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VOL. VI.
PALEONTOLOGY.
PART II.
CARBONIFEROUS AND CRETACEOUS.

SAMUEL W. WILLISTON,
Paleontologist.



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Chancellor F. H. Snow,

Ex officio Director of the University Geological Survey:

SIR—I have the honor herewith to submit to you for your approval the second part of my report upon the Paleontology of Kansas, to constitute Volume VI of the University Geological Survey of Kansas. It is with great pleasure that I again acknowledge to you my appreciation of the uniform encouragement you have shown in the prosecution of the work.

Respectfully,

SAMUEL W. WILLISTON.

DEPARTMENT OF HISTORICAL GEOLOGY,
UNIVERSITY OF KANSAS, JUNE 1, 1900.

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PREFACE.

THE present volume on the paleontology of Kansas deals with the Carboniferous Invertebrates and the Cretaceous Fishes. The latter part has been made as complete as the present state of the collections and knowledge will permit; the part on the Carboniferous Invertebrates leaves yet several classes to be treated, but which, it is hoped, will find a place in the next or succeeding volumes of the series. The work on the fishes completes our present knowledge of the paleozoology of the Kansas Cretaceous, with the exception of that of the pterodactyls and plesiosaurs. It was the intention of the writer to make the discussion of these two groups of reptiles a part of the present volume, but the stress of duties in other directions has rendered this impossible; he can only hope to treat them fully in the early future.

It has been the aim to so treat the fossils of Kansas in the preceding and present volumes of this series that the work will be of immediate use to the people of Kansas. For this reason full descriptions and figures of every species have been given, so far as it is possible. Some of the descriptions and figures might have been omitted, giving merely a catalogue, of use only to the scientist, but such a plan would defeat the chief object intended—the preparation of manuals or texts for the use of the student in Kansas geology.

Messrs. Beede and Stewart, the authors of much the largest portion of the present volume, have been students and assistants in the paleontological laboratory of the University. While

their work has been done under general directions and advice, the merits or faults of their papers are their own. The zeal, intelligence and earnestness which they have devoted to the work will be sure to have produced valuable results. Doctor Beede, it is hoped, will be able in future papers to complete the review of the paleozoic invertebrates.

At the present time, Mr. E. H. Sellards, assistant in the department of paleontology, has well along a work on the paleozoic plants which, it is expected, will soon be published.

The writer desires to thank Mr. Sydney Prentice, who has made all the drawings of this volume, for the care and faithfulness he has given to the work.

SAMUEL W. WILLISTON.

PART I.

CARBONIFEROUS INVERTEBRATES.

By JOSHUA W. BEEDE.

Plates I to XXII.

A thesis presented to the Faculty
of the University of Kansas for the
degree of Doctor of Philosophy,
June, 1899.

INTRODUCTION.

FORAMINIFERA TO PELECYPODA, INCLUSIVE.

IN this report the terms Lower and Upper Coal Measures are only used relatively. The lowermost portion of the Coal Measures is referred to as the Lower Coal Measures, and the upper part as the Upper Coal Measures. As there is some controversy concerning the boundary lines between these two divisions, and as the material at hand is not of a decisive nature, no attempt is made to draw any sharp division line, if indeed one can be drawn otherwise than arbitrarily. The collections studied, covering the entire Coal Measures area in a very general way, show no very distinct faunal division between the upper and lower rocks of the Coal Measures. There are several species present in the lower portion of the rocks that are absent in the upper, but for the most part the species disappear gradually.

Cleiothyris roysii and *Chonetes mesoloba* are common to the lowermost strata only, and apparently below what is called the Erie limestone by the University geologists. Somewhat above this limestone *Lophophyllum westii* fades out, and in the Garnett limestone are found the last of *Productus cora americanus* and a wide variety of the same species, and also *Pleurotomaria missouriensis*. However, this is considerably above what is generally taken to be the limit of the Lower Coal Measures. For convenience, until a better and more complete study of the faunas can be made, the limestone known in the Kansas reports as the Erie limestone will be considered as the base of the Upper Coal Measures.

In almost all cases the labeling of the fossils herein described is not specific enough to tell whether or not they are from below this limestone; consequently, their exact position with refer-

ence to it can only be guessed at. Nevertheless, it is distinct enough to show that, in the Kansas area at least, there is no abrupt change in the faunas of the upper and lower parts of the Coal Measures, though the statement has been made that "the change in faunal features is striking."¹

The upper limits of the Coal Measures, as defined by Prosser, are followed in this report.

The fauna of the Coal Measures of Kansas presents some very interesting and important features. The vertical range of species is very great for both brachiopods and pelecypods. The fauna also seems to be a young one in some respects, though, as a whole, it is certainly that of the Coal Measures. There are several species ranging through it which are characteristic of the English Permian, some of them being even restricted to the lower portion. This would not be so very remarkable were they all brachiopods, but several of them are pelecypods.

For the area and thickness of the Coal Measures, the reader is referred to Volume III of these reports.

The writer wishes to gratefully acknowledge the kind assistance of Dr. S. W. Williston in many ways in the preparation of this report; also to thank Prof. Charles S. Prosser, of the University of Ohio, and Mr. Charles Schuchert, of the United States National Museum, for the loan of many valuable specimens and for offering many valuable suggestions and encouragement in the work. To Mr. Austin F. Rogers, of the University, much credit is due for assistance. The drawings for the illustrations accompanying this article were made by Mr. Sydney Prentice.

1. Keyes, *Amer. Geol.*, xxiii, p. 303, 1899 (May).

CLASSIFICATION OF FOSSILS

DESCRIBED IN REPORT.

KINGDOM.	SUB-KINGDOM.	Sub-branch.	CLASS.	ORDER.	Family.	Genus.
PROTOZOA.						
			RHIZOPODA.			
			FORAMINIFERA.....			
			Fusulinidæ.			
			<i>Fusulina.</i>			
			CÆLENTERATA.			
			Porifera.			
			SPONGIÆ.....			
			PHARETRONES.			
			<i>Somphospongia.</i>			
			SYCONES.			
			<i>Amblysiphonella.</i>			
			Cnidaria.			
			ANTHOZOA.....			
			Zaphrentidæ.			
			<i>Lophophyllum.</i>			
			Cyathophyllidæ.			
			<i>Campophyllum.</i>			
			<i>Axophyllum.</i>			
			Favositidæ.			
			<i>Michelinia.</i>			
			<i>Trachypora.</i>			
			Auloporidæ.			
			<i>Aulopora.</i>			
			<i>Cladochonus.</i>			
			Syringoporidæ.			
			<i>Syringopora.</i>			
			Chaetetidæ.			
			<i>Chaetetes.</i>			

CLASSIFICATION OF FOSSILS—Continued.

KINGDOM.	SUB- KINGDOM.	Sub-branch.	CLASS.	Sub-class.	ORDER.	SUB-ORDER.	Family.	Genus.

MOLLUSCOIDEA—continued.

BRACHIOPODA—continued.

TELOTREMATA.

Rhynchonellidæ.

Pugnax.

Terebratulidæ.

Dielasma.

Spiriferidæ.

*Spiriferina.**Spirifer.**Ambocælia.**Reticularia.*

Athyridæ.

*Hustedia.**Cleiothyris.**Seminula.*

MOLLUSCA.

PELECYPODA..... p. 107

ASIPHONIDA.

MONOMYARIA.

Anomiidæ.

Placunopsis.

Limidæ.

Lima.

Pectenidæ.

*Entolium.**Aviculopecten.*

Aviculidæ.

*Pteria.**Limopteria.**Pseudomonotis.**Posidonomya.*

Mytilidæ.

*Modiola.**Myalina.*

Pinnidæ.

*Aviculopinna**Pinna.*

CLASSIFICATION OF FOSSILS—Concluded.

KINGDOM.	{ SUB- KINGDOM.	Sub-branch.	CLASS.	Sub-class.	ORDER.	SUB-ORDER.	Family.	Genus.

MOLLUSCA—*continued.*PELECYPODA—*continued.*ASIPHONIDA—*continued.*

HOMOMYARIA.

Arcidæ.

*Macrodon.**Nuculana.*

Nuculidæ.

*Nucula.**Yoldia.*

Trigoniidæ.

Schizodus.

SIPHONIDA.

INTEGRIPALLIATA.

Solemyidæ.

Solenomya.

Astartidæ.

*Pleurophorus.**Astartella.*

Cardiidæ.

*Conocardium.**Cypricardinia.*

SINUPALLIATA.*

*Cardiomorpha.**Edmondia.**Allorisma.**Sedgwickia.**Chænomya.*

* Of uncertain position in this order.

DESCRIPTION OF FOSSILS.

FORAMINIFERA.

The foraminifera are an order of that class of animals known as rhizopods, the name meaning root-footed. The rhizopods are very minute animals, resembling, under the microscope, a mass of jelly full of little bubbles. They move about by pushing out portions of this jelly-like substance into thread-like protrusions, which may be absorbed back into the animal. This is how they get the name "root-footed." Food particles are taken into the body anywhere, as there is no mouth, and digested and the waste portions thrown out wherever they happen to be, as there are no digestive organs. The animal can best be understood as a minute bit of jelly-like substance, called sarcode, capable of motion and the assimilation of food. Some of these rhizopods have shells with minute holes in them through which the thread-like feet are protruded. These feet often interlace, forming a network about the animal. These animals are called foraminifera on account of the little holes in the shell. They live in both fresh and salt water, but are much more numerous in the oceans, where, minute as they are, their shells make up masses of deposits which become hardened into limestone and extend over vast areas.

The only foraminifera which have been made known from the rocks of eastern Kansas are those often called "petrified wheat." Their scientific name is *Fusulina secalica*, the latter name meaning a rye grain. They are very numerous; often layers of limestone from two to ten feet thick, made up almost entirely of these shells, extend across the state from north to south. For further information, the reader is referred to Mr. McClung's article in Volume IV of this Survey, entitled "Microscopic Organisms of the Upper Cretaceous," on page 415.

FUSULINA.

Fischer, Oryct. Moscou, p. 126, pl. XVIII, ff. 1-5, (1837).

Fusulina secalica. Plate I, figs. 1, 1b.*Miliolites secalicus* Say, Long's Exped., p. 151, foot-note, (1823).*Fusulina cylindrica* Fischer, *ibid.*, (1837); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 140, pl. I, f. 2; pl. II, f. 2; pl. V, f. 3; pl. VII, ff. 8a, b, (1872).

For further synonymy, see Weller, Bull. U. S. Geol. Surv., 153, p. 280, (1898).

Meek's description: "Shell small, fusiform or subcylindrical, more or less ventricose in the middle, somewhat obtusely pointed at the extremities, which generally have the appearance of being a little twisted. Surface smooth excepting the septal furrows, which are moderately distinct, more or less regular, and a little curved as they approach the extremities. Aperture apparently linear, and not visible as the specimens are generally found. Volutions 6 to 8, closely coiled, the spaces (near the middle) being rarely more than twice the thickness of the shell walls. Septa about 20 to 33 in the last or outer turn of adult specimens, counting around the middle; comparatively straight near the outer walls, but strongly undulated laterally within; foramina passing through the walls, moderately distinct in well-preserved specimens—as seen under a high magnifying power, in transverse sections near the middle of the shell, somewhat radiating, and numbering in the outer turn of a medium-sized specimen, from 12 to 20 between each two of the septa. Varying considerably in size and form."

Range and distribution: Very abundant throughout the Upper Coal Measures of the state.

There have been two species and three varieties of this little shell described from the rocks of the United States. These varieties were considered species by their author at one time and were later reduced to varieties by him. Nearly all the forms that have been described are found in the rocks of the state. They are: *Fusulina gracilis*, *robusta*, and *F. ventricosa* Meek, as well as *F. elongata* Shumard. In dividing these foraminifera into species, it is to be remembered the conditions for their growth were extremely favorable here during Carboniferous time, for

their skeletons make solid strata of limestone several feet in thickness, extending over vast areas. Under such conditions we always find a single species appearing in many forms, and consequently great care should be taken in separating them into species and varieties. So far as the external form and appearance of the Kansas *Fusulinas* are concerned, I think it will be impossible to divide the species, though a more careful study of the minute structure of the interior of large numbers of individuals may reveal certain constant variations worthy of varietal or even specific recognition. But even then, when the fact is taken into account that they are but simple undifferentiated animals, susceptible of such great variations from environment, great care would have to be taken in not making too many divisions of them.

Say's description of *Miliolites secalicus* is good enough, when the locality from which his specimens were taken is brought into account, so that it is practically impossible for it to be missapplied, and consequently that specific term, together with Fischer's generic designation, will stand.

SPONGIÆ.

The sponge is a rather loose collection of single cells variously grouped into one mass, forming a compound organism. The connection of the different cells with each other is slight. These cells are arranged in a series, so that canals are formed running through the sponge, the cells facing the canals. The inner canals are generally larger where they flow together for the water to flow out, and this enlargement is called a "cloaca." Water is kept flowing through the canals by means of rapidly moving cilia which some of the cells possess. These little whips also aid in the capture of particles of food, which are taken from the water as it flows through the canals.

The cells of the sponge are held together by horny, calcareous or flinty needles called spicules. The sponge of commerce, as we generally see it, is not the entire animal, but only its skeleton, made up of horny fibers so interlaced as to form a network.

The larger holes in it indicate where the larger canals were located. In most of the fossil sponges these fibers of the skeleton were made of lime or flint, and are known as calcisponges and silicisponges, respectively. The spicules are often compound and possess several points. Some are simple, like a needle pointed at each end; some have three points, some four, and some six; some are anchor-shaped and some are dagger-shaped.

Most sponges are attached to rocks or other objects during their life, but some are free. They inhabit both fresh and salt water, but are, for the most part, found in the sea, in moderately shallow water. The only fossil sponges known from the Kansas rocks are calcisponges in which the spicules are rarely preserved.

SOMPHOSPONGIA.

Beede, Kans. Univ. Quart., VIII, p. 128, (1899).

A globular to mushroom-shaped calcisponge, attaining a large size, and generally possessing a more or less spherical-shaped cloaca near the base; the canals are all very irregular and crooked, distributed over the entire surface, and moderately large. A rather thick dermal layer is present. They were free, apparently resting with the base in the mud in the adult stage.

Somphospongia multiformis. Plate I, figs. 6-10; plate II, figs. 1-5.

Somphospongia multiformis Beede, Kans. Univ. Quart., VIII, p. 128, pl. xxxiii, ff. 1-10, (1899).

A small to very large sponge, varying in form from globular to mushroom-shaped, free, and gregarious. Connecting with the cloaca there is an irregular, branching canal system, which communicates with the exterior over the whole surface, though in large individuals they are smaller and probably nearly useless at the base. These canals are very irregular in shape, and, when viewed on the surface, appear to be labyrinthine; they become smaller and less numerous as they proceed inward toward the cloaca. When not worn the entire sponge is covered with a moderately thick dermal layer, the folds in which form the walls of the canals. There is no sign of attachment in any of our specimens, and the young ones seem to have rolled about

until they had gained some considerable size, as the pores are about equally developed all over them; they are somewhat globular in form. Where they were abundant, as is generally the case wherever they are found, they soon come in contact with each other and form a solid mass, sometimes appearing to coalesce, but generally in breaking they part along the line of contact, and neither specimen seems to be ruptured. As yet spicules have not been positively made out. There are no siliceous spicules, and several thin sections have failed to show any calcareous ones. The absence of siliceous spicules and chert in the specimens, and the absence of chert in the rock, makes it practically certain that they are calcareous sponges. There is on weathered specimens, where the dermal layer has been removed, a peculiar, more or less haphazard arrangement of pits, surrounded by elevations, which is probably caused by an internal calcareous skeleton, composed of fused spicules. The different individuals of this species vary from half an inch to a foot in diameter, but seldom are more than six inches high.

They are found in abundance in the northwestern part of Atchison, in western Doniphan and eastern Brown counties. It is not uncommon to find them making up a stratum of limestone six inches thick. They are confined to a single narrow horizon in the Burlingame shales.

The cloaca is generally filled with limestone, which, except at the center, is arranged in concentric layers as it was filtered in, giving the cloaca and the parts immediately surrounding it much the appearance of a concretion.

The sponge evidently belongs to the *Pharetrones*, and appears most closely related to *Corynella* and *Stellispongia*. It differs from the former in not having the cloaca funnel-shaped, and the fact that the cloaca does not terminate below in vertical branching tubes any more than it does above, and possesses no distinct exhalent aperture. It is much more closely related to the latter, but is simple, and appears quite different in its spicules, while the cloaca is confined to the base.

AMBLYSIPHONELLA.

Amblysiphonella prosseri. Plate I, figs. 2-2f; plate II, fig. 6.

Amblysiphonella prosseri Clarke, Amer. Geol., xx, p. 387, pl. xxiii, ff. 1-9, (1897).

Clarke's description: "The bodies from Netawaka and Weeping Water are simple subcylindrical individuals, straight or gently curved, the largest fragment measuring 70 mm., and indicating an entire length of not exceeding 100 mm. The fossils are from a calcareous shale and have, for the most part, been somewhat compressed. Their interior cavities, the cloaca and interseptal chambers, are filled with compact gray limestone, distinctly and fine oolitic, and their exteriors are frequently entangled with encrusting Bryozoa and the remains of other fossils. The septate or annulate aspect of the exterior is always shown, and when this external surface is free from other organic remains and cleansed from the attached matrix, it presents the aspect of a *Fistulipora* or of a small-celled *Alveolites*; that is, the meshwork of the skeleton is made up of polygonal cells, all of a small size, not always opening directly outward, but in places frequently presenting oblique apertures. So fine is this superficial network, and so uniform the size of the cells, that one might casually interpret the entire fossil as a macerated *Orthoceras*, overgrown with an encrusting bryozoan.

"One of the specimens is preserved with its aperture entire, which shows it to have been a simple, narrow, circular cavity. On cutting these bodies along their longer axis, we observe, first, a continuous central cloaca, relatively much wider than would be the siphon of an orthoceran of the same size, but slightly constricted at intervals, where its walls meet the septa. This cloaca is delimited by a well-defined circular wall, and thus has no communication with the septal chambers or the cavities of the annuli, except through the perforations in this wall. The septa are at quite regular intervals and are convex upward. On the gastral surface they project slightly inward, as observed, into the cloaca. Each of these septa presents a former apertural surface, and the sponge affords, thus, an interesting instance of periodical intensity of growth force. The walls of the sponge

thus exposed in section are very thin, approximately uniform in this respect, and are all perforated with straight, simple, relatively large canals. Those traversing the gastral walls (exhalent pores) are larger than the rest and appear to be of uniform size. The canals perforating the septal (that is, apertural) and exterior walls are inhalent pores, and, with this necessary interpretation, the septal cavities may properly be regarded either as chambers for the accumulation and discharge into the cloaca, or as true ciliary chambers. We find that, for the most part, these skeletal walls have been, perhaps by secondary changes, converted into crystalline calcite, and this change has obliterated the spicular structure, and in some places the perforate structure of the walls. Elsewhere, especially on the external walls, there has often been a deposit of adventitious calcite which, in sections, gives the wall an unusual thickness. It is to be noted that there is no breach in the continuity of the external wall of any given annulation. The septal or enclosed portions of the wall do not meet the outer or exposed part as they meet the gastral wall, but the entire external wall is arched from the peripheral base of the chamber beneath to the apertural margin of the cloaca." Thin vesicular tissue often extends from the gastral to the dermal wall and sometimes between each other.

Range and distribution: Upper Coal Measures; Thayer, Topeka.

I have a single specimen of this species from the Topeka limestone. It agrees very well in all respects with the specimens figured by Clarke. The smaller end was broken away before fossilization, making it appear to have the aperture at the smaller end of the specimen, and the septa sag downward instead of curve upward. There are several specimens probably of this species from Thayer, which are too poorly preserved interiorly to determine specifically, but the exterior resembles very much this species, to which it is referred. Associated with the above, at Thayer, is a smaller variety, very much more constricted at the juncture of the septa and the outer wall, giving it very much the appearance of a row of large beads set

together. It has a very different external aspect from the specimens of the form above mentioned from the same place, and is probably a different species, but until specimens can be secured showing the internal characters, it is referred provisionally to this species.

ANTHOZOA.

Corals are exclusively marine animals. The reef-building corals are found in comparatively shallow water, while some other forms are found as deep as 1500 fathoms. The corals here treated are all closely related to the reef-building forms, and consequently indicate that the rocks in which they were formed were laid down in shallow water. The coral is an animal with a distinct digestive sac and body cavity. There are three layers of the body walls—the outer layer or ectoderm, the middle layer or mesoderm, and the inner layer or endoderm. The hard parts or skeleton are deposited by the inner layer between the inner layer and the middle layer. This hard part forms a complete layer around the lower part of the animal beneath the skin. There are thin walls of the hard part projecting inward in the folds of the mesentery. These walls are called septa. There are often cross-plates or table-like platforms across the lower part of the hard parts extending clear across the body; these are called tabulæ. Around the mouth of the polyp, as the animal is called, there is a row of tentacles, or feelers, which are used to create currents of water and assist in securing food.

Corals very often increase by budding; that is, by a little bud-like projection growing out of one side of a coral and in a



FIG. 1. Transverse section of a simple coral (after Nicholson). *s*, septum; *c*, columella.

short time becoming a polyp exactly like the first and connected with it. In a little while such a coral will form a cluster. Some kinds bud much more abundantly than others, when the cluster becomes a solid mass and is called a compound coral.

At Fort Scott there is a large limestone stratum almost entirely made up of a coral called *Chætetes milleporaceus*. At the time when the corals were living it was a small coral reef. The other fossil corals in Kansas are much more rare, though large masses of two other families are often found.

LOPHOPHYLLUM.

Milne-Edwards and Haime, Brit. Foss. Corals, pl. LXVI, (1850).

Lophophyllum profundum. Plate II, figs. 7-7b.

Cyathaxonia profunda Milne-Edwards and Haime, Mon. des Polyp. Foss., p. 323, (1851); etc.

Cyathaxonia prolifera McChesney, Descr. New Pal. Foss., p. 75, (1860); *ibid.*, pl. II, ff. 1-3, (1865); etc.

Lophophyllum proliferum Meek, U. S. Geol. Surv. Neb., p. 149, pl. v, ff. 4a, b, (1872); etc.

Lophophyllum profunda Foerste, Bull. Den. Univ., III, p. 136, (1888); Worthen, Geol. Surv. Ill., VIII, p. 79, pl. x, ff. 14, 14a, (1890).

Meek's description, in part: "Corallum elongate-conical, more or less curved, or sometimes nearly straight, tapering to a pointed base; epitheca very thin, with more or less distinct encircling wrinkles and striæ of growth, crossed by longitudinal striæ; rarely sending off a few spines near the base. Calice nearly, or quite circular, moderately deep; columella prominent, compact in texture, compressed above, with its longer axis coincident with the general curve of the corallum; septa from about 30 to 50, every alternate one being generally considerably shorter than the others, which latter are extended to the columella, near which they are sometimes a little tortuous." Columella formed by the enlarged prolongation of one of the septa; tabulæ moderately remote, arching from the columella outward and downward, sometimes a little upwards at first. Septa striated obliquely upward. Columella striated by somewhat revolving longitudinal striæ. Measurements: Length, 30 mm.; width of calyx, 9 mm.

Range and distribution: Upper and Lower Coal Measures;

Fort Scott, Marmaton, Bourbon county, Thayer, Olathe, Kansas City, Lawrence, Lecompton, Topeka, McFarland, Grand Summit. Common throughout the Coal Measures.

In young specimens, the septa, except the cardinal, do not reach quite to the columella.

Lophophyllum westi. Plate II, figs. 8, 8b; plate III, fig. 12.

Amplexus westi Beede, Kans. Univ. Quart., VII, p. 17, (1898).

Corallum simple, subcylindrical to attenuate-conical, straight, curved or geniculated, epitheca thin, longitudinal striæ prominent, and concentric lines and undulations of growth distinct. The septa extend about half the distance to the center, 18 to 24 or more in number; the counterseptum extends to the center, where it is somewhat enlarged; others of about equal length; indications of secondary septa visible but very small. The tabulæ are well developed 1 to 3 millimeters distant and reaching from wall to wall; on leaving the walls they are directed obliquely upward for a short distance, and then, slightly arching and undulating, cross the center, occasionally branching at or near the bend. Length, 60 mm.; diameter in larger part, 9 mm.

Range and distribution: Upper Coal Measures; Kansas City, Lecompton, Neosho county.

This species is very variable in size and shape as well as degree of development of the septa. It was at first referred to the genus *Amplexus*, as it seemed to have no columella, but more material showed that many of the specimens had the cardinal septum prolonged to or beyond the center and slightly enlarged, which seems to make it agree more closely with *Lophophyllum* than *Amplexus*. That the species is intermediate between the two genera there can be but little doubt, as different specimens of the same species seem to possess the characters of each genus about equally.

It is the fossil usually identified by collectors as *Cyathaxonia distorta* Worthen, and indeed there is no external difference visible (judging from Worthen's figures) in the smaller, more distorted forms. But if his species is a true *Cyathaxonia* it is

of course specifically distinct from our coral. I have been unable to secure specimens of Worthen's species for comparison, and in his description he does not mention the generic characters nor does he figure the interior of the specimen so as to show whether or not it had any tabulæ. If it turns out to be a *Lophophyllum*, his name will, of course, have priority.

CAMPOPHYLLUM.

Milne-Edwards and Haime, Brit. Foss. Corals, pl. LXVIII, (1850).

Campophyllum torquium. Plate IV, fig. 1; plate V, figs. 1-4.

Cyathophyllum (vermiculare?) Owen, Geol. Rep. Wis., Iowa, and Minn., tab. iv, fig. 3, (1852).

Cyathophyllum torquium Owen, ibid., tab. iv, f. 2.

Cyathophyllum flexuosum (?) Owen, ibid., tab. iv, ff. 3a, b.

Campophyllum torquium Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 145, pl. 1, ff. 1a-d, (1872); etc.

Meek's description, in part: "Corallum simple, attaining a rather large size, elongate conical, and often geniculated or bent when two or three inches in length, but becoming nearly straight, subcylindrical and considerably elongated in the larger half of adult individuals. Epitheca thin, with small encircling wrinkles and strong undulations of growth, showing no traces of septal costæ when unabraded, but, where even slightly worn, exposing the regularly disposed septa and thin intervening dissepiments distinctly. Calice circular or slightly oval, comparatively shallow, with thin margins, from which it slopes rather steeply inward for some distance and then descends very abruptly into a deeper, narrow, central depression; provided at the outside of the general curve of the corallum with a moderately distinct septal fossula, formed by the shortening of one of the primary septa, and the bending down of the tabulæ at that point. Principal septa from 30 to 48, extending from about one-half to two-thirds the distance from the exterior toward the center, stout and usually straight inside of the outer vesicular zone, but becoming distinctly more attenuated (as seen in transverse sections) and somewhat curved or a little flexuous in crossing the vesicular area, where they alternate with an equal number of very short, thin ones; tabulæ very wide, or occupying about two-thirds the entire breadth, as seen

in longitudinal sections, and passing nearly horizontally across with a more or less upward arching; dissepiments thin and forming numerous obliquely ascending, small vesicles, in transverse sections seen to pass across between the costæ with an upward curve. Entire length unknown."

In young specimens the cardinal septum and all the other septa on that side of the corallum are very greatly developed laterally after passing inward from the vesicular zone; the inner wall of the vesicular zone is also thickened on that side of the corallum. As a result of this great thickening of the septa the interspaces are small, producing a peculiar appearance in cross-section. The septal development becomes less and less marked as the specimen advances in age, until in old specimens it is hardly noticeable, save in the cardinal septum, though a close comparison generally shows them a little larger on the outside of the general curve. These peculiarities may be seen by sectioning the large and small ends of any adult specimen. The thickness of the dissepimental zone and also the number of tabular dissepiments are very variable. The young specimens are either rather slender or quite turbinate.

Range and distribution: Kansas City, Jefferson, Douglas and Chautauqua counties.

Some specimens in the University Museum are about nine inches long and apparently incomplete at both ends. Such specimens are usually a little crooked through the entire length.

AXOPHYLLUM.

Milne-Edwards and Haime, Brit. Foss. Corals, pl. XXI, (1850).

Axophyllum rudis. Plate II, figs. 9-9c.

Axophyllum rudis White and St. John, Trans. Chic. Acad. Sci., i, p. 115, (1867); Meek and Worthen, Geol. Surv. Ill., vi, p. 525, pl. xxxii, ff. 6a, b, (1875); White, 13th Ann. Rep. St. Geol. Ind., pt. 2, p. 118, pl. xxiii, ff. 8, 9, (1883); Keyes, Geol. Surv. Mo., iv, p. 107, pl. xii, ff. 5a, b, (1894).

Corallum simple, occasionally clustered by gemmation at the base, turbinate, curved or geniculated, generally attached at the base or side. The outer portion of the calyx is shallow and the central portion is rather deep; pseudocolumella flattened, moderately prominent, and approaching subquadrate when seen

in a section below the calyx. The septa are alternately equal, the larger nearly or quite joining the pseudocolumella. Surface marked by irregular concentric wrinkles; spines or rootlets are sometimes present; septal furrows moderately distinct.

Range and distribution: Upper Coal Measures; Kansas City, Lawrence, Osage, Cowley and Elk counties.

This coral tapers very rapidly from the calyx to the apex, being about as broad as long.

MICHELINIA.

de Koninck, Descr. Anim. Foss. Belg., p. 29, (1842).

Michelinia eugeneæ. Plate II, figs. 12-12b.

Michelinia eugeneæ White, 13th Rep. St. Geol. Ind., 1883, pt. II, p. 119; pl. XXIII, ff. 14-16, (1884).

Original description: "Corallum usually in the form of a small globular or irregularly ovoid mass, higher than broad, with the corallites usually opening upon all sides, except its very small base, which is often concave and irregular; corallites small, but very irregular in size and shape; calyces moderately deep, their walls rather thin and margins narrow or even sharp. Height on one of the larger masses in the collection, 26 mm.; diameter of the same, 17 mm. Diameter of the larger calyces, 3 mm.; of the smaller ones, 1 mm."

Range and distribution: Upper Coal Measures; Pomeroy, Wyandotte county, Kansas.

He also remarks that "usually the calyces cover the whole outer surface of the corallum except the small base, which was evidently attached to some foreign body; but occasionally a considerable surface above the base is free from calyces, and is covered with a wrinkled epitheca." It may be interesting to note that we have younger masses of but few corallites, one of which is attached to a crinoid stem.

TRACHYPORA.

Milne-Edwards and Haime, Pol. Foss. d. Terr. Pal., p. 305, (1851).

Trachypora austini. Plate V, fig. 8; plate VI, figs. 7-7b.

Trachypora austini Worthen, Geol. Surv. Ill., VIII, p. 81, pl. XI, ff. 1-1d, (1890).

Worthen's description: "Corallum dendroid, the branches generally cylindrical, sometimes irregular, from 15 to 25 mm. in diameter, and infrequently divided. Corallites conical, diverging from an imaginary axial line to open on all parts of the free surface. The calyces all oval or circular, very variable in size, the larger ones 1.1 mm. in diameter, and either level with the general surface, or with an elevated margin. Each orifice is adorned with small tubercles or short ridges arranged in a radiate manner around the calyx margin. Openings of the corallites separated by dense calcareous tissue of variable thickness, but apparently always as wide as, or wider than, the diameter of the tube orifices. Sections show that the tubes are prismatic and in contact with each other, that their walls are greatly thickened by a calcareous deposit on the inner side of the tubes, and that the amount of thickening increases toward the orifices. Mural pores of large size are present, but apparently not numerous. Tabulæ are best developed in the axial region, where they cross the tube cavity at intervals equaling once or twice the diameter of the tubes. Tangential sections show that the corallite cavities are surrounded by blunt, thick, septal ridges. The walls are now composed of fibro-crystalline calcite, and the change has destroyed the finer details of structure."

Range and distribution: "Coal Measures; Labette county, Kansas."

"In all important respects the species described here resemble the *Trachypora ornata* Rominger sp., from the Hamilton group, and I do not think any reasonable objection can be urged against placing them in the same genus. Specifically they are quite distinct, the corallum of Rominger's species being much smaller, the corallites much less variable in size and not so prominently margined, nor are the interspaces so thick."

AULOPORA.

Goldfuss, Petref. Germ., p. 82, (1826).

Aulopora? prosseri. Plate III, fig. 2; plate IV, fig. 2.*Aulopora? prosseri* Beede. Kans. Univ. Quart., VII, p. 18, pl. —, f. 2, (1898).

Corallum large, prostrate, bifurcating, the calyces rising vertically or obliquely from 3 to 7 mm. or more; average diameter 2 mm. or less; average diameter of prostrate portion a trifle less. Calyces not campanulate, cylindrical, openings nearly circular; corallites wrinkled; weathered specimens show longitudinal striæ indicating rudimentary septa; the corallites are one to three diameters distant. In the lower portion of the corallite the cavity is nearly or quite closed on account of the internal thickening of the wall. Tabulæ generally wanting, occasionally present in moderate numbers and pass from wall to wall, sagging regularly near the center. Size of corallum unknown. Colonies twenty-two inches across were recently collected in the southeastern part of Douglas county, and still appear to be incomplete. The base of this species broadens rapidly, and in good specimens appears somewhat like coarse lace.

Range and distribution: Upper Coal Measures; Lyndon, Osage county, Lecompton and near Twin Mounds, Douglas county.

In large slabs this species looks not a little like *Syringopora*, but differs from it very markedly in the absence or sparsity of tabulæ and the fact that the tubes are always rather short.

Aulopora? anna. Plate III, fig. 3.*Aulopora? anna* Beede, Kans. Univ. Quart., VII, p. 18, pl. —, f. 3, (1898).

Corallum prostrate, diffusely branched, branches interlacing and anastomosing at every contact; walls thin, save at the base of the corallite; tubes very short, slightly subconical, immediate openings slightly flaring, circular to oval; no tabulæ distinguishable; septa occasionally represented by a faint ridge in the best-preserved corallites; diameter of calyx opening, 2 mm., contiguous to one or two diameters distant. Corallite low, a little larger at upper extremity than at the base.

Range and distribution: Upper Coal Measures; Morehead.

This species is profusely branched baso-laterally and anastomoses to such an extent as often to form solid mats of coral. It differs from *Aulopora* in having no tabulæ, in which respect it agrees with *Cladochonus*, but it is prostrate, and does not seem to reproduce by lateral gemmation as does the latter; hence it is referred, provisionally, to *Aulopora*. At first it was thought to be the base of a colony of *Syringopora*, as it was attached to the top of a colony of that species, but, on examining the bases of *Syringopora*, they were found all to contain very great numbers of tabulæ, which clearly separates the genera.

It differs from *A. ? prosseri* in the proximity of the corallites and the degree to which it anastomoses, and the corallites are generally shorter and the mouths more flaring.

CLADOCHONUS.

Cladochonus? bennetti. Plate III, fig. 1; plate V, fig. 7.

Cladochonus? bennetti Beede, Kans. Univ. Quart., VII, p. 17, pl. —, f. 1, (1898).

Corallum loosely fasciculate; corallites one or two or more diameters distant; erect corallites larger than the basal branches, often five times as high as thick, upper portion budding and sending off branches as at the base; epitheca strongly wrinkled, upper portion of the wall of the calyx thin, opening circular, deep, funnel-shaped by the thickening of the wall interiorly, in the lower portion of which, as a rule, there is only a small capillary opening, though sometimes larger. Average diameter of corallite, 2 mm.; length, 6 to 18 mm.

Range and distribution: Upper and Lower Coal Measures; Fort Scott, Howard.

This species resembles *Aulopora? prosseri* more closely than any other Kansas species. It differs from this, so far as known, in having no tabulæ, and in the manner of budding profusely at the upper part of the corallites. It resembles *Romingeria umbellifera* Rom., but the absence of tabulæ removes it from this genus. It agrees with *Cladochonus* McCoy, save that they are only funnel-shaped when young, and very slightly so then. The corallites are long and very stout, resembling *Syringopora* in general appearance.

SYRINGOPORA.

Goldfuss, Petref. Germ., p. 75, (1826).

Syringopora multattenuata. Plate II, figs. 10, 10b; plate V, fig. 6.

Syringopora multattenuata McChesney, Desc. New Pal. Foss., p. 75, (1860); *ibid.*, pl. II, ff. 4a, b, (1865); Trans. Chic. Acad. Sci., I., p. 2, pl. II, f. 4, (1867); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 144, pl. I, ff. 5a-d, (1872); White, U. S. Geogr. Surv. West 100 Mer., IV, p. 100, (1877); Keyes, Geol. Surv. Mo., IV, p. 122, pl. XIV, f. 6b, (1894).

Corallum forming large masses; corallites subcylindrical, somewhat tortuous, spaced one to two diameters distant; epitheca wrinkled, thick; septa obsolete; tabulæ very numerous, somewhat funnel-shaped, often forming a tube down the center of the corallite, running into each other laterally, forming vesicles. Size of corallum unknown, specimens eighteen inches in diameter appearing incomplete on all sides. Connecting tubules numerous and irregularly placed. The diameter of the corallites varies from 3 by $1\frac{1}{2}$ to 2 by 2 mm.

Range and distribution: Upper Coal Measures; Atchison, Le-compton, Lyndon, Osage county.

CHÆTETES.

Troost, manuscript (1849?). Milne-Edwards and Haime, Monog. des Polyp. Foss., p. 272, (1851).

Chætetes milleporaceus. Plate II, figs. 11-11b.

Chætetes milleporaceus Milne-Edwards and Haime, Monog. des Polyp. Foss., p. 272, (1851); Hist. Nat. des Corr., III, p. 271, (1860); White, Powell's Geol. Uinta Mts., p. 88, (1876); U. S. Geol. Surv. West 100 Mer., IV, p. 98, pl. VI, f. 2a, (1877); Keyes, Geol. Surv. Mo., IV, p. 123, pl. XIV, ff. 12a, b, (1894).

Corallum large, massive, somewhat globose; corallites very closely arranged, very long, same size throughout the entire length; walls thin, roughly five- to seven-sided, one diameter usually longer than the other; average diameter about a third of a millimeter. Tabulæ about a third to a seventh of a millimeter distant, horizontal, not always uniform throughout the group.

Range and distribution: Coal Measures, Girard; very abundant in the Oswego limestone, in which they form large masses.

Specimens of this species often attain a very large size. Some from the Oswego limestone are thirty inches in diameter, and still appear to be incomplete.

CRINOIDEA.

Crinoids are those animals known as sea-lilies or stone-lilies. They live in the sea at varying depths, from shallow water to 3000 fathoms. They were very abundant during geological time, and probably reached their maximum development during the Carboniferous period. They are not well adapted for preservation as fossils. Their skeletons are made up of angular pieces fitted together, but which usually fall apart when the animals decay, so that the preservation of an entire individual is a comparatively rare occurrence. It is not uncommon to find masses of stone almost entirely made up of these pieces, since the animals were gregarious, living in colonies as they do at present. During the Carboniferous and Triassic periods they were much more abundant than now.

Most of the crinoids are attached to the mud by stems which have rootlets at the base to anchor them. However, some of the forms are free during most, or all, of their lives. These stems had small canals running through their centers. They were either round or three- to five-sided. They are often found weathered out in the forms of little discs, which are generally called "Indian beads." Upon the upper end of this stem rests the calyx or cup-shaped base of the animal. The calyx is generally composed of three circlets of plates. First, the infrabasals, or the plates which rest on the top of the stem. There are usually five of them, and they are quite small, and occasionally are united into one, or they may be entirely wanting. Above these are the basals, or second ring of plates, which are longer and generally six-sided. Upon these rest the third row, or the radials, which support the arms and the top part of the animal. There are usually five of the radials, which are flat on top and five-sided. On the posterior side of the animal there is often a series of plates supporting the ventral tube, above which the anal opening is situated. These plates often take part in the formation of the cup, and are called the anal plates.

Resting on the radials are the arm plates. The arms are five or ten in number. They are composed of short plates laid one on top of another, and capable of motion. The inner side of the arms has usually a groove, along each side of which is a row of smaller armlets or pinnules. These grooves connect at the base of the arms with what are called the ambulacral areas, which in turn connect with the mouth, where food particles which are carried in the water are selected out.

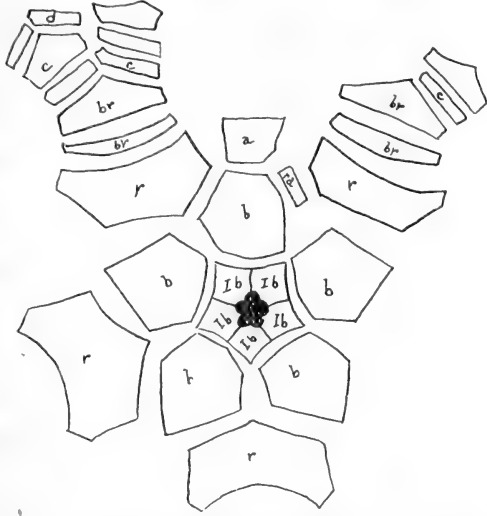


FIG. 2. Diagrammatic view of a crinoid with the plates separated, showing their relative form and positions. The black spot in the center is the hole in the base of the calyx that communicates with the stem. *Ib*, infrabasals; *b*, basals; *r*, radials; *br*, costals; *a*, anal. The remainder are arm plates.

The ventral side or top of the animal is often produced into a ventral sac, or anal tube, as it is sometimes called. The anal opening is either on top or in one side of this sac. The mouth is almost always centrally located. The crinoids are more closely related to the starfish and the sea-urchins or sea-cookies than to any other animals.

In the accompanying figures the various parts of the crinoid are shown and designated.

SCAPHIOCRINUS.

Hall, Geol. Surv. Iowa, p. 550, (1858).

Scaphiocrinus? washburni. Plate VI, figs. 2, 2a.

Scaphiocrinus? washburni Beede, Kans. Univ. Quart., 1, p. 21, pl. v, ff. 2, 2a, (1899).

Calyx broadly obconical, somewhat wider than high, rather stout, and smooth. Infrabasals rather large, bent upward at outer end, exterior outline pentagonal, plainly visible in the side view of the calyx, well defined. Column large, circular,

composed of alternately thick and thin pieces, the outer half of the sutures radially milled, the median canal of moderate size. Basals large, three hexagonal, and the posterior and right posterior ones heptagonal for the reception of the anals; the plates are nearly all equal, and the sutures are placed in a shallow, rounded furrow, which in branching at the angles of the plates gives them a rounded appearance, so that the plates appear subsemicircular in outline. The radials are the largest plates of the calyx, all pentagonal, all about equal, save the right posterior, which is smaller than the rest; the entire surface truncated above, edge slightly beveled, wider than high, entire upper surface faceted; the transverse ridge is milled, the lateral corners of the plates drawn in, apparently leaving a pore which connected with the body cavity of the calyx; there is a dorsal canal piercing the upper surface of the plates; the inner edges of the plates are drawn in at the center and extend in the form of a ridge to the canal. Costals 1×5 , about half the size of the radials, pentagonal, line of articulation with the radial gaping, lateral edges constricted and apparently not in contact, about twice as wide as high. The first interrarial is large and situated well down in the cup, supported by the posterior basal and the one at its right, on the sides by the special anal and the right posterior radial, and supports another anal above it on its truncated top. The special anal is moderately large and hexagonal, bounded on the right by the two interradians, below by the truncated upper surface of the posterior basal, on the left by the left posterior radial and the space between it and the costal; it is about half within the calyx. Above the first interrarial is a second, somewhat smaller, pentagonal plate which is about, or a little less than, half within the calyx. This plate, together with the special anal, supports the posterior portion of the ventral sac (apparently two columns of plates), which seems to be composed of rather stout five- to seven-sided plates with no or very small pores at the angles; they have a botryoidal surface. At one side and on the top of the sac there seems to be a madreporite plate pierced by large-sized pores. The sac was apparently about the size of the calyx,

or perhaps the calyx and costals together. Arm plates rounded on the exterior, not at all or very slightly wedge-shaped at the base, and moderately stout. Pinnulæ present and of moderately large size.

	Height.	Width.	
Column.....	8 mm.	5 "	
Infrabasals.....	3 mm.	5 "	
Basals.....	10 "	11 "	
Radials.....	8 "	14 "	} Right posterior smaller.
First interradial.....	8 "	9½ "	
Second interradial.....	5 "	6 "	
Special anal.....	8 "	8 "	
Costal.....	6 "	11 "	
Calyx.....	17 "	28 "	

Range and distribution: Upper Coal Measures; Topeka, Kan., from the horizon of the Osage coal. Now in the collection of Washburn College, in honor of which it is named.

This species seems to belong to the *Poteriocrinioidea*, though there is some difficulty in locating it generically, as it seems to combine some of the characters of several genera. It agrees with *Homoerinus* in having a round dorsal canal piercing the first radials, but differs from it in that it has pinnules, a robust calyx, and the entire top of the radials truncated. According to the definition of *Poteriocrinus*, the presence of the round dorsal canal in the radials removes it from that genus, as would also the fact that the facets of the radials face upward rather than outward. It differs from *Scaphiocrinus* in having a circular column, and the fact that the transverse ridge does not occupy nearly the whole of the upper surface of the radials and the brachials are not long. However, it agrees in other respects with this genus better than any other, and it is provisionally referred to it.

ZEACRINUS.

Troost, Cat. Foss., (1850).
Hall, Geol. Surv. Iowa, p. 541, (1858).

Zeacrinus? *robustus*. Plate VI, figs. 1, 1a.

Zeacrinus? *robustus* Beede, Kans. Univ. Quart., 1, p. 21, pl. v, ff. 1, 1a.

Calyx shallow, saucer-shaped or nearly flat, unsymmetrical, five or six times as broad as high, deeply concave at the base; plates tumid, and the sutures are in depression; surface finely granular. Infrabasals five, equal, half concealed by the col-

umn, deeply concave and superior to the basals, forming a large elevation in the interior of the cup, nearly one-fourth its entire width and fully one-half its height; column round, composed of thin plates, which are carinated, and the sutures are crenulated; the canal is round and small. Basals five, large, tumid, three hexagonal and two heptagonal, unequal, situated below the infrabasals and forming a large part of the real body cavity of the cup. The three anterior basals are equal, about as broad as high, very convex, the posterior one compressed laterally, superior lateral edges longer than the others; truncated side for the support of interrarial short, side next the radianal long; the right posterior basal heptagonal very broad, left posterior side very long, side adjacent for the reception of the radianal very short, the latter being situated between the posterior basal and the right posterior radial. Radials five, large, very moderately ascending, placed superior to the basals, five- to seven-sided, quite massive, more than twice as large as the basals, convex, twice as wide as high, upper exterior portion much beveled and concave; plates separated at the corners and often along the line of union; at the upper union there seems to be an opening that communicates with the calyx cavity between the arms; right and left posterior radials forced apart fully one-half the diameter of either by the interrarial and radianal; the upper surface is faceted the entire width of the plate, two external ridges present and milled; the remainder of the surface is nearly flat or a little concave; the plane of these surfaces is not horizontal but the inner side of each is higher than the outside, so that if each were produced inward they would form rather an obtuse cone; the inner notch occupies about a third of the upper surface of the plate. Radianal long, coffin-shaped, curving upward above, about twice as long as wide, pentagonal, side adjacent to the right radial much the longer; the superior side supports an anal which is hexagonal, very thick, six-faceted above, touching right radial for a short distance, one and one-half times as high as wide, widest above, mostly without the calyx. Anal large, heptagonal, very thick,

one-third within the calyx, broadest above; height one and one-half times the width.

A portion of the vault of this specimen remains, somewhat crushed down into the calyx. It appears to have been in the form of a pyramid, about as broad as high, composed of rather heavy plates, which were rather rough. It appears to have been rather angular, though it may have been conical. Several rather irregular plates are preserved, three of which seem to be from around the aperture; they are rather massive, five- or six-sided, nearly smooth on the exterior; articular surfaces are deeply faceted and roughened, while the articular surfaces of the other plates of the sac are milled.

	Height.	Width.
Column segments.....	1 to $1\frac{1}{2}$ mm.	$4\frac{1}{2}$ mm.
Infrabasals.....	4 "	3 "
Three anterior basals.....	8 "	9 "
Right posterior basal.....	$9\frac{1}{2}$ "	11 "
Posterior basal.....	9 "	$7\frac{1}{2}$ "
Radial.....	9 "	19 "
Radial.....	$8\frac{1}{2}$ "	$4\frac{1}{2}$ "
Interradial.....	$7\frac{1}{2}$ "	$5\frac{1}{2}$ "
Anal.....	8 "	$4\frac{1}{2}$ "
Calyx.....	7 "	36 "

Range and distribution: The specimen is labeled, "From the Upper Coal Measures; Kansas City." University of Kansas Museum.

It is impossible to locate the specimen generically with any degree of certainty without having more of the specimen preserved. The ventral sac seems to have been angular and the stem round. For this reason it is left with *Zeacrinus*. The upper extremities of the radials do not meet, but leave a small aperture, which seems to communicate in life with the general body cavity. I know of no Coal Measures crinoid with which it is likely to be confounded.

CERIOCRINUS.

White, U. S. Geol. and Geogr. Surv. Wyo. and Idaho for 1878, p. 123, (1883).

Ceriocrinus craigi. Plate VI, figs. 9, 9b.

Eupachyerinus craigii Worthen, Geol. Surv. Ill., VI, p. 527, pl. XXXII, f. 1, (1875).

Ceriocrinus craigii Wachsmuth and Springer, Proc. Acad. Nat. Sci. Phil., p. 178, (1886); Rev. Paleocrin., III, p. 254.

Calyx basin-shaped, smooth, concave at base, about three times as broad as high, roundly pentagonal in outline when viewed from below. Infrabasals hidden by the column, situated within the calyx. Basals probably pentagonal or hexagonal, if they have two short sides at base, except the dorsal one, which is truncated for the support of the interradial; height about equal to the width, strongly incurved at the base to meet the infrabasals. Radials pentagonal, nearly equal, convex, twice as wide as high, upper edge beveled, with a slight depression in the center, upper side faceted over the entire top of the plate, ridges prominent, crenulated, the large one not notched interiorly, furrows distinct, inner portion of the plate depressed. Interradial small, hexagonal, compressed laterally, about half within the calyx, upper portion curving strongly inward. Costals five, short, obtusely spinous, extending half their length beyond the calyx; lower interior surface faceted to articulate with the radials, upper surface faceted to the tips of the spines for the reception of the two distichals, each of which supports an arm. There is a strong keel on the upper side of the plate extending to its inner edge; it also gives rise to two lateral ridges which diverge from the tip of the upper surface to the corners of the plate; the ridges are crenulated; between these ridges are long depressions. The surface of the calyx is smooth.

	Height.	Width.	Length of spine.
Basals	7½ mm.	7½ mm.	_____
Radials	6½ " "	12 " "	_____
Interradial	4½ " "	3 " "	_____
Costals	6 " "	10 " "	9 mm.
Calyx	6 " "	21 " "	(slightly compressed).

Range and distribution: Upper Coal Measures; Kansas City. According to Worthen, *C. craigi* differs from *C. fayettensis* in

its "larger size, more robust form, and less convex plates." In these respects, judging from the figures, our specimens agree more closely with *C. craigi*.

Ceriocrinus? monticulatus. Plate VII, fig. 2.

Ceriocrinus? monticulatus Beede, Kans. Univ. Quart., VIII, p. 123, pl. XXXII, f. 2, (1899).

Calyx basin-shaped, moderately deep, slightly concave at base ; arms moderately stout, their number not known ; pinnules moderately long. Infrabasals not known, but probably small and nearly covered by the stem. Basals large, hexagonal, convex, curved regularly inward at the base, about as high as wide, upper lateral edges sometimes a little unequal on account of the unequal radials, which makes some of the upper and lower lateral edges unequal also. Radials a little unequal in size, pentagonal, the upper edges beveled, about twice as wide as high, upper surface faceted, the line of articulation with the costal gaping. Costals five, pentagonal in outline, somewhat produced exteriorly but not spinous, twice as wide as high, with single facet below to meet the radial and two above for the articulation with the distichals. Distichals 2 x 5, quadrangular or pentagonal according to the number of arms supported, apparently faceted above and below ; those supporting two arms very similar in shape to the costals. There are often one or two palmars before the postpalmars are reached, at the base of the arms. Arms long, rather stout, somewhere from fourteen to eighteen in number, ten in view above three radials ; they are made up of two series of short, stout, interlocking, cuneiform plates, each bearing a single, long pinnule. Pinnules composed of at least eight long, slender joints, slightly grooved on the inner side ; along each side of the groove is a row of closely set nodes, or little plates. The entire surface of the cup and arms is covered with monticules and fine granulations.

	Height.	Width.
Basals	10 mm.	10 mm.
Radials.....	6 "	11 "
Costals	5 "	10 "
Distichals.....	5 "	7 "
Arms.....	53 "	3 to 4 "
Pinnules	11 "	1 "
Calyx	12 "	24 "

Range and distribution: Upper Coal Measures; Topeka, horizon of the Osage coal.

On account of the general resemblance of this species to some of the species of *Ceriocrinus*, it is left there for the present, until the azygous plates and infrabasals can be determined.

Ceriocrinus hemisphericus. Plate VI, figs. 5, 5b.

Poteriocrinus hemisphericus Shumard, Trans. St. L. Acad. Sci., 1, p. 221, (1858.)

Scaphiocrinus? hemisphericus Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 147, pl. v, ff. 1a, b, pl. vii, ff. 1a-c, (1872); Meek and Worthen, Geol. Surv. Ill., v, p. 561, pl. xxiv, f. 5, (1873).

Ceriocrinus hemisphericus Keyes, Geol. Surv. Mo., iv, p. 220, pl. xxviii, ff. 2, 5, (1894).

Meek's description: "Body below the summit of the radials subhemispherical, with the under side deeply concave. Base very small, pushed or inverted entirely within the cavity of the body, and nearly or quite hidden externally; column facet round and deeply sunken. Radials of moderate size, very nearly equal, having a general pentagonal form, excepting on the anal side which is a little truncated above by the anal piece so as to give it a general hexagonal outline; each, however, has an additional very obscure mesial angle at its connection with the base, and all are strongly incurved below to form the concavity of the under side. Radials nearly twice as large as the basals, twice as wide as high, and equally pentagonal, the upper side being longer than any of the others and all evenly truncated. Costals (at least the two on the anal side) comparatively narrow, but still wider at the base than high, rounded on the outer side, a little constricted in the middle, and pentagonal in form, the two upper sloping sides supporting the first divisions of the arms, which are composed (at least for the first three ranges) each of a single series of wedge-formed pieces. First anal piece comparatively small, a little concave, resting upon one of the basals and connecting with the radials on each side, above which it projects, supporting upon its slightly incurved upper edge a second piece, the form of which is unknown. Surface smooth, or only with traces of minute granules."

Range and distribution: Upper Coal Measures; Jefferson county. Now in the collection of Washburn College.

Ceriocrinus missouriensis. Plate VI, fig. 6.

Delocrinus missouriensis Miller and Gurley, Jour. Cinc. Soc. Nat. Hist., XIII, p. 14, pl. II, ff. 11-13, (1890); 16th Rep. St. Geol. Ind., p. 336, pl. II, ff. 11-13, (1890).

Delocrinus hemisphericus Miller and Gurley, *ibid.*, p. 335, pl. II, ff. 8-10, pl. X, f. 5; Jour. Cinc. Soc. Nat. Hist., XIII, p. 12, pl. II, ff. 8-10. These species referred to the proper genus by Weller, Bull. U. S. Geol. Surv., 153, p. 172, (1898).

Calyx basin-shaped, shallow, pentagonal in outline viewed from below, nearly four times as broad as high, base quite concave. Infrabasals small, not entirely hidden on the exterior. Basals five, moderately large, pentagonal (the angle at the base, if it exists, is so small that it is almost impossible to discover it) except the posterior one, which is truncated for the reception of the interradial, giving it a hexagonal outline, about as high as wide; supralateral edges about equal, basal edge very short; plates not very sharply convex in the center. Radials five, nearly equal, about twice as large as the basals, and about twice as wide as high, upper edge beveled and upper side faceted, ridges of facet crenulated. Interradial small, laterally compressed, the upper portion bent strongly inward. Costals five, roughly triangular in outline, stoutly spinous, faceted below for the articulation with the radials, entire surface of the inner portion faceted above for the support of the two arms; the spines are stout and blunt. The arms are composed of two series of cuneiform interlocking plates which are rather convex on the exterior on the base of the arms. The surface is smooth.

	Height.	Width.	Length of spine.
Basals.....	8 mm.	6 mm.	—
Radials.....	6 "	12 "	—
Costals.....	8 "	11 "	14 mm.
Interradial.....	5 "	3 "	—
Calyx (another individual).....	6 "	21 "	—

Range and distribution: Upper Coal Measures; Kansas City, Argentine.

It is impossible to distinguish this species from *C. craigi* by the calyx alone (if it is distinct from that species) unless the base is so preserved as to show whether or not the infrabasals are concealed, unless the costals be present. The only difference between the two species is that in *C. missouriensis* the

spines are much longer, the infrabasals not hidden by the column, and that the cup is perhaps a little shallower, as is also the concavity of the base.

If Meek's determination of *C. hemisphericus* is correct, it does not have the costals developed into spines at all, and hence it is distinct from the spined forms. The minute differences between the two spined forms, as figured by Miller and Gurley, are of little value.

PHIALOCRINUS.

Trautschold, Mon. Kalkbrueche von Mjatschkowa, p. 122, (1879).

Phialocrinus magnificus. Plate VI, fig. 10.

Esioocrinus magnificus Miller and Gurley, Jour. Cinc. Soc. Nat. Hist., XIII, p. 15, pl. II, f. 1, (1890).

Phialocrinus magnificus Carpenter, Ann. and Mag. Nat. Hist., p. 96, (1891); Keyes, Geol. Surv. Mo., IV, p. 220, pl. XXVIII, f. 4, (1894).

Calyx bowl-shaped, base truncated, of medium size, surface finely granulated. Infrabasals five, cuneiform, pentagonal, half covered by the column, stem facet radiately furrowed. Basals five, hexagonal, posterior one heptagonal; the two sides at the base rather indistinct, edges straight; plates convex, curving inward at the base to meet the infrabasals, very slightly wider than high. Radials convex, nearly equal, the right and left posterior ones occasionally a trifle smaller than the rest, pentagonal, width about one and one-half times the height, upper outer edges beveled. Interradial resting on the truncated upper surface of the posterior basal, large, pentagonal, within the calyx, wider above, greatest width equal to the height, supporting two anals. First brachials large, quadrangular, the lower outer edge beveled. The second brachials pentagonal, highest in the center, superior side faceted for the support of the two arms, about twice as broad as high. Arms ten, slender, often 100 mm. long, pinnulate, pinnulae often 10 mm. long. The arms are composed of a single series of slightly cuneate plates, the inner side of which is furnished with a deep, broad groove. Above the interradian rest at least two anal plates which curve moderately inward. The proboscis is long, rather slender, subquadrate in transverse outline; in adult specimens, between the lobes of the tube, are

deep reentrant angles, giving it the appearance of four vertical tubes closely placed. In young specimens it is more round and less rough than in the adult. The plates are so closely united that it is difficult to make out their exact outline, but they are very convex on the exterior. The upper plates in young specimens are almost smooth, becoming more highly ornamented as the base is approached, while on old specimens the plates are highly tuberculated and the sides are ornamented by raised ridges which seem to surround apertures in the plates.

	Height.	Width.
Infrabasals.....	3½ mm.	3 mm.
Basals.....	5½ "	6 "
Radials.....	5½ "	9 "
Interradial.....	4 "	5 "
First costals.....	2½ "	8 "
Second costals.....	3 "	7 "
Distichals.....	3½ "	5 "
Proboscis.....	58 "	11 "

Range and distribution : Upper Coal Measures ; Kansas City and Argentine.

ERISOCRINUS.

Meek and Worthen, Am. Jour. Sci., LXXX, p. 174, (1865).

Erisocrinus megalobrachius. Plate VII, figs. 1a, 1b.

Erisocrinus megalobrachius Beede, Kans. Univ. Quart., VIII, p. 124, pl. XXXII, ff. 1a, b.

Calyx basin-shaped, quite concave, ornamented by very coarse granulations, which are sometimes arranged in wavy rows. Infrabasals unknown, covered, or nearly so, by the small column. Basals large, convex, the lower portion curved upward to meet the infrabasals forming a deep cavity in the base of the cup, the inner (or lower) end of the basals being in about the same horizontal plane as the upper end, and hence forming most of the base of the calyx and leaving the infrabasals entirely within the body cavity ; higher than wide, all about equal, and apparently pentagonal, the lower side (or sides, if two) short, superior and inferior lateral edges nearly equal, the apical angle extending upward between the radials to fully one-half the height of the latter. Radials five, equal, pentagonal, twice as wide as high, massive, convex, considerably beveled at the upper edge ; upper surface faceted for the

reception of the costals, the line of articulation with which is gaping, raised portions of the facet milled. Costals five, massive, stoutly spine-like, pentagonal in outline, lower inner surface faceted to meet the radials, upper surface faceted, except the portion protruding in the form of a stout spine to support the large arms. Distichals either one or two to each arm, more commonly two in our specimen, the lowermost quadrangular in outline, massive, a little more than twice as wide as high; the second distichals are very variable, from four to six times as broad as high. There are ten arms which are very broad and stout, each made up of two series of wedge-shaped, interlocking plates which are twice as long as high in the lower portion of the arms and each supporting a single pinnule. The pinnulæ are not well preserved, but are stout, composed of rather large, square plates near their junction with the arms, while farther away they assume a cylindrical form. Where not worn the entire specimen is covered with coarse granulations which are usually a little prolonged.

	Height.	Width.	Length.
Basals.....	11 mm.	10 mm.	_____
Radials.....	8 "	16 "	_____
Costals.....	5 "	15 "	9 mm.
1. Distichals.....	1-2 "	8 "	_____
2. Distichals.....	2 "	4 "	_____
Average lower arm plate.....	2 "	4 "	_____
Calyx.....	10 "	27 "	_____

Range and distribution : Upper Coal Measures ; Topeka, from the horizon of the Osage coal.

This species agrees in many respects with *Ceriocrinus craigi* (Worthen) W. and S. and *C. hemisphericus* (Shumard) W. and S., but each of these possesses an anal plate; the specimen in hand, though preserved in very perfect condition, shows no indication of such a plate. It is also very much like *Erisocrinus typus* as figured and described by White (Contributions to Invertebrate Palaeontology No. 6, p. 126, p. 33, f. 5), but the arms of our species are flatter, plates much less convex laterally, and granulated on the surface instead of smooth. The brachials also are more spine-like in our specimen, and the basals are not nearly so sharply convex as in that species, and

the cavity in the base is deeper and the calyx is not so high. It may belong to *Stemmatocrinus*, as the infrabasals are not known, but as that genus is not yet known from this country, it is more probable that it is an *Erisocrinus*.

Erisocrinus typus. Plate VI, figs. 4-4b.

Erisocrinus typus Meek and Worthen, Amer. Jour. Sci., xxix, p. 174, (1865); Geol. Surv. Ill., II, p. 317, f. 33; Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 146, pl. I, ff. 3, a, b, (1872); Meek and Worthen, Geol. Surv. Ill., v, p. 561, pl. xxiv, f. 6. (1873); White, Geol. Uinta Mountains, (Powell's Rep.), p. 89, (1876); Cont. Inver. Pal., No. 6, p. 126, pl. xxxiii, f. 5a, (1880).

Erisocrinus nebrascensis Meek and Worthen, Amer. Jour. Sci., xxxix, p. 174, (1865).

Philocrinus pelvis Meek and Worthen, Amer. Jour. Sci., xxxix, p. 350, (1865).

Meek's description: "Body below the summit of the first radials [radials], basin-shaped, rounded below, and obscurely subpentagonal in outline as seen from above or below; composed of thick, smooth, slightly convex plates. Basal pieces [infrabasals] small, occupying a shallow convexity of the under side, about half hidden by the column, all pentagonal in external form. Subradial [basal] considerably larger than the basal [infrabasal], and all equally hexagonal in form. First radial [radial] pieces four or five times as large as the subradials [basals], wider than long, equal, and all pentagonal; supporting upon their broadly and evenly truncated superior sides the second primary radials [costals], which are of nearly the same size and form as the first, but have their sloping sides above instead of below, while they each support above two first brachials [distichals], or a series of secondary radials [distichals] yet unknown. Surface smooth. Breadth of body below the first primary radials, 0.72 inch; height of same, 0.35 inch."

Range and distribution: The specimen here under discussion is from the Upper Coal Measures, Jefferson county, and now in the collection of Washburn College.

The specimen is a beautifully preserved calyx and a single costal. It differs very materially from the type specimen figured by Meek and Worthen. The calyx is much higher, which is due largely to the very much larger basals, which, in-

stead of being one-fourth or one-fifth the size of the radials, are nearly as large. The costals show a marked spinous development on the upper side, but in one of the figures (Geol. Surv. Ill., V, pl. xxiv, fig. 6) of the Illinois forms the costal is shown as being somewhat extended above. It is quite different from the figure of the species by White above referred to, in being quite plain and in having the plates less convex. It is also more sharply pentagonal in outline than most of the members of the species. However, this is a somewhat variable species, and our specimen is probably a true *E. typus*, but presenting interesting variant features.

EUPACHYCRINUS.

Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 169, (1865).

Eupachycrinus magister. Plate VI, figs. 3-3b.

Eupachycrinus magister Miller and Gurley, Jour. Cinc. Soc. Nat. Hist., XIII, p. 4, pl. i, ff. 1, 2; 16th Rep. St. Geol. Ind., p. 328, pl. i, ff. 1, 2, pl. x, ff. 6-8, (1890); Keyes, Geol. Surv. Mo., iv, p. 218, pl. xxvii, ff. 1a, b, 3.

Original description: "This species is very large; calyx low and broad, somewhat saucer-shaped, bulged a little on the azygous side, height about half the width, sutures deep, excavation extending about half the thickness of the plates, plates very strongly tuberculated, tubercles conical, elongated, and irregular in form and distribution. The five basals [infrabasals] are sunk in a cavity on the other side, projecting only half their length beyond the column; even this projection is tubercular; they form in the interior of the calyx a pyramid, which is pierced at the summit by a five-rayed opening connecting with the canal in the center of the column; the points of the rays are rounded. The basal plates are made pentagonal by the truncation made at the points of the rays for the central canal. The diagrammatic views which have been made of the basal plates in this genus are incorrect, in so far as they indicate a pentagonal opening with the angles directed toward the sutures, instead of truncating the plates with the concave depression for the five-rayed opening to the columnar canal. The two basals on the azygous side of the species before us are larger than the others, being nearly as large as the other three.

“The subradials [basals] are very large, extending into the basal cavity, and curve gently upward; three hexagonal, the two longer sides unite with the subradials; the two upper sloping sides, uniting with the first radials, are a little shorter, and the two under sides, uniting with the basals [infrabasals] are very short; two are heptagonal, the one on the right of the first azygous plate being much larger, and, except the two short sides uniting with the basals, the other sides are of subequal length; the one upon the left has, in addition to the two short sides uniting with the basals, a short side uniting with the second azygous plate. Four of the first radials are pentagonal, twice as wide as high; the upper face is the full width of the plates, and projects over the interior of the calyx so as to give the appearance of having great thickness when viewed from above. The other first radial, upon the right of the azygous plates, is quadrilateral, except a very slight truncation by the second azygous plate below the depth of the suture. The first radial is separated from the second or brachial piece, on the outer face, by a wide suture, but within a crenated ridge extends from one angle of the plates to another, forming a pentagon, except as separated by the second azygous plate; the ridge has a furrow upon the outer side in the central part of each plate, and within this is a wide expansion which supports the brachial arm pieces. The first azygous plate has four sides, rests between the upper sloping sides of the two subradials and along the under side of the first radial on the right, with the shorter side abutting on the second azygous plate. The second azygous plate is hexagonal, curves inward, and supports upon its two short inner faces the third and fourth azygous plates, side by side. The vault and other parts unknown.” In our specimen the right posterior radial seems to be covered by one of the plates of the ventral sac.

Range and distribution: Upper Coal Measures; Kansas City.

HYDREIONOCRINUS.

de Koninck, Bull. Acad. Royale Belgique, VIII, pt. II, p. 13, (1858.)

Hydreionocrinus kansasensis. Plate VII, figs. 4-7.

Hydreionocrinus kansasensis Weller, Trans. N. Y. Acad. Sci., XVI, p. 372, (1898.)

Weller's description: "Dorsal cup depressed, nearly saucer-shaped, more than twice as wide as high, truncated below. The margins of all the plates, except the lateral margins of the infrabasals, ornamented by narrow papillose bands parallel to the sutures. Exclusive of the papillose bands the plates are smooth. Infrabasals five, large, extending far beyond the column, anchylosed into an irregularly hexagonal, nearly flat disc, the sutures marked by slightly elevated ridges; central portion of the disc slightly excavated for the attachment of the column, the excavation surrounded by a low ridge. Basals five, four of them broader than high, spherical-triangular in outline, in lateral contact only at the extreme lateral angles. The posterior basal higher than wide, quadrangular in outline, truncated distally for the reception of the special anal plate, the lateral and proximal sides curved as in the four other plates. Radials large, twice as wide as high, the three anterior ones heptagonal in outline, the two posterior ones hexagonal. The proximal sides concavely curved to conform to the curved sides of the basals, the proximal angles meeting the distal angles of the infrabasals and the lateral angles of the basals. First brachials twice as wide as high, pentagonal in outline, bearing upon the two upper sloping sides of the two main divisions of the arms. Arms uniserial, the component plates broader than long, except near the tips, rectangular in outline except the axials, which are pentagonal. In the right posterior arm, the only one known, each main division bifurcates several times, the most posterior one showing ten divisions at the tip. Radianal nearly as large as the basals, pentagonal, higher than wide, lying upon the truncated right posterior infrabasal and between the posterior basal and the right posterior radial. Special anal larger than the radianal, hexagonal, higher than wide, lying upon the truncated posterior basal and between the

radial and the left posterior radial. First tube plate partially included in the calyx, higher than wide, lying upon one of the upper sides of the radial and between the special anal and the right posterior radial. Ventral sac very large, expanding above and surrounded at its summit by a row of large, spatulate, spinous plates which form a crown of diverging spines around the summit of the sac."

Range and distribution: "From the Upper Coal Measures, about 700 feet below the horizon of the Cottonwood limestone, at Neal, Greenwood county, Kansas."

"Remarks: The form of the plates in the dorsal cup of the species differs materially from the other species of the genus, but the ventral sac, which is the most remarkable feature of the genus, and which is said by Wachsmuth and Springer² to be the best character for distinction, in all respects like that in the remaining species. This organ is much crushed and only partially preserved in the type specimen, but enough is present to show its great expansion toward the summit and the crown of large, spinous plates. Eight of these spatulate spinous plates are recognizable in the specimen, all of them belonging to one side, so that there must have been at least fifteen or more altogether.

"The dorsal cup is remarkable for the large size of the infrabasals which extend far beyond the column and do not rest in a deep cavity, but are consolidated into an irregularly hexagonal flat disc. The spherical-triangular form of the basals is different from any of the other species of the genus, and the manner of meeting in one point of the distal angles of the infrabasals, the proximal angles of the radials and the lateral angles of the basals is quite remarkable."

Hydreionocrinus subsinuatus. Plate VII, fig. 14.

Hydreionocrinus subsinuatus Miller and Gurley, Bull. 3, Ill. State Museum Nat. Hist., pp. 40, 41, pl. vi, ff. 11-14, (1893).

Original description: "Calyx depressed, saucer-shaped, slightly concave below, longitudinally concave on the ventral side; sutures distinct; surface smooth. When viewed from

2. Revision of the Paleocrinoidea, I, p. 130.

above or below, hexagonal, in outline, by reason of the truncated first radials, and the concave, wide azygous area. Column round.

“Basals form a pentagon one-half wider than the column, with a central, columnar cavity surrounded by an external rim, for the support of the attaching column. Subradials of moderate size, three of them apparently pentagonal, though as each one abuts upon two basals, where there is an obscure angle, they are really hexagonal. The two adjoining the azygous area are heptagonal. They curve very slightly down to the basals, and upward, toward the acute angles between the first radials. They are not uniform in size or shape; the heptagonal plate on the right of the azygous area is the wider, and the one on the left the longer one. First radials twice as wide as high, truncated the entire width above, much thickened within, and separated from the second radials, on the outer face, by a gaping suture, but immediately within a straight ridge extends from one outer angle to the other, having a furrow on each side so as to form a hinge on which the second plates articulate; behind this hinge, in the middle part of each plate, there is a socket for the reception of a tooth-like projection. Second radials short and heavy and produced externally in a moderately strong spine.

“First azygous plate longer than wide, pentagonal, upper side short, abutting below on a subradial and resting very slightly oblique between another subradial and the under sloping side of the first radial on the right. Second azygous plate longer than wide, truncates a subradial, abuts upon the superior lateral side of the first radial on the left, and the first and third azygous plates on the right. Third azygous plate longer than wide, truncates the first azygous plate, and abuts upon the superior lateral side of the first radial on the right. The second and third azygous plates are hexagonal, but the plates abutting the superior side are not preserved in our specimens. A small part of a proboscis is preserved in one of our specimens, that shows some heavy, transversely furrowed plates. Other parts not preserved.

"This species is so different from any other referred to this genus, that no comparison will serve further to distinguish it. There is a possibility that it is a *Zeacrinus*, but we think it is not."

Range and distribution: Upper Coal Measures; Cameron's Bluff, near Lawrence.

AGASSIZOCRINUS.

Troost, Jour. Amer. Asso. Adv. Sci. Camb. Meeting. p. 60, (1850).
Wachsmuth and Springer, Revis. Paleocrin., III, p. 262, (1885).

Agassizocrinus carbonarius. Plate VI, fig. 8.

Agassizocrinus carbonarius Worthen, Geol. Surv. Ill., v, p. 566, pl. xxiv, f. 4, (1873).

Infrabasals large, completely fused, semielliptical. The upper faces of the infrabasals are quite concave, and consequently angular at the suture. The cavity is moderately deep. Measurements: Height of the infrabasals, 10 mm.; diameter at their summit, 11 mm. The faces of all five plates are equal.

Range and distribution: Upper Coal Measures; Kansas City.

The infrabasals of this species were figured by Worthen, without description, from Illinois. It is the only species of the genus known in the Coal Measures of the United States. The radials, basals, arms, etc., of this species are not yet known.

ECHINOIDEA.

The "sea-urchins," "sea-eggs," "sand-dollars," and "sea-cookies," as they are variously called, are animals varying in form from spheres to discs. They live in moderately shallow water, especially near oyster beds, while some bury themselves in the sand, and one kind is known to make holes for itself in the solid rock. They always inhabit the sea. The parts that are generally found fossil are the spines and the plates, which are here explained.

The body of the animal is encased in a kind of box made up of calcareous plates, which are united at their edges. A more or less long spine is attached to each of certain plates. The spines project out from the body in all directions. They are attached to the plates by a sort of ball-and-socket joint, and are movable. There are two kinds of plates—those with, and those without, spines. The latter are called the ambulacral plates, or the plates through which the tube-feet project, while those with spines are called the interambulacral plates. The ambulacral plates are arranged in five bands, or areas, between which the interambulacral plates are arranged. Each band generally extends from the top to the center of the bottom of the animal.

The mouth is located at the center of the bottom side. In some sea-urchins the mouth is provided with five long teeth and a complicated set of calcareous supports. The whole arrangement is known as "Aristotle's lantern." On the top side of the animal near the center there is a sieve-like plate, which connects with a long membranous tube beneath. This tube runs downward to the base of the inner cavity and connects with another tube which forms a ring around the esophagus. There are five branches to this latter tube, one extending along the center of each ambulacral area. In the ambulacral plates there are series of holes through which the numerous branches of these tubes extend to the outside of the shell.

These branches, or tube-feet as they are called, extend out-

ward for quite a distance and end in little disc-like suckers. This tube system is filled with water, and is known as the "water-vascular system." By filling these tubes with water, and dilating them, the animal is enabled to move along. However long the spines may be, the tube-feet may be extended beyond them. The figures illustrate the hard parts which are generally found fossil. There are at least four kinds known in the Kansas rocks.

ARCHÆOCIDARIS.

McCoy, Carb. Foss. Ireland, p. 173, (1844).

Archæocidaris trudifer. Plate VIII, fig. 10.

Archæocidaris trudifer White, Prelim. Rep. Invert. Foss., p. 17, (1874); Powell's Rep. Geol. Uinta Mts., p. 89, (1876); U. S. Geog. Surv. West 100 Mer., iv, p. 104, pl. vi, f. 8, (1877); Keyes, Proc. Iowa Acad. Sci., II, p. 191, (1895).

White's description: "Interambulacral plates comparatively broad, rather thin, having an elevated border all around, which is apparently composed of a series of small tubercles; areolar surface apparently plain; central tubercle small, perforated at the center, surrounded at its base by a very slightly raised ring, and immediately outside of that by another ring, which is so much elevated as to form a little cup with its rim somewhat expanded. Diameter of the largest plate in the collection about 20 mm. Spines very long and slender, one of these in the collection having been, when perfect, about 12 cm. in length, terete; diameter of the basal ring, which expands from the shaft, greater than that of any portion of the shaft; diameter of the shaft nearly uniform for more than half its length above the basal ring, the upper portion gradually tapering to a point. Greatest diameter of the shaft of the long spine referred to, scarcely 5 mm.; diameter of the basal ring, 7 mm. Surface of the spine for a short distance above the basal ring apparently smooth, but, from that portion to the distal end, it is ornamented with numerous small points or incipient spinules, which are often removed by weathering, but in well-preserved specimens they are seen to be arranged around the spine in imperfectly spiral lines. The very long, slender, terete spine, having a basal ring often much greater in diameter than

any part of the shaft, together with the other characters described, distinguish this species from all others."

Range and distribution: Upper Coal Measures; Topeka limestone, Topeka.

Our specimen is a single spine with the proximal end buried in the matrix, the distal three-fourths being exposed. The exposed part agrees more closely with this species than any other yet described, and it is provisionally referred to it.

Archæocidaris agassizi. Plate VIII, figs. 6-6e.

Archæocidaris agassizi Hall, Geol. Iowa, I, pt. II, p. 698, pl. xxvi, ff. 1a-d, (1858); Keyes, Geol. Surv. Mo., IV, p. 127, pl. xv, f. 5, (1894); Jackson, Bull. Geol. Soc. Amer., VII, p. 213, (1896); Keyes, Proc. Iowa Acad. Sci., II, p. 185, pl. xviii, f. 5, (1895).

Hall's description: "Body unknown; plates small, hexagonal, except those adjacent to the ambulacral area, which are a little rounded on that side, becoming pentagonal; central tubercle slender, elongated, tubuliform, and projecting above the surrounding annulation, the latter abruptly elevated, and leaving, between its inner face and the central tubercle, a deep cavity. Surface of the plate, immediately around the annulation, elevated in a distinct low, annular ridge, beyond which it is depressed and again elevated towards the margin, which is ornamented by a series of low elongated nodes. Spines elongated, compressed, contracted below and swelling out above, so that the greatest diameter is about one-third the length above the base; from this point very gradually tapering to the summit. Surface of the lower contracted portion smooth, mucronate above, with small spiniform tubercles, which, on the lower part, are arranged in somewhat distant curving annulating rows, becoming more curved above, or in oblique ascending rows, giving a quincunx order. Point of attachment somewhat elongate, the thickened annulation strongly striate."

Range and distribution: Upper Coal Measures; Topeka.

This species was described from the Burlington by Hall. We would hardly expect Coal Measures specimens to be conspecific with the Burlington, but I am unable to detect any differences that could be called specific in our specimens, which consist of

spines and plates. Without doubt, if we had entire specimens from both formations to compare, they would be found to be different; but until such differences are found it is best to leave them in the same species.

Archæocidaris megastylus. Plate VIII, fig. 7.

Archæocidaris megastylus Shumard, Trans. St. L. Acad. Sci., I, p. 225, (1858); Keyes, Geol. Surv. Mo., IV, p. 189, pl. xv, ff. 2a, b, (1894); Proc. Iowa Acad. Sci. II, p. 189, pl. xviii, ff. 2a, b, (1895).

Shumard's description: "The interambulacral plates of this species in the collection are large, hexagonal, wider than long, and rather thick. The areolar surface is very broad, nearly circular, slightly concave at its exterior portion and rising gently to the base of the central boss. It is encircled by a single series of small, secondary tubercles. The boss is broad, smooth, and the central tubercle deeply perforated. The primary spines are long, robust, cylindrico-fusiform, and the transverse section circular. The surface is very finely striated longitudinally; and studded either rather distinct granules or minute short spines, arranged spirally or promiscuously. The ring at the base is oblique to the axis, its border neatly crenulated, and the diameter less than the greatest diameter of the spine. The socket is deep, rather wide, and its margins smooth. The neck is marked with a slightly raised ring, which is finely striated longitudinally."

Range and distribution: Upper Coal Measures; Kansas City.

This species often attains a length of three inches or more. Our specimens are but spines, and they are worn so that the minute surface markings are all removed, but, from their size and shape, there is little doubt of their identity.

OLIGOPORUS.

Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 474, (1860).

Oligoporus? minutus. Plate VII, fig. 3.

Oligoporus? minutus Beede, Kans. Univ. Quart., VIII, p. 126, pl. xxxii, f. 3, (1899).

Small, depressed globular, melinitic ridges not very distinct. There are four columns of pores, each column consisting of two rows, in each ambulacral area; each row is generally, though not always, made up of two pores placed side by side and very

close together; each of the two series is apparently separated by a row or two of imperforate plates at the ambitus. Both series are in contact at the apex and near the mouth. Number of columns of interambulacral plates unknown, but apparently about three. The ambulacral area is very wide and the two series are widely separated at the ambitus. Some of the interambulacral plates seem to be pierced by a single pore, or, sometimes, two. Indistinct elevations seem to be present in three columns, one of large and two of small size.

Diameter of specimen.....	23 mm.
Maximum diameter of ambulacral area.....	6 "
Maximum diameter of each series.....	2 "
Maximum diameter of interambulacral area.....	7 "
Pores distant in vertical rows.....	$\frac{2}{3}$ "
Pores distant in the same series.....	$1\frac{1}{2}$ "
Pores distant in single pair.....	$\frac{1}{4}$ "

Range and distribution: Upper Coal Measures; collected from the Deer Creek limestone, near Topeka.

The specimen is badly worn and somewhat compressed; the surface markings are almost entirely removed. It agrees to some extent with *Oligoporus*, but the ambulacra are divided into two series with, apparently, two columns of imperforate plates between them. However, this is not unquestionably shown by this specimen. It will, in all probability, be found to belong to an entirely different genus. It is referred to *Oligoporus* for convenience, until better material can be secured. It does not seem to present the appearance of any other Carboniferous sea-urchin with which I am acquainted.

BRACHIOPODA.

Brachiopods are small animals with a two-valved shell, resembling the clams somewhat in external appearance, though they are very different in internal structure. They are in some respects much more closely allied to the bryozoans, or sea-mats, and worms, than to the clams. They are strictly marine animals, living, as a rule, in rather deep water. Their distribution, in this respect, has been divided into five zones,³ which may be described as follows: Shore zone, or the beach between high and low tide-marks; the shallow-water zone, or water to a depth of 90 feet; the moderately deep zone, or water from 90 to 300 feet deep; the deep zone, or water from 300 to 1668 feet deep; and the very deep zone, or water from 1668 to 17,670 feet, or three and one-half miles deep. In each of these zones there are species which do not occur in any of the others, while some are common to two or more zones. There are, according to Hall and Clarke, about 147 species of living brachiopods known, which are distributed over the Atlantic, Pacific and Arctic oceans, ranging from the island of Spitzbergen, north of Norway, to Cape Horn, but being most abundant in tropical and temperate waters. As a rule, they are distributed along coast-lines and in the vicinity of islands.

The living brachiopods are but a remnant of what was once one of the most abundant and varied classes of animals of their size that ever inhabited the earth. While the known living forms are only 147 in number, the fossil species known at present probably reach the enormous number of 6000, and of these, upwards of 2000 are represented in the American rocks. They are among the earliest fossils of which we have any record, and culminated in the earlier part of geologic time. In the Cambrian, or earliest period of which we have any definite knowledge of life, there are about 125 species known; in the

3. This introduction is largely drawn from Eastman's Translation of Zittel's Handbook of Paleontology, Schuchert's Synopsis of American Fossil Brachiopoda (Bulletin of the U. S. Geological Survey No. 87), Paleontology of New York, vol. VIII. and Annual Report of the State Geologist of New York for 1891, to which the reader is referred for more detailed information.

Devonian they reached their highest point in respect to numbers, about 1400 species; while at the close of the Paleozoic era they appear to have fallen back to less than 100 species, and to have continued to the present comparatively few in number.

Before entering upon the description of the Kansas species, it may be well to give an idea of what the animal was and what the markings found on the shells mean. In the first place, there are two shells, or valves, generally unequal in size. The hinge, or the place of union of the two valves, is considered the posterior, or hind end, and the opposite edge the front end, while the two sides at right angles to the hinge are the lateral margins or sides. The animals were attached to some foreign object during all or a part of their life, either by a *pedicle*, a long muscular projection from the shell, or by a portion of the shell being cemented to the object. Those having a pedicle usually have an opening in the beak on one of the valves, the *pedicle valve*, sometimes called the ventral valve, near the hinge, while the others simply have the pedicle extended between the posterior ends of the valves.

