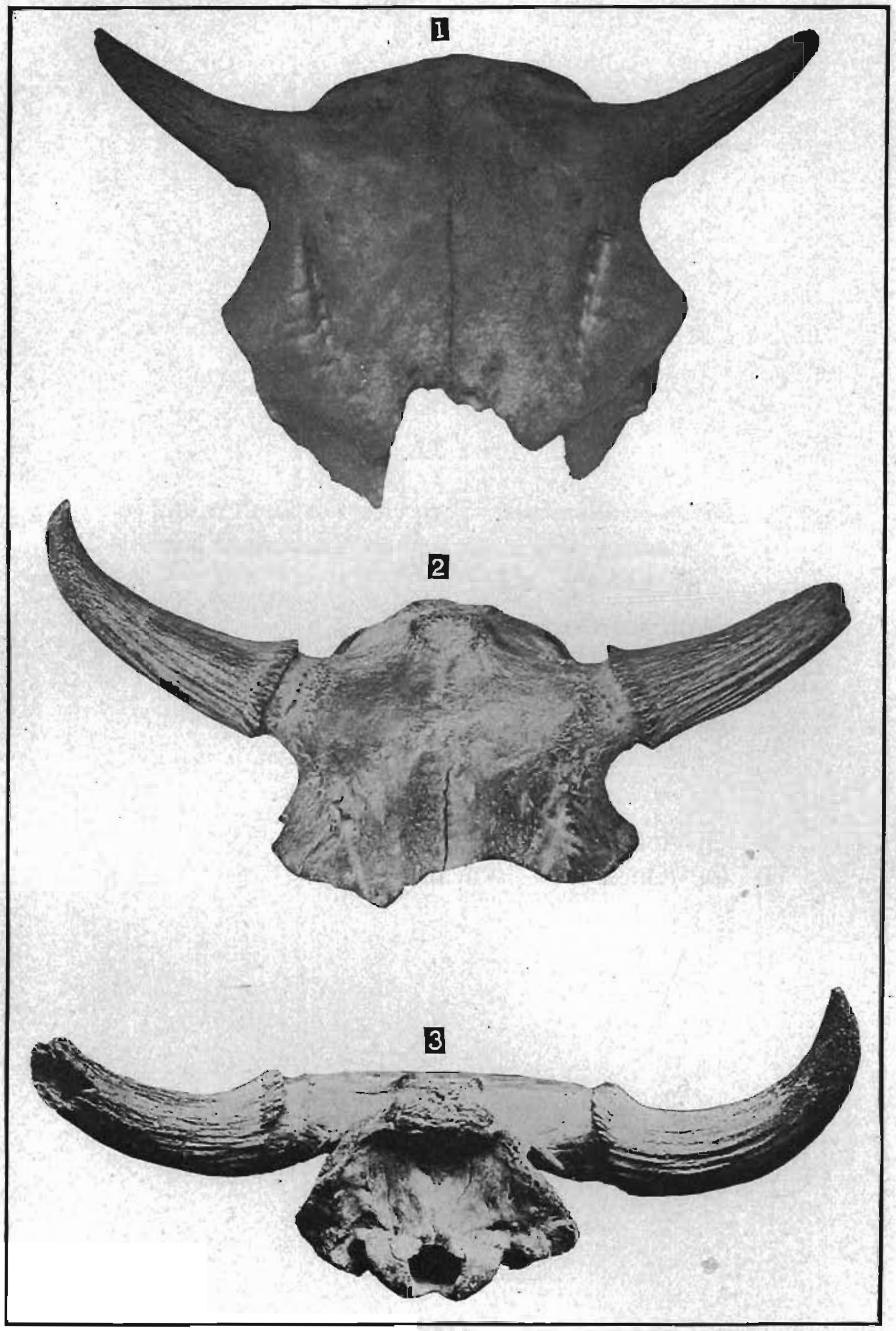
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Plate XL.

Figs. 1,2. *Bison occidentalis.* Two views of skull found in Alaska; now in American Museum of Natural History. x 1/9 . . . . p. 319

1. Skull seen from above.
2. Skull seen from the rear.

Figs. 3,4. *Bison occidentalis.* Left side of skull and horn-core of specimen found in Hamilton county, Iowa. x 1/5 . . . . pp. 82, 323

3. Specimen seen from above.
4. Specimen seen from behind.

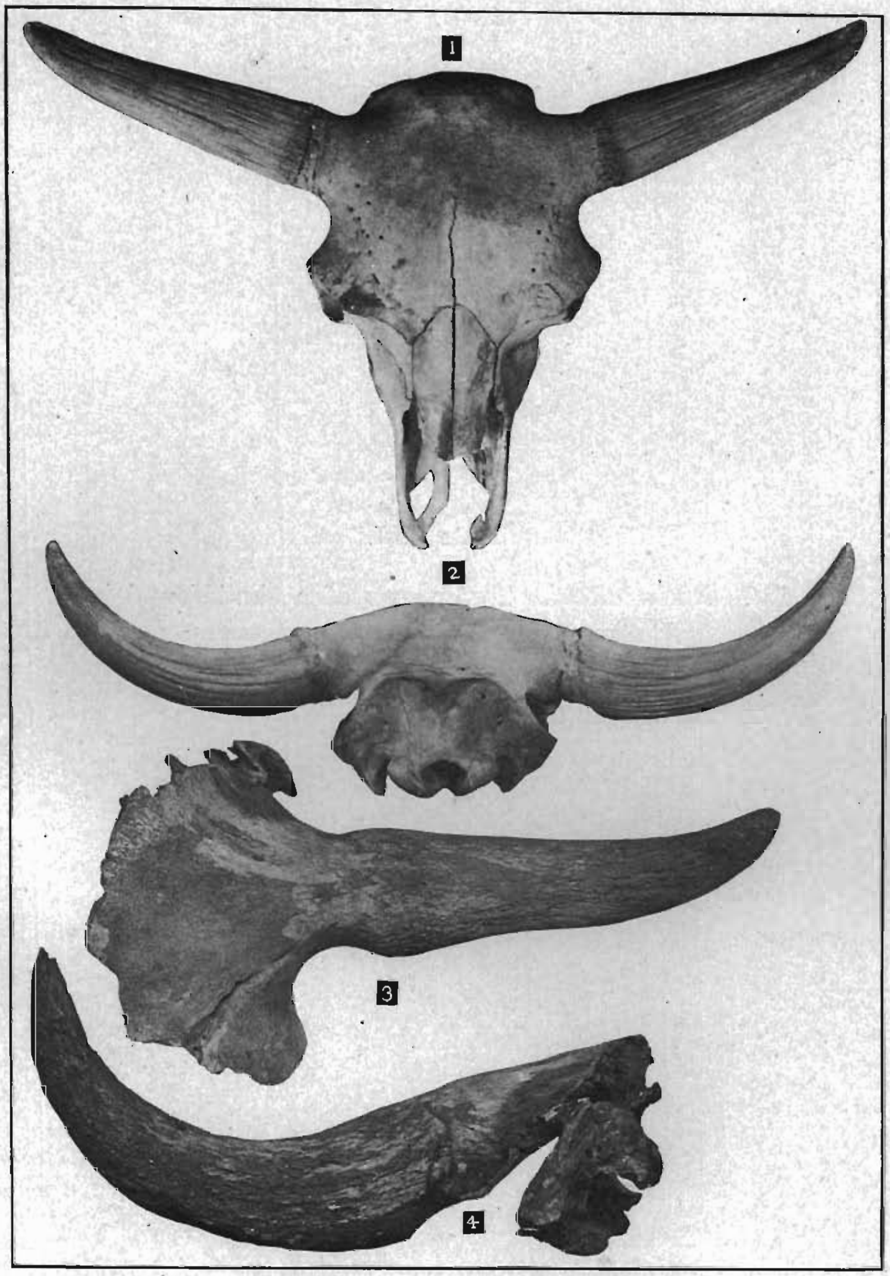
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Plate XLI.

Figs. 1,2. *Bison alleni.* Two views of a skull found in Alaska; now in National Museum. x .12. .p. 326

1. Skull seen from above.
2. Skull seen from the rear.

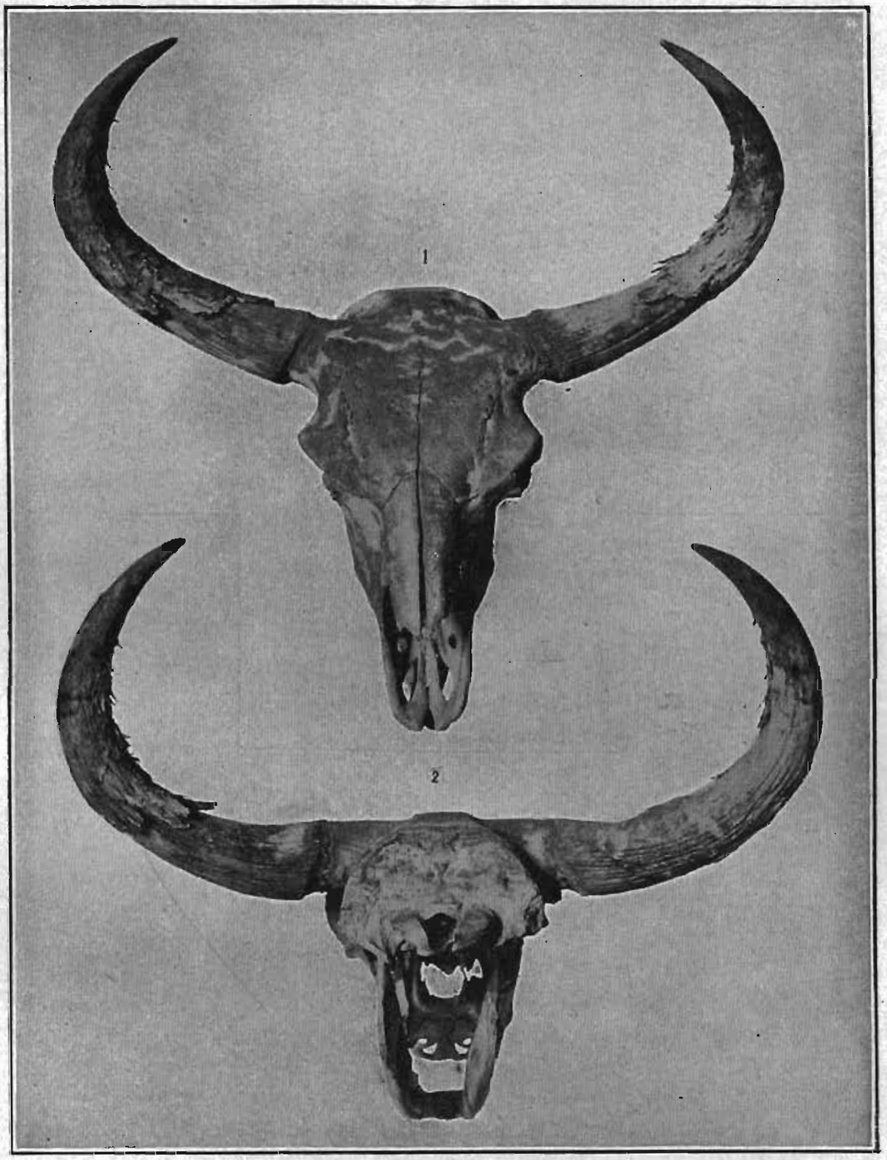
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Plate XLII.

Fig. 1. *Bison latifrons.* View of part of skull and the horn-cores, to show the curvature of the latter. x 1/12. Specimen in Cincinnati Society Natural History ....p. 327

Figs. 2, 3. *Bison regius.* Two views of skull of the type. x 1/12. Specimen in American Museum Natural History, New York ....p. 237

2. Skull seen from the rear.
3. Skull seen from above.

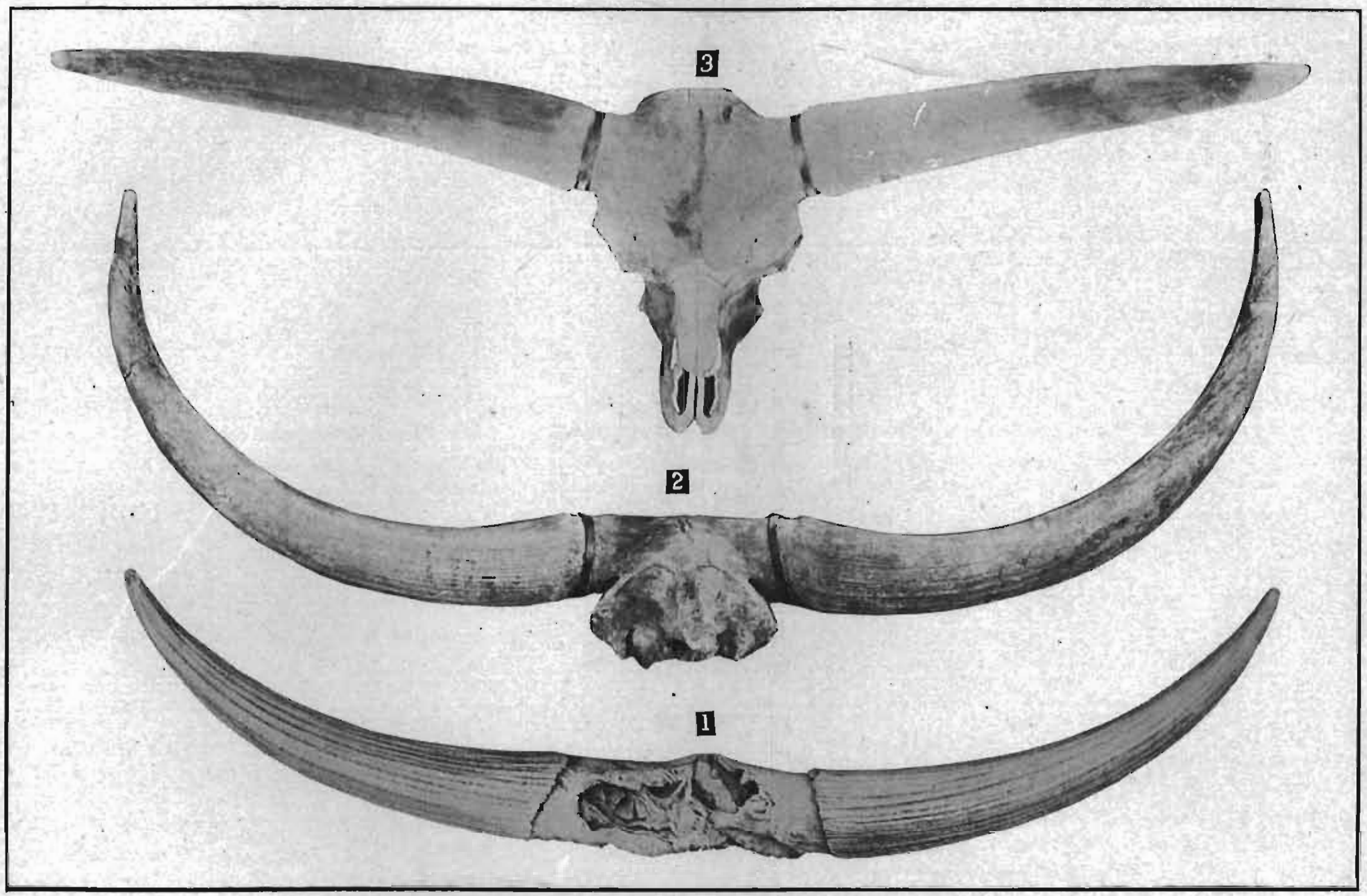
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Plate XLIII.