The front portion of the shell is lined by a membrane which divides the cavity into two parts, the anterior or *brachial cavity*, and the posterior or *visceral cavity*. In the latter are located the visceral organs and the muscles which open and close the shell and retract and protude the pedicle. The nervous system consists of a single ring around the esophagus, in which there are located two ganglia which give off branches to the different organs of the body. The digestive canal consists of but a single convolution, and terminates blindly in the living forms, though it probably communicated with the exterior in certain fossil forms. The pair of muscles which close the shell, the *adductors*, are large muscles which extend directly from the postero-central part of one valve to the other. By their contraction the shell is closed. The impression left in the shell by these muscles is usually quite prominent. The *diductors*, or muscles which open the shell, are large muscles attached to the middle of the rear end of the pedicle valve just outside of the adductors, while the other end is attached to a prolongation of the other, *brachial*,

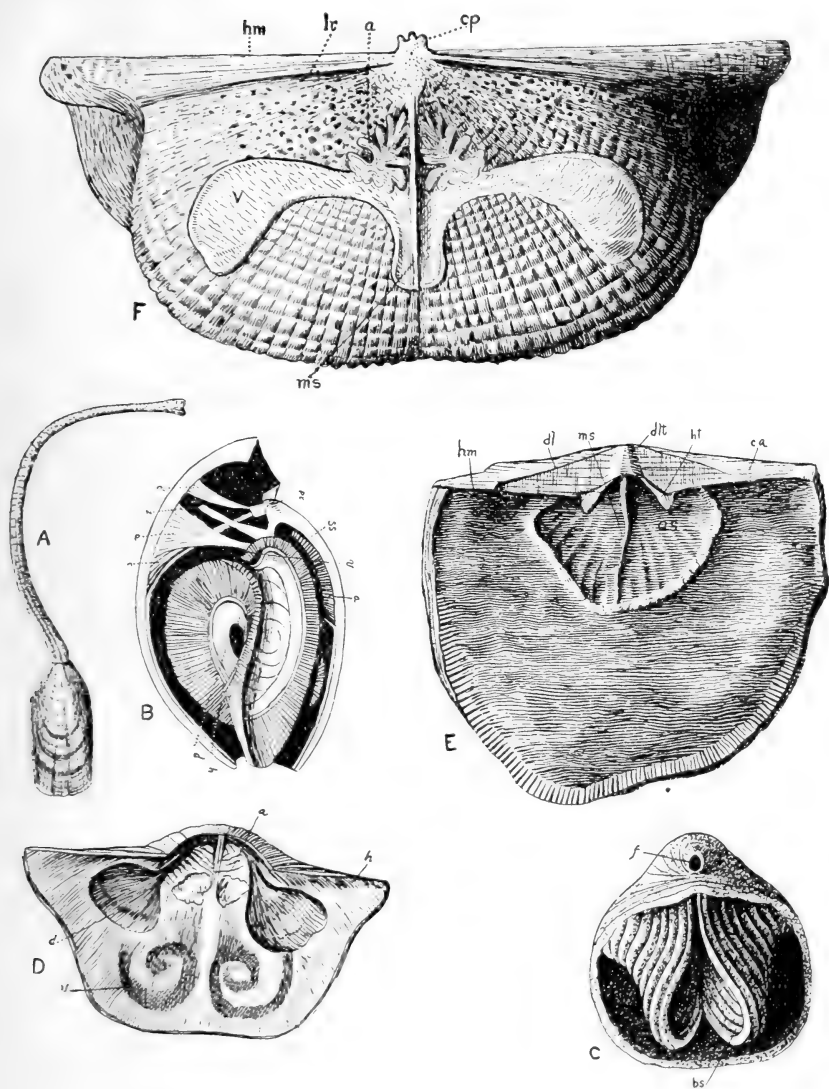


FIG. 3. A, *Lingula murphiana* (after Hall and Clarke), showing the pedicle, which is greatly developed in this genus; B, *Magellania flavescens* (after Schuchert, in Eastman's Trans. of Zittel); C, *Seminula argentea*; D, *Productus giganteus* (after Schuchert, in Eastman's translation of Zittel); E, *Derbya robusta*; F, *Productus semireticulatus*; a, adductors; cc, diductors; d, spiral brachia; bs, same as seen in a fossil; dl, diverging lines; dl, deltidium; as, adductor scar; ca, cardinal area; cp, cardinal process; f, foramen; h, fringe on brachia; hm, hinge line; lr, ridge diverging from base of cardinal process; ms, mesial septum; ht, teeth; z, alimentary canal; v, mouth; vm, brachial markings.

sometimes called *dorsal valve*. This process extends beyond the hinge backward under the beak of the other valve, and when the muscle contracts acts as a lever opening the shell.

In the front cavity are situated the *brachia* or arms, as they are called. They are often of coiled or spiral form, supported by horny or calcareous supports which are sometimes preserved in the fossils. These brachia carry a long fringe, which by its vibration keeps a current of water flowing through the shell, from which the animal separates its food. There are no special organs of respiration, which is performed probably by the blood flowing through many thin membranes which are constantly in contact with the current of water passing through the shell. The figures on page 53 serve to illustrate the parts of the animal and the muscular impressions found in the shells.

The full synonymy is given for the species herein described, but not a full bibliography. For a full bibliography, the reader is referred to Mr. Charles Schuchert's work on the North American Brachiopoda, Bulletin No. 87 of the United States Geological Survey of 1897.

LINGULA.

Bruguiere, Encyc. Metho., I, p. 250, (1792).
Meek and Hayden, Pal. Upp. Mo., p. 63, (1861); etc.

Lingula mytiloides. Plate VIII, fig. 5.

Lingula mytiloides Sowerby, Min. Conch., 1, p. 55, pl. xix, ff. 1, 2, (1813);

Meek and Hayden, Geol. Surv. Ill., v, p. 572, pl. xxv, f. 2, (1873).

? *Lingula umbonata* Keyes, Geol. Surv. Mo., v, p. 38, pl. xxxv, f. 4, (1895).

Shell small, elliptical, posterior extremity slightly narrowed; beak extending to the hinge line, not prominent. Anterior margin broadly rounded, lateral margins subparallel; the greatest diameter about the middle of the shell. The surface is marked by fine concentric lines of growth. Length, 7 mm.; breadth, 5 mm.; larger specimen, length, 11 mm.; breadth, 7 mm.

Range and distribution: Upper Coal Measures; Kansas City, Topeka, Burlingame.

ORBICULOIDEA.

d'Orbigny, *Prodrome de Pal. Strat.*, I, p. 44, (1850).
Dall, *Bull. Mus. Comp. Zool.*, III, p. 37, (1871); etc.

Orbiculoidea missouriensis. Plate VIII, figs. 1-1c.

Discina missouriensis Shumard, *Trans. St. L. Acad. Sci.*, I, p. 221, (1858).

Discina nitida? Meek and Worthen (non Phillips), *Geol. Surv. Ill.*, v, p. 572, pl. xxv, f. 1, (1873); White, 13th Ann. Rep. St. Geol. Ind., p. 121, pl. xxv, f. 10, (1884); etc.

Discina meekiana Whitfield, *Ann. N.Y. Acad. Sci.*, II, p. 288, (1882); etc.

Orbiculoidea missouriensis Schuchert, *Bull. 87, U. S. Geol. Surv.*, p. 281, (1897).

White's description (in part): "Shell small, subcircular, depressed conical, the sides sloping nearly straight from the apex to the margin; apex prominent, situated about one-third the diameter of the shell from the posterior border; lower valve flat with the usual depression around the foramen; surface of both valves marked by concentric lines and fine lamellations. Diameter of an average example about 8 mm."

In this shell the height of the apex is about one-third the diameter of the shell. The concentric lines are prominent in well-preserved specimens and are sharply elevated, separated by wider, shallow furrows. The sulcus extends two-thirds or all the distance to the posterior margin. The inner laminae of the dorsal valve show a radiate structure.

Range and distribution: Upper and Lower Coal Measures; Fort Scott; Rosedale, Wyandotte county; Lansing, Leavenworth county; Topeka.

Orbiculoidea convexa. Plate VIII, figs. 3, 3b.

Discina convexa Shumard, *Trans. St. L. Acad. Sci.*, I, p. 221, (1858);

White, 13th Ann. Rep. St. Geol. Ind., p. 121, pl. xxv, f. 9, (1884); etc.

Orbiculoidea convexa Schuchert, *Bull. 87, U. S. Geol. Surv.*, p. 278, (1897).

White's description: "Upper valve broadly but somewhat prominently convex; subcircular in marginal outline; the height nearly equal to one-half the diameter; apex somewhat obtuse, but moderately prominent, situated about one-third the diameter of the shell from its posterior margin; surface marked by the usual distinct lines of growth. A small under valve was found in the same locality as the upper valve above described, and probably belongs to this species. It shows a similar sur-

face, which is nearly flat, but it is depressed above the foramen, which is of the usual character; the foramen is situated just beneath the beak of the upper valve." The posterior portion of the shell of one individual which has the outer portion of the shell exfoliated shows distinct, discontinuous, alternating, radiating ridges, from near the beak to the posterior margin. "Diameter of the upper valve just described, 27 mm.; height, 12 mm."

Range and distribution: Upper Coal Measures; Kansas City, Topeka.

Orbiculoidea manhattanensis. Plate VIII, figs. 2-2b.

Discina manhattanensis Meek and Hayden, Proc. Acad. Nat. Phil., (1859), p. 25.

Orbiculoidea manhattanensis Hall and Clarke, Introduction to Study of Brach., pt. I, pl. v, f. 12, (1892); Pal. N. Y., VIII, pt. I, pl. IV, f. 20, (1892).

Shell of medium size for this genus, nearly circular, dorsal valve moderately elevated; umbo situated about one-half of a diameter from the posterior margin; surface of dorsal valve marked with concentric lines, which are much heavier near the margin and finer and more wavy near the apex. The anterior slope is slightly convex, posterior a little concave, distinctly so in casts. The ventral valve is flat, shell quite thick; sulcus in distinct depression, extending about half way from the center to the margin; opening linear-elliptical. There is a thick callosity near the outer margin which is marked by radiating ridges corresponding to those of the other valve. Diameter of large specimen, 12 mm.; height, $2\frac{1}{2}$ mm. Outer surface marked by concentric lines similar to the convex valve.

Range and distribution: Upper Coal Measures; Wabaunsee formation; black shale in wagon-road cut east side of Blue Mount, Manhattan, Kan. In collection of E. A. Popenoe.

This species differs from *O. missouriensis* in being more compressed, thicker shelled, shorter sulcus, and in having more distinct concentric lines; from *O. convexa*, in being much less convex and much smaller.

CRANIA.

Retzius, Schrift. Ges. Naturf. Freunde, Berlin, II, p. 72, (1781).
Hall and Clarke, Pal. N. Y., pt. I, p. 145, (1892); etc.

Crania modesta. Plate VIII, fig. 4.

Crania modesta White and St. John, Trans. Chic. Acad. Sci., I, p. 118, (1868); White, 13th Rep. Ind. St. Geol., p. 121, pl. xxxv, f. 9, pl. xxxvi, f. 5, (1884).

Crania carbonaria Whitfield, Ann. N. Y. Acad. Sci., II, p. 229, (1892); Geol. Ohio, VII, p. 484, pl. XI, ff. 11, 12, (1895); etc.

Whitfield's description: "Shell small, none of the specimens observed exceeding three-eighths of an inch in diameter; suborbicular in outline, or varied in form by the outline of the objects to which they are attached. Free valve depressed convex, marked by a few concentric lines of growth; attached valve thin, but with a slightly thickened margin. Posterior muscular impressions large and submarginal, the others being nearly central and forming a small elevation just posterior to the middle of the valve." Measurements: Diameter, 9 mm.; height, 3 mm.

Range and distribution: Upper Coal Measures; Kansas City, Eudora, Grand Summit.

The specimens are attached to *Productus semireticulatus*, and the convex valves reproduce the markings of the host. One near the front of the shell shows the large radiating costæ quite plainly, while on the reticulated area shows both the radiating and concentric marks, while still another situated partly on the reticulated area shows the reticulated markings on one side and only the radiating on the other. Two specimens on worn shells show none of the markings of the host. The attached valves are thin, but show the muscular markings quite distinctly.

DERBYA.

Waagen, Pal. Indica, ser. XIII, I, pp. 576, 591, (1884).
Hall and Clarke, Pal. N. Y., VIII, pt. I, p. 261, (1892); 11th Ann. Rep. N. Y. St. Geol., p. 286, (1895), for 1894.

The genus *Derbya* has been divided by Waagen into groups, but I see no sufficient reason for such divisions for our American shells.

A considerable stress has been laid upon the nature of the hinge area in the different American species of the genus. I

find, upon examination of the Kansas Coal Measures forms, that the length of the hinge and the height of the area, as well as the relative convexity and bilobation of the brachial valve, are quite variable. The diverging lines which pass from the apex of the deltidium obliquely to the hinge line, nearly bisecting the area, are common to all the well-preserved specimens from the Coal Measures that I have examined. The same is true of the vertical striation of the area between these lines.

The area between the diverging lines is composed of two large dental plates not entirely united to the remainder of the hinge area. This is clearly shown by specimens with the area crushed. In such cases it almost always breaks along these lines with smooth fracture.

They also present some striking peculiarities in the surface markings of the shell. Upon a cursory examination there seem to be two distinct kinds of surface markings—those shells in which the striæ are small, somewhat rugose, separated by wider channels; and those with more rounded, crowded, rugose ridges with narrow valleys. Upon examination of several specimens of different species, the difference in these respects is found to be due, either to weathering or to wearing previous to fossilization. The striæ are rounded, thicker at the top of the ridge than at the base, furrows and ridges crossed by numerous fine, concentric lamellæ, which are raised into rugæ on the ridges and nearly imperceptible in the furrows. In the slightly worn specimens a portion of the top and sides of the ridges are worn away, making them appear keel-shaped, with wider furrows. The wearing of the shell does not seem to diminish the roughness of the striæ very perceptibly, while it seems to bring out the concentric markings of the furrows more distinctly.

Derbya bennetti. Plate VIII, figs. 8-8c.

Derbya bennetti Hall and Clarke, Pal. N. Y., VIII, pt. 1, pp. 263, 348, pl. XI-A, ff. 34-39, (1892); Ann. Rep. St. Geol. N. Y. 1894, p. 347, pl. v, ff. 3-8, (1895).

Original description: "Shell subtrihedral in general aspect, quite irregular in its growth. Hinge line short, its extremities on both valves being auriculate. Pedicle valve much more irregular in growth, sometimes retaining the scar of attachment at its apex. Cardinal area usually high, narrow, erect or slightly incurved, and frequently distorted; delthyrium curved. General surface of the valve depressed, convex in the middle, sometimes rapidly sloping in all directions, at others concave in the umbonal region; as a rule very unsymmetrical. The brachial valve is deep, more regularly convex, and has a full rounded umbo and a conspicuous median sinus. On the interior the pedicle valve bears an extremely high median septum which is united with the dental ridges near the apex. The cardinal process is high, erect and deeply bilobed, each of its apophyses being strongly grooved on its posterior face. Other internal characters unknown. The surface of both valves is covered by fine, elevated, thread-like striae, increasing very slowly by intercalation. The edges of these striae bear numerous minute asperities which may be due to the crossing of fine concentric lines. Irregular lines and wrinkles of growth are abundant near the margins."

Range and distribution: Upper Coal Measures; Lecompton. Mr. Bennett informs me that the type specimen which was sent Professor Hall, and upon which the description was based, was from near St. Joseph, Mo., instead of Kansas City.

Hall and Clarke described another species from Kansas City (*D. broadheadi*) with very much the same characteristics as the species given above. Among the specimens before me I am unable to separate the two satisfactorily, and believe that they will have to be united under a single species. *D. broadheadi*, in some of its forms, approaches *D. affinis* so closely, being so slightly bilobate, that the two forms seem to merge completely, as well as the characters of the beaks, which also approach each

other closely, so that it would be better to leave *D. bennetti* for the species, should the two be found identical. *D. broadheadi* may, perhaps, be varietally distinct from *D. bennetti*, but our material would hardly seem to indicate it.

Derbya cymbula. Plate XII, fig. 10.

Derbya cymbula Hall and Clarke, Pal. N. Y., VIII, pt. 1, p. 348, pl. XI-B, ff. 2, 3, (1892); Rep. N. Y. St. Geol. 1894, p. 348, pl. VI, ff. 1, 2, (1895).

Original description (in part): "Shell large; marginal outline transversely subelliptical. Hinge line straight, its length being about two-thirds the greatest diameter of the shell. On the pedicle valve the cardinal area is high, its base being one-third longer than its sides, and it may be somewhat unsymmetrical from distortion. Its surface is finely striated both longitudinally and transversely, and is divided into an outer and inner portion by two lines diverging from the apex and meeting the hinge line half way between its extremities and the edges of the deltidium. Deltidium broad at the base, rapidly narrowing for one-third its length, thence tapering more gradually to the apex; its surface is marked by a well-defined median groove for its entire extent. The surface of the valve is elevated in the umbonal region, and slopes irregularly to a low depression over the pallial region and about the margins. The brachial valve is broadly concave at the umbo, but rapidly becomes regularly convex, the greatest convexity being in the middle of the valve, whence it slopes almost equally in all directions. There is no tendency to irregular growth in this valve. Surface covered with numerous fine, sometimes irregular striæ, increasing by implanation. Over the umbonal and pallial regions these striæ are of about equal size, but above the margin the tendency to fasciculate arrangement is more apparent." The mesial septum of the pedicle valve very high, attach to the teeth, which extend to the top of the deltidium for about a third of its height, and extending about a third of the distance to the front of the shell, highest at the anterior end. Teeth of the brachial valve narrow, extending well into the opposite valve, where they curve inward, locking around

a process from the cardinal process of the brachial valve. Cardinal process of the brachial valve large, elongated, and expanded laterally, divided by a deep sinus at the summit, each lateral lobe having a very deep groove on its posterior side extending nearly its entire length. The cardinal process is very strongly recurved backwards, fitting closely into the deltidium of opposite valve, and backing the process on either side are two high plates extending well back into the visceral cavity, and attached to the brachial valve. Measurements: Length (hinge to front), 45 mm.; width, 58 mm.; convexity (maximum), 39 mm.; length of hinge, 35 mm.; height of area, 13 mm.

Range and distribution: Upper Coal Measures, and base of Permian? Kansas City, Cambridge, Cowley county.

This species can be easily recognized and separated from the preceding by its larger size, relatively lower beak (as a rule), and its non-bilobate brachial valve. Hall and Clarke have described another species from Kansas City, *D. affinis*, which is, to say the least, exceedingly closely related to *D. cymbula*, the principal difference being in the location of the point of greatest convexity in the pedicle valve and smaller size. So far as the topography of the pedicle valve is concerned in this genus, except, perhaps, the relative length and height of the hinge area, it seems to be governed largely by the immediate surroundings of the individual. The location of the point of greatest convexity, and, even as to whether or not there is a concavity in the valve, vary greatly in those species which have a convex or raised valve. In the specimens of *D. cymbula* in our collection I find no two with the same topography of the pedicle valve, and they vary from regularly convex from the apex of the beak to the extreme front margin to irregularly concave over the same area. Some are regular in their growth, while others are very irregular. It seems to me that the specimens described as *D. affinis* are young or stunted forms of *D. cymbula*, for it is almost impossible to separate the two forms at all, if we possess the specimens of the two species, and we have specimens that answer the descriptions very closely.

Derbya crassa. Plate VIII, figs. 11, 11b.

Orthis arachnoides Roemer (non Phillips), Kreidebildung Texas, p. 89, pl. xi, f. 9, (1852); etc.

Orthisina crassa Meek and Hayden, Proc. Acad. Nat. Sci. Phil. 1858, p. 261.

Orthis lasallensis McChesney, Desc. New Pal. Foss., p. 32, (1860); *ibid.*, pl. i, f. 6, (1865).

Orthis richmonda McChesney, *ibid.*, p. 32; also pl. i, f. 5.

Hemipronites crassus Meek and Hayden, Pal. Upp. Mo., Smiths. Cont. Knowl., xiv, 172, p. 26, pl. i, f. 7, (1864); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 174, pl. v, f. 10, pl. viii, f. 1, (1872); etc.

Orthis crenistria Geinitz (non Phillips), Carb. u. Dyas in Neb., p. 46, pl. iii, ff. 20, 21, (1866).

Hemipronites lasallensis McChesney, Trans. Chic. Acad. Sci., i, p. 28, pl. i, f. 6, (1868).

Hemipronites richmonda McChesney, *ibid.*, p. 28, pl. i, f. 5.

Hemipronites crenistria White, Wheeler's Expl. Surv. West. 100 Mer., iv, p. 124, pl. x, f. 9, (1875).

Streptorhynchus richmondi Hall, 2d Ann. Rep. N. Y. St. Geol., pl. xl, ff. 10, 11, (1883).

Derbya crassa Waagen, Pal. Indica. ser. xiii, i, p. 592, (1884); etc.

Meek's description (in part) : "Shell varying from nearly circular to truncato-subcircular, or transversely suboblong, generally wider than long, varying from compressed to distinctly convex; hinge margin equaling or shorter than the greatest breadth of the valves, rectangular, or sometimes more or rather less than rectangular, at the extremities; anterior outline forming a more or less regular semicircular curve. Dorsal valve always convex, sometimes very distinctly so, the greatest convexity being near the middle; beak not distinct from the cardinal margin. Ventral valve varying in convexity at the umbo, sometimes very prominent, and occasionally distorted there; less convex, flattened, or not unfrequently a little concave, around near the front; area varying in height in proportion to the elevation to the beak, and either flat or with the beak a little arched, usually rather distinctly striated; its closed fissure varying in the proportions of height and breadth with the greater or less elevation of the beak; interior always provided with a prominent mesial septum extending from the beak forward to near the middle of the valve; surface on both valves marked by numerous strong, raised radiating striæ of unequal size, there being generally one or several smaller ones between each two of the larger; crossing the whole are also numerous fine, regular con-

centric striæ, more or less defined both between and upon the radiating striæ, to which latter they impart a neatly crenate appearance." The dental lamellæ are narrow and thin in younger specimens, more rounded and heavier in old ones, extending the entire length of the deltidium and projecting beyond the hinge margin. Muscular impressious of this valve are usually indistinct in young specimens, but are well impressed in the old, thick-shelled individuals, varying from nearly circular to linear-elliptical in outline, in some cases extending two-thirds the distance to the front of the shell, though as a rule it only covers the central portion of the posterior half of the valve. There is a faint mesial ridge in the posterior portion of the brachial valve, extending about half way to the front in old specimens. The muscular scar is nearly circular and marked by longitudinal ridges extending about half way to the front and sides of the valve. Cardinal process moderately prominent, bifid at its apex, and possessing a lateral lobe on each of the supporting plates near their anterior portions. Measurements: Length, 25 mm.; width, 31 mm.; length of hinge, 20 mm.

Range and distribution: Upper and Lower Coal Measures; Fort Scott, Kansas City, Lawrence, Topeka.

This little depressed or moderately convex shell is very easily distinguished from the other species by its smaller size, moderately low hinge area, and thick, or sometimes thin, shell.

Derbya keokuk. Plate VIII, fig. 13; text fig. 3, E.

Orthis crenistria Yandall and Shumard, Cont. Geol. Ky., pp. 19, 21, (1847).

Orthis keokuk Hall, Geol. Surv. Iowa, I, pt. II, p. 640, pl. XIX, f. 5, (1858); etc.

Streptorhynchus keokuk Hall, 2d Ann. Rep. N. Y. St. Geol., pl. XLI, ff. 1-3, (1883).

Streptorhynchus crenistria Walcott, Mon. U. S. Geol. Surv., VIII, p. 279, pl. XVIII, f. 14, (1884).

Derbya keokuk Hall and Clarke, Pal. N. Y., VIII, pt. I, p. 262, pl. XI, ff. 1-3, (1892).

? *Orthis umbraculum* Owen (non Schlotheim), Geol. Surv. Wis., Iowa, and Minn., pl. v, f. 11, (1852).

? *Orthis robusta* Hall, Geol. Surv. Iowa, I, pt. II, p. 743, pl. XXVIII, f. 5, (1858).

? *Streptorhynchus robusta* Hall, 2d Ann. Rep. N. Y. St. Geol., pl. XL, ff. 12-17, (1883).

? *Derbya robusta* Waagen, Pal. Indica, ser. XIII, I, p. 592, (1884); Hall and Clarke, Pal. N. Y., VIII, pt. I, p. 262, pl. X, ff. 12-17, pl. XI B, ff. 7, 8, (1892).

Hall's description (in part): "Shell resupinate, somewhat broadly semielliptical in outline, depressed hemispheric; cardinal extremities rounded. Ventral valve flat or slightly concave; area low, extending to the hinge extremities; foramen forming an equilateral triangle, closed by a pseudo-deltidium. Dorsal valve broadly convex, the greatest convexity a little above the middle, and often equal to one-third the width of the shell. Surface marked by even rounded radiating striæ, which increase by bifurcation and interstitial addition, and are crossed by fine concentric striæ." Interior of pedicle valve marked by large, deep, semicircular impression, with raised irregular periphery, moderately high mesial septum extending to the front of the muscular impression, which is marked by irregular radiating ridges and furrows of variable size. Area of the valve outside of the impression finely pitted to the edge, where the striations of a new layer of shell form a radiate periphery. Hinge area possessing the usual diverging lines, within which are vertical striæ. Entire hinge area marked by horizontal lines or lamellæ.

Range and distribution: Upper Coal Measures to Permian; Kansas City, Carbondale, Topeka, Cambridge, Cowley county.

This shell agrees in many respects with the description of *D. keokuk* and in others with *D. robusta*. If the previous remarks on surface markings of the valves and the hinge area hold good for the genus, there is little doubt that the two will prove synonymous. The fact that our Coal Measures shells have the outline and also the interior of the pedicle valve almost exactly as *D. robusta* and, where the shells are not worn, the markings of *D. keokuk*, would seem to indicate that they are the same. Specimens broken from limestone always leave a portion of the shell attached to the stone, which makes the specimens look like those with the markings ascribed to *D. robusta*. Some of our specimens differ from *D. keokuk* in that the hinge is hardly as short as ascribed to that species, though some of them approach it quite closely. However, the length of the hinge is not a very constant character in any species of the genus that I have examined. The front and lateral margins expand

much more rapidly than does the hinge after the shell reaches middle age.

Professor Clarke writes me concerning these two species that "There can be no question of the close similarity of these two species, and *D. robusta* was founded upon a single specimen remarkable for the convexity of its brachial valve and its sub-circular outline, but I recollect distinctly that we had a comparatively meager representation of this species from the Coal Measures. I have little doubt that one represents the continuation of the other specific type, perhaps with some slight variation, and that the genus attained its culminant variability of expression in the Coal Measures."

The relative convexity of the brachial valve varies to a considerable degree, though the most of them are very convex. Considering these points as a whole, the only grounds left, so far as I can see, for *D. robusta* to rest upon, are its relatively little longer hinge and greater convexity of the pedicle valve, both of which are variable characters, and the two species approach each other very closely in this respect. However, it may be sufficient to distinguish them, though I think that they will prove to be the same.

MEEKELLA.

White and St. John, Trans. Chic. Acad. Sci. I, p. 120, ff. 4-6, (1868).

Hall and Clarke, Pal. N. Y. VIII, pt. I, p. 264 (1892); etc.

Meekella striatocostata. Plate XII, figs. 9-9c.

Plicatula striatocostata Cox, Geol. Surv. Ky., III, pt. I, p. 568, pl. VIII, f. 7, (1857).

Orthisina shumardianus Swallow, Trans. St. L. Acad. Sci., I, p. 183, (1858).

Orthisina missouriensis Swallow, *ibid.*, p. 219: etc.

Orthis striatocostata Geinitz, Carb. u. Dyas in Neb., p. 48, pl. III, ff. 22-24, (1866).

Meekella striatocostata White and St. John, Trans. Chic. Acad. Sci., pp. 129, 122, ff. 4-6 (1868); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 175, pl. v, f. 12, (1872); etc.

Streptorhynchus (Meekella) striatocostata Hall, 2d Ann. Rep. N. Y. St. Geol., pl. XL, ff. 18-23, (1883).

Meek's description (in part): "Shell trigonal-subglobose, becoming very convex with age, generally a little longer than wide; hinge line very much shorter than the breadth of the valves. Dorsal valve convex, the greatest prominence near the

umbo, thence rounding over to the front, being usually somewhat flattened over the central and anterior regions, but without any mesial sinus; beak strongly incurved, and with its most prominent part sometimes projecting a little beyond the hinge line, but in others flattened, and with its immediate apex nearly always terminating at the margin of the hinge; posterior lateral margins laterally compressed and converging toward the umbo at nearly a right angle; surface ornamented by about ten to thirteen large, radiating, more or less angular, simple or rarely bifurcating plications, which are themselves (as well as the furrows between) marked by fine but distinct radiating striæ, which, toward the front, instead of continuing parallel to the furrows and plications, converge forward on each side of the latter so as to intersect along the crests of the same at acute angles. Crossing all of these, there are usually toward the front and lateral margins a few strong zigzag marks of growth. Ventral valve more convex than the other, the greatest convexity being at or near the beak, which is elevated and usually more or less distorted, being sometimes twisted to one side, and in other examples straight or somewhat arched backward; cardinal area narrow transversely, but proportionally high, being often distinctly higher than wide, but well defined, and usually finely striated transversely and vertically, either flat or more or less arched backwards; false deltidium closing the fissure, narrow, and provided with a slender, rounded, prominent mesial ridge extending to the apex of the beak; surface as in the other valve." The two dental lamellæ of the pedicle valve extend from the apex of the beak to the hinge and forward about half the distance to the front of the shell, dividing the beak into three nearly equal compartments. The cardinal process of the brachial valve is curved forward and upward, long, and thickened at the extremity. Measurements of average specimen: Length, 23 mm.; width, 29 mm.; convexity, 18 mm.; length of hinge, 14 mm.; height of cardinal area, 9 mm.

Range and distribution: Upper and Lower Coal Measures; Fort Scott, Olathe, Kansas City, Eudora, Lawrence, Lecom-

ton, Topeka, Beaumont, Grand Summit. Widely distributed, but moderately rare throughout the Coal Measures and base of the Permian. Abundant near the base of the Permian.

The individual variation of this species is very great. In most of the larger specimens the width is considerable greater than the length as indicated by the above measurements. The distinctness of the plications varies with age, being very faint in young specimens and very distinct and sharp in old ones. Young specimens are much less convex and comparatively longer than the old ones. The comparative height of the cardinal area varies greatly, some specimens having the beak only moderately elevated.

CHONETES.

Fisher and Waldheim, *Oryct. du Gouv. de Moscou*, pt. II, p. 134, pl. XXVI, ff. 8, 9, (1837).
Hall and Clarke, *Pal. N. Y.*, VIII, pt. I, *Brachiopoda*, p. 363, pl. XV-a, ff. 11-13, pl. XVI, ff. 1-11, 14, 15, 18-27, 32-36, 39, 43, 44, 48, (1892).

Prior to 1844 species belonging to this genus were described under the generic terms *Pecten*, *Hysterolythos*, *Terebratulites*, *Leptæna*, *Orthis*, *Spirifera*, *Strophomena*, *Productus*, and *Delthyris*. Since that time the genus has been better understood.

After giving the generic description (*loc. cit.*), Hall and Clarke say of the genus: "*Chonetes* is remarkable for the persistence of its characters. From its appearance in the middle of the Silurian to its disappearance in the Permian, this type of structure has been maintained with few essential modifications. On account of this stability in its features it is difficult to establish any satisfactory subdivision of its members, especially since the genus has been left more compact by the recent elimination of some of its more aberrant forms."

The following is a summary of the sections of the genus, as compiled by them, now accepted by leading authorities; these sections are mechanical and arbitrary:

- I.—*Concentrica*, those with concentric folds or undulations, like *C. concentrica*.
- II.—*Striata*, those with more than thirty radiating striae.
- III.—*Plicosa*, those with less than thirty striae.
- IV.—*Rugosa*, those with rugose radiating striae.
- V.—*Grandicostata*, those with high, strong radiating costae.
- VI.—*Læves*, those with smooth shells.

All of our Kansas shells fall within two of these sections, the second and the sixth. The *Striatæ* include: *C. mesolobus*, *vernulianus*, and *granulifer*. The *Læves* include *C. glaber* Gein.

Chonetes glaber. Plate IX, fig. 2.

Chonetes glaber Geinitz, Carb. u. Dyas in Neb., p. 60, pl. iv, ff. 15-18, (1866); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 171, pl. xiv, f. 10, pl. viii, ff. 8-8c.

Chonetes geinitziana Waagen, Pal. Indica, ser. XIII, vol. I, p. 261, (1884).

Chonetes levis Keyes, Proc. Acad. Nat. Sci. Phil., p. 229, pl. xii, f. 3; Geol. Surv. Mo., v, p. 55, pl. xxxvii, f. 5, (1895).

Chonetes geinitzianus Miller, N. Amer. Geol. and Pal., p. 339, (1889).

Chonetes glaber Schuchert, Bull. No. 87, U. S. Geol. Surv., p. 74, (1897).

Meek's description: "Shell thin; transversely subsemicircular, length being more than half the breadth; hinge line a little longer than the greatest breadth of the valves, at any point farther forward; lateral extremities abruptly pointed and sometimes slightly recurved; anterior and anterior lateral margins, forming a semicircular curve in outline, excepting that the former is generally faintly sinuous in the middle; lateral margins curving abruptly outwards just before intersecting the hinge extremities. Pedicle or larger valve moderately convex, the most gibbous part being in the form of two broad, rounded, undefined prominences, which diverge from the beaks to the anterior lateral regions, leaving a rather broad, rounded, deep mesial sinus between them, extending nearly to the beak, but widening and deepening rather rapidly to the front; outside of these prominences the posterior lateral regions are more or less compressed; beak small, compressed, slightly arched, and scarcely projecting beyond the cardinal margin; area narrow, inclined obliquely backward; its fissure small, nearly semicircular and partially closed by the cardinal process of the other valve; cardinal margin armed on each side of the beak by four or five slender, moderately long, oblique spines, with sometimes remains of one or two much smaller rudimentary additional ones near the beak; cardinal teeth compressed, their longer diameter ranging nearly parallel to the hinge line—as seen under a strong lens, finely striated on the outside, at right angles to their length. Interior, excepting the regions of the

muscular impressions, with numerous, rather distinct granules, arranged in radiating rows—immediately within the fissure, provided with a short, rather prominent, compressed ridge ranging at right angles to the hinge; muscular impressions very obscure.

“Dorsal or concave valve, following nearly the curve of the other; area of about the same size as in the dorsal [ventral] valve, inclined forward from the hinge; cardinal process small, not very prominent, and, as seen on the outer side, somewhat trilobate, the middle lobe or ridge being divided by a linear sulcus; socket ridges very oblique; interior granulated as in the other valve. A very small, obscure linear ridge occupies the middle of the valve, without, however, extending up to the hinge; muscular impressions unknown.

“Surface of both valves nearly smooth, but showing obscure, concentric marks of growth. In some conditions of weathering there is a faint appearance of radiating markings, but this is due rather to the structure of the shell and not to proper external lines. When a single one of the thin valves is cleaned, and examined by the aid of a good magnifier and a strong transmitted light, very scattering punctures or pores are seen arranged in quincunx, and passing obliquely through the shell. These appear to have been connected with minute tubular spines, arranged over the whole surface, during the life of the animal.”

Range and distribution: Upper Coal Measures; Topeka.

Chonetes granulifer. Plate IX, figs. 1-1c.

Chonetes granulifera Owen, Geol. Rep. Iowa, Wis., and Minn., p. 583, tab. v, f. 12, (1852); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 171, pl. iv, f. 19, pl. viii, f. 8, (1872); etc.

Chonetes smithii Norwood and Pratten, Jour. Acad. Nat. Sci. Phil., III, p. 24, pl. II, f. 2, (1854); etc.

Chonetes mucronata Meek and Hayden, Proc. Acad. Nat. Sci. Phil., p. 262, (1858); Pal. Upp. Mo., p. 22, pl. I, f. 5, (1864); etc.

Chonetes granuliferus Beecher, Am. Jour. Sci., 3d ser., xli, p. 357, pl. xvii, f. 15, (1891).

Chonetes granulifer Schuchert, Bull. 87, U. S. Geol. Surv., (1897).

Meek's description: “Shell attaining a rather large size, semicircular in outline, having its greatest breadth on the hinge line, which often terminates in extended mucronate ears.

Larger or ventral valve moderately convex, the greatest convexity being in the central region, or rather on each side of it, as there is usually a broad, shallow, mesial depression; ears and lateral regions compressed; front somewhat straightened along the middle; beak small, rather compressed, a little arched, and scarcely projecting beyond the cardinal margin, which is provided with from seven to eleven oblique spines on each side of the beak; area rather narrow, ranging nearly parallel with the general plane of the valves, its fissure broad, partly closed by the arching deltidium; hinge teeth well developed, compressed, and minutely striated; interior with impressions of cardinal muscles subovate, diverging, attenuate above; adductor muscular scars small, narrow-subelliptical; mesial ridge prominent near the beak, much lower, and nearly extending forward to the central region; most of the interior occupied by granules, which are largest and most crowded on a narrow space around and near the front and lateral margins; but around the immediate margin they are much smaller, and arranged in distinct radiating rows. Dorsal or smaller valve following nearly the curve of the other, the beak and central regions being concave, and the ears flat; area well developed, but narrower than in the other valve; bifid cardinal process and mesial prominence, nearly or quite closing the fissure of the other valve. From the base of this process there are extending, on the inner side of the valve five radiating ridges, two of which pass obliquely outward, forming the inner margins of the dental sockets, while a third mesial one extends at right angles to the hinge, a little more than half way to the front; the other two are much shorter, oblique, and occupy intermediate positions between the middle and two latter ones; granules of the interior as in the other valve. Surface of both valves ornamented with a few subimbricating marks of growth, crossed by very fine, obscure, regularly and closely arranged radiating striæ, of which about 150 can be counted around the free border of a large individual, where about eight or nine of them may be counted in the space of one line."

Measurements : Length, 15 mm. ; width, 28 mm. ; convexity, 5 mm.

Range and distribution : Common throughout the Coal Measures ; from Kansas City to Topeka and Manhattan, Grand Summit, etc.

There are two specimens from Grand Summit, Kan., which show a remarkable variation from the average specimens of this species. In these the ears are elevated, distinctly and deeply notched, the lateral margins curving inward, then, making an acute angle, are directed outward and backward to the hinge tip. In all other respects, so far as can be determined from the exterior appearance, they are exactly like the above species. Two other specimens from eastern Kansas also show this remarkable characteristic, though in a less pronounced manner.

This species differs from the preceding in possessing radiating striæ on the surface of both valves and a thicker shell ; it is more broad, and the ridges on either side of the mesial sinus are less prominent.

Chonetes mesolobus. Plate IX, figs. 3, 3b.

Chonetes mesolobus Norwood and Pratten, Jour. Acad. Nat. Sci. Phil., III, p. 27, pl. II, f. 7, (1854) ; White, Wheeler's Geog. Surv. West 100 Mer., IV, p. 123, pl. IX, f. 7, (1875) ; etc.

Shell small, broader than long, moderately convex, transversely subelliptical or subquadrate in outline ; hinge line a little more than equal to the greatest width of the shell. Mesial sinus extending from near the beak, broadening and deepening to the anterior margin, bifurcating near its origin and enclosing a mesial fold. Anterior margin nearly straight or slightly sinuate ; antero-lateral margin sharply rounded, then passing nearly in a slightly convex line directly backwards to the hinge line, making a slight outward turn before joining it. Cardinal area narrow, foramen broad and shallow, nearly filled by the small, trifid process of the other valve. Surface ornamented with fine radiating striæ, rather coarsely and sparsely punctate. Four or five small spines on each side of the beak point obliquely backward from the hinge line. The markings on the interior of the ventral valve are rather similar to the preceding.

The mesial septum is apparently short and thick. Two small, sharp elevations mark the location of the double sinus on the exterior. The adductor scars are located close beneath the beak, oblique and ovate-elliptical in outline, and rather deeply impressed. The pustules are arranged as in *C. granulifer*, except that they are not always arranged in radiating rows around the periphery, though they are in some specimens. The interior of the dorsal valve is different from the rest of our species. The sinus dividing the extremity of the deltidial process splits into two, making the end of the process appear trifid. The radiating ridges are nearly as in the preceding species, except that the middle pair are recurved, forward and inward, enclosing a depression resembling a muscular marking. The mesial septum extends fully half the length of the shell, ending in a slight enlargement. On either half of the valve, corresponding to the folds of the other valve, are rather crescent-shaped brachial areas, the outer edges of which are beset with large, rather long, pustules. Pustules of the remainder of the surface as in the other valve. In the anterior half of the shell is a deep double sinus, enclosing a mesial fold, corresponding to the sinus and fold of the ventral valve.

Range and distribution: Lower Coal Measures; Fort Scott and Bronson, Bourbon county.

The features which distinguish this species from the remainder herein described are the mesial fold in the ventral valve and the short hinge line. Its range is restricted to the lower part of the Coal Measures.

Chonetes verneuillianus. Plate IX, figs. 4-4c.

Chonetes verneuillianus Norwood and Pratten, Jour. Acad. Nat. Sci. Phil., III, p. 26, pl. II, f. 6, (1854); Newberry, Ives' Rep. Col. Riv. of West, p. 128, (1861); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 170, pl. I, f. 10, (1872); Hall, 2d Rep. N. Y. St. Geol. pl. XLVII, ff. 20, 21, (1883); White, 13th Ann. Rep. St. Geol. Ind., p. 128, pl. XXV, ff. 7, 8, (1884); Hall and Clarke, Pal. N. Y., VIII, pt. I, pl. XVI, ff. 29, 21.

Meek's description (in part): "Shell rather small, varying from subsemicircular to suboblong; hinge line more or less extended beyond the breadth of the valves at any other point; sometimes greatly produced. Ventral valve very convex, with

a deep rounded mesial sinus, starting near the beak and deepening and widening rapidly to the anterior margin, to which it imparts a distinctly sinuous outline, thus dividing the gibbous part of the valve into two prominent rounded lobes or diverging ridges, separate from each other by a broad rounded depression; ears more or less angular, sometimes extended and acutely pointed, slightly arching, and a little reflexed; beak rather prominent and recurved; area moderately developed and common to both valves, but widest in the ventral; foramen wide; cardinal margin provided with four oblique spines on each side of the beak. Dorsal valve following rather nearly the curve of the other, and provided with a mesial ridge corresponding to the sinus of the other valve." The interior of the ventral valve possesses a short, sharp mesial septum extending beneath the umbo; each side of the septum, close under the beak, there is an oval muscular depression, the broader end extending obliquely forward; near the posterior end is a small elliptical scar. Immediately in front of the scars the shell is smooth. Around the visceral cavity are large pustules, while exterior to these, on the periphery of the shell, are smaller ones arranged in radiating order. There is a small, distinct tooth on each side of the foramen. The deltidial process of the dorsal valve is reenforced by five radiating ridges on the interior of the valve, the first pair of which are nearly parallel to the hinge line, but pointing a little forward and disappearing before reaching the margin. Immediately in front of the process, which is somewhat elevated and broad, is a small depression or cavity. The second pair of ridges extend obliquely forward from in front of this cavity. The mesial septum reaches about half way to the front of the shell. On either side of it is the semi-circular brachial area. Pustules on the surface of the valve arranged as in the other valve. "Surface [exterior] of each valve ornamented with about 100 fine, bifurcating, radiating striæ, and sometimes near the front, by a few marks of growth." Length, 9 mm.; width, 15 mm.; convexity, 4 mm.

Range and distribution: Lower and Upper Coal Measures;

Bronson, Bourbon county, Kansas City, Buffalo Mound, Wabunsee county.

This species is easily distinguished by its deep mesial sinus and strong bilobate appearance, together with a long hinge.

PRODUCTUS.

Sowerby, Min. Con., I, p. 153, (1814).
de Koninck, Recher. Anim. Foss., I, p. II, (1847).
Hall, 29th Rep. N. Y. St. Cab. Nat. Hist., p. 245 (1867); Pal. N. Y., IV, p. 146, (1867).
Hall and Clarke, Pal. N. Y., VIII, pt. I, p. 321, (1892); 11th Ann. Rep. N. Y. St. Geol., p. 297, (1894).

This genus has been divided into groups, as follows:

Group I. *Lineati* Waagen. "Surface covered with fine radiating costæ which are rarely spinous and are not crossed by concentric plications or wrinkles. The shells are greatly produced and sometimes the anterior margins of the shells are modified by the development of a fold or sinus. The shells were very fragile and have usually been subject to much distortion in fossilization."⁴

Group II. *Irregulares* Waagen. "Elongate shells very narrow at the beak, mytiliform in outline; mode of growth quite irregular. Surface as in the *Lineati*; spines grouped almost wholly about the cardinal line."⁴

Group III. *Semireticulati* de Verneuil. "The longitudinal ribs are sparsely spinous; surface of visceral disc covered with concentric wrinkles."⁴

Group IV. *Spinosi* de Verneuil. "Surface strongly tuberculose or spinous; not reticulated."⁴

Group V. *Fimbriati* de Koninck. "Surface without radiate striæ or ribs; covered with concentric ridges or plications, bearing rows of small thickly set spines."⁴

Group VI. *Horridi* de Verneuil. "Surface without concentric or radiating plications; pedicle valve with a deep sinus."⁴

Group VII. *Mesolobi* de Koninck. "Surface without radiating or concentric plications except a prominent median rib."⁴

All of our Kansas species come in groups I, III, IV, and V.

I.—*Lineati*: *P. cora* and its varieties.

III.—*Semireticulati*: *P. semireticulatus*, *costatus*, *pertenuis*, *longispinus*.

IV.—*Spinosi*: *P. nebrascensis*.

V.—*Fimbriati*: *P. punctatus*, *symmetricus*.

4. Hall and Clarke, Pal. N. Y., VIII, I, p. 326.

Concerning the synonymy of the American species of *Productus* there is considerable difference of opinion. As far as our Kansas forms are concerned, they have not heretofore been collected and preserved in a manner that indicates the exact range of the different forms, or, indeed, the exact location of the specimens themselves; in fact, if we are to judge from the localities given in paleontological papers, there has been very little if any accurate systematic collecting done in the Coal Measures west of the Mississippi river, except that of Meek in southeastern Nebraska. As a natural result, the range of the different forms is not known, or even the degrees of variation in the same horizon. Under these circumstances, it seems best to be quite conservative in the number of species recognized until further and better work is done; however, I am of the opinion that some of the forms here referred to a single species will, on more careful study of range restrictions, be separated. This is especially true of *P. cora*, though the data at hand will hardly permit of it now.

***Productus cora*.** Plate XI, figs. 1-1f.

Productus cora d'Orbigny, Voy. dans l'Amér. Mér. Pal., p. 55, pl. v, ff. 8-10, (1842); Owen, Geol. Rep. Wis., Iowa, and Minn., pp. 103-106, pl. v, f. 2, (1852); White, 13th Rep. St. Geol. Ind., p. 126, pl. xxvi, ff. 1-3, (1884); etc.

Productus lyelli de Verneuil, Lyell's Travels in North America, II, p. 221, (1845); Dawson, Acad. Geol., p. 219, f. g, (1855).

Productus semireticulatus Hall, Stanberry's Expl. and Surv. Valley Gt. Salt Lake, Utah, p. 411, pl. III, ff. 3, 5.

Productus prattenianus Norwood, Jour. Acad. Nat. Sci. Phil., III, p. 17, f. 10, (1854); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 163, pl. II, f. 5, pl. v, f. 13, pl. VIII, f. 10, (1872); etc.

Productus flemmingi Geinitz (non de Verneuil), Carb. u. Dyas in Neb., p. 53, pl. IV, f. 5, (1866); etc.

Productus calhounianus Geinitz, ibid. (non Swallow).

Meek's description of *Productus prattenianus* (in part): "Shell attaining a medium to large size; breadth generally exceeding the length, especially when the ears are entire; cardinal margin usually somewhat longer than the transverse diameter of the valves at any point farther forward; anterior and anterolateral outline regularly rounded. Ventral valve distinctly and rather evenly convex, with or without a shallow mesial sinus;

umbonal region gibbous; beak incurved, but scarcely passing the hinge margin; ears large, rather compressed, and provided with a few large, strongly defined concentric folds, which ascend a little upon the sloping sides of the umbo and extend more or less along the postero-lateral margins, but never cross the shell; surface ornamented with rather small, regular, rounded costæ or striæ, and armed with stout, erect, long spines, those along the hinge margin are more frequent, larger, directed backward, with an inward curve. Some specimens seem to be nearly destitute of spines. Dorsal valve concave, sometimes a little flattened in the visceral region, and following the curve of the other valve around the front and anterior lateral margins; ears with folds as in the other valve, and each separated from the concave central region by an oblique ridge or prominence; surface without spines, but with radiating striæ, as in the ventral valve, and usually crossed by very obscure concentric wrinkles and a few imbricating marks of growth, particularly near the front and sides; cardinal process small but strongly prominent and bifid, while from its base a slender mesial ridge extends forward to, or a little beyond, the middle." The internal markings of this valve are obscure. Proboscis well developed, bifid, and well produced into the beak of the other valve. Lateral ridges small, straight or curved backward, soon disappearing; adductor scars dim, placed well to the posterior, nearly semicircular in outline; brachial markings indistinct, enlarging and bending to the front at the extremities. A cast of the interior of the pedicle valve shows a narrow, short beak, with a small depression on either side, faint mesial ridge extending across the central portion of the visceral area; adductor scars long and narrow, placed close beside the ridge; exterior to these are the linear markings of the diductors. Anterior marked by fine pittings. Length of fair-sized specimen, 50 mm.; width, 70 mm.

Range and distribution: Upper Coal Measures; Kansas City, Eudora, Lawrence, Lecompton, Topeka, Geary county, Melvern, Osage county.

The size of the costæ in this species is variable, those with

the larger ones possessing the larger and more numerous spines, while those with fine costae seem to be nearly destitute of spines.

The forms of this species with the front margin emarginate are restricted, or at least seem to be, to the base of the Upper Coal Measures, and are for this reason worthy of varietal distinction. There is also a very wide form that is very much less gibbous than the ordinary form, which is likewise restricted to the same rocks as the preceding, and will probably prove varietally distinct from the species. Waagen⁵ suggests that *Productus cora* should be divided into two series of forms, one with, and the other without a mesial sinus in the visceral area. This will hardly hold for our western forms, for those of the form described by Swallow as *P. americanus* and those without the fold characteristic of that form both possess the sinus. The form that is the most common in the Kansas Coal Measures is that described by Norwood as *P. prattenianus*, found abundantly at the Nebraska City, Neb., locality of Meek, and throughout the Kansas Coal Measures.

Productus cora americanus. Plate XI, fig. 2.

Productus americanus Swallow, Trans. St. L. Acad. Sci., II, p. 91, (1863).
XVII-A, ff. 22, 23, (1893).

Productus aequicostatus Hall (non Shumard), Pal. N. Y., VIII, pt. I, pl.

This shell differs from the preceding species in possessing a fold in the anterior portion of the shell, which is less developed anteriorly than the sides, forming a deep sinus in the anterior margin. In the most distinct forms of the variety the shell is sometimes less gibbous and more alate than is true of the species.

Range and distribution: Upper and Lower Coal Measures; Kansas City, Eudora, Anderson county. Seems to be confined to the base of the Upper Coal Measures and to the Lower Coal Measures.

5. Pal. Indica, Salt Range Foss., 676.

Productus semireticulatus. Plate X, figs. 2-2d; text fig. 2, f.

Anomites semireticulatus Martin, Petref. Derb., p. 7, pl. xxxii, ff. 1, 2, pl. xxxiii, f. 4, (1809).

Productus inea d'Orbigny, Voy. dans l'Amér. Mérid. Pal., p. 51, pl. iv, ff. 1-3, (1842); Derby, Bull. Mus. Comp. Zool., iii, p. 280, (1876).

Productus semireticulatus Norwood and Pratten, Jour. Acad. Nat. Sci. Phil., iii, p. 11, (1854); White, 13th Ann. Rep. St. Geol. Ind., p. 125, pl. xxiv, ff. 1-3, (1884); etc.

Productus setigerus Hall, Geol. Surv. Iowa, i, pt. ii, p. 638, pl. xix, f. 3.

Productus setigerus var. *keokuk* Hall, ibid.

Productus martini A. Winchell, Proc. Acad. Nat. Sci. Phil., p. 4, (1863).

Productus magnus Hall and Clarke, Pal. N. Y., viii, pt. i, pl. xvii-A, f. 15, (1892).

Shell large, very convex, broader than long (measured from the hinge to the front); hinge line straight, equal to the greatest width of the shell; cardinal area very narrow but distinct; beak prominent, appressed, barely arching around the hinge line. Pedicle valve much inflated, greatly prolonged anteriorly in old individuals. Beak broadening rapidly from its point at the hinge toward the anterior; ears nearly flat, well defined, separated from inflated portion of the shell by a gentle curve; mesial sinus beginning well toward the beak and continuing to the anterior margin. Surface marked by radiating costæ, and the visceral area is also marked by more or less regular, concentric costæ, giving the shell a semireticulated appearance. Sometimes both sets of striæ extend over the ears, the concentric taking the form of wrinkles, which, together with the bases of stout tubular spines, make the ears appear quite rough. Spines sparsely and irregularly distributed over the costæ of the shell but thickest on the ears; radiating costæ increasing by bifurcation and insertion. The interior of the valve is marked on the ears, anterior and lateral border by a pitted surface. Adductor scars are elongate-elliptical, arborescent, having their anterior extremities raised, situated centrally in the shell. Longitudinal linear lines or folds are present on the outside of these impressions. The dorsal or brachial valve is strongly concave, visceral region nearly flat, in front of which it curves abruptly downward. A slight indistinct mesial fold is present, corresponding to the sinus of the other valve. Ears and surface markings same as in the other valve, except that

there are no spines.* Beak extending back of the hinge, producing a concavity below. Proboscis not visible from exterior of complete specimens, only a minute projection seen fitting into a small notch in the hinge of the other valve. The entire inner surface of the valve coarsely punctate, except the portion occupied by the brachial and adductor markings. Proboscis projecting, obovate in outline, trifid, at the base of which there are three radiating ridges; two high lateral ones, which roll slightly backward, extend nearly to the ears, where they fade out; the third ridge extends directly forward, smaller and sharper than the others, to the anterior portion of the flat surface, where it ends abruptly. Situated about one-third, or less, the distance from the posterior to the front of the flat surface and close to the mesial ridge are the arborescent adductor markings, triangular to elliptical in outline. The brachial markings extend nearly directly outward from the anterior end of the adductors, then bending forward and expanding, approaching very close to the antero-lateral extremity of the flat surface of the valve. The front inner portion of these markings extends forward to the anterior end of the mesial ridge, the posterior portion connecting with the front of the adductor scar. In some specimens the brachial area is finely crinkled, as are some other parts of the surface back of the muscular scars. There are sometimes short, sharp pustules on the front curve of the valve. Length, hinge to front, 40 mm.; width, 58 mm.; convexity, 40 mm.

Range and distribution: Upper Coal Measures; Kansas City, Lawrence, Lecompton, Topeka, Alma, Marysville, etc. Common throughout the Coal Measures of the United States and the world.

Productus costatus. Plate IX, fig. 8; plate X, figs. 1-1c; plate XI, fig. 4.

Productus costatus Sowerby? Min. Con., VI, p. 115, pl. DLX, f. 1, (1827).

Productus costatus de Koninck, Recher. Anim. Foss., pt. I, p. 92, pl. VIII, f. 3, pl. X, f. 3, pl. VII, f. 3, (1847); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 159, pl. VI, f. 6, (1852); Hall and Clarke, Pal. N. Y., VIII, pt. I, pl. XIX, ff. 8-13, (1892); etc.

Productus portlockianus Norwood and Pratten, Jour. Acad. Nat. Sci. Phil., III, p. 15, pl. I, f. 9, (1854).

Productus viminalis White, Proc. Boston Soc. Nat. Hist., IX, p. 29, (1862).

Meek's description (in part) : "Shell of medium size, wider than long, very convex; hinge margins about equaling the greatest breadth of the valves. Pedicle valve exceedingly gibbous, and very strongly incurved, with a deep rounded sinus extending from near the beak to the front, to which it imparts a sinuate outline; umbo prominent and strongly incurved, so as to pass somewhat within the hinge margin; ears well defined, arched and rather distinct from the abrupt swell of the umbo, from which they are sometimes separated by a small ridge or fold. Brachial valve flattened in the visceral region, and more or less abruptly curved or geniculated toward the front and anterior lateral margins, the former of which usually shows a small mesial ridge. Surface of both valves ornamented with distinct, rather unequal, depressed and rounding radiating costæ, which sometimes bifurcate, or, in other instances, two or more of them coalesce in front of the visceral portion, to form a larger one; crossing all of these, on the visceral region, are numerous, well-defined, concentric wrinkles, producing a distinct reticulated appearance, while the whole surface of the ventral valve is sometimes provided with a few scattering, rather stout, erect spines, somewhat regularly arranged in quincunx. Sometimes nearly all the spines, excepting those on the lateral regions, apparently wanting." The internal markings of the ventral valve consist of long, narrow, arborescent adductor scars mesially situated along the vaulted part of the shell, with, exterior to these, the long linear folds, or line-like diductor scars. The beak, as shown in a cast, is quite pointed, possessing a depression on either side running obliquely backward, near the posterior end of which there is an elevation, in front of which the pit is deeper than back of it. Above this depression is a rounded ridge on each side of the mesial sinus. The proboscis of the dorsal valve extends beyond the hinge line, and is backed by three radiating ridges, one of which extends directly forward to the front of the flattened area, rounded, not prominent; one extends antero-laterally on each side of the mesian ridge, running nearly outward until the edge is approached, when it curves forward, joining the border

of the flattened area, and fades out. Adductor scars moderately small, elliptical in outline, placed longitudinally and close to the median ridge, a little anterior to the lateral ridges. Brachial markings not prominent and generally indistinct, extending outward from the anterior end of the adductor scars, curving forward and ending near the antero-lateral portion of the flattened area. Other internal markings unknown. Length, 20 mm.; width, 35 mm.; convexity, 33 mm.

Range and distribution: Upper Coal Measures; Kansas City, Turner, Wyandotte county, Lawrence, Topeka, Wabaunsee county. Common throughout the Coal Measures and lower portion of the Permian.

This species differs from the previous in being smaller, having a more distinct mesial sinus, ears separated from the body of the shell by a ridge which generally bears spines and unequal costæ on the anterior slope.

The markings of this shell vary considerably in different individuals. They are not so distinct as those of a Russian example in the collection, and the shell is smaller; though the ridge separating the ear from the shell is present and spinous, it is not nearly so pronounced as in the Russian specimen.

Productus longispinus? Plate IX, figs. 9-9d.

Productus longispinus Sowerby? Min. Con., I, p. 154, pl. LXVIII, f. 1, (1814).

Productus longispinus Salter, Quart. Jour. Geol. Soc. Lond., XVII, p. 64, pl. IV, f. 2, (1861); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 161, pl. VI, f. 7, pl. VIII, f. 6, (1872); etc.

Productus flemmingi Roemer (non deKoninck), Kreidebildung Texas, p. 89, pl. XI, f. 8, (1852); etc.

Productus splendens Norwood and Pratten, Jour. Acad. Nat. Sci. Phil., III, p. 11, pl. I, f. 5, (1854); etc.

Productus wabashensis Norwood and Pratten, *ibid.*

Productus orbignyans Geinitz (? non de Koninck), Carb. u. Dyas in Neb., p. 56, pl. IV, ff. 8-11, (1866).

Productus horridus Geinitz, *ibid.*, f. 7.

Meek's description (in part): "Shell small, thin, wider than long; hinge line generally longer than the transverse diameter of the valves at any point farther forward, and terminating in more or less distinct, rather vaulted, and often reflexed ears; anterior and anterior-lateral outlines approaching a semicircu-

lar curve, but the middle of the front is generally rather distinctly sinuous. Ventral valve gibbous, the greatest convexity being usually behind the middle, and the curve to the beak more rapid than to the front, provided with rather deep mesial sinus; posterior lateral slopes descending nearly vertically to the ears; umbonal region moderately prominent, and usually projecting rather distinctly beyond the hinge, as seen in looking down upon the shell when lying with the dorsal valve beneath; beak small, strongly curved, but scarcely passing beyond the cardinal margin; surface ornamented with generally rather obscure, somewhat variable radiating costæ, which are often obsolete in the umbonal region, or, in some examples, over much of the valve farther forward, in other specimens quite distinct to the beak, sometimes bifurcating, and in other instances coalescing to form larger, faintly defined ribs in front; fine, indistinct marks of growth are also sometimes seen, and occasionally very obscure traces of small, concentric wrinkles may be observed near the beak; spines stout, erect, long, scattering, and arranged in quincunx. Ventral valve distinctly concave, or following nearly the curve of the other, and provided with a small mesial ridge corresponding with the sinus of the latter; surface marked as in the other valve, but apparently always without spines." Proboscis short, trilobate; two ridges extend laterally from its base nearly parallel to the hinge line, until the border of the visceral region is reached, where they bend abruptly forward, and in very old individuals form a ridge entirely around the visceral and brachial cavity, but in many adult specimens it fades out before it reaches the front side of this cavity; the lateral borders of the shell are often striated from this ridge to the margin; mesial ridge faint, extending nearly to the front of the viscerobrachial area. Adductor scars small, not prominent, ovate, placed close beside the mesial ridge, well to the back of the shell, directed obliquely forward; directly in front of these the brachial markings extend toward the antero-lateral margin of the brachial area, near which they enlarge; in front of these the surface of the valve is marked by many or few (according to the age of the shell)

spinous projections; the remainder of the surface of the valve is smooth. Length, 11 mm.; width, 16 mm.; convexity, 10 mm.

Range and distribution: Upper Coal Measures; Kansas City and Turner, Wyandotte county, Eudora, Lawrence, Lecompton, Topeka, Wabaunsee county. Common or abundant throughout the Coal Measures of the state.

This species is easily distinguished from the preceding by its smaller size, fainter surface markings, longer hinge, and in the shell being more transverse in appearance, as well as having no fold separating the ears from the umbo. There is also great difference in the internal markings of the two, as can be seen by referring to the plate.

This species is quite variable in the distinctness of its markings, spines, distinctness of the mesial sinus, and size. The internal markings vary greatly with age, the very old specimens presenting the marginal ridge surrounding the visceral and brachial areas, which forms the generic characters of *Marginites*; but I am inclined to think that characters that are only developed in aged specimens are not of generic value in the brachiopods.

***Productus pertenuis*.** Plate IX, figs. 5-5c.

Productus canerini Geinitz, Carb. u. Dyas in Neb., p. 54, tab. iv, ff. 6 a-d, (1866).

Productus pertenuis Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 164, pl. I, ff. 14a-c, pl. VIII, ff. 9a-d, (1872); Drake, Proc. Am. Phil. Soc., xxxvi, p. 405, pl. ix, ff. 8-10, (1898).

Meek's description: "Shell small, very thin, truncato-hemispherical; sides and front regularly rounded; hinge line usually less than the greatest breadth of the valves. Ventral valve without any traces of a mesial sinus, moderately gibbous, the greatest convexity being slightly behind the middle, from which point it rounds off in all directions, but most abruptly toward the beak and ears, which latter are flattened and subrectangular; beak small, slightly prominent, and but little incurved beyond the hinge line; surface with fine, regular, radiating striæ, crossed by small, rather distinct and regular, concentric wrinkles, which latter are generally most strongly

defined on the ears; over the whole there are also regularly arranged in quincunx, very slender spines, .20-.30 inch in length, rising from the slight prominences or swellings of the radiating striæ. Dorsal valve distinctively concave, following nearly the curvature of the other valve, its greatest convexity being in the central region, while its ears are nearly flat; surface with concentric wrinkles and radiating striæ as in the other valve, but apparently without spines, though a series of rather distinct pits are arranged over it in the same order as in the other valve." Length, 8 mm.; width, 11 mm.; convexity, 5 mm.

Range and distribution: Upper Coal Measures; Kansas City, Eudora, Lawrence, Lecompton, Topeka.

This species differs from the preceding ones of the genus in the absence of the mesial sinus, thin shell, very small size and semicircular outline, as well as being much less gibbous. It is likely to be confounded with no other shell of the Coal Measures of Kansas.

Productus nebrascensis. Plate IX, figs. 7-7f.

Productus nebrascensis Owen, Geol. Rep. Wis., Iowa, and Minn., p. 584, pl. v, f. 4, (1852); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 165, pl. II, f. 2, pl. IV, f. 6, pl. V, ff. 11a-c, (1872); etc.

Productus rogersi Norwood and Pratten, Jour. Acad. Nat. Sci. Phil., 2d ser., III, p. 9, pl. I, f. 3, (1854); etc.

Productus asperus McChesney, New Pal. Foss., p. 34, (1860); etc.

Productus wilberanus McChesney, *ibid.*, p. 36; etc.

Stropholosa horrescens Geinitz (non Murchison, etc.), Carb. u. Dyas in Neb., p. 49, (1866).

Meek's description (in part): "Shell of about medium size, approaching subhemispherical; length most usually a little less than the breadth; hinge line nearly or quite equaling the greatest transverse diameter; anterior outline nearly straight, or a little sinuous near the middle, rounding into the lateral margins, which are generally straight posteriorly, and ranging at an angle of from 90 to about 100 degrees with the hinge; ears nearly rectangular or a little rounded in outline at the immediate extremities. Ventral valve rather convex, most gibbous behind the middle, thence rounding regularly to the

front and more abruptly to the beak, generally with a moderately distinct mesial sinus; posterior lateral slopes descending almost vertically to the ears; umbonal region gibbous, and with strong incurved beak projecting beyond the hinge line. Dorsal valve somewhat flattened in the visceral region, but most concave near the beak and near the anterior lateral regions, the concavity widening rapidly forward, so as to leave a kind of a broad, obscure, oblique ridge between it and the flattened ears, and another in the middle; anterior and lateral margins following the curvature of the other valve; cardinal process prominent, bifid, and rather narrow; interior with mesial ridge, narrow, well defined, extending forward beyond the middle," bifid, at its connection with the cardinal process enclosing a moderately deep pit. The two lateral ridges are well defined and parallel with the hinge, fading out before the extremity is reached. The adductor scars are either subsemicircular or spatulate in outline, placed well to the posterior, with the smaller end forward, ending in a small elevated lobe. The brachial markings of this species are very obscure; they extend from the anterior extremity of the adductor scars outward and a little forward, rounding off near the antero-lateral edge of the flattened area. The markings of the interior of the other valve are rather indistinct. The adductor scars are long, slender, subspatulate, with the larger end toward the beak, situated in the middle of the visceral area; the two are separated in the extreme posterior portion by a low mesial ridge; exterior to these are the diductor scars, occupying a rather large space, indicated by longitudinal folds or nearly parallel lines. "Surface of the ventral valve with more or less defined, rather broad concentric undulations, and obscure striæ of growth, over the whole of which are arranged two sets of spines, connected at their bases with short interrupted ribs or elongated tubercles. One of these sets consists of small, short, appressed spines, and the other of stout, more erect, long ones. Surface of dorsal valve with small concentric ridges and striæ, with many little pits; spines nearly or quite all small, short, and appressed."

Measurements: Length, 26 mm.; width, 30 mm.; convexity, 16 mm.

Range and distribution: Upper Coal Measures; Kansas City, Turner, Eudora, Lawrence, Lecompton, Topeka, Manhattan, and Grand Summit. Common throughout the Upper Coal Measures of the state.

This shell, when found with the shell and spines well preserved, looks so very different from specimens which are ordinarily found with the spines removed that one could hardly imagine that they were the same. Those without the spines seem to be complete specimens, with regular, concentric zones of elongated tubercles, betraying very little indication that they are the bases of detached spines.

This shell is very readily distinguished from the foregoing species by its narrow, prominent beak and its peculiar surface markings. The concentric zones of spines are found on none of them.

Productus symmetricus. Plate IX, figs. 6-6b.

Productus symmetricus McChesney, New Pal. Foss., p. 35. (1860); Trans. Chic. Acad. Sci., 1, p. 25, pl. 1, f. 9, (1868); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 167, pl. v, f. 6, pl. viii, f. 13, (1872); etc.

Meek's description (in part): "Shell of medium size, sub-orbicular, or a little wider than long; hinge line somewhat less than the greatest breadth; sides rounding regularly to the front, which is rather broadly rounded in outline; ventral valve somewhat compressed, or only moderately convex, without any traces of a mesial sinus; ears compressed but not abruptly separated from the swell of the umbo, obtusely angular or a little rounded at the extremities; beak moderately large, incurved, but not curving much within the hinge margin. Dorsal valve rather evenly, and only moderately concave, cardinal process slender, prominent, curved [not always], trifid, the middle division being more prominent than the others, and emarginate at its extremity, the emargination being caused by a distinct mesial furrow that extends the entire length of the process [and sometimes two-thirds the length of the mesial septum]." Lateral ridges elevated, extending outward parallel

to and a little in front of the hinge nearly to its extremity, where it turns abruptly forward, forming a margin to the visceral area, and disappearing about the middle. Mesial ridge distinct, broad posteriorly, narrowing and rising to the end, which is two-thirds the distance to the anterior margin. Adductor scars distinct, the two nearly forming a circle or broad ellipse, ending in an elevated anterior lobe. Scars placed well to the posterior. Brachial markings very indistinct, beginning at anterior end of adductor scars and extending outward, as nearly as can be made out, similarly to those of the preceding shell. "The remainder of the interior covered with pustules. Surface of both valves ornamented by small, rather obscure, more or less regular concentric wrinkles, and covered by numerous small, short, rather appressed spines, which are larger on the ventral valve where they are often connected with little, sometimes elongated tubercles." Measurements: Length, 40 mm.; width, 59 mm.; convexity, 25 mm.

Range and distribution: Upper Coal Measures; Kansas City, Lawrence, Topeka.

This species can be distinguished from the preceding by the less convex pedicle valve, which has no sinus, narrower concentric wrinkles, and the fact that it has but a single set of spines, which are small and appressed. In some respects this species is intermediate between the one preceding and the following, and is sometimes hard to distinguish from them without good specimens.

Productus punctatus. Plate X, figs. 3-3e; plate XI, fig. 3.

Anomites punctatus Martin, Petref. Derb., pl. xxxvii, f. 6, (1809).

Productus punctatus? Morton, Amer. Jour. Sci., xxix, p. 153, pl. xxvi, f. 38, (1836).

Productus punctatus Shumard, Marcy's Rep. U. S. Expl. Red Riv. Louis., p. 201, pl. i, f. 5, pl. ii, f. 1, (1853); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 169, pl. ii, f. 6, pl. iv, f. 5, (1872); etc.

Productus scnipunctatus Shephard, Amer. Jour. Sci., xxxiv, f. 9, (1853).

Productus tubulospinus McChesney, New Pal. Foss., p. 37, (1860).

Meek's description (in part): "Shell attaining a rather large size, thin, varying from rotund-subquadrate to longitudinally subovate, being sometimes wider than long, and in other ex-

amples longer than wide, with all intermediate forms; hinge always shorter than the greatest breadth of the valves; anterior outline regularly rounded, or faintly sinuous in the middle. Ventral valve more or less gibbous, with a moderately distinct mesial sinus extending from near the beak to the front; beak incurved a little beyond the cardinal margin [considerably so]; ears rather compressed, but not distinctly defined from the swell of the umbo. Dorsal valve moderately concave with a small mesial elevation. Surface of both valves ornamented with numerous rather regular concentric ridges, increasing in size from the beaks toward the front, but becoming again smaller and more crowded in adult shells near the margin; in the ventral valve these ridges are a little prominent at the margin, separated from each other by smoother spaces, and support numerous small appressed spines, those of the upper row of which are larger and less crowded than the others; on internal casts, or partly exfoliated specimens, the spines are represented by small tubercles; surface of the dorsal valve as in the other, excepting that the ridges are represented by little furrows." Interior of the pedicle valve with a very small, thin, nearly obsolete mesial septum; adductor scars long, narrow, larger at posterior extremity, situated well to the back part of the shell. Diductors occupying a large space outside of the adductors, indicated by longitudinal folding ridges or parallel lines. In the brachial valve, the cardinal process is long, arched, bifid, slightly enlarged at the extremity; mesial ridge prominent, extending three-fifths the distance to the front margin, and is slightly thickened at the end. Lateral ridges strong, situated just in front of the hinge and parallel to it, but disappearing before the edge of the shell is reached. Adductor scars prominent, situated well to the front, varying in outline from narrowly elliptical to nearly ovate, with heavy, narrow lobe at the anterior end. Traces of brachial markings very hard to obtain and nearly obsolete. They extend outward from the anterior end of the adductor scars and make a broad, subelliptical loop forward to a point which is back of the end of the mesial ridge. Measurements: Moderately large, perfect specimen:

Length, 58 mm. ; width, 75 mm. ; convexity, 35 mm. A smaller specimen : Length, 36 mm. ; width, 36 mm. ; length, 36 mm. ; convexity, 23 mm.

Range and distribution : Upper Coal Measures ; Kansas City, Turner, Lawrence, Lecompton, Topeka, Moline.

This species can be distinguished from the previous by its mesial sinus and corresponding fold of the dorsal valve, more recurving beak, longer, more arched cardinal process, more slender and elongate adductor markings on dorsal valve, and also by the lateral ridges, which do not turn forward.

There seem to be two forms of this species in Kansas : One, a large, rather depressed shell, occurring in the lower part of the Upper Coal Measures at Kansas City ; and the other, the more common in the upper part of the stage, more narrow, gibbous and smaller. They may possibly prove to be varietally distinct, occupying different horizons.

AULACORHYNCHUS.

Dittmar, Verhand. Kais. Min. Gesellsch. St. Petersburg, 2d ser., VIII, p. Q, pl. I, ff. 1-13, (1871).
Hall and Clarke, Pal. N. Y., VIII, pt. II, p. 311, (1893).

Aulacorhynchus millipunctatus. Plate XI, fig. 6; plate XII, figs. 1, 1b.

Chonetes?? millipunctata Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 35, 1870; Geol. Surv. Ill., v, p. 566, pl. xxv, f. 3, (1873).

Isogramma millipunctata Meek and Worthen, *ibid.*, p. 568.

Aulacorhynchus millipunctatus Hall and Clarke, Pal. N. Y., VIII, pt. II, p. 312, pl. LXXXIII, ff. 14, 15, (1893).

Meek and Worthen's description : "Shell attaining a large size, very thin, transversely subsemicircular, or more than twice as wide as long, with lateral extremities rounded. Dorsal valve nearly flat, or but slightly and evenly concave ; hinge line a little less than the greatest transverse diameter ; cardinal process rather stout, with an obscure linear ridge (or sulcus) extending forward from its base nearly to the front ; cardinal edge slightly thickened within so as to form a faintly defined ridge extending about half way from the cardinal process toward each lateral margin, but apparently without any sockets for the reception of teeth in the other valve ; muscular and other internal markings unknown ; surface ornamented

by numerous slender, exceedingly regular, closely arranged concentric lines, extending parallel with each other and the front and lateral margins. Ventral valve unknown. Length of medium-sized specimen, 1.3 inches; breadth, 2.95 inches."

Range and distribution: Upper Coal Measures; Kansas City, Lawrence.

Two small specimens very similar in form and markings to the one above described were collected by the writer at Topeka. They were only about an inch in width and only the cast of the shells remain. They are probably specifically different, but too poorly preserved to admit of description. There is a very large form in the University collection which is quite convex and seems to possess an extra number of "platforms" from the one figured by Hall and Clarke, and may belong to a different species. It is figured in plate XII, figure 1b.

Rhipidomella pecosi.

Orthis pecosi Marcou, Geol. N. Amer., p. 48, pl. vi, f. 14, (1858); etc.

Orthis carbonaria Swallow, Trans. St. L. Acad. Sci., I, p. 215, (1858); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 131, pl. I, f. 8, (1872); etc.

Meek's description: "Shell small, suborbicular, slightly wider than long, moderately convex in adult specimens; lateral margins rounded, or, in some examples, faintly straightened posteriorly; front more broadly rounded, but usually very slightly sinuous in the middle; valves nearly equally convex; hinge line very short, or only equaling about half the breadth of the valves. Ventral valve usually most convex in the umbonal region, sometimes a little flattened anteriorly, so as to give the shell slightly the form unusually called 'resupinate,' though in gibbous specimens this character is nearly obsolete; beak moderately prominent, rather pointed and arched; area small, well defined, and arching with the beak; foramen narrow. Dorsal valve usually most convex between the middle and the beak, which is small, and nearly as prominent and arched as that of the other valve, generally with a shallow sinus extending from the middle to the front; area well developed but smaller than in the other valve, arched, and divided

by a proportionally shorter foramen. Surface of both valves ornamented with concentric marks of growth and fine radiating crowded striae, which increase mainly by intercalation, and, as in many other species of the genus, show occasional perforations toward the front, apparently left by the removal of very small tubular spines." "Length of a well-developed gibbous specimen, rather above medium size: .38 inch; breadth, .43 inch; convexity, .27 inch."

Range and distribution: Upper and Lower Coal Measures; Fort Scott, Kansas City, Eudora, Lawrence, Lecompton.

ENTELETES.

de Waldheim, *Oryct. Gouv. Moscou*, p. 193, tab. XXVI, ff. 6, 7.
Waagen, *Pal. Indica*, ser. xiii, I, p. 550, (1884); etc.

Enteletes hemiplicata. Plate XII, figs. 6, 6b.

Spirifer hemiplicata Hall, *Stansbury's Expl. Gt. Salt Lake*, p. 409, pl. iv, f. 3, (1852).

Rhynchonella angulata Geinitz (non Linné), *Carb. u. Dyas in Neb.*, p. 37, pl. III, ff. 1-4, (1866).

Syntrichasma hemiplicata Meek and Worthen, *Geol. Surv. Ill.*, II, p. 323, f. 36, p. 324, f. 37, (1866); Meek, *Fin. Rep. U. S. Geol. Surv. Neb.*, p. 177, pl. vi, f. 1, pl. viii, f. 12, (1872); etc.

Meek's description: "Shell in young examples only moderately convex, and having all the external appearances of a true *Orthis*; in adult specimens, often globose, or even more convex than long or wide. Hinge line very short, or not more than one-third the greatest breadth of the valves, and, owing to the gibbosity of the shell, imparting little or no angularity to the outline of the lateral slopes. Dorsal valve more convex than the other, and very strongly arched, particularly in mature shells; umbonal region gibbous, and often, in adult examples, projecting somewhat beyond the beak of the other valve; beak strongly incurved, so as to bring its apex under the beak, and nearly against the area of the other valve; area rather narrow, and distinctly incurved with the beak. Ventral valve convex, beak moderately prominent, and arched or more or less incurved; area triangular, small, about one-third as high as wide, and moderately well defined; its triangular foramen scarcely as wide as high. Surface of both valves ornamented with rather fine, regular, crowded, radiating striae, and

a few very large, rounded or more or less angular, radiating plications, which latter are never formed on the umbones, but occupy the anterior half, and become more prominent toward the front, where they often terminate in deeply interlocking angular marginal projections. Of these plications there are two, rarely three, on each side of the larger and more prominent one forming the mesial fold on the dorsal valve, while on the ventral valve there are three, rarely four, on each side of the mesial sinus; a few zigzag marks of growth also traverse the anterior and lateral margins of the valves, parallel to their deeply notched edges." The measurements of three specimens are here given — one rather large, one medium, and one young specimen: Length, 23 mm., 16 mm., 8 mm.; width, 29 mm., 28 mm., 9 mm.; convexity, 32 mm., 20 mm., 5 mm.

Range and distribution: Upper Coal Measures; Kansas City, Independence, Iola, Edwardsville, Eudora, Lawrence, LeCompton, Topeka.

Besides the variation in size and age, this shell often presents very much the appearance of a *Pugnax*, which is caused by the mesial plication being divided into two, and the presence of a small fold to correspond in the mesial furrow of the other valve. This gives the brachial valve quite a large mesial fold, and a correspondingly large sinus in the pedicle valve. This is hardly noticable in the majority of specimens, but in some it is very marked.

PUGNAX.

Hall and Clarke, Pal. N. Y., VIII, pt. II, p. 202, (1893); Ann. Rep. N. Y. St. Geol., p. 208, for 1895.

***Pugnax rockymontana*.** Plate XII, figs. 8, 8b.

Terebratula rockymontana Marcou, Geol. N. Amer., p. 59, pl. vi, f. 13, (1858).

Rhynchonella catoniaeformis McChesney, New Pal. Foss., p. 49, (1869).

Rhynchonella rockymontana White, Wheeler's Expl. Surv. West 100 Mer., iv, p. 131, pl. ix, f. 1, (1875).

Pugnax eatoniiformis Hall and Clarke, Pal. N. Y., VIII, pt. II, p. 204, (1893).

Pugnax rockymontana Schuchert, Bull. U. S. Geol. Surv. 87, p. 336, (1897).

White's description: "Shell rather large, inflated, subtriangular in outline, broadest near the front; sides somewhat regularly rounded from the antero-lateral portions to the beaks.

Ventral valve having its greatest convexity toward the beak; sides sloping away from the middle with a slight convexity and becoming flattened or sometimes a little concave near the lateral margins; beak rather small, prominent, and closely incurved over that of the other valve; mesial sinus very broad but not deep, prolonged far upward at the front, becoming obsolete about the middle of the valve and is entirely wanting upon its posterior portion; from two to four depressed, angular plications occupy the mesial sinus and disappear with it, the sides and posterior portion being free from plications. Dorsal valve more capacious than the ventral; mesial fold distinct at the front, and, like the mesial sinus, becoming obsolete about the middle of the valve; from three to five plications like those of the other valve mark the fold, but the surface upon each side of it is plain, like that of the posterior portions of both valves. The whole surface marked by fine striæ of growth, but no radiating striæ have been detected." Measurements of two specimens: Length, 19 mm., 23 mm.; width, 19 mm., 23 mm.; convexity, 15 mm., 16 mm.

Range and distribution: Lower Coal Measures; Coffeyville, Montgomery county, Kansas City.

Our specimens seem to agree very well with White's figures and description, the principal difference being that the lateral angles at the beak seem to be a little smaller. While there are no radiating striæ in our specimens, the shell is very fibrous and where exfoliated might appear to be striated. It differs from *P. pugnus missouriensis* in having no plications on the sides of the shell, and also in outline.

Pugnax utah. Plate XII, figs. 7-7c.

Terebratula uta Marcou, Geol. N. Amer., p. 58, pl. vi, f. 12, (Feb. 1858).

Rhynchonella (*Camarophoria*) *osagensis* Swallow, Trans. St. L. Acad. Sci., 1, p. 289, (June, 1858).

Rhynchonella utah Meek and Hayden, Proc. Acad. Nat. Sci. Phil., p. 27, (1859): etc.

? *Rhynchonella* species Salter, Quart. Jour. Geol. Soc., London, xvii, p. 64, pl. iv, f. 5, (1861).

Camarophoria globulina Geinitz (non Phillips), Carb. u. Dyas in Neb., p. 38, pl. iii, f. 5, (1866).

Rhynchonella osagensis Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 179, pl. 1, f. 9, pl. vi, f. 2, (1872); etc.

Pugnax utah Hall and Clarke, Pal. N. Y., VIII, pt. II, p. 204, pl. LX, ff. 39-42, (1893).

Rhynchonella uta Keyes, Geol. Surv. Mo., v, p. 103, pl. XLI, f. 7, (1895).

Meek's description: "Shell small, more or less variable in form, often subtrigonal, generally wider than long, more or less gibbous; front truncated, or sometimes sinuous in outline; anterior lateral margins rounded in outline; posterior lateral margins convex, or nearly straight and converging toward the beaks at an angle of from 90 deg. to 120 deg. Dorsal valve more convex than the other, greatest convexity near the middle or between it and the front, which has a broad, rather deep, marginal sinus, for the reception of the corresponding projection of the front of the other valve; mesial fold somewhat flattened, but slightly prominent, and rarely traceable back of the middle of the valve; generally composed of three, but sometimes four—rarely more—plications; sides rounding down rapidly on each side of the mesial fold, and each occupied by about three or four simple plications; beak curving strongly beneath that of the other valve; interior with a faint linear mesial ridge, on each side of which is a raised curved line enclosing an ovate space, occupied by the adductor muscular impressions. Ventral valve distinctly less convex than the other, with a broad, shallow, short sinus occupied by about two or three short plications; anterior lateral margins on each side of the sinus, with from two to four plications; beak moderately prominent, and more or less arched, rather pointed; foramen small." Measurements: Length, 8 mm.; width, 9 mm.; convexity, 7 mm.

Range and distribution: Upper Coal Measures; Bronson, Bourbon county, Kansas City, Iola, Olathe, Lawrence, Lecompton, Topeka, Beaumont, Grand Summit.

The young of this species are perfectly plain and betray no indication that they are of the same kind as the folded, plicated adults. It can be readily distinguished from the previous species by its smaller size, shallower and more ill-defined sinus, and the presence of plications on its sides.

DIELASMA.

King (non Phillips), Mon. Perm. Foss. Eng. Pal. Soc., p. 46, (1850); etc.

King, Proc. Dublin Univ. Zool. Bot. Asso., I, p. 260, (1859).

Beecher and Schuchert, Biol. Soc. Wash., VIII, pp. 71-82, (1893).

Hall and Clarke, Pal. N. Y., VIII, pt. II, p. 293, (1893); etc.

Dielasma bovidens.

Terebratula bovidens Morton, Amer. Jour. Sci., XXIX, p. 150, pl. II, f. 4, (1836); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 187, pl. I, f. 7, pl. II, f. 4, (1872); etc.

Terebratula millipunctata Hall, Expl. Surv. R. R. Route Miss. R. to Pac. Ocean, III, p. 101, pl. II, ff. 1, 2, (1856); etc.

Terebratula elongata Shumard (non Schloth.), Trans. St. L. Acad. Sci., I, p. 393, (1859).

Terebratula geniculosa McChesney, New Pal. Foss., p. 82, (1861); *ibid.*, pl. I, f. 2, (1865).

Dielasma? *bovidens* White, Wheeler's Expl. Surv. West 100 Mer., Prel. Rep., p. 21, (1874).

Terebratula (*Dielasma*) *bovidens* White, *ibid.*, Fin. Rep., IV, p. 144, pl. XI, f. 10, (1875).

Terebratula hastata Walcott (non Sowerby), Mon. U. S. Surv., VIII, p. 224, (1893); etc.

Dielasma bovidens Hall and Clarke, Pal. N. Y., VIII, pt. II, pp. 295, 296, f. 213, pl. LXXXI, ff. 29-35, (1893).

Meek's description (in part): "Shell ovate, rounded and rather compressed at the anterior and anterior lateral margins, and the most convex a little behind the middle; valves nearly equally convex; ventral valve strongly arcuate longitudinally, and presenting a regularly increasing curve, from the front to the beak, which is moderately prominent, and very strongly and closely curved over and upon that of the other valve; foramen a little oval and not truncating the immediate apex of the beak, but situated directly outside of it; mesial sinus rather wide, and rounded at the front, but narrowing and becoming less deep further back, until it dies out near the curve of the umbo, which is sometimes slightly flattened. Dorsal valve often nearly straight, or but slightly convex along the middle, from the beak to the front, where its margin is usually somewhat raised for the reception of the sinus; sides sloping from the middle to the lateral margins along nearly the entire length of the valve, but terminating directly under that of the other valve, without any distinct curvature. Surface nearly smooth, or showing moderately distinct marks of growth; and, by the aid of the magnifier, exhibiting very distinctly the moderately

large regularly arranged punctures." The dental lamellæ do not extend much beyond the teeth, and are situated close to the sides of the shell, so that the lateral space enclosed is very small. There seems to be a rounded, indistinct ridge extending about two-thirds the distance to the front on the interior of the ventral valve. Loop situated a little posterior to the middle of the shell, and is about one-third the length of the shell, the two pointing obliquely forward. Measurements of two specimens illustrating the variation: Length, 21 mm., 25 mm.; width, 14 mm., 19 mm.; convexity, 10 mm., 16 mm.

Range and distribution: Upper Coal Measures: Kansas City, Eudora, Lawrence, Lecompton, Topeka, Grand Summit.

SPIRIFERINA.

d'Orbigny, Paris Acad. Sci., Comptes Rendus, XXV, p. 268, (1847).
Hall and Clarke, Pal. N. Y., VIII, pt. II, p. 51, (1893); etc.

Spiriferina cristata.

Terebratulites cristatus Schlotheim, Beit. zur Naturg. der Verst., Akad. der Wiss. zu Muenchen, pl. I, f. 3, (1816).

Spirifer octoplicata? Hall (non Sowerby), Stansbury's Expl. Gt. Salt Lake, p. 409, pl. IV, f. 4, (1852).

Spirifer kentuckyensis Shumard, Geol. Surv. Mo., I, p. 293, (1855); etc.

Spiriferina cristata Davidson, Quart. Jour. Geol. Soc. London, p. 170, pl. IX, f. 6, (1863); etc.

Spirifer laminosus Geinitz (non McCoy), Carb. u. Dyas in Neb., p. 45, pl. III, f. 19, (1866).

Spirifer kentuckyensis var. *propatulus* Swallow, Trans. St. L. Acad. Sci., II, p. 489, (1866).

Spiriferina kentuckyensis Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 185, pl. VI, f. 3a-d, pl. VIII, f. 11a, b, (1872); etc.

Spirifer (Spiriferina) kentuckyensis Hall, 2d Rep. N. Y. St. Geol., pl. LXI, ff. 14-16, (1883).

Spiriferina cristata Schuchert, Bull. U. S. Geol. Surv. 87, p. 410, (1897).

Meek's description: "Shell rather small, varying from subglobose to semicircular, or even subfusiform, always wider than long; breadth sometimes twice or even three times the length; hinge line always equaling the greatest breadth of the valves, occasionally greatly extended, and terminating in slender mucronate ears; anterior and lateral margins generally forming a nearly semicircular curve. Ventral valve somewhat more convex than the other, the greatest convexity being between the beak and the middle; beak moderately prominent and

rather distinctly arched or incurved; area arched, usually of moderate height, well defined, and extending nearly or quite to the lateral extremities, while it increases rapidly in height, with concave lateral margins toward the beak; foramen generally higher than wide, with a marginal furrow on each side, and, so far as known, not closed by a deltidium; mesial sinus narrow, rather deep, sometimes with a small obscure rib along its middle, but more frequently without it; plications on each side of the sinus about five to eight or nine, rather narrow, simple, prominent, and a little rounded; mesial septum of the interior moderately prominent. Dorsal valve with greatest convexity near the middle; beak scarcely projecting beyond the hinge margin, more or less incurved; area very narrow, and incurved with the beak; mesial fold narrow, not very prominent, nor greatly larger than the first plication on either side, most generally rounded, but not infrequently with an obscure sulcus along the middle, near the front; lateral plications as in the other valve. Entire surface of both valves ornamented with numerous closely crowded, very regularly arranged, subimbricating lamellæ of growth, strongly arched in passing over the costæ; over the whole may also be seen, by the aid of a magnifier, numerous granules, apparently connected with the punctures passing through the shell which are comparatively large and distinct, though regularly arranged." Measurements of an average specimen: Entire length, 9 mm.; width, 15 mm.; convexity, 7 mm.

Range and distribution: Upper and Lower Coal Measures; Fort Scott, Bronson, Bourbon county, Thayer, Kansas City, Lawrence, Lecompton, Topeka.

Not having foreign specimens for comparison, Schuchert is followed in referring our specimens to *S. cristata*.

SPIRIFER.

Sowerby, Min. Con., II, p. 41 (1815).
 Hall and Clarke, Pal. N. Y., VIII, pt. II, pp. 1-40, (1893); etc.
 Billings, Can. Jour., VI, p. 253, (1861); etc.

This genus is very greatly developed in the Paleozoic rocks of America, though there are but two forms that have been recognized with certainty in our Coal Measures. Hall (loc. cit.) divides the genus into six groups, as follows:

I. *Radiati*. "Smooth, radially undulated or plicated; fold and sinus smooth; entire surface covered with fine, filiform radiating striæ which may be minutely crenulated or granulose."

II. *Lamellosi*. "Radially plicated; surface covered with numerous concentric lamellæ. In Silurian species the fold and sinus are non-plicate; the later forms usually bear a low median depression on the fold accompanied by a corresponding median ridge in the sinus." He further divides this group into two smaller ones—the *Septati*, those possessing a mesial septum in the pedicle valve, and the *Aseptati*, without this septum.

III. *Fimbriati*. "Shells with a few low plications or none; hinge line not greatly extended, often shorter than the greatest diameter of the shell; dental lamellæ moderately, sometimes notably, developed; a low median septum may exist in the pedicle valve. Surface covered with concentric rows or fringes of fine spines." He also divides this group into two smaller groups—the *Unicispinei*, those species in which the concentric fimbriæ are made up of short, simple, hollow spines (*Delthyris* Dolman), and the *Duplicispinei*, those with larger, compound, hollow spines (*Reticularia* McCoy).

IV. *Aperturati*. Those having plications on the fold and sinus. These are the typical *Spirifers*. They are divided into several smaller sub-groups which are of little interest here.

V. *Ostiolati*. Median fold and sinus without plications.

VI. *Glaserati*. Surface smooth; fold and sinus faintly developed. These he divides into two smaller groups, the *Aseptati* and the *Septati*, according to the presence or absence of the dental lamellæ and mesial septa. These are equal to *Martinea* of McCoy, *Martinopsis* Waagen, and *Mentzelia* Quenstedt.

Our two species, *Reticularia perplexa* and *Spirifer cameratus*, belong to the *Fimbriati* and *Aperturati* respectively. *Spiriferina* is, in some respects, more closely related to the *Lamellosi*.

Spirifer cameratus. Plate XII, figs, 5-5e.

Spirifer cameratus Morton, Amer. Jour. Sci., xxix, p. 150, pl. II, f. 3, (1836); etc.

Spirifer meuschachanus Roemer, Kreidebildung Texas, p. 88, pl. XI, f. 7, (1852).

Spirifer triplicatus Hall, Stanbury's Expl. Surv. Gt. Salt Lake, p. 410, pl. IV, f. 5, (1852).

Spirifer fasiger Owen (non Keyserling), Geol. Surv. Iowa, Wis., and Minn., pl. V, f. 4, (1852).

Spirifer inequicostatus ? Owen, *ibid.*, p. 586, pl. V, f. 6, (1852).

Spirifer striatus var. *triplicatus* Marcou, Geol. N. Amer., p. 49, pl. VII, f. 3, (1858).

Spirifera camerata Newberry, Ives' Rep. Colo. Riv. West, p. 127, (1861); etc.

Spirifera camerata var. *kansasensis* Swallow, Trans. St. L. Acad. Sci., II, p. 409, (1867).

Spirifer (Trigonotreta) camerata Meek, King's U. S. Expl. 40th Parallel, IV, p. 91, pl. IX, f. 2, (1877).

Shell medium to large in size, greatest convexity back of the middle, variable in outline from subsemicircular to trigonal; anterior margin sharply rounded to truncate-sinuate; lateral margins slightly curved to nearly straight, pointing outward and backward to the ears; hinge line equaling the greatest width of the shell, sometimes prolonged into attenuate ears; cardinal area broad, extending to the extremity of the hinge line; foramen broadly triangular and nearly equilateral, partly closed in the upper part by a pseudo-deltidium; beak high, prominent, somewhat recurved over the cardinal area, which is sometimes slightly arched; mesial sinus prominent, beginning at the beak and broadening and deepening until the front margin is reached; fold of the dorsal valve to correspond, and the beak of the same moderately rounded beneath that of the other valve. Interior of pedicle valve marked by a subelliptical muscular impression in the vicinity of the beak, posterior end of this impression extending to the hinge line or beyond, bisected by an indistinct mesial ridge, radiating from which are small indistinct ridges for the attachment of the muscles. The cardinal area projects over a portion of the visceral cavity,

leaving a large space beneath; the shell here is well pitted; a small tooth and depression are developed on the inner corners of the cardinal area. Shell of the brachial valve thin, muscular marking distinct; hinge line at beak broadly and shallowly arched, one prominent socket on each side of the arch, for the teeth of the other valve; two small elevations in the center for attachments. The exterior markings of the shell consist of rather large, bifurcating, radiating striæ or costæ, almost always fasciculated, covering the entire shell to the tips of the ears, where they are nearly parallel. There are, in unweathered, unworn specimens, minute pustules arranged in somewhat radiating order, as well as lines of growth visible on the front border. In exfoliated specimens the fasciculation is less distinct. Measurements of average specimen: Length, 32 mm.; breadth, 44 mm.; convexity, 21 mm.

Range and distribution: Upper Coal Measures; Kansas City, Lawrence, Lecompton, Topeka, Grand Summit. Common throughout the Upper Coal Measures to the base of the Permian.

The variation in outline, convexity and length of the hinge line is great in this species. This species has been considered by some as identical with *S. striatus* (Martin) Davidson. Schuchert has pointed out characters which separate it from that species.⁶ There is also a marked difference in the spires of the two, those of *S. striatus* being long, loose, and acute, while those of *S. cameratus* are short, compressed, and obtuse, and they enclose a slightly smaller angle. The striæ of *S. cameratus* are nearly always fasciculated, while those of *S. striatus* are not.

There is also a marked variation in the interior of the pedicle valve of this shell. In some specimens the muscular scar in this valve is elliptical and extends well back beneath the delthyrium into the beak, the teeth are not supported by heavy deposits of shell or lamellæ, and the cavity formed by the jutting of the cardinal area forms a general posterior cavity extending across the shell, only slight ridges being present below

6. Bull. U. S. Geol. Surv. 87, p. 384: "The latter species [*S. striatus*], however, is closely and finely reticulated with concentric growth lines, while in *S. cameratus* the plications are covered with small pustules, which are arranged in radiating lines."

and behind the teeth. In other specimens the posterior of the shell is much thickened, the muscular impression not extending beneath the beak or hinge line, that portion of the cavity being filled with shell, which has encroached upon the muscular area until it is small and nearly circular. This heavy deposit of shell also forms strong supports for the teeth, dividing the posterior cavity into a right and a left cavity.

AMBOCÆLIA.

Hall, 13th Rep. N. Y. St. Cab. Nat. Hist., p. 71, ff. 1-3, p. 72, ff. 4-6, (1860).
Meek and Hayden, Pal. Upp. Mo., Smiths. Cont. Knowl., XIV, 172, p. 20, (1864); etc.

Ambocælia planoconvexa.

Spirifer planoconvexa Shumard, Geol. Rep. Mo., p. 202, (1855); etc.
Ambocælia gemmula McChesney, New Pal. Foss., p. 41, (1860); *ibid.*, pl. I, f. 3, (1865).
Spirifer (Martinia) planoconvexa Meek and Hayden, Pal. Upp. Mo., Smiths. Cont. Knowl., XIV, 172, p. 20, ff. a-e, (1864); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 184, pl. IV, f. 4, pl. VIII, f. 2; etc.
Martinia planoconvexa McChesney, Trans. Chic. Acad. Sci., I, p. 34, pl. I, f. 3, (1868).
Ambocælia planoconvexa Hall and Clarke, Pal. N. Y., VIII, pt. II, p. 56, pl. XXXIX, ff. 10-15, (1893).

Meek's description: "Shell very small, plano-convex, or very rarely a little concavo-convex, sometimes wider than long, in other examples slightly longer than wide; hinge margin always shorter than the greatest transverse diameter of the valves, and rounded at the extremities; lateral margins and front regularly rounded; surface apparently smooth, excepting a few very obscure concentric marks of growth, but, when examined by the aid of a magnifier, showing the remains of the bases of minute hair-like spines. Dorsal or smaller valve truncato-suborbicular in outline, generally nearly flat, with faint longitudinal depression in front, sometimes slightly convex near the beak, and concave around the anterior and lateral margins; beak scarcely distinct from the cardinal margin; area narrow, but well developed, or about half as large as in the other valve; socket plates projecting like diverging teeth on each side of the small fissure. Ventral valve very gibbous, particularly in the umbonal region, sometimes with obscure traces of a narrow longitudinal depression along the middle, but without a proper mesial sinus; beak very prominent and strongly arched back over the hinge;

area subtriangular, being moderately high under the beak, but narrowing rapidly, with moderately defined concave margins, to the extremities of the hinge, and arching with the beak; fissure rather narrow, or higher than wide, apparently rounded above under the beak, and spreading at the hinge." Measurements: Length, 9 mm.; width, 10 mm.; convexity, 5 mm.

Range and distribution: Upper and Lower Coal Measures; Fort Scott, Fredonia, Eudora, Lawrence, Lecompton, Topeka, Emporia.

RETICULARIA.

McCoy, Carb. Foss. Ireland, p. 142, (1844).
 Waagen, Pal. Indica, ser. xiii, I, p. 538, (1893).

Reticularia perplexa. Plate XII, figs. 4-4c.

Spirifer lineatus Shumard, Geol. Surv. Mo., p. 216, (1855); etc.

Spirifer perplexus McChesney, New Pal. Foss., p. 43, (1860).

Spirifer lineatus var. *perplexus* Swallow, Trans. St. L. Acad. Sci., II, p. 408, (1866).

Spirifera lineata Meek, Fin. Rep. U. S. Geol. Surv. Neb., pl. II, f. 3, (1872); etc.

Spirifer (Martinia) perplexa Derby, Bull. Cornell Univ., p. 16, pl. III, ff. 27, 39, 40, 45, 50, pl. VIII, f. 13, (1874).

Spirifer (Martinia) lineata? White, Wheeler's Expl. Surv. West 100th Mer., III, Appendix, (1881); later without query; etc.

Spirifera perplexa Keyes, Geol. Surv. Mo., v, p. 84, (1895).

Reticularia perplexa Schuchert, Bull. U. S. Geol. Surv. 87, p. 342, (1897).

White's description: "Shell moderately gibbous, transversely subelliptical in marginal outline, the front and sides regularly rounded; hinge much shorter than the width of the shell; cardinal extremities rounded; cardinal area distinct, arched, and moderately high; ventral valve convex; umbonal portion prominent; beak prominent, incurved; area small, without median sinus, but there is a slight flattening of the valve in front, which gives the front margin a slight sinuosity; dorsal valve regularly convex, both transversely and longitudinally; umbonal portion prominent, but not so much so as that of the other valve; beak moderately prominent and projecting a little beyond the hinge line; surface marked by very numerous very faint radiating lines and somewhat stronger concentric lines, the latter being impressed and finely crenulate, the minute crenulations apparently marking the bases of hair-like

spines when the surface of the shell is perfect." Measurements: Length, 19 mm.; width, 23 mm.; convexity, 15 mm.

Range and distribution: Upper and Lower Coal Measures; Fort Scott, Iola, Lawrence, Topeka, and so on to the base of the Permian.

The shell varies a great deal in marginal outline, some having the beak prolonged and sides somewhat compressed, giving it a very different appearance from the normal form.

HUSTEDIA.

Hall and Clarke, Pal. N. Y., VIII, pt. II, p. 120, (1893); 13th Ann. Rep. N. Y. St. Geol., p. 197, (1895).

Hustedia mormoni. Plate IX, figs. 10-10d; plate X, fig. 3.

Terebratula mormoni Marcou, Geol. N. Amer., p. 51, pl. VI, f. 11, (Feb. 1858); etc.

Retzia punctulifera Shumard, Trans. St. L. Acad. Sci., I, p. 220, (June, 1858); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 181, pl. I, f. 13, pl. V, f. 7, (1872); etc.

Retzia mormoni Meek and Hayden, Proc. Acad. Nat. Sci. Phil. 1859, p. 27; etc.

Retzia subglobosa McChesney, New Pal. Foss., p. 45, (1860); *ibid.*, pl. I, f. 1, (1865).

Retzia compressa Meek, Geol. Surv. Cal., I, p. 14, pl. II, f. 7, (1864); etc.

Retzia radialis Walcott (non Phillips), Mon. U. S. Geol. Surv., VIII, p. 220, pl. 7, ff. 5d-h, (1893); etc.

Eumetria punctulifera Derby, Bull. Cornell Univ., I, p. 4, pl. VIII, ff. 4, 5, 7, 8, 10, pl. IX, f. 3, (1874).

Hustedia mormoni Hall and Clarke, Pal. N. Y., VIII, pt. II, p. 120, f. 196, pl. LI, ff. 1-9, (1893).

Meek's description: "Shell small, ovate; in mature specimens, gibbous; hinge line short, or scarcely extended enough to show distinctly the little ears at the extremities. Ventral valve more convex than the other, the greatest convexity being between the middle and the umbo, which is prominent, rounded, more or less strongly arched, and provided with a moderately large circular foramen; area well defined, triangular, and arching with the beak. Dorsal valve most convex near the middle; beak extending a little beyond the hinge margin, and distinctly incurved. Surface of each valve ornamented by fourteen or fifteen (very rarely sixteen to seventeen) simple, rather prominent, radiating costae, one or two of which are sometimes slightly more depressed than the others, near the front of the ventral

valve, so as to cause some appearance of an obscure mesial sinus, but without producing any corresponding mesial elevation on the other valve, or visibly interrupting the general straightness of the uniting margins of the two valves; lines of growth obscure; punctures visible under a good pocket lens, and very regularly disposed." Measurements: Length, 10 mm.; width, 8 mm.; convexity, 7 mm.

Range and distribution: Upper Coal Measures; Fort Scott, Iola, Kansas City, Lawrence, Lecompton, Topeka, Beaumont.

CLEIOTHYRIS.

King (non Phillips), Mon. Perm. Foss., Pal. Soc., p. 137, (1850).
Hall and Clarke, Pal. N. Y., VIII, pt. II, p. 90, (1893); etc.

Cleiothyris roissyi. Plate XII, fig. 2; plate XI, figs. 5-5c.

Spirifer de roissyi L'Eveille, Mém. Soc. Geol. de France, II, p. 39, pl. II, ff. 18-29, (1835).

Terbratula roysii Marcou, Geol. N. Amer., p. 51, pl. VI, f. 10, (1858).

Athyris sublamellosa Hall, Geol. Surv. Iowa, I, pt. II, p. 702, pl. XXVII, f. 1, (1858); etc.

Athyris parvirostris Meek and Worthen, Proc. Acad. Nat. Sci. Phil., 1860, p. 451.

Spirigera americana Swallow, Trans. St. L. Acad. Sci., II, p. 89, (1863).

Spirigera pectenifera Swallow (non Sowerby), *ibid.*, p. 88.

Athyris planosulcata Geinitz (non Phillips), Carb. u. Dyas in Neb., p. 42, (1866); etc.

Spirigera planosulcata? White, Wheeler's Rep. Geog. Expl. Surv. West 100 Mer., IV, p. 257, pl. IV, ff. 10, 11, (1877).

Athyris hirsuta Walcott, Mon. U. S. Geol. Surv., VIII, p. 222, pl. XVIII, f. 5, (1884).

Cleiothyris roysii Hall and Clarke, Pal. N. Y., VIII, pt. II, p. 91, pl. XLVI, ff. 23, 24, pl. LXXXIV, f. 32, (1893).

Cleiothyris sublamellosa Hall and Clarke, *ibid.*, p. 91.

Meek and Worthen's description: "Shell of medium size, quadrato-subcircular, moderately gibbous, length and breadth nearly equal, sometimes a little wider than long (other examples a little longer than wide); greatest convexity at the middle; valves equally gibbous; lateral margins usually prominent, and narrowly rounded in outline at the middle, thence converging with a slightly convex outline to the faintly subtruncate front; postero-lateral margins a little inflected, so as to form slight concavities, converging to the beaks at an angle of about ninety-seven degrees. Both valves destitute of a mesial

fold or sinus, but each sometimes slightly flattened in the middle near the front, where they meet without the slightest sinuosity in the margin of either. Beak of ventral valve small, pointed, closely incurved upon that of the other valve, which is but little less prominent; foramen round and very small. Surface with small, obscure, concentric marks of growth. Spiral appendages each making about twelve turns. Surface (probably exfoliated) showing only small, obscure, concentric ridges." Measurements, two specimens: Length, 10 mm., 10 mm.; width, 11 mm, 13 mm.; convexity, 6 mm, 5 mm.

Range and distribution: Lower Coal Measures; Fort Scott, Marmaton station, Bourbon county, Prescott, Linn county.

This rare little fossil is rather variable in form. Most of our specimens are rather more straight along the hinge than those usually figured from this country, approaching, in this respect, the form figured by C. Nikitin from the Upper Carboniferous and Lower Permian of Europe, one specimen in particular being quite straight and wide along the hinge. The shells, in unworn specimens, show the surface fimbriae very well.

SEMINULA.

McCoy, Carb. Foss. Ireland, pp. 550, 558, (1844).
Hall and Clarke, Pal. N. Y., VIII, pt. II, p. 93, (1893); etc.

Seminula argentea. Text fig. 3, C.

Terebratula argentea Shephard, Amer. Jour. Sci., xxxiv, p. 152, f. 8, (1838).

Terebratula roisyi d'Orbigny [non L'Eveille], Voy. dans l'Amér. Mér. Pal., p. 46, (1842).

Terebratula antisienensis d'Orbigny, *ibid.*, p. 46, (non 36).

Terebratula peruviana d'Orbigny, *ibid.*, pl. III, ff. 17-19, (non p. 36).

Terebratula subtilita Hall, Stanbury's Expl. Gt. Salt Lake, p. 409, pl. iv, ff. 1, 2, (1852); etc.

Terebratula? subtilita Davidson, Mon. Brit. Carb. Brach., p. 18, pl. i, ff. 21, 22, (1857); etc.

Spirigera subtilita Meek and Hayden, Proc. Acad. Nat. Sci. Phil., p. 20, (1859); etc.

Athyris differentis McChesney, New Pal. Foss., p. 47, (1860).

Athyris subtilita Newberry, Ives's Rep. Colo. Riv. West, p. 126, (1861);
Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 180, pl. i, f. 12, pl. v, f. 9, pl. viii, f. 4, (1872); etc.

Seminula subtilita Hall and Clarke, Pal. N. Y., viii, pt. II, p. 95, ff. 66, 67, p. 86, ff. 58, 59, pl. XLVII, ff. 17-31, (1893).

Athyris argentea Keyes, Geol. Surv. Mo., v, p. 92, pl. xxxix, f. 11, (1895).

Seminula argentea Schuchert, Bull. U. S. Geol. Surv. 87, p. 377, (1897).

Meek's description (in part): "Shell ovoid, being usually widest a little in advance of the middle, and nearly always somewhat longer than wide, moderately convex, becoming rather gibbous with age. Ventral valve usually a little more convex than the other, its greatest convexity being generally behind the middle; beak prominent, rounded, and distinctly incurved upon that of the other valve; foramen round, of moderate size, and truncating the immediate apex of the beak; mesial sinus absent, or very shallow, in young or compressed individuals, but well defined, and round, flattened or angular in adult gibbous specimens, in which it rapidly increases in size, from near the middle to the front, where it produces a more or less prominent marginal projection, fitting into a corresponding sinuosity in the margin of the other opposite valve. Dorsal valve moderately convex, the greatest convexity in small or compressed specimens often near the middle or between it and the umbo, but in large, gibbous individuals, with a well-defined, prominent mesial fold, sometimes near the front; beak rather distinctly incurved under that of the opposite valve. Surface of both valves nearly smooth, or with mere lines of growth, in young shells, but in large or mature specimens with well-defined, imbricating marks of growth on the anterior half; exfoliated surfaces also show, under a magnifier, obscure traces of radiating striæ." The spires are large and generally acutely pointed. Measurements of two specimens: Length, 36 mm., 26 mm.; width, 37 mm., 23 mm.; convexity, 26 mm., 18 mm.

Range and distribution: Upper and Lower Coal Measures; Marmaton station, Bourbon county, Iola, Kansas City, Eudora, Lawrence, Lecompton, Topeka, Manhattan, Grand Summit. Very abundant throughout the Coal Measures of the state.

Hall has figured this species as having the ascending edges of the spire straight and forming an obtuse angle at the apex. In all the specimens at hand the sides of the spires are concave and the tip of the spire is acute. However, they vary a great deal in this respect. Swallow has described another form, *S. caputserpentis*,⁷ from the Kansas Carboniferous, but I am able

7. Trans. St. L. Acad. Sci., II, p. 90, 1863.

to recognize but the one species, and think there is but little doubt that his *Spirigera caputserpentis* is the same as the form above described. The shells vary enough to easily include Swallow's description. The microscopic indications of striae mentioned in the various descriptions of this shell are probably due to the fibrous structure of the shell, which is quite coarse.

PELECYPODA.

Pelecypods (sometimes called lamellibranchs) are a group of animals known under the names of mussels, clams, and oysters. They live in fresh and salt water, and are covered by a shell which is made up of two halves, or valves. Brachiopods have one valve on top and one on the bottom of the animal, but the halves of the clam shell are located one on the right side and one on the left. The body is nearly enclosed in a mantle or fleshy membrane, which nearly surrounds the soft part of the body. It is divided into two parts or halves, called lobes, which secrete the two halves of the shell. Sometimes this mantle is somewhat grown together for a large part of the way along the lower sides of the animal near the open edges of the shell.

In those with the mantle edges fastened together there are two openings in the rear end; these openings are sometimes prolonged into tubes called siphons, which are used in breathing. A current of water passes constantly in through one of these and out through the other. In those which do not have the mantle united there is generally no siphon.

The edge of the mantle is also attached to the shell, impressing a line nearly parallel with the edge of the shell. When the siphons are present there is an inward notch or angle in the line in the back part of the shell, caused by the muscles used in pulling the siphon into the shell. When the siphons are absent the notch is not present. The line formed by the edge of the mantle is called the pallial line.

Near the front of the shell lies an organ called the foot, which

is generally a muscular organ, hatchet-shaped in most fresh-water clams; it aids the animal in moving. Sometimes this organ secretes a substance which hardens quickly on being exposed, and by this means the animal cements its shell firmly to some rock or other object. The foot generally becomes small in such cases on account of disuse. There is an opening in one of the valves for it, so that the attachment may be more certain. This opening is called the byssal groove or notch, and the foot, in this case, is called the byssus.

There are other muscles in the clam which are important. One or two large muscles are used in closing the shells together, and run nearly directly across from one shell to the other, and when two are present one is located near the front of the shell and the other near the rear of it, and are known as the anterior and posterior adductors, respectively. These muscles are firmly attached to the shell, causing a depression in it, showing the size, shape and position of the muscle.

The pelecypods have no true heads. In the front part of the animal is an opening, or mouth, surrounded by a pair of membranous flaps. In the oyster these flaps are called the beard. This opening is the end of the esophagus, or gullet, which leads to the stomach, which is generally surrounded by the liver. From the stomach the intestine is somewhat convoluted, generally passing through a part of the heart, and finally ending near the back part of the shell.

The circulatory system consists of a heart, having two or three chambers and a few arteries. The heart propels the blood from the gills through the body of the animal. The respiratory organs consist generally of two pairs of gills. The water, in the siphoned clams, enters through one side of the siphon, or one tube, flows over the gills, constantly bathing them with fresh water, and then flows past the mouth, where the food particles are selected out of it, when it passes out of the other siphon tube.

The nervous system consists of two knots of nerves near the mouth and one near the posterior adductor muscle.

Now, since we have a general idea of the anatomy of the

pelecypod, let us turn our attention to the shell. The hard parts of animals are the only ones preserved in the rocks. In the clams the shell only is found, and the impressions on the inside of it are all we have to judge from as to the exact nature of the animal which inhabited it; consequently, it is of great importance to know what these markings are and what they represent.

The elevated portions of the shell, which project upward near the hinge, or where the two halves are fastened together, are called the beaks or umbones. These generally point toward the front of the shell. If we hold the shell so that the beaks point away from us, the half on the right side will be the right valve and the other half the left valve. The edge of the shell on which the beaks are situated is the dorsal edge or portion of the shell. The side opposite (below) this is called the ventral portion, and its edge is called the ventral or pallial margin. The line where the two halves are united is called the hinge line. The hard, gristly material that forms the hinge is called the ligament. The projections along the hinge line, which fit into the corresponding sockets in the opposite valve, are called the teeth. We have previously mentioned the adductor scars, the pallial line, and the notch in the pallial line caused by the muscle (retractor) which pulls in the siphon.

The pelecypods described in the following page were inhabitants of salt water.

I wish to acknowledge the kind aid in this work given by Mr. Austin F. Rogers. He has also found and worked out several species in the following list since the work closed. For full bibliography the reader is referred to Weller, Bull. U. S. Geol. Surv. No. 153, (1898).

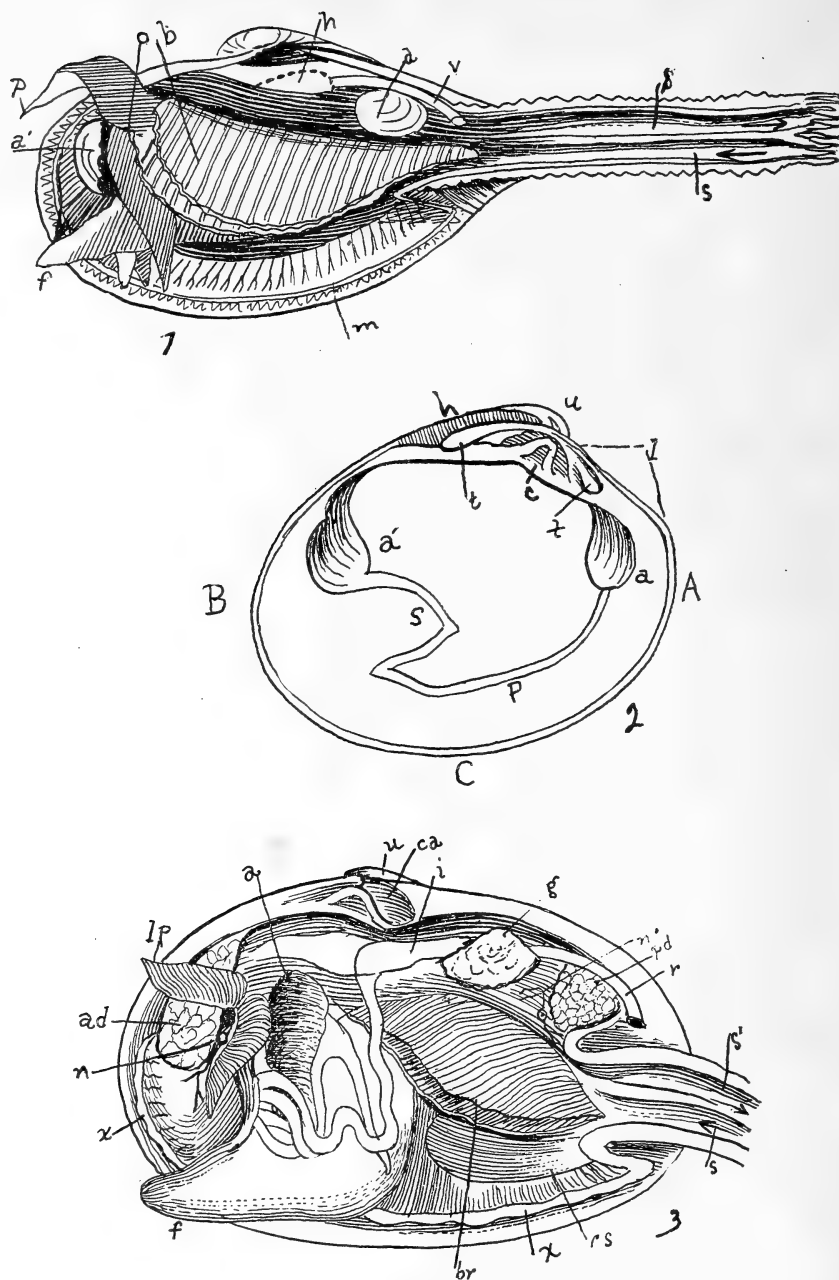


FIG. 4. 1. Anatomy of a bivalve mollusk, *Mya arenaria* (after Woodward); left valve and mantle lobe, and half the siphons, are removed: *ss*, respiratory siphons (the arrows indicate the direction of the currents); *aa'*, adductor muscles; *b*, gills; *h*, heart; *o*, mouth, surrounded

PLACUNOPSIS.

Morris and Lycett, Mon. Foss. Great Oolite, (1853).

Placunopsis carbonaria. Plate XX, fig. 18.*Placunopsis carbonaria* Meek and Worthen, Proc. Chic. Acad. Sci., 1, p. 13, (1866); Geol. Surv. Ill., v, p. 578, pl. xxvii, f. 2, (1873).

Meek and Worthen's description: "Shell orbicular, compressed subhemispherical, extremely thin. Upper or right valve irregularly convex, sometimes rather gibbous; hinge margin straight, generally equaling about one-third to one-half the diameter of the valves, and usually showing slight disposition to develop small, obtuse ears at the extremities; beak very small, sometimes compressed and nearly obsolete, marginal, but not projecting distinctly beyond the cardinal border, located at the middle of the hinge, and showing a slight forward curvature. Under valve flat or conforming to the inequalities of the surface to which it was attached; beak marginal, and very nearly obsolete. Surface of both valves marked with irregular, undulating or interrupted radiating lines, with broad, faint, irregular concentric wrinkles, and a set of obscure striæ of growth. Often there is also an entirely independent series of parallel ridges, crossing the umbonal region, or sometimes the whole surface obliquely and partly, or sometimes almost entirely, obliterating the other markings. Diameter of the largest specimen found, from the hinge to the pallial margin, 1.30 inches; oblique parallel ridges uniformly numbering seven to eight in 0.2 inch."

Range and distribution: Upper Coal Measures; Topeka.

by (*p*) labial palpi; *f*, foot; *r*, anus; *m*, cut edge of the mantle (after Nicholson). **2.** Left valve of *Cytheria chione* (after Woodward): *A*, anterior margin; *B*, posterior margin; *C*, ventral margin or base; *u*, umbo; *h*, ligament; *c*, cardinal tooth; *ll*, lateral teeth; *a*, anterior adductor; *a'*, posterior adductor; *p*, pallial line; *s*, pallial sinus caused by the retractor muscles of the siphons (after Nicholson). **3.** Diagrammatic representation of the anatomy of a siphonate pelecypod: the left valve and the left mantle lobe are removed, and the siphons are cut short; *u*, umbo; *ca*, cartilage pit; *o*, the mouth; (*p*, labial palpi; *a*, stomach, surrounded by liver; *i*, intestine perforating the heart; *r*, rectum, terminating in the anus; *ad*, anterior adductors; *pd*, posterior adductors; *n*, supraesophageal or cerebral ganglion (the mouth is a little displaced upwards, so that the ganglion comes to lie below the gullet instead of above it); *n'*, parieto-splanchnic or branchial ganglion; *f*, foot; *xx*, cut edge of the right mantle lobe; *rs*, retractor muscles of the siphon; *br*, branchiæ of the left side; *g*, renal organ; *s*, inhalant siphon; *s'*, exhalant siphon (after Nicholson).

LIMA.Brugueire, *Encycl. Meth.*, (1791).Deshayes, *Desc. de Coq. Foss. des Inv. de Paris*, (1824).**Lima retifera.** Plate XIII, fig. 5.

Lima retifera Shumard, *Trans. St. L. Acad. Sci.*, 1, p. 214, (1858); Meek, *Fin. Rep. U. S. Geol. Surv. Neb.*, p. 188, pl. ix, f. 5, (1872). See Weller, *Bull. 153, U. S. Geol. Surv.*, p. 324, (1898).

Meek's description: "Shell obliquely subovate, moderately convex, apparently not gaping in front; hinge line short, or between one-half and one-third the antero-posterior diameter of the valves; base forming a nearly regular semicircular curve; anterior side extended obliquely forward, rather narrowly rounded below, and straight or slightly concave in outline, with a rather long, oblique slope to the hinge above; posterior side distinctly shorter than the other, and rounding from near the ear into the base; ears subequal, the front margin of the anterior one forming an obtuse angle with the hinge line, rather distinctly flattened from the swell of the umbo, and somewhat extended along the anterior margin below; posterior ear a little more convex than the other, with its upper margin incurved, and its lower margin separated from the umbo by a faint oblique furrow, sometimes faintly sinuous behind, and nearly rectangular at its extremity; umbones rather convex or moderately compressed, extending very little above the cardinal margin, and placed near the middle of the same; surface ornamented by about twenty-five slightly irregular, angular, radiating costæ, about equaling the spaces between, and occasionally bifurcating on the umbones and lateral margins of the body part of the valves, where they become obsolete; crossing all of these, as well as on the ears and lateral margins, are numerous fine concentric striæ. Height, 15 mm.; length, 18 mm.

Range and distribution: Upper Coal Measures; Lawrence, Topeka.

ENTOLIUM.

Meek, Geol. Surv. Cal. II.

Entolium aviculatum. Plate XIX, fig. 1.*Pecten ariculatus* Swallow, Trans. St. L. Acad. Sci., 1. p. 213, (1858).*Entolium aviculatum* Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 189, pl. ix, ff. 11a-g, (1872).

Meek's description: "Shell compressed lenticular, very thin, nearly or quite equivalve, suborbicular, or broad subovate in outline exclusive of the ears, the antero-posterior diameter being often a little less than that at right angles to the same; sides and base more or less regularly rounded; lateral margins above the middle apparently a little gaping, straight, and converging to the beaks at an angle of 115° to 125° ; cardinal margin very short, or less than one-third the transverse diameter of the valves, and in the left valve generally concave, or more or less sloping in outline from the extremities of the ears to the beaks; straight or nearly so in the right valve; ears small, flat, very nearly equal, obtusely angular at the extremities, and separated from the body of the valves by an impressed line, not defined by any proper sinus in either valve, though the broad obtuse notch separating the anterior one from the straight, sloping adjacent margin is slightly more defined than the other; beaks small, rather compressed, equal, and not projecting beyond the cardinal margin. Each valve with two shallow undefined impressions diverging from the beak nearly to the anterior and posterior margins; that on the posterior side being longer than the other. Surface with very fine close concentric striæ, scarcely visible without the aid of a magnifier; crossing these are sometimes seen traces of extremely minute radiating striæ, curving gracefully outward toward the lateral margins." In a foot-note he says: "In most of these specimens these radiating striæ are entirely obsolete, even as seen under a magnifier; and it is generally only on specimens that have been slightly weathered that they are most distinctly seen, while even on these they seem to be more due to some peculiarity of the shell structure than proper surface sculpturing, the shell showing a disposition to crack along these curved lines.

Both these and the concentric striæ are almost invisible to the unassisted eye."

"Anterio-posterior diameter of a specimen a little under medium size, 0.85 inch; height, 0.89 inch; length of the hinge line, 0.27 inch. Specimens are sometimes found of nearly double these dimensions." In some delicately preserved casts there are traces of zigzag markings on the anterior of the ventral margin of the left valve.

Range and distribution: Upper Coal Measures; Lawrence, Topeka.

AVICULOPECTEN.

McCoy, Ann. Mag. Nat. Hist., 2d ser., VII, p. 171, (1851).

Aviculopecten occidentalis. Plate XIII, fig. 7.

Pecten occidentalis Shumard, Geol. Rep. Mo., p. 207, pl. c, f. 18, (1855); Newberry, Ives's Colo. Expl. Exped., p. 128, (1861).

Pecten cleavelandicus Swallow, Trans. St. L. Acad. Sci., I, p. 184, (1858).

Aviculopecten—? Meek and Hayden, Pal. Upp. Mo. (Smiths. Cont. Knowl., xiv), p. 50, pl. II, f. 10, (1864).

Aviculopecten occidentalis Meek and Worthen, Geol. Surv. Ill., II, p. 331, pl. xxvii, ff. 4-5a, (1866); Meek, U. S. Geol. Surv. Neb., p. 191, pl. IX, f. 10, (1872); etc.

Pecten missouriensis? Geinitz, Carb. u. Dyas in Neb., p. 35, pl. II, f. 18, (1866).

Meek's description: "Shell distinctly inequivalve, not oblique; subovate exclusive of the ears; lateral and basal margins regularly rounded; hinge margin nearly or quite equaling the greatest breadth of the valves; cardinal plate of moderate breadth. Left valve convex, with ears subequal; anterior one with distinct radiating costæ, more convex, shorter, and more obtuse than the posterior, as well as more defined from the swell of the umbonal slope; posterior ear flattened and more angular at the extremity than the other, sometimes without radiating costæ, but in other instances having them more or less developed, each separated from the margin below by a rounded, rather broad, more or less deep sinus. Right valve nearly flat and having the general outline of the other excepting that its beak is scarcely distinct from the cardinal margin, and its anterior ear much narrower and defined by a deep, sharp angular sinus. Surface of valve ornamented

with rather depressed or flattened irregular radiating costæ, of which only about twelve or fourteen of the largest reach the beak, others dying out at various distances between the margins and the umbo; in proportion to size, the larger of the intercalated ones being longer than the smaller. Crossing all of these are numerous fine concentric striæ, some of which on the ears, particularly the anterior one, often form little vaulted scales; in well-preserved specimens these vaulted projections are strongly developed on one of the posterior costæ of the body part of the valve. Surface of right valve generally with only very obscure radiating costæ and fine crowded lines of growth." Measurements: Length, 24 mm.; height, 26 mm.; convexity, about 5 mm.

Range and distribution: Upper Coal Measures; Turner, Eudora, Lawrence, Topeka, Wabaunsee county.

Aviculopecten rectilaterarius.

Avicula rectilateraria Cox, Geol. Surv. Ky., III, p. 578, p. IX, f. 2, (1857).

Aviculopecten rectilaterarius Meek and Worthen, Geol. Surv. Ill., II, p. 326, (1866).

Shell variable in outline, about as long as high; ventral margin rounded, nearly semicircular; posterior margin nearly straight, meeting the hinge at nearly a right angle; anterior margin slightly sinuate at the lower part of the ear, then, rounding upward, meets the hinge line; lower anterior margin more abruptly rounded than the corresponding posterior one; hinge line slightly shorter than the shell, the beak not extending above the hinge; posterior ear not separated from the shell by a sulcus, anterior ear separated from it by an indistinct furrow. The anterior ear of the right valve contains a sharp byssal notch. The shell is marked by fairly prominent, slightly sinuous, radiating striæ, which increase by implanation and bifurcation; on the posterior ear of the left valve these striæ are very dimly visible but are more prominent on the anterior ear. These striæ are crossed by very fine, close, concentric striæ and larger lines of growth. Measurements, two specimens: Length, 18 mm., 18 mm.; height, 19 mm., 15 mm.

Range and distribution: Upper Coal Measures; Leavenworth, Wyandotte county.

Specimens are abundant in the shales at Topeka which may belong to this species or to *A. whitei*. The material in hand is too poor to assign with certainty to either species. The probability is, however, that they belong to *A. whitei*.

This species can be easily distinguished from *A. occidentalis* by its smaller size, thinner shell, and the fact that the posterior ear is not so distinct and the shell is less elongate vertically.

***Aviculopecten interlineatus*. Plate XIII, fig. 6.**

Aviculopecten interlineatus Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 454, (1860); Geol. Surv. Ill., II, p. 329, pl. XXVI, ff. 7a, b, text fig. (1866); Whitfield, Ann. N. Y. Acad. Sci., v, p. 694, pl. XVI, ff. 10, 11, (1891); Keyes, Geol. Surv. Mo., v, p. 112, pl. XLII, f. 6, (1894); Whitfield, Geol. Surv. Ohio, VII, p. 489, pl. XII, ff. 10, 11.

Aviculopecten? interlineatus White, U. S. Geog. Surv. West 100 Mer., IV, p. 149, pl. XI, f. 3, (1877); 13th Ann. Rep. Ind. St. Geol., p. 145, pl. XXX, f. 9, (1884).

Meek and Worthen's description: "Shell (left valve) rather small, compressed, broad ovate or subcircular exclusive of the ears, not oblique; length and breadth nearly equal; hinge straight, about equaling the greatest breadth of the valve below, ranging at right angles to the vertical axis of the shell. Base regularly rounded; posterior and anterior margins rounded from below the ears to the base. Anterior ear triangular, flattened so as to be very distinct from the umbonal slope; posterior ear somewhat larger than the other, compressed, triangular, the hinge side being longer than either of the others, rather acutely angular at the extremity. Beak compressed, a little nearer the anterior than the posterior extremity of the hinge; umbonal slopes diverging from the beaks at an angle of about 78° ; anterior one subangular. Surface ornamented by about fifteen regular, very prominent, slender, and obscurely crenulated concentric costæ, which are separated by spaces from four to six times their own breadth, excepting on and near the ears; spaces between the costæ occupied by numerous fine, regular, closely arranged concentric striæ, which are crossed by faint indications of radiating ribs. Diameter, from

the pallial border to the hinge, 15 mm.; breadth, from the anterior to the posterior margin, 16 mm.; convexity, 3 mm. Right valve unknown." In the discussion they also add:

"This exceedingly beautiful species seems to have varied a little in the details of its surface markings at different ages. In young shells the regular concentric costæ seem to be nearly or quite smooth, but as the shell advanced in its growth, they gradually assumed a regularly crenulated outline, and became themselves ornamented with extremely fine longitudinal striæ, not visible without the aid of a lens. These striæ are very much finer and less distinct than those occupying the spaces between the costæ. The faint indications of radiating costæ, seen crossing the concentric striæ in the depressions between the concentric ribs, are also wanting in young shells."

Range and distribution: Upper Coal Measures; Kansas City.

The absence of radiating striæ and costæ and the strong concentric costæ with the fine concentric striæ between them easily and clearly distinguish this species from all others of the genus

Aviculopecten carboniferus. Plate XIII, fig. 9.

Pecten carboniferus Stevens, Amer. Jour. Sci. and Arts, xxv, p. 261, (1858).

Pecten broadheadii Swallow, Trans. St. L. Acad. Sci., II, p. 97, (1862).

Pecten hawni Swallow and Geinitz, Carb. u. Dyas in Neb., p. 36, pl. II, ff. 19a, b, (1866).

Aviculopecten carboniferus Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 193, pl. IV, f. 8, and pl. IX, ff. 4a, b, (1872).

Meek's description: "Shell rather small, slightly oblique, moderately convex, length and breadth nearly equal; hinge line nearly or quite straight, and somewhat less than the greatest breadth of the valves, provided with a marginal ridge in both valves; basal margin regularly rounded. Left valve more convex than the other; posterior ear rather well defined from the swell of the umbo, somewhat extended and terminating in an acute point, separated from the margin below by a deep, rounded sinus; anterior ear about two-thirds as long as the other, and rather more distinct from the umbo and more obtuse, but still rather acutely angular, defined by a moderately distinct subangular sinus. Right valve nearly flat, or distinctly

less convex than the other; its anterior ear narrow, and defined by a deep, rather sharp sinus; posterior ear of the same size and form as in the left valve. Surface ornamented in the left valve with about fifteen or sixteen regular, distinct, angular, radiating plications separated by furrows of the same size, each one of which terminates at the free border in little spine-like projections, with curved-up margins; lines of growth fine on the body of the valve, but becoming more distinct and irregular on the ears, where there are rarely any defined radiating costæ. At a few distantly separated intervals there are prominent imbricating lamellæ of growth, showing the same digitate margins as the free borders of the shell. In the right valve the surface markings are somewhat like those of the other valve, but much more obscure, excepting on the anterior wing, where there are a few more distinct radiating costæ."

Measurements: Height, 29 mm.; length, 22 mm.; convexity, about 4 mm.

Range and distribution: Upper Coal Measures; Kansas City, Turner, Eudora, Lawrence, Lecompton, Topeka.

The strong radiating costæ with the vaulted and spine-like projections of the free margins and larger lamellæ of growth distinguish this species from all others of the genus. When broken from limestone, the larger lamellæ of growth are generally broken away.

Aviculopecten maccoyi. Plate XIII, fig. 10.

Aviculopecten Mccoyi Meek and Hayden, Pal. Upp. Mo., p. 50, pl. II, f. 9, (1864); White, U. S. Geog. Surv. West 100 Mer., IV, p. 150, pl. XI, f. 2a, (1877).

Shell below medium size, moderately convex, subovate in outline exclusive of the ears; hinge nearly or quite equaling the greatest length of the shell, slightly falling from the beak, which extends a trifle above it; posterior ear larger and more acute than the anterior. The ventral margin is broadly rounded; the posterior margin is more abruptly rounded than the lower anterior margin; anterior ear separated from the shell by a moderately deep, rounded sinus, and from the body of the shell by a distinct, moderately deep, rounded depression;

anterior extremity of the ear somewhat rounded; posterior ear separated from the margin by a larger and rounder sinus, and from the shell by a nearly equal depression with that of the anterior one; the sides of the beak converge at an angle of about 85° . The surface of the left valve is ornamented with radiating striæ, from three to six of which are marked at intervals with vaulted, scale-like projections, give them a rough appearance; between each of these are four to eight smaller, slightly flexuous striæ, increasing by implanation; crossing all of these are fine, closely set, concentric striæ and occasionally larger lines of growth; anterior ear marked by radiating and fine concentric striæ; the radiating striæ on the posterior ear are less distinct. Measurements: Height, 21 mm.; length, 29 mm.; convexity, 4 mm.; length of the hinge line, 19 mm.

Range and distribution: Upper Coal Measures; Turner, Lawrence, Lecompton, Topeka, Cowley county.

This species can almost always be distinguished by its larger ribs, with the vaulted scale-like elevations and smaller striæ between. Care must be taken, however, not to confound it with *Pseudomonotis*, which it resembles to a considerable degree, in an outward way, but it is much more regular and has the ears better developed than in *Pseudomonotis*.

Aviculopecten providencesis. Plate XIII, fig. 2.

Pecten providencesis Cox, Geol. Surv. Ky., III, p. 556, pl. VIII, f. 1, (1857).

Aviculopecten providencesis Worthen, Geol. Surv. Ill., VIII, p. 116, pl. XXI, ff. 4, 4a, (1890).

Aviculopecten fasciculatus Keyes, Geol. Surv. Mo., v, p. 113, pl. XLII, f. 7, (1894).

Shell large, broadly subovate in outline, somewhat oblique; margins, except the ears, broadly and regularly rounded, the beak extending very slightly beyond the hinge line, which is shorter than the length of the shell; height about equal the length. Ears large, well defined, the posterior one much more acute than the anterior, which is somewhat rounded, and separated from the body of the shell by a somewhat shallow, distinct sinus; posterior ear separated from the swell of the umbo by a sharp depression and from the margin by a distinct sinus. Sur-

face of the shell ornamented by about twenty-three radiating costæ, each consisting of three to five striæ, which extend nearly to the beak; these bundles are separated by rather broad depressions or grooves. There are fine crowded lines of growth visible; they are prominent on the margins of large specimens as lamellar striæ. The anterior ear is ornamented by ten to fifteen simple radiating striæ and concentric lines of growth; the posterior ear is similarly marked, except that the radiating lines are fewer and less distinct. Measurements: Height, 69 mm.; length, 64 mm.; length of hinge, 40 mm.; convexity, 12 mm.

Range and distribution: Upper Coal Measures; Kansas City, Turner.

The truncation of the posterior side, nature of the fascicles, ears and the general appearance of this shell are so similar to *A. providencesis* of Cox that I do not hesitate to refer it to that species. Worthen evidently considered it as belonging to that species, for he borrowed a fine specimen from Mr. W. J. Parrish, of Kansas City, to figure, in the volume above referred to, for comparison, with his new species which he named *A. chesterensis*. Mr. Parrish, so he informs me, collected the specimens figured by Worthen from the Kansas City rocks. Some of our specimens are from the same locality. It is therefore probable that they are the same as Keyes's *A. fasciculatus*, which also is from Kansas City. Keyes, in his diagnosis, gives no characters which distinguish his species from that of Cox. It differs from Worthen's species in the larger fascicles and the truncated upper posterior extremity of the outline, as well as having a comparatively longer hinge. Our specimens are also much more convex than those of *A. chesterensis*.

The species can be easily separated from the remainder of our Carboniferous species by its large size and the fasciculation of the striæ.

Aviculopecten hertzeri. Plate XIII, figs. 8, 1, 1b.

Aviculopecten (Streblopteria?) hertzeri Meek, Proc. Acad. Nat. Sci. Phil., 1871, p. 61; Pal. Ohio, II, p. 330, pl. XIX, ff. 13a-c, (1875).

Aviculopecten hertzeri Herrick, Bull. Den. Univ., II, p. 25, pl. I, ff. 5, 10.

Meek's description: "Shell usually under medium size, higher than wide, rather compressed, the right valve being nearly flat, and the left only moderately convex; subovate in general outline (exclusive of the ears), with a slight backward obliquity, caused by the greater prominence of the anterior margin; basal outline semicircular and rounded regularly into the rather prominently rounded anterior margin; posterior margin less prominent than the anterior, and forming a longer and more or less gentle curve from the posterior ear into the base; hinge distinctly shorter than the antero-posterior diameter of the valves; posterior ear in both valves very small, flattened, very obtusely angular, and much shorter than the margin below from which it is only separated by a slight sinuosity, though it is well defined from the umbo; anterior ear of each valve distinctly larger than the posterior, though not nearly so prominent as the anterior margin below, rather strongly compressed or flattened, so as to be abruptly separated from the umbo, and in both valves defined by a distinct sinus from the margin below, the sinus being deeper and more angular in the right valve; beaks compressed, scarcely projecting above the cardinal margin, and placed a little behind the middle of the hinge, as well as that of the valves. Surface of both valves elegantly ornamented by numerous, sometimes sharply elevated, nearly equal, very regularly arranged radiating and concentric lines, which are larger and more strongly defined on the anterior ear of the right valve, particularly the radiating markings, which there sometimes assume the character of small costæ, while the concentric markings there in some examples project as little lamellæ above the hinge margin, so as to give it a subtended appearance. Height of one of the largest specimens seen, 1.32 inches; antero-posterior diameter, 1.20 inches; convexity, about 0.18 inch."

Range and distribution: Upper Coal Measures; Topeka. From the horizon of the Osage coal.

The fine, regular, cancellated striæ and the larger striæ on the anterior ear distinguish this species from any of the preceding. We have a single specimen from Topeka which seems to agree very well with this species.

Aviculopecten sculptilis. Plate XIII, figs. 3, 3b.

Aviculopecten sculptilis Miller, 17th Ann. Rep. St. Geol. Ind., p. 702, pl. xx, f. 5, (1892).

Shell a little large, somewhat oblique, ovate in outline, tapering to the beak at an angle of 90° or less, very moderately convex; beak extending to or a trifle beyond the hinge line, and located back of the middle of it. The ears are small, the anterior flattened, and separated from the swell of the umbo by a deep depression, and considerably larger than the posterior ear; the margin of the ear makes a deep sinus at its junction with the margin of the shell; however, the anterior border of the shell generally extends beyond the ear; posterior ear small, well defined, margin not separated from the margin of the shell by a very distinct sinus; the posterior is about two-thirds as long as the anterior. Both ears (in the left valve) are marked by small, well defined, concentric striæ. Entire border below the ears regularly rounded and subsemicircular. The shell is marked by numerous, closely set radiating striæ, which are crossed by about equally prominent closely set concentric striæ, giving the shell a beautifully cancellated appearance; the radiating striæ increase by implanation. At the anterior border the shell often becomes quite rough in appearance on account of the enlarging of the striæ. The anterior ear seems to be crossed by a few indistinct radiating striæ. According to Miller, the anterior ("posterior") ear of the right valve is marked by more prominent radiating striæ which "give it a strongly pitted aspect." Measurements: Height, 49 mm.; length, 40 mm.; length of hinge, 23 mm.; convexity, about 8 mm.

Range and distribution: Upper Coal Measures; Kansas City. Taken from the oolite.

This species differs from *A. hertzeri* Meek in being much larger, in having a much more (20°) acute beak, which makes it a more slender shell. Aside from the species just mentioned, it can easily be distinguished from our other Coal Measures species by its strongly reticulated surface.

The specimen at hand agrees very well with Miller's description and figure, though there are a few minor differences, but both are from the same locality, so there can be but little doubt of their identity.

Aviculopecten germanus. Plate XIII, fig. 4.

Aviculopecten germanus Miller and Faber, Jour. Cinn. Soc. Nat. Hist., xv, pp. 81, 82, pl. 1, f. 9, (1892.)

Original description: "Shell small, a little higher than long; inequilateral; oblique; base regularly rounded; antero-basal and postero-basal margins rounded. Hinge oblique, nearly straight, not quite equaling the greatest length of the valves below. Posterior ear extends to the lateral border, with which it forms nearly a right angle; it graduates into the shell below without the presence of a sinus. Anterior ear rather shorter than the posterior one, angular at the extremity and rounding on the margin below into a notch, and arching from the wing into a deep and distinct sinus that separates it from the posterior margin of the shell. Umbo tumid and umbonal slopes diverging to the margin. Beak high, pointed and projecting beyond the cardinal margin a little forward of the middle of the hinge line. There are two costæ on the posterior ear, and three or more finer ones on the anterior ear. There are about twelve principal radiating ribs on the body of the shell and about as many rudimentary and intercalated shorter ribs between them; they are separated by wider flattened spaces. It is difficult to tell from our specimens whether or not there were any concentric lines, though they are quite well preserved; if there were such lines they were very fine.

"This species approaches more nearly to *A. rectilaterarius* than to any other, but it may be readily distinguished by the scarcity of the radiating ribs and the wide flattened spaces between

them; the beak, too, is higher and more pointed, as well as having a more tumid umbo."

Range and distribution: Upper Coal Measures; Lawrence.

Aviculopecten coxanus. Plate XIX, fig. 2.

Aviculopecten coxanus Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 453, (1860); Meek, U. S. Geol. Surv. Neb., p. 196, pl. ix, ff. 6a,b, (1872).

Meek's description: "Shell very small; thin, compressed, slightly oblique; broad subovate exclusive of the ears; basal margin rounded; anterior margin more or less rounded, rather straight and oblique above; posterior margin more prominent than the anterior, often subangular at the point where the postero-basal margin rounds up to meet the obliquely sloping edge above. Hinge generally a little less than the greatest breadth of the valves below. Left valve with anterior ear of moderate size, flat, triangular, with the extremity generally a little less than a right angle, sometimes very slightly rounded, separated from the margin below by an abruptly rounded or subangular sinus; posterior ear slightly larger and much more acutely angular than the other, but shorter than the most prominent part of the margin below, from which it is separated by a moderately deep rather broadly rounded sinus; beak small, compressed, scarcely projecting beyond the cardinal margin, and placed a little in advance of the middle of the hinge; surface ornamented with linear, simple, often more or less flexuous costæ, which alternate in size, the smaller ones dying out at varying distances between the free margins and the umbo—crossing all of these are numerous, extremely fine, regular, closely arranged concentric striæ, which, like the costæ, are more or less distinctly defined on the ears, as well as on the body of the valve. Right valve unknown."

Range and distribution: Upper Coal Measures; Lecompton.

A single specimen of a left valve of this species agreeing very well indeed with Meek's description and figure was collected in the shale underlying the Upper Oread limestone at Lecompton.

PTERIA.

Pteria longa. Plate XVI, fig. 4.

Gervillia longa Geinitz, Carb. u. Dyas in Neb., p. 32, pl. II, f. 15, (1866).

Avicula longa Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 199, pl. IX, f. 8, (1872); Meek and Worthen, Geol. Surv. Ill., v, p. 578, pl. XXVI, f. 1, (1873); etc.

Meek's description: "Shell nearly or quite equivalve; body part obliquely elongated and more or less arcuate; posterior end narrow and abruptly rounded; base nearly straight and parallel to the cardinal margin behind, but ascending obliquely forward from near the middle of the valves; anterior side oblique, and broadly and faintly sinuous under the ear. Hinge line about three-fourths the length of the valves, and provided with a marginal ridge, produced behind into a very narrow, elongated ear, considerably shorter than the oblique portion of the valves, from which it is separated by a deep sinus which narrows to an abruptly rounded or subangular extremity close under the ear; anterior ear shorter and much broader than the other, in the left valve convex, with its extremity pointed, and faintly sinuous just below the point—separated from the swell of the umbo by an oblique sulcus extending from the anterior side of the same to the back part of the broad, shallow marginal sinus of the ear. Beaks of both valves convex, very oblique, placed one-fourth to one-fifth the length of the hinge back of the anterior extremity; in the right valve, rising a little above the hinge, but in the left somewhat more prominent, according to Professor Geinitz's figures. Length of medium-sized specimen, measuring obliquely from the extremity of the anterior ear to the posterior end of the body part of the valves, 9.61 inch; height, measuring at right angles to the hinge, 9.33 inch; length of hinge, about 9.23 inch."

Range and distribution: Upper Coal Measures; Lawrence, Topeka.

Pteria sulcata. Plate XVI, fig. 3.

Gervillia sulcata Geinitz, Carb. u. Dyas in Neb., p. 33, pl. II, f. 16, (1866).

Avicula? sulcata Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 200, pl. IX, f. 9, (1872).

All the specimens before me having the ears either broken off or not visible, Meek's description of Geinitz's figure is given, with remarks on the specimens at hand. "Rhombic oblique shell, with short, compressed, triangular anterior ear, defined by a faint, wide marginal sinus; and a larger compressed, somewhat elate, posterior ear, with a marginal ridge, showing a tendency to be produced into a narrow appendage behind, separated from the margin below by a rather deep, rounded sinus. The posterior basal extremity is rather narrowly rounded, but not much produced; while the outline of the base is broadly semielliptical, and the umbo convex, and rising somewhat above the hinge line, which is apparently shorter than the greatest length of the valve. Surface ornamented by fine lines of growth, and before by two or three sulci, extending from the anterior side of the beak to the antero-basal margin, leaving ridges between which are more or less crenated by the crossing of the marks of growth; just behind the posterior one of these sulci, the margin of the latter is ornamented with regular, rather strongly defined wrinkles, or little folds, some of which are prolonged backward parallel to the lines of growth."

Range and distribution: Upper Coal Measures; Kansas City, Lawrence.

Most of our specimens are younger than the one figured by Meek and Geinitz, and, as a result, somewhat less ornamented. The ornamentation is varied somewhat in different individuals. In some the ridge between the sulci is very crenate, and less so in the others. It may easily be distinguished from the other species by the ornamentation of this part of the shell.

LIMOPTERIA.

Meek and Worthen, Proc. Chic. Acad. Sci., I, p. 29, (1866).

Limopteria longispina. Plate XVI, fig 6.*Gervillia longispina* Cox, Geol. Rep. Ky., III, p. 568, pl. VIII, f. 6, (1857).*Monopteria longispina* Keyes, Geol. Surv. Mo., v, p. 114, pl. XLIII, f. 1, (1894).

Shell elliptical-subquadrate in outline; antero-dorsal margin nearly straight to the anterior margin, which is nearly circular, the curve rapidly decreasing again to the extremity of the shell, where it is sharply curved, almost angular; the posterior margin is a deep U-shaped sinus between the acute point of the ear and the extremity of the shell. Beak placed well forward; shell very oblique; umbonal ridge very prominent, extending to the extremity of the shell, greatest curve about one-third the distance from the beak, which protrudes slightly beyond the hinge line. Anterior portion of the shell quite convex. The deflection of the margin anterior to the beak, forming the lunule, is very sharp, almost angular, and extends backward some distance. The internal muscular impressions very faint, as excellently preserved casts show practically no traces of them. Spine acute, about three-fourths the length of the shell. The posterior ear is separated from the shell by a moderately well-defined depression, which falls directly from the umbonal ridge, which is very prominent. Surface marked by concentric striæ of growth which are nearly parallel to the outline of the shell.

Range and distribution: Upper Coal Measures; Kansas City, Turner, Lawrence.

Some specimens from Lawrence are extremely long when measured from the tip of the ear to the anterior margin. The great length of the ear, with the convexity of this portion of the shell, are its principal features.

Limopteria marian. Plate XVI, figs. 5-5c.

Monopteria marian White, Prelim. Rep. Inv. Foss., p. 22, (1874); U. S. Geog. Surv. West 100 Mer., iv, p. 151, pl. xi, ff. 4a-c, (1877).

White's description (with additions): "Shell of moderate size, slender, nearly or quite equivalve, narrow and much extended posteriorly, the curvature being much the greater in the anterior half of the shell, the posterior half being nearly straight; body of the shell gradually tapering to near the posterior end, which is abruptly rounded; a more or less prominent ridge, which is sometimes in part raised as a distinct carina, extends along the middle of the body of each valve from the beak to the posterior end; from this carina, or angle, the sides slope abruptly to both the inferior and upper borders, so that a cross-section of the shell behind the ear would have a rhomboidal outline; beaks moderately prominent, separate; hinge equal in length to about one-half the full length of the shell, and its direction is nearly parallel with the posterior half of the body; posterior wing well developed, not sharply defined from the body by an auricular furrow; its cardinal portion narrow and moderately extended; anterior ear obsolete; lunule moderately large and deep, the borders of which are slightly prominent laterally, but its margins sharply rounded inward. Surface smooth in aspect, but it is marked by very numerous fine lines of growth. Length, from the front to the posterior extremity, about 4 cm.; height, from the base to hinge margin, 18 mm.; average width of the body of the shell, about 1 cm."

We have a left valve, probably of a large specimen of this species, showing part of the muscular impressions. The adductor is located behind the umbonal ridge, just above and in front of the marginal sinus formed by the ear and the body of the shell. From the lower side of the impressions a slight line runs directly forward across the umbonal ridge, then turns abruptly and runs toward the anterior end of the lunule, but fades out at about two-thirds of the distance. In front of the scar, and crossing the front edge of it, is a line at right angles to the first, beginning a little above the scar and fading out

about half way to the lower end; beyond the line appears to be a very indistinct furrow near to the ventral margin. In a cast of what appears to be a right valve of another specimen the adductor impression is shown, located nearly opposite to that of the left as described above. It is situated mostly behind the umbonal ridge but extends over it, is deeper and roundly ovate. The pallial line extends from the lower side of the impression a little forward and then upward, reaching to the anterior edge of the beak. The umbonal ridge appears to be much less sharp in this specimen than in the other.

Range and distribution: Upper Coal Measures; Turner, Topeka.

This species may be easily distinguished from the foregoing by its more slender form, more gently curving front, and less spinous ear.

Limopteria gibbosa. Plate XVI, fig. 9.

Pterinia (Monopteria) gibbosa Meek and Worthen, Geol. Surv. Ill., II, p. 330, pl. xxvii, ff. 11-11b, (1866).

Monopteria gibbosa White, 13th Ann. Rep. Ind. St. Geol., p. 139, pl. xxx, ff. 11, 12, (1884).

Monopteria (Pterinia) gibbosa Heilprin, 2d Geol. Surv. Penn., Ann. Rep. 1885, p. 455, f. 11a, p. 444, f. 11, (1886).

White's description: "Shell, exclusive of the wing and posterior prominence, irregularly suborbicular in marginal outline; the valves moderately convex or a little gibbous; the anterior and basal margins forming an almost regular semicircular curve; posterior portion of the shell produced, narrow and narrowly rounded, or subangular, at the extremity; wing slender, compressed and extending backward as far as the narrow extremity, between which the posterior margin forms a deep, broad notch, that is narrowly rounded at the bottom; umbonal ridge moderately distinct; beaks equal, not so far forward as the front margin of the shell; anterior lunule deep; cardinal border not so long as the full diameter of the shell; surface marked only by the ordinary lines of growth. Length, from posterior extremity to front, 27 mm.; height, from base to beaks, 23 mm."

Range and distribution : Upper Coal Measures ; Kansas City, Turner, Lawrence.

The short, gibbous shell with a moderately long spine separates this species from the rest of the genus.

***Limopteria alata*.** Plate V, fig. 5.

Monopteria gibbosa alata Beede, Kans. Univ. Quart., VII, p. 189, f. 5, (1898).

Shell small, extremely thin, laterally compressed ; beak extending a trifle beyond the hinge line, prominent on account of the lunule, but not much elevated, and placed well back for a member of this genus ; umbonal ridge less prominent than in any other species of the genus and less curved. Posterior ear very greatly developed, about equaling the entire body of the shell in area. Antero-dorsal margin sinuate on account of the turning down of the margin to form the lunule ; anterior margin circular nearly to the postero-ventral extremity of the shell, which is acute ; the posterior margin consists of a broad, shallow sinus, extending from the postero-ventral end to the point of the ear, which is apparently rounded and obtuse. The ear is not separated from the shell by a distinct depression, but slopes gradually from the umbonal swell, save at the extreme lower edge, where the depression is more abrupt. Very fine concentric lines of growth are visible, all of which pass around the shell with a double curve to the ear, where they again curve backward, and then forward to the hinge line. Length, 20 mm. ; depth, 18 mm. ; convexity of single valve, a trifle less than 4 mm.

Range and distribution : Upper Coal Measures ; Turner, Lawrence.

This shell differs from *L. gibbosa* M. and W., to which it is most closely related in some respects, in being much less gibbous, the ear much larger and more obtuse, antero dorsal outline more sinuous, umbonal ridge more nearly straight and less prominent, beak placed farther back, and the depression separating the ear from the umbonal ridge more shallow.

***Limopteria subalata*.** Plate XXI, figs. 3a, 3b.

Monopteria? subalata Beede and Rogers, Kans. Univ. Quart., VIII, p. 133, pl. XXXIV, ff. 3a, 3b, (1899).

Shell moderately small, subcrescentic in outline, gibbous, a little longer than high; valves subequal, but beak prominent, slightly projecting, somewhat inflated, situated about one-fifth the length of the shell from the anterior margin, which is truncated, on account of the lunule which is formed by the turning in of the shell. The anterior margin is convex below. Ventral margin broadly rounded to the postero-ventral extremity, where it is abruptly rounded to meet the concave posterior. Hinge short and straight; posterior ear but slightly developed; umbonal ridge prominent, somewhat sickle-shaped, sloping abruptly posteriorly, forming a cavity broadly convex anteriorly. Surface marked by moderately distinct lines of growth. Length, 16 mm.; height, 14 mm.; convexity of single valve, 4 mm.

Range and distribution: Upper Coal Measures; Lawrence, Topeka.

At two localities in the lower part of the Upper Coal Measures are found great numbers of *Limopteria*. Beside the three large species are found two smaller species, *L. alata* and *L. subalata*; one with an exceedingly large wing and compressed shell, and the other with a gibbous shell and the wing almost wanting. There are many variations of the two species and they seem to grade into the other species to some extent, but differ sufficiently, so far as we can observe, from even the young of those, to be considered as distinct.

The size of the shell and the exceedingly small ear easily separate *L. subalata* from any other member of the genus.

PSEUDOMONOTIS.

Beyrich, Zeitsch. der Deutsch. Geol. Gesellsch., XIV, (1862).

Pseudomonotis hawni. Plate XIII, figs. 11-11c; plate XV, figs. 1-1f, 2, 2a.*Monotis hawni* Meek and Hayden, Trans. Alb. Inst., iv, p. 76, (1858);
Proc. Acad. Nat. Sci. Phil. 1859, p. 28.*Eumicrotus hawni* Meek and Hayden, Pal. Upp. Mo., p. 54, pl. II, ff.
5a-c, (1864); White, 13th Ann. Rep. Ind. St. Geol., p. 142, pl. xxx,
f. 10, (1884); etc.

Meek and Hayden's description: "Shell subcircular, or subovate; hinge straight, equaling about half the length of the valves; beaks subcentral, short, not oblique; ears nearly obsolete; base rounded; antero-ventral and postero-ventral margins rounded, the latter being somewhat more prominently rounded than the other. Left valve convex; anterior margin sometimes slightly sinuous near the hinge above; posterior margin intersecting the hinge at an obtuse angle; beak convex, extending but little beyond the hinge line. Right valve nearly or quite flat; beak flat, not projecting beyond the hinge; byssal sinus narrow, deep, or extending back parallel to the hinge to a point nearly under the beak. Surface of both valves, particularly the left one, ornamented by more or less distinct radiating costæ, which are usually separated by spaces three or four times their own breadth, and armed with regularly disposed vaulted, spinelike prominences, formed apparently from the projecting laminæ of growth. Between each two of the principal radiating costæ from one to three or four much smaller radiating ribs or lines are usually seen, crossed by obscure concentric markings. Hinge and muscular impressions unknown. Length, 1.47 inches; height, 1.42 inches; convexity, about 0.40 inch."

Range and distribution: Upper Coal Measures; Turner, Lawrence, near Topeka.

To the above synonyms should be added, I think, *P. radialis* Meek, described in the Nebraska report. From his description and figures, it seems to agree more closely with *P. hawni* than with any other form.

Pseudomonotis kansasensis, nom. nov. Plate XIV, figs. 1-1d.

Pseudomonotis tenuistriata sp.? var.? Beede, Kans. Univ. Quart., VIII, p. 81, pl. XVIII, ff. 1-1d, (1899).⁸

Shell large, ovate in outline, rather compressed; beak moderately prominent, projecting beyond the hinge, which is nearly straight. Anterior ear small, rounded to meet the hinge, rather flat, the shell rising rather abruptly to the swell of the umbo. Anterior margin slightly sinuate; antero-ventral margin broadly rounded to the ventral portion of the shell, where it becomes nearly straight, then rounding more abruptly to the posterior ear, which is also rounded to the hinge. Greatest convexity a trifle below the beak, but it is very slight. The surface is marked by many fine, wavy, radiating striæ of uniform size, extending from the beak to the ventral margin; occasionally one striation will be a trifle larger than another on the central portion of the shell, but it soon loses itself, and on old individuals the striæ on the ventral border are all about equal. They increase by implantation and are rather sharply defined, separated by troughs from one to three times their width, and are generally crossed by fine concentric lines or laminae. Right valve unknown. Height, 62 mm.; length, 69 mm.;⁹ length of hinge, 23 mm.; convexity, 10 mm.

Range and distribution: Upper Coal Measures; Turner, Topeka, Auburn (Shawnee county). This species differs from *P. hawni* in always having small, regular striæ and shorter hinge in the large individuals, as well as being a larger species.

Pseudomonotis? robusta. Plate XIV, figs. 2-2c.

Pseudomonotis? robusta sp.? var.? Beede, Kans. Univ. Quart., VIII, p. 82, pl. XVIII, ff. 2-2c, (1899).

This shell differs from the preceding in being much more convex and arcuate, in having a longer hinge, higher umbo, beak very much more compressed and scarcely distinct from the

8. Through the kindness of Mr. Charles Schuchert, my attention was called to the description of a species of this genus under the name *tenuistriata*, by Mr. Bittner. The paper was published in the Jahrbuch der K. K. Geolog. Reichsanstalt, xlix, hefts iii and iv, (1899). The species is from the Triassic of central Asia. As the paper probably appeared before my article, the name of the Kansas species will have to be changed. *Kansasensis* is proposed as the new name of the species.

9. The specimen used as the type is somewhat crushed on the posterior end, making the shell appear longer than it really is. The length given here is that of the specimen in its crushed condition.

umbo, not projecting very sensibly above the hinge. The striæ are more regular and much fainter, and either very indistinct or absent on at least the upper third of the shell. Both concentric wrinkles and lamellæ of growth are distinct. Length, 48 mm.; convexity, 18 mm.; height, 42 mm.; length of hinge about 28 mm.

Range and distribution: Upper Coal Measures; Turner.

This species differs from *P. hawni* in being very arcuate, having a plain umbo, and full anterior and posterior marginal outlines, and fine, even striæ on the margins. It differs from *P. kansasensis* in its broad, smooth umbo and indistinct beak, long hinge, and more circular outline.

***Pseudomonotis hawni equestriata*.** Plate XIV, figs. 3-3b.

Pseudomonotis hawni equestriata Beede, Kans. Univ. Quart., O. 82. pl. XVIII, ff. 3-3b, (1899).

Shell of medium size, ovate in outline, moderately to quite gibbous, a little oblique with respect to the hinge; beak moderately prominent, extending to or a little beyond the hinge, which is about half the length of the shell and somewhat arcuate. Umbo quite gibbous. Posterior ear very slightly developed, merging into and forming a slight sinus in the posterior margin; ventral, antero- and postero-ventral margins regularly rounded; anterior margin sinuate in the upper portion on account of the anterior ear, which is small and round. The surface is marked by fine, somewhat regular, rather wavy striæ, which increase by intercalation, each fourth to tenth being usually a little larger than the remainder, though not very conspicuously so. Small lamellæ of growth sometimes distinguishable. Some of the striæ extend nearly to the beak. The right valve is flat, or a little concave; otherwise unknown. Measurements, two specimens: Height, 31 mm., 34 mm.; length, 24 mm., 26 mm.; convexity, 7 mm., 13 mm.; length of hinge, 12 mm., 16 mm. These two specimens represent the extremes of convexity.

Range and distribution: Upper Coal Measures; Turner.

This variety differs from *P. hawni* in being a shorter shell and

a little more convex, having regular striæ, and in being a little smaller. *P. cf. hawni*, in the article above referred to, should also be considered as a true member of the species. The species here separated are, I believe, distinct from *P. hawni*; and this variety is worthy of varietal distinction, as often shells of these kinds are found in localities where the others are absent and some method of distinguishing the two forms of the species is necessary.

POSIDONOMYA.

Bronn, Leth. Geogn., (1837).

Posidonomya? recurva. Plate XIX, figs. 6-6c.

Posidonomya? recurva Beede, Kans. Univ. Quart., VIII, p. 126, pl. XXXII, f. 6, (1899).

Shell of medium size, lenticular, oblique, and thin. The hinge line is nearly straight, about two-thirds the length of the shell. The beak is moderately prominent, recurved, projecting very slightly beyond the hinge. The greatest convexity is on the upper half of the shell and constitutes the umbonal swell, which is moderately prominent and curved backward, making the shell oblique. The surface is marked by concentric undulations of growth, and fine, closely set, concentric striæ. Height, 23 mm.; length, 23 mm.; convexity of valve, about 4 mm.

Range and distribution: Upper Coal Measures; Lawrence.

A specimen from the dam, at Lawrence, and shown in figs. 6b, 6c, Plate XIX, is probably of the same species, though it has a somewhat different appearance and outline. It shows the beak projecting beyond the hinge, and the cast of the interior shows the beak to have been hollow beyond the hinge. The cast figured is of both valves in place, one of which is slightly crushed. It may be a distinct species, though as it is from the same horizon it is probable that the difference is individual rather than specific.

The character of the hinge and the internal markings are too poorly shown in our specimens to permit of accurate location of the species. It resembles very much in appearance species of the genus *Posidonomya*, to which it is provisionally referred, and with which it agrees in its surface markings and in having a

very thin shell. It also agrees very well in these respects with *Paracyclas*, but that genus is not at present known from the Carboniferous.

Posidonomya? pertenuis. Plate XIX, fig. 5.

Posidonomya? pertenuis Beede, Kans. Univ. Quart., VIII, p. 127, pl. xxxii, f. 5, (1899).

Shell a little larger than in the previous species and less oblique. Transversely ovate in outline, very thin, quite compressed. Hinge line is nearly straight, about equaling half the length of the shell. The posterior? margin is somewhat truncate and nearly straight; anterior extension of the hinge longer than the posterior, rather flat, not separated from the shell by well-defined depression. The front and ventral margins regularly rounded. The shell is compressed, probably most convex near the middle; beak obtuse, not very prominent, protruding above the hinge line. The surface is marked by concentric undulations of growth, and fine, close, concentric striæ. Height, 40 mm.; length, 36 mm.; convexity of single valve, 4 or 5 mm.

Range and distribution: Upper Coal Measures; Lawrence.

This species belongs to the same genus as the preceding. It has some resemblance to the figure of Keyes,¹⁰ which he refers to *Placunopsis carbonaria*, though it is very difficult to see why it should be referred to that genus or species; his species may be the same as the one here described.

MODIOLA.

Lamarck, Hist. Nat. les Anim. sans Vert., (1801).

Modiola subelliptica.

Clidophorus (Pleurophorus) occidentalis Geinitz, Carb. u. Dyas in Neb., p. 23, pl. II, f. 6, (1866).

Modiola? subelliptica Meek, Fin. Rep. U. S. Geol. Surv. Neb., 211, pl. x, f. 5, (1872).

Meek's description: "Shell narrow, subelliptical, rather convex, extremely thin, usually a little more than twice as long as high; basal margin nearly straight, or sometimes very slightly convex or sinuous near the middle, rounding up at each ex-

10. Geol. Surv. Mo., V, p. 108, pl. XLIII, fig. 9.

trernity; anterior margin narrowly rounded; posterior extremity more compressed, and more broadly rounded, sometimes a little oblique above; cardinal margin somewhat straightened along the middle, but rounding imperceptibly into the anterior and posterior extremities; beaks much depressed; or scarcely distinct from the cardinal margin, moderately convex, and placed very near the anterior margin, but not terminal; umbonal slopes forming a very obscure narrow ridge, which extends, with a slight curve from each umbo, to the posterior basal margin. Surface marked with moderately distinct lines of growth, which on the posterior dorsal region above the umbonal ridge are crossed by very minute or microscopic radiating and rather distinctly divericating striæ. Length of the largest specimen seen, 1.03 inches; height of the same, 1.43 inches; convexity, about 0.25 inch."

Range and distribution: Upper Coal Measures; Topeka.

MYALINA.

de Koninck, Desc. Anim. Foss. Carb. Belg., p. 125, (1844).

Myalina swallovi. Plate XVI, fig. 7.

Myalina swallovi McChesney, Desc. New Pal. Foss., p. 57, (1860);
Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 201, pl. ix, ff. 7a, b, (1872);
etc.

Aucella hausmani Geinitz, Carb. u. Dyas. in Neb., p. 25, pl. ii, f. 8,
(1866).

Meek's description: "Shell rather small, nearly or quite equivalve, modioliform or mytiloid, convex, or even subangular, along the umbonal slopes from the beak to the anterior basal margin; posterior and postero-dorsal regions, cuneate; cardinal margin nearly straight, and about half the length of the shell, passing almost imperceptibly or without any angularity into the posterior margin, which rounds down with a semicircular curve to the narrowly rounded basal extremity; antero-basal margin ascending obliquely forward, more or less sinuous near the middle or sometimes a little above, usually swelling out into kind of lobe or protuberance above the middle in front of the umbonal slope, as in *Modiola*. This prominence sometimes extends a little beyond the beaks, and varies more

or less in breadth. Beaks small, very oblique, not projecting beyond the cardinal margin, and located so near the anterior extremity as often to appear very nearly terminal. Surface rather smooth, but showing fine concentric lines, which in well-preserved specimens are sometimes crossed by very fine, obscure traces or radiating striæ that curve upward on the posterior dorsal region."

Range and distribution: Upper Coal Measures; Kansas City, Topeka, Turner, Lawrence.

***Myalina subquadrata*.** Plate XVI, figs. 10, 10b.

Myalina subquadrata Shumard. Geol. Surv. Mo., p. 207, pl. C, f. 17, (1855); Meek, Fin. Rep. U. S. Geol. Surv. Neb., 202, pl. iv, f. 12, pl. ix, f. 6 (1872); etc.

Meek's description: "Shell large and thick, oblong or subquadrate, the height being greater than the antero-posterior diameter; right valve nearly flat; left convex, both somewhat compressed and alate above and behind the umbonal prominence. Hinge line nearly straight, about equaling the greatest breadth of the valve, and ranging at right angles to the vertical axis; the basal margin regularly rounded; posterior margin nearly vertical, rounding into the base below, a little sinuous above the middle, and intersecting the hinge above at very nearly right angles; anterior margin thickened within, rounding into base, thence rising nearly vertically with a broadly rounded concavity mainly above the middle. Beaks terminal and directed forward. Cardinal plate or area usually rather broad, with cartilage furrows distinctly defined. Surface of the left valve marked with fine concentric striæ, and stronger imbricating lamellæ of growth. These markings are much less distinct on the right valves."

Range and distribution: Kansas City, Melvern (Osage county), Topeka, Lawrence.

This species can readily be distinguished from the previous by its much larger size, by the hinge forming about a right angle with the vertical axis, and by the sinuosity or at least straight manner in which the margin approaches the posterior end of the hinge.

Myalina ampla. Plate XVI, figs. 1, 1b.

Myalina ampla Meek and Hayden, Pal. Upp. Mo., p. 33, ff. A, B, (1864).

Myalina subquadrata Meek and Hayden, *ibid.*, p. 32.

Meek and Hayden's description: "Shell attaining a large size, compressed and somewhat alate in the postero-dorsal region, and convex anteriorly—considerably higher than long; posterior margin forming a broad gentle curve, being nearly straight and ranging almost vertically near the middle, and curving forward so as to intersect the hinge at an obtuse, undefined angle above, while below it arches regularly forward into the rather narrowly rounded base; anterior margin thickened within above, broadly arcuate or concave in outline, its curvature being nearly parallel to that of the posterior margin. Beaks terminal, directed forward; umbonal ridge most prominent and oblique above, and in adult shells curving downwards so as to range nearly vertically near the middle. Hinge line straight, and ranging nearly at right angles to the longer or vertical axis of the valves; cartilage furrows distinct, straight, and in mature shells numbering about ten or twelve; area broad. Height, about 4 inches; antero-posterior diameter at the middle, 2.40 inches; convexity of a left valve, 0.83 inch."

Range and distribution: Upper Coal Measures; the type specimen was collected at Leavenworth.

There is one specimen in the collection from the type locality which probably belongs to this species, the only difference being that the lines of growth do not bend quite so sharply forward as in the ones figured by Meek. The principal differences between this shell and *M. subquadrata* are: Very convex posterior outline instead of a straight or concave outline, greater size, and the curving forward of the lines of growth.

Meek was in doubt as to whether it was the same as *M. subquadrata* of Shumard or not. He proposes the name at the close of the description of the shell, and comments upon it, stating that he is of the opinion that it is a distinct species. Later, in the final report on Nebraska, he states, in the discussion of *M. subquadrata* (page 203): "The large species figured by Doctor Hayden and the writer on page 33 of the Paleontology of the

Upper Missouri as *M. subquadrata* is, as we then suspected, a distinct species, differing in having the posterior margin rounding forward into the hinge above, and not sinuous or meeting the hinge at right angles, as in *M. subquadrata*. It will have to take the name *M. ampla*, suggested by us for it, in case it should be found distinct."

I have collected a large specimen of this species near Topeka with both valves present, but separated.

Myalina kansasensis. Plate XVI, fig. 11.

Myalina kansasensis Shumard, Trans. St. L. Acad. Sci., 1, p. 213, (1858);
Keyes, Geol. Surv. Mo., v, p. 117, pl. XLIII, f. 5, (1894).

Original description: "Shell sub-rhomboidal, sub-inequivalve, inequilateral, gibbous, the left valve more gibbous than the right; height about double the length; in young specimens the greatest length is at the cardinal border, but in the adult toward the pallial margin; cardinal margin oblique, slightly arched, and forming with the posterior border an angle of about 120° ; posterior margin rather strongly arched in adult specimens, and very gently rounded in the young; pallial margin rounded; buccal margin concave; umbones very prominent anteriorly, and declining with a moderate slope to the posterior margin; anterior slope very abrupt; beaks terminal, attenuated, directed obliquely forward, incurved; surface with strong, imbricating, sub-equidistant, concentric lamellæ, whose free edges are often irregularly crenate; lamellæ most prominent on the left valve. The ligament face is broad, marked with equidistant, close, deeply impressed lines parallel to the cardinal edge, the number varying with the age of the shell; beneath these is a rather broad, smooth space, which is continuous with a similar space extending from the pallial region. Each valve exhibits a singular muscular impression, which is large, ovate, and situated towards the posterior margin. Height, $2\frac{1}{2}$ inches; length, 1.17 inches; thickness, 0.88 inch.

Range and distribution: Upper Coal Measures; Argentine, Cowley county, Neosho river near Council Grove.

This species may be easily recognized by the arched lamellæ

of the shell when these are not worn away, and also by the convexity of the left valve and the small angle formed by the hinge line and anterior margin (exclusive of the beaks).

Myalina? exasperata. Plate XIX, fig. 4.