Figs. 1,2. *Mammut americanum.* Two views of skull of specimen in the National Museum........ ....pp. 333, 334, 335, 370

1. Palatal view of skull.
2. Lower jaw seen from above.

Fig. 3. *Mammut americanum.* Upper left third molar, seen from outside. x 1/2. No. 2220, National Museum .... p. 338

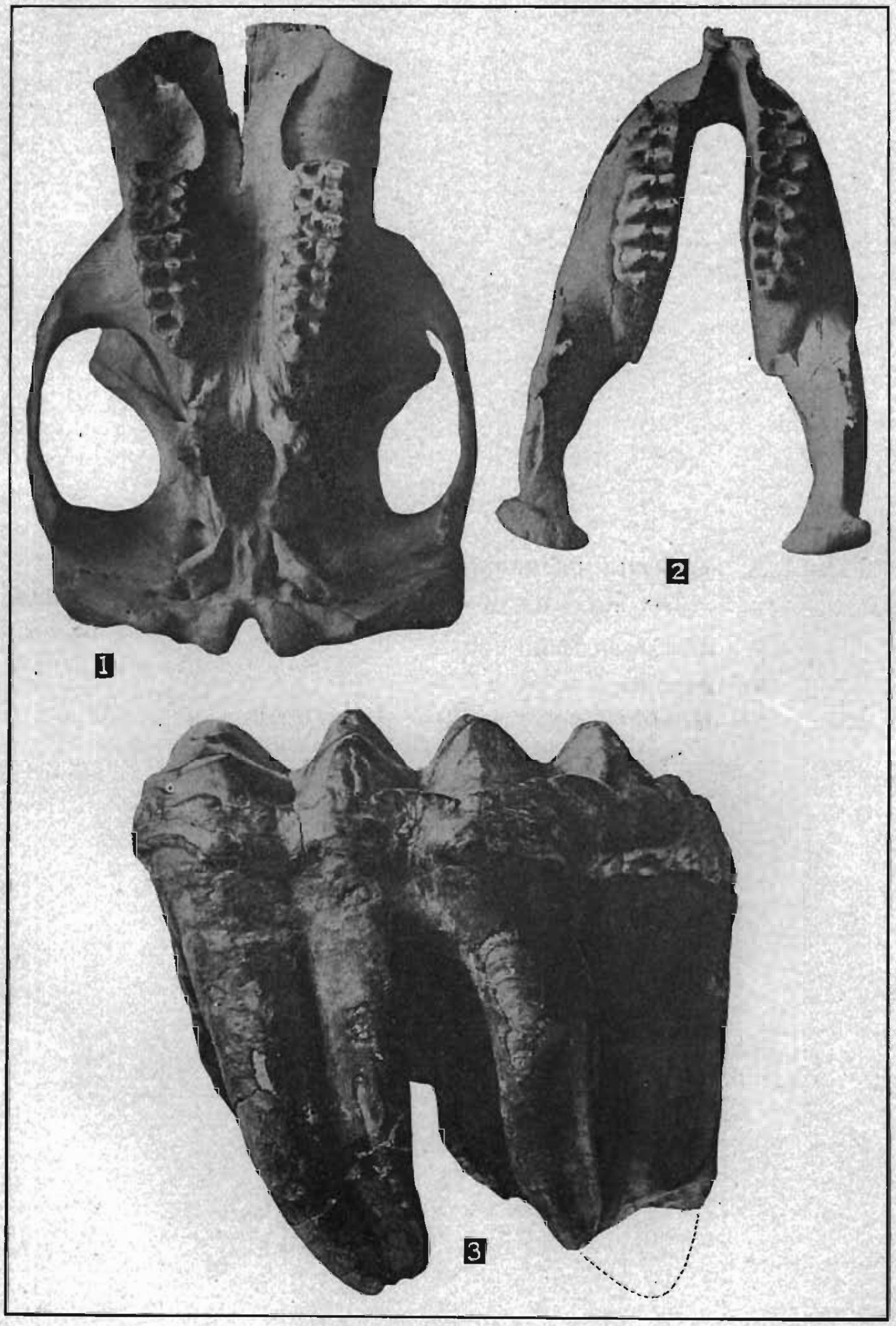
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Plate XLIV.

Figs. 1,2. *Mammut progenium.* Two views of the lower jaw forming the type. x 1/7. . . . . .p. 368

1. Jaw seen from above.
2. Jaw seen from left side.

Fig. 3. *Mammut americanum.* Crown view of upper right hindermost molar. x .46. No. 2218, National Museum. . . . . .p. 339

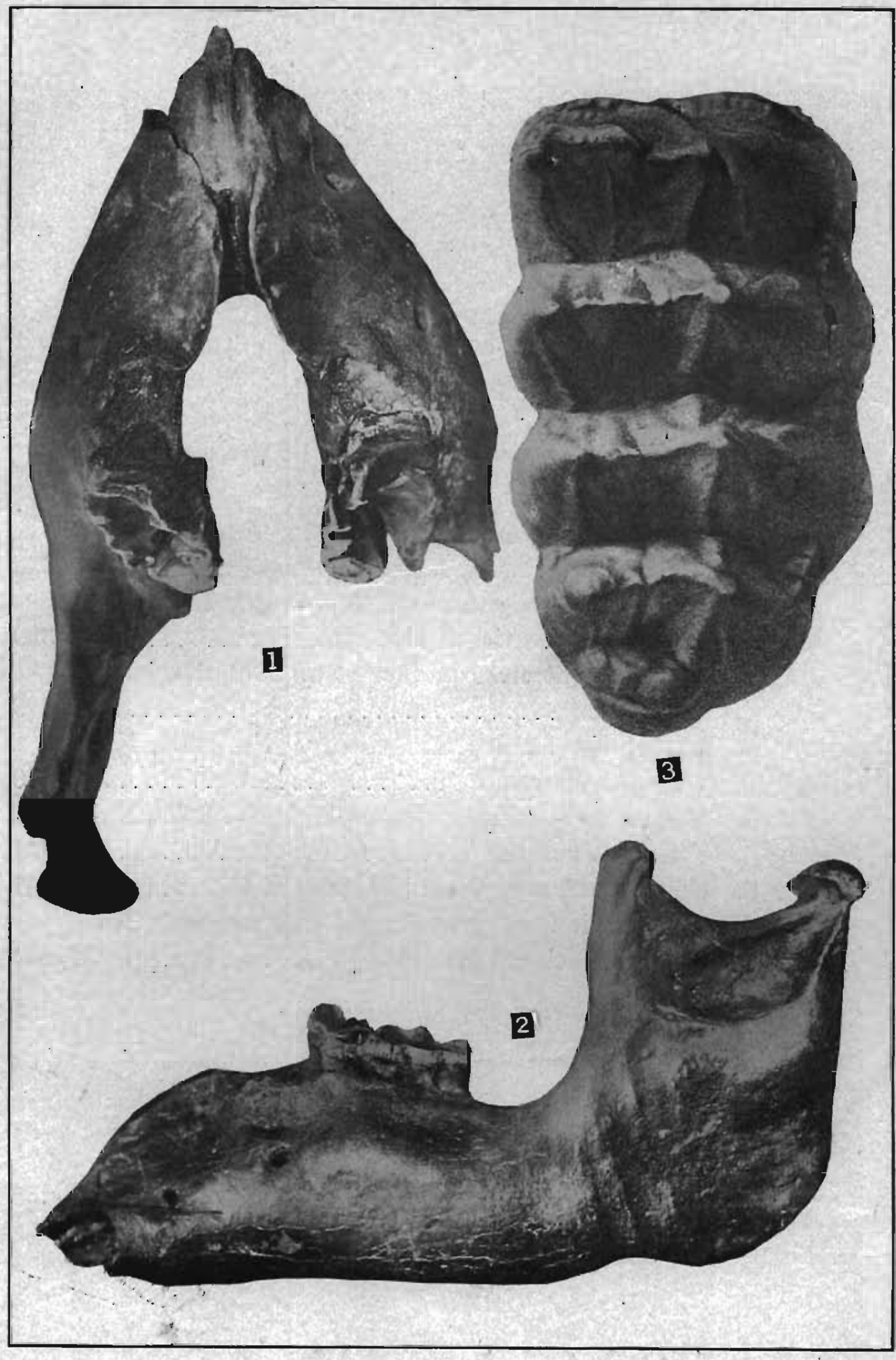
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Plate XLV.

Figs. 1-7. *Mammut americanum.* Views of various teeth. x 1/2.

1. Upper left second molar, front end toward the right. No. 2261, National Museum.........p. 339
2. Upper left second molar. Shows grinding face. No. 2258, National Museum................p. 339
3. Upper right first molar. No. 2243, National Museum .... p. 339
4. Upper right third milk molar. No. 2230, National Museum ....p. 340
5. Upper right second milk molar. No. 6689, National Museum ....p. 341
6. Same tooth seen from the outer side..........p. 341
7. Crown view of lower right last molar. No. 2221, National Museum ....pp. 337, 341

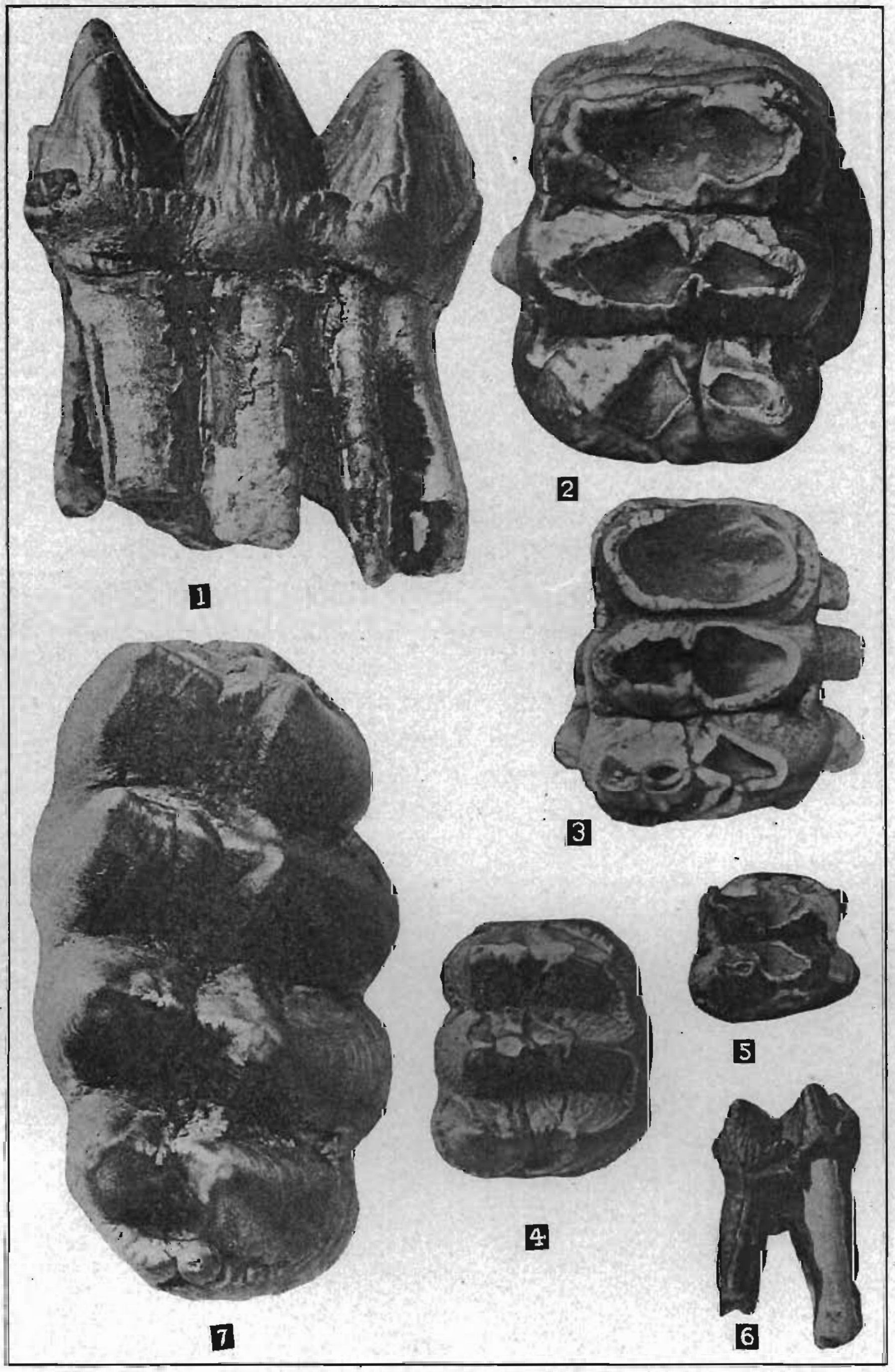

Plate XLVI.

Figs. 1-3. *Mammut americanum.* Views of three lower last molars. x 1/2 . . . . .pp. 337, 341, 342

1. Lower right last molar from below, to show great pulp cavity. No. 2221, National Museum.
2. Lower left last molar, seen from above. No. 2384, National Museum.
3. Lower right last molar, seen from outer, or right side. No. 5101, National Museum.

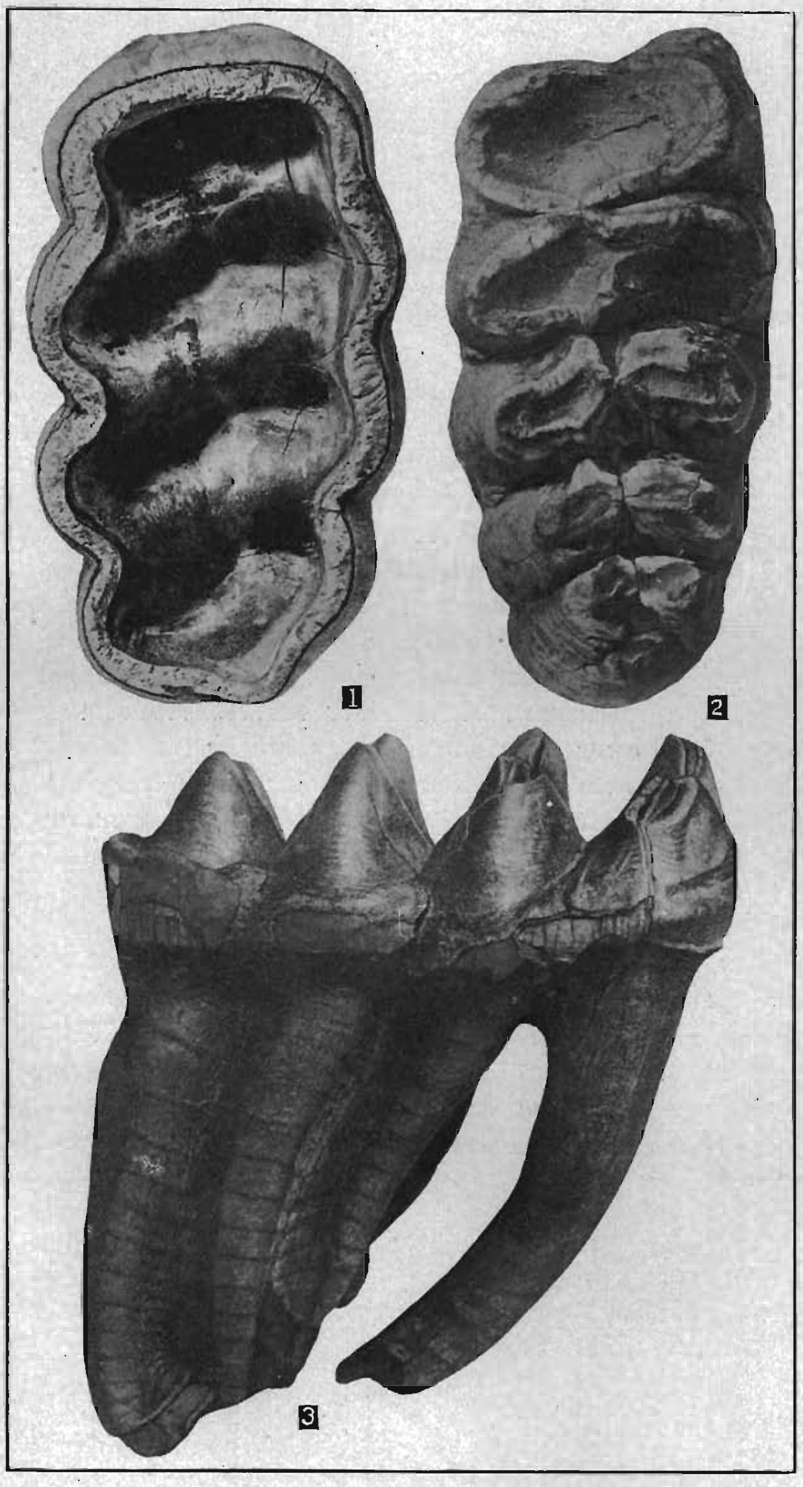
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Plate XLVII.

Figs. 1-10. *Mammut americanum.* Views of various teeth.