Myalina? exasperata Beede, Kans. Univ. Quart., VIII, p. 128, pl. XXXII, f. 4, (1899).

Shell cuneate-ovate in outline; beaks pointed, terminal; shell very thin, apparently composed of a single layer, compressed; valves nearly or quite equal. The anterior? margin nearly straight above, and merging into the narrowly rounded ventral region; the posterior? region similar to the anterior, but more oblique. The surface is granular and marked by indistinct, rather broad, concentric striæ. Height, 43 mm.; length, 28 mm.; convexity, 3 mm.; length of hinge, about 29 mm.

Range and distribution: Upper Coal Measures; Topeka.

The hinge of this shell is not sufficiently well shown to permit of its proper classification. It is left in *Myalina* for the present, for want of better information concerning its beak and muscular impressions. The extreme thinness of the shell makes it very probable that it does not belong to that genus.

Myalina perattenuata. Plate XVI, fig. 8.

Myalina perattenuata Meek and Hayden, Trans. Albany Inst., IV, p. 77, (1858); Pal. Upp. Mo., p. 32, pl. I, ff. 12a, b, (1864).

Meek and Hayden's description: "Shell very thin and fragile, obliquely elongate, narrow and slightly arcuate; valves convex anteriorly, and compressed behind. Beaks pointed, terminal, and attenuate; hinge line equaling rather more than half the entire length of the shell, and ranging at an angle of about fifty degrees above the oblique anterior margin. Posterior border sloping from the end of the hinge, nearly parallel to the anterior side above, and rounding to the narrow antero-basal extremity below; anterior margin of the valves a little arcuate, and rather abruptly deflected inward from the umbonal ridge above the middle, and in outline nearly straight below. Umbonal slopes prominent from the beaks down the anterior side. Surface with obscure subimbricating marks of growth. Length,

from the beaks to the postero-basal extremity, 1.50 inches; breadth, 0.65 inch; convexity, about 0.44 inch."

Range and distribution: Upper Coal Measures; Topeka.

This species can be distinguished at once from *M. subquadrata* by the small angle at the beaks. It differs markedly from *M. swallowi* in its attenuate beak, and the fact that the beak is not recurved and the umbonal ridge is more nearly straight.

Myalina congeneris. Plate XVI, figs. 2, 2b.

Myalina congeneris Walcott, Pal. Eureka Dist., Mon. U. S. Geol. Surv. No. 8, p. 237, pl. XIX, f. 6, pl. XXII, f. 10.

Walcott's description: "Shell oblong, the height being twice the width even in the broad examples; hinge line straight and ranging at an angle of 60° with the nearly straight anterior margin; base narrow, but rather broadly rounded, posterior very broadly rounded, curving slightly inwards towards the cardinal line. General surface of the valves strongly convex towards the front border, and beaks becoming more depressed on the posterior portion. Surface of both valves marked by slightly imbricated lamellæ of growth."

Range and distribution: Upper Coal Measures; Topeka.

Walcott does not mention the nature of the hinge line in his description. In one of our specimens the beak is exposed, showing it to be acute, extending a little beyond the hinge. The hinge line is similar to that of *M. swallowi* in having a single groove, but there is no swell in front of the beak. Our specimens agree more closely with the narrow form as figured on Plate XIX.

Our Kansas forms are from nearly the same horizon as *M. perattenuata*, to which they are most closely related, but differ in having their anterior and posterior margins parallel, and, as a consequence, are not trigonal in outline and the anterior margin is straight, while that of *M. perattenuata* is concave.

AVICULOPINNA.

Meek, Amer. Jour. Sci., XLIV, p. 282, (1867).

Aviculopinna americana. Plate XVIII, fig. 2.*Avicula pinnæformis* Geinitz, Carb. u. Dyas in Neb., p. 31, pl. II, f. 13, (not *S. pinnæformis* Geinitz, 1848), (1866).*Aviculopinna americana* Meek, Amer. Jour. Sci. ser. II, XLIV, p. 282, (1867); Fin. Rep. U. S. Geol. Surv. Neb., p. 197, pl. IX, ff. 12a-d, (1872); Pal. Ohio, II, p. 337, pl. XX, f. 2, (1875); Herrick, Bull. Den. Univ., II, p. 38, pl. I, f. 20, (1887); Keyes, Geol. Surv. Mo., v, p. 115, (1894).

Meek's description: "Shell small, compressed, with the slender elongated form of some of the Carboniferous species of *Pinna*; cardinal and ventral margins generally nearly straight (the latter being more convex in outline) and converging gradually from behind to the rather obtusely pointed anterior extremity; posterior side truncated, rounding into the base, and intersecting the posterior extremity of the hinge very nearly at right angles—a little sinuous just below the extremity of the hinge. Cardinal margin so slightly convex in outline as to appear quite straight, very nearly equaling the greatest length of the valves, and provided with a well-developed marginal ridge, which narrows to a mere line, or dies out before reaching the beaks, and widens gradually to the posterior extremity. Beaks nearly or quite obsolete, extremely oblique, and very slightly behind the very narrow, obtusely pointed, anterior extremity. Surface with two or three broad, nearly obsolete radiating ridges on the posterior dorsal region, and ornamented by numerous slender, very regularly disposed and abruptly elevated lines or lamellæ, much narrower than the spaces between, and curving gracefully parallel to the posterior border, while on the basal half of the valves they are closely approximate and curved forward."

Range and distribution: Upper Coal Measures; Kansas City, Lansing (Leavenworth county), Topeka.

Aviculopinna illinoiensis. Plate XVII, figs. 1-1c.*Aviculopinna illinoiensis* Worthen, Bull. No. 2 Ill. St. Mus. Nat. Hist., p. 13, (1884); Geol. Surv. Ill., VIII, p. 128, pl. XX, ff. 5, 5a, (1890).

Shell of medium size, both valves convex; dorsal and ventral margins moderately curved, converging at an angle of about 20°. Beak very small and indistinct but placed about as in

A. americana. Surface ornamented with concentric lines parallel to the posterior end of the shell. They are directed from the hinge line obliquely backward until they pass the central part of the valve, where they curve rapidly forward, finally becoming nearly parallel to the ventral margin before reaching it. These lines are sharp, thread-like elevations or lamellæ, abruptly elevated from the surface of the shell and separated by broad, shallow spaces of several times their width. Length of specimen (the posterior portion is shortened by compression), 55 mm.; height, at the posterior end, 19 mm.; convexity, 9 mm.

Range and distribution: Upper Coal Measures; Kansas City, head of Deer creek (western portion of Douglas county).

This specimen agrees with Worthen's description and figures, except that the angle formed by the dorsal and ventral margins is a little smaller. It differs from *A. americana* in being a little more convex, larger, in having the lines farther apart and larger.

PINNA.

Linnæus, Syst. Nat., 10th ed., (1758).

Pinna peracuta. Plate XVII, figs. 3, 3b.

Pinna peracuta Shumard, Trans. St. L. Acad. Sci., I, p. 214, (1858); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 198, pl. VI, ff. 11a, b, (1872); White, U. S. Geog. Surv. West 100 Mer., IV, p. 151, pl. XI, f. 5a, (1877); etc. See Weller, Bull. 153 U. S. Geol. Surv., p. 429, (1898).

Pinna adamsi, McChesney, New Pal. Foss., p. 74, (1860).

Meek's description: "Shell thin, very narrow, elongated, and tapering gradually and regularly from the larger to the smaller extremity; convex or almost subcylindrical, excepting toward the posterior extremity, which is compressed and obliquely rounded, or subtruncated. Hinge margin very long, and almost perfectly straight—carinated in consequence of the sudden erection of the dorsal edges of the valves; ventral margin equally as straight as the dorsal, and ranging at an angle of about 12° with the latter. Surface nearly smooth, or showing very obscure lines of growth."

Range and distribution: Upper Coal Measures; Kansas City, Lawrence, Topeka.

Pinna subspatulata. Plate XVII, fig. 2; plate XVIII, figs. 1, 1d, and 3.

Pinna subspatulata Worthen, Geol. Surv. Ill., vi, p. 524, pl. xxx, f. 4, (1875).

Shell very large, triangular in outline, cardinal and ventral margins diverging at an angle of about twenty degrees; compressed laterally. Dorsal and ventral margins nearly straight, the dorsal slightly convex. Surface ornamented by very fine lines of growth with occasionally larger ones; beginning at the dorsal margin, which is ridged, the lines pass across the central portion of the valve nearly transversely and curve rapidly forward, finally reaching the ventral edge several centimeters in front of their origin in the dorsal margin. The hinge furrow down the dorsal margin makes a corresponding ridge on the outside of the shell. Length of specimen, incomplete at both ends, 23 cm.; from broken posterior edge to the beaks, or apex of the angle formed by the sides, 27 cm.; height at the posterior end, 5.5 cm.; convexity (both valves), in the central portion of the shell, about three-sevenths the height at that place.

Range and distribution: Upper Coal Measures; Topeka.

This species differs from *P. peracuta* Shumard in being much more compressed, and the angle of the dorsal and ventral margins being about twice as large. If the concentric lines of growth cross the shell and reach the ventral margin nearly as directly as the figure indicates, and the angle at the anterior end of the shell is as small as represented, they will sharply distinguish our species from *P. subspatulata* Worthen. He makes no statement concerning the convexity of the shell, but according to the figure it appears nearly flat, even more so than our specimen.

Some large specimens from near Kansas City, all of which are either incomplete or crushed, may belong to this species, or may be exceedingly large specimens of *P. peracuta* Shumard. Near the anterior end they are very much more convex than the Topeka specimens while they are nearly flat at the posterior end. The angle of divergence of the anterior end is about the same as in *P. peracuta*.

MACRODON.

Lycett, Murch. Geol. Chelt., (1845).

Macrodon sangamonensis? Plate XX, figs. 2-2b.*Macrodon sangamonensis* Worthen, Geol. Surv. Ill., VIII, p. 123, pl. XXI, ff. 3, 3a, (1890).

Worthen's description: "Shell large, transversely elongated, hinge line equal to about four-fifths of the entire length of the shell. Posterior margin compressed and obliquely truncated, so as to meet the hinge line at a rather acute angle; posterior extremity quite narrow and rounding gently downward to the basal margin. Anterior margin regularly rounded from the anterior extremity to the basal margin, which is slightly sinuous about the middle. Beak depressed, strongly incurved, placed about one-fifth the length of the hinge line from the anterior extremity. A gradually widening depression extends from the beaks to the posterior extremity on the dorsal margin, and on this flattened portion six or seven strong striæ may be seen, which extend from the beak to the posterior extremity. Strong lines of growth extend around the basal margin, and minute transverse striæ are visible under a lens, especially on the anterior portion of the shell. Length, $2\frac{1}{4}$ inches; length of hinge, $1\frac{3}{4}$ inches; height, $\frac{1}{16}$ inch; convexity of the valve, $\frac{7}{16}$ inch."

Range and distribution: Upper Coal Measures; Turner (Wyandotte county).

It is with much hesitation that I refer these specimens to this species, even provisionally. The specimens from Turner are very closely related on the one hand to *M. sangamonensis* Worthen, and on the other to *M. striatus* (Schloth.). They differ from the former in not possessing minute radiating striæ on the anterior portion of the shell, but striæ larger than on any other part of the shell except on and above the umbonal ridge, and in possessing a large shallow sinus with obsolete costæ in the central portion of the shell. It differs from *M. striatus* also in the obsolete area in the central or sinuate portion of the shell, and very markedly in the nature of the teeth in the front of the hinge; in *M. striatus* (as represented by King) there are

three or four teeth on the anterior of the hinge which are but slightly oblique, having a small angle with the long teeth of the posterior part of the shell. The first three teeth are much more oblique, and just back of them are six small, round teeth, back of which are two or three teeth oblique in the opposite direction to those on the front of the hinge. It differs from *M. carbonarius* (Cox) in the area of obsolete striæ, in having the beak placed farther toward the rear, in having the coarse striæ in front, and the posterior margin curving farther forward to meet the hinge.

These specimens are from about the same locality as that figured by Keyes as *M. sangamonensis*? Keyes's¹¹ figure agrees exactly with neither *M. sangamonensis* as figured by Worthen, nor entirely with our specimens, and, inasmuch as there is no description given that will distinguish this from several other species of the genus, I am in doubt as to whether his figure represents a specimen more like *M. sangamonensis* or like ours; but he has the hinge line indicated as longer than the rest of the shell and the umbonal ridge as nearly destitute of striæ, while our specimens possess large striæ at this place.

It is with some difficulty that the young of these specimens can be distinguished from *M. tenuistriatus* Meek, but the striæ are much heavier on the anterior than on the central portions of the shell, even in the young specimens. The outline and general appearance aside from this are very similar.

Macrodon obsoletus. Plate XX, fig. 13.

Macrodon obsoletus Meek, List Carb. Foss. W. Va., v, (Ex. Rep. Reg. Univ. W. Va.), (1871); Geol. Surv. Ohio, II, Pal., p. 334, pl. XIX, f. 9.

Shell oblong, elliptical, of medium size; hinge line about equaling the length of the shell; anterior margin making a right angle, or sometimes less, with the hinge line, and rounding gradually into the ventral margin, which is a little sinuate near the center and nearly parallel with the hinge line; posterior margin abruptly but regularly rounded, curving forward to meet the hinge line. Sinus across the shell from the umbo to

11. Gen. Surv. Mo., V, p. 121, pl. XLVI, f. 2, (1894).

the ventral margin nearly obsolete; sinus along the hinge line widening considerably at the posterior extremity, making the posterior umbonal convexity narrow. Valves rather convex. There are three long teeth on the posterior portion of the hinge, nearly parallel, but apparently do not reach more than one-third the distance from the posterior to the anterior end of the shell; beneath the umbo there are four or more small, comb-like, transverse teeth. In front of these there is a thickening of the shell; anterior to the thickening of the shell, and near the front, are one or two large, oblique teeth making an angle of about 45° with the hinge line. Concentric lines of growth visible, distinct but not prominent. Length, 20 mm.; height, 7 mm.; convexity, single valve, 5 mm.

Range and distribution: Upper Coal Measures; Olathe, Turner, Lawrence.

I am able to find no trace of radiating striæ, mentioned by Meek, on these specimens. However, the specimens appear to have been water-worn before being enclosed in the matrix, and may have been abraded. The specimens seem to be identical with some from Carbon Hill, Ohio, except that the latter are a little larger. The hinge markings are also very similar. The anterior margin of the shell often meets the hinge line at an angle of less than 90° ; otherwise it seems to correspond very well to *M. obsoletus*.

NUCULANA.

Likn, Rost. Samml., III, p. 55, (1807).

***Nuculana bellistriata*.** Plate XX, figs. 14, 14b.

Leda bellistriata Stevens, Amer. Jour. Sci., (2), xxv, p. 261, (1858).

Nucula (*Leda*) *kazanensis* Swallow, Trans. St. L. Acad. Sci., I, p. 190, (1858).

Nuculana bellistriata White, 13th Rep. Ind. St. Geol., p. 146, pl. xxxi, ff. 8, 9, (1884).

White's description: "Shell transversely elongate-subovate, gibbous anteriorly and attenuate behind; basal margin broadly convex, straightened in the middle; anterior margin narrowly rounded; posterior margin very narrow; postero-dorsal margin nearly straight, sloping backward and a little downward from the beaks; umbonal ridges well defined, situated near to

the postero-dorsal margin, their outline, as seen from above, forming an elongate ellipse which has a concave surface on each side of the median ridge, which is formed by the upflexed margins of the valves there; umbones prominent; beaks incurved, situated about two-fifths the full length of the shell from its front; surface marked by fine, regular, concentric, raised striæ, which are obsolete upon the umbonal ridges and the space which they enclose."

Length of our specimen, 27 mm.; height, 14 mm.; convexity, 10 mm.

Range and distribution: Upper Coal Measures; Kansas City, Rosedale, Lawrence, Topeka.

Nuculana bellistriata attenuata.

Nuculana bellistriata var. *attenuata* Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 206, pl. x, ff. 11a, b, (1872).

Some are inclined to doubt the validity of this variety. There are forms of *N. bellistriata* which are more pointed, more finely striated and considerably smaller than others. The striations on this small shell are much smaller, and are separated by much narrower spaces, than the corresponding striæ of the umbonal regions of the larger specimens. I believe they are varietyally distinct.

Range and distribution: Upper Coal Measures; Kansas City, Topeka.

NUCULA.

Lamarck, Anim. Sans Vert., p. 87, (1801).

Nucula beyrichi. Plate XXII, fig. 8.

Nucula beyrichi Geinitz, Carb. u. Dyas in Neb., p. 21, pl. i, ff. 36, 37, (1856); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 203, pl. x, f. 18, (1872); etc.

Meek's description: "Shell very small, longitudinally sub-ovate, moderately convex, widest posteriorly; anterior end somewhat narrowly rounded; base forming a semiovate curve, the most prominent part being near the shorter end; posterior side comparatively wide, and subtruncated; beaks near the posterior extremity; hinge line nearly rectangular at the beaks; denticles comparatively large, about seven on the longer side,

and five or six on the shorter ; surface marked with moderately distinct regular concentric striae. Length, 0.16 inch ; height, 0.10 inch."

Range and distribution : Upper Coal Measures ; Grand Summit.

A single worn specimen, probably of this species, is in the University collection, from Grand Summit. The markings are abraded, and most if not all of the shell is gone. However, it agrees very well with the figures of the species given by Meek in the base of the plate in the Nebraska report.

***Nucula ventricosa*.** Plate XXII, figs. 9, 9b.

Nucula ventricosa Hall, Geol. Iowa, I, pt. II, p. 716, pl. xxix, ff. 5a, b, (1858); Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 204, pl. x, ff. 17a-c, (1872).

Meek's description : "Shell small, thick, subovate, very convex ; the greatest convexity slightly in advance of the middle of the valve ; posterior (shorter) end obliquely truncated from the beaks to its narrowly rounded or subangular connection with the base, rather deeply excavated just behind the beaks ; anterior (longer) end rather narrowly rounded, its most prominent part being near or slightly above the middle ; dorsal outline declining gently, with moderate convexity from the beak to the anterior extremity ; basal margin forming a nearly semioval curve, being a little more prominent before than behind the middle ; beaks convex, rather prominent, and placed about half way between the middle and the most projecting part of the postero-ventral extremity. Surface with (at least near the base) fine, regular, concentric striae. Length, 0.42 inch ; height, 0.22 inch."

Description of the cast : The posterior adductors are strongly developed, ovate in outline, situated at the lower part of the posterior extremity of the shell, nearly beneath the beaks ; palial line very heavily impressed, forming a somewhat oval curve. Anterior adductor scars also prominent, considerably larger and more circular in outline than the posterior, situated on the upper side of the extremity of the umbonal ridge. Immediately to the rear of this are a pair of small pyriform impressions.

There is a depression on some casts on the anterior side of the umbones extending somewhat below to about the elevation of the upper part of the posterior scar, in front of which is a corresponding nodose ridge. This character varies greatly in different specimens, but the characters are generally sufficiently developed to be detected. In the cast, the beaks are rather widely separated and the top of the cast in front of them is slightly concave, yet nearly flat.

Range and distribution: Upper Coal Measures; Kansas City, Rosedale, Turner, Topeka, Grand Summit.

This species may be easily distinguished from the preceding by its larger size, longer shell, and more robust appearance.

Nucula pulchella. Plate XXI, figs. 5a-c.

Nucula pulchella Beede and Rogers, Kans. Univ. Quart., VIII, p. 132, pl. xxxiv, ff. 5a-c, (1899).

Original description: "Shell very small, subtrigonal in outline, ventricose; anterior border straight, rounding abruptly to the ventral margin, which is rounded; posterior abruptly truncated nearly at right angles with the ventral margin. Beaks prominent, incurved, situated nearly at the posterior end of the shell; lunule not well defined. The greatest convexity is at the umbo. The surface is ornamented by fine, elevated, concentric striæ and undulations of growth. Length, $4\frac{1}{2}$ mm.; height, $3\frac{1}{2}$ mm.; convexity, 3 mm."

Range and distribution: Upper Coal Measures; Lawrence.

This species differs from *N. beyrichi* in being more triangular, shorter, and the beaks more prominent. It differs from *N. ventricosa*, also, in the above respects, as well as being very much smaller and having very much more prominent surface markings.

YOLDIA.

Moeller, Kroyer's Nat. Tid., IV, p. 91, (1842).

Yoldia subscitula. Plate XX, fig. 8.*Leda subscitula* Meek and Hayden, Trans. Alb. Inst., iv, p. 79, (1858).*Yoldia subscitula*? Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 205, pl. x, f. 10, (1872); etc.

Meek's description: "Shell longitudinally subovate or sub-elliptic, compressed, the greatest convexity a little in advance of the middle, about twice as long as high; anterior extremity wider than the other but rather narrowly rounded, the most prominent point being usually slightly above the middle; outline of base forming a broad semioval curve, being more prominent anteriorly than behind; posterior side narrowed, its margin rounding up gradually from the base, so as to meet the dorsal margin at nearly right angles, sometimes faintly truncate at the immediate extremity; posterior dorsal margin compressed or cuneate, and declining gradually, with a nearly straight, or slightly concave outline; anterior dorsal margin not cuneate, sloping forward gradually, and a little convex in outline; beaks rather depressed or subcentral, or very little in advance of the middle; umbonal slopes without any defined ridge or angle. Surface smooth, or only showing traces of very minute concentric striæ. Length, 0.77 inch; height, 0.37 inch; convexity, 0.14 inch.

"It is with considerable doubt that I have concluded to refer this shell to *Y. subscitula* M. and H., because the specimens from Nebraska City are distinctly more compressed than the type upon which that species was founded, their convexity being uniformly not more than half as great proportionally. The five or six individuals in the collection are constant in this character, and yet show no evidences whatever of accidental compression. Otherwise the two forms are very similar in their general outline, but we know nothing of the internal and hinge characters of the form under consideration. I strongly suspect, however, that it will be found to be a distinct species, in which case I would propose to call it *Yoldia propinqua*, from its near resemblance to *Y. subscitula*."

Range and distribution : Upper Coal Measures ; Topeka.

Only a single left valve of this species has been collected by the writer, at Topeka, Kan. It agrees so well with this description that it is referred to it, though the lines of growth pass forward on approaching the hinge and become nearly parallel to it.

Yoldia glabra. Plate XXI, figs. 4a, b.

Yoldia glabra Beede and Rogers, Kans. Univ. Quart., VIII, p. 133, pl. XXXIV, ff. 4a, b, (1899).

Shell of medium size for this genus, truncate-subelliptical in outline, nearly flat, greatest convexity at the umbo, sloping gently in all directions from the central portion of the valve ; anterior dorsal outline nearly straight, sloping gently, and broadly rounded into the anterior ventral margin, which forms an elliptical curve to the posterior end, where it is somewhat truncate, meeting the hinge at an obtuse angle. Hinge line back of the beak nearly straight. Beaks depressed, nearly central. Surface nearly smooth, with traces of obscure, distant, concentric striæ parallel to the ventral outline ; lines of growth visible on the postero-dorsal region. Measurements : Length, $14\frac{1}{2}$ mm. ; height, 7 mm. ; convexity of single valve, $1\frac{1}{2}$ mm.

Range and distribution : Upper Coal Measures ; Lawrence.

This shell differs from *Y. levistriata* M. and W., from the St. Louis group, in having its posterior border truncated, striæ distant rather than closely arranged, and in being much less convex. It differs from *Y. subscitula*? Meek, or *Y. propinqua* Meek, in being more depressed and the posterior end much more broadly rounded.

***Yoldia knoxensis*?** Plate XX, fig. 4.

Leda polita McChesney, New Pal. Foss., p. 53, (1860).

Leda knoxensis McChesney, Ill. New Spec. Foss., pl. II, ff. 9a-c, (1865).

Yoldia knoxensis McChesney, Trans. Chic. Acad. Sci., I, p. 39, pl. II, ff. 9a-c, (1868).

Shell rather large for this genus, ovate in outline. The hinge line in front of the beaks bends somewhat downward; the entire anterior and ventral border from near the beaks around to the antero-dorsal border forming a regular, perfectly ovate curve, the broad end of which is placed foremost; postero-dorsal border rounded more sharply but not angulated, turning considerably forward to meet the hinge, in an almost straight line. Hinge, back of the beak, nearly straight; teeth numerous and very fine; valves moderately convex; umbones not prominent; beaks closely approximated and incurved. Greatest convexity in front of the middle of the shell; the greatest vertical diameter near or a little in front of the center; beaks placed about one-third the distance from the front end of the hinge. There is a faint depression extending from back of the umbo, near the hinge line, obliquely backward over the umbonal ridge but soon vanishing. This is so faint as to be hardly noticeable, yet it is present in every specimen before me. Surface ornamented by very fine, regular, concentric lines of growth. Length, 28 mm.; height, 16 mm.; convexity (both valves), 8 mm. Specimen a little larger than the average.

Range and distribution: Upper Coal Measures; Leavenworth, Lansing coal-shaft.

This shell agrees very well with McChesney's description of *Y. knoxensis*, Proc. Chic. Acad. Nat. Sci., I, pl. II, f. 9, but differs from the figure of the species in being about as wide just back of the beaks, near the center of the shell, as at any other place, in being less attenuate behind, less abruptly rounded on the posterior extremity, and meeting the hinge line at a very much greater angle than is shown by his figure, which shows the posterior extremity of the shell to be subtruncate.

SCHIZODUS.

King, Ann. Mag. Nat. Hist., XIV, p. 313, (1844).

Schizodus wheeleri. Plate XXII, figs. 1-1c.*Cypricardia? wheeleri* Swallow, Trans. St. L. Acad. Sci., II, p. 96, (1862).*Schizodus obscurus* Geinitz, Carb. u. Dyas in Neb., p. 20, pl. I, ff. 30, 31, (1866).*Schizodus wheeleri* Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 209, pl. x, ff. 1a-f, (1872).

Meek's description: "Shell attaining a medium size, longitudinally subovate, moderately convex; anterior side wider than the other, and regularly rounded; posterior side narrowed, and obliquely truncated; basal outline rather prominently rounded anteriorly, and straightened, or slightly sinuous between the middle, and sharply rounded or subangular posterior basal extremity; dorsal margin straight, and sloping from the beaks to the truncated posterior edge; beaks rather depressed (for a species of this genus), incurved, placed about half way between the middle and the front, or perhaps nearer the middle; posterior umbonal slope rather prominent, or usually forming a rather obtuse ridge near the posterior basal extremity; surface with merely fine lines and obscure marks of growth."

Range and distribution: Upper Coal Measures; Kansas City.

Schizodus harii. Plate XXII, figs. 2-2d.*Schizodus harii* Miller, 17th Ann. Rep. St. Geol. Ind., p. 701, pl. xx, ff. 1-3, (1892); Keyes, Geol. Surv. Mo., v, p. 123, pl. XLVI, f. 4, (1894).

Shell moderately large, quite convex, rather obliquely subovate in outline, transverse outline ovate. The outline is regularly rounded from near the beaks around the anterior end to the postero-ventral margin, where it bends rather abruptly upward and forward to meet the hinge line, which is somewhat arcuate. Beaks placed well forward, moderately prominent, somewhat incurved, pointing a little forward, and moderately approximate. Valves very regularly convex for this genus. Greatest gibbosity a little in front of the middle; umbonal ridge very indistinct or almost wanting; the depression extending back from the beaks along the cardinal line very

indistinct and ill defined. Posterior portion of the shell somewhat wedge-shaped. The fine concentric striae of growth are most apparent on the anterior and posterior ends and along the ventral margin. The interior of the shell is marked by rather deep adductor scars, the anterior being situated very near the anterior dorsal margin, rather broadly elliptical in outline, while the posterior is situated near the posterior end of the ligament and is much larger, rather ovate in outline. The pallial line is indistinct, but seems to pass rather closely to the ventral margin around to the anterior end, where it curves rather regularly upward to the anterior adductor. There is a ridge in the interior of the shell extending from the umbo obliquely backward about one-half to two-thirds the distance to the postero-ventral margin. In the right valve the tooth is quite large and extends obliquely forward and downward, and is largest at its extremity; in front of this is a depression or socket for the smaller anterior tooth of the left valve, while back of it is a larger cavity for the large central tooth of the left valve; back of this cavity there is a slight sharp elevation extending obliquely backward. In the left valve there is a small, thin tooth extending obliquely forward, back of which is a large socket for the reception of the large tooth of the right valve. Posterior to this there is a thin, deep depression, extending nearly parallel to the hinge, for the reception of the thin posterior tooth of the right valve. Length, 52 mm.; height, 40 mm.; convexity of single valve, 13 mm.

Range and distribution: Upper Coal Measures; Kansas City, Lansing (probably from the penitentiary coal-shaft).

One specimen, somewhat below the average size, was worked from the shale, showing the internal and external features of both valves, including the hinge.

Schizodus subcircularis.

Schizodus subcircularis Herrick, Bull. Den. Univ., II, p. 41, pl. III, f. 24, (1887).

Schizodus subcircularis Girty, U. S. Geol. Surv., XIX, pt. III, p. 582, pl. LXXII, f. 8a, (1899).

Herrick's description (in part): “. . . The anterior and lower margins are continuous parts of almost a circle, which is only a little produced posteriorly; the posterior margin is inclined; beak submedian, posterior umbonal ridge not sharp. The shell is moderately convex and is nearly smooth, except for the distant lines of growth. Length, 0.63 inch; width, 0.59 inch; convexity (single valve), about 0.20 inch.”

Range and distribution: Upper Coal Measures; Lawrence.

A single right valve from the dam rock at Lawrence agrees well with Herrick's figure and description. It is a little smaller and, apparently, better preserved than Herrick's specimen, for it shows exceedingly fine, inconspicuous concentric striae in addition to the distant lines of growth mentioned in his description.

Schizodus compressus, n. sp. Plate XXII, figs. 6, 6d.

?*Schizodus wheeleri* Herrick, Bull. Den. Univ., II, p. 42, pl. III, f. 15, (1887).

Shell medium size for this genus, not very convex, elongate subovate in outline, cuneate posteriorly. Antero-dorsal margin non-sinuate; anterior margin broadly rounded; ventral margin quite convex, terminating posteriorly in a rather prominent acute angle; posterior margin obliquely truncate; dorsal margin nearly straight, curving very slightly upward. Hinge line straight, a little less than one-half the length of the shell. Beaks depressed, incurved, inconspicuous, scarcely elevated above the hinge line, located about one-third the length of the shell from the anterior end. Umbonal slope subangular, rather prominent, becoming obsolete towards the posterior angle of the shell. Greatest convexity of the shell below and slightly behind the umbo. Posterior to the umbonal slope the shell is much compressed. Adductor scars small, sub-elliptical in shape, anterior one situated near and a little above the middle of the anterior margin; posterior one placed close to the dorsal margin, a little behind the beak. Pallial line sub-

parallel to the ventral margin. Surface smooth, showing occasional very faint undulations of growth. Length, 31 mm.; height at beak, 21 mm.; convexity of single valve, 5 mm.

Range and distribution: Upper Coal Measures; Lawrence.

There is but little doubt that our shells are specifically identical with Herrick's specimen, as far as can be learned from his figure and brief description. At any rate, our species is not *S. wheeleri*! It is much more nearly related to *S. chesterensis* M. and W., from the Chester group of Illinois. The beak is less elevated and placed farther back, the shell is less convex, and the posterior adductor scar is placed farther forward than in that species. It bears some resemblance to *S. meekanus* Girty,¹² but the beak is a little less prominent, the shell less elongate, and the ventral margin curves up more rapidly posteriorly, the posterior angle being nearer the hinge line than in that species.

A large number of these shells have been collected from the dam rock at Lawrence, and from its equivalent at Cameron's Bluff. They all agree well with the above description and represent a distinct species.

SOLENOMYA.

Lamarck, Hist. Nat. Anim. sans Vert., V, p. 488, (1818).

Solenomya parallella. Plate XXI, fig. 1.

Solenomya parallella Beede and Rogers, Kans. Univ. Quart., VIII, p. 131, pl. XXXIV, f. 1, (1899).

Shell large, moderately convex, elongate-subquadrate in outline; anterior margin broadly rounded to nearly truncate, meeting the hinge at a little more than a right angle; dorsal and ventral margins straight, nearly parallel; postero-dorsal margin sloping obliquely downward, meeting the rounded posterior margin at an obtuse angle. Beaks depressed, incurved, situated about one-fourth the distance from the posterior to the anterior end of the shell. The greatest convexity is at the umbo, the shell gaping a little wider anteriorly than behind. Surface marked by flat, radiating plications, which become obsolete at either end of the shell, the whole surface of which

12. U. S. Geol. Surv., 19th Ann. Rep., pt. III, p. 583, pl. LXXII, ff. 7a-c, (1899).

is apparently covered with radiating striae parallel to the plications. Neither the plications nor the striae radiate directly from the beak, but from a point above the beak and a trifle in front of it. These are crossed by fine obscure lines of growth. The anterior and posterior adductors are prominent; the posterior one is triangular, located between the beak and the posterior margin, along its anterior side, and extending above it is a ridge caused by the thickening of the shell, which produces a slight oblique furrow in the cast. The anterior scar is located on the upper side of the shell, near the anterior angle. The pallial line is indistinct, parallel to the ventral margin, curving backward to meet the anterior adductor scar. Length, 53 mm.; height, 18 mm.; convexity of single valve, about 5 mm.

Range and distribution: Upper Coal Measures; Kansas City, Lawrence.

Solenomya trapezoides. Plate XXI, figs. 2a, b.

Solenomya sp. Meek and Worthen, Geol. Surv. Ill., v, p. xxvii, ff. 1a, b, (1873).

Solenomya trapezoides Meek, Amer. Jour. Sci., (3), vii, pp. 582, 583, (1874); Beede and Rogers, Kans. Univ. Quart., viii, p. 132, pl. xxxiv, ff. 2a, b, (1899).

Shell large, subelliptical in outline, length from two to two and a half times the height, convex, open at both ends. Ventral margins slightly convex, curving abruptly upward on the posterior extremity and more gently on the anterior; posterior side obliquely truncated above; hinge straight in front of the beaks, which are depressed, approximate, located about one-fourth the length of the shell from the posterior extremity. Surface marked by rather obscure concentric undulations of growth, crossed by faint radiating striae, which seem to radiate from the beak. Posterior adductor scar moderately prominent, more or less irregularly subcircular; the ridge in front of the scar is broad and its outline is rather indistinct, nearly perpendicular to the hinge, curving backward below; anterior scar indistinct, somewhat subcircular; pallial line extending backward and downward from the lower side of the posterior scar,

then curving abruptly forward parallel to the ventral margin to the middle of the shell, where it becomes too indistinct to trace in our specimens. Measurements of a specimen a little below the average size and a larger specimen: Length, 56 mm., 76 mm.; height, 24 mm., 33 mm.; convexity, 15 mm., 25 mm., respectively.

Range and distribution: Near the junction of the Upper and Lower Coal Measures, at Porterville, Kan., and Westport, Mo.

***Solenomya radiata*.** Plate XXII, figs. 5-5b.

Solenomya radiata Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 457, (1860).

Solenomya radiata Meek and Worthen, Geol. Surv. Ill., IX, p. 349, pl. XXVI, ff. 10a, b, (1866).

Meek and Worthen's description: "Shell thin, narrow oblong-oval or subelliptical, moderately convex, nearly closed at the each end; pallial margin rather straight or very slightly contracted along the middle, and rounding up more gradually in front than behind; anterior (longer) side narrowly rounded, its most prominent part being above the middle; posterior (shorter) side narrowly rounded below and obliquely subtruncate above; dorsal outline nearly parallel to the base; beaks much depressed, located less than one-fourth the entire length of the shell in advance of the posterior extremity. Surface with obscure marks of growth, crossed by flat, nearly obsolete radiating plications, which are sometimes separated, near the middle of the valves, by spaces greater than their own breadth; plications very oblique and more closely arranged on the anterior side. Length, 1.17 inches; height, 0.47 inch; convexity, about 0.33 inch."

Range and distribution: Upper Coal Measures; Topeka.

PLEUROPHORUS.

King, Ann. Mag. Nat. Hist., XIV, p. 313, (1844).

Pleurophorus subcostatus. Plate XX, figs. 11-11b.*Pleurophorus subcostatus* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 246, (1865).*Pleurophorus subcostatus* Meek and Worthen, Geol. Surv. Ill., II, pp. 347, 348, pl. xxvii, ff. 2, 2a, (1866).

Meek and Worthen's description: "Shell elongate-oblong, moderately convex; umbonal ridges the most convex part of the valves, and extending obliquely from the beaks toward the postero-basal margin; anterior ventral region somewhat compressed; basal and cardinal margins very nearly straight and subparallel, the former being usually somewhat sinuous or arcuate along the middle; extremities rather narrowly rounded, the posterior being generally a little wider than the other, and sometimes faintly subtruncate obliquely. Hinge line long and nearly straight; posterior lateral tooth of each valve elongated parallel to the hinge margin, very remote from the cardinal teeth, and extending back a little beyond the posterior muscular impression. Beaks depressed upon a line with the dorsal margin, small, somewhat compressed, and placed about one-ninth the entire length of the shell behind the anterior margin. Scar of the anterior adductor muscle deep, trigonal-subovate, pointed above, and strongly defined by the prominent vertical ridge just behind it; those of the pedal muscles small, nearly marginal, and located directly over the anterior adductors; posterior adductor scars larger and more shallow than the anterior, subquadrate in outline, and placed close up under the posterior hinge teeth. Pallial impression well defined. Surface of casts showing traces of a few obscure concentric markings, crossed on the postero-dorsal region by traces of about three equal obscure radiating costæ. Exterior surface and cardinal teeth unknown. Length of a medium-sized specimen (internal cast), 0.88 inch; height of same, 0.37 inch; convexity, 0.26 inch. Some larger specimens, of same proportions, measure 1.33 inches in length."

Range and distribution: Upper Coal Measures; Kansas City, Mo.

Pleurophorus tropidophorus. Plate XX, fig. 7.

Pleurophorus tropidophorus Meek, Geol. Surv. Ohio, II, Pal., p. 338, pl. XIX, ff. 10a, b, (1875).

Original description: "Shell transversely oblong, much compressed, with length a little greater than twice the height; posterior margin flattened and bifurcated, the lower truncation being nearly vertical, and the upper sloping obliquely downward and backward from the hinder end of the hinge; cardinal margin straight, equaling about two-thirds the length of the valves; anterior rounded below and sloping abruptly forward from the beaks above; basal margin long, parallel to the hinge, nearly straight for most of its length, or faintly sinuous near the middle, rounding up anteriorly, and forming a more or less defined angle at its connection with the lower part of the posterior margin behind; posterior umbonal slope distinctly angular from the beaks to the angular posterior basal extremity, while a second carina passes obliquely backward and downward along the middle of the dorsal space above the umbonal ridge of each valve; beaks depressed to the line of the cardinal margin, very little projecting, and placed one-fifth to one-fourth the length of the valves from the anterior margin. Surface marked by distinct concentric lines of growth, that become strongly defined on the flanks and anterior parts of the valves, but are less distinct on the space above and behind the umbonal angles. Length, 1.10 inches; height, 0.52 inch; convexity, about 0.20 inch."

Range and distribution: Upper Coal Measures; Kansas City, Mo.

Pleurophorus costatus.

Arca costata Brown, Trans. Man. Geol. Soc., I, p. 32, pl. VI, ff. 34, 35, (1841).

Pleurophorus costatus Brown, King, Cat., p. 11, (1848); King, Mon. Perm. Foss. Eng., p. 181, pl. xv, ff. 13, 14, (1850).

Pleurophorus costatiformis Meek and Worthen, Geol. Surv. Ill., III, p. 535, pl. XIX, f. 8, and text fig., (1868).

Meek and Worthen's description: "Shell elongate, suboval, moderately convex, slightly arcuate; the dorsal and ventral margins rather long, and more or less nearly parallel, the

former being a little concave in outline, and the latter convex; extremities narrowly rounded. Beaks small, depressed, or rising little above the hinge line, very oblique, somewhat compressed, incurved, and placed very near the anterior end; lunule apparently small and deep. Surface ornamented by concentric striæ of growth, and a few larger, obscure, concentric wrinkles, crossed on the postero-dorsal region by five distinct, equidistant and radiating ridges, extending obliquely from the beak to the posterior margin, the lower one being the largest, and forming the umbonal ridge, while the upper one runs parallel to the cardinal margin, and forms the edge of the long corslet, or escutcheon. Length, about 1.10 inches; height, 0.46 inch; convexity, near 0.43 inch."

Range and distribution: Upper Coal Measures; Kansas City, Mo.

I see no reason for putting this shell in a distinct species. Our Kansas City specimens agree well with King's descriptions and figures, being longer than Meek and Worthen's figures. It seems that the principal reason for making a distinct species of this shell was the fact that it came from a much lower horizon than the European forms, but this is true of several species of fossils which are common to the Coal Measures of the Missouri valley and the Permian of Europe. The lines of growth (or striæ) on our specimens meet the hinge at a very obtuse angle, while Meek's figure represents them meeting nearly at right angles. In this respect it is like *costatus*:

ASTARTELLA.

Hall, Geol. Iowa, pt. II, p. 715.

Astartella vera. Plate XXII, fig. 10.

Astartella vera Hall, Geol. Iowa, pt. II, p. 715, pl. XXIX, ff. 1a-c, (1858);
Keyes, Geol. Surv. Mo., v, p. 125, pl. XLVI, f. 6, (1895); etc.

Original description: "Shell somewhat rhomboid-ovate, gibbous on the umbones; beaks subanterior, elevated, approximate; anterior end slightly concave below the beak and rounded below, posterior end obliquely truncate. An oblique undefined ridge extends from the beak to the posterior basal margin, having the space between it and the ligamental area flattened;

lunule cordiform, strongly impressed; ligamental area deeply marked, and extending to the posterior extremity. Anterior and posterior muscular impressions distinct; hinge strong. Teeth of right valve separated by a deep pit; the anterior tooth with a longitudinal pit in the summit, and a callosity on the inner margin at its base. Surface marked by strong concentric furrows, which are separated by sharp angular ridges; the intermediate space finely striated."

Range and distribution: Upper Coal Measures; Grand Summit.

CONOCARDIUM.

Bronn, Leth. Geo., I, p. 92, (1835).

Conocardium parrishi. Plate XX, fig. 9.

Conocardium parrishi Worthen, Geol. Surv. Ill., VIII, p. 112, pl. xx, f. 7, (1890); Keyes, Geol. Surv. Mo., v, p. 124, pl. XLVI, ff. 6a, b, (1894).

Worthen's description: "Shell obliquely triangular, hinge line straight, beaks depressed, umbonal ridge elevated into a strong rounded fold, with faint traces of fine striæ towards the lower extremity. Anterior side evenly and rapidly sloping from the umbonal fold to the extremity, traversed by radiating costæ, only four or five of which extend to the hinge line, but increasing by division and implantation so that ten or more may be counted on the margin of the shell, the one nearest the umbonal ridge being somewhat stronger than the others. Posterior side flattened towards the extremity, and marked by eight or more flattened striæ, nearly all of which extend to the hinge line. Length, about $\frac{5}{16}$ inch."

Range and distribution: Upper Coal Measures; Kansas City.

CYPRICARDINIA.

Hall, Pal. N. Y., III, p. 266, (1860).

Cypricardinia? carbonaria. Plate XX, fig. 16.

Cypricardinia? carbonaria Meek, Proc. Acad. Nat. Sci. Phil., p. 163, (1871).

Cypricardinia? carbonaria Meek, Geol. Surv. Ohio, II, Pal., p. 342, pl. XIX, ff. 8a, b, (1875).

Meek's description: "Shell small, longitudinally oval, less than twice as long as high, the widest (highest) part being under the posterior extremity of the hinge; rather gibbous, with usually a broad impression extending from the beaks ob-

liquely backward and downward to the middle of the base of each valve; anterior side extremely short, or nearly obsolete, convex, and rounded; posterior side broader, more compressed or cuneate, with its upper edge straight and sloping obliquely backward to the regularly rounded posterior margin; base broadly and slightly sinuous in the middle, and rounding upward at the extremities; hinge line straight, between one-half and two-thirds as long as the valves, ranging at an angle of about twenty-five degrees with the oblique, longer axis of the shell, so as to meet the sloping upper edge of the posterior margin at a very obtuse but moderately well-defined angle, thus imparting to the somewhat compressed posterior dorsal region a very faintly alate appearance; beaks extremely oblique, depressed nearly to the dorsal margin, very nearly terminal, and scarcely projecting beyond the rounded outline of the anterior extremity. Surface ornamented by about fifteen to twenty exceedingly regular, well-defined, subimbricating, flattened, concentric ridges or undulations, that gradually become smaller and more closely approximating on the umbones."

Range and distribution: Upper Coal Measures; in the oolite at Rosedale and Turner.

CARDIOMORPHA.

de Koninck, Anim. Foss. Carb. Belg., p. 101, (1844).

Cardiomorpha missouriensis. Plate XX, fig. 17.

Cardiomorpha missouriensis Shumard, Trans. St. L. Acad. Sci., 1, p. 207, (1858); Meek and Worthen, Geol. Surv. Ill., v, p. 588, pl. xxvii, f. 8, (1873).

Nucula mercerensis McChesney, Trans. Chic. Acad. Sci., 1, p. 40, pl. ii, ff. 12a-c, (1868).

Nucula cylindrica McChesney, New Pal. Foss., p. 54, (1860).

Original description: "Shell inequilateral, elliptico-subquadrate, very thin, length double the height; superior and inferior borders subparallel; cardinal margin long, slightly arcuate, inferior border slightly arched; anal and buccal margins strongly rounded, the latter being very short; umbonal region moderately convex in young specimens, and very gibbous in the old, greatest convexity short distance below the beaks; beaks situated near the anterior margin, rounded, closely incurved and nearly

approximate; surface marked with very fine crowded, concentric striae, which are sometimes more or less flexuous. Length of full-grown specimen, 1.30 [inches?]; height, 0.64; thickness, 0.62."

Range and distribution: Upper Coal Measures; Topeka.

EDMONDIA.

de Koninck, Anim. Foss. Carb. Belg., p. 66, (1844).

Edmondia nebrascensis. Plate XX, fig. 5.

Astarte nebrascensis Geinitz, Carb. u. Dyas in Neb., p. 16, pl. 1, f. 25, (1866).

Edmondia nebrascensis Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 214, pl. x, f. 8-8b, (1872).

Meek's description: "Shell subovate, compressed, more or less rounded at the extremities; length nearly once and a half the height; basal margin broadly semielliptic or semiovate in outline; dorsal margin sloping from the beaks, but more abruptly in front than behind, rounding into the extremities; beaks moderately prominent, and located somewhat in advance of the middle. Surface marked by broad, rounded, rather regular concentric furrows, separated by sharp, moderately prominent concentric linear ridges, sometimes show under a magnifier indications of being minutely crenate; impressions or furrows between the ridges, showing concentric striae, which, by the aid of a lens, in a cross-light appear to be crossed by fine, nearly obsolete radiating markings. Length of the largest specimen seen, 1.35 inches; height, 0.95 inch; convexity, about 0.30 inch."

Range and distribution: Upper Coal Measures; Kansas City, Turner, Topeka.

Edmondia aspinwallensis. Plate XXII, figs. 3-3b.

Edmondia aspinwallensis Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 216, pl. iv, ff. 2-2c, (1872); etc.

Original description: "Shell longitudinally subovate, moderately convex, the greatest convexity being a little in advance of and above the middle; base nearly semielliptic in outline; posterior side rather narrowly rounded, or sometimes very faintly subtruncate obliquely above; dorsal margin nearly straight just

behind the beaks, but very gradually declining, with a slightly convex outline posteriorly; anterior side quite short, declining very abruptly from the beaks above, and rounded below; beaks rather depressed, incurved, and located nearer the anterior end than the middle. Surface of cast with moderately distinct, irregular concentric undulations, showing behind the beaks distinct impressions of the cartilage fulcra. Length, 1.45 inches; height, 1.03 inches; convexity, about 0.68 inch."

Range and distribution: Upper Coal Measures; Cherryvale, Kansas City, Turner, Topeka.

This species may be distinguished from the foregoing by its more undulate and less carinate concentric ridges, which are never crenate, and the absence of the nearly obsolete radiating striae.

ALLORISMA.

King, Ann. Mag. Nat. Hist., XIV, p. 315 (1844).

Allorisma geinitzi. Plate XX, fig. 6.

Allorisma elegans Geinitz, Carb. u. Dyas in Neb., p. 13, pl. I, f. 31, (1866), (non King).

Allorisma (Sedgwickia) geinitzi Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 219, pl. x, ff. 16a, b, (1872).

Allorisma geinitzi Meek, Geol. Surv. Ill., v, p. 586, pl. xxvi, f. 23, (1873).

Meek's description: "Shell small, rather compressed, longitudinally subovate, abruptly narrowed from the beaks posteriorly; umbonal slopes distinctly carinate from the beaks to the posterior basal angle; anterior side subtruncate, with an abrupt slope from the beaks obliquely forward above, and rounding into the base below; basal margin somewhat prominently rounded anteriorly, and nearly straight or faintly sinuous behind; posterior end compressed, its margin abruptly truncated vertically, so as to make its upper and lower parts nearly rectangular; cardinal margin sloping, with a slightly concave outline, from the beaks to the truncated posterior end; beaks elevated, incurved, and placed about half way between the middle and the anterior extremity of the valve. Surface ornamented with numerous minute, closely crowded granules, which, on the umbones and other parts of the valves in front of the angular umbonal slope, show a tendency to arrange

themselves in radiating lines, which are crossed by more or less distinct lines of growth; on the compressed corselet, above and behind the umbonal carina, there are usually two or more obscure radiating ridges and furrows, crossed by moderately distinct, granular lines of growth, parallel to the truncated posterior margin. Length of the largest example seen, 0.50 inch; height of the umbones in the same, 0.30 inch; height of the truncated posterior end, same, 0.16 inch; convexity, about 0.13 inch."

Range and distribution: Upper Coal Measures; Topeka.

Allorisma granosum. Plate XX, fig. 10.

Leptodomus granosus Shumard, Trans. St. L. Acad. Sci., 1, p. 207.

Allorisma (*Sedgwickia*) *granosa* Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 220, pl. 11, f. 8, (1872).

Allorisma granosum Keyes, Geol. Surv. Mo., v, p. 128, (1895).

Meek's description: "Shell very thin, approaching an irregular, oblong form, the length being less than twice the height, very convex, most gibbous part being near the middle of the valves; beaks prominent, incurved, somewhat flattened on the outer side, and placed about half way between the middle and the front. Dorsal margin striæ straight behind the beaks and nearly parallel to the general outline of the base, inflected so as to form a distinct, flattened, lanceolate, lunule-like area, bounded on each side by a well-defined subangular ridge; posterior side nearly or quite closed, obliquely truncated, with sometimes a faint sinuosity near the middle; anterior side rather abruptly sloping forward, and straightened above, and rounding into the base below, near which it seems to be a little gaping; base somewhat straightened, or even a little sinuous in outline, just in front of the middle, at the termination of a broad, very shallow cavity, extending a little obliquely downward and backward from the umbonal region; behind this rather prominent, thence ascending obliquely, with a slightly convex outline, to the truncated posterior margin. Posterior umbonal slopes very prominently rounded above, and continued as a low undefined ridge, obliquely backward and downward; posterior dorsal slope, above the umbonal ridge, with an oblique, shal-

low, rounded sulcus, extending from the back part of the beaks to the middle of the truncated margin behind. Surface marked with fine lines of growth and small irregular, concentric wrinkles, which latter are not defined on the posterior dorsal region above the umbonal ridge; crossing these are the usual radiating rows of minute granules. Length, 2 inches; height, 1.15 inches; convexity, 1 inch."

Range and distribution: Upper Coal Measures; Kansas City, Iola, Lawrence, Lecompton, Topeka.

This species may be very easily distinguished from the foregoing by its very much larger size and less angular and more robust form, and the sinuosity of the ventral margin.

Allorisma subcuneatum. Plate XX, figs. 1-1b.

Allorisma regularis? Owen, Geol. Rep. Wis., Iowa, and Minn., pl. v, f. 13, (1852).

Allorisma subcuneata Meek, Fin. Rep. U. S. Geol. Surv. Neb., p. 221, pl. II, f. 10a, b, (1872); etc.

Meek's description: "Shell attaining a large size, longitudinally elongated, or twice to three times as long as high, proportional length increasing with age; greatest convexity a little in advance of the middle and in the umbonal region; cuneate and a little gaping behind, where the margin is more or less narrowly rounded in outline. Basal and dorsal margins nearly parallel, the latter being more or less concave in outline, or nearly straight, and inflected so as to form a lanceolate kind of false area, bounded by an obtuse ridge on each side, just outside of which there is a shallow undefined sulcus; basal margin slightly convex, or somewhat straightened along the middle, and sometimes very faintly sinuous just under the beaks, rounding up more abruptly before than behind; anterior margin very short, a little gaping and rather prominently rounded below; beaks convex, incurved, and placed near the anterior end, rather depressed, but rising moderately above the dorsal margin. Surface ornamented with fine striæ of growth, and well-defined concentric undulations usually more distinct and regular on the beaks and umbonal region. Length of the largest specimen

seen, 4.81 inches; height from the ventral to the dorsal margins, near middle, 1.76 inches; convexity, 1.57 inches."

Range and distribution: Upper Coal Measures; Westport (Mo.), Kansas City, Mont Ida (Anderson county), Lawrence, Lecompton, Topeka, Elmont, Grand Summit.

This species is distinguished, on account of its larger and more graceful form, from either of the preceding.

Allorisma costatum. Plate XX, fig. 12.

Allorisma costata Meek and Worthen, Proc. Acad. Nat. Sci. Phil. 1869, p. 171; Geol. Surv. Ill., v, p. 585, pl. xxvi, f. 15, (1873).

Meek and Worthen's description: "Shell under medium size, longitudinally oblong, the length being more than twice the height, very thin, rather convex in the central umbonal regions; anterior margin rather short, closed and narrowly rounded; basal margin forming a long, rather semielliptic curve, with a very slight sinuosity in front of the middle; posterior side compressed, but apparently a little gaping and distinctly truncated nearly vertically from the base about half way up, and thence a little obliquely forward and upward to the dorsal margin; posterior dorsal region compressed above the umbonal ridge; cardinal margin equaling about two-thirds the entire length of the shell, very nearly straight, and inflected so as to form a narrow or lance-linear corselet, extending over its whole length; beaks convex, rising a little above the cardinal margin, and placed slightly more than one-sixth the length of the valve behind the anterior extremity; lunule well defined and lance-ovate in form. Surface ornamented by about twenty-five very regularly arranged, distinctly elevated, concentric costæ, which commence near the lunule and extend backward parallel to the base, to the well-defined, angular umbonal ridge leading from the beaks to the posterior basal extremity, at which ridge they become suddenly obsolete, or very nearly so, being mainly represented on the more compressed posterior dorsal region by distinct lines of growth, which are crossed on the middle of this area by a second oblique linear ridge extending from the beaks to the middle of the posterior margin. Some indications

of the usual minute surface granules appear to be visible in some of the molds left in the matrix. Length, about 1.20 inch; height, 0.53 inch; convexity, 0.44 inch."

Range and distribution: Upper Coal Measures; Kansas City, Lawrence, Topeka.

This species may be easily distinguished by its large, even, sharply elevated ribs and the radiating costæ on the upper posterior portion, as well as its long, graceful shape.

SEDGWICKIA.

McCoy, Synop. Carb. Foss. Ireland, p. 61 (1844).

Sedgwickia topekaensis. Plate XX, fig. 3.

Leptodomus topckaensis Shumard, Trans. St. L. Acad. Sci., 1, p. 208.

Sedgwickia topekaensis? Meek and Hayden, Pal. Upp. Mo., p. 40, A, B, (1864).

Allorisma topckaensis Keyes, Geol. Surv. Mo., v, p. 128.

Meek and Hayden's description: "Shell depressed subovate, about twice as long as high, extremely thin and fragile, gibbous in the region of the beaks and along the oblique umbonal slopes. Sides flattened above, and becoming a little concave towards the base in front of the middle. Dorsal border nearly horizontal, and slightly concave in outline behind the beaks, where its inflected edge is margined by a rather distinct ridge; ventral border presenting a broad semiovate outline, excepting a very slight sinuosity just in advance of the middle—rounding up abruptly in front and more gradually behind; anterior side prominent, gibbous, and narrowly rounded below, obliquely truncated above; posterior side compressed, narrowed, and apparently subtruncate and somewhat gaping at the extremity. Lunular impression in front of the beaks (in casts) moderately distinct, defined by a faintly impressed line. Beaks prominent, gibbous, a little flattened, incurved, and placed between the middle and the anterior extremity, but nearer the former. Entire surface, in well-preserved specimens, closely covered with minute granules arranged in radiating rows; and ornamented with small concentric ridges, which are almost regular and distinct on the umbones, and end abruptly along an impressed line extending from the posterior side of each beak obliquely

towards the postero-basal margin, thus leaving the compressed postero-dorsal region comparatively smooth. (Muscular and pallial impressions unknown.) Length, about 2 inches; height, 1 inch; convexity, 0.75 inch."

Range and distribution: Upper Coal Measures; Topeka.

Our specimens differ somewhat from those figured in having the sides less depressed near the beaks and ventral margin; they having shells a trifle thicker than the description calls for.

CHÆNOMYA.

Meek, Pal. Upp. Mo., p. 42, (1864).

Chænomya leavenworthensis. Plate XIX, figs. 3-3b.

Allorisma? leavenworthensis Meek and Hayden, Proc. Acad. Nat. Sci. Phil. 1858, p. 263.

Chænomya leavenworthensis Meek and Hayden, Pal. Upp. Mo., p. 43, pl. II, ff. 1a-c, (1864); etc.

Meek and Hayden's description: "Shell subcylindrical; anterior side rounded, a little compressed and apparently entirely closed; posterior side long, truncated, and very widely gaping, the margins being even a little reflexed. Base nearly straight, or slightly convex in outline, rounding up gradually in front, and very abruptly behind; dorsal side concave in outline from the beaks to its elevated posterior extremity, and nearly parallel to the base. Beaks rather depressed, somewhat flattened, incurved, nearly or quite touching, and located about half way between the middle and the anterior end. Surface marked by fine lines of growth, and a few irregular, nearly obsolete concentric undulations, which curve up abruptly behind, parallel to the truncated posterior margin. Crossing these, the radiating rows of minute granules may be seen by the aid of a good lens, on well-preserved specimens. Internal casts of this species show quite distinctly the scar of the anterior adductor muscle, which is oval, and located near the buccal margin, with its longer axis nearly at right angles to that of the shell. At its upper extremity the small oval pedal scars are also well defined in both valves. The posterior muscular impressions broad, oval, and rather faintly marked; from near the middle of the under side the pallial line descends with a gentle

forward curve, so as to form a broad, rounded, very shallow sinus. Length, 2.85 inches; height, from the ventral margin to the middle of the dorsal side, 1.36 inches; length, from the base to the line drawn from the beaks across to the most elevated part of the posterior extremity, 1.50 inches; greatest convexity, near the middle, 1.11 inches; breadth of the posterior hiatus, 1.07 inches; height of the posterior hiatus, 1.44 inches."

Range and distribution: Upper Coal Measures; Kansas City, Lawrence.

EXPLANATION OF PLATES.

NOTE.—The page numbers printed in the following matter refer to where the description is given. Numbers (1, 2, 3, etc.,) refer to figures on the plate. The plates will be found beginning on page 189.

PLATE I.

Fusulina secalica, (p. 10.)

1. Illustrates the different forms and sizes of these shells.
- 1*b*. Longitudinal section of a specimen, showing the foramina in the inner walls (*f*).

Amblysiphonella prosseri, (p. 14.)

2. Longitudinal section much enlarged, showing pores in the walls and the thin gastral tissues. (After Clarke.)
- 2*b*. Cross-section enlarged to show the structure. (After Clarke.)
- 2*c*. Longitudinal section about natural size, showing the cloaca in the center and the apertural walls. (After Clarke.)
- 2*d*. Average-sized specimen. About natural size. (After Clarke.)
- 2*e*. Section of specimen as seen in matrix, from Topeka. Oblique longitudinal section.
- 2*f*. Specimen of different form, and possibly different species.

Somphospongia multiformis, (p. 12.)

6. Drawing to illustrate the thickness of the dermal layer. Magnified.
7. Outline of larger specimen, showing mushroom form. One-half natural size.
8. Tracing of a section through the top of one of the sponges, showing the arrangement of the canals, which are stippled. The unstippled portion is the body of the sponge. One-half natural size.
9. Semidiagrammatic section through the cloaca of a small individual, showing canals, which are stippled, and the semiconcretionary nature of the outer part of it.
10. Portion of the surface of a weathered specimen, showing what appears to be the body skeleton of the sponge. Magnified.

PLATE II.

Somphospongia multiformis, (p. 12.)

- 1 to 5. Photographs showing the various forms of the smaller specimens, the last showing the manner in which the tops of the sponges weather, bringing out the canals. Less than natural size.

Amblysiphonella prosseri, (p. 14.)

6. Specimen showing aperture. About natural size. (After Clarke.)

Lophophyllum profundum, (p. 17.)

7. Side view of specimen, with part of the calyx broken away, showing the protruding columella. Natural size.

7b. Section of a specimen, showing the tabulæ. Natural size.

Lophophyllum westi, (p. 18.)

8. Side view of moderately large specimen. Incomplete.

8b. Cross-section of the same, showing the tendency to form a columella from the counter septum.

Axophyllum rudis, (p. 20.)

9. Side view of the average-sized specimen. Natural size.

9b. View from above, showing the interior of the calyx and the pseudocolumella.

9c. Cross-section of a specimen below the calyx, showing the structure of the pseudocolumella in the center and the arrangement of the septa and vesicles around it. Magnified.

Syringopora multattenuata, (p. 25.)

10. Enlarged cross and oblique sections across the top of a specimen as it appears when polished, showing the funnel-shaped tabulæ.

10b. Longitudinal section, showing funnel-shaped tabulæ. Enlarged.

Chaetetes milleporaceus, (p. 25.)

11. Longitudinal section, showing tabulæ and arrangement of the corallites. Magnified.

11b. Cross-section of the same, showing shape of the corallites. Enlarged.

Michelinia eugeneæ, (p. 21.)

12. Side view of average specimen. Natural size.

12b. View of base of another specimen, showing its attachment to a crinoid stem.

PLATE III.

Cladochonus bennetti, (p. 24.)

1. Side view of type. Enlarged two diameters.

Aulopora? prosseri, (p. 23.)

2. View from above. Natural size.

Aulopora anna, (p. 23.)

3. Top view, showing the way in which it anastomoses. Natural size.

Lophophyllum westi, (p. 18.)

12. Side view of type. About natural size.

PLATE IV.

Campophyllum torquium, (p. 19.)

1. Typical slab of these corals. Reduced in size.

Aulopora? prosseri, (p. 23.)

2. View of base, showing how the individual expands, and the absence of tabulæ and septa. Reduced in size.

PLATE V.

Campophyllum torquium, (p. 19.)

1. Cross-section of young individual, showing the thickening of the septa on one side. Natural size.
2. Cross-section near the calyx of an older individual, showing the septa nearly equal, except the counter septum, which is thickened. Natural size.
3. Longitudinal section of a rather young individual, showing the comparatively simple tabulae and a narrow vesicular zone.
4. Side view of young individual, showing a rapidly expanding form. Twice natural size.

Limopteria alata, (p. 130.)

5. View of right valve. Twice natural size.

Syringopora multattenuata, (p. 25.)

6. Side of specimen. Nearly natural size.

Lophophyllum westi, (p. 18.)

7. Longitudinal section of specimen, showing nature of the tabulae. Enlarged.

Trachypora austini, (p. 22.)

8. Lateral view of specimen. (After Worthen.)

PLATE VI.

Zocrinus?? robustus, (p. 29.)

1. Base of calyx of type. Natural size.
- 1a. Side view of same (inverted).

Scaphiocrinus? washburni, (p. 27.)

2. Azygous side of calyx, showing base of arms. Natural size.
- 2a. Opposite side of type. Natural size.

Eupachyerinus magister, (p. 40.)

3. Side view of calyx, showing the anal plates on the right. Natural size.
- 3b. Base of calyx. Natural size.

Erisocrinus typus, (p. 39.)

4. Base of calyx. Natural size.
- 4b. Side view of calyx. Natural size.

Ccriocrinus hemisphericus, (p. 34.)

5. Base of calyx. Natural size.
- 5b. Side view of same.

Ccriocrinus missouriensis, (p. 35.)

6. View of the base of the calyx.

Trachypora austini, (p. 22.)

7. Cross-section. (After Worthen.)
- 7b. Section showing microscopic structure. (After Worthen.)

Agassizocrinus carbonarius, (p. 45.)

8. Side view of calyx.

Cerioocrinus craigi, (p. 32.)

9. Base of calyx. Natural size.

9b. Side view of same.

Phialocrinus magnificus, (p. 36.)

10. Side view of specimen, showing calyx, arms, and anal tube. Natural size.

PLATE VII.

Erisocrinus megalobrachius, (p. 37.)

1a. View of base of type. Natural size.

1b. Side view of same.

Cerioocrinus? monticulatus, (p. 33.)

2. Side view of type. Natural size.

Oligoporus? minutus, (p. 49.)

3. Apical? view. Natural size. Type.

Hydreionocrinus kansasensis, (p. 42.)

4 to 7. Showing structure and appearance of various parts. (After Weller.)

H. subsinuatus. See plate VIII.

PLATE VIII.

Orbiculoidea missouriensis, (p. 55.)

1 and 1b. Upper and lower aspects of the flat valve. Enlarged.

1c. Convex valve as seen from above. Enlarged.

Orbiculoidea manhattanensis. (p. 56.)

2. Internal appearance of the flat valve, showing the peripheral ridge. Natural size.

2b. Convex valve. Enlarged.

Orbiculoidea convexa, (p. 55.)

3. Convex valve. About natural size.

3b. Flat valve, perhaps of this species, internal view. Natural size.

Crania modesta, (p. 57.)

4. Upper view of specimen on a smooth shell. Natural size.

Lingula mytiloides, (p. 54.)

5. Specimen. Natural size.

Archæocidaris agassizi, (p. 48.)

6 to 6c. Illustrations of plates and spines.

6e cross-section of 6d. All natural size. (After Hall.)

Archæocidaris megastylus, (p. 49.)

7. Mass of spines and plates. (After Keyes.)

Derbya bennetti, (p. 59.)

8. View of brachial valve.

8b. View of hinge area.

8c. Lateral view of specimen. (All after Hall.)

Archæocidaris tridifer, (p. 47.)

10. Spine. Natural size. (After White.)

Derbya crassa, (p. 62.)

- 11, 11b. External and internal views, respectively. Natural size.

Derbya biloba?

12. Specimen, perhaps of this species, from Lecompton. (Rogers.)

Derbya keokuk, (p. 63.)

13. Brachial valve. Natural size.

Hydreionocrinus subsinuatus, (p. 43.)

14. Basal view of calyx. Natural size.

PLATE IX.

Chonetes granulifer, (p. 69.)

1. External view of pedicle valve. Natural size.
1b. Internal view of brachial valve, showing radiating ridges, indications of the brachial areas, and the granular inner surface.
1c. External view of a peculiar specimen of this species, showing the auriculation. Natural size.

Chonetes glaber, (p. 68.)

2. Exterior of pedicle valve. Natural size.

Chonetes mesolobus, (p. 71.)

3. Pedicle valve. Natural size.
3b. Interior of brachial valve, showing the cardinal process, brachial and other markings. Enlarged.

Chonetes verneuillianus, (p. 72.)

4. Pedicle valve of long-eared variety. (After Meek.)
4b. Same of short-hinged specimen. Natural size.
4c. Interior of brachial valve, showing the markings. Natural size.
4e. Interior of pedicle valve, showing adductor and diductor scars. Natural size.

Productus pertenuis, (p. 83.)

5. Pedicle valve. Natural size.
5b. Brachial valve, interior view, markings removed. Natural size.
5c. Longitudinal section, showing the relation of the valves in this species.

Productus symmetricus, (p. 86.)

6. Interior of brachial valve, showing adductor markings, lateral ridges, and mesial ridge. Natural size.
6b. Pedicle valve, partially covered by matrix. Natural size.

Productus nebrascensis, (p. 84.)

7. View showing the curvature of the beak and the relation of the pedicle to the brachial (or flatter) valve. Natural size.
7b and 7d. Lateral and full view of pedicle valve of the same specimen.
7e. Cast of specimen, showing adductor and diductor scars. Natural size.
7e. Pedicle valve, showing the nature of the spines when not removed. Natural size.
7f. Interior view of brachial valve, showing the cardinal process, large pit immediately back of it, mesial septum, adductor markings, and a dim outline of the brachial marks. Natural size.

Productus costatus, (p. 79.)

8. View of concave side, showing the relation of the two valves. Natural size.

Productus longispinus, (p. 81.)

9. Interior of brachial valve of very old specimen. The lateral ridges are well developed and extend entirely around the valve, forming a very prominent feature. Natural size.
- 9b. Brachial valve, showing relation of that valve to the pedicle valve. Natural size.
- 9c. Pedicle valve, spines removed. Natural size.
- 9d. Interior of brachial valve of younger specimen (full grown), showing the lateral ridges developed along the hinge only, with slight turn to the front where they fade out. Natural size.

Hustedia mormoni, (p. 103.)

10. View of brachial valve.
- 10b. Lateral view.
- 10c. View of pedicle valve. All natural size.
- 10d. Surface enlarged to show punctures in shell.

PLATE X.

Productus costatus, (p. 79.)

1. Pedicle valve, showing the ridge between the umbo and the ears on which are spines. Natural size.
- 1b. Side view of same.
- 1c. Interior of brachial valve, showing adductor markings, cardinal process, mesial ridge, lateral ridges, and brachial markings. The border in front is matrix between the brachial and pedicle valve. Natural size.

Productus semireticulatus, (p. 78.)

2. Exterior of brachial valve, showing hinge and beak. Natural size.
- 2b. Pedicle valve. The umbo of this specimen is narrower than most of the Coal Measures forms, which are probably varietally distinct from the one figured, which is from the Permian, but is figured here on account of its being a much better specimen. Natural size.
- 2c. Interior of pedicle valve, showing adductor and diductor markings. The central ones are the adductors. Natural size.
- 2d. Interior of brachial valve, showing adductor, brachial and other markings. Natural size. (Small specimen.)

Productus punctatus, (p. 87.)

3. Pedicle valve. Natural size.
- 3b. Brachial valve, exterior view, showing the beak and hinge. Natural size.
- 3c. Lateral view of the same specimen.
- 3d. Pedicle valve of young specimen. Natural size.
- 3e. Cast of interior of the pedicle valve, showing the adductor and diductor scars. Natural size.
-

PLATE XI.

Productus cora, (p. 75.)

1. Pedicle valve of the common form. Natural size.
- 1b. Cast of pedicle valve. (After Hall.)
- 1c. Brachial valve, interior view, showing traces of brachial markings. Natural size.
- 1d. Pedicle valve of large specimen. Natural size.
- 1e. Spine as seen on a slab of shale, from a large specimen. Natural size.
- 1f. Pedicle valve of broad, large variety. Natural size.

Productus cora americanus, (p. 77.)

2. Pedicle valve of typical form. Natural size.

Productus punctatus, (p. 87.)

3. Interior of brachial valve, showing adductor scars. Natural size.

Productus costatus, (p. 79.)

4. Cast of pedicle valve, view of beak. Natural size.

Cleiothyris royssii, p. 104.)

5. Outline of specimen with nearly straight hinge.
- 5b. Brachial valve and beak of pedicle valve of specimen.
- 5c. Lateral outline of specimen. All natural size.

Aulacorhynchus millepunctatus, (p. 89.)

6. External view of one of the valves. (After Meek and Worthen.)

PLATE XII.

Aulacorhynchus millepunctatus, (p. 89.)

1. Interior of brachial valve. (After Meek and Worthen.)
- 1b. View of a specimen from Kansas City, showing indications of extra platforms, and probably a different species. Natural size. It is quite convex for the genus.

Cleiothyris royssii, (p. 104.)

2. Side view of more robust specimen. Natural size.

Hustedia mormoni, (p. 103.)

3. Hinge apparatus. (After Hall.)

Reticularia perplexa, (p. 102.)

4. Pedicle valve. About natural size.
- 4b. Opposite valve of same.
- 4c. Side view of same.
- 4d. Surface enlarged. (After Grity.)

Spirifer cameratus, (p. 99.)

5. Interior of brachial valve, showing sockets for cardinal teeth. Natural size.
 - 5b. Pedicle valve of long-eared form.
 - 5c. Brachial valve and hinge area of robust form.
 - 5d. Young specimen. All natural size.
 - 5e. Spire of one of this species (broken). Natural size.
-

Entelctes hemiplicata, (p. 91.)

6. Side view of specimen. Natural size.

6b. Front view of same.

Pugnax utah, (p. 93.)

7. Brachial side, showing beak of the opposite valve, with the pedicle opening. Natural size.

7b. Front view of same.

7c. Side view of same.

Pugnax rockymontana, (p. 92.)

8. Side view of specimen. Natural size.

8b. Front view of same.

Meekella striatocostata, (p. 65.)

9. Lateral view.

9b. Pedicle valve.

9c. Brachial valve and hinge area. All natural size.

Derbya cymbula, (p. 60.)

10. Interior view of hinge apparatus.

PLATE XIII.

Aviculopecten hertzeri, (p. 121.)

1. Left valve.

1b. Surface markings enlarged.

Aviculopecten providencensis, (p. 119.)

2. Left valve. Natural size.

Aviculopecten sculptilis, (p. 122.)

3. Lateral view of left valve. Natural size.

3b. End view of same.

Aviculopecten germanus, (p. 123.)

4. Left valve. Natural size. (Rogers.)

Lima retifera, (p. 112.)

5. Left valve of shell. Natural size.

Aviculopecten interlineatus, (p. 116.)

6. Left valve. Natural size.

Aviculopecten occidentalis, (p. 114.)

7. Left valve. Natural size.

Aviculopecten hertzeri, (p. 121.)

8. Right valve. (After Meek and Worthen.)

Aviculopecten carboniferus, (p. 117.)

9. Left valve. Natural size.

Aviculopecten mccoysi, (p. 118.)

10. Left valve. Natural size.

Pseudomonotis hawni, (p. 132.)

11. Interior view of flat valve, showing byssal notch.

11b. End view of convex valve.

11c. Lateral view of convex valve. (All after Meek.)

PLATE XIV.

Pseudomonotis kansasensis, (p. 133.)

1. Left valve of type. Postero-ventral portion crushed, probably giving it undue prominence. The striae are finer and more crinkly than represented in drawing. About natural size.
- 1a. Outline showing convexity of the same.
- 1b. Outline showing the convexity of the adult long-hinged forms.
- 1c and 1d. Young specimen of the long-hinged form, showing different degrees of development of the hinge and ears. About natural size.

Pseudomonotis robusta, (p. 133.)

2. Left valve of type. The striae are finer and more wavy than represented, and the upper third is practically glabrous, only the faintest traces of striae being present. About natural size.
- 2a. Anterior view of the same shell, showing gibbosity and arcuity of shell, as well as concentric lines of growth. About natural size.
- 2b and 2c. Anterior and lateral views of the left valve of a young individual of the above shell. About natural size.

Pseudomonotis hawni equistriata, (p. 134.)

3. Left valve of type. A little less than natural size.
- 3a and 3b. Anterior views of two left valves, showing variation in convexity and indistinctness of beak. About natural size.

PLATE XV.

Pseudomonotis hawni. Lobed variety, (p. 132.)

1. Convex valve, showing the bending of the costae and the lobe on the end of the shell. All natural size.
- 1a. Interior of left valve, showing retractor scars and adductor scar.
- 1b. Outline showing convexity of same.
- 1c. Hinge view of a specimen, showing the indistinctness of the beak and the great convexity of the shell.
- 1d. Specimen showing the stronger lobing of the shell.
- 1e. End of outline of a specimen, showing the great convexity of the beak in some individuals.
- 1f. Hinge view of a specimen, showing the great convexity and the manner in which the shell flattens out on the end where the lobe is located.
2. Large, old specimen, showing umbonal region with only the finer striae.
- 2a. Flat valve of the same specimen, showing the place of attachment to foreign object.

Pseudomonotis kansasensis, (p. 133.)

3. Enlargement of the surface of the type, showing the lines of growth extending backward up the furrows and down farther toward the ventral margin on the ridges.

PLATE XVI.

Myalina ampla, (p. 139.)

1. External view of shell. (After Meek.)
- 1b. Interior of same. Both reduced one-half.

Myalina congeneris, (p. 142.)

2. Exterior of specimen. (After Walcott.)
- 2b. Another specimen. (After Walcott.)

Pteria sulcata, (p. 126.)

3. Left valve enlarged. (After Meek.)

Pteria longa, (p. 125.)

4. Left valve of specimen. Natural size.

Limopteria marian, (p. 128.)

5. Right valve. Natural size. (After White.)
- 5b. End view of specimen. (After White.)
- 5c. Surface markings enlarged.

Limopteria longispina, (p. 127.)

6. (After Keyes.)

Myalina swallowi, (p. 137.)

7. Left valve. Natural size.

Myalina perattenuata, (p. 141.)

8. Right valve of specimen. Natural size.

Limopteria gibbosa, (p. 129.)

9. Right valve. (After White.)

Myalina subquadrata, (p. 138.)

10. Impression of left valve. (After Meek.)
- 10b. Part of left valve broken away, showing the interior of the right valve and outline of the specimen. (After Meek.)

Myalina kansasensis, (p. 140.)

11. Specimen showing left valve. (After Keyes.)

PLATE XVII.

Aviculopinna illinoiensis, (p. 143.)

1. Outline of cross-section.
- 1b. Specimen. Natural size.
- 1c. Surface markings. Enlarged.

Pinna subspatulata, (p. 145.)

2. Drawing of cast. Reduced one-half.

Pinna peracuta, (p. 144.)

- 3 and 3b. Lateral and dorsal views. (After Keyes.)

PLATE XVIII.

Pinna subspatulata, (p. 145.)

1. Semidiagrammatic dorsal aspect. Does not show dorsal ridge.
- 1b. Aspect of broken right valve.
- 1c. Same of left valve.
- 1d. Cross-section. All natural size.

Ariculopinna americana, (p. 143.)

2. Lateral view of shell. Natural size.

Pinna subspatulata, (p. 145.)

3. View of another cast from different locality.

PLATE XIX.

Entolium ariculatum, (p. 113.)

1. Left valve. (After Meek.)

Ariculopecten coxanus, (p. 124.)

2. View showing left valve. Natural size. (After Rogers.)

Charnomya leavenworthensis, (p. 172.)

3. Lateral view of specimen. (After Meek.)
- 3b. Dorsal aspect of same.

Myalina? exasperata, (p. 141.)

4. Left? view of type. Natural size.

Posidonomya? pertenuis, (p. 136.)

5. Left? valve of type.

Posidonomya? recurva, (p. 135.)

- 6a. Left? valve of type.
- 6b. Right? valve of another specimen.
- 6c. Left? valve of the preceding, with a part of the shell adhering on one side. The beak is somewhat crushed and twisted, so that it does not seem to extend above the hinge. All natural size.

PLATE XX.

Allorisma subcuneatum, (p. 169.)

1. Lateral view of specimen. (After Keyes.)
- 1b. Dorsal aspect of the same.

Macrodon sangamonensis? (p. 146.)

2. Dorsal view of left valve.
- 2b. Lateral view of same. Natural size.

Sedgewickia topekaensis, (p. 171.)

3. Left valve of specimen.

Yoldia knoxensis? (p. 154.)

4. Specimen with valves distended. By mistake, this is not the specimen described in text, and may possibly be a different species.

Edmondia nebrascensis, (p. 166.)

5. Left valve of specimen. Natural size.

Allorisma geinitzi, (p. 167.)

6. Right valve of specimen. Natural size.

Pleurophorus tropidophorus, (p. 162.)

7. View of right valve. Natural size.

Yoldia subscitula, (p. 152.)

8. Right valve. Natural size.

Conocardium parrishi, (p. 164.)

9. Left valve. (After Keyes.)

Allorisma granosa, (p. 168.)

10. Left valve of specimen. Natural size.

Pleurophorus subcostatus, (p. 161.)

11. Cast of left valve. (After Meek and Worthen.)

- 11b. Dorsal aspect of the same.

Allorisma costatum, (p. 170.)

12. Right valve of specimen. Natural size.

Macrodon obsoletus, (p. 147.)

13. Right valve of specimen. (After Meek.)

Nuculana bellistriata, (p. 148.)

14. Dorsal view of specimen. Natural size.

- 14b. Left valve of same.

Nucula ventricosa, (p. 150.)

15. Exterior view of specimen. Natural size.

Cypricardinia? carbonaria, (p. 164.)

16. Left valve. Natural size.

Cardiomorpha missouriensis, (p. 165.)

17. Right valve. Natural size.

Placunopsis carbonaria, (p. 111.)

18. Lateral view of specimen. (After Meek and Worthen.)

PLATE XXI.

Solenomya parallela, (p. 158.)

1. Side view of type.

Solenomya trapezoides, (p. 159.)

- 2a. Left valve. Anterior adductor scar and pallial line a little too strong.

- 3b. Dorsal view of another specimen.

Limopteria subalata, (p. 131.)

- 3a. Side view of left valve.

- 3b. Side view of right valve. Both natural size.

Yoldia glabra, (p. 153.)

- 4a. Side view of type. Natural size.

- 4b. Surface markings. Enlarged.

Nucula pulchella, (p. 151.)

- 5a. Side view of type. Enlarged.

- 5b. End view of same.

- 5c. Surface markings. Greatly enlarged.

PLATE XXII.

Schizodus wheeleri, (p. 155.)

1. Dorsal view of cast. (After Keyes.)
- 1b. Side view of specimen with shell on.
- 1c. Side view of No. 1.

Schizodus hari, (p. 155.)

2. End view of specimen. Natural size.
- 2b. Left hinge.
- 2c. External view of right valve.
- 2d. Internal view of same.

Edmondia aspenwallensis, (p. 166.)

3. Lateral view of right valve. (After Keyes.)
- 3b. Dorsal aspect of same.

Solenomya radiata, (p. 160.)

5. Lateral view of specimen. (After Meek and Hayden.)
- 5b. Dorsal view of same.

Schizodus compressus Rogers. N. sp., (p. 157.)

6. Internal apparatus of a worn right valve.
- 6b. Same of left valve.
- 6c. Outline showing convexity of shell.
- 6d. Outer appearance of better specimen. All natural size.

Nuculana bellistriata attenuata, (p. 149.)

7. Lateral view. Enlarged.
- 7b. Surface markings. Enlarged.

Nucula beyrichi, (p. 149.)

8. Side view of specimen. (After Meek.)

Nucula ventricosa, (p. 150.)

9. Cast showing adductors and pallial line. Natural size.
- 9b. External appearance of shell.

Astartella vera, (p. 163.)

10. View of right valve of specimen.

CORRECTIONS.

Page 18: Following *Lophophyllum westi*, after fig. 12, add "plate V, fig. 7."

Page 24: Following *Cladochonus? bennetti*, after fig. 1, erase "plate V, fig. 7."

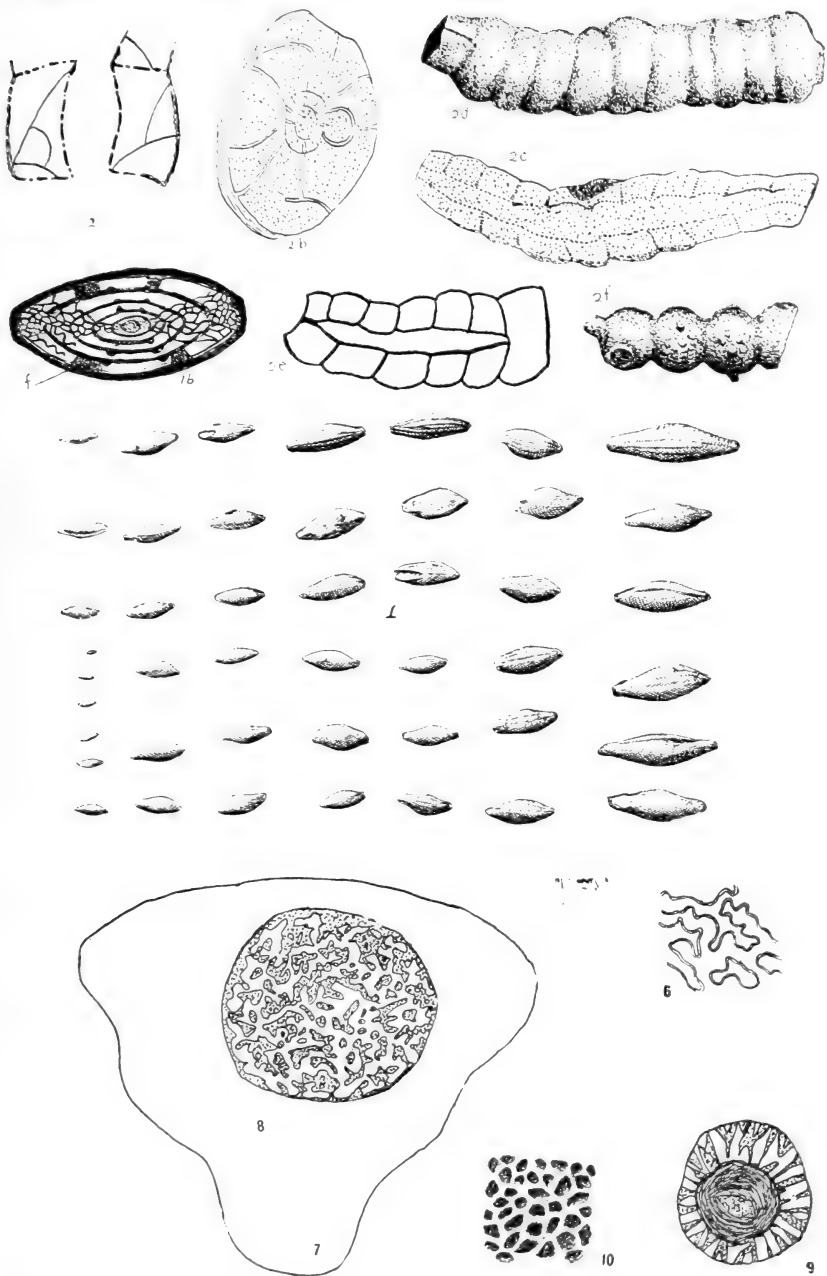
Page 43: After *Hydreionocrinus subsinuatus*, instead of "Plate VII, fig. 14," read "Plate VIII, fig. 14."

Page 78: Following *Productus semirecticulatus*, after figs. 2-2d, instead of "text fig. 2, f," read "text fig. 3, f."