1. Lower right second molar. x .36. No. 342, National Museum .... p. 343
2. Lower left second molar. x .47. No. 2228, National Museum. The front of the tooth is toward the left. .... p. 343
3. Lower left first molar. x .44. No. 2233, National Museum .... p. 343
4. Lower right third milk molar. Shows a moderately worn tooth. x 1/2. No. 2231, National Museum .... p. 344
5. Lower right third milk molar. x 1/2. Specimen in National Museum from Virginia. Shows a wholly unworn tooth, seen from the side. .... pp. 344, 345
6. Same tooth seen from above. x 1/2. .... pp. 344, 345
7. Lower right second milk molar. x .46. No. 6690, National Museum .... p. 345
8. Lower left second milk molar, much worn. x .48. No. 6701, National Museum .... p. 346
9. Lower right first milk molar. x .48. No. 4986, National Museum .... p. 346
10. Same tooth seen from the outer side. x .48.... p. 346

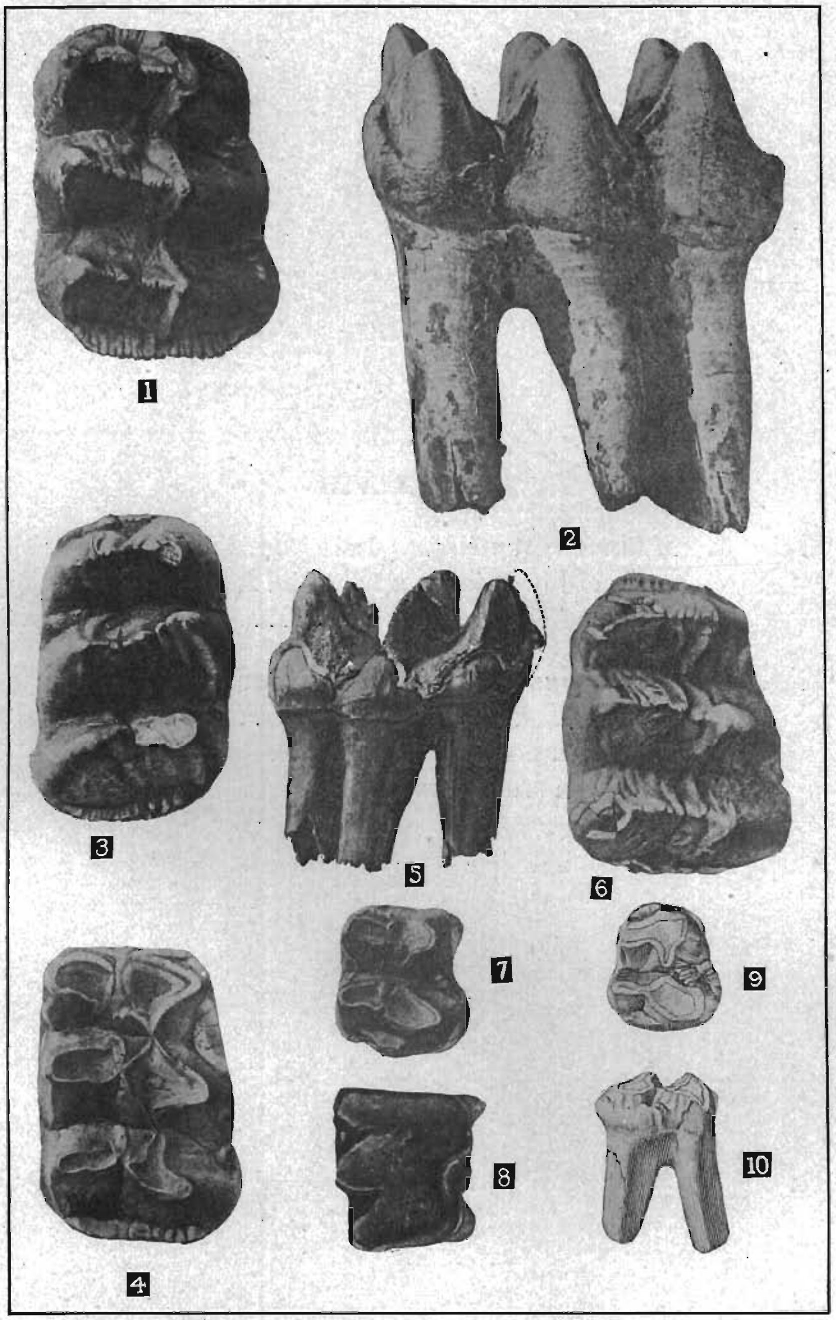

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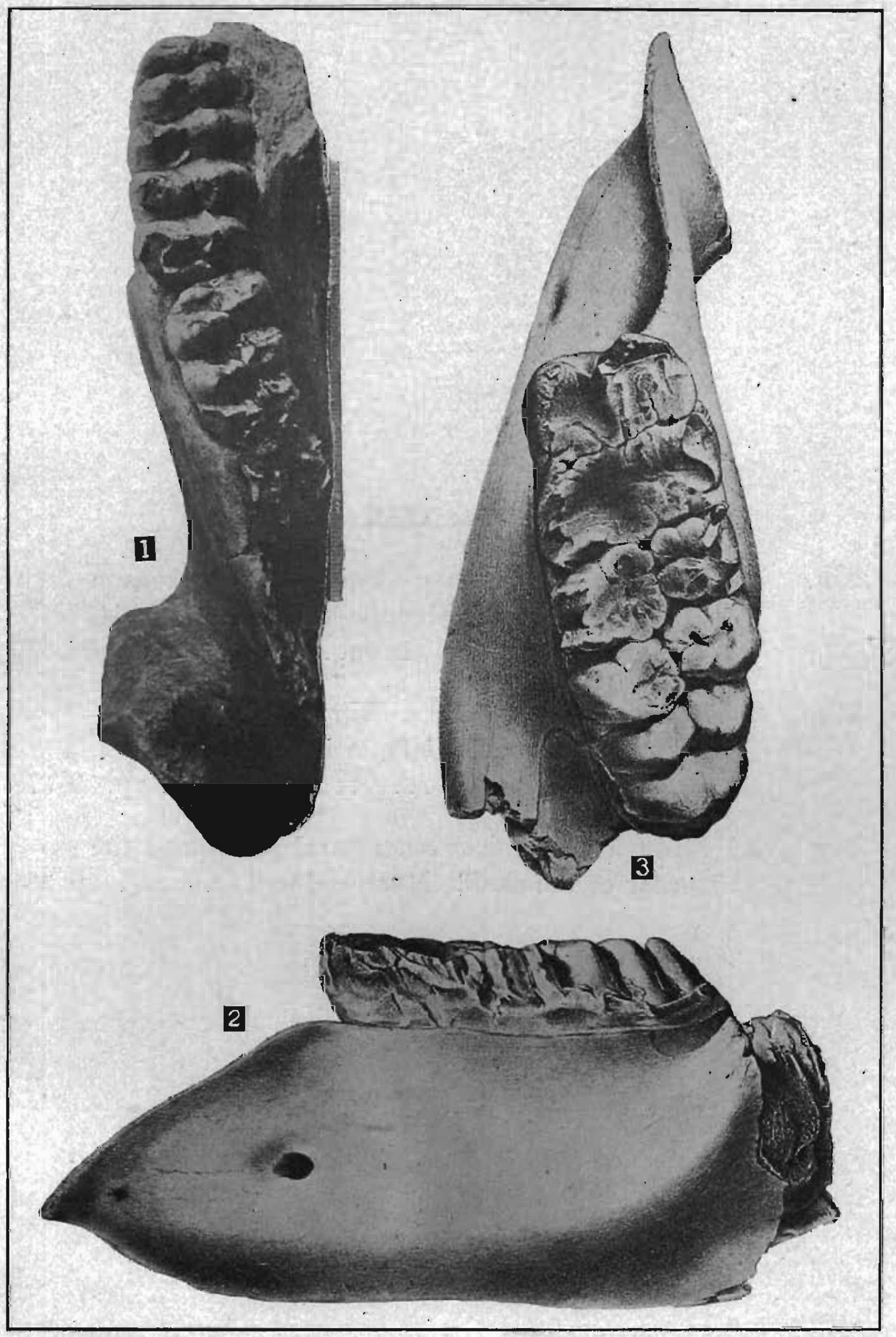
Plate XLVIII.

Fig. 1. *Mammut progenium.* Left ramus and symphysis of lower jaw. x 1/7. No. 2, State University of Iowa..............................p. 372

Figs. 2,3. *Rhabdobunus mirificus.* Left ramus of the lower jaw. x 1/4. After Leidy ....p. 375

2. Jaw seen from the outer side.

3. Jaw seen from above.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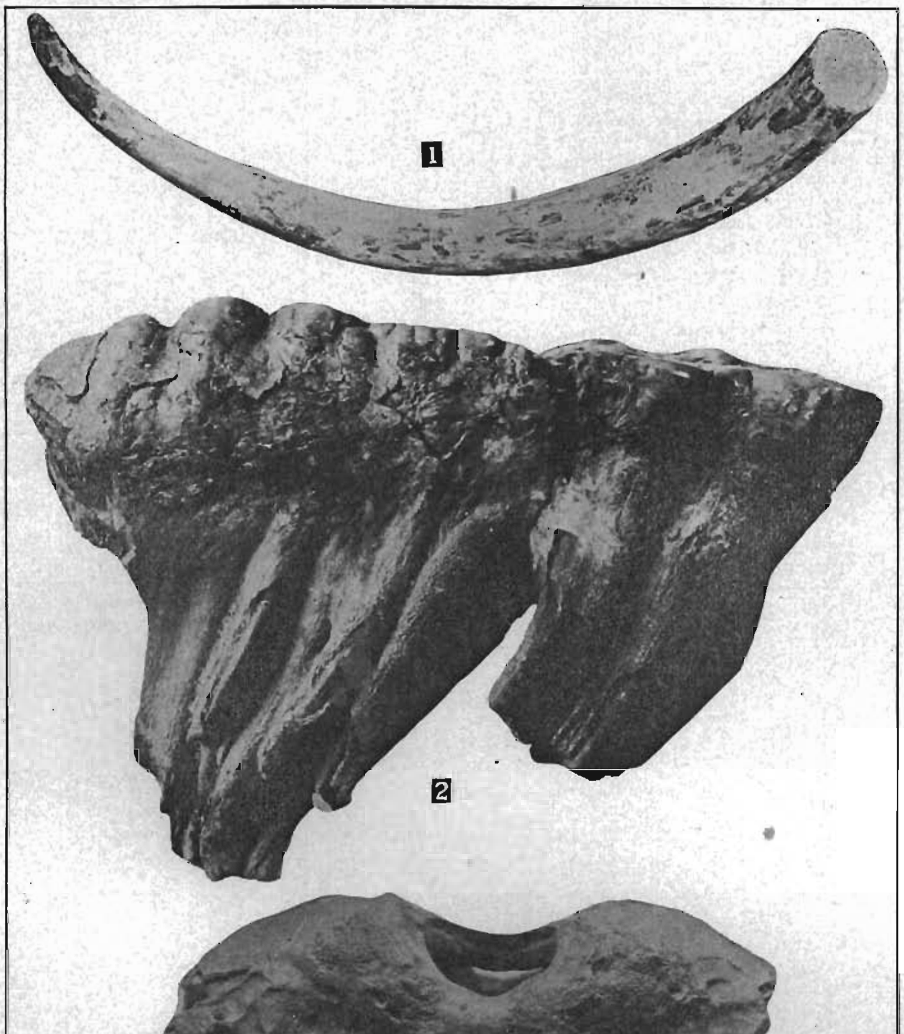
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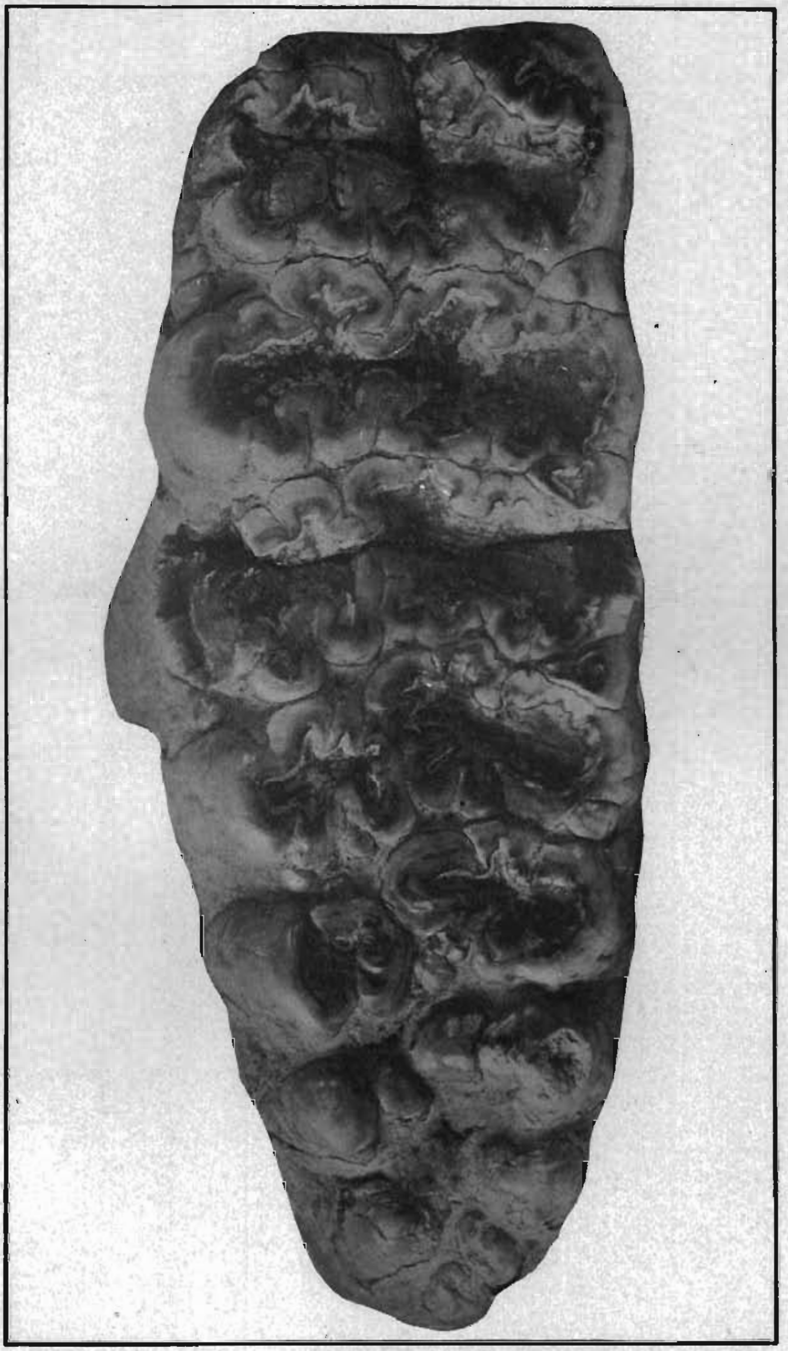

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2. Tooth presenting the inner face. The front end is toward the left.