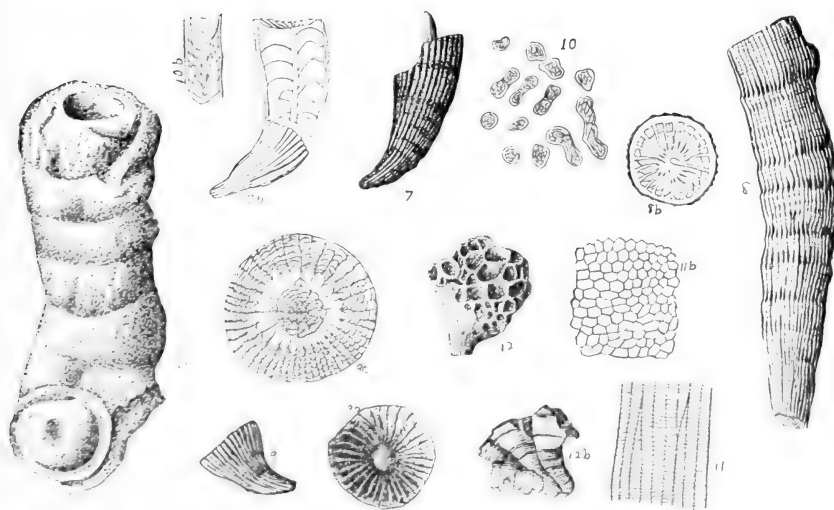
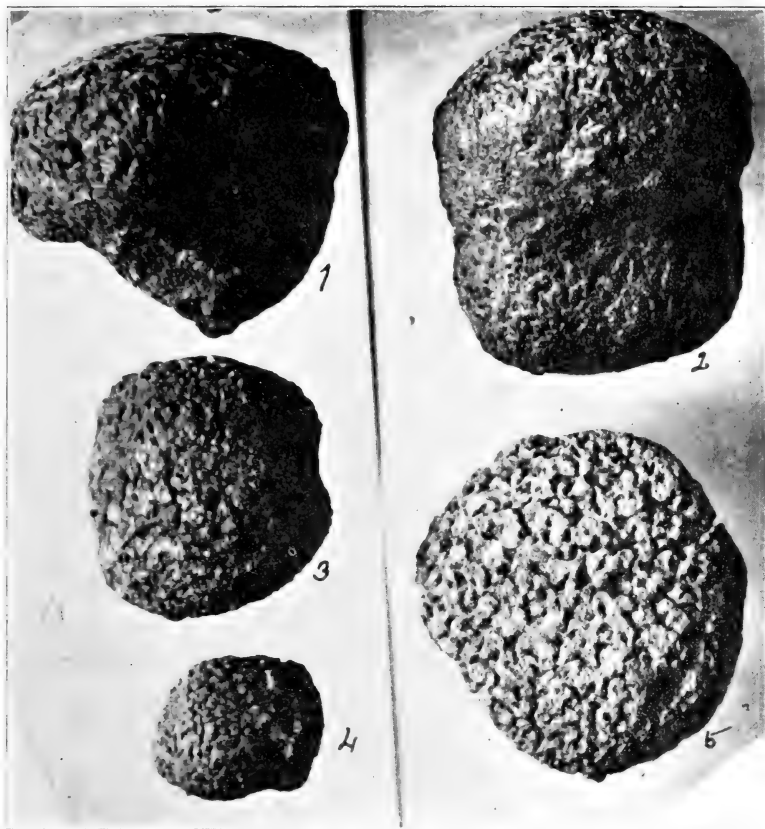
Page 103: Following *Hustedia mormoni*, for "plate X, fig. 3," read "plate XII, fig. 3."

Page 149: After *Nuculana bellistriata attenuata*, add "Plate XXII, figs. 7, 7b."





FUSULINA, 1. AMBLYSIPHONELLA, 2. SOMPHOSPONGIA, 6-10.



SOMPHOSPONGIA, 1-5.

AMBLYSIPHONELLA, 6.

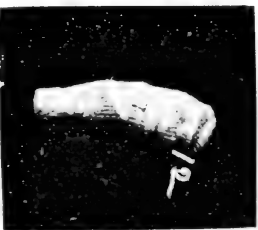
LOPHOPHYLLUM, 7, 8.

AXOPHYLLUM, 9.

SYRINGOPORA, 10.

CH.ETETES, 11.

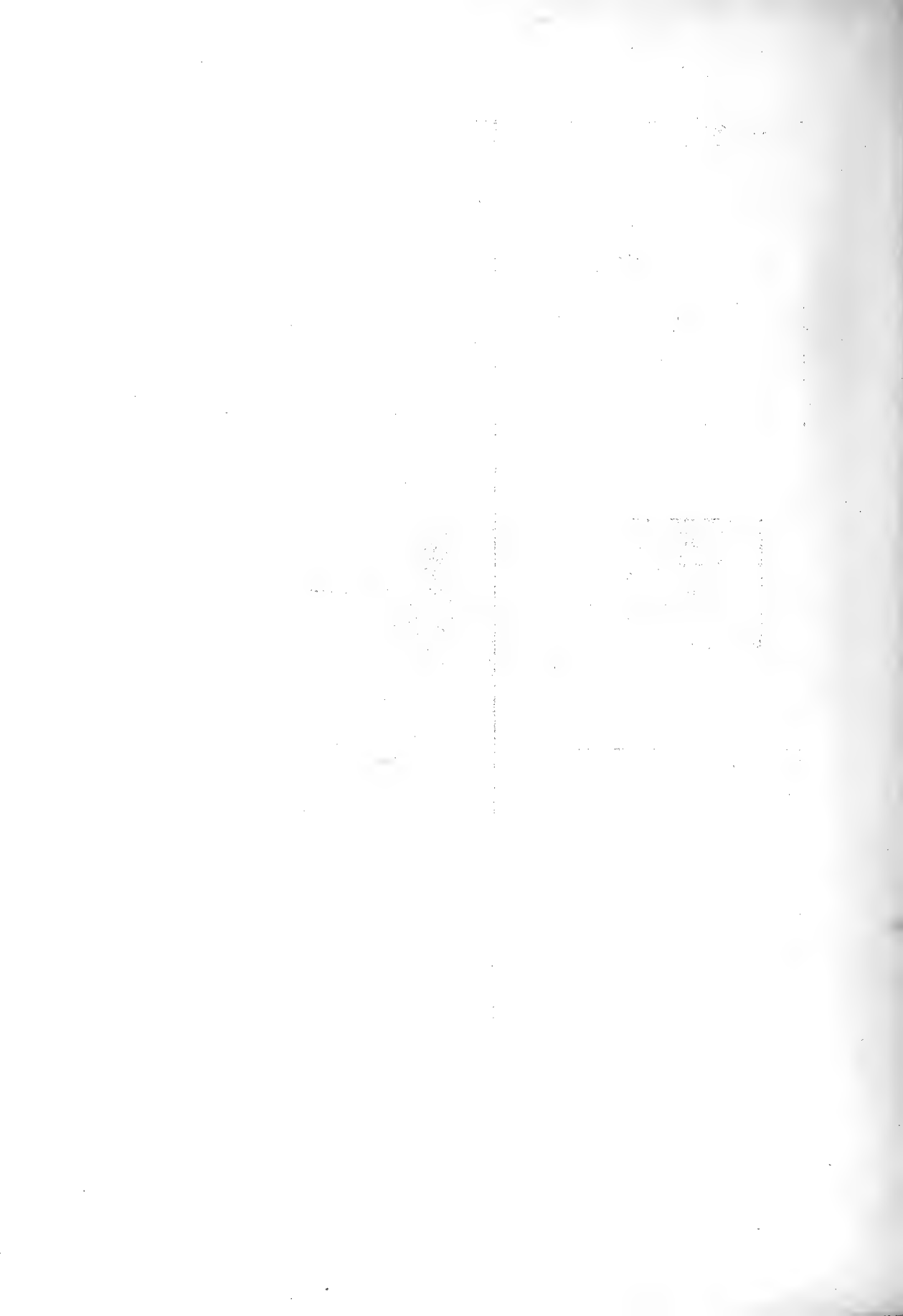
MICHELINIA, 12.

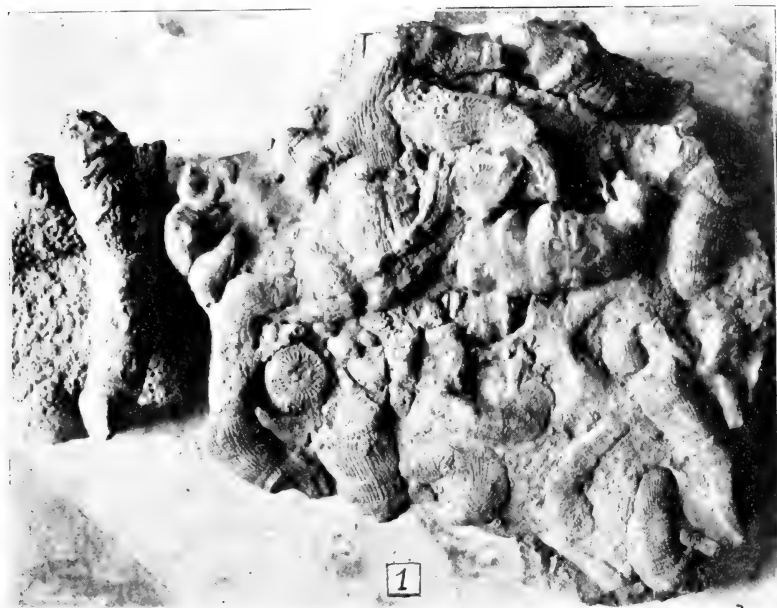


CLADOCHONUS, 1.

AUTOPORA, 2, 3.

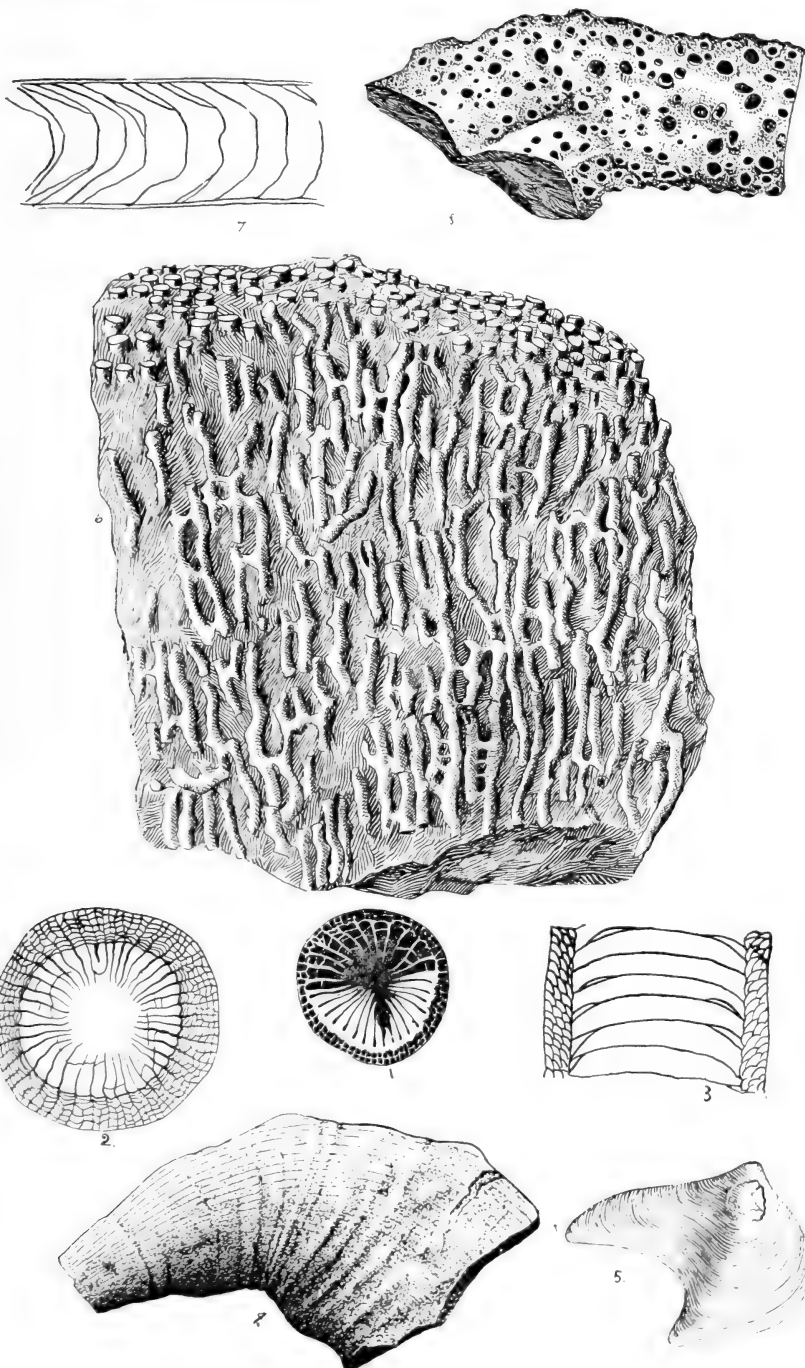
LOPHOPHYLLUM, 12.



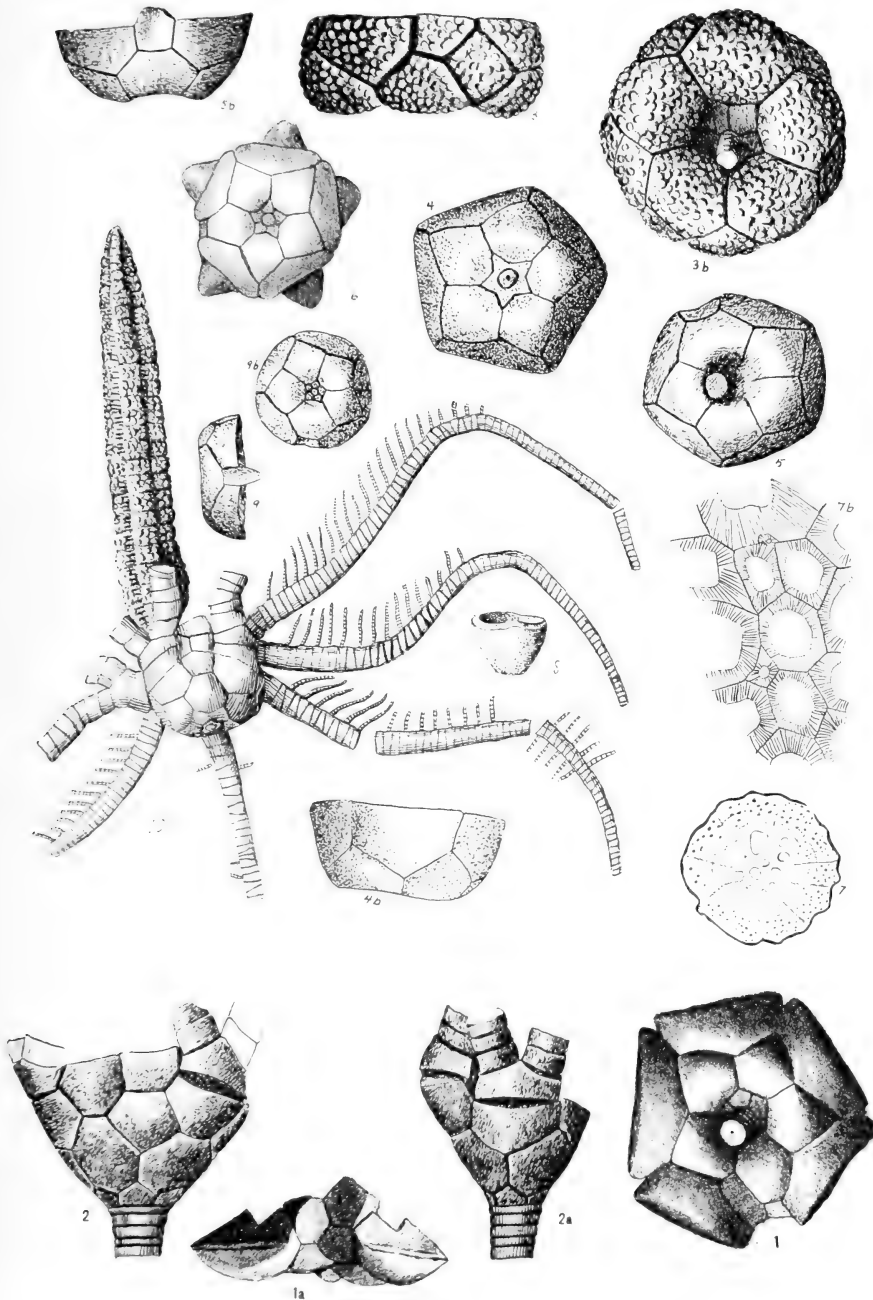


CAMPOPHYLLUM, 1.

AULOPORA, 2.



CAMPOPHYLLUM, 1-4. LIMOPTERIA, 5. SYRINGOPORA, 6.
LOPHOPHYLLUM, 7. TRACHYPORA, 8.



ZEACRINUS, 1.

SCAPHIOCRINUS, 2.

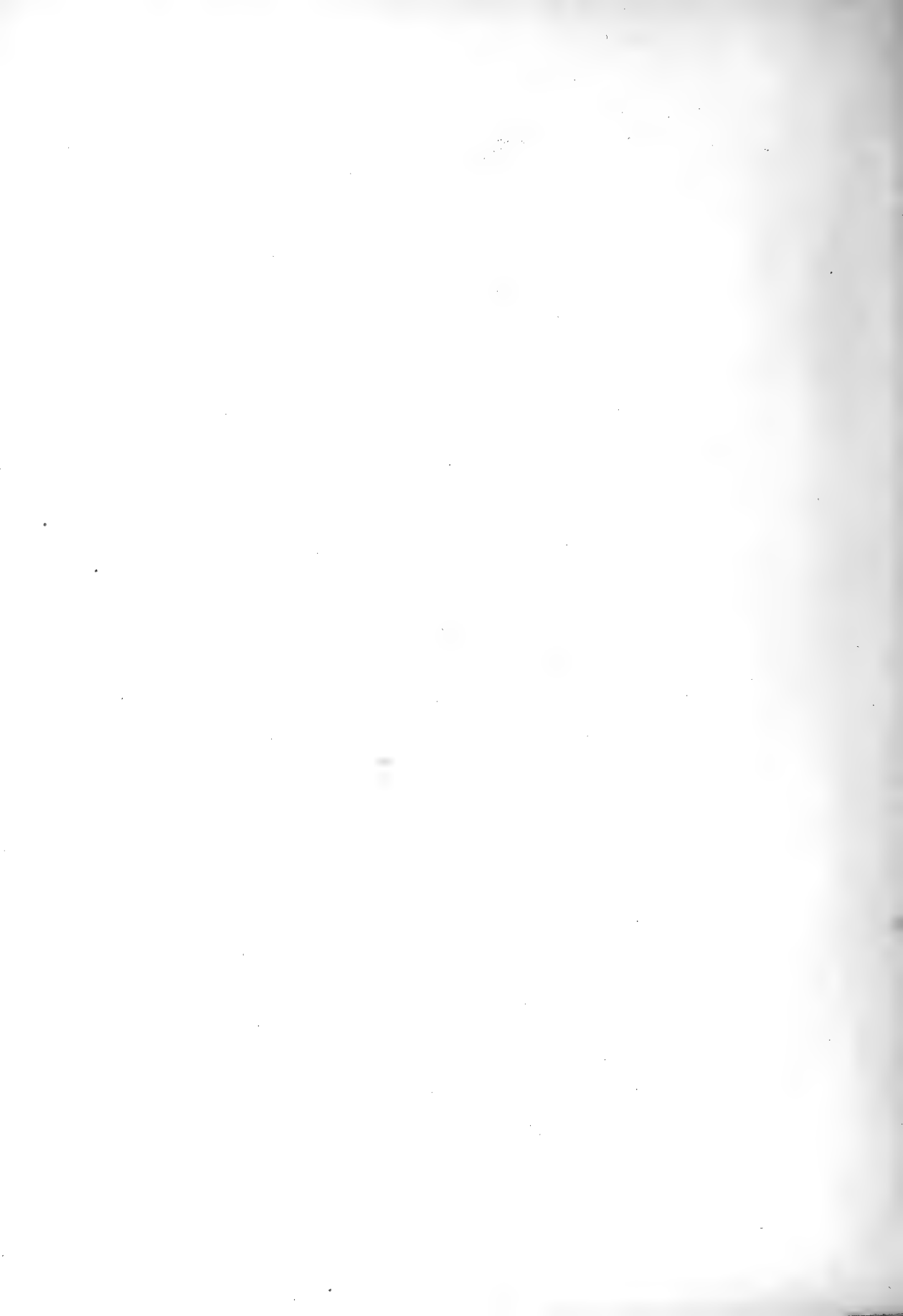
EUPACHYCRINUS, 3.

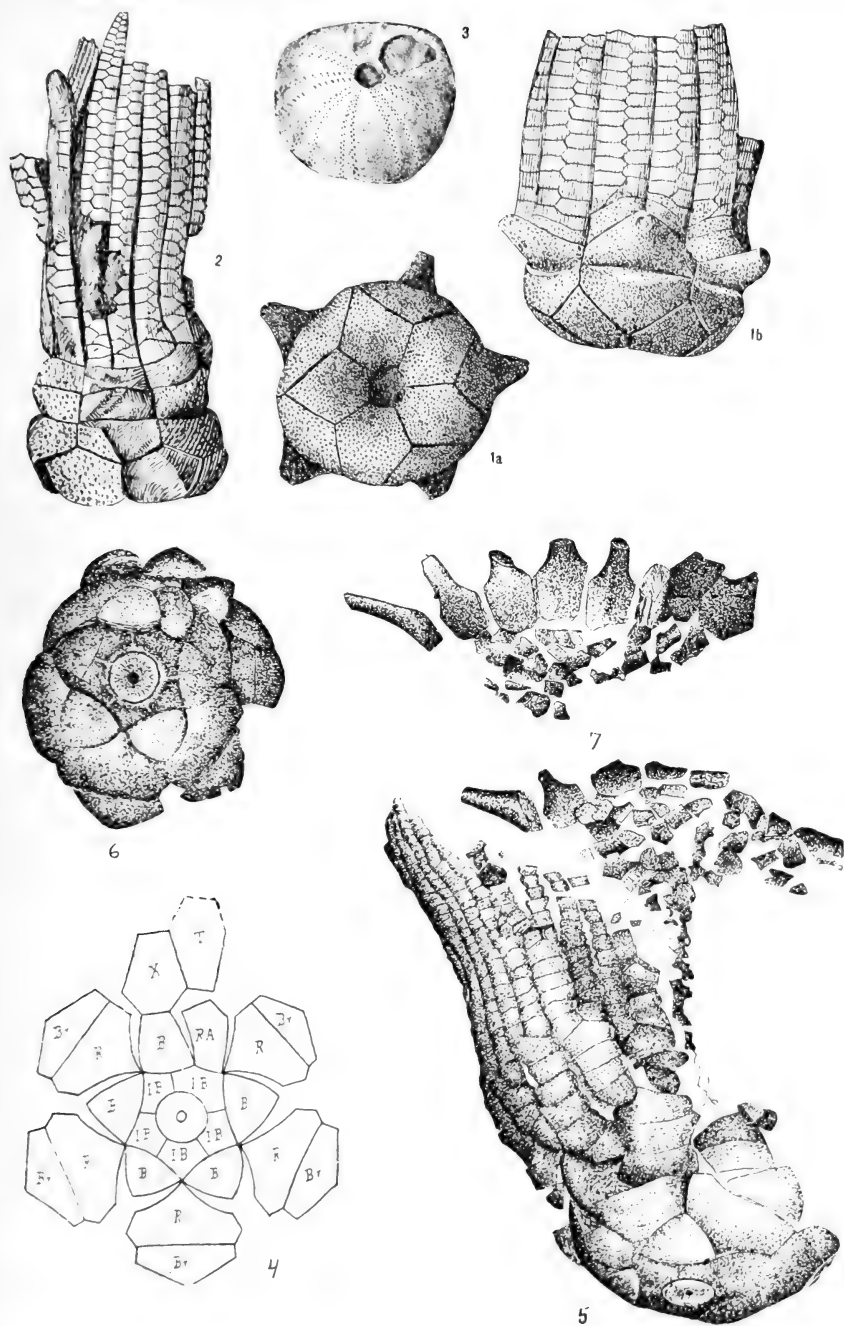
ERISOCRINUS, 4.

CERIOCRINUS, 5, 6.

TRACHYPORA, 7.

AGASSIZOCRINUS, 8.



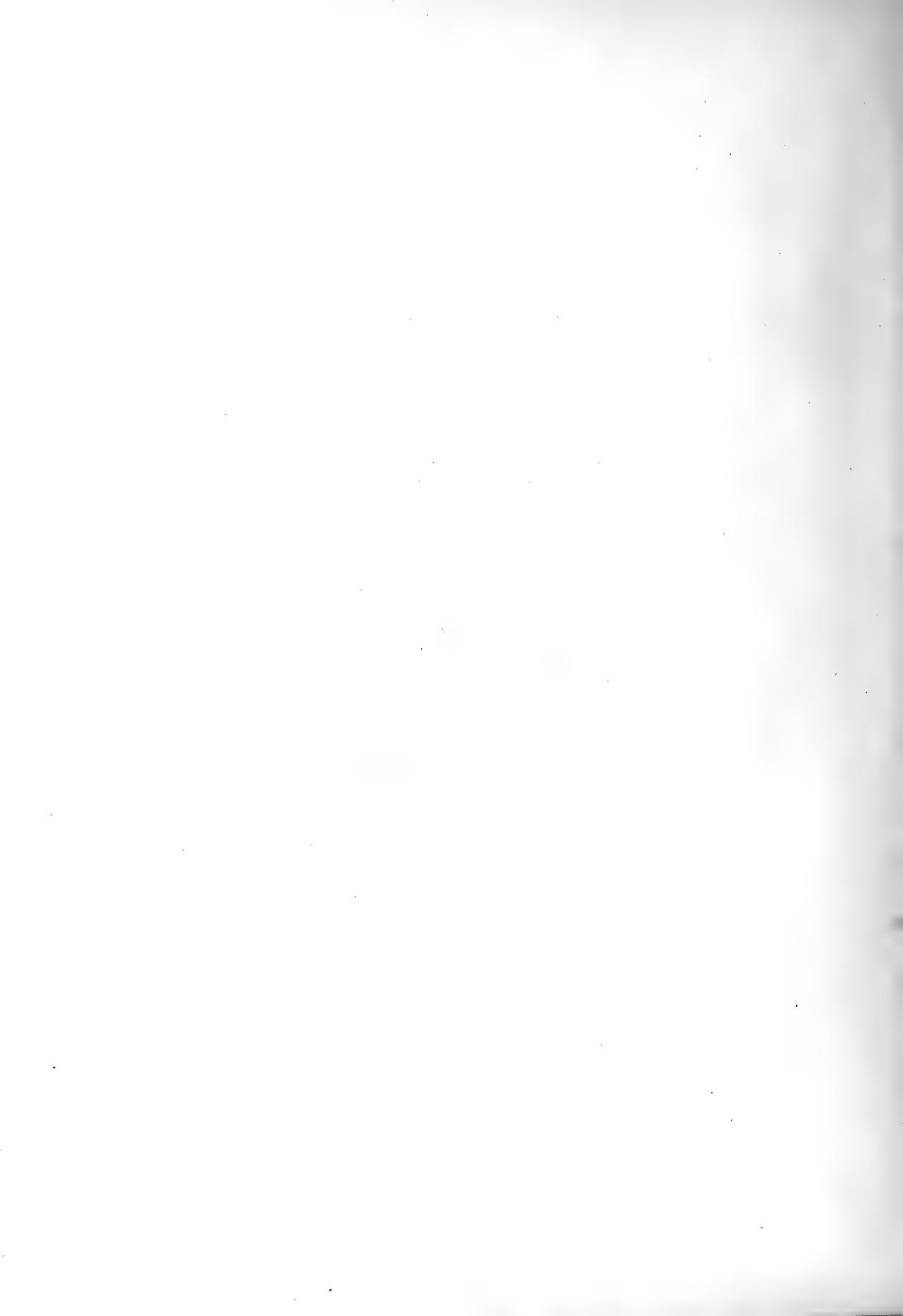


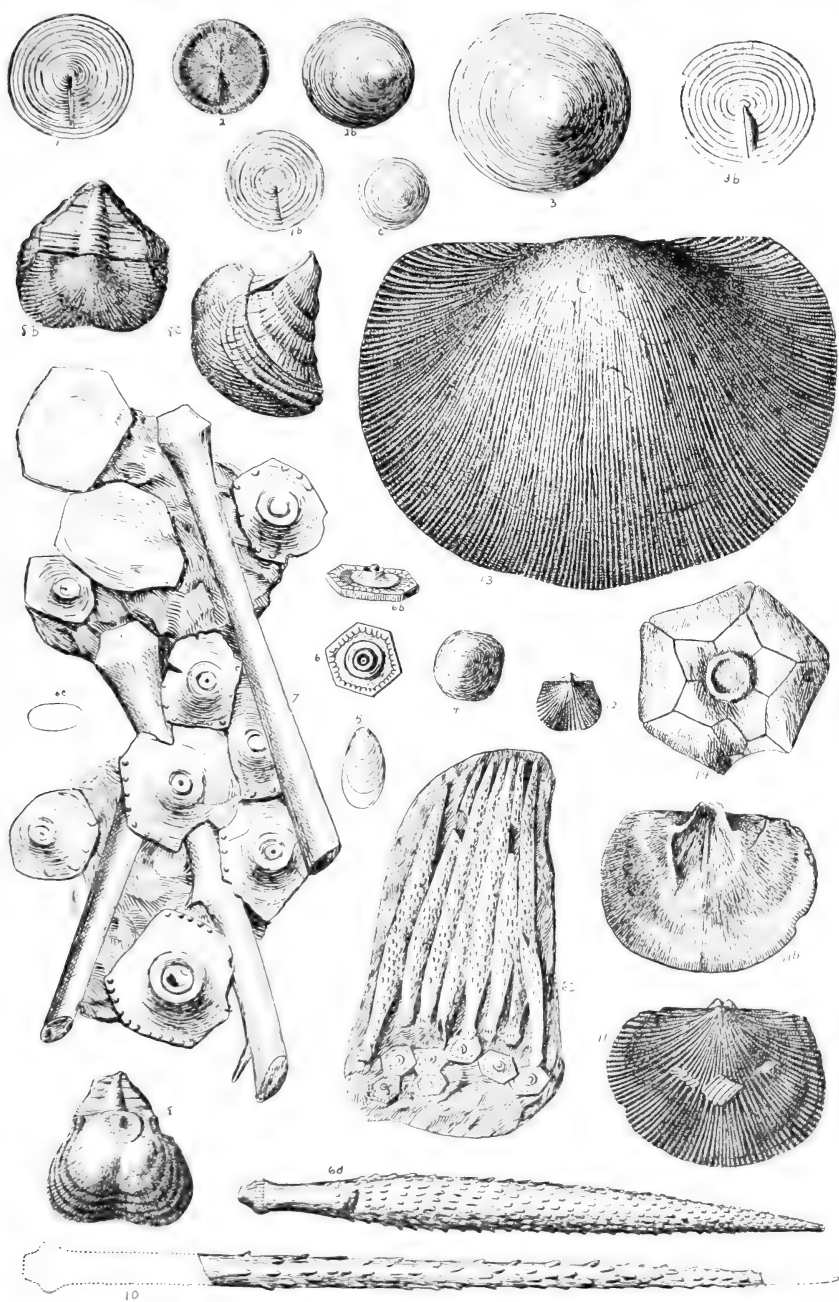
ERISOCRINUS, 1.

CERIOCRINUS, 2.

OLIGOPORUS, 3.

HYDREIONOCRINUS, 4-7.



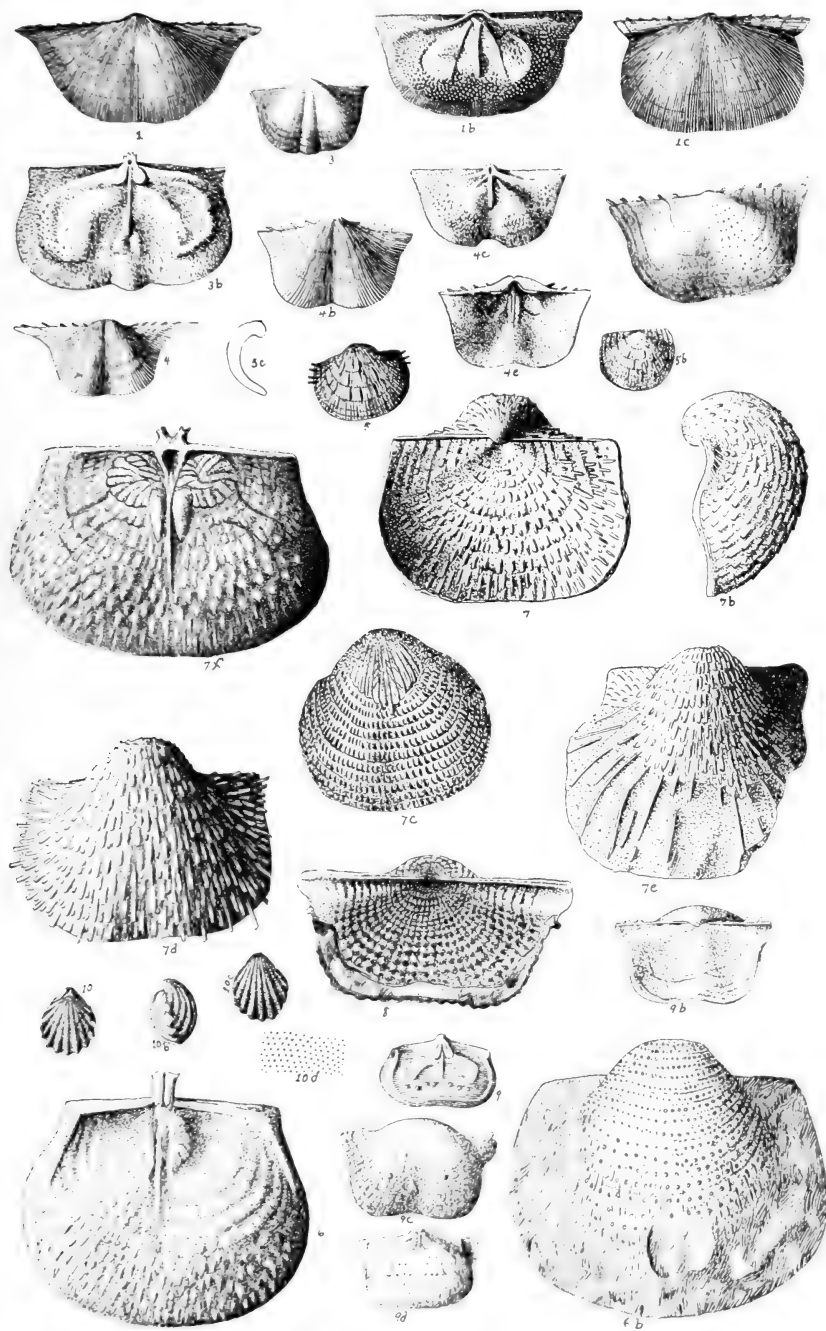


ORBICULOIDEA, 1-3.
CRANIA, 4.

LINGULA, 5.
ARCHEOCIDARIS, 6, 7, 10.

DERBYA, 8, 11-13.
HYDREIONOCRINUS, 14.

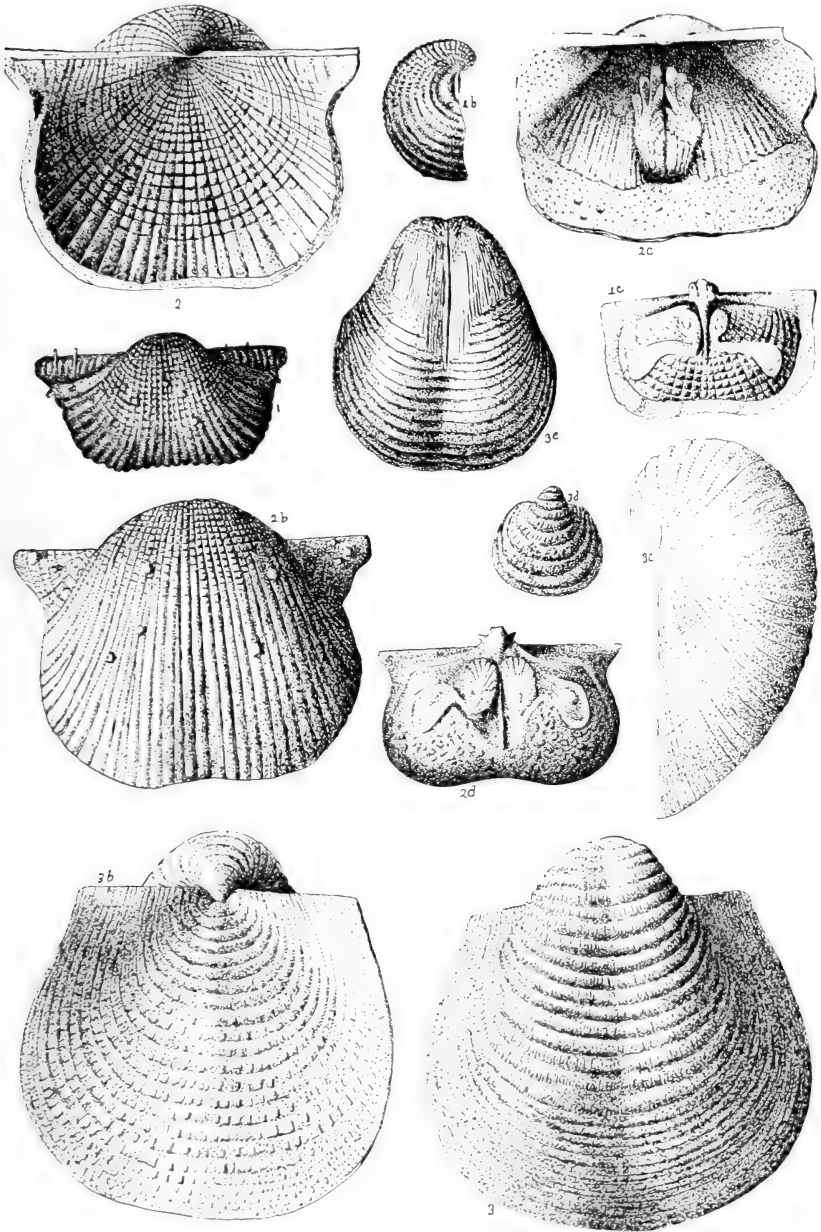




CHONETES, 1-4.

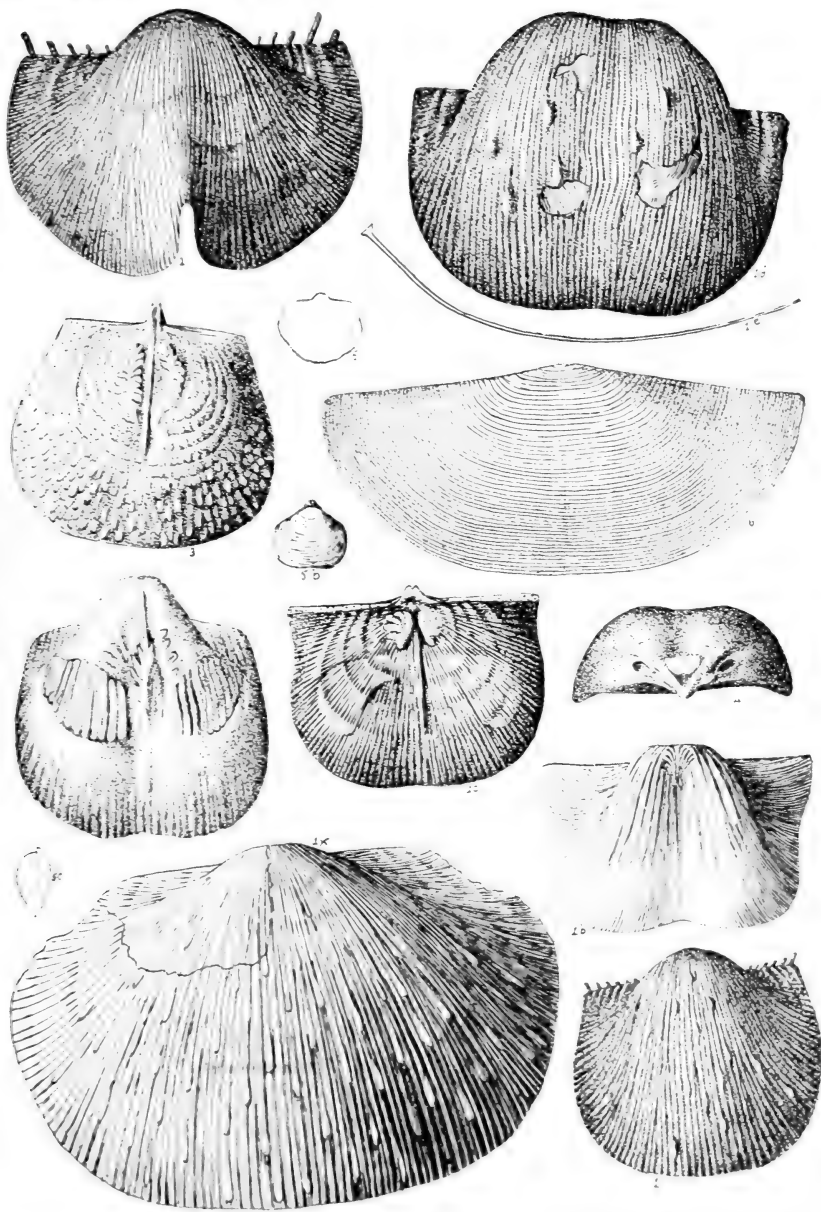
PRODUCTUS, 5-9.

HUSTEDIA, 10.



PRODUCTUS.

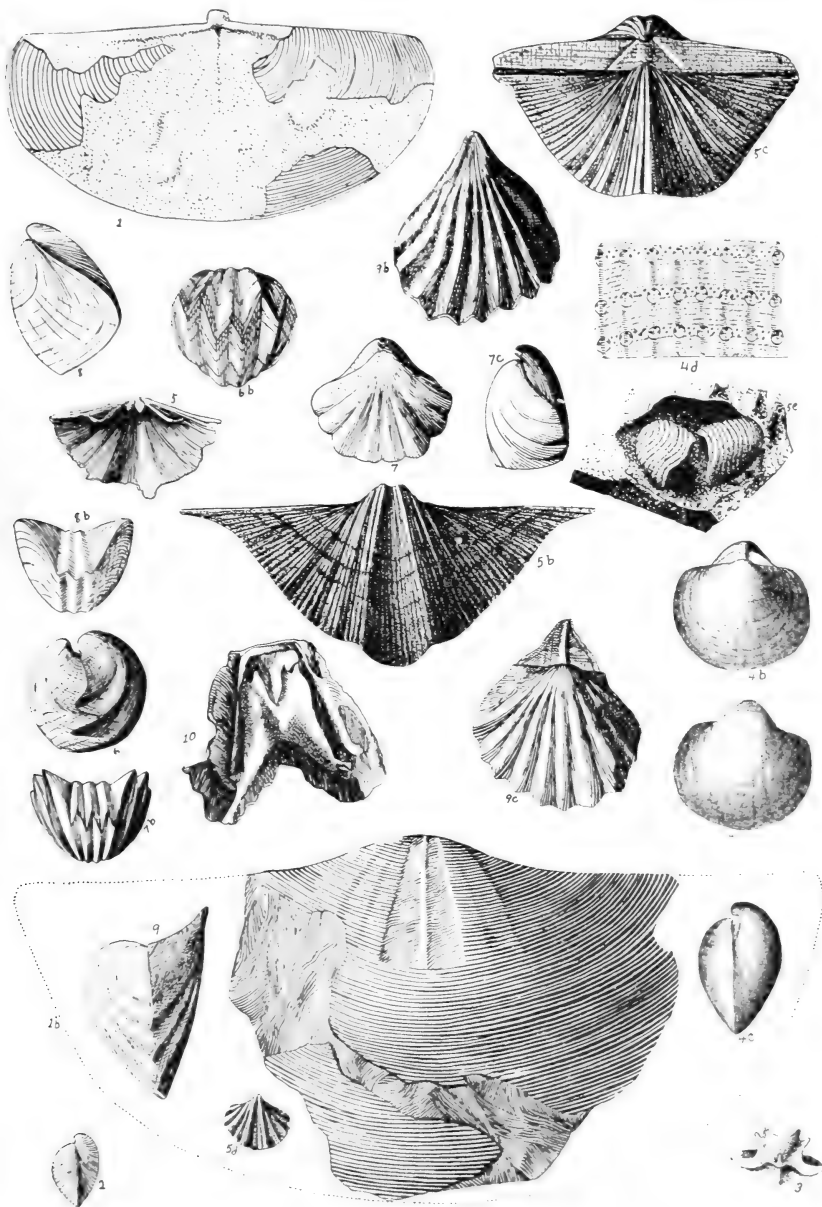




PRODUCTUS. 1 4.

CLEIOTHYRIS. 5.

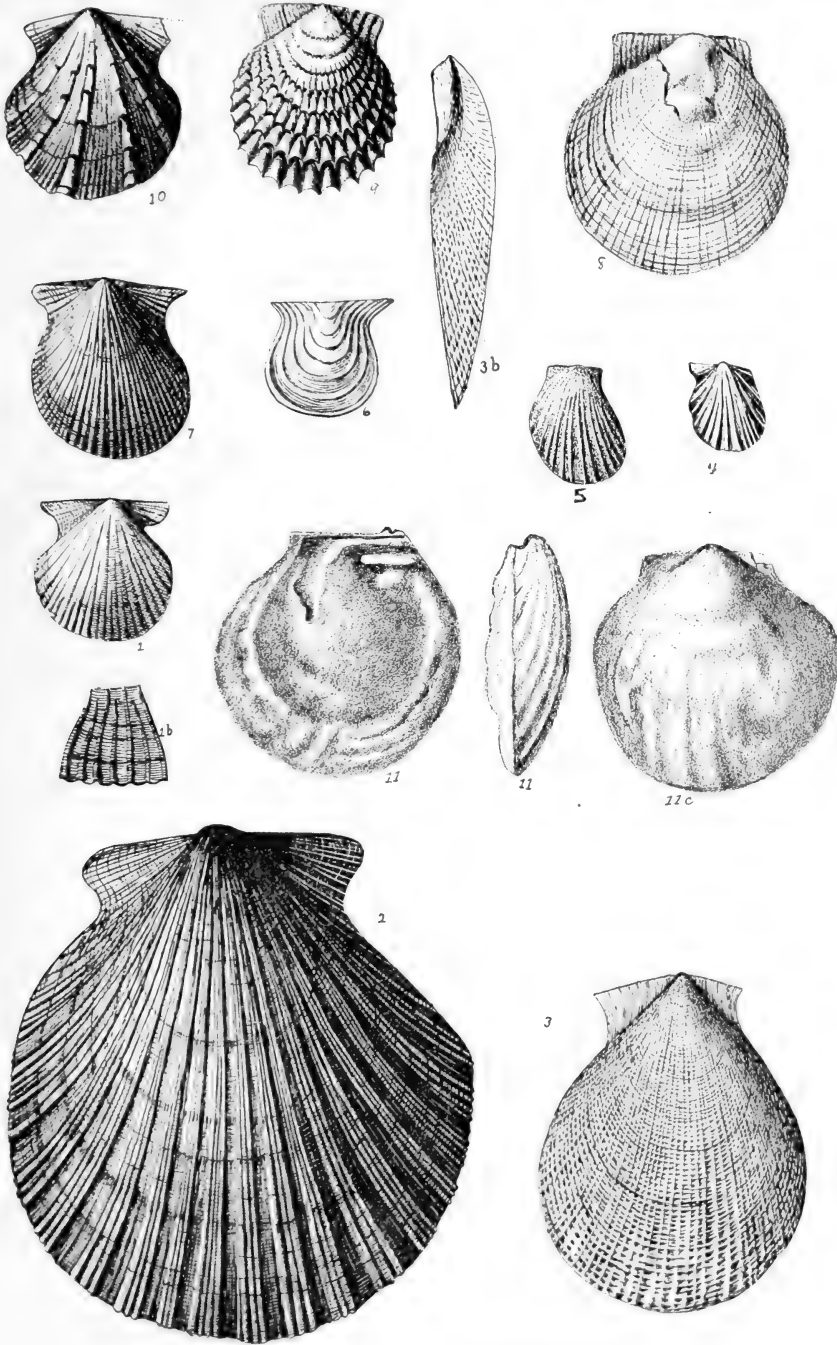
AULACORHYNCHUS. 6.



AULACORHYNCHUS, 1.
CLEIOTHYRIS, 2.
HUSTEDIA, 3.

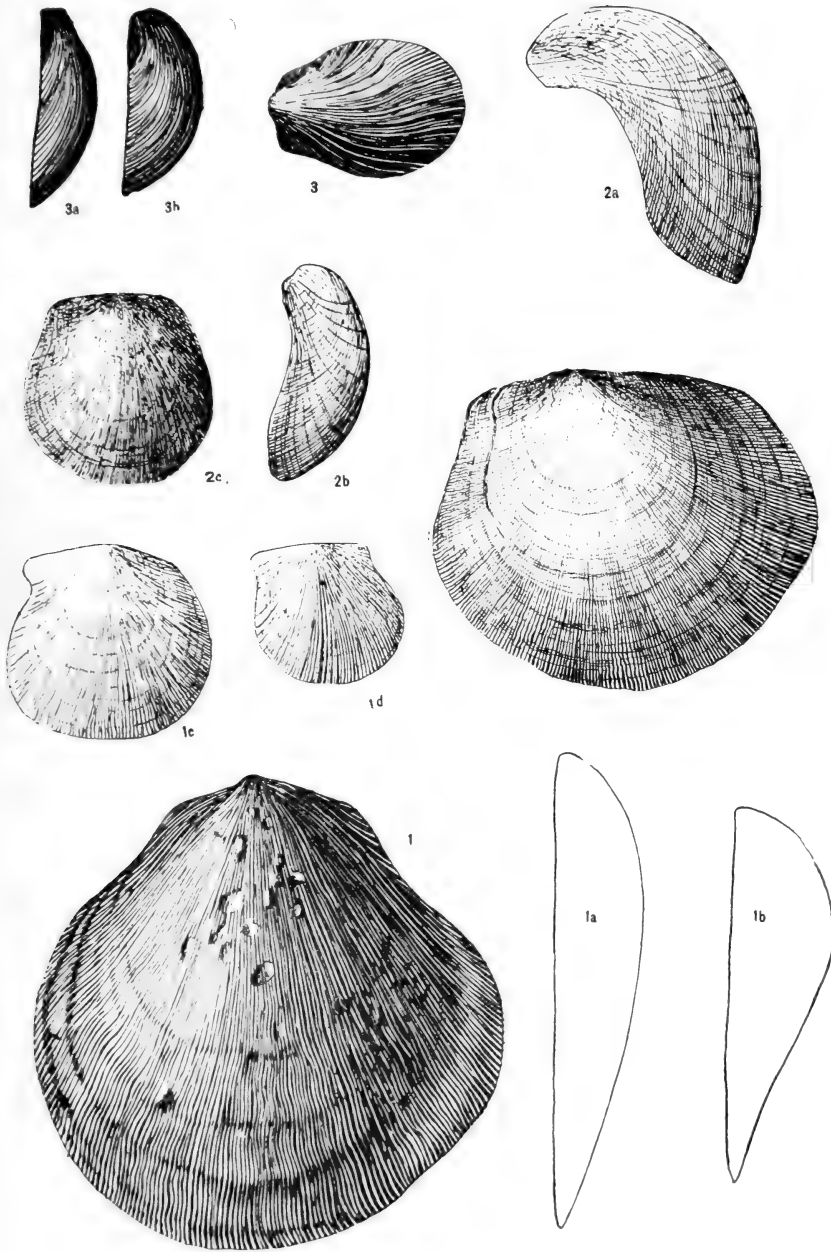
RETICULARIA, 4.
SPIRIFER, 5.
ENTELETES, 6.

PUGNAX, 7, 8.
MEEKELLA, 9.
DERBYA, 10.

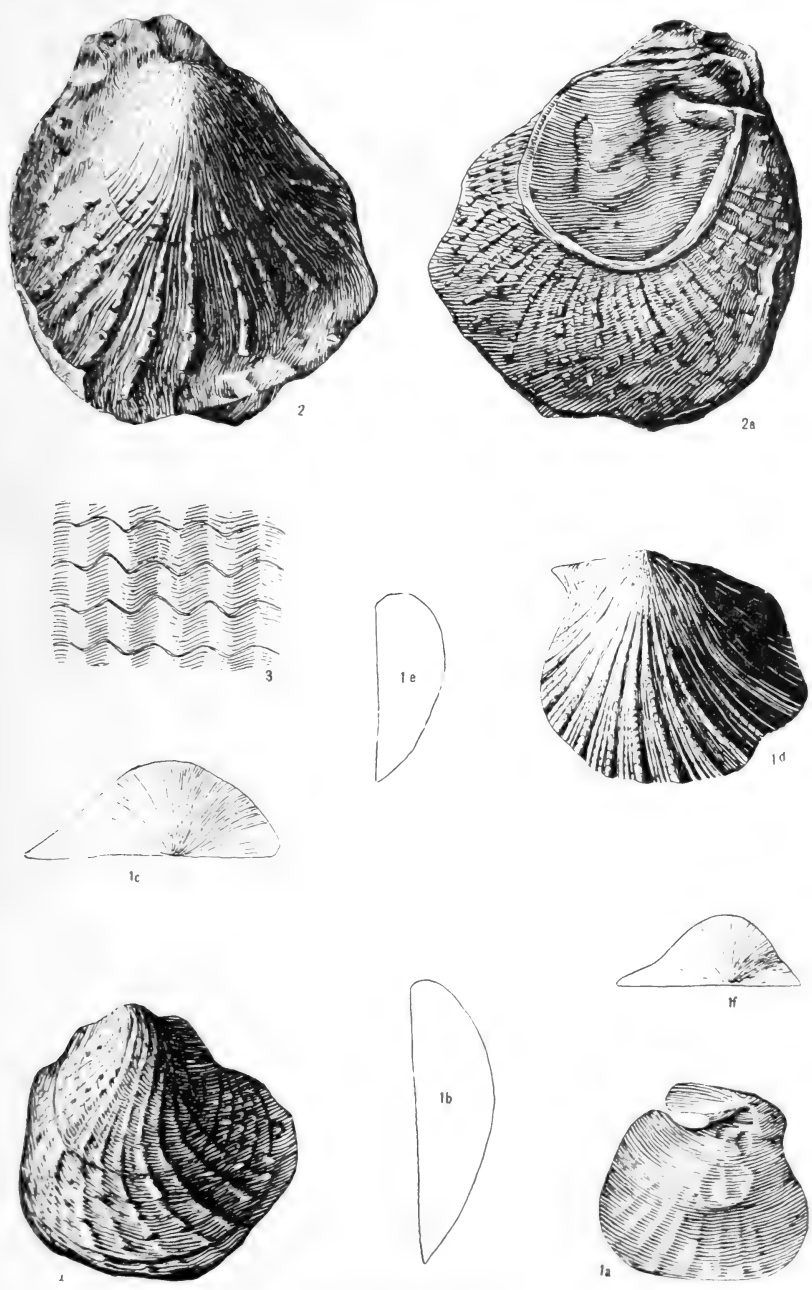


AVICULOPECTEN, 1-10.

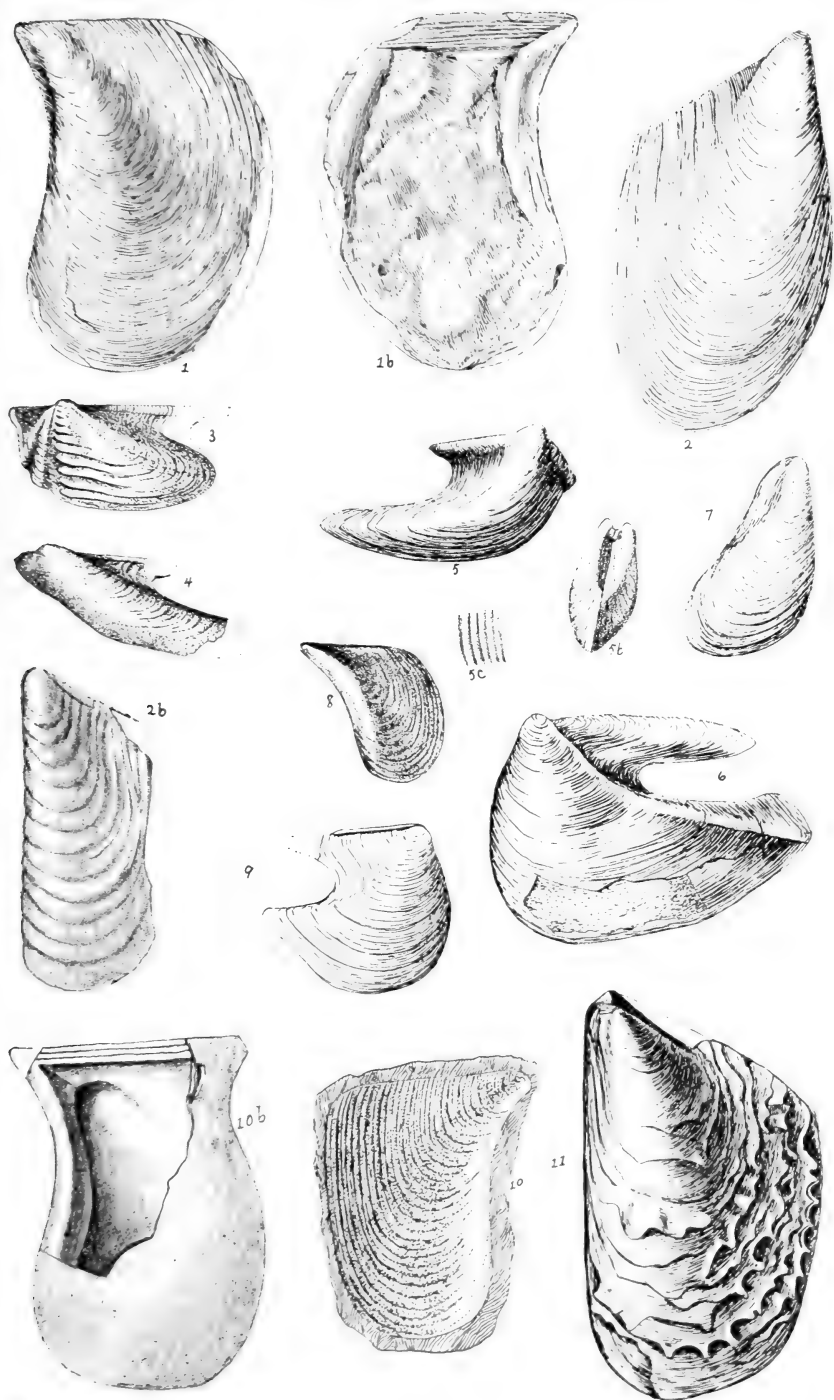
PSEUDOMONOTIS, 11.



PSEUDOMONOTIS.



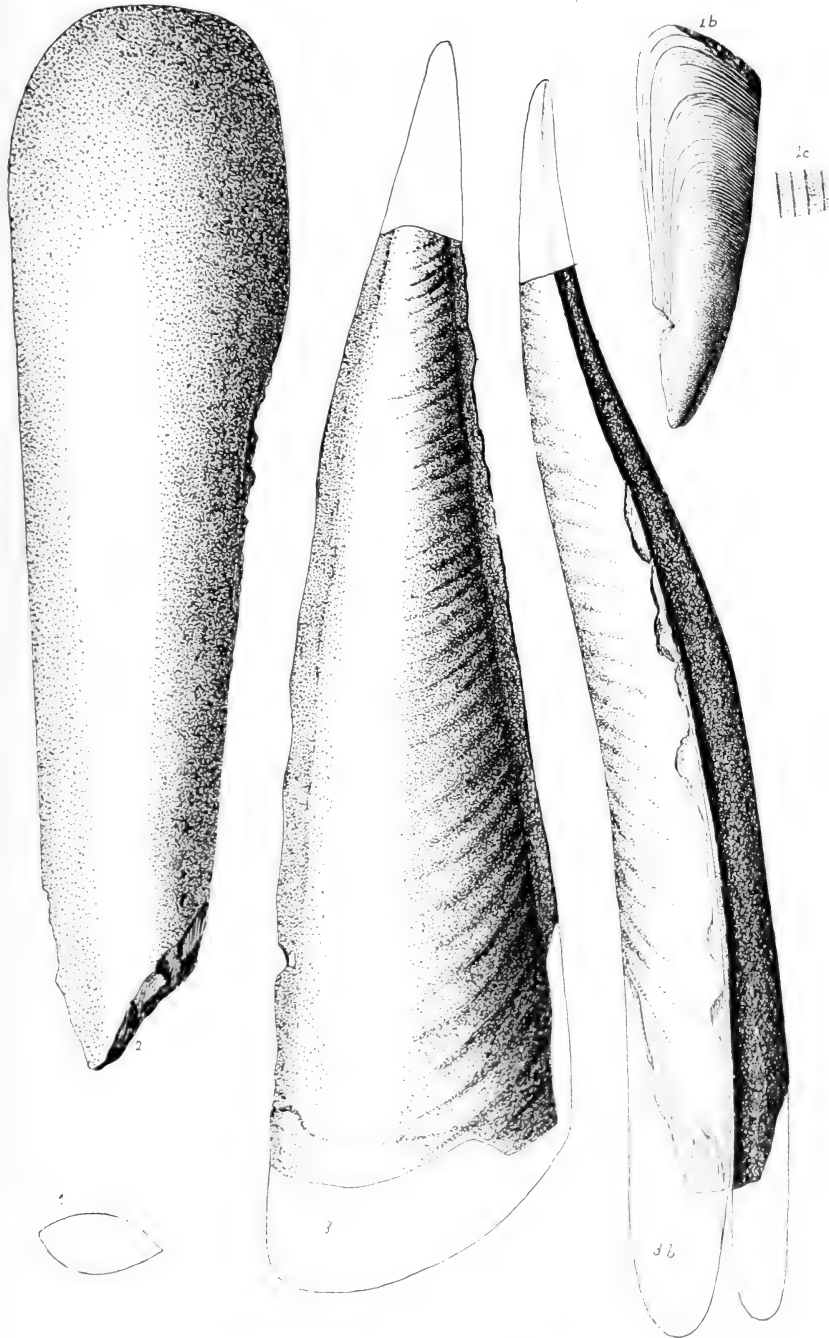
PSEUDOMONOTIS.



MYALINA, 1, 2, 7, 10, 11.

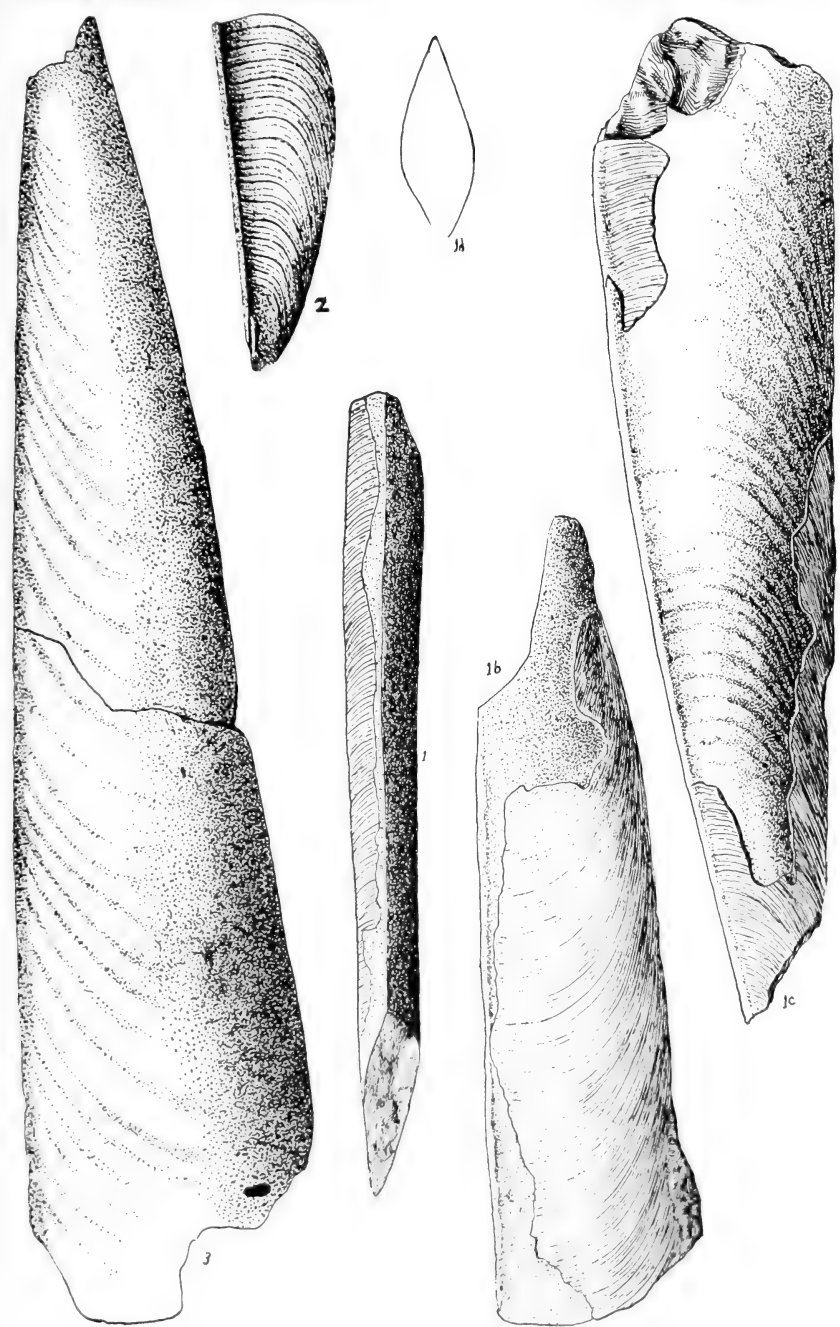
PTERIA, 3, 4.

LIMOPTERIA, 5, 6, 9.



AVICULOPINNA, 1.

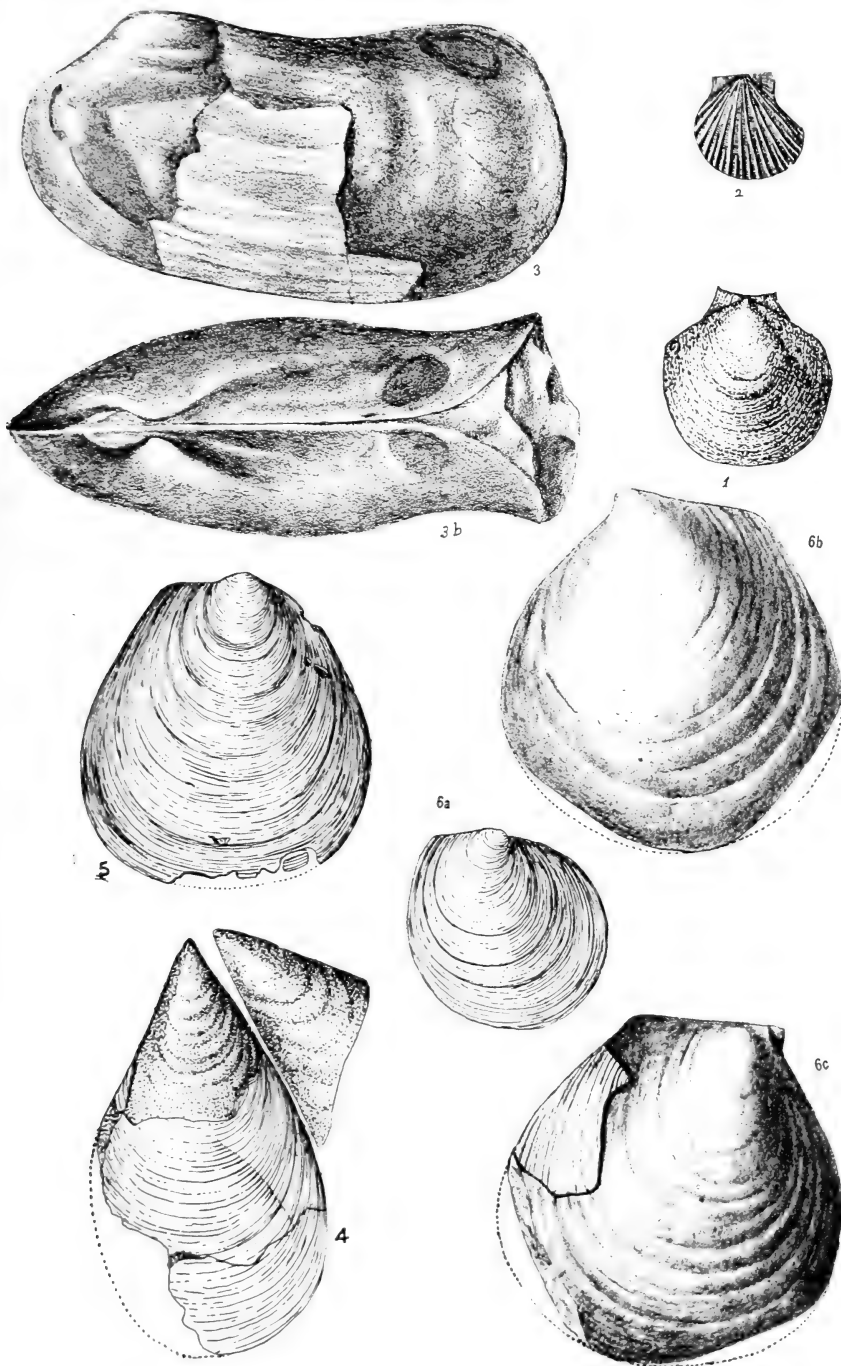
PINNA, 2, 3.



PINNA, 1, 3.

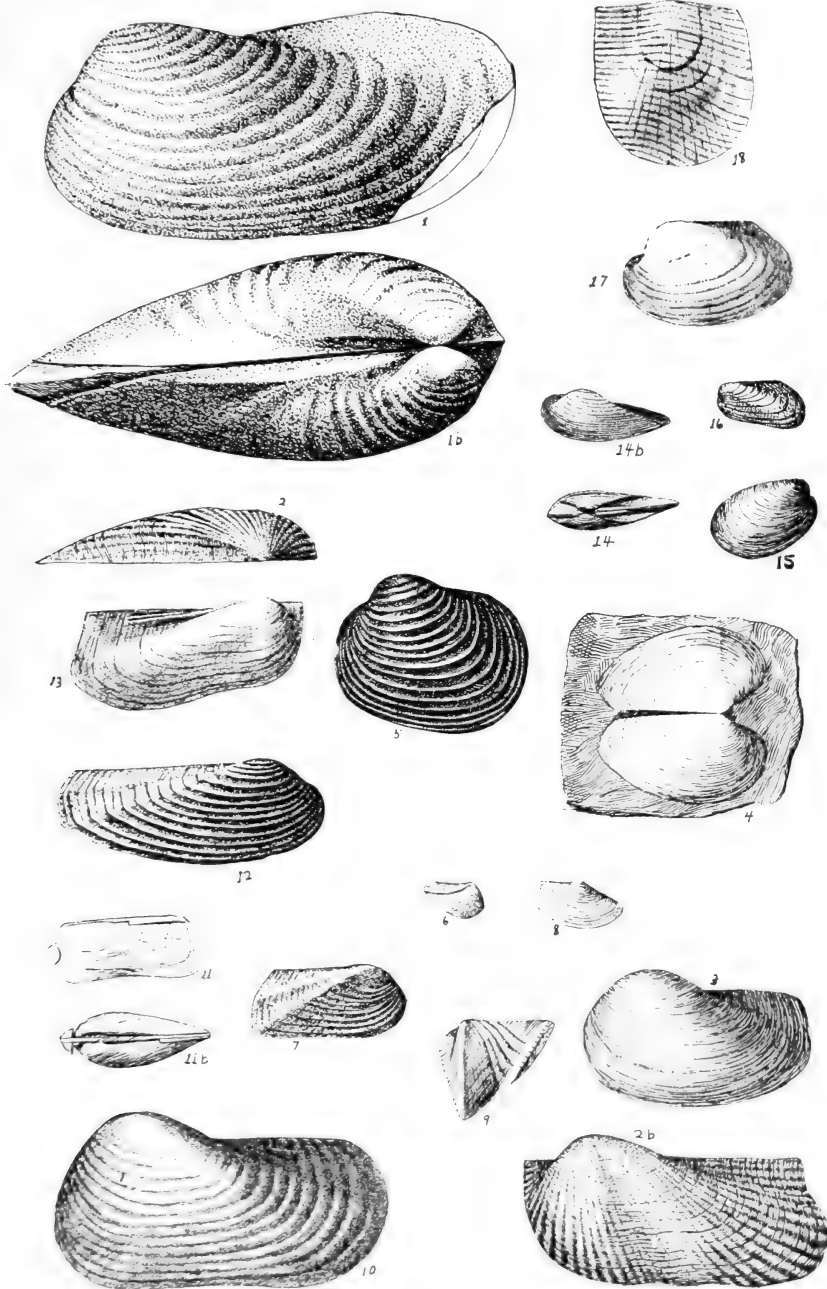
AVICULOPINNA, 2.





ENTOLIUM, 1. AVICULOPECTEN, 3. CHENOMYA, 3.
MYALINA, 4. POSIDONOMYA, 5, 6.



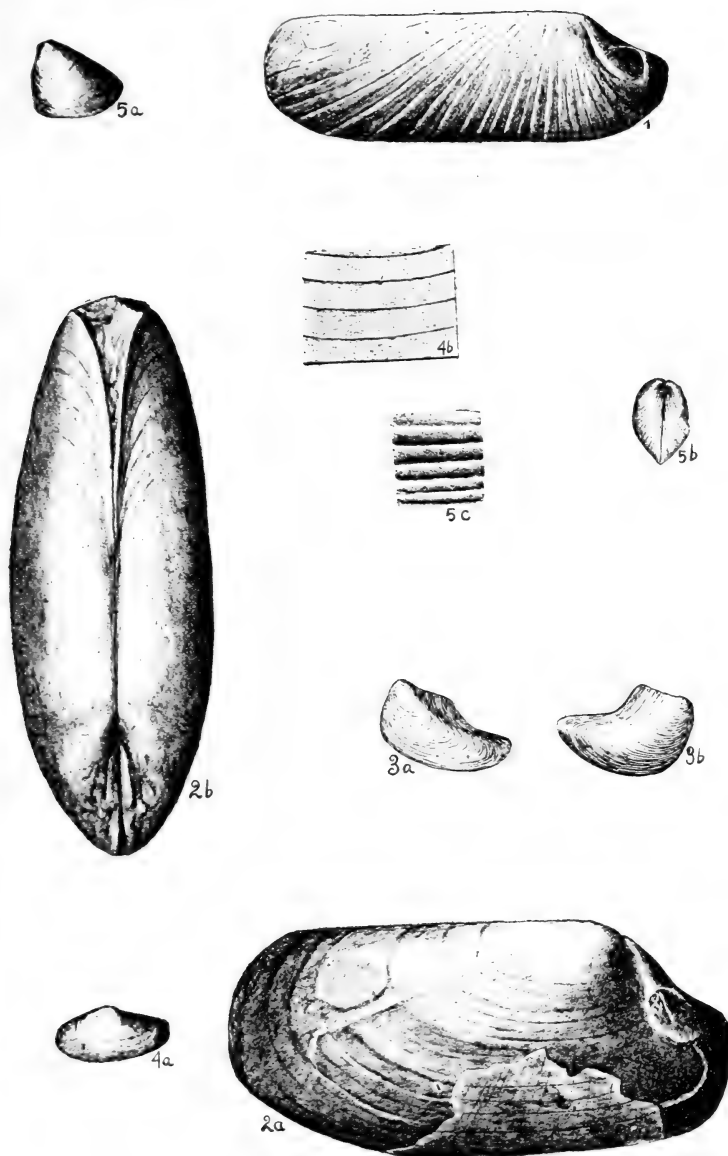


ALLORISMA, 1, 6, 10, 12.
MACRODON, 2, 13.
SEDGEWICKIA, 3.
YOLDIA, 4, 8.

EDMONDIA, 5.
PLEUROPHORUS, 7, 11.
CONOCARDIUM, 9.
NUCULANA, 14.

NUCULA, 15.
CYPRICARDINIA, 16.
CARDIOMORPHA, 17.
PLACUNOPSIS, 18.

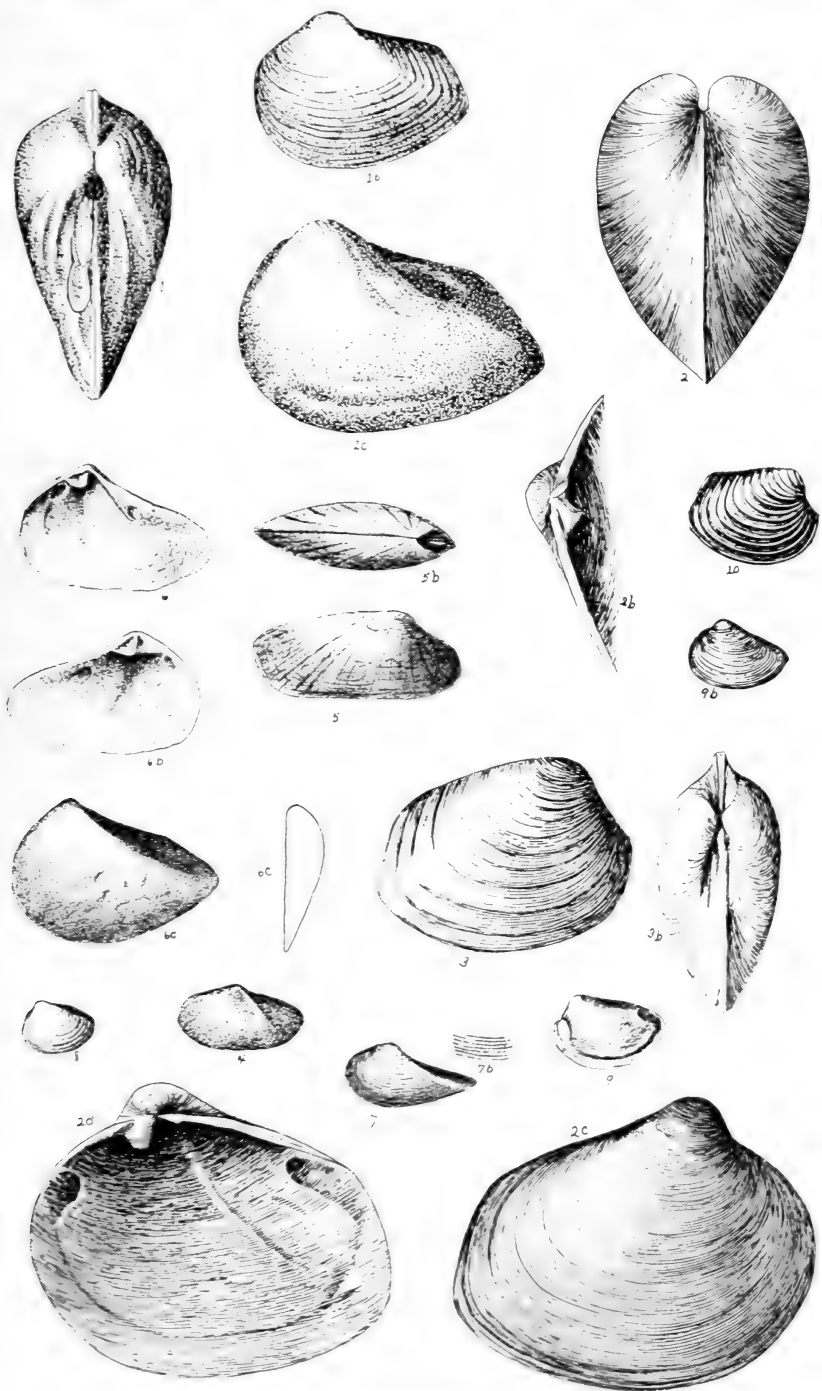




SOLENOMYA, 1, 2.

LIMOPTERIA, 3.
NUCULA, 5.

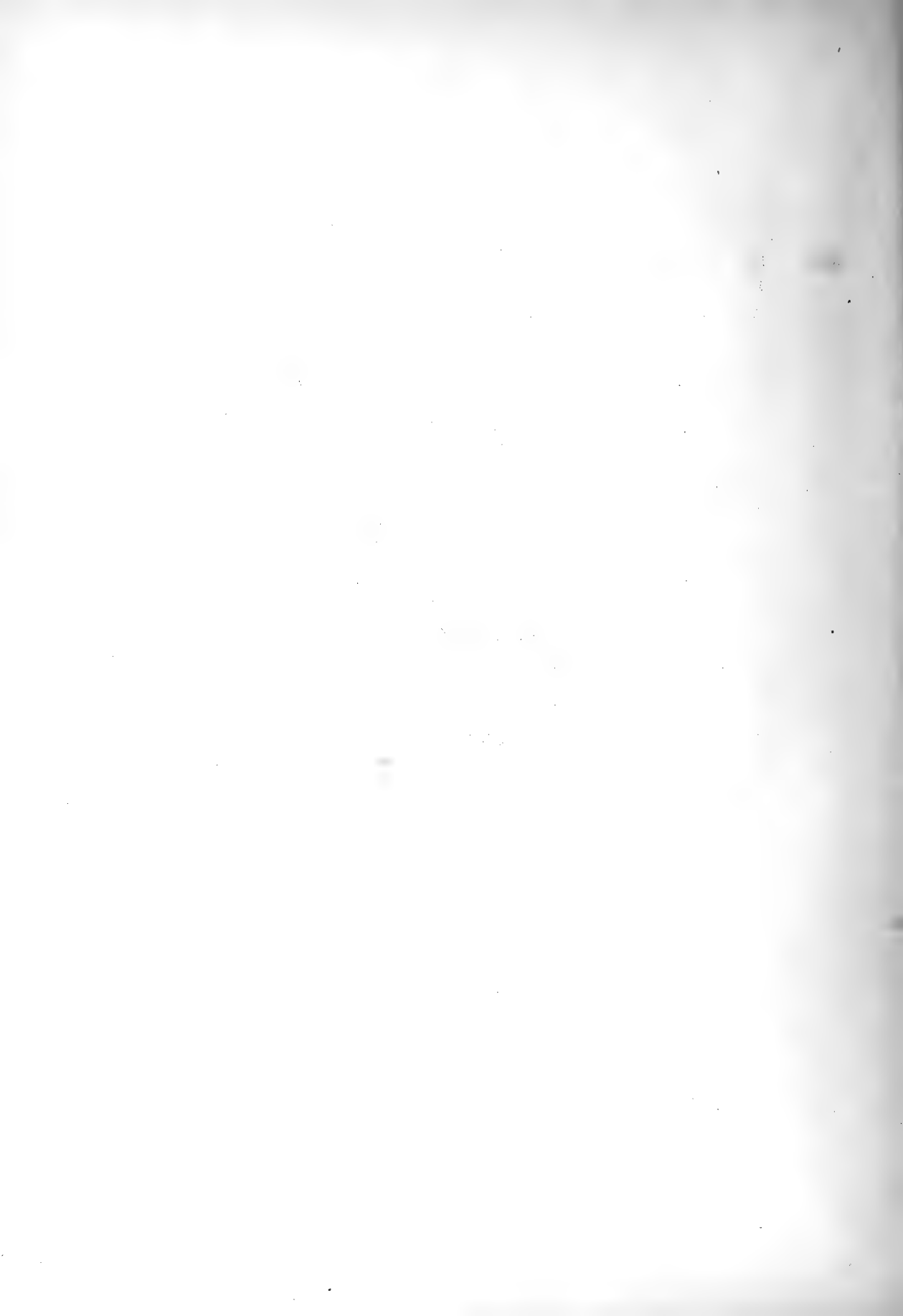
YOLDIA, 4.



SCHIZODUS, 1, 2, 6.
EDMONDIA, 3.

SOLENOMYA, 5.
NUCULANA, 7.

NUCULA, 8, 9.
ASTARTELLA, 10.





Hesperornis.

Pterodactyl.

Mosasaur.

Plesiosaurs.

KANSAS CRETACEOUS SEA.

S. PRATT, DEL.

PART II.

CRETACEOUS FISHES.

SELACHIANS AND PYCNODONTS,

By S. W. WILLISTON.

TELEOSTS,

By ALBAN STEWART.

Plates XXIII to LXXIII.

SELACHIANS AND PYCNODONTS.

By S. W. WILLISTON.

THE following notes and descriptions of selachian and pycnodont teeth are based upon the material that has accumulated in the University of Kansas Museum during the past ten or twelve years, supplemented by a collection kindly loaned for study by Mr. T. W. Stanton, of the National Museum. The material is by no means exhaustive, nor even sufficient to settle several doubtful points, but I trust that, incomplete as it may be, it will be of service in the determination of our numerous forms.

"The specific determination of the detached teeth of sharks and skates is little more than guesswork, and to decide upon their generic relationships with any approach to certainty is also often very difficult."¹ Nevertheless, because such detached teeth are so often found, and connected series so rarely, an attempt at their determination is desirable. Fortunately, in the present collection there are several forms represented by such complete specimens that the positive addition they afford to the knowledge of the species and genera is very welcome.

MYLIOBATIDÆ.

PTYCHODUS.

Teeth with the crown more or less elevated and overhanging, ornamented with transverse or radiating ridges, and surrounded by a larger or smaller, finely marked area. Surface of root smooth.

This genus of Upper Cretaceous selachians was for a long time placed among the cestracionts, but recent discoveries of the nearly complete dentition render it more probable that its

1. Woodward: Proc. Geol. Assoc., XIII, p. 190.

proper location is with the Myliobatidæ. The living members of the family, the sea-devils, are broad, flat fishes, allied to the rays, with a disk-like body. Many attain an enormous size, fifteen or twenty feet in length, and weigh a thousand pounds or more. In some the pectoral fins take on almost the character of limbs, and are said to be used in scooping up their food and transferring it to the mouth. The teeth are flat and pavement-like, and are used for crushing crabs and shell-fish. The fish are viviparous, and for the most part live in tropical or semitropical waters.

The teeth in *Ptychodus* are not less than 600 in number in each jaw, at least in some species. They are arranged in parallel rows, decreasing in size from within outward, except that in the supposedly upper jaws the median row is composed of small, low and smooth teeth, very much unlike the immediately adjacent ones. In *P. mortoni* there are eight rows on either side of this median row, or seventeen in all. The lateral teeth become more transversely elongated, the surface markings less conspicuous, and the form more unsymmetrical. About fifteen species of the genus have so far been discovered, all from the Upper Cretaceous. One or two species, including our most common one, have been discovered in both Europe and North America, and it is not improbable that the identity of yet others will be established when they are better known. The teeth vary so much in size and shape in the same individual that the identification from single specimens is often impossible or a matter of great uncertainty.