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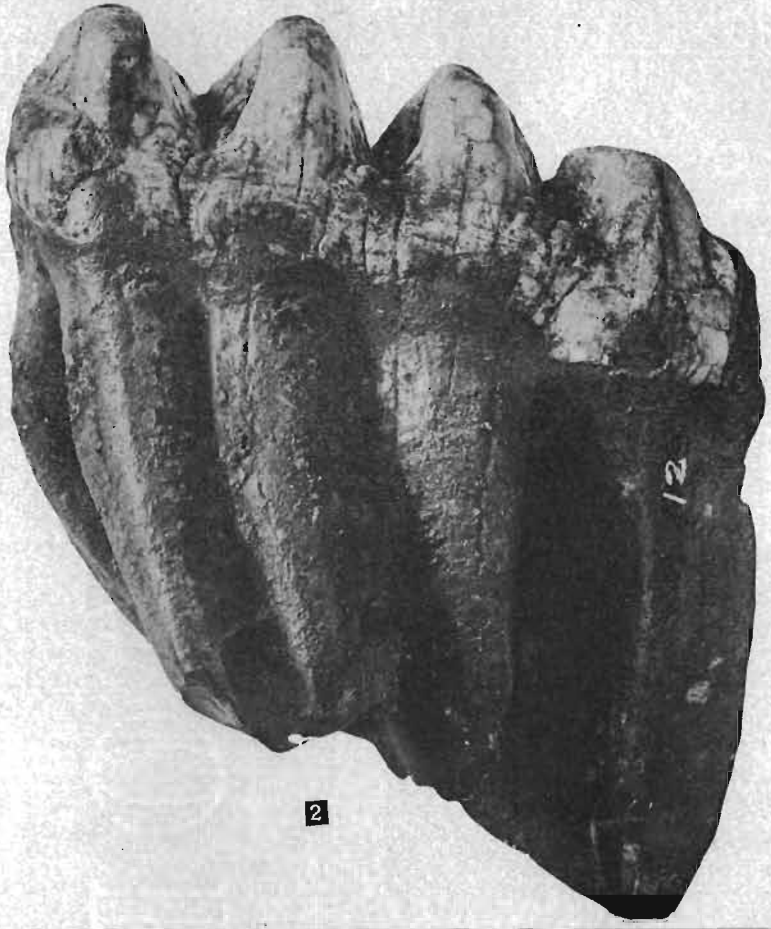

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Figs. 7, 8. *Elephas primigenius.* Lower first milk molar. x 1. From A. Leith Adams...............p. 401

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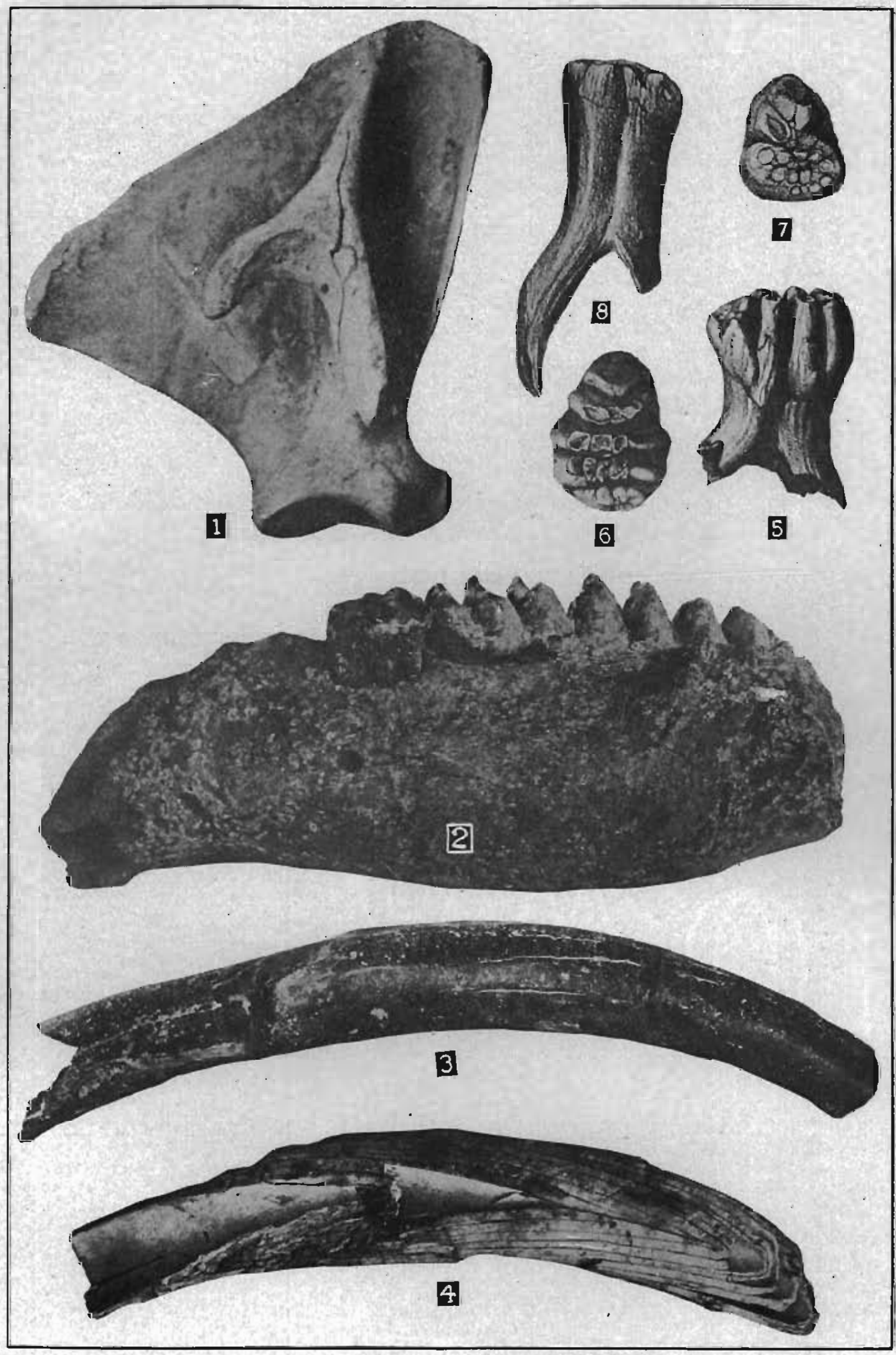
8. View from the side.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Wisconsin
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Illinoian.
Kansan.
Driftless.
Old Channel
Moraines.

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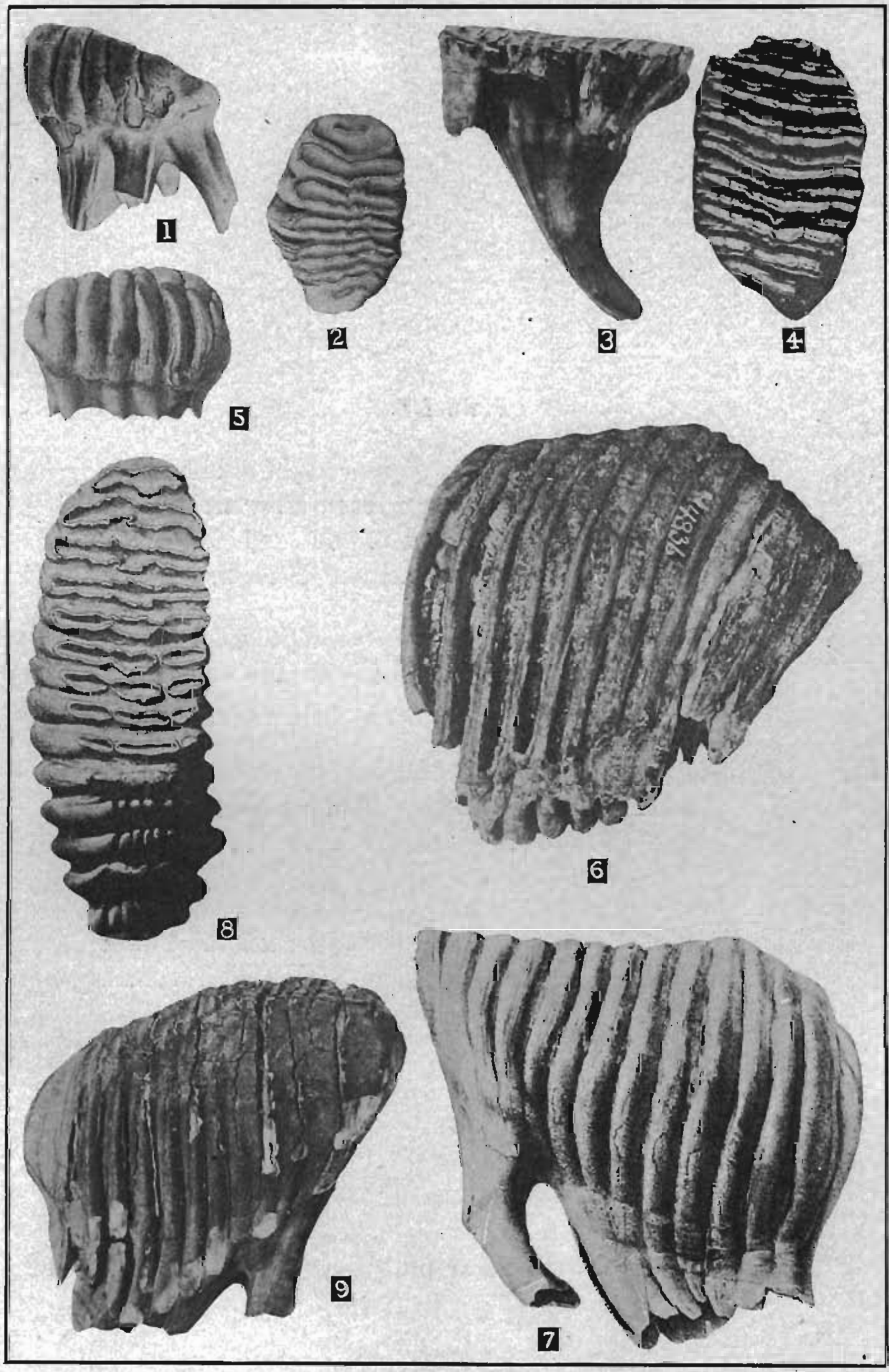
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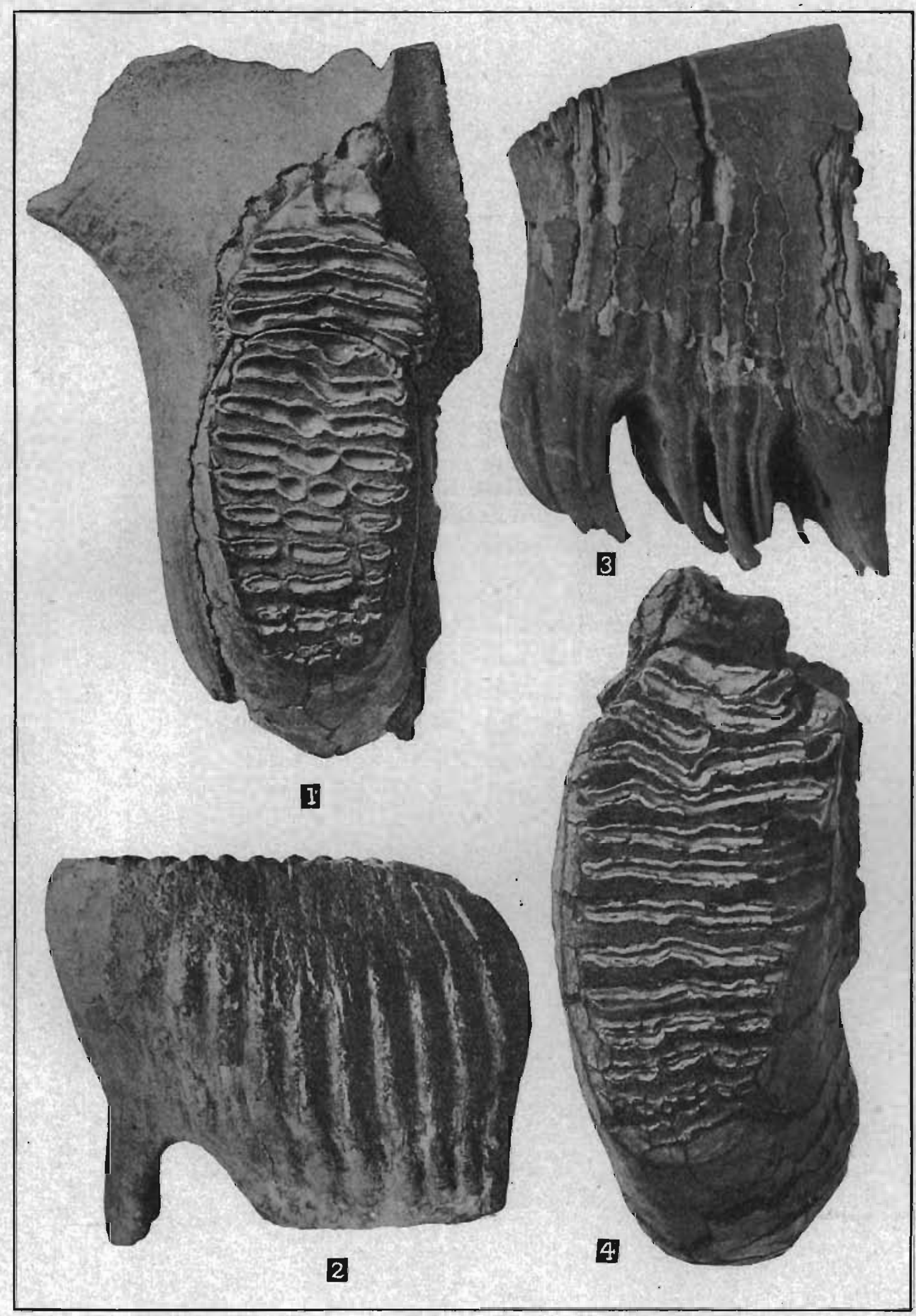
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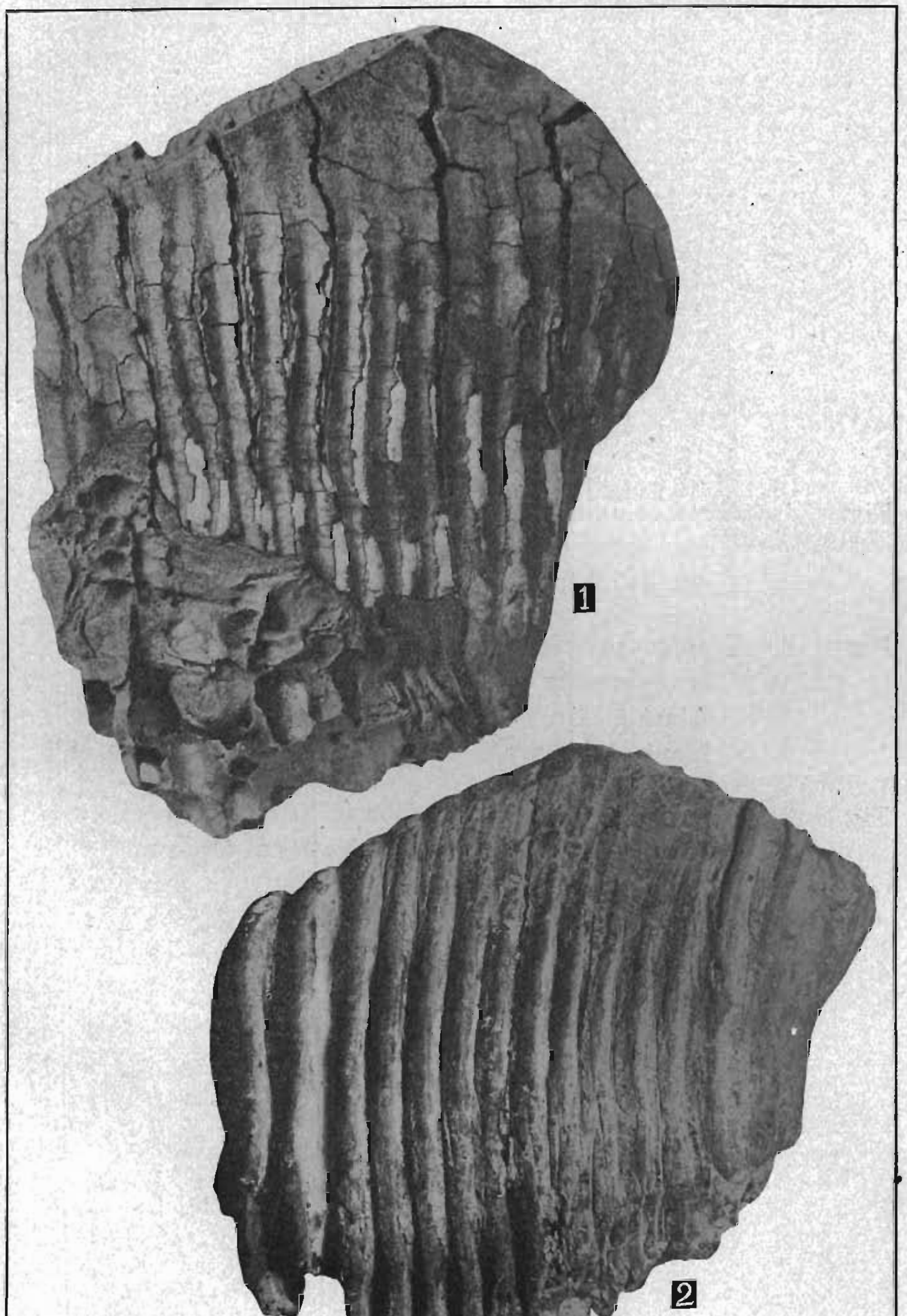
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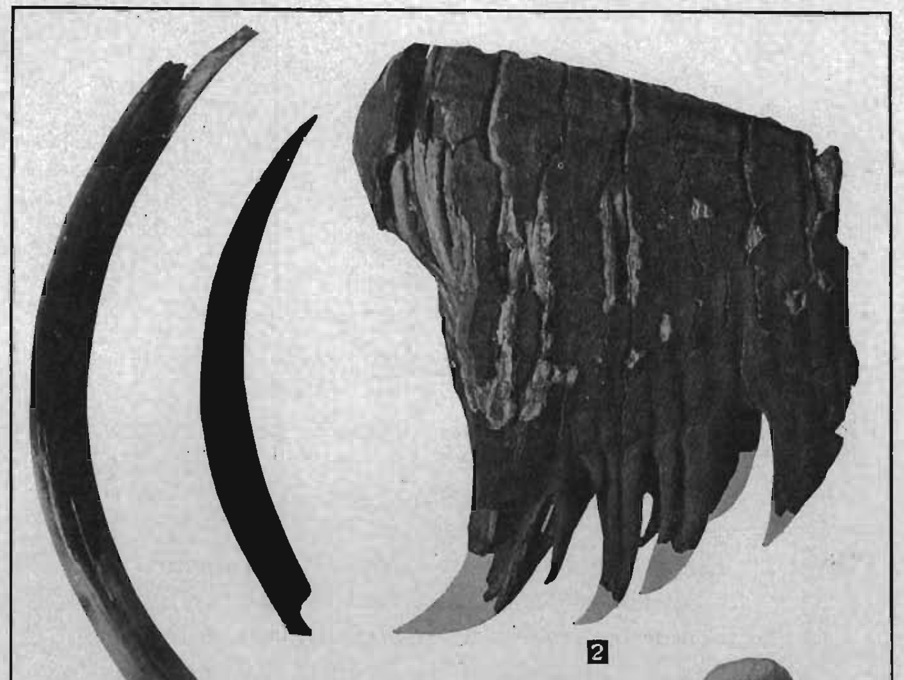
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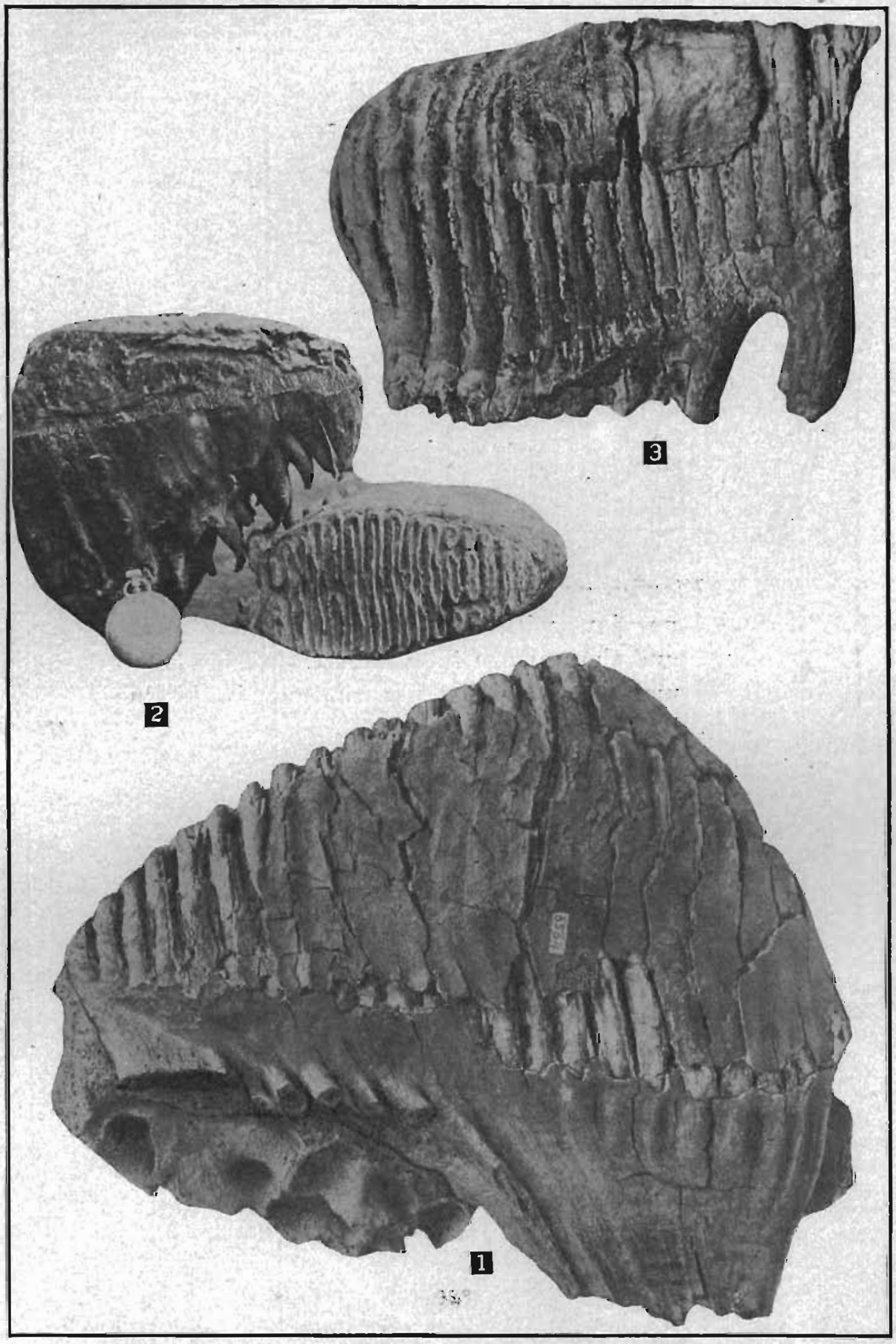
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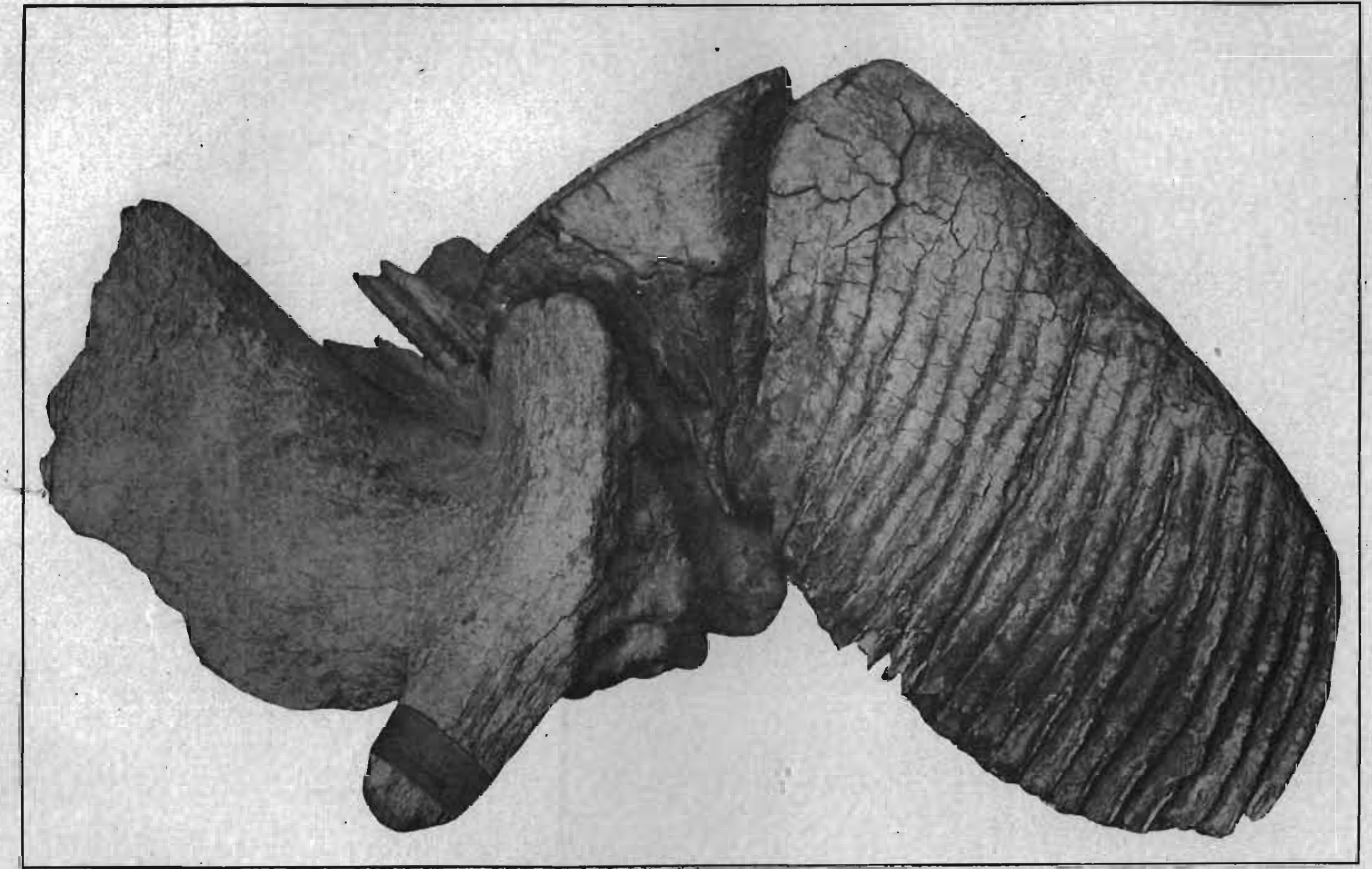

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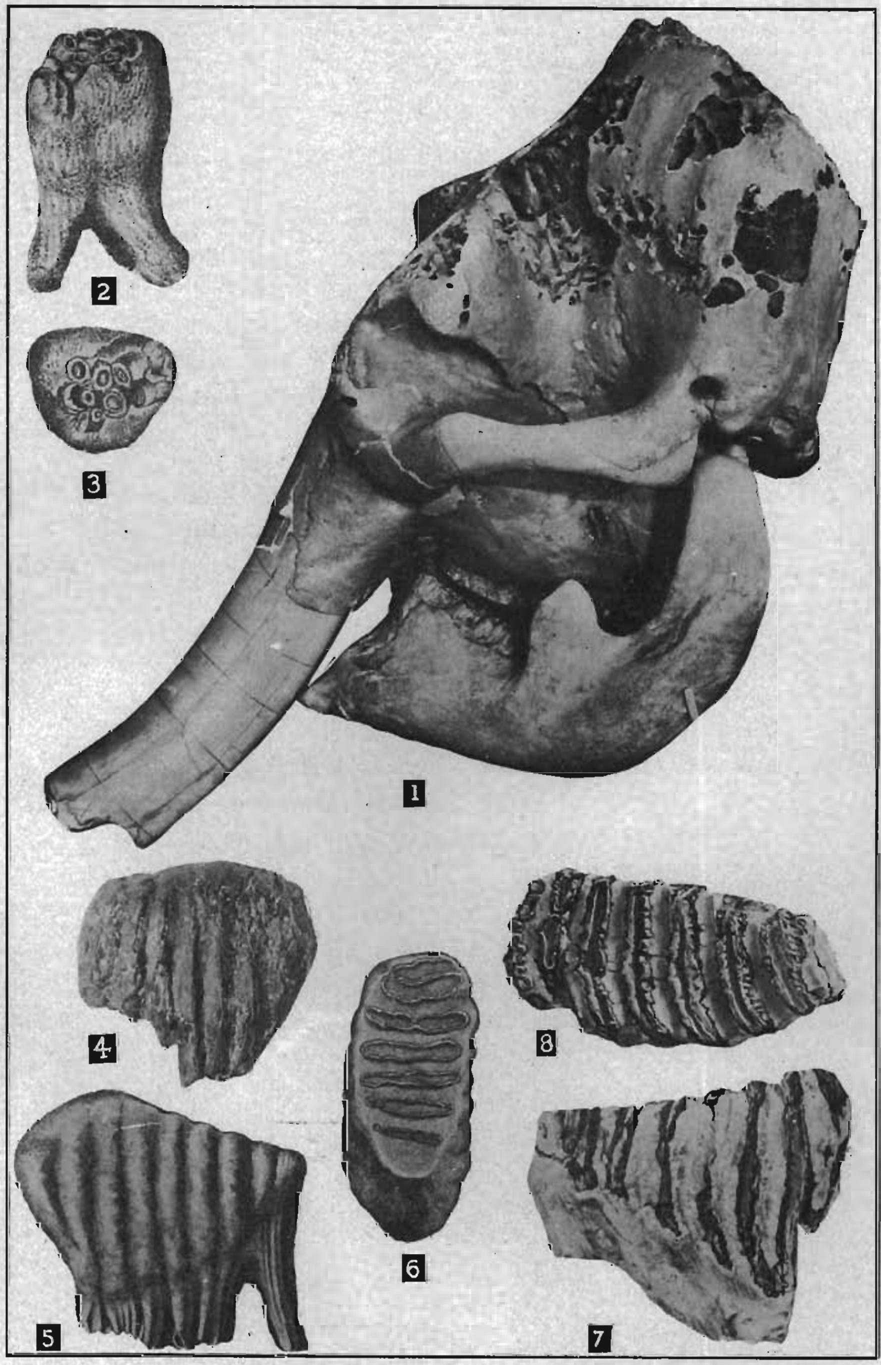
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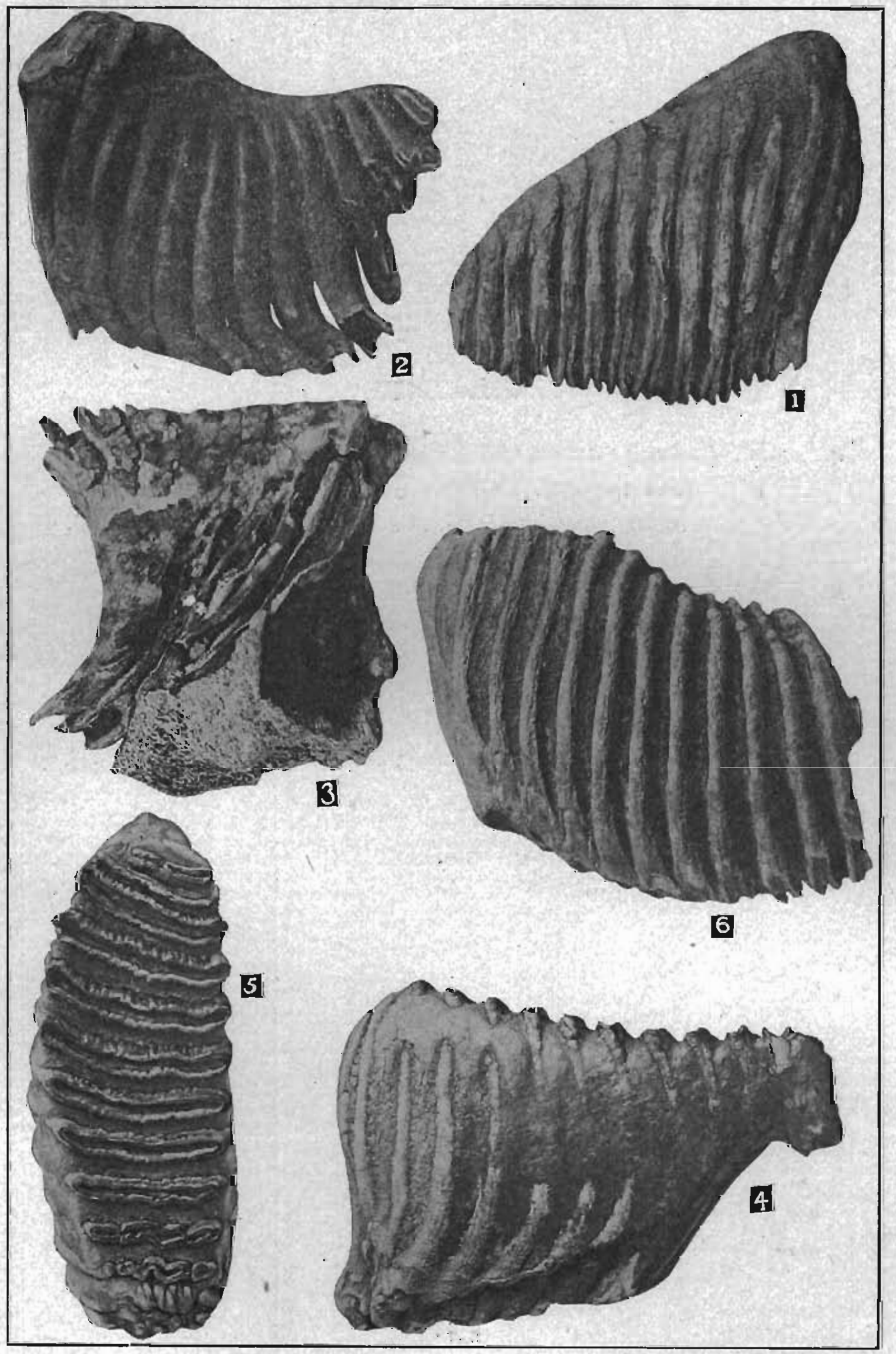