***Ptychodus mortoni*.** Plate XXV; plate XXVI, fig. 1; plate XXVII.

Ptychodus mortoni (Mantell) Morton, Journ. Acad. Nat. Sci. Phil., VIII, p. 215, pl. x, f. 7; Agassiz, Poiss. Foss., III, p. 158, pl. xxv, ff. 1-3; Leidy, Proc. Acad. Nat. Sci. Phil., (1868), p. 205; Ext. Vert. Fauna, p. 295, pl. xviii, ff. 1-14; Cope, Cret. Vert., p. 294; Woodward, Quart. Journ. Geol. Soc., XLIII, p. 130; Cat. Foss. Fishes Brit. Mus., I, p. 159; Proc. Geol. Assoc., XIII, p. 191, pl. v, f. 4; Williston, Kans. Univ. Quart., IX, p. 30, pl. VII, VIII, f. 1, pl. IX—Alabama, Mississippi, Niobrara of Kansas, English Chalk.

This species is the most common one of this genus in the Kansas Cretaceous, occurring only in the Niobrara beds, so far as I am aware, and, for the most part at least, in the lower part

of the beds. I have before me at the present time two excellent series of teeth of this species; one, including about eighty teeth, obtained from the estate of the late Joseph Savage; the other collected in the vicinity of Castle Rock, in Trego county, by Prof. G. E. Rose—an exceedingly interesting specimen, because most of the teeth are in place in the matrix. A number of the teeth of the Savage specimen have been arranged serially and photographed in plate XXV. Of course the arrangement is not the natural one, but the plate will show in an excellent way many of the characters of the teeth better than they can be described. In plates XXVI and XXVII are given three views of portions of the Rose specimen; that of plate XXVI (fig. 1) shows a little more than one-half of the upper view. One end (the left of the figure) has been folded underneath obliquely. This folded end is shown in plate XXVIII, fig. 1. Figure 2 of the same plate gives a view of a transverse series, as arranged from the loose teeth taken from the right end of the specimen—the one that protruded from the chalk when discovered. About 550 teeth, all told, have been obtained, and doubtless not a few had been lost before the specimen was discovered. The set is referred to the upper jaw, on the supposition of Woodward that the small median teeth belong in this jaw.

Not a trace of osseous substance is preserved in the specimen. The cartilage of the sharks' jaws is often preserved in a soft, calcified condition, but it is evident that the material in which the teeth of *Ptychodus* were lodged was of a more perishable nature, accounting doubtless for the fact that *Ptychodus* teeth are so rarely found associated.

The teeth of this species differ markedly from those of all other known species, in having the center of the crown raised into a conical apex, the summit of which is crossed by a short transverse ridge from which other diverging ridges run. In the smaller lateral teeth these ridges become less well marked and occupy a relatively smaller space, becoming almost obsolete in the fifth row. The marginal area is formed of fine reticulations in many of the larger teeth, though in most of these and in all the smaller teeth the markings are more like a fine punc-

tulation, clearly visible only with the aid of a lens, giving a uniform, finely roughened appearance. The median upper row is composed of low, flattened teeth, transversely oval or subquadrate in shape, with a slight elevation in the middle, and finely roughened throughout the whole coronal surface, there being only the slightest trace of the divergent ridges on the summit of the elevation. This does not quite agree with Woodward's description of these teeth, in which he states that they are "not marked with the radiating ridges, but exhibit a minute smooth eminence in the middle of the crown." Possibly this effect is due to wear.

Ptychodus polygyrus. Plate XXIX, fig. 9; plate XXX, fig. 14.

Ptychodus polygyrus (Buckland) Agassiz, Poiss. Foss., III, p. 156, pl. xxv, ff. 4-11, pl. xxv-B, ff. 21-23; Gibbes, Journ. Acad. Nat. Sci. Phil., I, p. 299, pl. II, ff. 5, 6; Leidy, Proc. Acad. Nat. Sci. Phil. 1868, p. 208; Cope, Cret. Vert., p. 294; Woodward, Cat. Foss. Fishes Brit. Mus., I, p. 143, pl. v, f. 7—Senonian, Turonian of Europe, Rotten Limestone of Alabama, Niobrara of Kansas; Williston, cf. cit. 31.

? *Ptychodus latissimus* Agassiz, l. c., fig. 8; Dixon, Foss. Sussex, pl. xxx, ff. 1, 2.

A single tooth of very large size from the lower beds of the Niobrara Cretaceous of the Smoky Hill river is referred to this species provisionally. Until numerous specimens are examined there can be no certainty of its correct location, though the resemblances are sufficiently great to render the determination not improbable; at least with some of its varieties.

Ptychodus martini. Plate XXVIII.

Ptychodus martini Williston, cf. cit. 32.

A large series of teeth, 110 in number, found together in the Niobrara chalk of the Smoky Hill river, and collected by Mr. H. T. Martin, cannot be identified with any described species. I have photographed them, arranged as symmetrically as possible, but with no assurance that the arrangement is a natural one. In fact, it is not improbable that the teeth belong to both upper and lower jaws. The teeth apparently from the lower median row are much elongate transversely, with a very flat crown, wherein they differ from the teeth of other known species. The ridges are nine or ten in number, and reach nearly to the lateral

margin. In some of the teeth several of the ridges form loops near the extremities. The marginal area of granulations is small, and presents scarcely any distinct vermiculations. The teeth of the lateral rows are less elongated than those of the middle one, though still more so than is usual. The granulations become rather more extensive in area proportionally in the small teeth, as is the case with other species. A series (left vertical row of the plate) that may belong in the medio-lateral rows of the upper jaws are more nearly square in shape, and the crown has a distinct, though low, convexity extending over nearly its whole area. Antero-posteriorly the surface is nearly flat, with a moderate convexity of the margin. The surface posterior to the large grooves on the upper part shows small, radiating and branched ridges.

The largest teeth measure 45 by 20 mm.; the ones more nearly square, 35 by 25 mm.

Ptychodus anonymus. Plate XXIX, figs. 5-8, 16-18, 20-22, 24.

Ptychodus anonymus Williston, cf. cit. 32.

Seven teeth of nearly uniform size, four of them united in the matrix, from Walnut creek, Kansas, seem to belong to a species distinct from any previously described (figs. 16-18). They are of about the same size as those described as *P. whippleyi* and *P. occidentalis*, but will be distinguished from the former by the more broadly conical crowns. In the teeth of this size of *P. whippleyi* the crown is much compressed, standing up, tooth-like; in the present specimens they are nearly straight or gently concave from the apex to the rims. From *P. occidentalis* the species will be distinguished by the very distinctly reticulate marginal areas, the transverse ridges not reaching to the rims of the crown. Other specimens agreeing in these characters are from the Niobrara. The horizon is probably Benton.

Ptychodus occidentalis. Plate XXIX, fig. 4; plate XXX, fig. 13.

Ptychodus occidentalis Leidy, Proc. Acad. Nat. Sci. Phil. 1868, p. 207; Ext. Vert. Fauna West. Terr., p. 308, pl. xvii, ff. 7, 8, pl. xviii, ff. 15-18; Cope, Cret. Vert., p. 244; Williston, cf. cit. 33—Niobrara, Benton of Kansas.

Two teeth, one from the same conglomerate that yielded the teeth referred to *P. janewayii*, the other, without locality, from Mr. Joseph Savage's collection, I refer to this species. The species differs from the following in having the transverse ridges continued to the lateral rims, and not separated by an area of fine reticulation. The anterior surface has finer, elongated, nearly straight ridges and grooves in this species, while in the others the markings are reticulate or vermiculate.

Ptychodus janewayii. Plate XXX, figs. 9, 10, 11.

Sporetodus janewayii Cope, Hayden's Bull. U. S. Geol. Surv. No. 2, (1874), pl. XLVII.

Ptychodus janewayii Cope, Cret. Vert., p. 244; Williston, cf. cit. 33.

"Surface irregularly convex, covered with a dense layer, which does not exhibit pores, and is thrown into transverse or oblique ridges. Surface with four folds, which traverse it obliquely from border to border. At the base of the outer, at one end, is a series of adherent tubercles; at the basis of that, at the opposite end, is a broken fold, with tubercles at its outer base. Length, 0.0045 m.; width, 0.0025 m. A portion of a larger and more central tooth has the surface with an unsymmetrical convexity, and is crossed transversely by five folds, from border to border."²

Three small teeth, shown enlarged in plate XXX, ff. 9-11, from the conglomerate containing specimens of *Corax curvatus*, appear to belong to this species. The horizon of the conglomerate is near the line of contact between the Dakota and Benton, in Ellsworth county. Cope's type was from a bed of conglomerate containing *Lamna* and *Isurus* teeth of small size near Stockton. It is probable that the horizon is the same in both.

2. Cope, l. c.

Ptychodus whippleyi. Plate XXIX, figs. 10-15.

Ptychodus whippleyi Marcou, Geol. North Amer., p. 33, pl. ix, f. 4: Leidy, Ext. Vert. Fauna, p. 300, pl. xviii, ff. 19, 20: J. S. Newberry, Rep. Expl. Exp., p. 147, pl. iii, f. 2: Cope, Cret. Vert., p. 294: Williston, cf. cit. 34—Cretaceous, Texas (Marcou, Leidy): Kansas, Arkansas Valley (Cope): Colorado, New Mexico.

Thirteen teeth from Dallas, Tex., and a number of others received from Mr. Frank Springer, collected in the vicinity of Las Vegas, in New Mexico, agree with the descriptions and figures of this species, as given by Leidy. The same species has been referred to the Niobrara chalk of the Arkansas valley by Cope. If his determination and locality are correct the species must be referred to the Benton of Kansas, since the Niobrara does not occur in the Arkansas valley. A single specimen from the Benton of Kansas in the museum, without definite locality, seems to agree pretty well with the Texas specimens, but the specimen is an uncharacteristic one and may pertain to some other species.

Some of the teeth referred to this species show a marked resemblance to those figured by Woodward³ (*P. rugosus*), and by Dixon (*P. altior* Dix.)

The European species is described as having the sides of the median elevation of the crown smooth, which is not the case with the present species, the grooves continuing midway into the lateral granulations.

Ptychodus, sp. Plate XXIX, figs. 2, 3: plate XXXI, fig. 53.

Ptychodus, sp., Williston, cf. cit. 34.

Four teeth of moderately large size, from the Benton Cretaceous, of Salt creek, Russell county, and two others of smaller size, also from the Benton, seem to belong to a species distinct from any hitherto known. The larger ones will be distinguished from those referred to the upper series of *P. martini*, which are of nearly the same size and shape, by the smaller area of transverse ridges, and the much larger area of marginal reticulations, which are coarser. The teeth are more nearly square and the convexity of the crown is greater. The two teeth of smaller

3. Cat. Foss. Fishes Brit. Mus., I, pl. V, fig. 2.

size probably belong with the others. It is possible that some of these teeth may belong with *P. polygyrus*.

The other described species of this genus are the following:

Ptychodus mammilaris Agassiz.—Senonian, Turonian, and Cenomanian, Europe.

Ptychodus rugosus Dixon.—Senonian, England.

Ptychodus decurrens Agassiz.—Senonian, Turonian, and Cenomanian, Europe.

Ptychodus multistriatus Woodward.—Senonian and Turonian, England.

Ptychodus latissimus Agassiz.—Turonian and Senonian, Europe.

Ptychodus papillosus Cope, Cret. Vert. 294.—Upper Cretaceous, Colorado.

Ptychodus triangularis Reuss.—Upper Cretaceous, Bohemia.

Ptychodus levis Woodward.—Lower Chalk of England.

SCYLLIIDÆ.

The family Scylliidæ comprises small sharks with sharp-pointed cuspidate teeth, arranged in numerous series. The following genera are given by Woodward:⁴ *Paleoscyllium* Wagner, Lower Kimmeridgian of Bavaria; *Scylliorhinus* Blainv., Turonian and Senonian; *Pristiurus* Bonaparte, Lower Kimmeridgian of Bavaria; *Mesiteia* Kramb., Senonian and Middle Eocene; *Chiloscyllium* Müller and Henle, Molasse; *Crossorhinus* Müller and Henle, Gault; *Cantioscyllium* Woodw., Turonian; *Ginglymostoma* Müller and Henle, Danaian, Eocene.

Numerous teeth from the Lower Cretaceous of Kansas seem in all probability to belong in this family, and agree pretty well, though rather large, with the teeth of *Scylliorhinus*, to which I refer them provisionally.

Scylliorhinus rugosus. Plate XXIV, fig. 5.

Scyllium rugosum Williston, Kans. Univ. Quart., ix, p. 35.

Central cusp broad, pointed, nearly symmetrical, the cutting edges nearly straight, one of them a little longer than the other and slightly convex near the tip; a single pair of lateral denticles, which are nearly equilaterally triangular in shape; principal cusp with six or seven strong ridges on the basal two-fifths; denticles with four or five similar ridges reaching two-thirds of

4. Cat. Foss. Fishes Brit. Mus., I, p. 338.

the way to the apex; root narrow, apparently not at all produced at the angles; thinned and not at all tumid.

Type No. 1949, U. S. National Museum, Greenleaf sandstone at Greenleaf ranch.

Height of middle cusp	7 mm.
Width of same at base	4 "
Height of denticles	3 "
Width of same	2½ "

Scylliorhinus planidens. Plate XXIV, fig. 7.

Scyllium planidens Williston, Kans. Univ. Quart., ix, p. 35.

Central cusp broad, pointed, convex from side to side, with sharp, non-crenulate edges; lateral cusps sharply pointed, smooth, two in number; root thin, narrow, moderately produced below the posterior denticle, smooth.

Height of median cusp	4 mm.
Width of same at base	3 "
Width of base of tooth	6 "
Height of denticles	1½ "

Type No. 1949, U. S. National Museum. From same horizon as the preceding species.

I refer provisionally to this species numerous other specimens from the same horizon and collection. They differ in the relative size of the denticles, the more posterior direction of the main cusp, and the size. One tooth seems to lack the anterior denticle, which is always the smaller of the two; its absence may be due to injury.

Scylliorhinus (Lamna?) gracilis. Plate XXIV, fig. 6.

Scyllium (Lamna?) gracilis Williston, Kans. Univ. Quart., ix, p. 35.

Main cusp elongate, slender; inner surface smooth, gently convex longitudinally, more so transversely, with sharp, smooth edges; the interior edge nearly straight, the posterior somewhat concave; denticles of nearly equal size, small, slender, acute; base narrow, prolonged into a slender root at each extremity.

Height of tooth	9 mm.
Length of middle cusp	6 "
Width of same at base	3 "
Length of denticles	2 "

One specimen, No. 1949, U. S. National Museum, with the preceding species.

LAMNIDÆ.

The Lamnidæ comprise the largest and most voracious of the sharks, represented by a number of species in the oceans of the present time. They are elongated fishes, the dorsal fin without spine; there is no nictitating membrane to the eye, and the gill openings are wide. The teeth are solid in the adult, and are 300 or more in number. The teeth are found very commonly in the Cretaceous deposits of Kansas, as elsewhere, usually scattered singly, though occasionally found more or less connected by the calcified cartilage of the jaws in several rows. Owing to the great variation of size and shape of the teeth in the same individual, it is often difficult or impossible to correctly determine the forms. Doctor Eastman has recently figured and described the nearly complete dentition of *Isurus mantelli*, the most common species of the family in Kansas. Doubtless similar variations will be found in the different species of the other genera of this family.

ISURUS.

This genus differs from *Lamna* only in the prevailing absence of the lateral denticles of the teeth. The teeth are large. The genus occurs from Jurassic to the present time.

Isurus mantelli. Plate XXXI, figs. 41-46; plate XXXII, figs. 2-2m.

Oxyrhina mantelli (Geinitz) Agassiz, Poiss. Foss., III, p. 282, pl. xxxiii, ff. 1-5, 7-9; Eastman, Paleontographica, xli, pp. 149-192, pl. xvi-xviii (where additional extensive synonymy will be found); Woodward, Proc. Geol. Assoc., xiii, p. 196—Cenomanian, Senonian and Turonian of Europe; Kansas, Texas, New Jersey, Alabama, Colorado, etc.

Oxyrhina extenta Leidy, Ext. Vert. Fauna, p. 302, pl. xviii, ff. 21-25.

“Moderate-sized, stout, three-cornered teeth; the crown on the outer side nearly flat, with one or more vertical wrinkles; on the inner side, lightly convex and smooth; root long, thick, low, moderately deeply furcate, usually obtuse at the ends, and on both sides more or less flattened.”⁵

This species is very common in the Kansas Niobrara, in fact,

5. Eastman, l. c.

the most common of all, and not infrequently it is represented by many associated teeth. From the plates, and from Eastman's figures, it will be readily identified in all its forms.

LAMNA.

Teeth, except some of the hindmost ones, with a narrow, compressed, conical cusp, with one or two pairs of small, pointed denticles.

Some of the following species may belong to *Odontaspis*, which can hardly be distinguished by the teeth alone, differing only in the relatively less high and less subulated character of the anterior ones, and in the usually larger size of the lateral denticles.

Lamna appendiculata. Plate XXVI, figs. 3-3c; plate XXXI, figs. 47-49.

Otodus appendiculatus (Roemer) Agassiz, Poiss. Foss., III, p. 279, pl. XXXII, ff. 1-25; Davis, Trans. Roy. Dubl. Soc., IV, p. 402, pl. XLI, ff. 1-11.

Lamna appendiculata Woodward, Cat. Foss. Fishes Brit. Mus., I, p. 393; Proc. Geol. Assoc. XIII, p. 196; Williston, cf. cit. 37—Senonian, Cenomanian, Turonian (?), Danian of Europe, Niobrara of Kansas, and Greensand of New Jersey.

"Teeth robust, with a thick root, having a much flattened postero-inferior face, the nutritive foramen not in a groove. Outer face slightly convex or flat, often with a few indefinite vertical folds on the basal half; inner side of crown markedly convex, smooth; cutting edges prominent; a single pair of lateral denticles, broad, but pointed. Anterior teeth narrow and upright; lateral teeth much inclined backward, the anterior teeth much more arcuate and longer than the posterior ones."⁶

Several teeth from the Niobrara chalk agree sufficiently well with the foregoing description, and especially with Woodward's figures, to permit their allocation here. They are somewhat broader than the specimens figured by Woodward. Two of the specimens differ markedly from the others in having the base flatter and the roots much less prolonged downward, the notch of the base shallower and shorter. Another tooth from the base of the Benton, in the conglomerate containing the specimens of *Corax curvatus* and *Ptychodus janewayii*, agrees well

6. Woodward, l. c.

with these last specimens and apparently belongs to the same species, if distinct. Their resemblance to *Odontaspis kopingensis* Davis likewise cannot be denied, but the lateral denticles are more triangular in shape.

Lamna sulcata. Plate XXIV, figs. 1-1b.

Otodus sulcatus Geinitz, Char. Schicht. u. Petrifact, saechs-boehm Kreideb. 5, pl. iv, f. 2.

Otodus divaricatus Leidy, Ext. Vert. Fauna, p. 305, vol. xviii, ff. 26-28; Cope, Cret. Vert., p. 295.

Lamna sulcata Woodward, Cat. Foss. Fishes Brit. Mus., I, p. 398 (where additional synonymy will be found); Proc. Geol. Assoc., xiii, p. 197; Williston, cf. cit. 37—Cenomanian and Turonian, England, France, Belgium, Saxony, Bohemia; Senonian, England; Cretaceous, Texas, (Leidy); Jewell county, Kansas, (Cope); Mississippi (Cope).

“Teeth very robust, the crown sometimes attaining a height of nearly 50 mm. Outer face of crown slightly convex, generally uneven; both the inner and the outer faces with more or less prominent series of vertical wrinkles near the base, usually irregular. A single pair of large, acuminate lateral denticles, slightly divergent, often incompletely separated from the principal cone. Root with a considerable inward prominence immediately below the base of the crown.”⁷

“A name given to very large, robust teeth with vertically wrinkled crown and slightly divergent acuminate lateral denticles. There are specimens in the British Museum from undetermined horizons in the chalk of Kent, Surrey, and Sussex.”⁸

This species is unknown to me. Its occurrence in Kansas is given on the authority of Cope. The horizon is evidently the Benton.

Lamna mudgei.

Lamna mudgei Cope, Cret. Vert., p. 207, pl. xii, ff. 11, 12; Williston, cf. cit. 38—Niobrara of Kansas, Greensand of New Jersey.

“Indicated by three teeth from the Niobrara epoch of Kansas and one from the Greensand No. 4, from New Jersey. These teeth are rather stout, especially at the base, and the crown is not very elongate. The root is excessively protuber-

7. Woodward, l. c.

8. Woodward.

ant, projecting horizontally beyond the convex side, and flat or truncate below the protuberance. The enamel is entirely smooth. Length, 14 mm."

This species is unknown to me, or unrecognizable from the description and figures of the mutilated type specimens.

Lamna macrorhiza.

Lamna macrorhiza Cope, Cret. Vert., p. 297, pl. XLII, ff. 9, 10; Woodward, Cat. Foss. Fishes, Brit. Mus., I, p. 399; Williston, cf. cit. 38—Niobrara of Kansas; Albian, of England; Cenonian, of S. E. Russia (Woodward).

"Teeth of small size, elevated though robust, the maximum total height being about 25 mm. Outer coronal face flat, or nearly so, with a faint median longitudinal elevation, and often a few folds at the base; inner coronal face very convex, smooth; cutting edges sharp; a single pair of relatively large, narrow, acuminate lateral denticles, divergent, also often marked at the base by minute vertical folds; root with a prominent inward projection below the base of the crown; nutritive foramen in a groove."

The above description by Woodward is drawn from a European specimen, while the type described and figured by Cope is from Ellis county, Kansas, probably Niobrara. I do not know the species.

***Lamna* (*Odontaspis*?)**, sp. Plate XXX, fig. 5.

Lamna (*Odontaspis*?), sp., Williston, cf. cit. 38.

A single tooth from the Lower Cretaceous (Kiowa shales, Clark county), resembles the figure of *Odontaspis kopingensis* Davis, as figured by that author⁹ except that it is smaller and has the base rather more prominent, more triangular, and more pointed. The tooth has also resemblance to *Lamna appendiculata*, but the denticles are stouter (compare Woodward.)¹⁰ Height of crown, 15 mm.; width of base, 18 mm.; width of base of crown, 9 mm.; distance between points of denticles, 14 mm.

9. Trans. Roy. Dubl. Soc., IV, XXXVI, figs. 27, 28.

10. Proc. Geol. Assoc., XIII, pl. VI, fig. 26.

Lamna, sp. Plate XXX, fig. 6.

Lamna, sp., Williston, cf. cit. 39.

A somewhat injured tooth, of larger size than the last, differs in having a larger and stouter base, the inner projection in the middle of the latter stouter and broader, and the lateral denticles smaller and more obtuse. Height of tooth (approximately), 32 mm.; width of base of crown, 12 mm.; width of base of tooth, 25 mm.

One specimen, Kiowa shales, Clark county.

Lamna quinquelateralis.

Lamna quinquelateralis Cragin, Colo. Coll. Studies, v, p. 189; Williston, cf. cit. 39.

"The specific name *quinquelateralis* is applied to a species of shark whose vertebræ differ from all others of which I have any knowledge. The type vertebra is short, much broader than high, shallow-cupped, and more or less sharply pentagonal ended.

"Measurements: Height, 20 mm.; length, 12 mm.; breadth, 12 mm. The two upper angles measure each about 130 deg.; either lateral angles about 105 deg.; the lower angle is broad and rounded.

"Occurrence: A single vertebra of this form was found by the writer at Belvidere, Kan., with the above-described remains of *Plesiochelys*, in the upper part of No. 4 of the Belvidere section."

Possibly this vertebra belongs with one or the other of the above-described teeth from these same deposits, but the correlation cannot be made until the teeth and vertebræ are found associated, which may be long hence.

Scapanorhynchus.

Rhinognathus Davis, Trans. Roy. Dubl. Soc. (2), III, p. 480.

Scapanorhynchus Woodward, Cat. Foss. Fishes Brit. Mus., I, p. 351, (1889).

? *Mitsukurina* Jordan, Proc. Calif. Acad. Sci. Zool., I, (1898); Amer. Nat., XXXIV, p. 234.

The genus *Scapanorhynchus*, first proposed by Davis under a preoccupied name, has been more closely defined by Woodward. The teeth themselves cannot in many cases be generically dis-

tinguished from those of *Odontaspis*, under which name some were originally described.

Recently Doctor Woodward¹¹ has identified a modern genus of sharks, from the deep sea off Yokahama, Japan, with this supposedly extinct type—*Mitsukurina* Jordan.

Possibly the positive identification is premature, but there seems to be no doubt of the close relationship of the two forms, at least.

Scapanorhynchus raphiodon. Plate XXVI, fig. 4; plate XXXII, fig. 5.

Lamna (Odontaspis) raphiodon Agassiz, Poiss. Foss., III, p. 296, pl. XXXVII-A, ff. 12-16.

Scapanorhynchus raphiodon Woodward, Cat. Foss. Fishes Brit. Mus., I, p. 353 (where additional synonymy will be found); Proc. Geol. Assoc. XIII, p. 196—Cenomanian, Russia and Galicia; Cenomanian and Turonian, France, Saxony, and Bohemia; Cenomanian-Senonian, England; Upper Cretaceous, S. India; Upper Cretaceous of Texas, Mississippi, New Jersey; Benton Cretaceous of Kansas.

Lamna texana Roemer, Kreideb. von Texas, p. 29, pl. I, ff. 7; Leidy, Rep. U. S. Geol. Surv., I, p. 304, pl. XVIII, ff. 46-50; Cope, Cret. Vert., p. 296.

Teeth of considerable size, slender, the anterior ones without lateral denticles; inner coronal face conspicuously and finely striate.

A number of teeth before me from the Cretaceous of New Jersey and one from the Benton Cretaceous of Kansas agree fairly well with the figures given by Leidy of specimens from Mississippi, New Jersey, and "from near the mouth of Vermilion creek, in Kansas," and which agree with those from Texas called *Lamna texana* by Roemer.

The specimens agree so well with the European species, especially as figured by Woodward (l. c.; I have no European specimens for comparison), that I think there cannot be much doubt of their identity, a conclusion suggested by Woodward.

The Kansas specimen described by Leidy was said to have been obtained by Hayden from a "gray sandstone from near the mouth of Vermilion river." The Vermilion in Kansas runs its whole length through the Carboniferous in eastern Kansas; nor do I think there is any gray sandstone (necessarily Dakota Cretaceous) in the state which will yield these teeth. In all

11. Amer. Mag. Nat. Hist., III, p. 487 (1899).

probability the specimens did not come from this state. However, a specimen in our collection agreeing with the species was obtained in the state, and probably from the Benton, though possibly from either the Niobrara or Fort Pierre.

CORAX.

The genus *Corax* is confined wholly to the Cretaceous, and is yet incompletely known. Its distinction from *Galeocerdo*, under which name some of its species have been described, is based upon the solidity of the teeth—those of *Galeocerdo* have a hollow cavity within. The teeth are small, compressed, more or less triangular, with marginal serrations, though this character may be more or less wanting in young individuals. They vary not a little in shape in the same individual. In some the crown is nearly bilaterally symmetrical, but they more usually have the crown directed more or less obliquely backward, the anterior margin convex, the posterior more or less straight and angulated.

Three species of the genus are known in England—*C. falcatus*, *C. pristodontus*, which is hardly distinct, and *C. affinis*. In addition, *C. antiquus* Desl., *C. incisus* Egert., *C. lævis* Gieb. and *C. pygmaeus* Munst. have been described from Europe, and *C. crassidens* Cope and *C. hartvelli* Cope from the United States.

Corax falcatus. Plate XXXI, figs. 1-40; plate XXXII, figs. 1-11.

Corax falcatus Agassiz, Poiss. Foss., III, p. 226, pl. xxvi, f. 14, xxvi-A, ff. 1-15; Woodward, Cat. Foss. Fishes Brit. Mus., I, p. 424 (where additional synonymy will be found); Proc. Geol. Assoc., XIII, p. 198, pl. vi, ff. 13-15—Cenomanian and Turonian of England, France, Switzerland, Saxony, Bohemia, Galicia, and Russia; Senonian of England and France; Cretaceous of Texas, New Jersey, and Mississippi; Niobrara of Kansas.

Galeocerdo falcatus Leidy, Ext. Vert. Fauna West. Terr., p. 301, pl. xvii, ff. 29-42.

The very variable shape of the teeth referred to this species will be seen in plate XXXI, figs. 1-40. Possibly the specimens there figured represent distinct species. *C. (Galeocerdo) crassidens* Cope seems to be represented by fig. 24, and *C. (Galeocerdo) hartvelli* Cope¹² by fig. 23. Possibly this species also includes

12. Cret. Vert., p. 244.

C. pristodontus and *C. lindstromi*, both of which seem to be imperfectly differentiated from *C. falcatus* at present.

In plate XXXIII, figs. 1-11, are shown a number of teeth pertaining to a single individual and found associated with many others, by Mr. Martin, in the Niobrara Cretaceous of the Smoky Hill valley. Isolated teeth of this species are the most abundant of the selachian teeth in the Niobrara of Kansas. Only in very few instances have many teeth been found associated, so that it is yet impossible to fully understand the dentition. The species occurs rarely, if at all, in the lower Niobrara horizons, where those of *Isurus* and *Ptychodus* are the most abundant.

***Corax curvatus*, n. sp.** Plate XXX, figs. 7, 8.

Two specimens from the same block which yielded those of *Ptychodus janewayii* and *Lamna* species, *antea*, seem evidently specifically distinct from the foregoing. These teeth, while not differing much in outline from certain ones referred to *C. falcatus*, show a marked variance in structure. In *C. falcatus* the outer surface of the tooth stands out but very slightly. In *C. curvatus* the crown is attached to the root very obliquely, so that when resting upon a plane the tooth forms a high arch, touching only by the extreme tips of the roots and crown. The inner surface, also, is very much more uneven and convex, the crown separated from the root by a marked, narrow, transverse ridge, which is scarcely indicated in the teeth of *C. falcatus*. Altitude, 8 mm.; greatest width, 14 mm.; horizon, lower or lowermost Benton of Ellsworth county.

LEPTOSTYRAX.

Williston, Kans. Univ. Quart., IX, p. 42, 1900.

***Leptostyrax bicuspidatus*.** Plate XXIV, figs. 15, 15a; plate XXVI, fig. 7.

Leptostyrax bicuspidatus Williston, cf. cit. 42.

Principal cusp long and slender, flattened upon the outer side, with sharp, smooth edges and a median convexity in the middle of the flattened surface; for the most part convex longitudinally, gently concave before the apex. Inner surface strongly convex from side to side, concave on the lower half

longitudinally, gently convex on the upper part. A single denticle present, slender, flattened cylindrical, with an anterior and posterior carina; it arises below the base of the main cusp, and is directed more outwards, its inner surface concave longitudinally. Immediate base of crown of both main cusp and denticle with short ridges. Base of tooth short, truncate (?) below the main cusp, prolonged downward below the denticle. Length of main cusp, 19 mm.; width of same at base, 5 mm.; length of denticle, 5 mm.; width of same at base, $2\frac{1}{2}$ mm.; height of tooth, 26 mm.; width of base, 10 mm.

A small tooth of the same form found with this has a total length of 14 mm. The base is deeply emarginate below, with two slender roots; that below the denticle the longer. Mentor beds, $4\frac{1}{2}$ miles southwest of Marquette, Kan.

U. S. Nat. Mus. No. 1979.

PYCNODONTIDÆ.

The pycnodonts are a peculiar group of ganoid fishes, whose remains have been found in the Jurassic, Cretaceous and Eocene deposits of Europe, North America, Asia, and Australia. They are all rather small fishes, very much flattened and oval in shape, covered with rhomboidal scutes having close-lying spines, which give a ribbed appearance. The united palatine and vomer of the upper jaws are provided with five rows of round or oval, smooth-pavement teeth; the premaxillary with two or four chisel-like teeth. The dentaries below have a like number of teeth, similar to those of the premaxillary, while on the splenial there are three, four or five rows of pavement teeth similar to those of the vomer.

Cœlodus brownii. Plate XXIV, fig. 12.

Cœlodus brownii Cope, Journ. Acad. Nat. Sci. Phil., ix, p. 447, pl. xx, f. 19; Williston, cf. cit. 28.

A fragment of the left lower jaw, containing two rows of teeth, the middle and the inner. There are four crowns preserved on the inner row, nearly corresponding in length with

the six teeth of the middle row, of which only two have the crowns preserved. Cope's type had only the middle and external rows, and none of the teeth had well-preserved crowns. The middle teeth seem to correspond exactly in size with the types.

On the inner side the jaw projects as a rather broad trough, with a thin edge, apparently broader posteriorly than anteriorly. Its width here is nearly as great as the width of the inner row of teeth. The inner teeth are large, their width equal to nearly half their length. The surface of the crowns is smooth and convex, more so antero-posteriorly than transversely. The middle row has the teeth placed a little obliquely to the others, and the surface is more flattened transversely in the middle. The axes of the crowns of the two rows are placed at a distinct angle with each other.

Length of four teeth, inner row	36 mm.
Transverse diameter of crowns, inner row	17 "
Length of five teeth, middle row	31 "
Transverse diameter of crowns, middle row	12 "
Thickness of jaw, at middle row of teeth	22 "

The specimen was collected from the Kiowa shales, near Belvidere, by Mr. C. N. Gould.

Cœlodus stantoni, n. sp. Plate XXIV, fig. 12; plate XXVI, fig. 6.

Cœlodus stantoni Williston, cf. cit. 28.

A fragment of the right lower jaw, containing two perfect crowns of the internal row, together with the bases of four teeth of the middle row, evidently represents a species distinct from the previous one. The teeth are much smaller in size, more elongated and distinctly kidney-shaped, the ends narrowed. The surface is smooth, strongly convex antero-posteriorly, and gently so from side to side. The jaw is much less robust than in the preceding species.

Transverse diameter of tooth, internal row	14 mm.
Antero-posterior diameter of same	5½ "
Length of four teeth, middle row	17 "
Transverse diameter of tooth, middle row	11 "

The middle teeth seem to be larger in proportion to those of the internal series than in the preceding species. Kiowa shales.

Mesodon abrasus.

Mesodon abrasus Cragin, Colorado College Studies, v, 1894; Williston, Kans. Univ. Quart., ix, p. 29.

"This name is proposed for certain pycnodont teeth of low, rhomboidal form and feebly convex upper surface which occur in No. 3 of the Belvidere section, southwest of the Belvidere railroad station, and seem to agree with the large mandibular teeth of *Mesodon*. The specific name refers to the occurrence in the type species of two small, oblique facets produced at one end by attrition. The type has a height (above root) of 3 mm., a length of 13 mm., and a breadth of 5 mm.

"To the vomerine set of the same species may belong the rotund, oval or nearly hemispherical teeth of similar height but smaller size, which occur not uncommonly at the same locality and horizon, the largest now available example of which measures about 6 and 7 mm. in major and minor horizontal diameters."

In the National Museum collection there are several teeth, occurring singly, corresponding to the vomerine teeth described by Cragin. That they belong with the other teeth there described is very doubtful—indeed it is doubtful whether the other teeth belong with *Mesodon*, since it is impossible to locate the genus from single teeth. It is not at all impossible that the vomerine teeth are identical with Cope's *M. diastematicus*. The larger teeth may be the same as those of either the above-described species of *Calodus*.

The largest of the specimens in the present collection measures 10 by $7\frac{1}{2}$ mm.; several smaller examples have diameters of 6 and 5 mm. (See plate XXX, fig. 4.)

LEPIDOSTEIDÆ.**Lepidotus, sp.**

In the National Museum collection there is a single example of a scute pertaining to some lepidotid fish (No. 1063, Kiowa shales). Cope has described *Macrepistius* of this family from a stratum between the Upper and Lower Trinity Sands of Texas. It seems very probable that the teeth referred to the vomer of *Mesodon abrasus* really belong here.

TELEOSTS OF THE UPPER CRETACEOUS.

By ALBAN STEWART.

INTRODUCTION.

ABOUT two years ago, through the kindness of Dr. S. W. Williston, I was given the privilege of working up for publication the excellent University collection of teleost fishes from the Upper Cretaceous formations of western Kansas, the results of which are given in the following pages. At the time the work was begun the literature on the subject was poorly represented in the University library, and, as some of it was very hard to obtain, the work has been delayed on this account, causing a later appearance of it than was first expected. However, it is hoped by the author that it is fairly complete, and that it will be a guide to students of the Cretaceous ichthyology of North America, and especially that of Kansas.

For more than twenty years past the Kansas Cretaceous fishes have been almost entirely neglected by writers on ichthyology, and not since the publication of Professor Cope's "Vertebrata of the Cretaceous Formations of the West," in 1875, has any work appeared beyond a few scattering papers on some special form or group; and, with the exception of those by Prof. O. P. Hay and myself, these have all been written by students of German universities, from collections which have been made in Kansas and sent to the museums there. Thus, it seems very proper that there should be a more complete work undertaken at home, where the collecting grounds are easy of access and the collections are probably more complete than elsewhere.¹³

In addition to the original collection made by Chancellor F. H. Snow, Dr. S. W. Williston, and others, the geological ex-

13. See also the Appendix to this part.—S. W. W.

pedition to western Kansas during the summer of 1898 obtained some valuable material from the Niobrara and Fort Pierre formations, among which several new types have appeared. Before entering into the work in detail, I wish to express my indebtedness to Dr. S. W. Williston for advice in the preparation and revision of the work, and also to Prof. O. P. Hay, of the United States National Museum, of Washington, D. C., for the loan of his type specimen of *Ichthyodectes cruentus* for comparison with some of our specimens, and also for information on some of the points on which I was in doubt. I must also express my sincere thanks to Mr. W. O. Bourne, of Scott, and Mr. Travis Morse, of Iola, for the loan of material from their collections of fossil vertebrates; and also to Mr. H. M. McDowell, of this city, for his present of the fine skull of *Saurodon xiphirostris*. The drawings from which the plates were made were all done by Mr. Sydney Prentice, under the writer's direction.

LAWRENCE, KAN., May 15, 1899.

TELEOSTEI.

The fishes belonging to this order are usually characterized by the margin of the upper jaw being formed of the maxilla and premaxilla and by the absence of spinous rays in the pelvic fin. Some of the Cretaceous forms are exceptions to this, as the pelvic fin often is provided with spinous rays. The parietal bones are united in the median line and the scales are usually cycloid. This order comprises the most generalized types of bony fishes, which are closely related to the bony ganoids. They are among the most abundant fossils obtained from the chalk of western Kansas, and are usually in an excellent state of preservation, which makes them easy to collect and study. They range in size from the gigantic *Xiphactinus*, which often attains a length of nearly twenty feet, to *Enchodus* and some of the other small forms, which are often less than a foot in length. They are found most abundantly in the Niobrara group, not because they were more abundant in that period, but probably because the conditions which prevailed at that time were more favorable for fossilization than in the Fort Pierre and Fox Hill time which followed. They include several families, which will be described and discussed below.

A. S. Woodward,¹⁴ of the British Museum, has divided these fishes into six groups, which are given below.

"I. Laterally compressed fishes with large and powerful maxillæ and premaxillæ, bearing teeth, the dentary being the only tooth-bearing bone of the lower jaw, provided with a single series, the palatine and ectopterygoid toothless. The teeth are placed in complete sockets. Vertebrae, except near the head, deeply two-grooved on each side in addition to possessing pits for insertion of neural and hæmal arches. Ex.: *Portheus* (*Xiphactinus*), *Ichthyodectes*, *Daptinus* (*Saurodon*), *Saurocephalus* (forming the family of *Saurodontidae* of Cope).

"II. Fishes somewhat less laterally compressed, provided with scales or bony scutes, or both, and having the premaxillæ and maxillæ large, bearing powerful teeth in one or more series. The teeth not implanted in sockets, but anchylosed

14. Proc. Geol. Assoc., vol. X, 1888, pp. 309, 310.

to the jaw-bones. Abdominal vertebræ, at least, without deep lateral pits, but longitudinally striated. Ex.: *Pachyrhizodus*, *Empo* (?), *Stratodus*.

"III. Fishes only moderately compressed from side to side, naked, or provided with scutes. Both maxilla and premaxilla long and slender, the former about half excluded from the margin of the upper jaw by the latter; the maxillary and premaxillary teeth small. Palatines and ectopterygoids powerful, and bearing a single series of large teeth, upon expanded, anchylosed to the bone. Dentary bone of lower jaw with one series of large teeth and one or more series of small teeth similarly anchylosed. Vertebræ with two deep lateral impressions and pits for the neural and hæmal arches. Ex.: *Enchodus*, *Eurygnathus*, *Eurypholis*, *Ischyrocephalus*, *Cimolichthys*, *Pomagnathus*.

"IV. Elongated fishes, with powerful dentition, and the trunk armed with several longitudinal series of bony scutes; not yet precisely defined and separated from groups II and III. Ex.: *Dercetis* (*Leptotrachelus*), *Pelargorhynchus*, *Plinthophorus*.

"V. The *Protosphyrcenidæ* (*Erisichtheidæ* Cope), with much elongated snout (ethmoid bone), and long maxilla loosely connected with the premaxilla; also believed to have an unusually complex mandible. Ex.: *Protosphyrcena*.

"VI. Clupeoids and salmonoids."

After making a careful study of the material at hand, I think it advisable to make some changes in the above grouping for the American genera, which are given below.

I. Fishes with skull laterally compressed; jaws powerful, and bearing a single row of cylindric teeth, without nutrient foramen or notches below the internal alveolar border; predentary not present; vertebræ deeply grooved, with pits above and below for the insertion of the neuro- and hæmapophyses. Embracing the genera *Xiphactinus*, *Icthyodectes*, *Gillicus*, and *Cladocyclus*; family, *Icthyodectidæ*.

II. Fishes with skull laterally compressed; jaws powerful, and bearing a single row of compressed, knife-like teeth, with nutrient foramina or notches below the internal alveolar border; predentary present and without teeth. Including the genera *Saurodon* and *Saurocephalus*; family, *Saurodontidæ*.

III. Fishes with skull depressed, the top of which is beautifully sculptured; jaws provided with one or more series of conical teeth, which are firmly anchylosed to the bone; vertebræ

striated and contracted medially. Including the genera *Empo*, *Stratodus*,¹⁵ and (?) *Cimolichthys*; family, *Stratodontidae*.

IV. Fishes with an elongated compressed body; palatines usually provided with a single large tooth; dentaries with an internal row of large teeth, and usually an external fringe of smaller ones. Including the genera *Enchodus*, *Tetheodus*(?); family, *Enchodontidae*.

V. Fishes with skull depressed, beautifully sculptured, and probably covered with bony plates. Maxillæ, premaxillæ and dentaries with many rows of minute teeth. Vertebrae striated and contracted but little medially. Including one genus, *Anognathus*; family, *Osteoglossidae*.

VI. Fishes with maxillæ and dentaries provided with a single row of cylindric subequal teeth, all of which are partially enclosed in alveoli and partially anchylosed to the bone. Bones of the skull without ornamentation. Vertebrae longitudinally striated. Including the genera *Pachyrhizodus* and *Oricardinus*; family, *Salmonidae*.

VII. Fishes with the ethmoid bone prolonged into a rostrum anteriorly. Teeth laterally compressed, lanciform in two series, the largest of which are set in alveoli. Predental bones probably present bearing teeth. Including one genus, *Protosphyrapna*; family, *Pachycormidae*.¹⁶

VIII. Body covered with large cycloid scales. Abdomen frequently compressed into a serrated edge. Dorsal fin elongate; caudal fin often deeply cleft. Including the American genera *Leptichthys*, *Sardinius*, and *Spaniodon*; family, *Clupeidae*.

IX. Body slender and covered with several rows of bony scutes. Teeth in a single series. Including the American genera *Dercetis* (*Leptotrachelus*), *Trianaspis*, *Ichthyotringa*, and *Leptecodon*; family, *Dercetidae*.

15. Dr. A. S. Woodward, of the British Museum, has since examined our specimen, and thinks the large size of the parietals, their meeting medially and the general shape of the top of the skull would indicate that *Stratodus* was closely related to *Dercetis*.

16. Vertebrate Palæontology (A. S. Woodward), p. 111.

X. Body short and covered with ctenoid scales. Mouth oblique. Jaws with many villiform teeth. Embracing the one genus, *Beryx*; family, *Berycidae*.

XI. Body somewhat elongate, compressed, and covered with large or medium-sized cycloid scales. Lateral line doubtfully present. Dental bones short and without teeth. Eye lateral. Gill openings large. Dorsal fin often elongated. Embracing the genera *Sylæmus*, (?) *Apsopelix*, and (?) *Pelecorapis*; family, *Mugilidae*.

ICHTHYODECTIDÆ Crook.

Saurodontidae Cope; *Saurocephalidae* Zittel.

The family name of *Ichthyodectidae* as characterized by Doctor Crook¹⁷ embraced the genera *Xiphactinus*, *Ichthyodectes*, and *Saurodon*, and was intended by the author to be used instead of the family name *Saurodontidae*, as given to this group of fishes by Professor Cope.¹⁸ The reasons given by Doctor Crook for changing the name of this family are that the teeth are not like those of saurians, and that the name *Saurodontidae* was pre-occupied by a family of ganoid fishes. Concerning this Professor Cope says:¹⁹ "In the first place, the author [Crook] has not observed that I have on several occasions published the fact that the name *Daptinus* Cope is a synonym of *Saurodon* Lea,²⁰ which was proposed many years previously. It was from this genus that I gave the family name first proposed of *Saurodontidae*. The fact that Professor Zittel many years later gave this name to a very distinct family does not authorize the giving of a new name to the family first called by me, as is done by Mr. Crook." Doctor Crook also removes the genus *Saurocephalus* from this group, and places it in the family *Protosphyraenidae* (*Pachycormidae*), concerning which he says of the maxilla, premaxilla, and dentary which he examined:²¹

"Sie ist so gänzlich verschieden von denjenigen der anderen Glieder dieser Familie, dass dies Merkmal allein genügt, um *Saurocephalus*

17. Paleontographica, 1892, p. 120.

18. Proc. Am. Phil. Soc. 1870, p. 529.

19. American Naturalist, vol. XXVI, p. 941.

20. Should be Hays.

21. l. c., 120.

einer anderen Gruppe zuzuweisen. Diese Annahme wird noch mehr bestätigt durch den Charakter der Maxilla und Dentale, die Foramina und die Art und Weise der Aufeinanderfolge der Zähne. Auf Grund der Gleichartigkeit der Zähne und der außerordentlichen Aehnlichkeit der Prämaxilla mit derjenigen von *Protosphyranan* dürfen wir *Saurocephalus* bis auf weiters in die Familie von *Protosphyrena* einreihen."

I have been unable to discover the similarity between the premaxillæ of the two genera mentioned above. In fact, they are very widely different, and I am inclined to think that Doctor Crook mistook the predentary for a premaxilla of *Saurocephalus*. However, this genus is too closely related to *Saurodon* to be far separated from it, and if one of these genera is removed from this family the other would have to follow.

As it is evident that these genera cannot be placed in the *Pachycormidæ*, and as some new characters have come to light since Doctor Crook's paper appeared, I deem it advisable to separate these two forms from the original group and place them in a separate family, to be known as the *Saurodontidæ*, and to use the name *Ichthyodectidæ* to include the three genera *Xiphactinus*, *Ichthyodectes*, and *Gillicus*.

Concerning the same *Saurocephalidæ* Zittel, it can only be said that even if the name *Saurodontidæ* had been used by Doctor Zittel to distinguish his family of ganoid fishes before Professor Cope applied it to his group, it would have to be abandoned in light of the fact that Cope's family is founded on the genus *Saurodon*, which would give it priority over another family of the same name.

In this family the tooth-bearing elements are each provided with a single row of teeth, and the upper border of the mouth is formed by the maxilla and premaxilla. The supraoccipital is raised into a prominent crest and the maxilla is bound to the skull by means of the palatine.

This family embraced some of the largest physostomous fishes of the Cretaceous period of North America, and from the size of the jaws and the powerful dentition we may suppose that they rivaled the Mosasaurs, the smaller ones at least, in strength

and ferocity. Below is the synopsis of the family *Sauroidontidæ*, as given by Cope :

- I. Jaws without foramina on the inner face below the alveolar margin:
 - a. Teeth cylindric:
 - Teeth of unequal lengths; some of them greatly developed.....*Portheus*.
 - Teeth of equal length.....*Ichthyodectes*.
 - aa. Teeth compressed, knife-like:
 - Teeth of unequal length; some of the anterior greatly developed.....*Erisicthe*.
 - Teeth equal.....*Daptinus*.
- II. Dentary bones pierced by foramina below the alveolar border:
 - Teeth with subcylindric crowns.....*Saurodon*.
 - Teeth with short, compressed crowns.....*Saurocephalus*.

Professor Cope also says : "There are some other forms to be referred to this family, whose characters are not yet fully determined. Thus *Hypsodon* Agass., from the European chalk, is related to the two genera first above named, but, as left by its author in the 'Poissons Fossiles,' includes apparently two generic forms. The first figured and described has the mandibular teeth of equal length. In the second, they are unequal, as in *Portheus*, to which genus this specimen ought, perhaps, to be referred. Retaining the name *Hypsodon* for the genus with equal mandibular teeth, its relations to *Ichthyodectes* remain to be determined by further study of *H. lewesiensis*. The view of the superior walls of the cranium given by Professor Agassiz presents characters quite distinct from what I have observed in *Portheus*." *Hypsodon* has since been shown to be a synonym of *Pachyrhizodus*, *Portheus* a synonym of *Xiphactinus*, *Erisicthe* a synonym of *Protosphyræna*, and *Daptinus* a synonym of *Saurodon*. Thus, it is seen that the old synopsis will no longer hold, so I give the following revised one :

- a. Teeth large and of unequal length.....*Xiphactinus*.
- b. Teeth medium, of equal length.....*Ichthyodectes*.
- c. Teeth small and fringe-like.....*Gillicus*.

The two large oval scales from the chalk of Lewes, figured by Agassiz²² as *Cladocyclus*, bear a close resemblance to those of

22. Poiss. Foss., vol. V, pl. XXVa, figs. 5, 6.

Ichthyodectes, and it may later be found that the two genera are identical. However, as *Cladocyclus* is so imperfectly known, it would hardly be safe to say that the two genera are synonymous.

Xiphactinus.

Xiphactinus Leidy, Proc. Acad. Nat. Sci. Phil. 1870, p. 12: Rep. U. S. Geol. Surv. Terr. 1873, p. 290, pl. xvii.

Portheus Cope, Proc. Am. Phil. Soc. 1871, p. 175: Cret. Vert. West, pp. 190-193.

The genus *Xiphactinus* was first described by Leidy²³ from the remains of a pectoral fin-spine from the Cretaceous deposits of Kansas. Three years later the spine was more completely described and figured by the same author in his Contributions to the Extinct Fauna of the Western Territories, (p. 290, pl. XVII.) Professor Cope recognized the relationship of this spine to his family *Sauroidontidae*, in a paper published in Hayden's Second Annual Report of the Geological Survey of the Territories, 1871, (p. 418,) but assigned it to the genus *Saurocephalus*, and always claimed that *Xiphactinus* was distinct from *Portheus* and *Ichthyodectes*, although he never stated in what way they differed. It has since been shown, without doubt, that *Portheus* is a synonym of *Xiphactinus*, the latter name having the priority by about a year.

This genus is represented in the museum by two specimens which are more than twelve feet in length each, and these are only medium-sized individuals; so there can be but little doubt that the species attained a length of twenty or more feet in the largest specimens. Besides their large size, the genus is well characterized by the tooth-bearing elements, which are all covered with a powerful dentition. The premaxillæ are firmly united with the maxillæ and usually have one or more large, fang-like teeth projecting downward from the alveolar border. The maxillæ are large and provided with a single row of teeth which vary greatly in size. The upper anterior portion of the bone is provided with two condyles which serve to bind the jaw to the skull. The dentaries are deep and also provided with a single

23. Proc. Acad. Nat. Sci. Phil. 1870, p. 12.

row of teeth, very irregular in size. The larger of these teeth are very deeply set in the jaw and Professor Hay has recently shown²⁴ that those near the symphysis descend nearly to the lower border. The pulp cavities are very large at the base and the displacement takes place by the young crown rising within the pulp cavity of the functional tooth and the absorption of the old root.

In the early work upon this genus, a great deal of stress was placed upon the number, size and arrangement of the teeth in the determination of the species, which characters have since been shown to be very inconstant.²⁵ The reason for the great inconstancy is easily explained when we consider the fact that the old teeth are being constantly shed and new ones taking their places, thus having fully developed and young teeth on the same jaw. The palatines and pterygoid bones are probably toothless; at least there are no teeth of any size upon them. The palatine is peculiar in having a malleolar portion connecting the maxilla with the skull. It is connected with the quadrate by means of the pterygoid bones, thus forming a strong arch.

The skull is provided with a prominent supraoccipital crest posteriorly. The orbital cavity is large and the orbit is surrounded by a heavy sclerotic ring, and also a chain of supra- and suborbital bones. The pterotics form prominent posterior lateral angles of the skull and also furnish the principal support for the hyomandibular. The parasphenoid forms a strong lower axis of the skull and has prominent transverse processes just in front of the brain case.

The opercular bones are large and thin, and probably all present. The pectoral fin is large and its rays powerful, probably forming weapons of offense and defense. The pelvic fins are supported by the pelvic actinosts, which are heavy, compact bones, strongly united in the median line by means of suture. The vertebrae are mostly two-grooved. The known American species are:

Xiphactinus audax Cope, Niobrara Cretaceous, western Kansas.

Xiphactinus lestrio Cope, Niobrara Cretaceous, western Kansas.

24. Zool. Bull., vol. II, p. 36.

25. Kans. Univ. Quart., vol. VII, pp. 115-119, pl. VII-X.

Xiphactinus mudgei Cope, Niobrara Cretaceous, western Kansas.

Xiphactinus lowii Stewart, Fort Benton Cretaceous, central Kansas.

Xiphactinus brachygnathus Stewart, Niobrara Cretaceous, central Kansas.

In a paper recently published by Professor Hay, of the United States National Museum,²⁶ the author recognizes two more species, *X. molossus* and *X. thaumas*, not mentioned in the list given above, and says that it is quite probable that *X. audax* is the same as some one of Professor Cope's species of *Portheus*. He also recognized the great variation in the size and arrangement of the teeth, but thought that the two species could be recognized by the difference in form of the superior condyles of the maxillæ, the variation of which will be discussed later.

Now it seems to me that, if *X. molossus* and *X. thaumas* are distinct species, Professor Cope failed to designate any constant characters by which they can be determined, and, until it is shown that such characters exist, we can do nothing more than call them synonymous. I have carefully compared the description and figure of Doctor Leidy's specimen with specimens of fin-spines in our collection that undoubtedly belong to one of these species, and find them identical with the description. This being the case, we must, for the present at least, consider *X. molossus* and *X. thaumas* Cope as synonyms of *Xiphactinus audax* Leidy.

***Xiphactinus audax*.** Plates XXXIII to XLVII.

Saurocephalus thaumas Cope, Proc. Am. Phil. Soc. 1870, p. 533.

Saurocephalus audax Cope, Proc. Am. Phil. Soc. 1870, p. 533.

Portheus molossus Cope, Proc. Am. Phil. Soc. 1871, p. 174; Cret. Vert. West., pp. 194-196.

Portheus thaumas Cope, Cret. Vert. West., pp. 196-201.

Xiphactinus audax Leidy, Proc. Acad. Nat. Sci. Phil. 1870, p. 12; Rep. U. S. Geol. Surv. Terr. 1873, p. 290, pl. xvii.

This species is by far the best represented of the physostomous fishes in the University collection, the material consisting of several individuals, some of which are almost complete and others remarkably well preserved in certain parts, so that from this material a better idea of the anatomy can be gained than from any of the other collections that have been described.

26. l. c., p. 27.

The premaxilla is large and oval in outline, convex externally and very irregular internally. The bone thickens toward the lower border, where there are alveoli for the large teeth, which are never more than three in number, and even three is an exception. The teeth are acutely pointed at the apex, non-striated, and directed slightly forward. Considerably more than half of the bone is supported on the anterior lamina of the maxilla, and in the larger specimens the posterior union with this bone is usually by a dentate suture. In the smaller specimens the suture is usually an undulating line, which seems to indicate that the dentate character of the suture becomes more evident with the age of the animal. There was no sutural union with its fellow on the opposite side, but, from the tubercular nature of the anterior border in some of the specimens, it seems that there may have been a cartilaginous or ligamentous union between the two. In some of the specimens there are a number of tubercular exostoses just above the alveolar border, but this character is as inconstant as the form of the suture mentioned above.

The maxilla is a large lanciform bone, much thickened toward the anterior end and thin posteriorly. Just back of the premaxilla the alveolar border is rather thin, and contains alveoli for several small teeth, usually four. Back of this the bone swells considerably for the accommodation of several large teeth, which are acutely pointed, non-striate, and vary in cross-section from a cylinder to an oval. Back of this the border is occupied by a varying number of small and medium-sized teeth, the alveoli of which are probably not all filled with functional teeth at once. The bases of all of these teeth are cylindric, or nearly so.

On the next page is given a table showing the great variation in the size and arrangement of the teeth on both the maxilla and premaxilla. The numbers in the left-hand column are the catalogue numbers of the specimens.

No.	MAXILLARY.					PREMAXILLARY.			
	Small.	Medium.	Large.	Small.	Total.	Small.	Large.	Small.	Total.
1	2	.....	5	.....	7+	.....	2	.....	2
2	4	.....	5	22	31	.....	2	.....	2
3	4	.....	5	23	32	.....	2	.....	2
4	4	.....	5	27	36	.....	2	.....	2
88	.....	.....	4	23	27	1	1	.....	2
132	1	.....	5	20	26	.....	.....	.....	.....
155	.....	1	5	.....	6+	.....	2	2	4
179	5	.....	4	26	35	.....	2	.....	2
266	2	.....	6	19+	27+	1	2	.....	3
275	2?	.....	5	25+	32+	.....	.....	.....	.....
279	2	.....	4	18	24	.....	3	.....	3
287	3	.....	5	26	34	.....	.....	.....	.....
301	5	.....	3	15	23	.....	.....	.....	.....
353	3	.....	4	22?	29?	.....	2	.....	2

From the above table, it is seen that in not a single instance do the size and arrangement of the teeth exactly agree with either of Cope's species, *X. molossus* or *X. thaumas*. The number of teeth is also as varied as is the size and arrangement. Two more or less constant characters are observed in the above table, viz.: The four small teeth on the anterior portion of the maxilla and the two large teeth on the premaxilla which are the least variable.

From the above, it is seen that the size and arrangement of the teeth on the maxilla cannot be taken as specific in character. The teeth on the premaxilla show a diversity in size and arrangement which is quite as marked as the size and arrangement of those on the maxilla. While the two large teeth are fairly constant, and in some specimens are about equal in size, yet in other specimens the anterior is much the larger of the two, while in still others the opposite is the case.

The outer surface of the maxilla is somewhat rugosely marked just above the alveolar border, while the internal surface is nearly smooth at this point. This surface curves regularly into the superior with no sharp break between the two, except near the posterior extremity, where the bone becomes very thin, but the external surface ends abruptly above and forms a slight shelf for the attachment of probably a jugal bone.

In some specimens this shelf is somewhat groove-like, while in others it is broad and flat. Near the anterior end superiorly there are two condyles, of which the posterior is large, irregular in outline, and slightly convex. Professor Hay is inclined to think that two forms can be determined from these condyles, as he says:²⁷ "I believe that the two species may be identified from the condyles of the maxillary. At least, these condyles are quite different in the two species which I have been able to examine, *X. thaumas* and *X. molossus*. Fig. 2 represents the maxillary of the former species, fig. 3 that of *X. molossus*. From these figures, it will be seen that in *X. thaumas* the posterior condyle is notched behind, while that of *P. molossus* [should be *X. molossus*] is excavated in front. It appears, too, that the condyle is more extended longitudinally in *X. thaumas*, more transversely in *X. molossus*." I am inclined to think that Professor Hay laid too much stress on this and the anterior condyle in the determination of his species, as a glance at the series of drawings of these parts on plate XLI will show that there was quite as much variation in these condyles as there is in the teeth, as shown above. I cannot be so sure about the variation of the anterior condyle, as it is broken away in many of the specimens. However, the constancy or inconstancy of this one minor character is of little specific value.

The anterior condyle, mentioned above, is oval in outline, convex, and occupies the extreme anterior part of the laminar portion of the maxilla, being thus well separated from the posterior condyle. The two condyles are more in line with each other antero-posteriorly than in *Ichthyodectes*. Just in front of the posterior of these condyles, the thickness of the maxilla becomes suddenly less and forms an abutment, against which the posterior portion of the premaxilla rests. In front of this the bone is laminar and supports more than one-half of the premaxillary bone. The posterior extremity is very thin, and in some specimens it is nearly straight, while in others it is curved strongly upward.

27. Zool. Bull., vol. II, No. 1, p. 34.

Maxilla: Distance from anterior condyle to posterior extremity, 338 mm.	
Depth of bone at posterior condyle	92 "
Distance between the two anterior condyles	44 "
Length of alveolar border	245 "
Thickness at posterior condyle	35 "
Premaxilla: Length of lower border	67 "
Depth	112 "

A table of measurements showing the great variation in size of the maxillæ in different individuals is given :

MAXILLÆ.					
No.	Length from pre-maxillary.	Depth at posterior condyle.	No.	Length from pre-maxillary.	Depth at posterior condyle.
1	.....	102	179	183	68
2	260+	111	266	.....	84
3	314	119	275	220+	94
4	216.5	78	279	263	90
88	273.5	92	287	220	80
127	.....	88.5	301	.....	90
132	264	98	353	219+	75
155	205+	83.5			

The dentary is deep, strongly built, and not incurved anteriorly. The alveolar border is slightly concave, and bears two large teeth at the anterior extremity, which are usually separated by a transverse groove from those following. Just back of this groove there are three or four large teeth which are followed by a number of medium-sized and small ones, the diversity in size and arrangement of which is shown in the table following this description. The teeth are all strongly implanted, with straight conical crowns, non-striate except under the microscope, and are cylindric in cross-section. The symphyseal portion slopes strongly backward and is very thick, but the principal articulation with the opposite jaw seems to be on the internal side, where the bone is very rugose. The lower border is rather sharp, and usually has a row of large nutrient foramina leading inward and forward just above it. The internal side is broadly vertically concave in the posterior portion, but becomes much less so anteriorly. At the end of the alveolar border the bone is projected upward and slightly outward into a weak coronoid process.

No.	MANDIBLES.										
	Medium..	Large	Small....	Large ...	Small....	Large	Small....	Medium and small..	Medium..	Small....	Total.....
1	2	.....	3	.....	.....	5	.....	9	1	20
2	2	1	1	.....	.....	8	12	.....	.....	24
3	2	.....	3	.....	.....	5	.....	2+	.....	12+
4	2	.....	2	2	.....	4	.....	10	2	22
88	2	.....	3	.....	.....	3	.....	10	4	22
127	2	.....	3	.....	.....	6	.....	10	.....	21
135	2	.....	3	.....	.....	7	.....	9	1	22
155	2	.....	1	2	1	.....	11	.....	2?	18
179	2	1	1	.....	.....	8	11	.....	.....	23
275	2	1	3	.....	.....	.....	.....	.....	.....	.....
279	2	.....	3	.....	.....	.....	.....	.....	.....	.....
287	2	.....	3	1	.....	4	.....	9	3	22
314	2	.....	4	.....	.....	8	.....	8	2	24
353	2	.....	.....	2	.....	.....	.....	17	.....	.....	21

The articular portion as described by Hay²⁸ is composed of the derm and antarticulars, but I am inclined to think that this author was somewhat mistaken in the extent of the last of these elements, as he says in the description of this part: "Relying on two good specimens of *Xiphactinus* and one of *Ichthyodectes*, I am confident that the proximal end of the antarticular is continuous with the long, sword-shaped process described by Cope, and that this process is entirely distinct from the dermarticular." Professor Cope states²⁹ that the articular is distinct, short, and irregularly wedge-shaped, and supports half of the cotylus. In this Professor Cope was correct, as the antarticular is not continued forward in a long, sword-shaped process, but is separated from this portion by a suture, which is indistinct in many of the specimens, and it is probably owing to this fact that Hay was unable to find it.

The dermarticular is a large bone, and in most of the specimens it supports less than one-half of the cotylus. On the external side it is exposed for some distance beyond the cotylus, when it is covered by the dentary, and continues forward on the internal side, as a long sword-shaped process, for nearly two-thirds the length of the jaw. The cotyloid process is promi-

28. Zool. Bull., vol. II, No. 1, p. 37.

29. Cret. Vert. West, p. 194.

ment and curved upward on the external side of the cotylus. In addition to the above bones, there is another, which is not mentioned by either Cope or Hay. It is a small bone, which lies in front of the antarticular, and is marked *sp.* in the figure of the lower jaw on plate XXXV. It presents a small facet above, which seems to have had attachment with something. This bone occupies about the same position as the splenial in some fishes, which name I will give it provisionally.

Length of alveolar border.....	260 mm.
Length of dentary from cotyloid cavity.....	325 "
Depth at symphysis.....	94 "
Depth at coronoid angle.....	136 "
Length of articular from cotyloid cavity.....	224 "

The above measurements are of a single specimen, No. 88 in the following table, which shows the great variation in the size of the mandible of this species :

No.	Length of alveolar border.	Depth at coronoid.	No.	Length of alveolar border.	Depth at coronoid.
1	242.5	145.5	179	185	94
2	251	144	266	.....	.....
3	279	140	275	.....	.....
4	194	109	279	.....	.....
88	260	136	287	210	.....
127	.....	.....	301	.....	.....
132	.....	.....	314	242	130
135	197	.....	353	195	115
155	215	.....		

The hyoid arch is represented by only one bone, the ceratohyal, and is the same bone figured by Cope³⁰ and described by Crook³¹ as an interopercular. The bone is elongated, and in outline is somewhat the shape of a parallelogram with one side crushed in. The posterior end is the broader of the two and bears an elongated, narrow and concave facet for the articulation with the epihyal. The anterior end is more irregular in outline and bears two facets for the hypo- and urohyals. The bone is thin and finely striated throughout.

30. Cret. Vert. West., pl. XL, fig. 7.

31. Paleontographica, 1892, p. 117.

Ceratohyal: Greatest length	238 mm.
Width across anterior end	86 "
Width across posterior end	97 "

The palato-quadrate arch is made up of six bones—the palatine, pterygoid, metapterygoid, mesopterygoid, symplectic, and quadrate. The first and last of these mentioned form the extremities of the arch, the other four intervening. The palatine presents a prominent malleolar portion, which has an articular face above and below for the prefronto-palatine articulation for binding the maxilla to the cranium, so characteristic of the *Sauroidontidæ* and *Ichthyodectidæ*. The lower of these faces is the larger and is slightly concave, while the upper is somewhat convex. The external surface presents no markings other than a prominent tuberosity on the posterior side. Just back and above this portion there are two prominent tubercles of bone, one of which may give attachment for a nasal bone.

The pterygoid and mesopterygoid are joined to the palatine posteriorly. The first of these is a long, thin bar of bone, which extends backward and downward nearly to the condyle of the quadrate and forms most of the lower border of the arch. The mesopterygoid is a somewhat triangular-shaped bone occurring just above the pterygoid. It is evidently united to the metapterygoid by means of a very broad squamose suture, as the bone appears to be rather small when seen externally, while the internal side, as figured by Professor Hay³² seems to be nearly as large as the metapterygoid. I have been unable to discover any teeth on the external side of this and the pterygoid, and none on the internal side of the pterygoid, as far as can be examined, which seems to be beyond the point where Professor Hay has shown them to be in his specimen. A second specimen shows that in this region there was a great deal of ossified cartilage covered with denticles, some of which is adhering to the matrix on the internal side of the mesopterygoid, and I am inclined to think that it was some of this cartilage that Professor Hay mistook for teeth on the bone. The

32, Zool. Bull., vol. II, p. 39.

metapterygoid is a broad, flat plate just above the quadrate, and is covered with fine striæ on the lower portion.

The symplectic is a rather small element, occupying a groove on the inner side of the quadrate. On its superior end it presents a small articular facet.

The quadrate is very thin above where it joins the metapterygoid, but in passing downward to the condyle it becomes more robust and is contracted into a neck. The condyle is somewhat elliptical in outline, the ellipse being invaded by a deep notch on the external side, and is strongly convex from before backward. On the internal side there is a deep groove for the symplectic, and just back of this groove, posteriorly, there is another smaller groove into which the anterior border of the preoperculum fits. The anterior border articulates with the pterygoid by means of a squamose suture. The bone is minutely striated, both externally and internally.

Greatest length of arch.....	342 mm.
Anterior depth of malleolar body.....	40 "
Between malleolar body and condyle for the quadrate.....	261 "
Antero-posterior length of palatine.....	298 "
Depth at center of the arch.....	131 "

The opercular bones are represented by the operculum, preoperculum, and a supposed suboperculum. There is still another bone (plate XLIII, fig. 3), which may represent an interoperculum.

The operculum is a broad, flat plate of bone, near the anterior superior portion of which there is a deep elliptical pit for articulating the bone with the hyomandibular. This pit is projected slightly outward from the rest of the bone, very closely resembling the corresponding portion of *Saurodon* in this respect. Just above this pit there is a sharp angular projection at the point where the anterior and superior borders meet, but I am inclined to think that this character will not be constant in all specimens. From this point the superior border extends backward and downward in an irregularly curved line to the lower border, which is less curved and somewhat striated just above it. The anterior border, extending from the articular portion just mentioned downward, is nearly straight and somewhat thickened. Back

of this border the bone is very thin, thus making it difficult to collect in perfect condition.

The preoperculum is a somewhat triangular-shaped bone with a very thick and concave anterior border. The lower portion of this border is directed forward at quite an angle, and is received in a slight groove on the back portion of the quadrate. Extending backward from the extremity of this portion there is a row of large, shallow foramina, the posterior ones of which have shallow grooves leading into them from behind. Below this line of foramina the bone is not so thick, and is covered with numerous fine striæ. The superior portion has a rather broad process extending upward, formed by the anterior and superior borders. The posterior portion of the bone is thin and striate on both sides of the upper portion.

There is still another opercular bone, which I regard as a suboperculum. The bone is broad and flat, thin along the borders, and thickened toward the central portion. The posterior extremity is the broader of the two and is somewhat rounded. The anterior end is much more narrow and bears a small elliptical facet on a slight elevation of the bone. It also presents a beak-like process, separated from the above by a slight depression. Both the external and internal sides are striated, the striæ becoming very pronounced near the posterior end of one of the sides. Measurements of the opercular bones are :

Operculum:	Length of the anterior border	* 373 mm.
	Length of the anterior border below facet for the hyomandibular	268 "
	Length of facet for the hyomandibular	55 "
	Transverse width of facet	22 "
Preoperculum:	Greatest length	* 345 "
	Width near superior extremity	80 "
	Width of inferior end	* 170 "
Subopercular:	Total length	290 "
	Width across anterior extremity	* 90 "
	Width across posterior extremity	* 146 "

There are four other bones, some of which are fragmentary, which are figured on plate XLIV. They were all found in connection with the skull and evidently belong to it. The first of these bones, figs. 1 and 5, is an elongated bone, expanded at

* Estimated.

one end and contracted into an elongated, narrow and somewhat thickened process at the other, at the extremity of which there is a roughened surface which probably gives attachment for cartilage. On one side of this process there is a long, thin lamina of bone extending toward the narrow extremity, and so closely applied to it that at first sight it has the appearance of being the border of a groove on the edge of the process. The expanded end is thickened and bears a small articular surface, the face of which is almost in line with the process mentioned above. This bone was figured by Cope³³ as a “?hyomandibular,” which has since been shown to be incorrect.

The second of these, fig. 2, is represented by portions of two bones, neither of which is complete. They are thin on one border, while the other is much thicker and is invaded by a shallow groove. This thickened portion was probably continued outward in a process beyond the end of the bone. The third, fig. 3, is plate-like and more or less sculptured on both sides. On one of the sides there is a broad, triangular-shaped depression, which is invaded by a notch from the edge of the bone, and on the other side there is a prominent ridge extending away from the apex. I have found a bone almost identical with this in connection with the supposed operculum of an unknown fish, which will be discussed later. This was figured by Cope as an “uncertain bone.”³⁴

The fourth and last of these bones (fig. 4) I have described as probably an infraopercular,³⁵ but it is probably a fragmentary coracoid. It is the largest of the four under consideration, and is very thin and flat, excepting near the posterior end, where it suddenly thickens into a prominent ridge, which probably continues to the point where the bone articulates with the scapula.

The hyomandibular is a large and somewhat triangular-shaped bone, with the base of the triangle above, where there is a long, narrow articular face for articulating this bone with the pit on the side of the skull for its reception. The face is convex

33. *Cret. Vert. West.*, pl. XL.

34. *l. c.*, pl. XL.

35. *Kans. Univ. Quart.*, vol. VIII, p. 21, pl. XI, fig. 4.

transversely and slightly concave in the middle. Extending downward and backward from near the anterior end of this facet there is a ridge, which becomes very prominent just in front of the condyle, and, continuing downward, forms a deep groove with the posterior border, into which the anterior border of the preoperculum is received to some extent. The anterior portion of the bone is thin and continued forward quite a distance. The condyle for the operculum is long, narrow, and situated about 45 mm. below the superior condyle. Just in front of this condyle, externally, there is a large and deep pit, which has another smaller one just above it. On the internal side there is a prominent crest, which ends opposite the lower end of the condyle just mentioned, and has another prominent excavation in front of it. The lower end of the bone is somewhat bluntly pointed, but it does not seem to possess a facet at this point, as is found in *Sauroidon*.

Hyomandibular: Length.....	265 mm.
Length of superior condyle	87 "
Length of condyle for operculum.....	50 "
Greatest width of bone (estimated)	160 "

The ethmoid is much thickened and narrow in front, where it forms a small beak, and broad and thin behind, where it joins the frontals by a somewhat dentate suture. The bone is moderately deep, and on the median line below there is a well-marked median ridge, on either side of which there is a small facet for the anterior condyle of the maxilla. In addition to this there is also a small pit on each side, which probably accommodates a part of the superior edge of the premaxilla. The upper anterior portion is often covered with numerous tubercles of bone, which fade out posteriorly.

The frontals are broad, flat plates, and are the largest bones entering into the formation of the top of the skull. Just back of the ethmoid they join the prefrontals, and back of this form the superior rims of the orbits. Posteriorly they unite with the postfrontals, parietals, and supraoccipitals. The two bones are united in the median line by a distinct suture, and possess no characteristic markings other than an irregular

articular surface near the anterior extremity, which probably gives attachment for a preorbital bone.

The prefrontals are stout bones, and are especially characterized by the presence of a large anterior facet for articulation with the malleolar portion of the palatine. In the figure of the skull of *Niphactinus*, as given by Crook,³⁶ the prefrontals are represented as extending well backward and forming a portion of the anterior and superior rim of the orbit. In this I am inclined to think that he was in error, for in several more or less disarticulated skulls in the collection I find that this supposed posterior portion of the prefrontal is a distinct bone which has become separated, showing a well-marked suture where it united with this bone and the frontal. This bone is the supra-orbital mentioned above, and is rather thick and lunate in outline.

The parietal bones have been much in doubt by most authors, probably owing to the fact that this portion of the skull is often much distorted and crushed, thus obliterating many of the sutures, or making them so indistinct as to render them unrecognizable.

Cope first thought that the supraoccipital might represent the conjoined parietals,³⁷ but concluded later³⁸ that this was not the case, and that the bones he had called epiotics were the parietals. Crook states that the parietals are completely separated in the median line by the supraoccipital,³⁹ but seems to have been somewhat in doubt about the exact extent of these bones, as the anterior portion is but poorly defined in his figure of the specimen on plate XVIII. Professor Hay has described them⁴⁰ as wedge-shaped narrow bones which lie between the anterior ends of the pterotics and the posterior ends of the frontals, probably meeting each other in the median line, and including the elevated granular portion assigned by Crook to the supraoccipital, in which I think he is right. If we examine a well-preserved skull of *Ichthyodectes* we will at once

36. *Paleontographica*, 1892, pl. XVII.

37. *Cret. Vert.*, p. 183.

38. *l. c.*, p. 185.

39. *Paleontographica*, 1892, p. 115.

40. *Zool. Bull.*, vol. II, pp. 28, 29.

see that this portion is entirely distinct from the supraoccipital, and that the bone he calls parietal is included in the pterotic and is not separated from it by suture.

The epiotics are wedged in between the pterotics and supraoccipital and form prominent inner processes of the skull. They become narrow anteriorly and are provided with prominent ridges along the superior borders, which end in slight upward projections posteriorly which are thickened at the extremity.

The supraoccipital forms a prominent crest and is projected well backward and upward. In some of the specimens having the posterior end preserved, I find that there are a number of tooth-like projections which closely resemble a suture, but they probably gave attachment to muscles alone. The bone is moderately thick and is somewhat rounded along the superior border. I think that I can detect the suture which separates this bone from the granular portion mentioned above. The bone is somewhat irregularly striated on the sides, and posteriorly it descends almost to the basioccipital, forming a prominent narrow ridge in the median line.

The pterotics lie just external to the epiotics and back of the parietals, and form prominent outer processes of the skull. The bones are very robust, and have deep grooves along the external borders, which articulate with the superior condyles of the hyomandibulars. The posterior extremities are somewhat expanded, and have small elliptical surfaces internally, which are covered with coarse striæ radiating from near the center. These surfaces probably are connected with the post-temporal. The sutures separating these bones from the parietals are often indistinct.

The postfrontals form prominent processes just back of the orbital cavities, and anteriorly they form the posterior sides of the conspicuous notches which accommodate the posterior supraorbitals mentioned above. Posteriorly, by their union with the pterotics and prootics, they give a small support to the hyomandibulars, and are excavated along the sides for this purpose. Internally they unite with the parietals.

The prootics have been correctly interpreted by Professor Hay as being the largest of the otic bones. They are irregular in outline and extend from the groove for the hyomandibular above to the parasphenoid below. Posteriorly they unite with the opisthotic, but are not separated from the basioccipital by the opisthotic, as Professor Hay has figured them in *Tarpon atlanticus*.⁴¹ Just below the hyomandibular facets there is a large foramen on each side, which, according to Professor Hay, transmits the glossopharyngeal nerve. Just back of these foramina there are large fossæ, the boundaries of which are formed by the pterotics, opisthotics, and prootics.

The sutures separating the lower portions of the opisthotics from the basioccipital and the prootics are well defined, but the ones separating them from the pterotics above are almost obliterated, although I think they can be traced in one of our specimens as extending downward just back of the articular face for the hyomandibulars. They are small bones and do not separate the prootics from the basioccipital, as mentioned above. The basioccipital is deeply concave, and the exoccipitals are not well defined in any of our specimens.

The parasphenoid is triangular in section and forms a strong lower axis of the skull. The posterior extremity of the bone is deeply emarginate where it joins the basioccipital, a short distance in front of which it sends up a short process on each side for union with the prootic. Extending outward from the sides of the bone, just in front of the brain-case, there are two well-developed transverse processes which are bluntly pointed and directed slightly forward. At the base of each of these processes there are two foramina which, according to Crook, transmit the facialis and trigeminus. Just above the transverse processes there is a Y-shaped bone, called basisphenoid by Hay,⁴² which unites with the prootic above. The anterior end of the parasphenoid is somewhat broadened and bifurcated for union with the vomer. The latter bone is not well defined in any of

41. Zool. Bull., vol. II, No. 1, p. 28.

42. l. c., p. 32.

the specimens, owing to the crushed condition of this part, thus making the line of separation indistinct between it and the ethmoid. The orbito- and alisphenoids are also in a much damaged condition, so as to render their boundaries only conjectural.

The orbital cavity was large, and bounded above by a chain of thickened supraorbital bones, and below by a chain of thin suborbitals, which seem to be quite large. Below this there seems to be a sheet of thin membranous bone covering the hyomandibular and the bones of the palato-quadrate arch. The sclerotic ring is composed of two pieces, which are found in place in one of our specimens. The outer borders of these are very heavy, but become thin internally and form a slight ring, which is extended inward.

Just below the suborbital ring there is a long, thin bar of bone which rests on the superior border of the maxilla, and is covered with minute canals leading inward. This I take to be the same bone called a "supernumerary bone" by Cope,⁴³ and an "extraknochen" by Crook.⁴⁴ It seems to me that both of these authors have been in error in regard to this bone, and that it is the jugal. Crook thought that the jugal was found just beneath this, and has it so marked in the figure of his skull of *Xiphactinus*,⁴⁵ but I am unable to find any such bone in our specimens.

PECTORAL GIRDLE AND FINS.

The pectoral girdle is represented by numerous specimens, some of which are preserved almost complete, thus giving a more correct idea of the form than any of the specimens heretofore described. This part was not well understood by the early writers on this form, and it was not until about a year ago that Professor Hay demonstrated⁴⁶ that this portion had been described in an inverted position.

The girdle is composed of the cleithrum, scapula, coracoid, and precoracoid, of which the first is the largest and the second the smallest and most compact. The cleithrum is a long bar of bone composed of two parts, which are bent almost at right

43. Cret. Vert. West., p. 194.

44. Paleontographica, 92, s. 115, 116.

45. l. c., t. XVIII.

46. Zool. Bull., vol. II, p. 42.

angles with each other, and are separated by a slightly constricted neck just in front of the scapula. The anterior portion is directed slightly downward at the extremity and is very thin, fragile, and it is probably owing to this fact that it is secured in so few specimens. Just above the scapula the cleithrum becomes very broad and continues so to near the upper extremity, when it suddenly contracts in width toward the anterior border, and ends in a somewhat thickened process, below which there is a well-marked dentate suture for the anterior end of the precoracoid. The whole of the anterior border is firmly united with the precoracoid, and the external side is covered with coarse striae, which radiate upward and backward from just over the scapula.

The scapula is a rather small bone, composed of a heavy compact portion which bears the glenoid surface and a rather thin lamina of bone which extends upward along the internal side of the cleithrum. The glenoid portion is united to the cleithrum above by means of a well-marked undulating suture, and bears three condyles, of which the uppermost is the largest, and is separated from the middle one by a slight ridge. The middle condyle is the smallest and is separated from the lower one by a slight groove. The condyles are all convex from before backward, the superior one very much so. Just internal to the glenoid surface there is a large irregular surface which gives a strong attachment to the coracoid, and also gives a partial support to one of the basiosts posteriorly. Just above this portion the precoracoid is united by a strong suture and extends upward as a broad bar on the internal side of the cleithrum.

The coracoid has been figured by Hay⁴⁷ as a broad, thin plate of bone which extends forward to probably the anterior end of the lower arm of the cleithrum. It is not well preserved in any of our specimens, but from the portions that are present I am inclined to think that it is the same bone described and figured by myself as a probable infraopercular.⁴⁸ It is somewhat thickened where it joins the scapula and has one deep pit and a portion of another for the extremities of two of the basiosts.

47. *I. c.*, p. 43.

48. *Kans. Univ. Quart.*, vol. VIII, p. 21, pl. XI.

There is a great variation in the size of the various specimens, and the measurements given are below the average, this specimen being selected on account of its completeness.

Cleithrum: Length from scapula superiorly.....	233 mm.
Length from scapula anteriorly.....	230 "
Precoracoid: Length.....	190 "

Numerous fragments of fins and fin-spines are present, which show that these formed powerful weapons of defense; they have been described by Crook as resembling ribs. The first pair of these are closely applied to each other and are each provided with articular surfaces at the proximal extremity, the first of which articulates directly with the upper condyle of the scapula while the second articulates with one of the basiosts. The first of these is broad and thin, while the second is slightly narrower but thicker toward the proximal end. The two opposing surfaces are much roughened while the outer surfaces are finely striated. The following rays decrease greatly in width and are much smaller from above downward. They are slightly bent at the proximal extremities and the cross-segmented character has disappeared throughout. The basiosts are three in number. The first of these is an irregular-shaped bone which is provided with two facets internally for articulating it with the two lower condyles of the scapula. These two are somewhat oval in outline, flat, and well separated from each other. The external facets are also two in number, one of which is nearly circular in outline and flat, while the other is irregular and strongly convex from above downward. The two remaining basiosts are somewhat thickened bars of bone which are slightly expanded at the extremities and are provided with convex condyles, the proximal ones of which are received into the pits on the coracoid and scapula for their reception. About midway between the extremities of each of these basiosts there is a thin transverse process extending outward.

The pelvic actinosts, called femora by Professor Cope,⁴⁹ consist of two parts—a massive posterior portion, bearing the facets for the attachment of the pectoral fin, and the thin,

49. Cret. Vert. West., p. 186.

somewhat wing-like, anterior portion, whose entire structure is not known. In the median line the two halves are strongly united together by suture, and at the point of union there is a prominent swelling of the bone all around. There are four facets on each for the fin attachment. The upper and lower are large, flat facets, somewhat ovoid in outline, and support the upper and lower halves of the first ventral fin-ray. When seen in cross-section from behind they are obliquely set, but hardly so much so as in *Ichthyodectes*. The lower one of these facets is the larger, and has two more facets between this and the upper, of a somewhat tubercular nature. The last two are for succeeding rays or basiosts. In front of the articular portion the bone becomes thin and somewhat expanded. On the outer border of this portion there is a prominent crest both above and below, of which the upper is the larger. It is likely that this crest did not extend very far forward, but was probably succeeded in front by another smaller crest or tuberosity, as something of the kind is shown in the figure of this part by Professor Hay,⁵⁰ but not described in the text. On the internal border there is a prominent ridge of bone extending forward on both the superior and inferior surfaces. These two ridges nearly coincide with each other, thus forming a rod of bone, which extends forward, but how far is not known. These two bars are separated by quite an interval, as is shown in the cut.

There seems to be some difference between this specimen and the one figured by Professor Hay. In his specimen the distance across the external crests was probably about 15 cm., and the distance between the internal ridges about 4.8 cm. In our specimen the first of these measurements is 12.3 cm.,⁵¹ while the last is 5 cm., making the distance between these ridges proportionally greater in our specimen.

Distance across superior facets.....	83 mm.
Distance across inferior facets.....	52 "
Distance across middle facets.....	86 "
Vertical depth of articular portion.....	52 "

There are none of the pelvic fin-rays present, but they were

50. Zool. Bull. 1898, p. 44.

51. Approximated.

probably eight or nine in number, of which all were very feeble excepting the first.

There are five vertebral columns of this genus preserved, two of which are practically complete, and the other three only partially so. There are also portions of several more columns, but, as they have not been numbered in the positions they occupied in life, I will not use them in the table given below. The most complete column has 77 centra present, which I think is all the animal had in life, with the exception of one of the terminal caudals. The other contains 73. Unfortunately, the neural and hæmal arches are gone, or so badly preserved that their characters cannot be made out in most instances. The first anterior vertebra is much shorter than those following, and the anterior end is not so deeply concave. It presents deep pits above for the neurapophyses, but none below for the pleurapophyses, the points where they should be being marked by scars. This one and the two or three following are usually without lateral grooves, but the second and third sometimes show them. The pits for the neurapophyses are large in these, as in the first, and the pits for the pleurapophyses become functional at about the third or fourth.

Back of the vertebræ just mentioned, the pits for the neurapophyses begin to assume the elongated form found farther back in the column, and the number of lateral grooves on the sides become somewhat varied.

To illustrate this last point, I have arranged the following table to show the individual variation in the different specimens. In this table the numbers at the heads of the columns represent the catalogue numbers of the various specimens, while those on the left are the numbers of the various vertebræ from the skull. A blank is left in some places where the vertebra is badly injured. The grooves are represented by 1-1 when there are two well developed, 1-0 when only one is present. When there is one well developed and another slightly so, they are expressed by 1-1— or 1-0+, 1-1— expressing a slightly greater development than 1-0+.

No.	1	2	3	4	ss	No.	1	ss
1.....	0-0	0-0	0-0	0-0	0-0	40.....	1 1-	1 1
2.....	0-0	0-0	0-0	0-0	0-0	41.....	1 0+	1 1
3.....	0 0	1 1-	0 0	1 1-	0 0	42.....	1 1	1 1
4.....	0 0	1 1-	1 0	1 0+	1-0	43.....	1 0	1 1
5.....	1 0+	1 1	1 0	1 0+	1 1-	44.....	1 0+	1 1
6.....	1 1-	1 1	0 0	1 0+	1 1-	45.....	1 0	1 1-
7.....	1 0+	1 1	1 0	1 0+	1 1-	46.....	1 1	1 1
8.....	1 0	1 1	1 1-	1 1-	1 1-	47.....	1 0	1 1
9.....	1 0+	1 1-	1 1-	1 1-	1 1-	48.....	1 0	1 1
10.....	0 0	1 1	1 1	1 1-	1 1-	49.....	1 1	1 1
11.....	1 0	1 1-	1 0	1 1-	1 1-	50.....	1 1	1 1
12.....	1 1	1 1	1 1-	1 0+	1 1-	51.....	1 1	1 1
13.....	1 1	.....	1-0	1 1	1 1-	52.....	1 1	1 1
14.....	1 1	1 1	1 1	0 0	1 1-	53.....	1 1	1 1
15.....	1 1	1 1	0 0	1 0+	1 1-	54.....	1 1	1 1
16.....	1 1	1 1	1 1-	1 1	1 1-	55.....	1 0+	1 1
17.....	1 1	1 1	1 1-	0 0	1 1-	56.....	1 0+	1 1
18.....	1 1	1 1	1 1-	1 1	1 1-	57.....	1 1	1 1-
19.....	1 1	1 1	1 1-	1 1-	1 1-	58.....	1 1	1 1
20.....	1 1	1 1	1 0	1 1	1 1-	59.....	1 0+	1 1-
21.....	1 1	1 1	1 0	1 1	1 1-	60.....	1 1	1 1
22.....	1 1	1 1-	1 0	1 1-	1 1-	61.....	1 1-	1 1
23.....	1 1	1 1-	1 0-	1 1-	.....	62.....	1 0+	1 1
24.....	1 1	1 1	1 1-	1 1	.....	63.....	1 0+	1 1
25.....	1 1	1 1	1 0	1 1	.....	64.....	1 1	1 0
26.....	1-1-	1 1	1 0	1 0	1 1-	65.....	1 0+	1 1
27.....	1 1	1 1	1 0	1 1	1 1-	66.....	1 0+	1 0
28.....	1 1	1 1	1 0	1 0+	1 1	67.....	1 1-	1 1
29.....	1 1	1 1	1 1-	1 1	1 1	68.....	1-0	.....
30.....	1 1	1 1	1 1-	1 0+	1 1	69.....	1 1-	1 1
31.....	1 1	1 1	1 1-	1 1	1 1	70.....	1 0+	1-0
32.....	1 1	1 1	1 0	1 0+	1 1	71.....	1 0+	1 0
33.....	1 1	1 1	1 0+	.....	1 1	72.....	1 1-	0 0
34.....	1 1	1 0+	.....	.....	1 1	73.....	.....	0 0
35.....	1 1	1 1	.....	.....	1 1	74.....	0 0	0 0
36.....	.....	.....	.....	.....	1 1	75.....	0 0	.....
37.....	1 1	.....	.....	.....	1 1	76.....	0 0	.....
38.....	1 0	.....	.....	.....	1 1	77.....	0 0	.....
39.....	1 1-	.....	.....	.....	1 1			

The ribs are not joined directly to the vertebra, but articulate with small masses of bone set in deep pits on the side of the centrum. Each of these has a concavity for the head of the rib.

According to Professor Cope, there are six vertebræ in the terminal caudal series,⁵² none of which, I am inclined to think, bore lateral grooves. They all, with the exception of the last, have broad surfaces below for the attachment of the hæmaphyses, which are modified into two surfaces, one behind the other, in next to the last vertebra. The last is a small tubercle

52. Cret. Vert. West, p. 199.

of bone with a quadrilateral face in front and a small spine projecting upward and backward behind. On the internal side there is a large, slightly concave facet, which has the appearance of having been united with a similar bone on the opposite side. All of these vertebræ are curved slightly upward.

Four of the hæmal spines from this region are present in one specimen. The two anterior of these are very similar, being broad, flat, and in contact with each other throughout. At the upper extremity of each there are two large, roughened, sutural surfaces for uniting the spine to the centrum. Between these two surfaces runs the small hæmal canal. The one following these two is not so flat but slightly thicker, and has the upper end expanded into a knob-like mass of bone. The articular surfaces have become conjoined and form a saddle-shaped articulation with the centra, the hæmal canal having become somewhat depressed. The spines following this have become modified into somewhat fan-shaped hypural bones. The upper extremities of these present convex condyles, which are probably received into pits on the last two vertebræ mentioned above.

There is one hæmal spine from somewhere in front of the caudal region which is of a different form from those described above. It is a Y-shaped bone with elongated and roughened articular surfaces on each of the arms for uniting it to the centrum. The hæmal canal is very large and below it the bone is rather thin.

The caudal fin-rays are represented by a mass of spines, only one of which is complete. The anterior of these are rod-like, but those following become expanded at the upper end, where they are longitudinally striated. These are followed by rays which are broader and probably shorter, on which the striæ just mentioned are more pronounced.

The neural spines are represented, in good condition, by only three or four from just back of the skull, some of which I have been able to fit to the vertebræ to which they belong. They all have knob-like expansions at the lower end which are received in the pits on the top of the centra. The two halves are in contact with each other above the neural canal and nearly or quite

so below. Extending backward from above the neural canal there is a somewhat expanded mass of bone which has an articular surface on the front of the arch following. These have a superficial resemblance to the zygapophyses of the higher vertebrates. Just opposite to this on the external side there are two more processes which extend outward and backward. These are what Professor Hay calls epineurals.⁵³ They are largest at the head and become much smaller at the fourth or fifth vertebra, and probably become insignificant or entirely disappear further back. The neural spines of these are directed upward and obliquely backward.

As we have no well-preserved neural arches farther back than those described above, I will quote Professor Hay's excellent description of the structure of these in the caudal region. Copies of his figures are given on plate XLII.⁵⁴ The neural arches here, as elsewhere in this fish, are connected with the centra by suture, and have usually fallen out before burial, leaving long grooves where their bases were inserted. This was the case with the third vertebra behind the right-hand one shown in fig. 1. When we come to examine the arches more closely, we discover that each lateral half is not a single piece, but consists of two pieces, a basal piece (*a, n, a*) and the arch proper (*n, a*). That the proper arch is a distinct piece is shown not only by the existence of a suture, but likewise by the fact that in the vertebra on the left hand of the figure the arch has fallen out of its place before fossilization. The basal or accessory piece is inserted by a shallow gomphosis into the centrum for nearly the whole length of the latter. It rises high in front, and projects so far forward as to come in contact with the basal piece of the next vertebra in front. Behind, the basal piece is directed upward and backward in a rather slender process, which abuts against the anterior edge of the basal piece of the next vertebra behind. It is thus seen that these basal pieces provide the anterior and posterior zygapophyses. They remind us of the articulating processes of certain other

53. Zool. Bull., vol. II, No. 1, p. 51.

54. See, also, Zool. Bull., vol. II, No. 1, pp. 47-51.

fishes (*Mugil*, etc.) Between the anterior and posterior processes the basal pieces are excavated to receive the bases of the neural arch, as shown in the figure. The two basal pieces of each vertebra are distinct. Together they seem to form a saddle in which the neural arch rides.

I find this same structure of the neural arches in some of the vertebræ belonging to specimens in the United States National Museum; but in one section of connected vertebræ an arch like those above is succeeded in the next vertebra by an arch in which every trace of a suture between the arch and the apparent basal piece is lost. This vertebra is shown in fig. 2. The form of the base of the arch is not greatly different from that of the arch with accessory piece in fig. 11,⁵⁵ and we may even convince ourselves that we can trace a part of the boundary line between the two portions. There is evidently at this point of the vertebral column a sudden change from neural arches furnished with basal accessory pieces to arches without these, or consolidated with them. Further backward the form of the arches becomes modified somewhat, so that they resemble the one shown in fig. 3. A section fourteen inches long and containing seven vertebræ having arches of this kind is before me. This condition shows us that the neural arches which are provided with basal pieces are confined to the anterior or middle portion of the tail region, while the hinder portion contains no such vertebral structures. We are reminded that in *Amia* the middle portion of the caudal vertebral column is composed of two for each muscular segment, while the anterior and posterior portions have the vertebral centra of the ordinary kind. It seems as if the tail portion of the vertebral column of the amioid fishes and of the Isospondyli retained primitive conditions longer than the abdominal portion.

It is difficult to determine what explanation is to be given of the presence of these basal pieces. The so-called zygapophyses of fishes are regarded as being outgrowths of the neural arches—exogenous and not autogenous processes. It might be said,

55. Fig. 11, in Professor Hay's article, refers to the pelvic actinosts, and seems to have no connection with the subject.

possibly, that the basal pieces are the proper arches, while the pieces which are borne on them are the spinous processes. I hold that there are two objections to this view. The first is, that what are sometimes called spinous processes are always unpaired pieces. The second is, that when the lateral halves of the arches remain distinct from each other and are prolonged into spines, as they are in various fishes—*Amia* and *Salmo*, for instance—the spinous portion is never, so far as we know, developed in the embryo as pieces separate from the base of the arcuala. This is true in the case of *Amia*, which I have investigated. We must, therefore, seek some other explanation. The key to the understanding of the problem is, it seems to me, to be found in the vertebral column of that primitive fish, *Amia*. We may call this fish to our assistance, since the Isospondyli are believed to have ancestors not far removed from *Amia*.

In the middle region of the tail of *Amia* there are, for each muscular segment, two vertebral rings, the one bearing the arches, upper and lower, the other archless. If a transverse section be taken through the arch-bearing ring, there will be found an X of cartilage, the upper arms of which are continuous with the cartilage of the neural arch. In like manner, the lower arms will seem to be continuous with the cartilage of the hæmal arch. If a section is made similarly through the archless disk, a similar X of cartilage will be found, but the arms project beyond the outer surface of the disk but a short distance. These archless disks are developed in *Amia* from ossifications arising in the intercalated cartilages, upper and lower, and the arms of the X are the unossified portions of these cartilages. There appears to be no reason why these intercalated cartilages should not sometimes take on a hypertrophied growth. In the sharks they often become considerably larger than the neural arches themselves.

In case these intercalated cartilages should become thus enlarged and arch-like, each might develop a bony investment that would simulate the bony neural half-arch, and thus would rest on the top its proper epicentrum.⁵⁶

56. For figures illustrating the architecture of the vertebral column of *Amia*, see the May number of the *American Naturalist*, 1893.

Coming now to the anterior region of the vertebral column of *Amia*, we find that each vertebra is formed through the suppression of certain of the elements which, in the tail region, constitute the vertebral rings or disks, and the union of the remaining elements of each muscular segment into a single mass. The lower intercalated cartilages are suppressed. The upper intercalated cartilages hypertrophy, and their ossifications unite with the bones developed in the bases of the lower arch, thus giving origin to the centrum. The ossification that we might expect to find developing in the base of the cartilaginous neural arch, the epicentrum, is absorbed, while the ossification of the enlarged intercalated cartilage, the pleurocentrum, pushes itself into the place of the epicentrum, and thereafter supports the neural arch.

Now, we have the choice of two suppositions, neither of which, however, may be the true one. We may hold that a distinct bone was developed in the somewhat elongated and projecting intercalated cartilage, and this, of course, rested on top of the pleurocentrum; when the latter was pushed forward beneath the neural arch to take the place of the aborted epicentrum, this newly developed bone was carried along, and thus brought between the pleurocentrum and the base of the neural arch.

Or, we may hold that the bone which I have found in *Xiphactinus* supporting the neural arch is simply the epicentrum itself, aborted, indeed, in *Amia*, nevertheless persisting in *Xiphactinus*, but crowded upward out of its original seat on the notocord.

Neither of the above suppositions presupposes that the upper half of the vertebral centrum takes its origin from the pleurocentrum. Professor Cope held that the vertebræ of fishes are "intercentra"—that is, have originated in the suppression of all the other elements through the excessive development of the hypocentra. But the very existence, in many genera, of a cartilaginous X in a transverse section of the centrum is proof that its upper portion was derived from either the bases of the upper arches or the pleurocentra. The deep gashes in the vertebral centra of *Xiphactinus*, where the arches have fallen out, furnish evidence that this cartilaginous X was present.

Xiphactinus lowii. Plate XLVIII, fig. 2.*Portheus lowii* Stewart., Kans. Univ. Quart., vol. VII-A, p. 24.

This species is based on the dentary bones of a single individual found at Fairbury, Neb., in the same horizon of the Fort Benton Cretaceous with *Desmatochelys lowii*, and was sent to the museum by Mr. M. A. Low, of Topeka, in whose honor the species is named. While this specimen has not been reported from Kansas up to the present time, yet it no doubt occurs here, as the same horizon from which it was obtained is found just across the line in this state. Special interest is attached to this specimen, as it is the first of this genus to be reported from so low a horizon as the Fort Benton.

The dentary is short, with a more oblique symphysis than in any other specimen of *Xiphactinus* that I have examined. It is also not so roughly marked at this point for the attachment of ligaments as in *X. audax*. The alveolar border is short, and does not have the prominent swelling just back of the symphysis which is found in the species just mentioned. The posterior extremity is projected upward into a short coronoid process, which is bent outward but slightly. The teeth are slightly oval in cross-section, acutely pointed, directed slightly backward at the extremities, and non-striate even under the microscope. Their arrangement is as follows: One large, two small, one large, ten or eleven medium and small. The number and arrangement will no doubt vary with the individual.

Length of alveolar border	177.0 mm.
Length of symphysis	79.5 "
Depth of bone just back of symphysis	65.0 "
Depth of dentary at middle	64.5 "

Xiphactinus brachygnathus. Plate XLV, figs. 3, 4.*Xiphactinus brachygnathus* Stewart, Kans. Univ. Quart., vol. VIII.

In addition to the forms described above, there is one specimen that I am unable to locate as *X. lestrio* or *X. mudgei*, described by Professor Cope. As has been shown above, Cope based most of the specific differences on very inconstant characters in his description of *X. molossus* and *X. thaumas*, and as he has used much the same characters in his description of the

two species mentioned above, I am inclined to think that these will have but little specific value until the type specimens of each are redescribed and figured in a way to render them recognizable.

The specimen, No. 155, consisting of the upper and lower jaws almost complete, fragments of the skull, and numerous vertebræ, was collected by Prof. B. F. Mudge from the Niobrara Cretaceous, four miles north of Gorham, Kan.

The premaxilla is somewhat oval in outline, and the anterior portion is thickened instead of the central, as is usually the case in *X. audax*. The posterior border is thin, and is peculiar in having the internal side of the bone beveled off to meet it, somewhat similar to that found in *Ichthyodectes* and *Saurodon*. The alveolar border is quite elongate, and supports three teeth on one side and an empty alveolus for a fourth, all of which are small, with the exception of one.

The maxilla is especially characterized by the manner in which it unites with the premaxilla, for instead of having the abrupt change to the laminar portion in front of the posterior condyle, the bone is gradually beveled off to a sharp anterior edge, similar to the condition found in *Ichthyodectes*. Both of the superior condyles seem to be small, and the anterior one is directed inward to a considerable extent. The two are well separated from each other. The bone is quite deep at the posterior condyle, and the superior border, back of it, presents a conspicuous groove for the attachment of the jugal. There are nineteen or twenty teeth on one side, the most of which are small or medium in size.

Premaxilla: Length of alveolar border	62.0 mm.
Greatest depth of bone.....	90.0 "
Maxilla: Length of alveolar border.....	220.0 "
Depth of condyle.....	83.5 "

The dentary bones are short and deep, thus giving them a very robust appearance. The bones are much thickened at the symphysis, and slope backward nearly as much as in *X. lowii*. The alveolar border is short and is remarkable for the small number and large size of the teeth toward the anterior extremity.

The arrangement is three large, two small, one large, and the twelve or thirteen medium and small. Many of the alveoli are empty, so the size of these teeth has to be estimated; the number of these, however, no doubt varies with the individual. The coronoid process is but poorly developed. The dermarticlar invades the dentary but little externally, and the cotyloid process of this bone is not so well developed as in *N. audax*.

Length of alveolar border.....	215 mm.
Depth of coronoid process.....	118 "
Length of symphysis.....	105 "
Depth of bone just back of symphysis.....	100 "
Length of bone from cotylus.....	270 "

There are fragments of several other bones, among which are the ethmoid, a prefrontal and palatine, and several vertebræ. The ethmoid is acutely pointed anteriorly, and the posterior suture is very dentate. The prefrontals are small, as are also the malleolar portions of the palatines. The external tuberosities of the latter are not so prominent as in *N. audax*. The vertebræ do not seem to differ materially from the species mentioned.

ICHTHYODECTES.

Cope, Proc. Am. Phil. Soc. 1870, p. 538.

This genus is so closely related to *Xiphactinus* that it does not need to be characterized, beyond pointing out some of the principal differences between the two forms. The teeth are more regular in size and never reach the enormous development of those in *Xiphactinus*. They are cylindrical in cross-section and are usually directed slightly inward at the apices.

As indicated by the size and dentition, this genus was much less ferocious than the form mentioned above, which no doubt preyed upon them to a great extent. The known American species, all from the Niobrara Cretaceous, Kansas, are:

<i>Ichthyodectes anaides</i> Cope.	<i>Ichthyodectes goodcanus</i> Cope.
<i>Ichthyodectes stenodon</i> Cope.	<i>Ichthyodectes acanthicus</i> Cope.
<i>Ichthyodectes hamatus</i> Cope.	<i>Ichthyodectes perniciosus</i> Cope.
<i>Ichthyodectes prognathus</i> Cope.	<i>Ichthyodectes cruentus</i> Hay.
<i>Ichthyodectes multidentatus</i> Cope.	

During the past summer, while collecting in the Fort Pierre group, at Lisbon, Logan county, Kansas, I discovered a string

of five vertebræ which I am inclined to think belong to this genus. They are about the same size as those of *I. anaides*, but, as there is nothing about them that would characterize them specifically, nothing more can be done with them until more complete specimens are found.

Ichthyodectes anaides. Plate XLIX, figs. 1-3.

Ichthyodectes anaides Cope, Proc. Am. Phil. Soc. 1871, pp. 339, 340.

This species is represented by the remains of several individuals, including the jaws, portions of the vertebral column, and one skull without the jaws, which probably belongs to this form.

The maxilla is represented in one specimen in a compressed and somewhat fragmentary condition, the posterior extremity being absent. The bone, as a whole, is about the same size as the maxilla of *I. cruentus*, but is much thinner in cross-section than in this form. The bone is moderately deep at the posterior condyle, which is slightly convex. Back of the condyle the superior border presents a sharp ridge which continues for some distance. Just back of the premaxillary surface the alveolar border is slightly concave and then slightly convex. The teeth are small, about 4.5 occurring to the centimeter.

Maxilla: Depth at posterior condyle.....	33 mm.
Thickness back of condyle.....	10 "

I am inclined to think that the dentary bone figured by Professor Hay⁵⁷ as that of *I. cruentus* belongs to this species. The bones are short and deep, with moderately sloping symphyses. There are also two convexities in the alveolar border, the posterior of which is not shown in Hay's specimen owing to this extremity of the border being absent. The coronoid process is not prominent, and the border seems to be very steep below and back of it. The teeth are large, directed slightly inward at the apices, and without striæ. The lower border is thin and has a number of large foramina just above it.

Dentary: Length of alveolar border.....	99 mm.
Depth of symphysis.....	41 "
Depth at coronoid process (estimated).....	59 "
Number of teeth in one centimeter.....	3

57. Amer. Jour. Sci., VI, p. 227.

The quadrate is thin and fan-shaped, and has the condyle bent forward to a considerable extent.

The skull that I regard as belonging to this species is much crushed, so that many of the sutures on the top cannot be made out. The otic region, however, is well shown. The ethmoid seems to have been rather blunt. The frontals are narrow, and each has a broad and prominent ridge which extends outward and forward from just in front of the supraoccipital and ends just above the prefrontals. They seem to have had supraorbital bones attached along the border. The prefrontal condyles are large, and the postfrontals are prominent and offer a considerable support for the hyomandibular. The pterotics are crushed beyond recognition above, but laterally the groove for the hyomandibular is very prominent. I am unable to make out the parietals in this specimen, but in another and much smaller skull I find no suture separating it from the pterotic, as figured by Crook,⁵⁸ and am inclined to think that the expanded portion of the supraoccipital represents the coalesced parietals, as has been suggested by Professor Hay.⁵⁹ The supraoccipital crest extends upward and backward at quite an angle, but the extremity is broken away. The epiotics are prominent and do not extend far forward. The prootics and opisthotics are very similar to those of *Xiphactinus*. The basioccipital is deeply concave and expanded in front of the condyle. The parasphenoid is bifurcated posteriorly, triangular in section, with rather small transverse processes in front of the brain-case.

So far as can be determined the vertebræ are all two-grooved, but near the posterior end of the column they become rather faintly marked. The neural spines are long and longitudinally expanded at their proximal ends. The caudal fin was much expanded and composed of large rays, which become flattened and longitudinally split toward the distal ends. The scales are large, with small grooves radiating outward from near the center on one of the sides.

58. *Paleontographica*, p. 92, pl. XV.

59. *I. c.*, p. 230.

Ichthyodectes hamatus. Plate XLVII, fig. 2; plate L, figs. 1-7.

Ichthyodectes hamatus Cope, Proc. Am. Phil. Soc. 1872, p. 340.

This species is represented by a fragmentary skull and anterior vertebræ of one individual and a portion of a dentary and a hyomandibular of another.

The maxilla is a long, slender bone, which is thickened along the superior border and rather thin along the inferior. The alveolar border is remarkable for the way in which it is directed downward anteriorly just back of the premaxilla. This border is concave from before backward, and supports alveoli for nearly fifty teeth, about half of which are functional at once. The surface for the premaxilla is directed inward and is coarsely striated. It is similar in many respects to *I. cruentus*, and the premaxilla was no doubt directed downward as in this species. The posterior superior condyle is irregular in outline, and has its internal portion continued downward on the inner side. The anterior condyle is rather small, directed inward, and separated from the posterior condyle by a long, smooth space. In front of this the anterior border descends almost vertically. The posterior extremity is expanded and directed slightly upward. The external surface is finely striated above, and covered with small pits just above the alveolar border. Unfortunately the premaxilla is not present.

Maxilla: Length of alveolar border.....	117 mm.
Depth of posterior condyle.....	30 "
Distance between superior condyles.....	20 "
Number of alveolæ in one centimeter.....	4

The condyle of the quadrate is elliptical in outline, and is not projected forward as much as in *I. ctenodon*. The groove for the symplectic is broad, and reaches downward to within 22 mm. of the condyle, below and back of which the bone is much thickened.

Only the upper portion of the dentary is preserved, which shows this part to be thicker in cross-section than in *I. anaides*. The anterior extremity of the alveolar border is produced upward into a hook-like process, from which character the species probably derives its name. This portion bears two teeth and is

directed slightly inward. The symphysis is much thickened and was about the same slope as that of *I. anaides*. Just back of the hook-like process mentioned above the alveolar border is somewhat excavated, and back of this slightly convex for a distance of 55 mm., when it is directed slightly upward. The teeth are closely set with elliptical crowns, the long axis of which is placed obliquely to the tooth line.

Dentary: Length of alveolar border (estimated).....	125.0 mm.
Length of long axis of cross-section of tooth.....	4.5 "
Length of short axis of cross-section of tooth.....	3.0 "
Number of teeth in one centimeter.....	3

The hyomandibular shows the anterior and posterior portions of the superior condyle to be more robust and the central portion to be more concave than in *Xiphactinus*. The condyle for the operculum is also proportionally longer and not projected backward so far as in the above. The groove for the preoperculum is deep.

Hyomandibular: Length of superior condyle.....	35 mm.
Length of condyle for the operculum.....	30 "
Total length of bone (estimated).....	115 "
Length of groove for the preoperculum (est.).....	93 "

The preoperculars are preserved in part. They are rather thick on the anterior border and are probably projected forward to the angle of the mandible below. Superiorly, there is a long, slender process of bone extending upward, which is much more prominent than in the corresponding portion of *Xiphactinus*. This portion is somewhat roughly striated externally. The remaining portion of the external surface is nearly smooth, excepting along the superior border, where there are numerous striae leading out to the border.

The malleolar portion of the palatine is rather thin in a vertical direction, resembling *I. anaides* somewhat in this respect. The inferior articular surface has the same general outline as the posterior condyle of the maxilla. Anterior to this, the bone is beveled off antero-superiorly, causing the prefrontal articular surface to be produced forward beyond the inferior. This surface is nearly flat. On the external side of the bone there is a prominent tuberosity.

The ethmoid is rather broad posteriorly and pointed anteriorly. The prefrontals are heavy masses of bone with large facets for the superior condyles of the palatines. The frontals are broad, and each has a prominent ridge extending from near the median line posteriorly, and curving outward to a point over the prefrontals. The parasphenoid is triangular, the base of which is below. The transverse processes are long and not very slender. The orbit is surrounded by quite a heavy ring of sclerotic bones.

The centra of several vertebræ are preserved. They are deeply concave and without lateral grooves in the anterior region. The more posterior vertebræ are grooved, and have the ribs attached to small processes of bone which fit into pits on the sides of the centræ.

***Ichthyodectes cruentus*.** Plate L, figs. 8a, 8b, 9, 10a, 10b.

Ichthyodectes cruentus Hay, Amer. Jour. Sci., vol. VI, 1898, pp. 225-228.

This species of *Ichthyodectes* has been recently established by Professor Hay from a fragmentary maxilla and a portion of a mandible supposed to belong with it, from the Butte creek region of western Kansas. Through the kindness of Professor Hay, I have been allowed to examine his type and compare it with a specimen of the same species in our collection, which fortunately is somewhat more complete than his.

The premaxilla is especially remarkable for its great depth and for the length of the alveolar border. The outer portion of the bone is very convex from before backward, especially so just above the alveolar border, where the bone is covered with minute canals, which give it a somewhat rugose appearance. The inferior third of the bone receives no support from the maxilla, thus causing it to be projected downward to a considerable extent. The bone becomes contracted in width superiorly, and bears an articular facet above, probably for the ethmoid. The lower portion of the anterior border is much roughened, probably for ligamentous union with its fellow on the opposite side. Alveoli for nine teeth are found, all of which are broken away.

The maxilla of this species is very similar in general form to that of *I. hamatus*, with the exception of being less slender and more robust. So far as can be seen, the superior border is nearly straight and much thickened, with a groove along the external side for the reception of the jugal. This border rounds off regularly into the internal. The condyle for the palatine is similar in form to that of *I. hamatus*, beneath which the bone is very thick. The anterior condyle is oval in outline and situated quite a distance from the last. The surface for the premaxilla is bent inward and is much roughened. The anterior border is very sharp and the lower is separated from the alveolar border by a prominent notch. This last border is very concave in the anterior portion and has a prominent hook-like projection extending downward in front, which is broken away in Professor Hay's specimen. The teeth are rounded in cross-section and non-striate under the microscope. Both the external and internal surfaces of the bone are finely striated.

Premaxilla: Greatest depth	50 mm.
Length of alveolar border	32 "
Maxilla: Depth at posterior condyle	31 "
Distance between superior condyles	21 "
Number of alveoli in one centimeter	3

Fragments of the dentaries show these parts to be remarkably thickened at the symphysis. At this point the alveolar border is directed slightly upward, forming a slight hook-like projection, below which the symphysis descends almost vertically.

Dentary: Greatest lateral width at symphysis	11 mm.
Number of teeth in one centimeter	3

This specimen, No. 180, was obtained from the Niobrara Cretaceous of Gove county by Mr. E. P. West some years ago.

***Ichthyodectes acanthicus* ?.** Plate LI, figs. 1-11.

Ichthyodectes acanthicus Cope, Proc. Am. Phil. Soc. 1878, p. 177.

This species, as described by Professor Cope, is the smallest member of the genus, but the description, as a whole, is so very meager that the species cannot be identified with any degree of certainty. There are two specimens in our collection which are much smaller than any of the other species described by Cope,

but I am far from certain that these belong to *I. acanthicus*. If they prove not to be this, I would propose the name of *Ichthyodectes parvus* for them.

The maxilla is long and slender, with the superior border moderately curved back of the posterior condyle. This condyle is slightly convex, and is invaded by a notch from behind. The surface for the premaxilla is bent inward to a considerable extent, and has a small tubercular condyle above and in front. The alveolar border is somewhat concave anteriorly, thin, and bears a row of teeth which do not seem to decrease much in size toward the posterior extremity. The teeth are cylindrical in cross-section, acutely pointed, and directed slightly inward at the apices. The premaxilla is thin and plate-like, with seven teeth on the alveolar border.

Premaxilla: Length of alveolar border.....	18 mm.
Maxilla: Depth at posterior condyle.....	19 "
Length of alveolar border (estimated).....	77 "
Number of teeth in one centimeter.....	8

Besides being smaller in size, the alveolar border does not have the two convexities found in *I. anaides*, but is convex in front and slightly concave in the middle and posterior portions. The symphyses are but slightly sloping and not much thickened. The coronoid process is poorly developed and the border back of it slopes gradually to the cotylus. The teeth are cylindrical in cross-section and directed slightly inward. The derm-articular extends well forward in a long, sword-shaped process which is very robust below. The antarticular is wedge-shaped and similar in general form to that of *Xiphactinus*.

Dentary: Length of alveolar border	75 mm.
Depth of symphysis.....	26 "
Depth at coronoid process.....	33 "
Number of teeth in one centimeter.....	4.5

Only the anterior portions of the palatines are preserved, which show the malleolar portions to be projected outward in a manner similar to that found in *I. hamatus*, but differs from this form in having them proportionally broader and not so deep. The articular facet for the prefrontal is the smaller of the two and is nearly flat, while the one for the posterior con-

dyle of the maxilla is slightly concave and much broader than the condyle articulating with it, thus forming a rather loose union.

There are numerous vertebrae present which show them to be two-grooved, and, with the exception of the difference in size, very similar to those of *I. anaides*. The pectoral fin is represented in a somewhat fragmentary condition, but enough of the rays are present to show that the upper ones are sword-like and but slightly less curved than in *Xiphactinus*. The pelvic actinosts are very similar in many respects to those of the genus just mentioned. The two halves are strongly sutured together in the median line, where the bones are massive for the support of the pelvic fin. The facets are obliquely set and are four in number on each side. The upper and lower of these are large and flat, while the two median ones are round and somewhat tubercular. Extending forward, both above and below, there are ridges of bone which are not so prominent as in *Xiphactinus*, which may have formed bars of bone on each side. External to these there are wing-like processes.

Ichthyodectes ctenodon. Plate XLIX, figs. 5-7; plate LI, figs. 12, 13.

Ichthyodectes ctenodon Cope, Proc. Am. Phil. Soc. 1870, p. 536.

There is one specimen, consisting of the mandibles, a portion of a maxilla, and other bones, which do not seem to differ materially from those of the specimen described and figured by Professor Cope. It evidently does not belong to any of the other American species, and for the present at least I will leave it here.

The dentary is about the same size as that of *I. anaides*, described above, but differs from this in the absence of the posterior convexity of the alveolar border. This border unites with the symphysis at an angle of about 75 deg., which is 10 deg. more than Cope describes of his specimen. There seems to be some discrepancy between Cope's description and figure, for in the latter the angle seems to be about the same as in our specimen, which evidently shows that Cope was wrong in one of the two. The teeth are large anteriorly but somewhat smaller posteriorly, round in section, non-striate, and directed inward.

Cope describes his specimen with the posterior teeth slightly larger than the anterior, which seems rather remarkable for this family. The posterior extremity of the maxilla shows this portion to be upturned, as Cope has indicated in his figure.⁶⁰

The quadrate has its condyle twisted forward until the face is almost in line with the anterior border. The upper border is straight and the groove for the symplectic narrow. The ceratohyal is concave posteriorly, convex and contracted in width anteriorly.

Dentary: Length of alveolar border.....	101 mm.
Length of symphysis.....	43 "
Length of crown, anterior.....	7 "
Number of teeth in one centimeter.....	3

This specimen was obtained from the Niobrara Cretaceous, five miles northeast of Russell Springs, Logan county, Kansas, by the geological expedition of the summer of 1898.

GILLICUS.

Hay, Amer. Jour. Sci., vol. VI (1898), p. 320.

The genus *Gillicus* has recently been proposed by Professor Hay, to include *Ichthyodectes arcuatus* Cope and *I. polymicrodus* Crook, which differ materially from the other species of *Ichthyodectes*, especially in the form of the teeth and tooth-bearing elements. Before entering into the description of this interesting form, it will be well to give a short *resume* of the discussion which has taken place over these two species, as is also done at some length by Professor Hay.⁶¹

In 1875 Professor Cope first described his *Portheus arcuatus* from some very imperfect remains from the yellow chalk of the Solomon river, Kansas. It is difficult to say just why Professor Cope first referred this to *Xiphactinus* (*Portheus*), as the dental and other characters are entirely different from that genus. Cope evidently discovered his mistake soon afterward, as he refers it to *Ichthyodectes* in 1877.⁶² Nothing more was done with this species until 1892, when Doctor Crook published his paper entitled "Uber einige fossile Knochenfische aus der mittleren

60. Cret. Vert. West, pl. XLVI, fig. 1.
61. I. c., pp. 228, 229.

62. Proc. Am. Phil. Soc., XVII, p. 177.

Kreide von Kansas," in which he described his *Ichthyodectes polymicrodus*. Shortly after this Professor Cope reviewed this paper in the *American Naturalist*,⁶³ and claimed that Crook's species is the same as the one already described by him as *I. arcuatus*. He further states that if it had not been for certain conditions, figures of this species would have been published, a statement which I think means that more characteristic parts would have been figured and described.

Cope was evidently in doubt about the specimen figured as *Ichthyodectes (Portheus) arcuatus*, as on plate XLVII of the "Cretaceous Vertebrata," he refers to it as ? *Portheus arcuatus*, while on the opposite page, in the explanation of the plate, it is *Portheus ? arcuatus*. Furthermore, on page 220 B of the same work, he refers to these figures of an unknown species of saurodont. Altogether I am inclined to think that Professor Cope's description and figures are for entirely different specimens, but the description, so far as it goes, does not seem to differ from the description and figures of *I. polymicrodus* of Crook.

When we take into consideration the fact that Professor Cope was able to recognize his species in Crook's description, and also that this form is so abundant in the chalk of western Kansas that it could hardly be missed by a party collecting fossil fishes for any length of time in that locality, I do not think we should hesitate to regard *Gillicus (Ichthyodectes) polymicrodus* Crook as a synonym of *Gillicus arcuatus* Cope. The characters in which *Gillicus* Hay differs from *Ichthyodectes* Cope are enumerated as follows by Professor Hay:⁶⁴ "While these forms can by no means belong to Cope's *Portheus (Xiphactinus* of Leidy), they can hardly belong to the genus *Ichthyodectes*. In the latter genus the maxilla is long, nearly equal to the distance from the tip of the vomer to the occipital condyle. The gape of the mouth must therefore have been large. In Doctor Crook's species and related forms the maxilla is short, between one-half and two-thirds the distance referred to above; hence the gape of

63. XXVI, p. 942.

64. Amer. Jour. Sci., vol. VI, p. 229.

the mouth must have been rather small. The maxillæ of typical species of *Ichthyodectes* are nearly straight along the tooth line, or sinuous, or, in *I. hamatus*, strongly concave. In *I. polymicrodus* the tooth line is strongly convex, except just behind the palatine condyle. The teeth of *I. polymicrodus* are numerous and feeble; in the other species, strong and in small number."

Gillicus arcuatus. Plates LII, LIII, and LIV.

Portheus arcuatus Cope, Cret. Vert. West., pp. 204, 274, pl. XLVII, figs. 7-9.⁶⁵

Ichthyodectes arcuatus Cope, Proc. Am. Phil. Soc. 1878, p. 177; Amer. Nat., vol. XVII, p. 942.

Ichthyodectes polymicrodus Crook, Paleonto., 1892, p. 112, pl. XVI.

Ichthyodectes arcuatus Cope, and *Ichthyodectes polymicrodus* Crook and Hay, Amer. Jour. Sci., vol. VI, p. 228.

This species is represented in the museum by the remains of three individuals with the skull in good condition, and fragments of several more.

The maxilla is a broad and thin bone, with the greater part of the alveolar border very convex. Just back of the surface for the premaxilla this border is directed sharply upward, forming a rather deep concavity near the anterior end, back of which it is gently curved. This border gives support to a single row of minute teeth, which are bent slightly inward at the apices. Doctor Crook says that twenty-four of these occur to the centimeter, in which I am inclined to think that he is mistaken, unless he intended it to apply to the posterior end, where the number will probably reach that many, but at the anterior extremity I have been unable to make out more than from seventeen to eighteen. The surface for the premaxilla is bent inward to a considerable extent and is separated from the alveolar border by a slight notch inferiorly. The condyle for the palatine is elliptical in outline, slightly convex, and elevated slightly above the rest of the bone. Professor Hay was able to distinguish some differences in the form of these condyles, as he says:⁶⁶ "In looking over my specimens it seems to me that I can observe characters that indicate two species. In one maxilla I find that

65. It is doubtful if these figures refer to this species.

66. Amer. Jour. Sci., VI, p. 229.

the posterior or palatine condyle is comparatively short, and has, in its hinder border, a distinct notch; in other maxillæ the condyle is longer and, apparently, without the posterior notch. The distance between the condyles appears to be greater in some cases than in others."

I have been unable to discover any such difference in any of our specimens, but, if this difference does occur, I think that it could not be called a specific character, as there is likely to be almost as much individual variation in *Gillicus* and *Ichthyodectes* as in *Niphactinus*, in which the variation is remarkably great. The superior border of the bone, back of the condyle, is slightly concave and presents a slight shelf, which probably accommodates the jugal. Unfortunately the premaxilla is preserved with none of the specimens, nor has it been found with any of the specimens described by other authors. It was, no doubt, a very small and light bone, thus easily washed away when the soft parts disintegrated.

Maxilla: Length of alveolar border (estimated)..... 97 mm.
Depth at posterior condyle 24 "

The dentaries are remarkable for their short length and great depth. The symphysis is very deep, almost vertically directed, and smooth. Just back of it on the internal side there is a broad, shallow and somewhat elliptical-shaped pit, similar to the one found in *Saurodon* and *Saurocephalus*. The alveolar border presents a slight convexity near the anterior end, back of which it is slightly concave. The teeth are all very small and form a fringe on the edge of the jaw. The coronoid process is not developed at all, and the lower border is very sharp. Posteriorly the bone descends very abruptly to the symphysis.

Dentary: Depth at symphysis..... 45 mm.
Length of alveolar border..... 55 "
Length of mandible from cotylus..... 81 "

The ceratohyal is preserved in one specimen. It is very thin, much contracted at the center, and expanded at the ends, the posterior of which is concave and the anterior convex.

The palato-quadrate arch is represented by the palatine, mesopterygoid, pterygoid, and quadrate. The palatine consists

of a broad, thin posterior plate and the malleolar portion. This latter is somewhat deeper than in *Ichthyodectes acanthicus*, and does not have a tuberosity on the external side. The two portions of the bone are separated by a constricted neck. Nothing more can be said of the mesopterygoid than that it is a very thin bone.

The quadrate is very deep, as might be expected from the corresponding depth of the mandible. The upper portion is very thin and has a slight groove on the internal side for the symplectic. The condyle is very convex and directed well forward. The upper border seems to be nearly straight and probably unites with the metapterygoid in a manner similar to that found in *Xiphactinus*. The preoperculum is very thin, broad below, and narrow above.

The ethmoid is very similar to this bone in *Xiphactinus* and *Ichthyodectes*, being formed into a beak anteriorly, and thin, and united with the frontals by a dentate suture posteriorly. The frontals are separated by a well-marked non-dentate suture, which is shown throughout its length in one of the specimens. Over the orbital cavities the bones are somewhat thickened, and evidently gave attachment to a chain of supraorbital bones, as in *Xiphactinus*. Posteriorly they unite with the postfrontals, parietals, and probably the pterotics.

As there has been some doubt as to the exact position of the parietals and pterotics, I quote the following paragraph from Professor Hay,⁶⁷ which seems to me to be the correct explanation of these parts:

"Crook has interpreted the bones of the posterior upper region of the skull of his *I. polymicrodus* as he has those of *Portheus* (*Xiphactinus*); but, as in the case of the latter, I am compelled to differ with him. However, many of the sutures are very difficult to demonstrate. According to Crook, the supraoccipital is greatly expanded in front, while the parietals lie laterad to the epiotics. It seems to me that the supposed expanded portion of the supraoccipital is really the area belonging to the parietals. There is a very distinct fold running along

67. Amer. Jour. Sci., vol. VI, p. 230.

the hinder border of the expansion, and this, continuing up to the midline, has the appearance of a suture. In the crushed specimen before me there is, along the middle line of the expansion, a break in the bone, but whether due to a fracture or to the parting of the bones along a suture I cannot determine. Possibly the parietals were coossified along the midline."

As to Crook's parietal, I cannot convince myself that there is any suture cutting off the area assigned to it from that assigned to the pterotic. I regard as pterotic the whole area extending from the posterior external angle of the skull to the lateral expansion considered by Crook as supraoccipital.⁶⁸

In one of the specimens before me the portion under consideration above is so well marked that there can be no more doubt that the expanded portion called supraoccipital by Crook is a separate and distinct bone, *which is not separated by suture in the middle line*. The portion called parietal by the same author often has numerous cracks running through it, which will easily lead one to believe that they are sutures.

The prefrontals are small, triangular-shaped bones which lie below the frontals and give attachment to the palatine, as in *Xiphactinus*. The postfrontals form prominent processes, and are somewhat irregular in form. They form the posterior boundaries of the orbits, and present grooves externally which support about one-fourth of the upper faces of the hyomandibulars.

The parasphenoid is completely preserved in three specimens. It is more slender than in either *Xiphactinus* or *Ichthyodectes*, and is quadrilateral in cross-section, instead of triangular, as in the forms mentioned. The transverse processes seem to be well developed, just back of which there are very thin lateral processes which extend upward to the prootics, just beneath which the bone is strongly bent at an angle of about 55 deg., thus giving a strong upward direction to the anterior portion of the skull.

The sclerotic ring is unusually large for the size of the specimen, the distance across the orbit being 37 mm., a distance

68. See Crook's fig. 5, pl. XVI, *Sq.* and *Pr.*

which is even greater than in *Xiphactinus*. The bones are very thin.

One specimen has fifty-seven vertebræ preserved, and there are probably several more missing. So far as can be determined, this specimen was at least four feet in length, and, judging from the skull, it does not seem to be larger than the other specimens.

SAURODONTIDÆ.

The characters that separate this family from the *Ichthyodectidæ* are found in the presence of a prementary in the mandible and in the form and manner of succession of the teeth. In other respects the skull is very similar to that of the *Ichthyodectidæ*, except that it is likely that *Saurodon* possesses a tooth-bearing element not found in this family. The prementary is a long, triangular element, pointed at the extremity, and was used as a weapon of offense. Contrary to what would be expected, this bone is not paired, and is also edentulous in both genera of this family, *Saurodon* and *Saurocephalus*. Doctor Crook⁶⁹ has removed one of these genera, *Saurocephalus*, to the family *Pachycormidæ*, the reasons for which are :

“Das Dentale hat andere Proportionen als dasjenige von *Ichthyodectes* und *Porthus* [*Xiphactinus*] indem es viel niedriger und gegen die zahntragende Oberfläche dicker wird. Die maxilla ist mehr dick als tief, die Præmaxilla dreieckig und lang, die längste Seite als zahntragender Rand ausgebildet. Sie ist so gänzlich verschieden von denjenigen der anderen Glieder dieser Familie, dass dies Merkmal allein genügt, um *Saurocephalus* einer anderen Gruppe zuzuweisen. Diese Annahme wird noch mehr bestätigt durch den Charakter der Maxilla und des Dentale, die Foramina und die Art und Weise der Aufeinanderfolge der Zähne. Auf Grund der Gleichartigkeit der Zähne und der ausserordentlichen Ähnlichkeit der Præmaxilla mit derjenigen von *Protosphyræna* dürfen wir *Saurocephalus* bis auf weiters in die Familie von *Protosphyrænidæ* einreihen.”

Concerning the above, I would say that I have been unable to recognize the great similarity between the premaxillæ of the

69. Paleontographica, 1892, p. 120.

two genera from the specimens in the museum. Furthermore, if *Saurocephalus* were removed to another family, *Saurodon* would have to follow, as the two genera are too closely allied to be far separated from each other, and the absence of the long rostrum, paired and toothed prementary, and the presence of more than one row of teeth on the maxillæ and mandibles would preclude any close relationship with the family to which he refers it. I think the two genera should be placed in a distinct family, as has been done above.

Revised synopsis of the *Saurodontidæ*:

Foramina below the alveolar border internally.

Teeth with short compressed crowns *Saurocephalus*.

Deep notches below the alveolar border internally.

Teeth with subcylindric crowns *Saurodon*.

SAURODON.

Hays, Trans. Am. Phil. Soc., 1830, p. 476.
Cope, Proc. Acad. Nat. Sci. Phil., 1873, p. 339.

In the year 1830, Doctor Hays⁷⁰ described the genus *Saurodon* from a portion of a skull and jaws from the Marl of New Jersey. He also examined the type specimen of *Saurocephalus*, described by Doctor Harlan⁷¹ six years before, and decided that the two genera were synonymous, and, as Doctor Harlan's genus was founded upon erroneous characters, the name *Saurodon* should take precedence over it. In 1856 Doctor Leidy⁷² re-described both of the above specimens and decided that the name *Saurodon* should be abandoned and *Saurocephalus* used instead. Nothing further was done with either of these forms until 1873, when Professor Cope added the genus *Daptinus*, which he later recognized as a synonym of *Saurodon*.

The exact date of Professor Cope's retraction I have been unable to exactly determine, but it was probably not until after 1878, as during this year Mr. E. T. Newton⁷³ described a fish from the Lower Chalk of Dover and provisionally placed it in *Daptinus*. A little later in the same year, Mr. Newton published another paper⁷⁴ in which he carefully goes over the

70. Trans. Am. Phil. Soc., vol. III, p. 471.

71. Jour. Acad. Nat. Sci. Phil., vol. III, p. 331.

72. Quart. Jour. Geol. Soc., 1858, No. 135, p. 439.

73. Trans. Am. Phil. Soc., vol. XI, p. 91.

74. I. c., No. 136, p. 786.

ground, and finally concluded, as Doctor Leidy had already done, that the name *Saurodon* should be no longer used.

It has since been shown that there are two distinct genera, the differences being found mainly in the more slender mandible and the occurrence of deep notches instead of foramina at the bases of the crowns of the teeth in *Saurodon*. There is also some difference in the shape of the teeth in the two forms.

Below is given a list of the known American species :

Saurodon leanus Hays, Marl. New Jersey.

Saurodon phlebotomus Cope, Niobrara Cretaceous, western Kansas.

Saurodon broadheadi Stewart, Niobrara Cretaceous, western Kansas.

Saurodon xiphrostris Stewart, Niobrara Cretaceous, western Kansas.

Saurodon ferox Stewart, Niobrara Cretaceous, western Kansas.

***Saurodon phlebotomus*.** Plate LVII, figs. 4 and 5.

Daptinus phlebotomus Cope, Cret. Vert. West, p. 213.

Saurocephalus phlebotomus Cope, Proc. Am. Phil. Soc. 1870, p. 530;
Hayden's Ann. Rep. U. S. Geol. Surv. 1871, p. 416.

There are remains of several specimens of this species, including the jaws, vertebræ, and portion of one skull, in the museum.

The maxilla is more slender than in *S. broadheadi*, and the surface for the premaxilla is bent inward very strongly, although this may be due to distortion. The alveolar border is nearly straight, and has alveoli for twenty-nine subcylindric teeth, which have the characteristic notches for nutrient vessels at the base of each. The posterior extremity of the border is edentulous, curved slightly upward. The condyle for the palatine is not elevated as in *Xiphactinus*, and is flatter than in *Saurocephalus*. The internal side of this condyle is invaded by a slight notch, which is absent in *S. broadheadi* and *S. ferox*. The anterior condyle is broken away, but it seems to have been elevated upon a slight pedestal, and was probably very small. The upper portion of the bone is striated; the lower portion, just above the alveolar border, is covered with numerous punctations.

The dentary is slender, and the symphysis is not so straight as in *Saurocephalus dentatus*, but is slightly convex in front, without the prominent bony tubercles which are so pronounced on

the internal side of the symphysis of the form just mentioned. Back of the symphysis there is a slight concavity in the alveolar border, just over the large shallow pit at this point. This pit, which is probably for the Mento-Meckelian ossicle, is much smaller than in *Saurocephalus* and the swelling above it is less pronounced. The alveolar border supports thirty-six teeth, the anterior ones of which are very small and the posterior ones about twice the size of those on the maxilla. The crowns are subcylindric, knife-like, and extend nearly to the coronoid process, which is rather weak, and not curved upward and outward as in *Xiphactinus*. The lower border of the bone is very thin, with numerous fine striæ extending obliquely upward and forward on both the external and internal sides.

The articular portion is divided into the dermarticular and antarticular portions. Owing to the crushed condition of the specimens these portions cannot be made out with certainty, but seem to be very similar to the same parts of *S. ferox*, described below. The prementary is not preserved in any of the specimens.

Maxilla: Length of	96.0 mm.
Depth at center.....	25.0 "
Length of palatine condyle.....	11.5 "
Number of teeth in one centimeter, 5.	
Length of crown.....	4.0 mm.
Breadth of crown.....	2.3 "
Depth of bone at palatine condyle.....	30.0 "
Mandible: Length of bone from cotylus.....	116.0 "
Depth of symphysis.....	26.0 "
Depth at coronoid angle.....	41.0 "
Length of alveolar border.....	92.0 "
Number of teeth in one centimeter, 4.	

Saurodon broadheadi.

Daptinus broadheadi Stewart, Kans. Univ. Quart., vol. VII, pp. 24, 25.

This species was established upon the left maxilla and one of prementaries found in Wallace county, Kansas, collected by Mr. Geo. W. Cooper. The catalogue number of the specimen is 212.

The maxilla is less elongate and ends more abruptly than in *Saurocephalus*. The anterior border slopes forward more obliquely than in *Xiphactinus*. The premaxillary surface is continuous

with the outer surface of the maxilla and is provided with numerous small protuberances, which probably fit into corresponding depressions in the premaxilla. It is seen from the above that the premaxilla is not so immovably fixed as in *Xiphactinus*, where this bone fits into a deep depression on the maxilla and has a thin lamina of bone extending forward nearly to the anterior extremity, which gives it additional support. The ramus is thin above and thickens but slightly at the alveolar border. The bone does not materially thicken below the palatine condyle as in *Xiphactinus*, and the anterior condyle is situated much nearer to it than in this form. The palatine condyle is elongated, elliptical, nearly flat, and does not have the internal notch found in *S. phlebotomus*. The teeth are closely set, with compressed, knife-like crowns and smooth enamel surface, appearing very slightly striated under the microscope. Alveoli for thirty-one are found, below each of which there is a deep notch, characteristic of this genus.

A prementary was found on the same slab with the above which has the form of the prementary of *Saurocephalus*. It is short and triangular, the posterior surface of which is very rough for cartilage, binding it to the symphysis. The upper border is edentulous, the lower thin and sharp, and the two meet at quite an acute angle in front.

Maxilla: Length (estimated).....	122.0 mm.
Depth at center.....	37.0 "
Depth at palatine condyle.....	44.0 "
Number of teeth in one centimeter, 3.5.	
Prementary: Length (estimated).....	30.0 mm.
Depth at symphysis.....	28.5 "

Saurodon xiphrostris. Plate LV.

Saurodon xiphrostris Stewart, Kans. Univ. Quart., vol. VII, p. 178.

This specimen consists of a skull crushed obliquely, the centra of several vertebræ, and also a portion of a shoulder girdle in a very bad state of preservation. The specimen is of nearly the same size as that of the type of *Saurodon (Daptinus) broadheadi*⁷⁵ described by myself.

75. Kans. Univ. Quart., vol. VII, pp. 21-29.

The maxilla is short and deep, the depth not being as great as in *S. broadheadi*. The alveolar border is nearly straight and has alveoli for about thirty-one teeth, which are about the size of those described in the above species. The posterior extremity cannot be examined, as there is a suborbital bone covering this portion on each side of the skull, but it is probably very similar to that of the figures of *Saurodon ferox* described below. The superior border is sharp, and gives attachment to some bone, probably a suborbital or jugal. The palatine condyle seems to be very similar to that of *S. broadheadi* already described. The bone, just above the alveolar border, presents a somewhat shagreened appearance. Farther than this, there seem to be no characteristic markings upon the external surface. As the maxilla is firmly attached to the skull, the internal surface cannot be examined.

The premaxilla is plate-like, and nearly twice as deep as broad. The superior border is irregular and presents no condyle at this point. The external markings are very similar to those found in *Saurocephalus dentatus*, and the bone is directed more obliquely backward than in that form. The anterior border is directed sharply inward, giving the external surface of the bone a very convex appearance. This border is very rugose, probably for ligamentous union with its fellow of the opposite side. The alveolar border is very convex, and has alveoli for twelve teeth, which are of about the same size as those on the maxilla.

Maxillary: Length of alveolar border (estimated)	82 mm.
Depth at palatine condyle	33 "
Number of teeth in one centimeter, 4.	
Premaxillary: Greatest depth	50 mm.
Greatest length	30 "
Length of anterior border	30 "

In the mandible is found one of the chief characters that separate this genus from *Saurocephalus*; instead of the upper and lower jaws terminating at about the same vertical plane as in the other member of the *Saurodontidae*, the mandible projects fully an inch beyond this point. The dentary is long and slender throughout; in *Saurocephalus* it is short and deep.

This difference is well illustrated by comparing the types of *Saurocephalus dentatus* and *Saurodon ferox*; the maxilla of the first is considerably longer than that of the second, but with the dentaries the reverse is the case. Only a small portion of the dentary can be seen, as most of the external and superior portions are hidden by the overlying maxillæ. The bones are irregular and shallow at the symphysis and seem to have given strong attachment for the prementary. The lower border is thin and sharp. Only twenty-seven millimeters of the alveolar border can be seen in the specimen, upon which the teeth are small and twelve in number. At the base of each tooth is found the deep notch for the nutrient vessels, so characteristic of this genus. As the articular portion does not seem to differ materially from that of *S. ferox*, its description may be deferred.

Contrary to anticipations, there is but one prementary, as is proven by the discovery of all of the parts in place. It is long and slender, triangular in outline, with a broad, elliptical articular surface at the posterior extremity. When this element was first made known⁷⁶ in this genus, I was under the impression that it was paired, which is not the case. This slender projection was no doubt used as a weapon of offense, analogous to the rostrum of *Protosphyræna*. In connection with the description of *Saurodon broadheadi*⁷⁷ I figured a prementary of an entirely different form from the above, which was found on the same slab with the maxilla described; the form is the same as that found in *Saurocephalus*. Whether the two bones belonged to the same individual or not only future discoveries can determine. After carefully comparing the type of *S. dentatus* with that of the species under consideration and *S. ferox*, I am convinced that there is but one prementary in the mandible of this form, as one would expect from the great similarity of the two genera.

Mandible: Length from cotyloid cavity	155 mm.
Depth at symphysis.....	23 "
Number of teeth in one centimeter, 4.5.	
Prementary: Length (estimated).....	73 mm.
Depth of symphyseal surface.....	23 "
Width of symphyseal surface.....	12 "

76. Kans. Univ. Quart., vol. VII, p. 24.

77. l. c., pl. II.

The ethmoid is broad and flat posteriorly, becoming thickened and pointed at the anterior extremity. The lower surface cannot be seen, but it probably is not materially different from that of *Ichthyodectes*. In Prof. E. T. Newton's description of *S. intermedius*⁷⁸ he says, concerning this part: "Anterior to the frontals, upon the upper surface of the skull, there are two bones (fig. 2) separated by a median longitudinal suture; towards the front of these an osseous band passes across at right angles, obliterating the suture." In our skull I am unable to detect any indication of a suture at this point such as is shown in the figure referred to above. I have also examined all of the specimens of *Xiphactinus* and *Ichthyodectes* in the museum, and find no trace of such a suture in any of them. It seems probable to me that the skull described by Mr. Newton was of a younger individual than are any of ours.

The frontals are broad, flat bones extending from the ethmoid, with which they are united by a squamose suture, back to the parietals. Laterally, they form the superior borders of the orbits. In the median line they are separated by a suture. The bones are probably in contact with the supraoccipital, but, owing to the crushed condition of this region, this point cannot be definitely determined.

The parietals (?) are small elements in contact with the pterotics and epiotics posteriorly. They are probably very similar to this portion of *Xiphactinus* and *Ichthyodectes*, although this region of the skull is so crushed as to render the determination of this portion somewhat difficult. There seems to be a faint suture between the pterotic and sphenotic. The epiotic does not seem to be produced as far backward in this species as in *S. intermedius*, figured and described by Mr. Newton.⁷⁹ They are heavy projections of bone, and form the inner lateral processes of the skull as in other members of the *Sauroidontidae* and *Ichthyodectidae*. Mr. Newton⁸⁰ seems somewhat in doubt about the bones in this region and is unwilling to accept the bone called parietal by Professor Cope, stating, for his reason, that the lines

78. Quart. Journ. Geol. Soc., vol. XXXIV, No. 135, p. 444, pl. XIX.

79. l. c., p. 444, pl. XXXIV.

80. l. c., pp. 444, 445.

indicative of the direction of growth were from the extreme posterior angle of the skull, instead of from the anterior portion, as we would expect if this bone were the parietal. In skulls of *Xiphactinus*, *Ichthyodectes*, and *Gillicus*, before me, I find the same condition, which seems to confirm Mr. Newton's idea. Recently Professor Hay⁸¹ has shown wherein Professor Cope was wrong in his identification of this part of *Xiphactinus* and *Ichthyodectes*, and, as the top of the skull as a whole seems to be very similar to that of the two genera mentioned, I have no doubt but that the same explanation will apply to *Saurodon*. The pterotics are large bones and seem to be very dense in structure.

The supraoccipital is very much crushed and partially broken away, but enough remains to show that the bone was raised into quite a prominent crest. It extends backward beyond the points of the epiotics, a condition different from that described by Newton.⁸² It probably does not join the frontals in front, the parietals intervening.

The orbit is somewhat smaller than in *Ichthyodectes* and is surrounded by a thin ring of sclerotic bones similar to that found in the genus just mentioned. Just in front of the orbit there is a small triangular bone attached to the frontal above, which I take to be a preorbital. The same bone is figured by Newton⁸³ but not named or described by the author. Just in front of this there is a long slender bar of bone, which seems to articulate somewhere in the palatine region. On one side the anterior end is crushed down to near the posterior condyle of the maxillary, but on the other side it fits in just back of the superior condyle of the palatine, and as a palatine of another specimen shows a sutural surface at this point, I think it not unlikely that this is the correct position of the bone. This may be the bone that Newton⁸⁴ figured as a "nasal bone," (?) although it is of an entirely different shape from that shown in the cut of his specimen. The bone Newton calls "jugal" (?) I am inclined to think is one of the suborbital bones, as found

81. Zool. Bull., vol. II, p. 28.

82. l. c., p. 444.

83. l. c., p. 444.

84. l. c., pl. XXXIV.

in *Xiphactinus*, especially as there seems to be a suture indicated between this and a bone just above which articulates with the jugal (probably a suborbital) above.

Owing to the crushed condition, the prefrontals are almost entirely covered by the ethmoid and frontal. The description of the palatine will be given with the next species. Parts of the operculum and preoperculum are present. The first is a broad flat plate of bone which articulates with the hyomandibular in a manner similar to that found in *Xiphactinus* and *Ichthyodectes*. The anterior border of the preoperculum is deeply concave, the anterior inferior extremity reaching forward to the angle of the mandible. The hyomandibular of this species is not visible.

The vertebræ are deeply concave, with deep grooves closely situated above for the neural arches. The ribs articulate with small ossicles set into pits on the side of the centrum. Just above these ossicles there is a deep pit on each side.

A part of the shoulder girdle, including a fragmentary fin, is present. The fin seems rather small.

The skull as a whole is especially remarkable for the extreme length of the mandible, and also the long prementary in front. This portion probably had a dermal covering similar to that covering the sword-fishes' sword, and was no doubt used as a weapon of offense. In an animal with such a weapon as this we might expect to find powerful fins, but this is not the case with this species. In other respects the skull does not materially differ, excepting in details, from the skull of other members of the *Saurodontidae* and *Ichthyodectidae*.

The type of this species was found in Gove county, Kansas, by Mr. H. M. McDowell, who presented the specimen to the museum.

Saurodon ferox. Plates LVI and LVII.

Saurodon ferox Stewart, Kans. Univ. Quart., vol. VII, p. 183.

This species is represented by the jaws, including the prementary, and other disarticulated bones and vertebræ.

The maxillary is larger than the one just described. The

posterior condyles above are somewhat elliptical in outline and but slightly convex from before backwards. Just anterior to this there is a large protuberance, which may support a condyle above, and on the external side of this there is a small facet, which probably gives articulation with the ethmoid. The surface for the premaxillary is very irregular and is directed inward, becoming thinner toward the anterior border, which is sharp. The superior border is strongly concave and sharp, and presents a sutural surface on the external side, probably for a jugal. The alveolar border is convex and has alveoli for forty or forty-one teeth, which are non-striate and knife-like. Each tooth has the characteristic notch at the base. The posterior extremity at the bone is very shallow and turned slightly upward. Aside from the shagreened surface of the bone above the alveolar border the external surface has no characteristic markings.

The premaxillary is very similar to that of the species described above, except that there are ten instead of twelve teeth. On the internal side, the bone is beveled off toward the posterior border in order to fit the surface for its reception on the maxillary.

Maxillary: Length of alveolar border.....	115 mm.
Depth at condyle for palatine	45 "
Greatest length of bone.....	128 "
Number of teeth in one centimeter, 3.5.	
Premaxillary: Depth.....	60 mm.
Length.....	32 "

The dentary is elongate and slender. The alveolar border is slightly incurved at the symphysis and supports forty-six teeth, similar in form but about twice as large as those upon the maxilla. Just back of the last tooth there is a slight coronoid process, somewhat similar to that found in *Xiphactinus*. The symphysis is very similar to that found in the last species described, and has a long, slender pit just back of it on the internal side. It is more elliptical than the corresponding pit in *Sauropscephalus*. The lower border of the bone is sharp.

The dermataricular supports only a small portion of the cotylus, in the lower portion of the cavity. It sends a long, sword-shaped

process forward internally, but does not encroach much upon the dentary externally. Posteriorly it sends a lamina of bone backward, which I think would be well named the cotyloid process, as in most of the genera of this family it is the only portion of this bone which articulates directly with the quadrate. Just beneath the cotyloid process there is a prominent angle.

The antarticular is a small element not extending forward beyond the sixth posterior tooth, and is fitted into a groove in the dermarticular. It supports nearly the whole of the cotylus, which is somewhat elliptical and concave from above downward. The prementary is not so elongated, but is slightly deeper than in the species described above.

Mandible: Length of alveolar border	149 mm.
Length from cotyloid cavity	174 "
Depth at symphysis	27 "
Depth at coronoid	46 "
Number of teeth in one centimeter, 3.	
Prementary: Length	55 mm.
Length of symphyseal surface	24 "

The quadrate is a broad, fan-shaped expansion. The condyle is elliptical in outline and convex. Extending upward from the condyle on the external side there is a ridge, which ends above in a deep notch, which accommodates a portion of the symplectic. This groove continues downward on the internal side for more than one-half the depth of the bone. The posterior border has a very slight groove, and extends upward the whole extent of the symplectic. The superior border probably articulates with the pterygoid and metapterygoid, as in *Xiphactinus*. The anterior border is sharp. Both the external and internal surfaces are covered with minute striæ radiating upward from the condyle. The symplectic is a long, slender element. The upper end presents an articular surface similar to that found on the superior border of the quadrate.

The whole of the palatine is preserved. It is an irregular-shaped bone, presenting a ragged sutural surface above and below for the pterygoid and mesopterygoid. The bone is especially remarkable for the great depth of the malleolar portion, being

nearly half as deep as the corresponding part in *Xiphactinus*. The superior articular surface is small and oval in outline, while the lower is larger and more elliptical. The depth of the malleolar portion is 20 mm.

The hyomandibular is very similar to that found in *Ichthyodectes*. The superior condyle is elongated, and depressed in the central portion. In the skull of *S. intermedius*, figured by Newton,⁸⁵ this condyle is shown to be regularly rounded from before backward. As all the figures and descriptions of the hyomandibular of this family and the *Ichthyodectidæ* show the depression described above, I am inclined to think that this portion may have been distorted in the specimen figured by Mr. Newton. Extending downward from the anterior and posterior angles there are two slight ridges, which converge toward the center and form a much larger one, which extends downward to nearly the lower extremity of the bone. It forms the outer border of the groove for the preoperculum. There is also another ridge on the internal side, just in front of the condyle for the operculum, but it is not so prominent as the one just mentioned. The condyle for the operculum is elongated, as in *Ichthyodectes*.

The lower extremity of the bone presents an articular surface similar in size and character to that found at the upper end of the symplectic. I think it is very likely that these two bones articulate at this point.

A small portion of a scapula is preserved. It shows only two distinct articular condyles, one large and one small, instead of three, as in *Xiphactinus*. Portions of several spines are preserved, of which one complete and a portion of another are shown in the figure and need no further consideration.

The first anterior vertebra has the posterior end deeply concave, but the anterior end is not so deep, and has a slight protuberance projecting forward above. On the superior surface there are two deep, rounded pits for the neurapophyses; aside from this there are no other grooves displayed upon the centra.

A small toothed element was found on the internal side of one

85. l. c., pl. XXXIV.

of the maxillæ at about the point where the pterygoid should lie, but it is too large to be a portion of this bone. There are nine teeth upon it, which are about the size of those on the anterior portion of the maxilla.

The type of the above was found in Gove county, Kansas, by Mr. W. O. Bourn, of Scott, Kan., who loaned it to the University for study.

SAUROCEPHALUS.

Harlan, Jour. Acad. Nat. Sci. Phil., vol. III, p. 337.

Saurocephalus is similar in many respects to the genus just described. Unfortunately the skull has never been found in either this country or England, but from the great similarity of the jaws to those of *Saurodon* a close relationship in general structure to this form can be expected. In *Saurocephalus* the mandibles are not so slender as in *Saurodon*, and do not project forward as in this form. There are distinct foramina instead of deep notches below the alveolar border internally, and the teeth have very short and compressed crowns instead of the subcylindric, knife-like crowns of *Saurodon*.

Thus far four species have been described from America, as follows:

Saurocephalus lanciformis Harlan, Cretaceous, Missouri river.

Saurocephalus arapahovius Cope, Niobrara Cretaceous, western Kansas.

Saurocephalus dentatus Stewart, Niobrara Cretaceous, western Kansas.

Saurocephalus pamphagus Hay, Niobrara Cretaceous, western Kansas.

Thus it is seen that only three species have thus far been discovered in this state, of which one, *S. arapahovius*, was founded upon only a small portion of a maxilla which presents but few characters that can be called specific. It is very hard to refer specimens to this species with any degree of certainty, and I am inclined to think that it may prove to be a synonym of *S. lanciformis*.

***Saurocephalus dentatus*.** Plate LVIII, 3a and b, 4a and b.

Saurocephalus dentatus Stewart, Kans. Univ. Quart. vol. VII, pp. 25-27.

This species differs from *S. arapahovius* in having the teeth slightly striated and never overlapping on the maxilla. It is also a slightly larger form. It was established upon the left

maxilla, premaxilla and mandible of one individual and the left mandible of another, and was collected from the Niobrara Cretaceous of Wallace county, Kansas, by Mr. E. P. West. The catalogue number of the specimen is 82.

The maxilla is much larger and more elongated than in *S. broadheadi*, and the superior border is very thin and more elevated just back of the condyle for the palatine than in this form.

This condyle is very convex; anterior to it there are two more condyles, which are probably for the ethmoid and vomer. The most posterior of these is broken away, but from the base it appears to have been elevated, as in *Saurodon*. The anterior condyle is large and triangular in outline, and is bounded in front by a shallow pit not found in the form mentioned above. There are alveoli for thirty-eight teeth, which decrease in size toward the posterior extremity, where they rise but slightly above the alveolar border.

The premaxilla is more or less plate-like; externally it is convex from before backward and the anterior border is quite oblique. There is probably no close connection with its fellow on the opposite side, and the upper portion of the bone is covered with fine lines radiating upward and backward from the anterior inferior angle. The teeth seem to be somewhat smaller than those on the maxilla; alveoli for nine are found.

The ramus of the mandible decreases more in depth toward the symphysis than in *Saurodon*. The lower border is very thin, but becomes thicker toward the alveolar border, though it never attains the robustness seen in *Xiphactinus*. Just back of the symphysis and below the alveolar border there is a prominent swelling, below which there is an elongated ovoid pit, near the position of the Mento-Meckelian ossicle in *Amia*. The predental surface descends in almost a straight line from the alveolar border, and has numerous bony tubercles internally, probably for ligaments attaching the two jaws. Just beneath the dentary there is a long thin element which seems to be united to it by suture and forms the lower border of the jaw. If this be true, it may represent a new element in the mandible, although more

material will have to be examined before this can be accurately determined. The teeth are compressed and appear minutely striated under the microscope. From the center to the anterior extremity of the dentary the teeth decrease in size, while those on the posterior portion are nearly twice the size of those on the maxilla. Spaces for about forty-two are present, but quite a number of the teeth seem to have been shed and never replaced, as the alveoli seem to be entirely closed in some instances.

The dermarticlar sends a long, dagger-like process forward internally nearly to the ovoid pit mentioned above; externally it is soon covered by the dentary. The cotylus is somewhat vertically directed, narrow laterally, and slightly convex from above downward.

The prementary is a triangular element joined to the dentary by a very irregular surface, broader above than below. The superior border is finely rugose and edentulous, and the tip is acute. This bone is unpaired, as in *Saurodon*.

Length of maxilla and premaxilla.....	161.5 mm.
Depth of bone posterior to condyle for the palatine.....	44.5 "
Height of condyle for palatine above the alveolar border....	48.5 "
Length of premaxilla, inferiorly.....	31.5 "
Average height of crown.....	3.9 "
Average anterior posterior length of crown.....	3.3 "
Number of teeth in one inch, 9.	
Mandible: Length from cotylus.....	161.0 mm.
Length of alveolar border.....	140.0 "
Depth of premental surface (estimated).....	33.0 "
Average height of crown, posterior.....	6.0 "
Average length of crown, posterior.....	4.4 "
Prementary: Length.....	29.5 "
Depth.....	34.0 "

STRATODONTIDÆ.

The family *Stratodontidæ*, as accepted by Professor Cope in his "Cretaceous Vertebrata," embraced certain genera of physostomous fishes which bear a general relationship to *Esox*, and included the genera *Stratodus*, *Empo*, *Pachyrhizodus*, *Enchodus*, *Tetheodus*, and *Anogmus*, for which the following synopsis was given :

- I. Premaxillary with several rows of teeth:
Palatine teeth numerous, large; all with pulp cavity, *Stratodus*.
- II. Premaxillary with two rows of teeth:
Maxillary bone short; dentary with equal large inner teeth and outer rows *en brosse*..... *Empo*.
Maxillary bone very long; one row of equal dentaries, *Pachyrhizodus*.
- III. Premaxillary with one or no row of teeth:
A large premaxillary fang; anterior maxillary and dentary teeth enlarged; cutting edges not opposite; unsymmetrical..... *Enchodus*.
Premaxillary toothless; anterior maxillary and dentary enlarged..... *Tetheodus*.

The characters of these genera are so varied that I have thought it best, in the present work, to divide the old family of the *Stratodontidæ* into four separate families, and to use this name for *Stratodus*, *Empo*, and *Cimolichthys*, which may seem remarkable when the great difference in the form of the teeth and tooth-bearing elements of the genera are taken into consideration. In *Stratodus* the teeth are all small and present a great similarity throughout the whole dental series, while in *Empo* they are of a different size and form on the several parts, and all are different from those in *Stratodus*. There are also marked differences in other parts, as the form of the palatine and the different lengths of the premaxillæ.

Notwithstanding all these differences, when we examine the top of the skull of each, a remarkable similarity between the two is seen, from which resemblance of the two forms we must conclude that there is a close relationship between the two, notwithstanding the differences of habits indicated by the dentition.

The top of the skull is very flat in both genera, and made up for the most part of the elongate, triangular-shaped frontals, which are united in the median line by means of a long, straight suture. These bones are covered on the superior surface by small ridges or striæ, which radiate from a point internal to the postorbitals and are most strongly marked in *Empo*. The supraoccipitals are small and invade the top of the skull but little. It is raised into a slight crest in *Empo*, and probably so in *Stratodus*.

Below is given a revised synopsis of the family :

- I. Premaxilla short, with several rows of teeth :
 Palatine and mandibular teeth numerous, in several rows *Stratodus*.
- II. Premaxilla elongate, with one row of small teeth :
 Mandibular teeth in two series, of which the outer are small and in several rows, while the inner are very large.
 Palatine teeth large and in two rows *Empo*.
- III. Premaxilla and maxilla elongate, with very small teeth :
 Palatines and ectopterygoids provided with powerful teeth, some of which are semibarbed in shape. *Cimolichthys*.

STRATODUS.

This genus, as characterized by Cope, is remarkable for the small size, great number and peculiar form of the teeth. Unfortunately the material from which the descriptions have been made was very fragmentary, from which no adequate conception of the cranial characters could be obtained. The jaws as well as most of the bones are very fragile, and it is probably owing to this fact that no perfect specimens have been collected. The geological expedition of 1898 to western Kansas obtained a specimen belonging to this genus from near Twin Buttes, Wallace county, that shows some points not known before. The specimen is far from perfect, but it is much better than any specimen heretofore described.

The premaxilla is small and has three or four rows of teeth on the lower side, of which those on the inner are the largest. The dentaries are very slender and are covered with numerous rows of small conical teeth on the internal side which are all

provided with a large pulp cavity. The teeth are largest on the external row, but toward the symphysis they are all reduced to nearly the same size. The symphysis is very shallow. The palatines (?) are long and slender plates of bone, which are covered with teeth probably similar in form and size to those found on the dentary. Fortunately the top of the skull is preserved, showing it to be slender, flat, with the different elements arranged very much as in *Empo*. The vertebræ are very similar to those of this genus.⁸⁶ "Their centra in both abdominal and caudal regions are elongate and contracted medially. There is a shallow longitudinal groove at the bases of the neural and hæmal arches, which are divided vertically by a median rib-like buttress. The median lateral portion is smooth or nearly so."

The known American species are :

Stratodus apicalis Cope, Niobrara Cretaceous, western Kansas.

Stratodus oxypogon Cope, Niobrara Cretaceous, western Kansas.

Stratodus apicalis. Plate LX; plate LXI, fig. 1.

Stratodus apicalis Cope, Proc. Am. Phil. Soc. 1872, p. 348; Cret. Vert. West, p. 227.

This species is represented by portions of the skull and tooth-bearing elements as mentioned above.

The dentary is elongate and covered with several rows of teeth above and on the internal side. These teeth are largest in the outer row, where they are seven millimeters or more in height, but become very small toward the inner and lower row. The teeth are round in section, acutely pointed, and with slightly recurved crowns. They are entirely without striæ even under the microscope. Toward the symphysis the number of rows diminish until only two remain at the extremity, with the exception of three or four small teeth situated external to the outer row. The symphysis is very shallow, in fact, there is only a small articular facet at this point, which shows that the jaws were very loosely united here. Throughout its whole length the dentary is very shallow and covered with coarse longitudinal striæ on the external side. Unfortunately the articular portion is not preserved.

86. Proc. Am. Phil. Soc. 1878, p. 181.

There is a bone which I think represents the premaxilla. The teeth are arranged in three or four rows, the largest being internal. The external face of the bone is non-striate, and extends upward and backward, while the internal side is grooved for the maxilla.

In the description of this part, as given by Cope,⁸⁷ he says that the premaxillary teeth are in two series. What he means by this statement I am unable to say, as four rows of teeth are shown in the figure of his specimen, and there does not seem to be any abrupt change in size transversely.

The palatine (?) is a long, slender plate of bone, contracted at both extremities, and covered with teeth on the lower side. The number of rows decrease toward both ends and the size of the teeth also becomes less toward one of them. The upper surface is divided longitudinally by a ridge and the three grooves mentioned by Cope,⁸⁸ but they are not so strongly marked as to attract particular attention.

Dentary: Greatest width of dental band	10 mm.
Length of dental band (estimated).....	137 "
Premaxilla: Length of dental band	28 "
Greatest width of dental band.....	9 "
Palatine: Length.....	121 "
Greatest width	17 "

The top of the skull is preserved completely, or nearly so. The bones represented are the frontals, parietals, exoccipitals, and probably the epiotics and pterotics.

The frontals are very long bones, broad behind, and probably tapering to a point in front where the extremities are covered with matrix and other bones. On the upper surface the bones are beautifully sculptured with long, coarse striæ extending forward from near the center of each bone, while the back portion presents only an occasional stria. These bones are especially remarkable for their great length and fragility. The suture between the parietals and the epiotics cannot be made out, although this portion is entirely free from matrix. For this reason I am inclined to think that these two bones are co-

87. *Cret. Vert. West*, p. 226, pl. XLIX.

88. *Cret. Vert. West*, p. 227.

ossified in the specimen. They are somewhat triangular in outline and meet each other in the median line, thus separating the supraoccipitals from the frontals. They do not seem to possess any very characteristic markings. The pterotics (?) are prominent processes of bone that project outward from the parietals and join the exoccipitals below. The supraoccipitals do not seem to be present in this specimen, but are probably not raised into a crest. The exoccipitals are rather large bones projecting upward and outward from the basioccipital and form a large portion of the back part of the skull. Each sends a fan-like process of bone backward. There is still another long, flat bone not connected with the rest of the skull that may represent a portion of the hyomandibular or an opercular. It is somewhat irregular in outline and presents a sharp longitudinal ridge near one of the borders. Measurements of skull are :

Distance from supraoccipital to anterior extremity of frontals, *166 mm.	
Transverse distance across pterotics.....	65 "
Greatest transverse distance across frontals.....	60 "

Just back of the skull there is a bone that is no doubt connected in some way with the vertebral column. It somewhat resembles a terminal caudal vertebra or urostyle. It is contracted and convex at one extremity and expanded and deeply concave at the other. Near the center of the convex end there is a foramina leading inward which probably continues through to the other side.

EMPO Cope.

This genus is represented in the museum by the remains of several individuals, more or less perfect, from the Niobrara Cretaceous and a portion of one specimen from the Fort Pierre of Kansas. It is probable that they include four species.

The palatines are much elongated and bear two rows of teeth on the anterior portion, of which the external are large and the internal somewhat smaller. The ethmoid is contracted into a rather sharp beak anteriorly and bears a number of small teeth on the median line below, which are either arranged in one or two rows or form a small cluster near the anterior extremity.

*Estimated.

The dentaries bear several rows of teeth, of which those on the external side are minute and somewhat thickly placed, while those on the internal side are large, set upon expanded bases, and are well separated from each other. The outer surface of the dentary is covered with numerous well-marked sulci. The cotylus is bifurcated in the center, each half appearing as a small hemispherical pit. There are several other tooth-bearing elements, among which is a long, slender bone with a single row of small conical teeth on the lower side, which probably represents a premaxilla.

The top of the skull is elongated and somewhat triangular in outline. It is especially remarkable for the great extent and delicate markings of the frontals, as well as of the other bones of this region. The supraoccipital is small and enters slightly into the formation of the top of the skull. The parietals are small and do not extend farther forward than the anterior extremity of the supraoccipital.

Throughout the whole extent of the top of the skull there is a close resemblance to the corresponding portion of *Stratodus*, the principal difference being found in the larger size of the parietals and their meeting along the median line.

There is one specimen at hand that has the vertebral column preserved completely, and another one nearly so, from which we see that there were altogether about fifty-three vertebrae. Those in the cervical and dorsal regions are finely striated, while those near the end of the tail are deeply grooved on the sides, the grooves commencing on the eighth or ninth vertebra from the end of the series. The neural canal is bounded by a lamina of bone on each side, outside of which the neuropophyses rise and form a vertical ridge on the side. The hæmal canal is bounded by laminæ similar to those described above. The hæmal arches are located outside of these, so that in a detached vertebra it is often difficult to determine the two sides.

In Cope's description of the vertebral column of *E. nepæolica*⁸⁹ he says that up to the fourteenth vertebra the neural canals are not bounded by vertical laminæ; in this I cannot agree with

89. Cret. Vert. West, p. 230.

him. I have been able to examine some of the detached vertebræ from near the head, and so far as I can judge the sides of the neural arches do not differ materially from those farther back in the column.

The abdominal cavity is short, with well-developed ribs. The caudal fin is not well preserved in any of the specimens, only the bases of the rays being present. On one of the slabs there are a number of small rays and other fragments just back of the abdominal cavity, which is probably a portion of the pelvic fin. The rays are small and have no great length. The pectoral rays are also rather delicate and curved near the proximal extremity, while near the middle portion and distal end they are cross-segmented. Along the back there are numerous dermal plates, the most of which have no characteristic markings.

The known American species are :

Empo nepæolica Cope, Niobrara Cretaceous, western Kansas.

Empo semianiceps Cope, Niobrara Cretaceous, western Kansas.

Empo contracta Cope, Niobrara Cretaceous, western Kansas.

Empo merrilli Cope, Niobrara Cretaceous, western Kansas.

Empo lisbonensis Stewart, Fort Pierre Cretaceous, western Kansas.

Empo nepæolica. Plate LIX.

Empo nepæolica Cope, Proc. Am. Phil. Soc. 1872, p. 347; Cret. Vert. West, p. 230.

Empo sulcata Cope, Hayden's Bull. U. S. Geol. Surv. No. 2, p. 46.

Cimolichthys sulcatus Cope, l. c., p. 351.

This species is represented in our collection by the remains of several individuals, among which is a skull almost complete, from which a fair idea of the anatomy of this portion can be gained.

The bone described and figured by Cope as a premaxilla has since been shown to be a palatine by specimens in the British Museum which have the maxillæ and premaxillæ in place. The bone is elongate and curved longitudinally, and at the anterior extremity there is a rostrum-shaped apex of dense bone which projects forward beyond the last tooth. On the superior border there is a slight crest of bone, which probably serves to loosely connect this portion to the skull. The teeth are arranged in two series. At the anterior extremity there are several large

teeth extending backward for three or four centimeters from the extremity, which are followed by a series of much smaller ones occupying the inner side of the bone and extending backward to near the posterior extremity, where there are usually one or more teeth much larger than any of the others. Near this point those on the internal side become very small. The bone called maxilla by Cope is probably a pterygoid. It is short, bar-like, and bears a single row of teeth, which decrease in size posteriorly. The posterior extremity is edentulous and somewhat expanded.

Palatine: Length to large posterior tooth.....	86 mm.
Greatest height.....	25 "
Transverse distance across alveolar border near center.....	11 "
Pterygoid (?): Length (estimated)	67 "

The dentaries are very much elongated and contracted regularly toward the symphysis, where the bones are very shallow. The symphysis is not very deep, consisting, for the most part, of a small flat facet on the internal side which meets its fellow on the opposite side, and to which it is probably united in a manner somewhat similar to that found in *Pachyrhizodus*. Cope⁹⁰ describes this part as presenting a marked fossa which I am unable to find in any of our specimens, and I think it not at all unlikely that this was an individual peculiarity of his specimen. The alveolar border supports two series of teeth, of which the internal are the larger of the two. There are usually about ten teeth present in this series, and room for probably as many more, which are often represented by the tooth scars of the shed teeth. These teeth are set upon hemispheres of bone firmly anchylosed to the jaw. The teeth are compressed, finely striated, and directed inward. The external series consists of several rows of teeth of which those on the internal row are the larger. They are all directed inward and seem to have both anterior and posterior cutting edges. Toward the posterior extremity both series fade out, leaving a considerable space between the last tooth and the end of the bone. The external surface of the dentary is covered with deep longitudinal sulci,

90. *Cret. Vert. West*, p. 231.

while the internal is nearly smooth and deeply grooved. The articular portion sends a long, sword-shaped process forward, but how far cannot be determined, as the anterior portion is covered by the overlying ceratohyal. The cotylus is very broad transversely but has no great vertical extent. It is composed of two concave facets separated from each other by a well-marked ridge. The external of these facets seems to be slightly the larger of the two.

Premaxilla: Length.....	117 mm.
Maxilla: Length (estimated).....	114 "
Dentary: Length of alveolar border to last tooth.....	182 "
Length of mandible from cotylus.....	252 "
Transverse diameter of cotylus.....	14 "
Length of articular from cotylus (estimated).....	133 "

The quadrate is compressed and fan-shaped; extending down its posterior border there is a deep groove, which probably accommodates the preoperculum. Just in front of this groove, on the internal side, there is still another groove which extends over half way down to the condyle, in which the symplectic probably fits. Cope⁹¹ was unable to discover a symplectic in the specimen of *E. semianiceps* which he described, and I am inclined to think he was of the impression that this genus did not possess this bone, but from the presence of this groove we can assume that it was proportionately broader than in the *Saurodontidæ*. The anterior border is very thin and is projected upward, with a small portion of the superior border, into quite a prominent process of bone. The condyle is bifurcate in the center and has a superficial resemblance to the distal end of the mammalian femur. The external side cannot be seen.

The preoperculum is long and very slender in the superior portion. Near the lower extremity the bone bends suddenly forward and broadens out into a thin plate below. The upper portion is only slightly curved and very roughly and irregularly marked. A portion of one operculum is present, showing the internal side. It is a broad, thin plate of bone, with a small condyle for the hyomandibular. The condyle is not situated so

91. Cret. Vert. West, p. 229.

near the superior border as in the *Ichthyodectidæ*, and has a strong ridge extending backward from it on the internal side.

The hyomandibular presents two articulating surfaces above for union with the skull. These are slightly grooved longitudinally and are separated from each other by a deep notch. The anterior of these is projected well forward. The condyle for the operculum is situated probably more than one-half the distance down the side of the bone, and is elliptical in outline and very irregular. Just in front of the condyle there is a prominent ridge which extends downward, but not to the lower extremity of the bone. The inferior portion is rather narrow; the anterior very thin.