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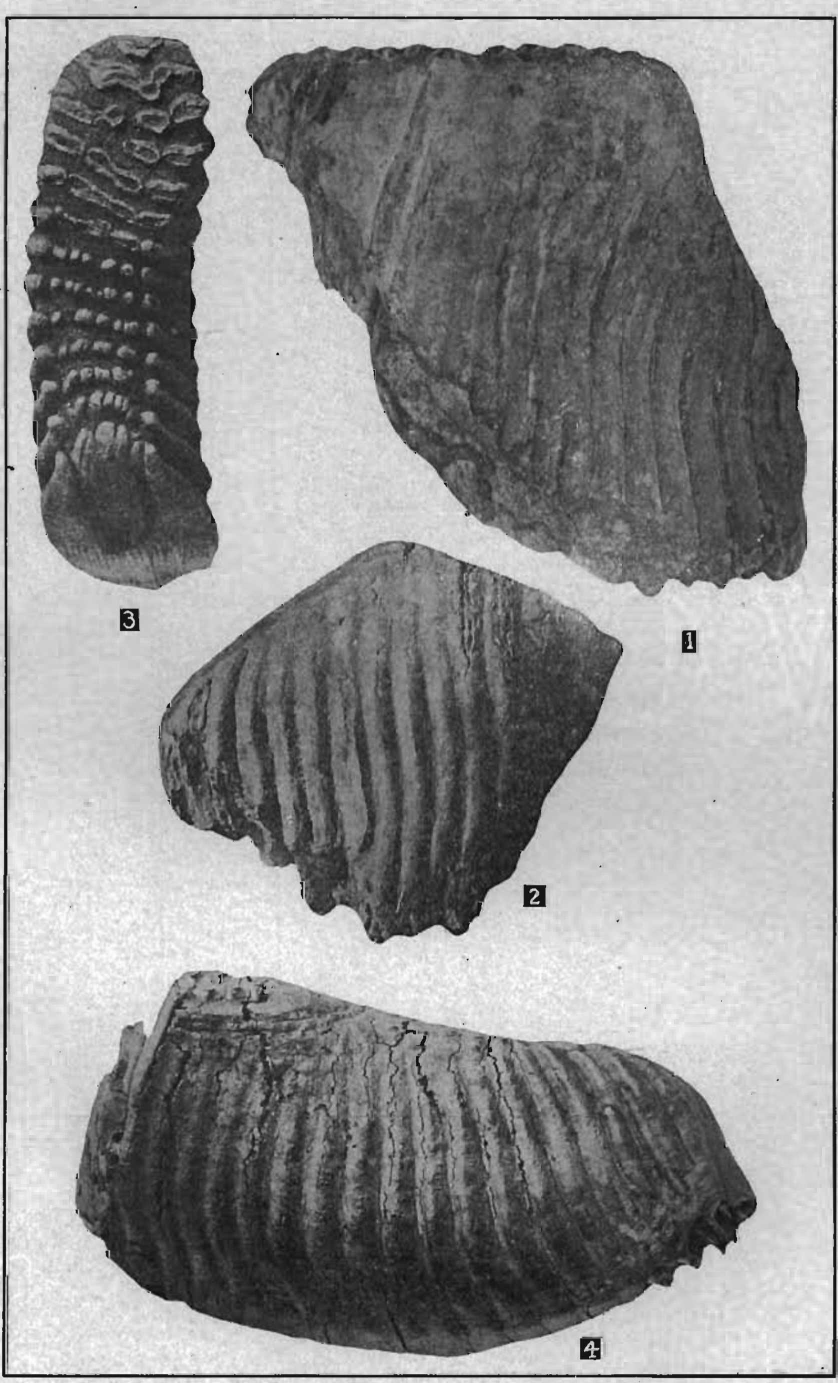
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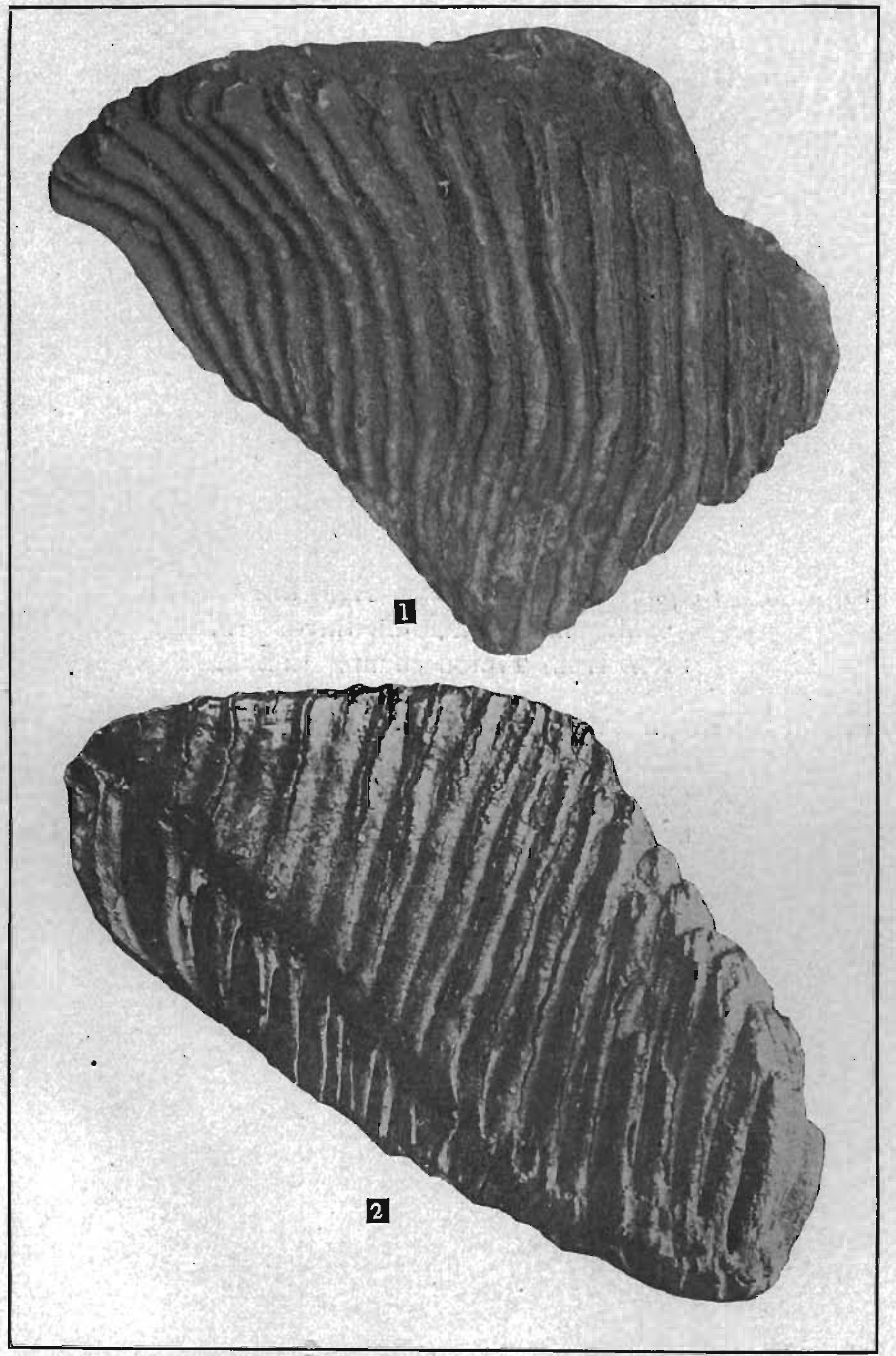
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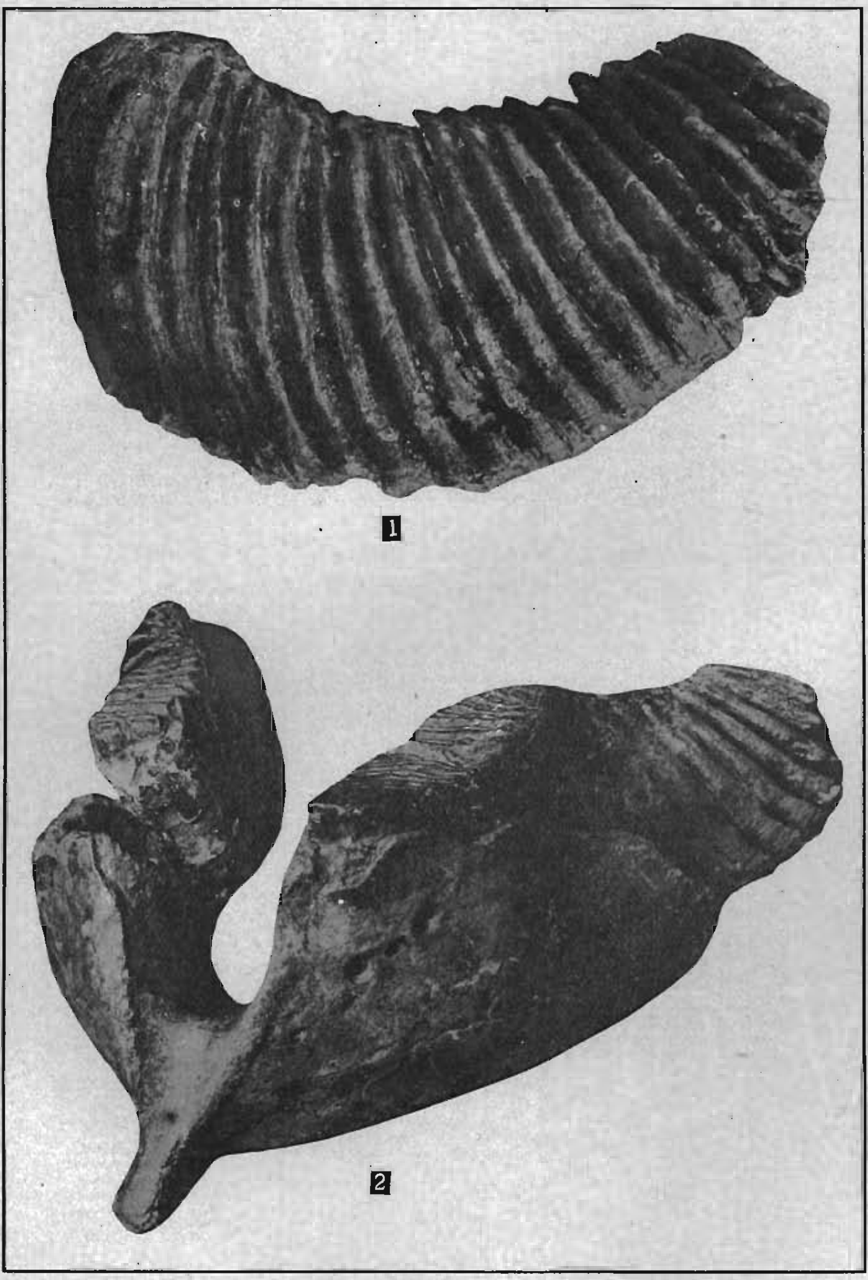
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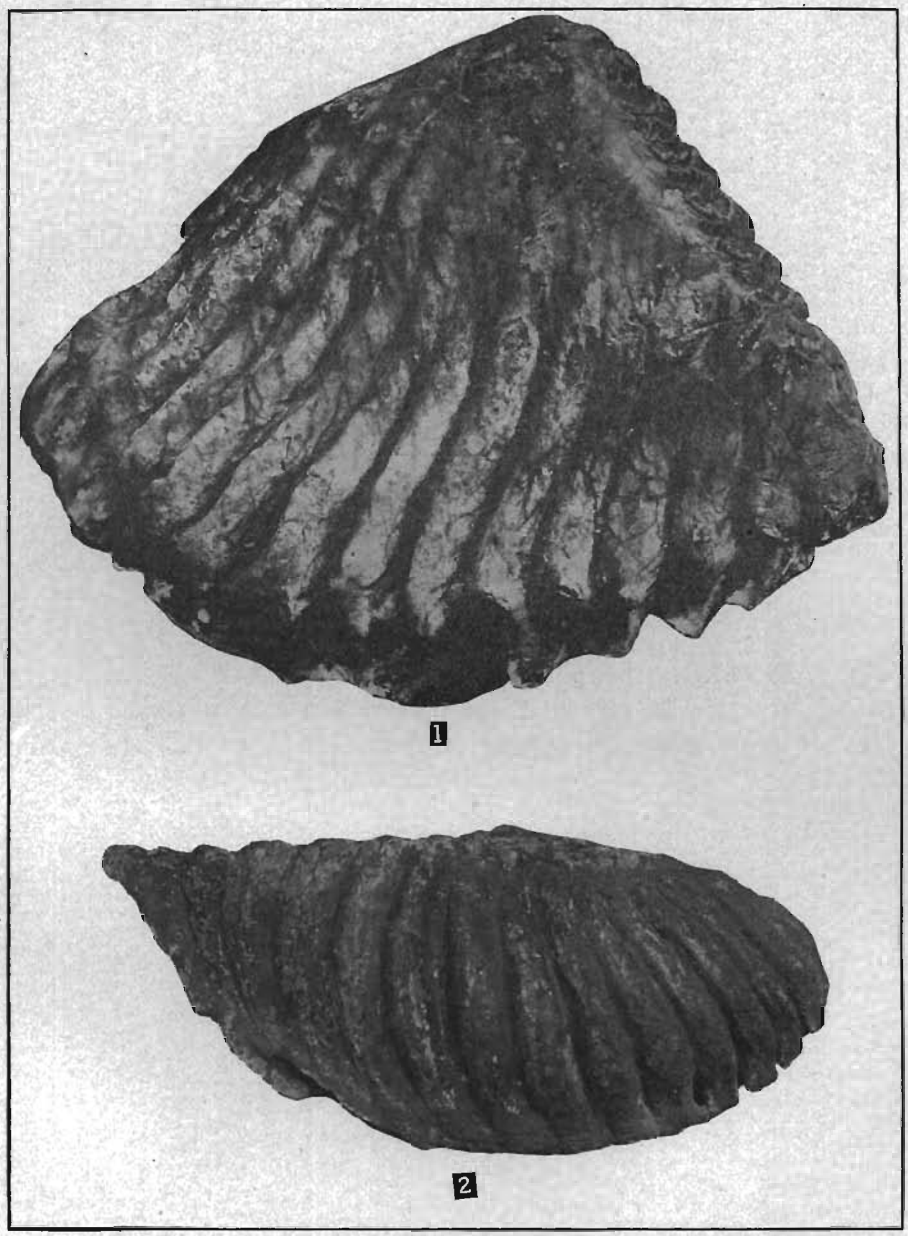
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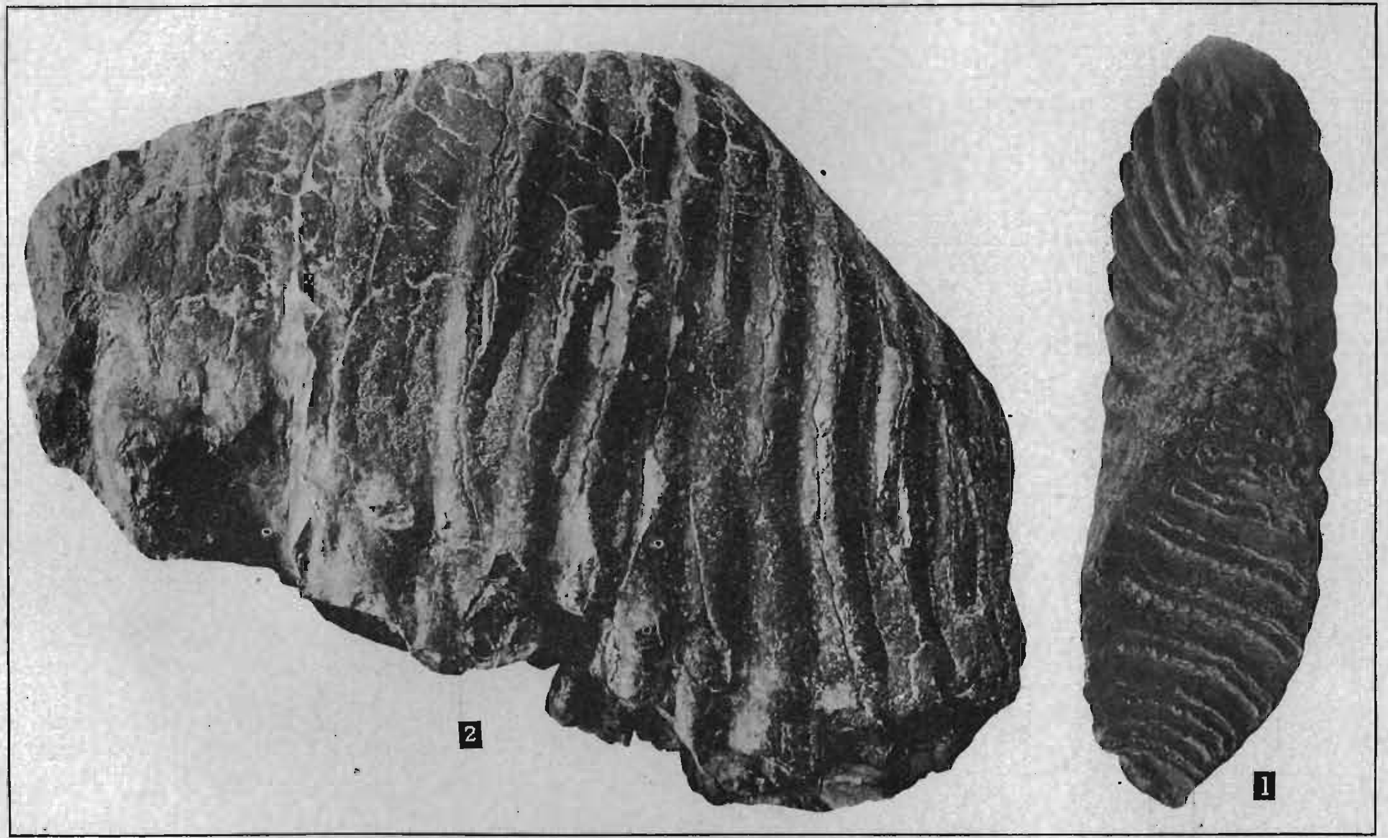
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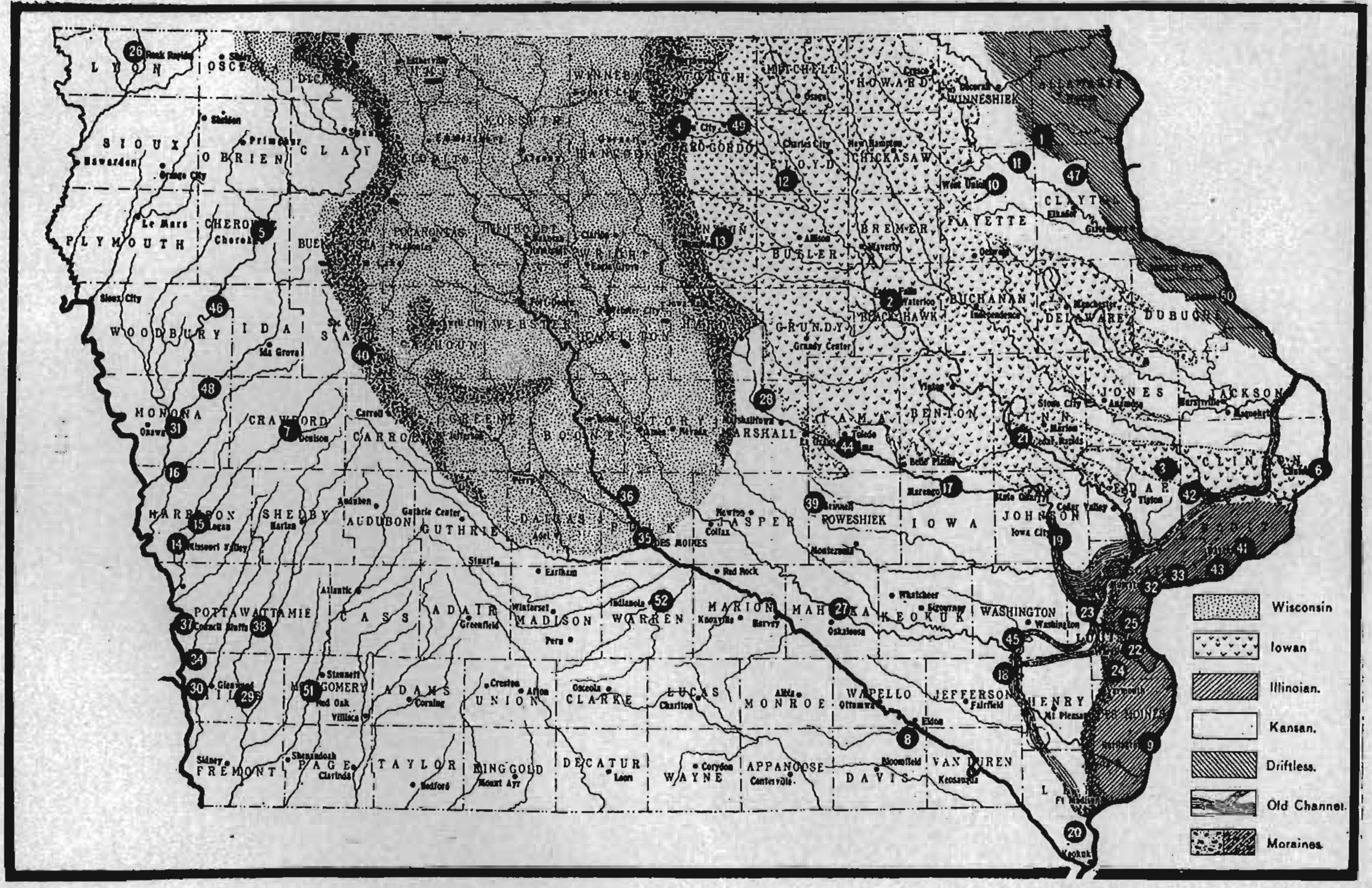
Wisconsin
Iowan
Illinoian.
Kansan.
Driftless.
Old Channel.
Moraines.

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4. Seen from front and somewhat below.
5. Seen from below.

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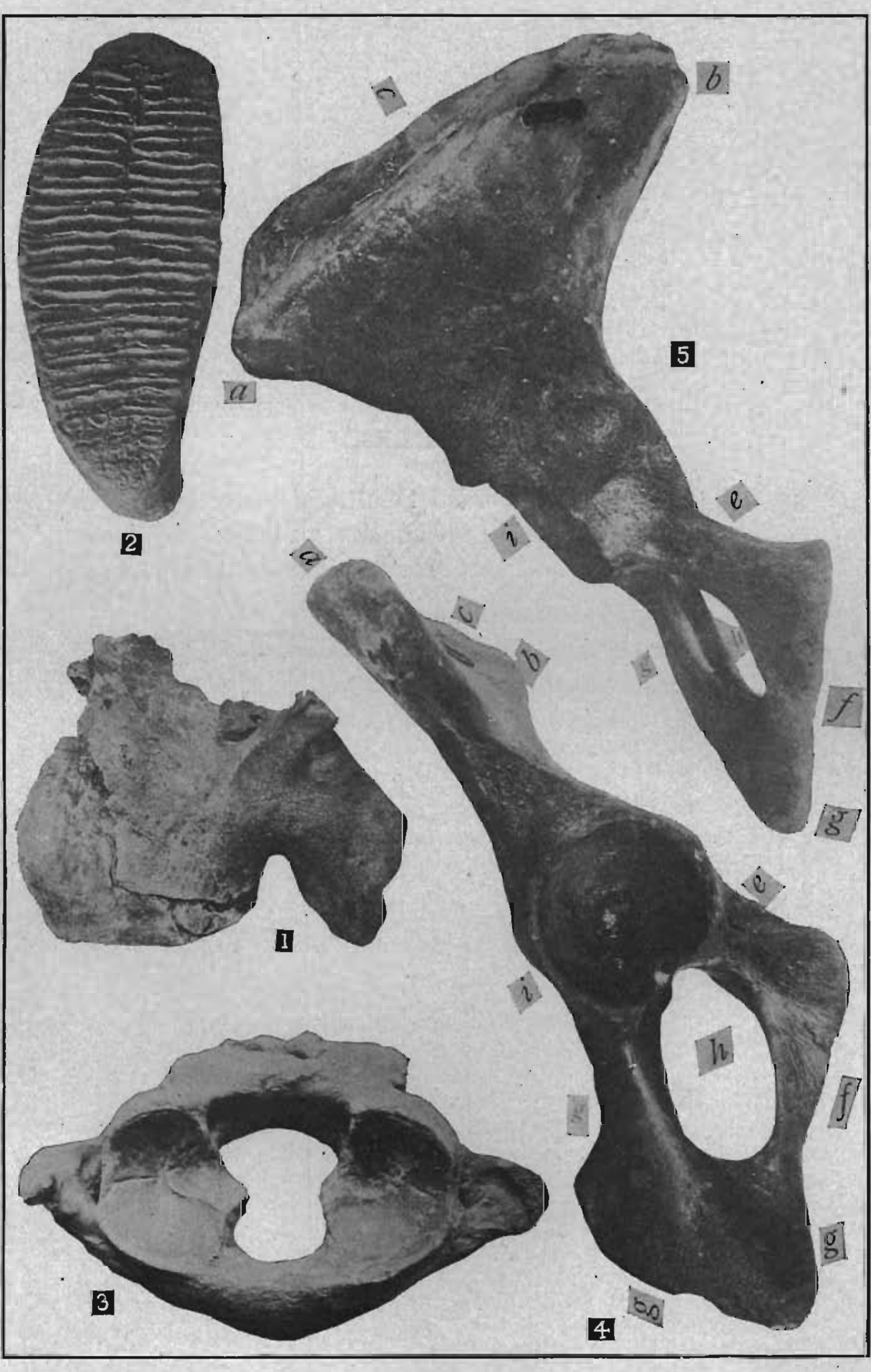
b. Angle which articulates with the sacrum.
c. Crest of the ilium.
e. Anterior border of the pubis.
f. Ischio-pubic symphysis.
g,g. Ischium.
h. Ischio-pubic foramen.
i. Acetabulum.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2. Lower jaw seen from the side.
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4. Lower jaw seen from above.

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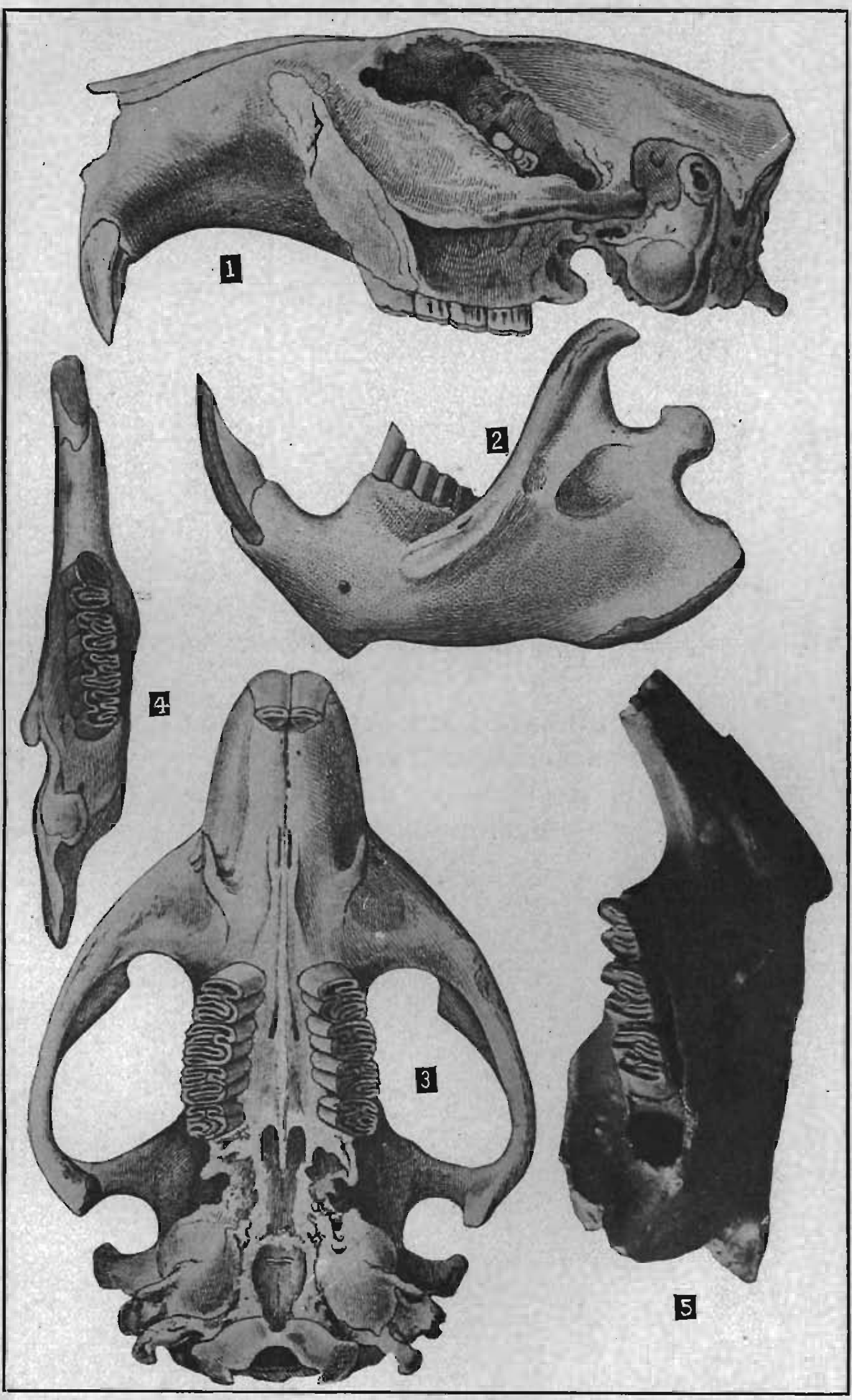
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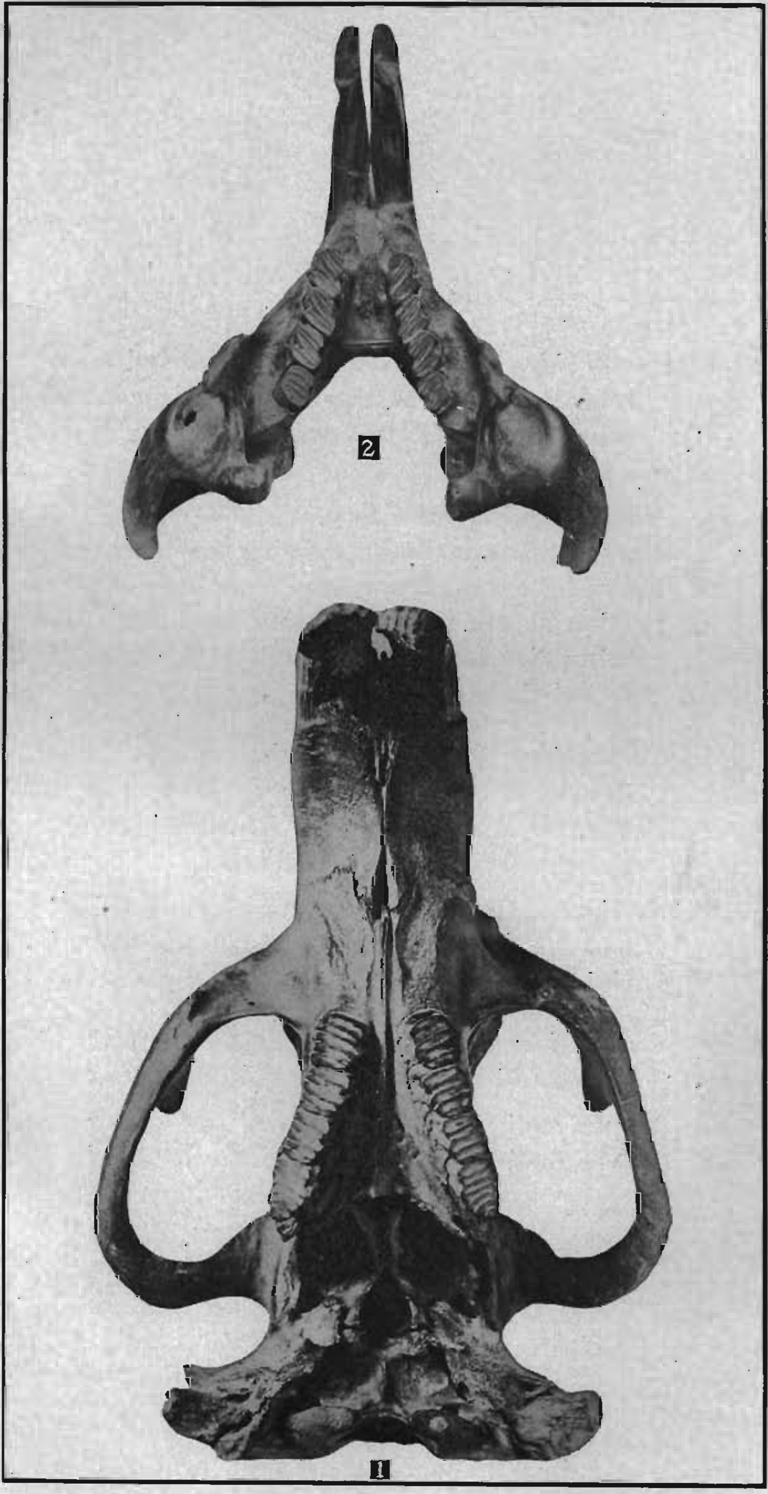
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2. Part of the same tooth, showing the inner face.
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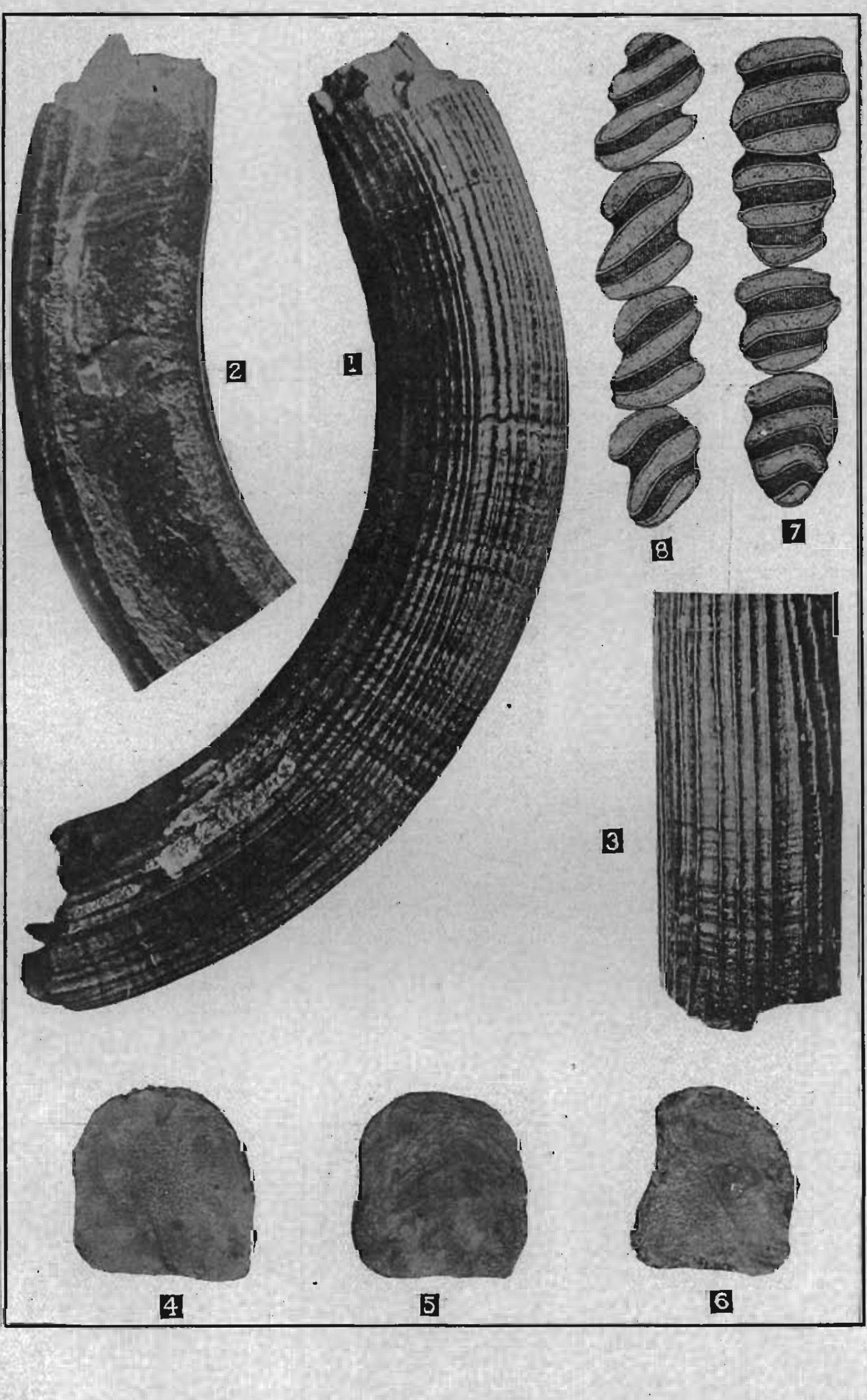

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6. Lower teeth.

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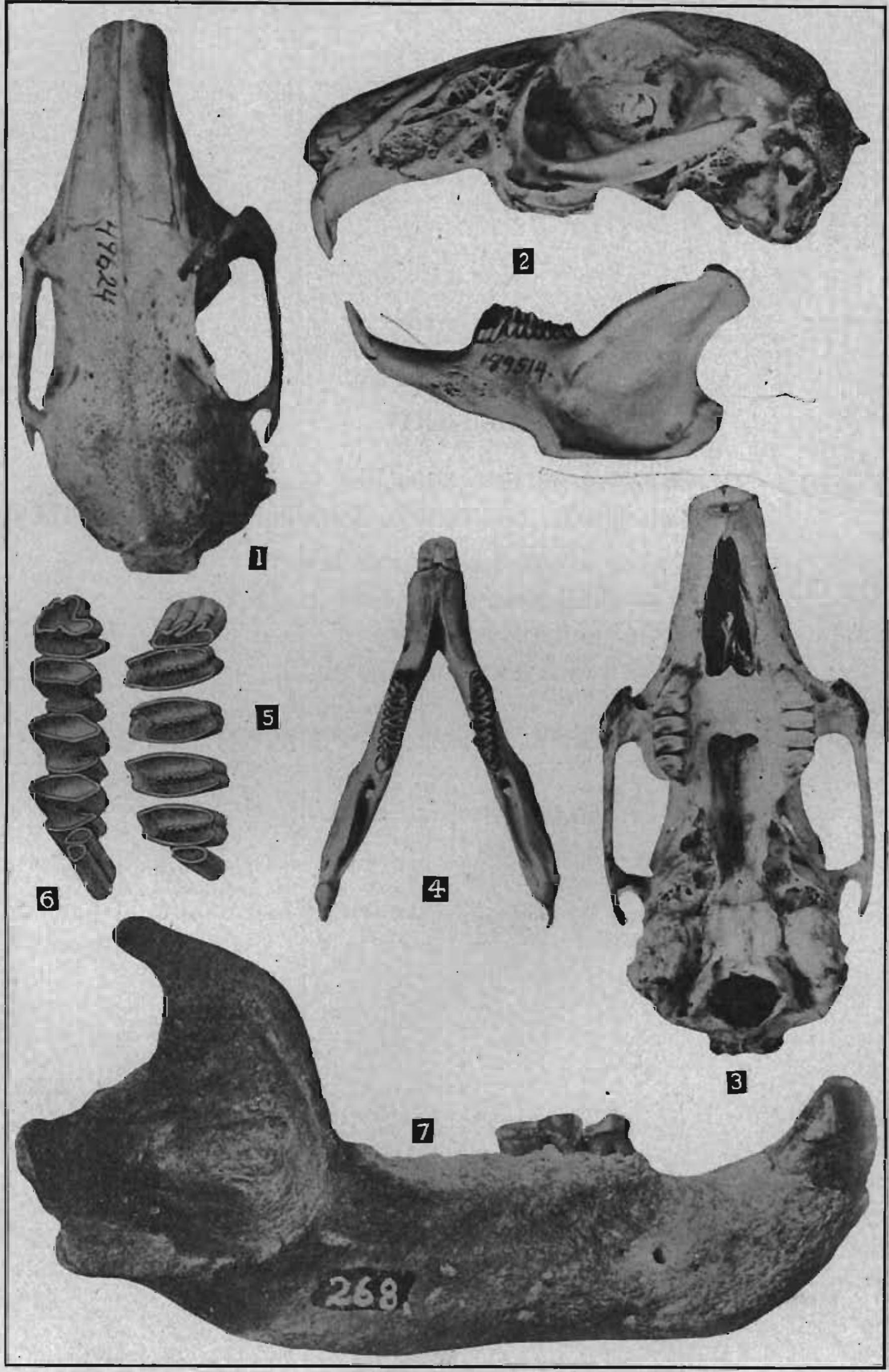
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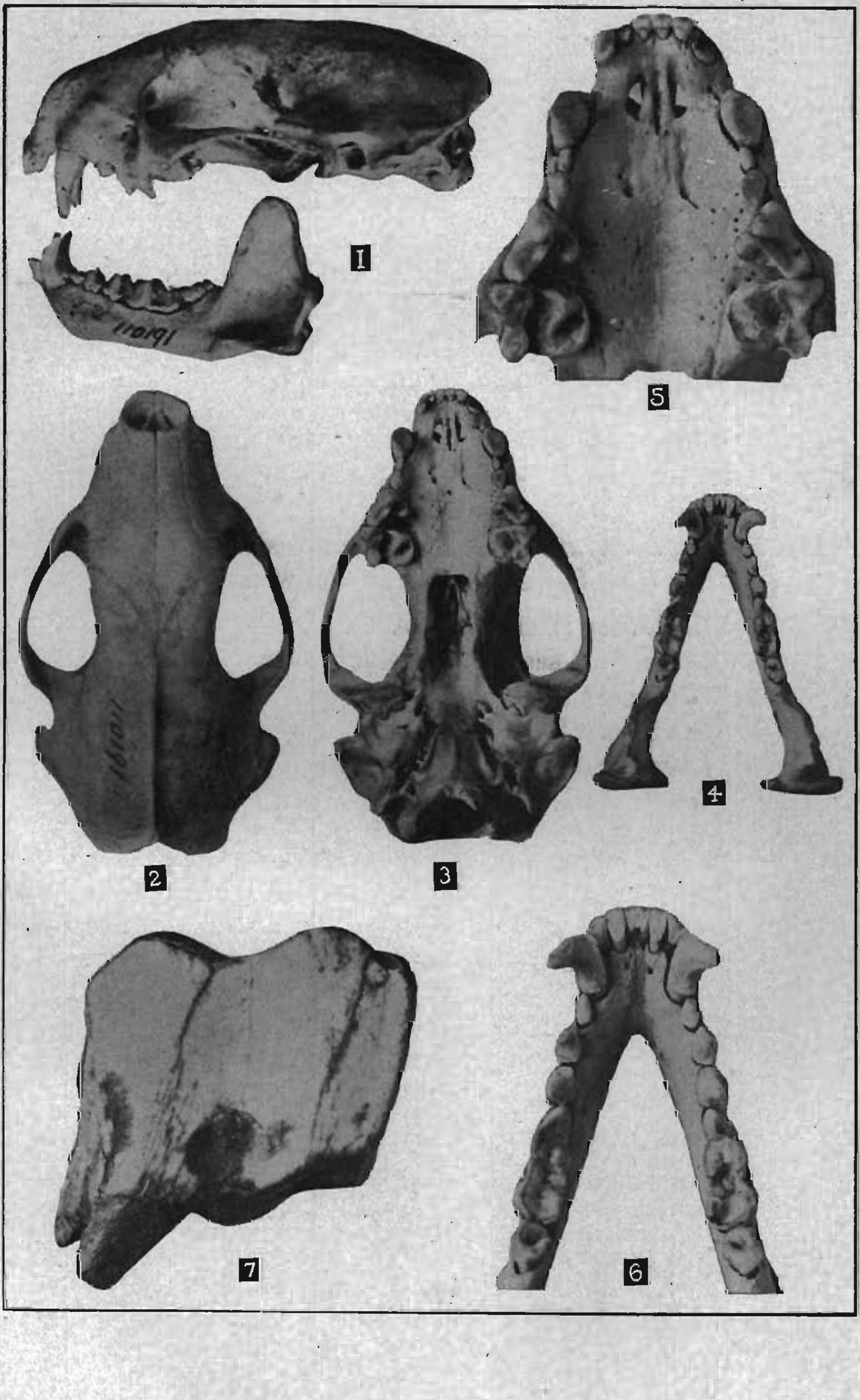
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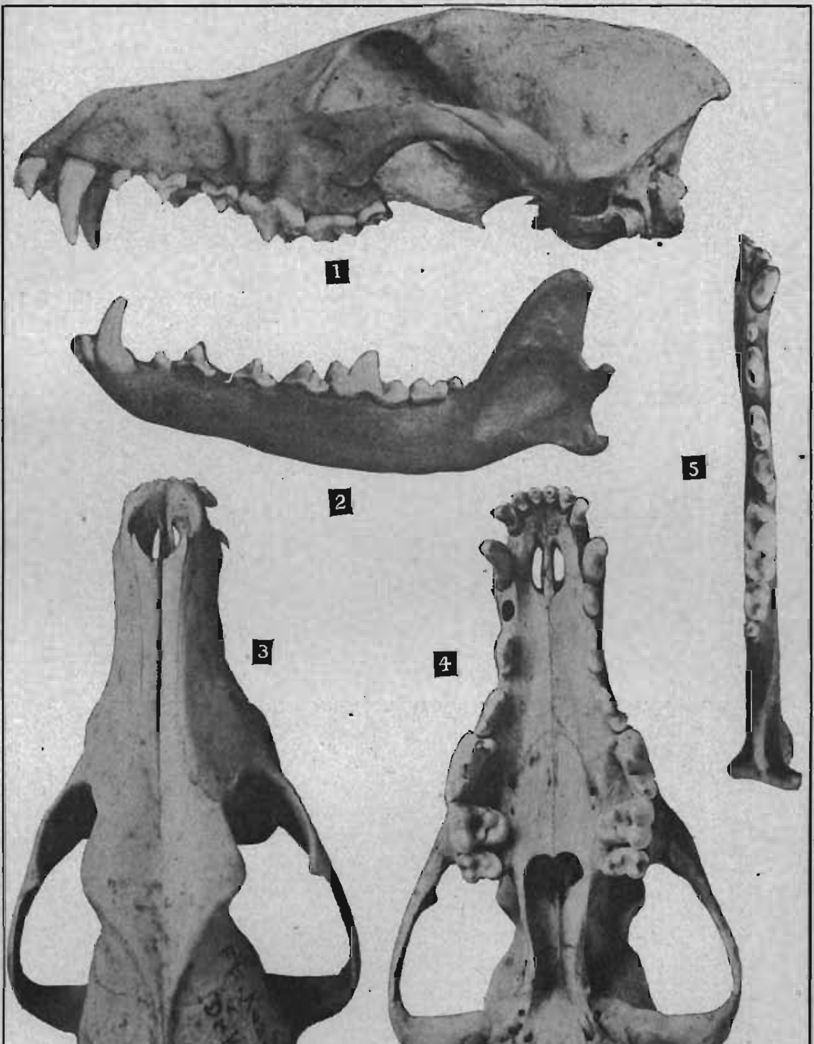
4. Skull seen from below.
5. Lower jaw seen from above.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