The cerato- and epihyals are preserved in one specimen, while the urohyal is shown in another. The epihyal is very thin and has the anterior extremity slightly convex for the ceratohyal. Near the postero-superior end there is a deep notch, probably for the accommodation of the interhyal. Both the external and internal sides are covered with fine striæ. The ceratohyal is an elongate, slender bone, expanded at the extremities and contracted slightly at the center. Both sides are covered with striæ, which are especially noticeable toward the extremities, which are nearly flat. The urohyal is a small, triangular element, badly crushed, with a small facet on the anterior end for its fellow on the opposite side.

There is a long, thin plate of bone that I am inclined to think represents the palatine. It is contracted to a blunt point at both extremities, and covered with fine striæ on one side which radiate from a point near the superior border and about one-third the distance back from the anterior end. The central portion of the lower border is covered with a single row of small conical teeth, each of which seems to be firmly ankylosed to the bone, with the apex directed forward. The extremities of this border are edentulous.

The ethmoid is a symmetrical tongue-shaped bone covered with teeth below. Professor Cope⁹² says this bone is sometimes symmetrical and sometimes unsymmetrical, and he was in-

92. Cret. Vert. West, p. 228.

clined to think that it represented a superior or inferior pharyngeal. In all of the specimens that I have examined it seems to be entirely symmetrical, and in one specimen it is in place at the anterior extremity of the skull, so there can be no doubt of its being an ethmoid. I am inclined to think that the asymmetry of Cope's specimen was due to distortion. The anterior end is extended forward into a beak of dense bone, which is directed slightly downward. Just back of the beak, on the lower side, there are a number of small teeth, which are elevated considerably above the rest of the bone when it is reversed. There seems to be a great deal of irregularity in the arrangement of these teeth. In some specimens they are grouped together, with the largest near the center, while in others there are a number of large teeth anteriorly, with a single row of smaller ones extending back from them. The upper surface of the bone is covered with numerous striæ radiating from the apex.

There are fragments of other bones whose location cannot be determined. One of these is a long bar of bone which has an articular surface at the anterior end and is expanded at the other; another is a flat semicircular plate, finely striated; while others are irregular in outline.

The whole of the upper part of the skull is preserved, either by the bones themselves or by their impression in the chalk. It is very flat and bears a marked resemblance in general outline to the top of the skull of *Stratodus*. The frontals form the greater part of the upper walls of the skull and the two are separated by a well-marked suture in the median line. The two bones together are somewhat triangular in outline and are beautifully sculptured, on the upper surface, by radiating ridges. These ridges are especially marked just internal to the postorbitals, from which point they radiate toward the front and back of the skull. They are in contact with the supraoccipital posteriorly. The supraoccipital enters but little into the top of the skull. It projects backward in a small crest, which is probably not raised above the rest of the skull. The postorbitals form beak-like processes on the sides and are

directed slightly downward. Inferiorly they form a prominent ridge on each side which extends inward toward the median line. The occipital condyle is rather flat in this specimen, but in another specimen, where the back of the skull is shown, the condyle is deeply concave. It is likely that this specimen may be of another species, as it seems to be more narrow than the one under consideration. It is crested below and united with the exoccipitals by well-marked sutures. There are several other bones at the base of the skull, but they are so badly crushed and their sutures so obliterated that they cannot be made out with any degree of certainty.

Total length of skull..... 239 mm.
Distance across postorbitals (estimated)..... 126 "

A portion of the pectoral fin is present, with fragments of the pectoral girdle. The rays are small in size and seem to be very numerous. They are nearly straight, excepting near the proximal end where they are strongly bent. The distal end of each ray is cross-segmented.

Empo lisbonensis. Plate LXI, figs. 10a and b.

Empo lisbonensis Stewart, Kans. Univ. Quart., vol. VIII.

This species was established on the left palatine of a single individual from the Lisbon shales, Fort Pierre Cretaceous. The specimen was found by myself one mile northeast of Lisbon, Logan county, Kansas, and is in a fair state of preservation. It indicates a fish of about the size of *E. nepvolica* Cope. The catalogue number of the specimen is 328.

The palatine is much more depressed than in the species just mentioned, but is broader across the alveolar portion, giving the bone a very robust appearance when seen from below. The anterior extremity was probably not so acutely pointed as in the other species of this genus. None of the teeth are preserved complete, but there are alveoli present which show that there was an outer row of large teeth and an inner row of small ones. The outer row are reduced in size toward the distal extremity, and may entirely disappear before the end is reached, as there are no tooth scars on this portion. At the posterior end of the

internal row there is a very large tooth, back of which there is a broad shallow pit.

Length to the large posterior tooth..... 82 mm.
Greatest transverse width..... 19 "

Empo semianiceps. Plate LXI, figs. 6-9.

Cimolichthys semianiceps Cope, Proc. Am. Phil. Soc. 1872, p. 351.

Empo semianiceps Cope, Cret. Vert. West, p. 233.

The material, consisting of the palatines, fragmentary mandibles, and portions of other parts, is referred to this species with some doubt. It seems to correspond with the figure and description of this species as given by Professor Cope,⁹³ but it may possibly be a specimen of *E. merrilli*. The specimen, No. 278, was collected from the Niobrara Cretaceous of Graham county by Messrs. Overton and Martin during the summer of 1895.

The palatine is nearly straight on the internal side and depressed above. The teeth are arranged in two series, as in *E. nepæolica*. The most anterior one of these is rather small, but is followed by two or three that are somewhat larger. The teeth following are of about the size of those just mentioned, excepting toward the posterior extremity, where they become slightly reduced in size. There seems to be a considerable difference in the arrangement of the teeth on the internal side in the two palatines of this specimen. On the bone of the right side there is a continuous row which are directed strongly backward, while on the left there are but two tooth scars present on the internal side. The pterygoid is very similar to that of *E. nepæolica* described above.

Palatine: Length..... 166 mm.
Greatest transverse width..... 10 "

The dentaries are elongate and contracted in depth at the symphysis, where the lower edge is beveled off to meet the superior border, thus forming an acute apex. The external side is covered with longitudinal striæ which are not as strongly marked as in *E. nepæolica*. These striæ are more noticeable on the external portion of the articular than on any other part. The lower border is rather sharp but soon becomes thickened

93. Cret. Vert. West, p. 233, pl. LIII, fig. 6.

above, especially in the posterior portion, where there is a strong bar just below the articular. The internal side is finely striate and deeply grooved. The small teeth on the external side are in two rows, of which those on the external row form a minute fringe, while those on the internal are larger and are directed slightly forward. Those of the internal series are large at the center but decrease in size toward the extremities. Each of these is set upon a bony tubercle, as in *E. nepæolica*. The articular portion is very similar to that portion of the species just mentioned.

Length of alveolar border	121 mm.
Depth at last tooth	38 "
Transverse diameter of cotylus	11 "

There are numerous other bones, including the ceratohyals, postorbitals, and a fragmentary ethmoid. The ceratohyals do not differ materially from those of *E. nepæolica* excepting in size. The ethmoid is more blunt than in the species just mentioned and bears a single row of eight or nine teeth on the median line below. The postorbital is somewhat hook-shaped and has a roughened articulating surface internally.

Empo contracta.

Empo contracta Cope, Hayden's Bull. U. S. Geol. Surv. Terr. No. 2, 1874, p. 46: Cret. Vert. West, p. 232.

The specimen referred to this species consists of the greater portion of palatine and dentaries, the hyoid arch, numerous vertebrae, and other bones. As the original description of this species is rather vague and the figures are of fragments only, it will always be difficult to identify this species with any degree of certainty unless access is had to the type specimen for comparison or until it is more completely described and figured. The specimen is much smaller than the one described above as *E. semianiceps*.

Only the internal sides of the dentaries are shown. The external series of teeth do not seem to be as large as in *E. semianiceps* described above. The teeth of the inner series are long, acutely pointed, and directed slightly inward at the apices. The maxillae are present with probably all of the teeth, which

are elongate, with anterior and posterior cutting edges, and are recurved. Their size seems to diminish very suddenly toward the posterior extremity, which is expanded. The epi-, cerato- and urohyals are in place on one side but do not seem to differ materially from those described above. A portion of the pectoral fin shows the rays to be cross-segmented as in *E. nepæolica*, but the proximal ends are straighter than in this form. The bones are for the most part in so fragmentary a condition that only approximate measurements can be made; hence they are omitted.

OSTEOGLOSSIDÆ.

The genus *Anogmius*, described by Professor Cope,⁹⁴ was left by the author in his family *Stratodontidæ*, to which, it seems evident, it does not belong.

After carefully studying the material at hand, it seems to bear a close relation in many respects to the genus *Plethodus*, recently described and figured by Dr. A. S. Woodward,⁹⁶ which the author is inclined to place in the family *Osteoglossidæ*. For the present, at least, I think that *Anogmius* should be left in this family.

ANOGLMIUS.

Cope, Proc. Am. Phil. Soc. 1870, p. 170.

This genus was first described by Professor Cope⁹⁵ from vertebrae and fin remains of an individual from the Niobrara Cretaceous of western Kansas; the name *Anogmius contractus* was applied to it, and, later, two more species,⁹⁷ *A. favirostris* and *A. evolutus*, were added to the genus by the same author. The first of these was a small individual, while the second was much larger, and is probably the same form described as ? *Beryx multidentatus*,⁹⁸ described by myself. Professor Cope also mentions another species, *A. aratus*, but so far I have been unable to find any other reference to it. I am inclined to think that this was a slip of the pen on the part of Professor Cope, and that *A. con-*

94. Proc. Am. Phil. Soc. 1871, p. 170.

97. Proc. Am. Phil. Soc. 1878, pp. 178-180.

95. Proc. Am. Phil. Soc. 1870, p. 170.

98. Kans. Univ. Quart., vol. VII—A, p. 196.

96. Annals and Magazine of Natural History, ser. 7, vol. III, pp. 353-361.

tractus was intended to be expressed, as the author says:⁹⁹ "The characters of the genus *Anogmius* Cope having up to the present time rested upon but one species (*A. aratus*), it is satisfactory to be able to confirm them by the study of new material," etc.

This genus is well characterized by the tooth bearing elements, all of which seem to be covered with villiform teeth. The premaxillæ are triangular in outline and covered with a semielliptical band of teeth below. The maxillæ are elongated and slightly concave on the lower border, which is covered with several rows of small teeth. The jaws are bound directly to the skull by means of a small condyle above, which presents a roughened surface, probably for cartilage. The dentaries are also covered with small teeth similar to those on the maxillæ and premaxillæ, and are incurved and loosely united at the symphysis. The angle is prominent, and the mouth as a whole is quite oblique.

The top of the skull is flat, and beautifully sculptured with coarse striæ radiating from near the center of each of the principal bones. The frontals are long, while the parietals are rather small. The supraoccipital is depressed and invades the top of the skull very little, if any. The orbital cavity is large and the sclerotic ring very thin. In this region there are numerous membranous bones which probably form a covering for the top of the skull to a greater or less extent. The opercular bones are thin and covered with coarse striæ.

In one specimen of *A. polymicrodus* there are seventy-two vertebrae exposed to view, and there are probably eight or ten more hidden by the opercular bones just back of the skull, making, in all, eighty vertebrae in the complete column. The centra are all rather short and do not present the lateral grooves found in the *Saurodontidæ* and *Ichthyodectidæ*, but are striated and somewhat resembling the vertebrae of the genus *Pachyrhizodus* Agassiz in this respect, and it is probably for this reason that Zittel gives *Anogmius* as a synonym of this genus.¹⁰⁰ Just in front of the caudal fin the vertebrae are crowded together,

99. l. c., p. 173.

100. Zittel's *Handbuch der Palæontologie*, b. III, s. 268.

and those supporting the fin are very much so. The last vertebra is succeeded by a fan-shaped expansion of bone or urostyle, which presents a well-marked lateral ridge on the side exposed. The neural arches fit into pits at their bases, and in the caudal region they have laminae of bone projecting down the sides, forming yoke-like articulations with the centra. The arches are expanded at their bases and are largest in the anterior region, where they are directed backward but slightly, while in the region of the fiftieth posterior vertebra the arches are very slender and directed strongly backward. The manner of attachment of the hæmapophyses cannot be made out with certainty, although they were probably inserted in gomphoses, as are the neurapophyses. The ribs are long and slender and slightly expanded at the proximal extremity. They seem to be inserted in pits on the sides of the centra. The caudal fin is homocercal, and is composed of numerous rays which articulate with the centra by means of the yoke-like articulation mentioned above. Toward the distal extremity these rays gradually split up into many small filaments, which makes this portion very difficult to collect in perfect condition. One of the smaller specimens of this genus shows an imperfect impression of the dorsal fin. It seems to have been composed of short spines rather far separated and extending along the greater extent of the back. There are no remains of the other fins sufficiently well preserved to show their important characters.

The following species are known :

Anogmius contractus Cope, Niobrara Cretaceous, western Kansas.

Anogmius aratus (?) Cope, Niobrara Cretaceous, western Kansas.

Anogmius evolutus Cope, Niobrara Cretaceous, western Kansas.

Anogmius polymicrodus Stewart, Niobrara Cretaceous, western Kansas.

Anogmius polymicrodus. Plate LXIV; plate LXV, figs. 1-7; plate LXVI; plate LXVII, fig. a.

Beryx polymicrodus Stewart, Kans. Univ. Quar., vol. VII, pp. 195, 196.

This species was first described by myself as *Beryx polymicrodus* from some fragments of jaws collected in western Kansas several years ago, but the material was too fragmentary to give any idea of the animal. During the past summer the geolog-

ical expedition to western Kansas was fortunate enough to find several good specimens from the Butte creek region of Logan county, and was also loaned an almost complete specimen, the fins excepted, by Mr. Travis Morse, of Iola, who secured it several years ago while collecting vertebrate fossils in this part of the state. From this specimen a good idea of the anatomy can be gained.

The bone called premaxilla in the preliminary description is evidently not a premaxilla, but some other bone, the location of which I have been unable to determine. The premaxilla is rather short, with a semielliptical tooth band on the inferior side covered with several rows of villiform teeth, all of which seem to be directed inward. Above the tooth band, on the external side, there is a thin wall of bone extending upward, which is covered with coarse longitudinal striæ on the posterior portion, while the anterior part, just behind the apex, is covered with minute tooth-like tubercles, which extend backward for some little distance just over the tooth band. The internal side of the bone is deeply concave, the width of the concavity becoming very narrow at the anterior end. The union between this bone and the maxilla was no doubt very loose, allowing this bone to be moved very freely. The two bones were probably not united anteriorly.

The maxilla is moderately long and thin transversely toward the posterior extremity. It bears a tooth band on the lower border, which is slightly concave longitudinally in front, where this band is the broadest. Posteriorly the tooth band gradually contracts in width until the two borders come together at the posterior extremity. The surface for the premaxilla is directed slightly inward, and in some of the specimens it is slightly roughened for the ligaments binding the two bones together. Just back of this, on the superior border, there is an elevated articular portion which serves to bind the maxilla to the skull proper. It is rather rough above and does not allow the free motion of the upper jaws found in some of the other families of physostomous fishes. Just back of this there is a thin crest of bone extending backward over one-half the length

of the jaw. Both the external and internal sides of the bone are covered with coarse longitudinal striæ, the intensity of which varies in different individuals.

Maxilla: Length of tooth band.....	118.0 mm.
Height at posterior extremity	34.0 "
Premaxilla: Length	81.0 "
Greatest height	37.5 "

The dentary has a tooth band above, covered with teeth very similar to those on the parts described above. It is nearly flat in front, but soon becomes directed downward internally, giving it a somewhat beveled appearance, which may be due to compression, although it seems to occur in all of the specimens examined. The band is broadest near the center and is overhanging externally and in front. The symphysis is composed of two parts: an upper facet, which is directed inward and comes in contact with a corresponding facet on the opposite side; and a lower one, which is directed forward and enters but little, if any, into the articulation of the two jaws. At the symphysis the bones are shallow, but they soon broaden and become very deep at the coronoid process. There are very coarse ridges and grooves on both the external and internal sides. The articular extends well forward on the external side, and is united with the emargination in the dentary by an indistinct suture. The cotylus is supported principally by a thick shelf of bone extending inward from the main portion of the bone. It presents a small concave facet which looks slightly forward, back of which the angle is slightly recurved, and has been described by Professor Cope¹⁰¹ as resembling a boot with the toe inverted.

Length of mandible from cotylus	204 mm.
Depth at coronoid process (estimated).....	65 "
Depth at symphysis.....	17 "
Length of tooth band (estimated).....	155 "

The bone originally described as a premaxilla¹⁰² may be a pterygoid, as it cannot be a vomer or palatine from the description of these parts, as given by Professor Cope. It is slightly curved longitudinally and has a broad tooth band on one sur-

101. Proc. Am. Phil. Soc. 1878, pp. 179, 180.

102. l. c., p. 195.

face, which bears denticles slightly larger than those on the parts described above. On the opposite surface from the tooth band there is a ridge extending its full length, which is overhanging on one side, thus forming a groove, which is probably for the reception of some other bone.

Length of tooth band..... 69 mm.
Greatest width of tooth band 17 "

There are two other bones which are covered with small pits, and somewhat resemble those found on the tooth-bearing elements described above, although it is likely that these bones never bore teeth. One of these is a cordiform bone, and is probably a pharyngeal. The pitted surface is slightly depressed in the middle, and the sides slope sharply toward the edges. The other element is not so thick as the one just mentioned; it has a broad band of these pits on one side and a median ridge on the other, somewhat similar to that found in the supposed pterygoid described above. At one of the ends there is a roughened articular surface. There is another long and slender element that bears a superficial resemblance to the palatine bone of *Stratodus apicalis*, which is no doubt the same bone described as a palatine by Professor Cope.¹⁰³ It is broader at one end than at the other. The lower (?) surface is covered with small pits similar to those described above, but there are no teeth present in any of the specimens that I have examined. The upper surface is somewhat striated at the anterior (?) extremity.

The ceratohyal is a broad and thin bone, concave at the posterior end and somewhat irregular in outline at the anterior, where there are two surfaces, for the hyo- and urohyals, respectively. The bone seems to be striated, especially so toward the extremities. Its length is 98 mm.

The quadrate is fan-shaped and very thin anteriorly. The condyle is very convex and has a superficial resemblance to the distal end of the mammalian femur. Extending upward from this, along the posterior border externally, there is a prominent

103. Proc. Am. Phil. Soc. 1878, p. 179.

ridge which continues upward to the superior border. The groove for the symplectic seems to be very small.

One specimen shows the top of the skull with most of the bones in place. The frontals are long, extending backward as far as the pterotics externally. They meet in the median line by a suture which is probably dentate, although this cannot be determined with certainty. On each side there is a small post-orbital process. The bones are beautifully sculptured above with coarse sulci, which radiate from near the centers of each, internal to the postorbital processes. The parietals are small, meet each other in the median line, and are covered with markings very similar to those on the frontals. The supraoccipital is in a poor state of preservation, but probably entered but little into the formation of the upper part of the skull. It seems to have been projected backward for quite a distance and was depressed, as is the rest of the top of the skull. The epiotics and pterotics seem to be united on the side of that skull in which they are preserved. The pterotics form prominent angles of the skull, while the epiotic processes are not so prominent. The two are covered with small pits and tubercles of bone. Just back of the skull there are portions of two other bones, which may be parts of the hyomandibular and supratemporal. The first of these presents two articular surfaces, one of which is extended outward from the rest of the bone, the two being separated by a wide space somewhat similar to that found in the hyomandibular bone of *Empo*. The other is an irregularly shaped bone and has an articular surface on the side next to the skull. There are numerous other small bones, sculptured in a manner similar to the bones of the top of the skull. Three of these are joined together in a chain, and from their position would indicate that they might form a part of the rim of the orbital cavity. The remainder of these bones are small and scattered along the top of the skull, indicating that this part was covered with dermal plates. The orbital cavity is quite large, and the orbit is surrounded by a very thin ring of bone, the number of pieces composing which cannot be determined, owing to their fragmentary condition. Just in front of the or-

bital cavity, and separated from it by the chain of bones just mentioned, there is a bone that occupies about the position of the ethmoid. It seems to be rather thin and crushed down on the opposite side, so that its remaining characters cannot be made out.

The opercular bones are thin and scale-like and are all in place. They are all covered with fine striæ and are so thin at the edges that the different directions that these striæ take is the only means of locating the boundary lines between some of the different bones. The preoperculum is small, narrow above, and extended well forward below. The operculum is large and is extended for some distance above its articulation with the hyomandibular. The inter- and suboperculars extend backward as far as the operculum.

Anogmius evolutus. Plate LXV, figs. 8, 9, and 10; plate LXVII.

Anogmius evolutus Cope, Proc. Am. Phil. Soc. 1878, p. 179.

Beryx? multidentatus Stewart, Kans. Univ. Quart., vol. VII, p. 196.

This fish was first described by Professor Cope from an entire left mandible, of which no figure is given, and I am inclined to think that it is the same form as was described by myself as *Beryx? multidentatus*,¹⁰⁴ the paper containing the description by Professor Cope¹⁰⁵ having escaped my notice until after my article was published. As *Anogmius evolutus* Cope has priority, *Anogmius multidentatus* will have to remain a synonym, unless there are other characters in Cope's specimen not mentioned in his description that will separate the two forms. About the only difference is in size, and I do not consider that sufficient to separate them.

The principal points of difference between this species and *A. polymicrodus*, just described, are found in the differences in form of the symphyses, the extension of the teeth over the external sides of the dentaries in this species, and the difference in form of the cotyloid cavities.

The dentary is elongated and slightly incurved at the sym-

104. J. c., p. 196.

105. I. c., p. 179.

physis. The symphysis presents but one articular surface, which is roughened, and does not have an extension of the tooth band overhanging it. In these respects the jaw bears a superficial resemblance to that of some of the recent siluroids. The symphysis is slightly deeper than wide. The tooth band is broadest at about the center and narrowest at the posterior extremity, where the two borders of the band are suddenly drawn inward. The teeth continue over the side externally, and the whole band is inclined inward toward the center and posterior extremity. The dental pits are small, and densely packed in somewhat irregular longitudinal rows, there being forty or more of these rows at the broadest portion of the band, which is ten more than Cope found in his specimen. The articular is more robust throughout than in *A. polymicrodus*, and the form of the cotylus is different, for, instead of being partially supported on a shelf-like expansion of bone, as in this species, it rests directly across the main part of the articular. It is concave longitudinally, slightly convex transversally, and is directed slightly backward instead of forward, as in the species just mentioned.

There is a small portion of a maxilla present, and also a fragment of another bone, which is probably a palatine, although it differs somewhat from that of *A. polymicrodus*. The tooth band of the maxilla seems to be more convex transversally than in the species just mentioned, and there seems to be a total absence of the coarse striæ which ornament the external and internal surfaces of the bone in this form. The supposed palatine is a long and thin plate of bone which is covered with small tooth pits on one side, which decrease in size toward one of the extremities. At the end where the teeth are the largest there is a projection which probably serves to bind the bone to something.

Below are given the principal measurements of the mandible of our specimen and the one described by Professor Cope.

	Cope.	K. U.
Length of tooth band	150 mm.	165.0 mm.
Depth of symphysis	16 "	19.5 "
Width of symphysis		21.0 "

SALMONIDÆ.

Pachyrhizodontidæ Cope, Proc. Am. Phil. Soc., vol. XII, p. 343.

In the year 1873 Professor Cope described his family *Pachyrhizodontidæ*, to include the genus *Pachyrhizodus*, and which he characterized as follows:¹⁰⁶ "This family of physostomous fishes differs from the last, *Sauroidontidæ* and *Ichthyodectidæ*, in the nature of its dentition. Instead of elongated conic fangs sunk in deep alveoli, it has shorter and stouter fangs occupying alveoli, of which the inner side and part of the antero-posterior walls are incomplete. The teeth are, in fact, more or less pleurodont, but the extremity of the root is received into the conic fundus of the alveolus.

"The premaxillary bones are well developed, but the maxillaries are more so, and enter largely into the composition of the border of the mouth. There is a well-developed angle of the mandible, but no coronoid bone is preserved in the specimens. The coronoid region is, however, broken in all of our specimens. The other characters of the family are not determinable from our imperfect material."

In the "Cretaceous Vertebrata," published in 1875, Professor Cope abandons the name *Pachyrhizodontidæ* and includes *Pachyrhizodus* in his family *Stratodontidæ*, to which it evidently does not belong. It seems to show some relation to the *Salmonidæ*, in which family it should probably be included, along with *Oriardinus*.

PACHYRHIZODUS.

Dixon, Geol. of Sussex, p. 374, 1850.

The muzzle of this genus is flat and the bones of the skull more fragile than in members of the *Ichthyodectidæ* and *Sauroidontidæ*, consequently indicating a less powerful and rapacious fish than those belonging to these families. The mandibles are loosely united at the symphysis and bear a single row of teeth which are somewhat pleurodont, sharply pointed, and bear a superficial resemblance to some of the Mosasaurs. Their mode

106. l. c., p. 343.

of succession, as described by Professor Cope, is as follows:¹⁰⁷ "The crown of the young tooth was developed in a capsule at the base of the crown, or on the inner side of the apex of the thick root. The absorption which followed excavated both the former and the latter; but the crown was evidently first shed. Finally the old root disappeared and the new one occupied the alveolus, leaving a free separation all round. Finally, on the accomplishment of the full growth of the root, it became ankylosed all round." The articular portion of the mandible does not seem to be formed of the derm and antarticulars, as in *Saurodon*, etc.

The premaxillæ are much more elongated and of an entirely different form from those of the *Stratodontidæ*. They bear a single series of teeth on the external side and two more larger ones internal to the regular series. The maxillæ are rather shallow and are not united with the palatine, as in the *Ichthyodectidæ* and *Saurodontidæ* mentioned above. There are several other elements covered with villiform teeth whose position is not known.

There is no complete skull preserved in the museum, but Professor Cope says:¹⁰⁸ "The cranium is flat and wide, and pressure has probably somewhat increased the effect in this instance. Exoccipital, supraoccipital, epiotic, pterotic, parietal and frontal bones are clearly distinguishable, but there are points where the sutures are obscure. The best defined are the epiotics, which are subtriangular bones presenting the apex inward and bearing a small round facet for the supratemporal on the posterior angle. The pterotics and postfrontals may be easily distinguished from adjoining bones, but not so well from each other. They have a thin outer margin, and their superior surface is marked by bands of irregular small fossæ and an obtuse longitudinal ridge. The middle line of the skull is occupied by the supraoccipital. Its proximal portion probably separates the exoccipitals, but this is not certain. It extends well forward, and the line of separation from the frontal is not

107. Cret. Vert. West, p. 220.

108. l. c., pp. 220a, 220b.

well defined. Its anterior part has a massive transverse elevation, which sends a short median process backward, producing a T-shaped body; the frontal suture is probably in front of this. The supraoccipital is contracted behind this body, and its postero-exterior suture presents a remarkable peculiarity in a straight and wide truncate articular face. This is opposed by a corresponding face of the parietal bone. The latter is of an irregular form, and carries on its outer portion next the pterotic a stout protuberance. This is at the inner end of a strong ridge, which disappears near the outer edge of the pterotic. The protuberance looks as though adapted for an articulation. The frontals send a process backward, between the 'supraoccipital' and the pterotic or postfrontal, to the base of the tuberosity of the parietal. The suture between the exoccipital and parietal is not clear. A suture is distinct enough, bounding the latter behind, but whether an expansion of the supraoccipital intervenes or not is not certain. The exoccipitals appear to be flat and quadrant-shaped, having convex antero-lateral borders. Each bears a strong condyle."

The vertebrae present no deep lateral grooves, but are longitudinally striated and rather elongated back of the cervical region.

The following species have been described from Kansas:

Pachyrhizodus kingi Cope, Niobrara Cretaceous, western Kansas.

Pachyrhizodus latimentum Cope, Niobrara Cretaceous, western Kansas.

Pachyrhizodus sheareri Cope, Niobrara Cretaceous, western Kansas.

Pachyrhizodus caninus Cope, Niobrara Cretaceous, western Kansas.

Pachyrhizodus leptopsis Cope, Niobrara Cretaceous, western Kansas.

Pachyrhizodus leptognathus Stewart, Niobrara Cretaceous, western Kansas.

Pachyrhizodus velox Stewart, Niobrara Cretaceous, western Kansas.

Pachyrhizodus minimus Stewart, Niobrara Cretaceous, western Kansas.

Pachyrhizodus leptognathus. Plate LXIX, fig. 1.

Pachyrhizodus leptognathus Stewart, Kans. Univ. Quart., vol. VII, p. 193.

This species is represented by the left mandible, quadrate, symplectic, preoperculum, and two broad, flat plates of bone, which are probably the operculum and suboperculum. With the exception of the anterior portion of the dentary, only the internal sides of the bones can be examined, as they are too

fragile to be removed from the matrix. The catalogue number of the specimen is 75.

The dentary is elongated, very slender, and bears eighteen small, conical teeth upon its superior border, each of which is set on a small, bony tubercle of bone, similar to those in *P. caninus*. The teeth are directed backward and inward, decrease in size from the center toward the extremities, and end posteriorly within about an inch of the coronoid process. The symphysis is of a more or less tubercular nature, similar in many respects to that found in *P. latimentum*, and there are no teeth arranged in a triangle here, as in *P. caninus*. The external surface of the dentary does not seem to possess any very characteristic markings.

The articular extends forward fully two-thirds the length of the mandible, and is deeply grooved. The cotylus is concave from before backward, and strongly convex laterally. The quadrate is triangular in outline and thin above. Toward the lower portion the bone thickens and assumes a somewhat twisted appearance at the condyle. The condyle is somewhat excavated at the center in order to fit the cotylus. On the internal side there is a well-marked ridge extending from the condyle upward through the center of the bone. The superior border presents a long, narrow sutural surface for uniting this with the metapterygoid. Just back of the quadrate, and articulating closely with it, there is a long, narrow element which may be the symplectic. It is covered in part by the preoperculum, so that its characters cannot be made out.

The supposed preoperculum consists of a horizontal and a vertical portion which meet each other at almost right angles. The horizontal portion possesses no marked characters beyond that it is the broader of the two parts. The vertical portion is broad below, but soon becomes more narrow as the upper extremity is approached. Just back of the anterior border there is a well-defined ridge extending downward to the junction of the two parts. The two flat bones which may represent portions of the operculum and suboperculum possess no characters beyond those shown in the figure.

In addition to the above there is a tooth-bearing element that may be a portion of the maxilla, but I think the teeth are too small to be a part of this bone. The teeth are closely set upon small, bony rostrums similar to those of the lower jaw. The external surface is nearly smooth.

Mandible: Length of alveolar border.....	110.5 mm.
Length from cotyloid cavity.....	123.0 "
Depth at coronoid angle (estimated).....	20.0 "
Number of teeth in one inch, 5.	
Quadrate: Depth.....	32.0 mm.
Length of superior border.....	34.5 "

Pachyrhizodus velox. Plate XLIX, fig. 2.

Pachyrhizodus velox Stewart, Kans. Univ. Quart., vol. VII, pp. 193-195.

This species is represented by a maxilla, both mandibles, fragmentary quadrate, numerous portions of branchiostegal rays, and a fragment of another bone that I first described as a portion of one of the hyoids.¹⁰⁹ I have since reached the conclusion that it must be some other part, as the bone is too much contracted back of the extremity to be a portion of a ceratohyal. The catalogue number of the specimen is 316.

The maxillary is long and slender and of about equal depth from the superior condyle backward. The condyle is elevated, but how much cannot be determined, as the superior portion is not preserved. Just beneath the condyle the bone thickens and the outer surface contracts inward. External to the condyle there is a broad shelf of bone which is very roughly striated. The premaxillary surface is not preserved. The alveolar border supports about forty-seven teeth, as near as can be estimated. They are conical, directed slightly inward, and closely set. The crowns present a smooth enameled surface. The whole of the posterior portion of the bone is finely striated. Just above the alveolar border in the anterior half of the bone there are many small, nutrient foramina leading inward.

The mandible differs from that of *P. latimentum* Cope in not having a tooth on the symphysis within the anterior one, and in having a greater depth at the coronoid with reference to its length.

109. Kans. Univ. Quart., vol. VII, p. 194.

The dentary is short and strongly incurved at the symphysis. The symphysis is divided by a groove into an external and internal portion. The external is small and tubercular in its nature. The internal is probably the only part that is in contact with its fellow on the opposite side, and it has a well-marked ridge extending backward which becomes more indistinct toward the posterior portion. This ridge causes the bone to be thickened just below the alveolar border. The lower portion of the dentary is thin and smooth externally, except on the lower border, where there are short and deep striæ extending backward. The alveolar border supports probably thirty-eight or forty teeth. These are closely set, non-striated, and directed inward. The external alveolar wall rises considerably above the internal.

The character of the cotyloid cavity cannot be made out, owing to the quadrate being firmly in place. The outer surface of the articular is covered with striæ, which become coarser toward the lower portion.

The head of the quadrate seems to be broad and bifurcated, as in *P. leptognathus*. Above the head the bone broadens anteriorly, and has a strong ridge extending upward along the posterior border. Between the jaws there are several pieces of ossified cartilage covered with minute denticles, somewhat resembling shagreen.

Maxillary: Length from premaxillary surface.....	135.0 mm.
Depth of condyle (estimated).....	26.0 "
Mandible: Length from cotyloid cavity.....	157.0 "
Length of alveolar border.....	122.0 "
Depth at coronoid angle.....	48.3 "
Number of teeth in one inch, 8.	
Hyoid (?): Distance across anterior end (estimated).....	23.0 mm.

***Pachyrhizodus leptopsis*. Plate LXX, fig. 1.**

Pachyrhizodus leptopsis Cope, Cret. Vert. West, p. 225, pl. LI, figs. 8a, b, and c.

Represented by a portion of the right dentary bone of one individual and a small portion of the left dentary of another. The number of the specimen is 289.

The dentary is elongate and the upper portion forms a thick-

ened bar with a broad superior surface. This bar is bounded by a well-marked ridge antero-internally, from which the inner wall descends almost vertically. The teeth are not closely set, the interspaces being occupied by the sockets of the shed teeth; they are all set on stout bases and are larger than in *P. leptognathus*. These bases vary from round to oval and the apices are about on a level with the external alveolar border.¹¹⁰ "The teeth diminish in size from the middle of the dentary bone to the symphysis; beside the latter are two teeth of reduced size," but on the posterior portion the teeth are but slightly reduced. Just back of the last tooth there is an edentulous portion of about an inch in length, which is followed by a somewhat elevated coronoid process. This process is bent outward and covered with irregular longitudinal striæ on the external and internal sides. The lower portion of the bone, below the alveolar border, is thin and laminiform, smooth externally, and covered with coarse striæ internally.¹¹¹ "The symphyseal part of the ramus is not incurved as in *P. caninus* and *P. kingi* but is obliquely truncate, indicating that the chin had a compressed form, and was not rounded, as in them."

Depth of ramus at last tooth	60 mm.
Diameter of base of tooth	7 "
Distance from tip of coronoid to last tooth	78 "
Number of teeth in one inch, 2.5 to 3.	

Pachyrhizodus caninus. Plate LXX, figs. 3, 4, 5, and 6.

Pachyrhizodus caninus Cope, Proc. Am. Phil. Soc., vol. XII, 1872, pp. 344-346.

This species is represented by portions of the premaxilla and mandibles of two individuals. There is also a flat plate of bone accompanying the mandibles whose identity cannot be determined. The numbers of the specimens are 145 and 315.

The teeth on the dentary are supported on a shelf of bone that becomes narrow toward the distal extremity. This portion ends abruptly below and is continued into an acute lower border. The jaw is probably shallow throughout its extent, and toward the symphysis the bone is incurved and swollen.

110. Cret. Vert. West. p. 226.

111. l. c., p. 225.

The symphyseal surface is of an irregular form, slightly convex, with an emargination entering from the internal side. The jaws were probably loosely united by cartilage at this point. The distal extremity is edentulous, and forms a rather thin coronoid process, coarsely striated internally. There are spaces for from twenty-nine to thirty-two teeth, which decrease in size toward the extremities, and at the symphysis a triangle is formed by three of these. The teeth are rather closely set in places, with enlarged striate bases, while in others the teeth are separated quite a distance from each other where the head crown has not been replaced. The external alveolar wall does not rise as high as in *P. leptopsis*, mentioned above.¹¹² "The articular cotylus is composed more largely of the angular than the articular. Its long diameter extends inward and backward, and is strongly convex; in the transverse direction, slightly concave. Below and in front of it the lower margin of the jaw is acute. The angle is oval and rather small; it is prominent on the middle line on the inner side; the edges are thin, the upper curved outward, concealing part of the cotylus."

The premaxilla is elongated, and in the posterior portion of the bone it is narrow transversally. Toward the anterior extremity it becomes much wider and presents alveoli for two large teeth situated internal to the regular series. It is likely that only one of these teeth is functional at a time, as in most of the specimens that I have examined I find only one tooth, and an empty alveolus for the other. The surface for its fellow on the opposite side is roughened by small protuberances of bone. The teeth are slightly larger than those upon the dentary, but this may be due to the difference in size of the two specimens. There are four preserved on the outer row, but there were probably several more, as Professor Cope describes ten in his specimen. The external surface is finely striated.

The plate of bone mentioned above shows one surface to be covered with small pits except at the central portion, which is smooth. These pits at first remind one of the empty alveolus on the tooth-bearing elements of *Anogmus* and some of the

112. Cert. Vert. West, p. 222.

recent *Silurida*. The opposite surface is irregularly marked, and one of the extremities is convex.

Length of alveolar border of dentary..... 174.5 mm.
Depth of symphysis..... 17.0 "
Number of teeth in one inch, 5.

***Pachyrhizodus latimentum* ?.** Plate LXVIII; plate LXX, figs. 9, 10.

Pachyrhizodus latimentum? Cope, Proc. Am. Phil. Soc. 1872, p. 346.

This species of *Pachyrhizodus* is the largest American member of the genus, and probably outrivalled some of the largest forms of *Ichthyodectes*. The specimen was found by myself in the Butte creek region, in Logan county, Kansas, during the summer of 1898, and consists of a portion of a disarticulated skull, the glenoid portion of a scapula, and a number of vertebrae. The catalogue number of the specimen is 316.

Both the extremities are broken away from the maxilla, so that the exact length of this bone cannot be determined. It is finely striated externally and internally, and is somewhat coarsely striated on the superior surface. The teeth are large and closely set, but they are not all functional at once. The bases of these are somewhat striated and hidden from view externally by the downward extension of the outer alveolar wall. The teeth probably end some distance from the posterior extremity, as there is an edentulous portion back of the last tooth that continues as far as the alveolar border is preserved in this direction. The greatest depth of the fragment is 35 mm.

The premaxilla is more slender and pointed anteriorly than in *P. caninus*. There are seventeen teeth and tooth scars on the outer border, and there are spaces for one or two more that show no indication of ever having borne teeth. The teeth seem to be very similar to those found on the maxilla, with the exception that they are slightly smaller. The external border is nearly straight, while the internal is beveled off toward the anterior end, giving the extremity a slightly blunted appearance. Internal to the regular series there is a tooth that is much larger than those in the external row which has a deep

pit in front of it, probably the empty alveolus for the second large tooth. Measurements of premaxilla are :

Length of alveolar border	107 mm.
Greatest transverse diameter	24 "
Greatest depth (estimated).....	36 "

The mandible seems to be slightly larger than the one described by Professor Cope. Only the posterior portion is preserved, showing the articular and a portion of the dentary, including several teeth. The dentary is coarsely striated externally and has a rather indistinct groove just below the alveolar border. The teeth are probably not much reduced toward the coronoid process and their bases are partially hidden on the outside, as in *P. leptopsis*. The last tooth is separated from the coronoid by a long, thin crest of bone which is somewhat elevated. The exact line of separation between the dentary and articular cannot be traced, probably owing to the fact that the outer portions of the bone are injured and broken away in some places. The cotylus is large, deeply concave from before backward, and convex laterally. On the external side posteriorly there is a wall of bone projecting upward that forms a slight groove with the external side of the cotylus and receives the outer rim of the quadrate. Just above and in front of the cotylus there is a shallow pit, which seems to be not so well marked as in the specimen described by Professor Cope. The angular is a small element, and does not enter into the formation of the cotylus, as in *P. caninus*. It is irregularly marked and has the appearance of being partially anchylosed to the articular. The posterior extremity shows a roughened surface, which is probably for muscular attachment.

Length of ramus (estimated).....	330 mm.
Distance from cotylus to last posterior tooth.....	118 "
Depth at coronoid angle (estimated).....	83 "
Depth at cotylus.....	36 "

The quadrate is a rather long bone, which is probably not very greatly expanded above. The condyle is deeply concave transversally, with sharp edges both externally and internally. The anterior portion is thin above the condyle, while the posterior portion is much thickened and has a well-marked ridge

extending upward on the external side. The superior border is badly preserved.

Greatest depth.....	101 mm.
Transverse diameter of condyle.....	24 "

There are several other tooth-bearing elements, the exact location of which cannot be determined. Two of these are long, slender bars of bone covered with denticles on one side, somewhat resembling shagreen. Another is more flat than the above and covered with somewhat larger denticles. Still another is very thin and covered with various-sized denticles on one side.

The basioccipital is separated from all of the surrounding bones. The condyle is deeply concave and broader above than below. Just in front of the condyle there are two lateral facets for the attachment of the exoccipitals, which are much roughened and look outward and forward. In front of these facets the bone is narrow and has a median ridge, which is continued downward on the anterior end. On the lower portion the bone has a deep carina, which extends forward to near the extremity and forms a sharp projection posteriorly. There is a slight groove in the median line that Professor Cope¹¹³ thought represented the muscular tube.

Transverse diameter of condyle above.....	39 mm.
Vertical depth of condyle.....	35 "
Length of superior border.....	57 "

There are several other bones present whose location cannot be determined, although they are probably located in the posterior part of the skull. Figures of these are shown on plate LXX. There are a number of vertebræ with the specimen, which are larger than in the largest specimens of *Ichthyodectes* that I have examined. The sides are devoid of lateral grooves, but are covered with numerous small ridges which inosculate with each other, giving the outer surface of the vertebra a somewhat lace-like appearance. In this respect the vertebræ have a superficial resemblance to those of *Anogmus*, but when they are examined closely it is found that the ridges are more irregu-

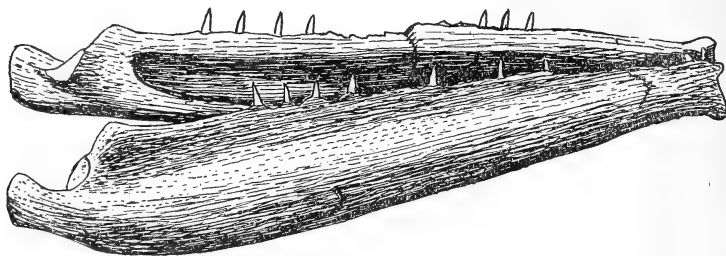
113. Cret. Vert., p. 220a.

lar and more sharply defined, especially at the extremities of the centrum. The neural arches probably fit into pits above, and the ribs seem to have been attached to tubercular processes of bone set into pits, as in the *Ichthyodectidæ*. Those in the anterior region are very thin, and the pits for the neural arches are large and widely separated.

Nearly the whole of the scapula is preserved. It shows a large convex superior (?) facet with a smaller one just below it, the two being separated by a sharp ridge. Just back (?) of the larger facet there is a large foramen, the anterior border of which is broken away.

There is a second specimen of a shoulder-girdle and a mass of fin-rays which probably belong to the same genus as the above, but probably a different species. The chief difference is found in the absence of the small facet on the articular portion of the scapula. At the lower extremity there is a large roughened surface that probably unites with the coracoid. The coracoid (?) is a broad, flat plate of bone which is thickened at the posterior extremity and presents a roughened articular surface for the scapula. The cleithrum is too fragmentary to determine its exact form, but it was probably concave on the internal (?) side and somewhat irregular and roughened on the external.

The proximal portions of the fin-rays of both sides are present. They are large and very numerous, fourteen being present on one side, and this probably does not represent all of them. The larger of these are slightly bent at the proximal extremities, and the smaller ones strongly so.



Lower jaws of *Pachyrhizodus minimus*, one-half natural size.

Pachyrhizodus minimus.

Pachyrhizodus minimus Stewart, Kans. Univ. Quart., vol. VIII, pp. 37, 38.

This species is represented by the mandibles alone, which are characterized as follows: The dentaries are slender and slightly incurved at the symphysis, where they also seem to be bent slightly downward. The symphysis is bifurcated by a deep groove on the external side, but internally it is continuous from above downward. On the external side there is a shallow groove just below the alveolar border, which becomes indistinct toward the symphysis; the lower border of the bone is sharp and nearly straight. There are eleven teeth preserved upon one of the rami, and room for at least as many more. They are conical, non-striated, and directed inward; the last is situated quite a distance from the coronoid angle, below which there is quite a depression.

Only a small portion of the articular is exposed on the external side, but internally it extends well forward. The cotylus is very convex transversally and situated well up toward the coronoid process, while below and extending backward from it on the external side is the prominent hook-like, angular process found in this and other genera of fishes.

Length of alveolar border from coronoid angle.....	52.0 mm.
Depth at coronoid angle.....	10.0 "
Length of bone from cotyloid cavity.....	56.0 "
Number of teeth in one centimeter, 4.	

The specimen, No. 327, was found by myself in the Butte creek region of Logan county, Kansas, during the summer of 1898.

PACHYCORMIDÆ.

Pelecopteridæ Cope. *Erisichtheidæ* Cope.
Protosphyrænidæ Woodward.

This family is very peculiar in having the ethmoid bone prolonged into a long rostrum or beak, and includes the single American genus *Protosphyræna*. For a long time this form was not well understood, as Professor Cope described the pectoral fins as belonging to the genus *Pelecopterus*, and the cranial portions to the genus *Erisichthe*, from which arose the family names of *Pelecopteridæ* and *Erisichtheidæ*. It was later discovered that these two genera were one and the same, and also that they were synonyms of the genus *Protosphyræna*, which was described by Leidy several years before.

PROTOSPHYRÆNA.

Protosphyræna Leidy, Trans. Am. Phil. Soc., vol. XI, pp. 91-95.
Xiphias Leidy, Trans. Am. Phil. Soc., vol. XI, pp. 94-95.
Erisichthe Cope, Proc. Acad. Nat. Sci. Phil., 1872, p. 280.
Pelecopterus Cope, Cret. Vert. West, p. 244 C.

¹¹⁴ "The teeth are laterally compressed and lanciform, without marginal serrations, and, when found in connection with the jaw, are seen to be fixed in distinct sockets. They were first noticed in 1822 by Doctor Mantell,¹¹⁵ who described one example as belonging to an unknown fish, and referred a second to an undetermined species of shark. Twenty-one years later Professor Agassiz studied the fossils, and thought that they were most probably identical with certain teeth discovered by Doctor Harlan¹¹⁶ in the Cretaceous strata of North America, which had been described under the name of *Saurocephalus lanciformis*, and erroneously placed among the Reptilia. They were accordingly made known as such in the great work on the "Poissons Fossiles,"¹¹⁷ and the determination was subsequently adopted by Dixon,¹¹⁸ in 1850, who figured more satisfactory specimens. At

114. A. S. Woodward, Proc. Geol. Assoc., vol. X, 1888, pp. 320, 321.

115. Foss. South Downs, p. 227, pl. XXXIII, figs. 7-9.

116. Jour. Acad. Nat. Sci., Phil., vol. III, 1824, pp. 331-337, pl. XII, figs. 1-5.

117. Poiss. Foss., vol. V, pt. I, p. 102, pl. XXVc, figs. 21-29.

118. Foss. Sussex, p. 374, pl. XXX, fig. 21; pl. XXXI, fig. 12; pl. XXXII, fig. 1; pl. XXXIV, fig. 2.

this time, moreover, an important addition to our knowledge of the species was rendered possible by a fine fossil in Sir Philip Egerton's collection, which showed that the fish had a remarkably elongate snout. Six years afterwards Professor Leidy¹¹⁹ carefully reexamined Doctor Harlan's original American specimens of *Saurocephalus*, and soon became convinced that Agassiz was mistaken in supposing that the English fossils were identical with these even generically. He thus proposed a new generic and specific name—*Protosphyræna ferox*—for the specimens figured by Mantell, Agassiz, and Dixon; wrongly suggesting, however, that Sir Philip Egerton's fossil rostral bone truly belonged to a swordfish, which might be appropriately termed *Xiphias dixonii*. Between 1875 and 1877 remains similar to those of the English Chalk were actually discovered in America, and not only proved that Egerton and Dixon were right in deciding upon the reference of the long snout to *Protosphyræna*, but further added important anatomical details. Professor Cope, however, who described these fossils,¹²⁰ proposed the difficultly pronounceable name of *Erisichthe*, which happily becomes a synonym."

The frontals of this genus are broad and flat, and are more or less covered with short corrugations. Anteriorly they unite with the ethmoids, which, with the prefrontals, vomer, and parasphenoid, form the long and pointed rostrum mentioned above. The frontals form the superior boundary of the orbits, which are large and surrounded by a ring of sclerotic bones. The pterygoids are covered with small, conical teeth, thickly set, and elevated upon small, bony hemispheres. The mesopterygoid is a broad and thin bone, covered with teeth similar to those found on the pterygoid. The upper jaw is composed of the maxilla and premaxilla. The first of these is slender and bears two rows of teeth, the inner of which is composed of large teeth with anterior and posterior cutting edges, each of which is set in a separate alveolus. The outer row is composed of small, conical teeth united directly with the bone. The

119. Trans. Am. Phil. Soc., vol. XI, 1860, pp. 91-95.

120. Cret. Vert. West, pp. 217, 218, and Bull. U. S. Geol. Surv. Terr., vol. III, 1877, pp. 821-823.

smaller of these teeth are mere tubercles of bone. The premaxillaries are small, triangular elements, loosely united to the maxilla. They bear both large and small teeth, of which the large are sharply pointed, smooth, and have anterior and posterior cutting edges. The prementary is paired, and bears both large and small teeth.

The fins of this genus were first described as the dorsal fin-spines of a shark, *Ptychodus*, by Agassiz,¹²¹ but were later recognized by Cope¹²² as belonging to a teleost, and described by him as a new genus, *Pelecopterus*, indicating a new order, *Actinochiri*, and family, *Pelecopteridæ*. These fins seem to form powerful spines, and are composed of slender, parallel rods of bone, closely placed. The anterior border is usually undulated more or less, and, in the smaller species, with tooth-like processes which are often covered with a substance which closely resembles enamel. Remains of this genus are found in the Fort Benton, Niobrara and Fort Pierre groups in Kansas.

There seems to be some doubt concerning the structure of the lower jaw, as the two authors, Cope and Felix, who have written upon the subject, seem to entertain somewhat different opinions. Cope¹²³ says: "A remarkable feature of the genus is displayed in the mandibles. Each of these is compound in the region usually composed of the simple dentary bone. It there consists of three parallel elements—an internal and an external, embracing a median element. The inner bears a band of teeth *en brosse* on its inner and superior aspects, and the external a few teeth of similar character on its superior edge. The large, lancet-shaped teeth are borne by the middle element, excepting some of the largest near the symphysis. Two of these on the inner side of the ramus originate in the internal bone." Concerning this point Felix¹²⁴ says:

"Wenn wir auch den Unterkiefer, abgesehen von dem Articular und Angular, aus vier Stücken gefunden haben, dem Prædentale und Dentale, sowie einem vorderen und einem hinteren Spleniale, so können doch dies nicht die Elemente sein, welche Cope meint.

121. Poiss. Foss., vol. III, pp. 56-59.
122. Cret. Vert. West, pp. 244, A-F.

123. Bull. U. S. Geol. Surv. Terr., p. 821.
124. l. c., 287.

Denn das hintere Spleniale reicht vorn nur bis an das hintere Ende des vorderen Spleniale, nirgends liegen drei Elemente parallel neben einander, keins von ihnen kann 'middle element' genannt werden. Vergleicht man mit der citirten Beschreibung der früher von ihm gegeben Abbildung¹²⁵ des vorderen Mandible-Theils, so muss man es auch befremdlich finden; dass Cope die grossen Fangzähne, mit Ausnahme allerdings von zwei, welche er in dem inneren Knochen entstehen lässt, von dem mittleren Theil getragen werden lässt, da dieselben dem äusseren Rande so nahe stehen, dass zwischen ihnen und jehnen nur eine sehr dünne Knochen-lamelle gedacht werden kann. Was sollte diese aber in osteologischer Hinsicht darstellen?"

Protosphyraena bentoniana.

*Protosphyraena bentonia*¹²⁶ Stewart, Kans. Univ. Quart., vol. VII A, pp. 27, 28.

This species was established upon the rostrum and numerous fragments of other bones which were, for the most part, in too poor a condition for identification. They were found by Dr. S. W. Williston in the Lincoln marble, on Rock creek, in southern Mitchell county, Kansas. The low horizon from which the specimen was obtained attaches special interest to it, as it is the first time that a specimen of this genus has been found below the Niobrara Cretaceous in America.

The proximal portion of the rostrum, bearing the large teeth, is not preserved. The base is broad, becoming more narrow toward the distal extremity, where it suddenly contracts, forming a rather blunt apex. The anterior portion is oval in outline instead of semicircular or round. The lower surface contracts more rapidly than the upper, causing the apex to be slightly above the center of the shaft. The superior and inferior surfaces gradually grade into each other, and are not separated by the angular ridge found in some of the species of this genus. The outer surface, where preserved, shows the rostrum to be covered with irregular longitudinal ridges which inosculate

125. Cret. Vert. West, pl. XLVII, fig. 6a.

126. Through a typographical error, this species first appeared as *P. bentonia* instead of *P. bentoniana*, as was intended.

more or less with each other, and give the outer surface of the bone a somewhat net-like appearance.

Length of rostral fragment.....	199 mm.
Transverse diameter 136 mm. from distal extremity	34 "
Transverse diameter 22 mm. from distal extremity	22 "

Protosphyraena recurvirostris.

Protosphyraena recurvirostris Stewart, Kans. Univ. Quart., vol. VII A, pp. 191, 192.

The material upon which this species was based consists of a complete rostrum, No. 373, with the adjoining portions of the vomer and parasphenoid, and differs from *P. nitida* in the following characters: The superior distal surface is regularly rounded and not flat, as in that species, and the cross-section at this point is round instead of semicircular or oval. The specimen corresponds in some respects with the rostrum of *P. penetrans*, and is more closely related to this species than to any of the other forms that have been described. I was inclined to it call *P. penetrans* until I found a rostrum of that species, when I discovered that it differed from it in a number of points which were sufficiently great to be called specific. The rostrum is more slender as a whole and is contracted to a more acute point than in *P. penetrans*. The markings are more sharply defined and the ridges inosculate with each other but rarely. In *P. pene-*



Rostrum of *Protosphyraena recurvirostris*, one-half actual size.

trans the markings are more or less reticulate. In the anterior portion of the species under consideration the ridges are closely placed to each other, while posteriorly they become scattered and are not so well marked as in the anterior portion of the bone. Their direction also becomes more varied in this region. On the posterior half of the inferior surface, the ridges become less

numerous and are larger than those on the superior surface and on the sides. In *P. penetrans* there is no difference of markings on the superior and inferior surfaces. A part of one of the large teeth at the base of the rostrum is preserved, and presents a smooth, enameled surface and probably anterior and posterior cutting edges.

A point that I have noticed is, that all of the figures and specimens of this portion show only one tooth, the alveolus for the other seeming to be filled with bone or matrix. This would lead to the belief that these teeth were alternately functional. The rostrum, as a whole, is slightly recurved.

Range and distribution: Niobrara Cretaceous, Gove county, Kansas.

Protosphyræna gigas.

Protosphyræna gigas Stewart, Kans. Univ. Quart., vol. VIII A, p. —.

The material upon which this species is based was obtained from the Lisbon shales, Fort Pierre Cretaceous, one mile northeast of Lisbon, Kan., during the summer of 1898. The specimen consists of the distal portion of a pectoral fin-spine, and is interesting in showing that this genus persisted into the Fort Pierre group. As only the distal portion of the fin is preserved the length of the fin cannot be determined, but judging from the width near the middle portion of the fragment it must have been larger than *P. gladius* Cope, which makes it probably the largest member of this family. The catalogue number of the specimen is 338.

The spine is made up of parallel rods closely placed. Near the center of the fragment there are about twenty-five of these, and probably more in life, as the posterior border is broken away and the exact number cannot be determined. These are broad in the central portion and become more narrow toward the distal extremity, where the spine seems to be regularly rounded on the end. Toward the anterior border the rods become much thicker and the border forms a rather blunt cutting edge, which differs from *P. gladius*, in which this margin is acute. This border is somewhat irregularly notched, the notches

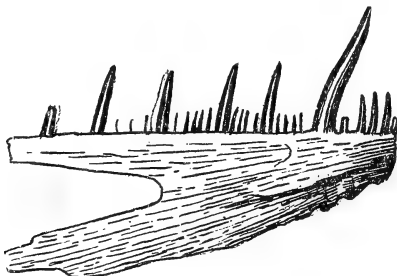
seeming to be more pronounced than in the species just mentioned, and are covered with an enamel-like substance.

	<i>P. gigas.</i>	<i>P. gladius.*</i>
Total length of fragment.....	49.0 mm.	.....
Width near the middle.....	195.0 "	175 mm.
Thickness, posterior, near the middle.....	11.5 "	12 "
Thickness, anterior, near middle.....	30.0 "	.....

Protosphyraena, n. sp.?

Protosphyraena, sp. nov., Kans. Univ. Quart., vol. VII A.

The material upon which this description is based consists of a right premaxilla from the Niobrara Cretaceous of western Kansas. Locality and collector not known. This material I consider too scant to justify a specific name being given until more complete specimens are found. It may prove to be the premaxilla of one of the other species of *Protosphyraena* that are at present known only from the rostral bones and fin remains. At present it will have to be considered as a new species with an interrogation. It is evidently different from the premaxilla of *P. nitida* described by Felix.¹²⁷



When seen from the side the bone is triangular in outline, with a thin superior and posterior border. The anterior extremity is broken away, but it was probably acutely pointed, as in *P. nitida*. The principal differences which characterize this from the premaxilla of the species just mentioned are found in the size and arrangement of the teeth. Near the center of the bone there are alveoli for four large teeth, the anterior three of which are almost complete, while the posterior one is broken off

*Measurements after Cope. Cret. Vert. West, p. 244 F.

127. Zeits. d. Deutsch. Geol. Ges. 1890, vol. XLII, p. 283.

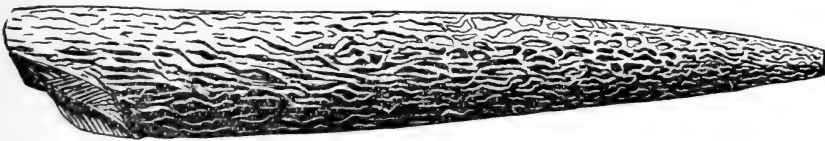
at the base, but enough remains to show that this and the anterior one were the smallest of the four. The two in the center are of about the same size; they are all directed forward, the anterior slightly more so than the rest. These teeth all have broad lanciform crowns, with anterior and posterior cutting edges and slightly striate enameled surfaces. Just back of the most posterior of these large teeth there is a row of small teeth, the anterior of which are scarcely more than bony tubercles, but posteriorly they assume definite dental characters; ten of these are preserved in the specimen. There are other teeth like these on the anterior portion of the border, but owing to the tip being broken away, the exact number of these cannot be determined. The surface for the maxillary contracts toward the anterior end, and is bounded below by a narrow shelf of bone extending inward.

Approximate length of the alveolar border	82 mm.
Depth just back of last large tooth.....	27 "
Height of first large tooth.....	15 "
Height of second large tooth.....	19 "

Protosphyraena penetrans. Plate LXIII.

Protosphyraena penetrans Cope, Bull. U. S. Geol. Surv. Terr. 1877, vol. III, No. 4, p. 821.

This species is represented in the museum by only one specimen, No. 372, consisting of a rostrum with a small portion of the apex, and the basal portion with the large teeth absent.



Rostrum of *Protosphyraena penetrans*, one-half natural size.

The superior distal surface was probably rounded in life, but, owing to depression, it has become slightly flattened, giving the cross-section at this point a somewhat ovoid or elliptical outline. In *P. nitida* this surface is finely rugose, with a strong angle bounding the superior plane on each side, while in this species there is no such angle, and the markings on this surface vary

but little if any from the markings on the front and sides of the bone. The markings on the inferior surface are similar to those on the sides, and do not become larger and more scattered, as in *P. recurvirostris*. The bone is pointed at the apex, giving a more acute shaft than in *P. nitida*, in which the rostrum contracts suddenly to a tip, but less acute than *P. recurvirostris*, where the shaft is more slender and the apex drawn to a more slender point. The markings are not so sharply defined and inosculate with each other more often than in the species just mentioned, especially on the anterior portion and sides. Niobrara Cretaceous, western Kansas. Collector, E. P. West.

There are remains of several pectoral fin-spines, and another which may be the pelvic fin, that I will refer to this species with doubt. They are much smaller than those described by Cope as '*Pelecopterus*,' and also differ from these in other minor details. Doctor Crook mentions in his paper on the "Kansas Cretaceous Fishes" ¹²⁸ that he had a right and a left pectoral fin-spine of this species in his possession at the time of preparing his paper, but failed to describe them, which makes the determination of the remains before me very difficult.

The fin is composed of parallel rods of bone, which are very slender at the posterior side, but toward the anterior border they become broader and slightly curved. The anterior border is nearly straight for a distance of 45 mm., when it begins to assume an undulated appearance, which becomes less marked and farther separated beyond the center, and probably finally disappears before the extremity is reached. In *P. nitida* these undulations assume a dentate appearance, and continue thus to the extremity, while in *P. gladius* and *P. chirurgus* this border is devoid of such undulations. This portion is covered with a thin layer of enamel-like substance, which seems to be thickest on the apices of the undulations. The spine is moderately broad at the base, where there are forty or more rods, but becomes more narrow distally. There are portions of probably seven basiosts, the anterior ones of which are probably paired. These are all provided with well-rounded condylar

128. Über ein. Knoch. fis. a. d. mitt. Krei. Kans., Paleontographica, 1892, 110.

heads where they articulate with the fin, and they probably have similar expansions at the other extremity.

	<i>P. agilis.</i>	<i>P. nitida.</i>	<i>P. gladius.</i>
Length of spine fragment.....	360 mm.	705 mm.	1,040 mm.
Width at base.....	62 "	67 "	120 "
Thickness at base.....	6 "	.....	12 "

The spine mentioned above, and thought to be pelvic, is about the size of the one described above, but differs from it in having the anterior border nearly straight, without the undulations, and but very little of the enamel-like deposit mentioned above. At the base of the spine there is a mass of bone which presents a large, flat articular surface, above and in front of which there is a large, pointed process of bone extending upward from the base of the anterior border. The spine is probably more narrow than the one just described.

Length, apex wanting.....	428 mm.
Width near center.....	45 "
Width at base (estimated).....	53 "
Long diameter of condyle at base.....	31 "
Short diameter of condyle at base.....	21 "

I am unable to say to what species the pelvic fin-spine, described above, may belong. It is of a different individual from the pectoral spine described as belonging to *P. penetrans*, but for the present, at least, I will consider it under this head.

CLUPEIDÆ.

The family *Halecidæ*¹²⁹ was made by Agassiz to include the two families *Salmonidæ* and *Clupeidæ*, fossil specimens often being so closely related to both of the above families as to render their exact relation to either of the above two families somewhat doubtful.

The tendency among ichthyologists seems to be to revive the two old family names; thus I use the name *Clupeidæ* to include the single genus *Leptichthys*, which seems to bear a close relationship to this family in many respects.

129. Am. Geol., vol. XXIV, pp. 78, 79.

LEPTICHTHYS.

Stewart, Am. Geol., vol. XXIV, pp. 78, 79.

There are several specimens of Cretaceous fishes in our collection that seem to differ from any of the other genera that I have seen described, and for which I have ventured to propose the generic name of *Leptichthys*. This genus seems to be related to *Osmeroides* Agassiz in some respects, but differs from it in the presence of a short dorsal fin and non-striated scales. It also differs from *Apsopelix* Cope in the anterior position of the dorsal fin.

The body is ellipsiform, and covered with large, thin cycloid scales, which are concentrically striated ventrally, but seem to lose this character to some extent in the dorsal region, where they are somewhat rugosely marked. The pelvic bones seem to be formed of heavy transverse bars of bone, which are thickened externally for the attachment of the pelvic fin. These bones probably had some anterior extension, but how much cannot be ascertained from the specimens at hand. The dorsal fin is short and composed of numerous rays, which are situated in front of the middle portion of the body. The pectorals are broad and rather elongated. The pelvic fin is broad and short. The caudal fin is deeply cleft. The skull seems to be rather bluntly pointed in front. The dentaries are short with acutely pointed teeth, and the lower borders of the bones are directed upward in front. The vertebræ are two-grooved, and are longer than deep. Only one species is represented in our collection, which is described below.

***Leptichthys agilis*, sp. nov.** Plate LXXII, fig. 1.

Scales large; about ten or twelve series to be seen across the body. The pectoral fins are composed of at least fourteen rays, the first two or three of which are cross-segmented, while the remainder are longitudinally split. The pelvic fins are situated posteriorly and the cross-segmentation is absent from their rays. The dorsal fin is composed of twelve or more short bony rays.

Length of body to cleft of caudal fin.....	290 mm.
Length from anterior extremity to base of dorsal fin.....	112 "
Depth of body at dorsal fin.....	59 "
Length of pectoral fin.....	46 "
Width of pectoral fin at base.....	16 "
Length of pelvic fin.....	29 "
Width of pelvic fin at base.....	10 "
Length of mandibular rami.....	32 "

ENCHODONTIDÆ.

This family may be characterized as comprising fishes with laterally compressed bodies, either naked or covered with scutes. The maxillæ and premaxillæ are elongated and covered with small teeth, which are firmly anchylosed to the bone. The dentaries are provided with a single row of large teeth, and usually one or more rows of smaller ones on the external side. Palatines and ectopterygoids powerful, and bearing a single series of large teeth on expanded bases.

It is probable that the only representative of this family in the American Cretaceous is the type genus *Enchodus*. There are several other European and Asiatic genera belonging to this group of fishes, among which are *Eurypholis*, from the Lebanon beds of Syria, *Pomognathus*, from the Chalk of Europe and Lebanon, and *Ischyrocephalus*, from the Upper Cretaceous of Westphalia.

ENCHODUS.

Agassiz, Poiss. Foss., vol. V, pt. I, p. 64.
Leidy, Rep. U. S. Geol. Surv. Terr., I, 1873, p. 289.

The remains of this genus are constantly met with throughout the Chalk of Kansas, but unfortunately in very fragmentary condition, consisting for the most part of the palatines and mandibles. The skull, as described by A. S. Woodward,¹³⁰ is triangular in form, with the roof flattened and slightly depressed, with the posterior lateral portions sculptured. The premaxilla is thin and deep, while the maxilla is long and slender, with small teeth along the lower border. The palatines, called premaxillæ by Cope, are dense masses of bone, with a single large fang extending downward from the anterior extremity. This,

130. Proc. Geol. Assoc., vol. X (1888), p. 315.

as well as the other teeth, is firmly anchylosed to the bone. The ectopterygoid, which joins the palatine posteriorly, is a long, thin bar of bone, with a number of teeth on the lower border of an irregular size. The mandible is moderately deep, and bears two series of teeth. Those on the internal side are very large and situated far apart, while those on the external side form a minute fringe.

The succession of the teeth, as described by Professor Cope,¹³¹ is very peculiar: "The first teeth appear on the alveolar surface at a considerable distance apart. The second teeth appear immediately in front of these, and by their presence create the irritation which results in the absorption of the root and shedding of the crown of the first. The teeth of the third series appear in advance of the second, occupying the space between them and the empty space previously occupied by No. 1. These may coexist for some time with teeth No. 2, as the specimen indicates, but the result is as before—the shedding of the adjacent older teeth. In the case of the anterior long tooth of each side, the movement is reversed. Here the successional tooth appears behind the position of the functional, which is consequently shed, and in the old fish this tooth occupies a position behind a concave symphyseal portion, which is concave and edentulous, or only provided with the small teeth of the marginal row."

The vertebræ are deeply grooved laterally.

There are several bones of a single specimen which I refer to this genus with doubt. These are figured on plate LXV, figs. 8, 9, and 10. The largest of these bones, fig. 8, is no doubt an opercular. It is very thin, excepting near the anterior-superior portion, where the bone is much thickened and presents an anterior and internal articular portion, for the hyomandibular, and also another along the lower border, where there is a long and narrow facet, probably for attachment of one of the other opercular bones. This bone is finely striated both externally and internally.

The second of these bones, fig. 9, presents an articular facet

131. *Cret. Vert. West*, p. 301.

at each extremity, one of which is much longer than the other. Along one of the borders there is a deep groove which is bounded on each side by a thin lamina of bone. The third, fig. 10, is a thickened mass of bone of an irregular shape, with a roughened articular surface at one end, which extends beyond the remainder of the bone in a spine-like projection. The fourth and last of these bones, fig. 10, is very peculiar, in that it is almost identical with that described and figured by myself as an opercular¹³² bone of *Niphactinus*. I would be inclined to think that I was mistaken in referring this to *Niphactinus* were it not for the fact that Professor Cope has figured this in his "Cretaceous Vertebrata"¹³³ as an "uncertain bone" of this genus. This bone is similar in structure, color, and in the matrix surrounding it, to those described above; so there is little probability of it having become mixed in collecting. The known American species are:

Enchodus ferox Morton, Leidy, below Greensand No. 5, New Jersey.

Enchodus pressidens Cope, Greensand, New Jersey.

Enchodus petrosus Cope, Niobrara Cretaceous, western Kansas.

Enchodus dolichus Cope, Niobrara Cretaceous, western Kansas.

Enchodus calliodon Cope, Niobrara Cretaceous, western Kansas.

Enchodus oxytomus Cope, Cretaceous, New Jersey.

Enchodus tetracus Cope, Cretaceous, Delaware and New Jersey.

Enchodus shumardi Leidy, Cretaceous, Dakota.

Enchodus (*Phasganodus*) *dirus* Leidy, Cretaceous, Dakota.

Enchodus (*Phasganodus*) *gladiolus* Cope, Niob. Cret., western Kansas.

Enchodus (*Phasganodus*) *anceps* Cope, Niob. Cret., western Kansas.

Enchodus (*Phasganodus*) *carinatus* Cope, Niob. Cret., western Kansas.

Enchodus (*Phasganodus*) *semistriatus* Marsh, Cretaceous, New Jersey.

Enchodus amicrodus Stewart, Niobrara Cretaceous, western Kansas.

Enchodus minimus Stewart, Niobrara Cretaceous, western Kansas.

Enchodus shumardi.

Enchodus shumardi Leidy, Proc. Acad. Nat. Sci. Phil., 1856, p. 257;
Rep. U. S. Geol. Surv. Terr., 1, 1873, p. 289; Cret. Vert. West, p. 238.

Represented by the dentary bones of several individuals collected by Professor Mudge from the Niobrara Cretaceous of Kansas, the exact locality of which is not known.

The dentaries are small and slender and are about 35 mm. in length. The internal alveolar border supports six large teeth,

132. Kans. Univ. Quart., vol. VIII A.

133. l. c., pl. XL, figs. 8, 9.

all of which are firmly anchylosed to the bone. The largest of these, situated just back of the symphysis, has a slightly expanded base and is directed inward at the apex. It is strongly striated and stands 8 mm. above the alveolar border. The teeth following are smaller than this one and all are probably of about the same size, except the last, which seems to be smaller than the ones in front of it. They are minutely striated under the microscope. The symphysis is incurved, and seems to have a strong articulation with its fellow on the opposite side by means of the prominent bony tubercles so characteristic of this portion of *Enchodus*. The external alveolar border bears a single row of minute teeth, the exact number of which cannot be determined on account of the greater part of them being broken away.

Enchodus petrosus. Plate LXX, fig. 11.

Enchodus petrosus Cope, Hayden's Bull. U. S. Geol. Surv. Terr. No. 2, p. 44; Cret. Vert. West, p. 238.

This species is represented by the palatines of numerous individuals and a small portion of one ectopterygoid.

The palatine is dense in texture and supports a very large tooth at the anterior extremity, which is directed downward and slightly forward. The anterior portion of this tooth presents a sharp cutting edge, which extends from the apex to near the base, along the sides of which the enamel is nearly smooth, while posteriorly it is covered with conspicuous vertical striæ. Posterior to this tooth there are a number of curved lines or scars formed in the replacement of this tooth, back of which the border is slightly carinate. The upper and posterior portions are very irregular.

Enchodus dirus. Plate LXX, fig. 14.

Phasganodus dirus Leidy, Proc. Acad. Nat. Sci. Phil., 1857, p. 167.

This species was first described by Doctor Leidy,¹³⁴ from a mutilated dentary bone from the Cretaceous deposits of Dakota, as *Phasganodus dirus*, making the specimen the type of a hitherto

134. l. c., p. 167.

unknown genus, which was later shown by Professor Cope to be a synonym of *Enchodus*.¹³⁵ The specimen here represented consists of a fragmentary mandible, No. 322, and was obtained by Mr. E. P. West from the Niobrara Cretaceous deposits of western Kansas, the exact locality of which is not known.

Only the internal side of the dentary is exposed, which shows four large teeth on the alveolar border, which are probably followed by one or two more. The most anterior of these is set upon an expanded base and has a sharp cutting edge antero-externally, while postero-internally it is rounded and covered with well-marked striæ. The cross-section is thus seen to be pyriform. At the base of the tooth, anteriorly, there is a slight pit, in front of which there are two small teeth near the symphysis. The second of the large teeth is the smallest preserved. It is non-striate and has anterior and posterior cutting edges directed slightly outward and inward. The third and fourth are slightly striated near the base and have the anterior cutting edges directed outward more than in the second. The symphyseal portion is not well preserved, but the bone probably becomes very shallow at this point. A well-marked fossa for the articular extends forward to a point about half way between the second and third large teeth.

Length of first large tooth (estimated).....	32 mm.
Distance from symphysis.....	12 "
Length of second large tooth.....	14 "
Distance from symphysis.....	47 "
Length of third large tooth.....	21 "
Distance from symphysis.....	77 "
Length of fourth large tooth (estimated).....	20 "
Distance from symphysis.....	101 "

***Enchodus dolichus*.** Plate LXX, fig. 12.

Enchodus dolichus Cope, Cret. Vert. West, pp. 239, 240.

This species is represented by portions of several individuals, consisting of the palatines, ectopterygoids, and fragments of other tooth-bearing elements.

The palatine is much smaller than in *E. petrosus*, and presents the long, fang-like tooth at the anterior extremity, which is non-

135. Cret. Vert. West, p. 301.

striate externally and has a cutting edge in front. Back of this tooth the bone is more slender than in the species just mentioned, and is very irregular above and behind where it joins the ectopterygoid. The ectopterygoid (?) is a long, slender bar of bone, called maxilla by Professor Cope, and is covered below with teeth well separated from each other. These teeth are large in front but become smaller toward the posterior extremity. There is one other tooth-bearing element that I have been unable to locate with any degree of certainty. It is expanded at one end and contracted at the other, long, very thin, and covered with small teeth on one of the edges. There are fragments of several mandibles which may belong to this species, but as none of them are associated with the palatines their identity as such cannot be ascertained.

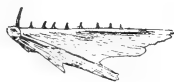
Palatine: Length.....	35 mm.
Greatest depth	8 "
Length of anterior tooth	18 "

Enchodus parvus.

Enchodus parvus Stewart, Kans. Univ. Quart., vol. VII A, p. 192.

This species is based on the right mandible of a single individual from Gove county, Kansas, the catalogue number of which is 321. It is of about the size of *E. shumardi* but differs from it in several characters.

The dentary is very thin and presents nine or ten large teeth on the border above. The first of these is the largest, but this is smaller than in the species just mentioned. The second of these is the smallest, while those following are of about the same size.



Left dentary of *Enchodus parvus*,
natural size.



Right dentary of *Enchodus amicrodus*,
natural size.

Enchodus amicrodus.

Enchodus amicrodus Stewart, Kans. Univ. Quart., vol. VII A, p. 193.

This species is represented by the type specimen only, which consists of the right dentary, the external side of which is exposed. The catalogue number of the specimen is 324.

The principal character that distinguishes this species from the others belonging to this genus is found in the absence of a row of minute teeth on the external alveolar border. The dentary is shallow and supports nine or ten large teeth. The anterior of these teeth is slightly recurved at the apex, and the base does not seem to be expanded as in some of the other species. The external surface of this tooth seems to be non-striated. The following teeth are mostly broken away but their bases show them to have been irregular in size.

Length of alveolar border.....	63 mm.
Height of anterior tooth above border.....	10 "
Distance from symphysis.....	5 "
Depth at symphysis.....	6 "

Enchodus, sp. Plate LXX, fig. 13.

This species is represented by the remains of the mandibles of several specimens, which may belong to *E. dolichus*. As Professor Cope did not characterize this portion in a way to render it recognizable, it will have to remain in doubt until the specimen mentioned by Cope is more fully described.

The dentary is rather elongated, and thin inferiorly. The alveolar border is slightly thickened, and bears teeth, of which those on the external side are very small, while those on the internal side are larger, less numerous. There are nine or ten of these large teeth, the anterior of which is the largest and slightly striated. The remaining eight or nine are non-striated, and extend farther back than do those on the external row. The posterior extremity of the dentary is toothless and directed slightly upward, forming a slight coronoid process. The depth of the bone decreases rapidly toward the symphysis, where there are numerous bony tubercles for attaching the two jaws together. The external surface is smooth, with the excep-

tion of several conspicuous striæ, which extend backward along the middle of the side.

The articular fits into a deep emargination in the dentary, and rises almost vertically from the cotylus. The bone is thin throughout, and is covered with rows of bony tubercles. The cotylus is very small, indicating a very weak articulation with the quadrate.

Length of dentary.....	76.0 mm.
Depth at coronoid.....	25.5 "
Length of articular.....	60.0 "
Length of first large tooth.....	16.5 "

DERCETIDÆ.*

Hoplopleuridæ Pictet and Humbert.

LEPTECODON.

Leptecodon rectus. Plate LXXIII.

Leptecodon rectus Williston, Kans. Univ. Quart., vol. VIII A, p. 113.

Slender and elongate; head elongate, the jaws slender, the anterior extremity in the specimen wanting. The hind end of the mandibles is represented by an impression situated below the posterior end of the skull. Teeth numerous, small, pointed, slender. The orbit is situated posteriorly; is of moderate size and round. Scapular arch strong, the large opercular space in front showing indications of the thin opercular bones. Vertebrae about forty-five in number, elongate, more than three times as long as deep, much constricted in the middle. Pectoral fins small, composed of seven or eight rays. Ventral fin very small, situated about the middle of the vertebral column; caudal fin small, the rays feeble, evidently cartilaginous, the outline indicated on the stone; the shape of the fin is regular apparently, the angles produced. Other fins wanting or not preserved. The side of the body, as preserved, shows three longitudinal rows of large, firmly united scutes, apparently of the same number in each series as the vertebrae. The scutes are in the

* By S. W. Williston.

form of a double trapezium, with the V posterior, the middle raised into a well-marked carina, which runs from the head to the tail. Apparently there are five rows of these scutes on the body. At the front the topmost row is near the middle line, the lateral row has its lower edge over the line of the vertebræ, while the lowest row has the carina just below the pectoral fin. The scutes have a finely roughened appearance, due to minute rounded and shallow pits. There are no indications of small scutes on the body intermediate between the larger ones.

Length of fish, as preserved	240 mm.
Estimated length	250 "
Length of vertebral column.....	175 "
Greatest width, just back of pectoral fin	27 "
Length of caudal fin, upper lobe.....	22 "
Length of pectoral fin	7 "
Length of ventral fin	9 "

The specimen lies on the shell of a large *Inoceramus*, explaining its excellent preservation. Close by are the remains, as seen in the illustration, of several examples of a small fish of unknown affinities, hitherto undescribed. The horizon is the Niobrara Cretaceous of the Smoky Hill river. The specimen was collected by Mr. H. T. Martin in 1895.

"The family *Hoplopleuridæ* was established by Pictet for fishes which were devoid of scales properly so-called, but which are protected on the back and sides by rows of scutes. The head is long and the jaws are provided with pointed teeth of unequal size. The bones of the head are frequently sculptured or granulose. The genera associated in this family by M. Pictet are: *Dercetis* Agassiz, *Saurorhamphus* Heckel, *Leptotrachelus* Von der Marck, *Plinthophorus* Guenther, *Euryophilus* Pictet, *Pelargorhynchus* Von der Marck. The fishes included in the genus *Dercetis* were considered by Agassiz to resemble the sturgeons in the arrangement of the dermal scutes, and were grouped among the ganoids. Heckel held the same opinion with respect to the position of *Saurorhamphus*, and Von der Marck also places the genera *Pelargorhynchus* and *Leptotrachelus* amongst the ganoids, but regards *Ischyrocephalus* as a teleostean. A careful review of the whole of the genera, assisted by additional specimens o

Leptotrachelus [*Dercetis*] and *Euryophilus* discovered in the Chalk of Mount Lebanon, convinced M. Pictet that they formed a group naturally associated, especially by the great analogy afforded by the peculiar arrangement of the series of scutes, and that they formed a family of the teleosteans, to which he gave the above name."¹³⁷

Cope long ago described three species and two genera of this group of fishes from Dakota, which seem to have been overlooked by subsequent writers.¹³⁸ Concerning the relationships, he says: "The relationship of the family of dercetiform fishes has been discussed by various authors, especially by Pictet and Von der Marck. The former regards them as teleosts; the latter as 'ganoids.' As I do not adopt the division signified by the last name, I find Professor Pictet's view nearer to the point. The specimens indicate, further, that the *Dercetidæ* belong to the *Actinopteri*, and probably to the order Hemibranchii. The only alternative is the order Isospondyli, and the characters which separate the two are not clearly shown in the specimens. Distinct bones below the pectoral fins may be interclavicles, which belong to the Hemibranchii."

The genus *Triænaspis*, from the Niobrara of Dakota, there described, has the dorsal and ventral scutes triradiate, the median branch of the three directed anteriorly, together with numerous band-like scutes. *Ichthyotringa* Cope, from the same locality, has the body covered with small, round scales. The third species is *Leptotrachelus longipennis* Cope, in which the dermal scutes consist of median, dorsal and ventral rows of tripodal form.

From all these, as well as other forms, the present genus seems distinct, though evidently nearest allied to *Aspidopleurus* Pictet and Humbert, from the Lebanon Cretaceous.¹³⁹

¹³⁷. Davis, On the Fossil Fish of the Cretaceous Formations of Scandinavia, Trans. Royal Dubl. Soc., IV, p. 428.

¹³⁸. Bull. U. S. Geol. Surv. Terr., IV, 67.

¹³⁹. Pictet and Humbert, Nouv. rech. s. les. Poissons fossiles du Mont Liban, p. 109, pl. X, fig. 1; Davis, On the Fossil Fishes of the Chalk of Mount Lebanon, Trans. Royal Soc., III, pl. XXXVIII, fig. 4.

MUGILIDÆ.

The family *Mugilidæ* is represented in our collection by only one genus, *Syllæmus*, and it is very doubtful if this belongs to it. In fact, it presents some characters which evidently do not belong to this family, which are the presence of the lateral line and more than four spines in the anterior dorsal fin. There are also more than twenty-four vertebræ, but it seems likely that this could hardly be called a family character. On the other hand, the absence of teeth seems to point to the *Mugilidæ*, and for the present, at least, I think that it should be left in this family until more complete specimens are found which will determine its exact position.

SYLLÆMUS. Plate LXXII, fig. 2.

Syllæmus Cope, Rep. U. S. Geol. Surv. Terr., vol. II, p. 180.

Cope has characterized this family as follows:¹⁴⁰ "A short, spinous dorsal fin. Ventral fins abdominal, posterior to the spinous dorsal. Pectoral fins subinferior in position. Coracoid bones forming a compressed, keeled body. Scales large, cycloid; lateral line present, extending along the middle of the sides. Parietal bones less than epiotics, entirely separated by the supraoccipital. Frontal bones large, wide, their common suture distinct.

"The opercular apparatus extends obliquely backward, while the mandible is produced forward. Hence the inferior part of the hyomandibular and the symplectic are directed obliquely forward. The opercular bones are, and their inferior borders reach the median line of the inferior side of the head."

The body is covered with moderately thick scales, which are covered with fine concentric striæ. The mandible is short, and the dentary apparently toothless. In some respects our specimens do not agree with Cope's, for there are evidently two dorsal fins in one of the specimens, which are separated from each other by a short space. The anterior of these is well de-

140. Rep. U. S. Geol. Surv. West 100th Mer., vol. IV, 1877, p. 26.

veloped, but the posterior was probably composed of only a few feeble spines, which were probably not preserved in the specimen described by Professor Cope.

Syllæmus latifrons. Plate LXXII, fig. 2.

Syllæmus latifrons Cope, Rep. U. S. Geol. Surv. Terr., vol. II, p. 181.

This species is represented by only two specimens in our collection, from the Fort Benton Cretaceous, the exact locality of which is not known.

The body is elongate and slightly larger than that of *Leptichthys*. The head is broad, flat, and, so far as can be determined, the frontals form the greater part of the roof of the skull. They are separated medially by a well-marked suture and possess no markings. The orbits are large and the skull is rather acutely pointed in front. The dentaries are short and seem to be without teeth. The opercular bones are large and are directed well downward. The pectoral fin is situated rather inferiorly, and is made up of numerous small rays, fifteen to twenty in number, which are strongly bent at the proximal ends. The anterior dorsal fin is short, and is made up of thirteen or more rays. The posterior dorsal is small, and with but few rays, which seem to be well separated from each other. The pelvic fin is in too poor a state of preservation to determine its characters, and the caudal fin is broken away in both of our specimens. Vertebrae longer than deep, about thirty-six present.

Length of specimen to base of caudal fin (estimated).....	345 mm.
Length of specimen to base of dorsal fin.....	132 "
Length of specimen to base of pectoral fin.....	90 "
Depth of body at anterior dorsal fin.....	69 "
Length of mandibular rami.....	39 "
Length of skull.....	70 "
Width of skull posteriorly.....	33 "

ON THE RANGE OF AMERICAN CRETACEOUS TELEOST FISHES
IN COMPARISON WITH THOSE OF SOME OTHER LOCALITIES.

After having treated the teleost fishes of the Kansas Cretaceous to as full an extent as our material will allow, I think it will be well now to devote a little space to tables showing their range in geological time, as well as to compare the fauna with those of some of the other principal localities that have yielded Cretaceous fishes. This work has already been done with the fish faunas of Syria and Westphalia by Doctor von der Marck, in his able paper entitled "Über die Verwandtschaft der syrischen Fischschichten mit denen der obern Kreide Westfalens," but as yet I believe no work of this nature has been done with the fish faunas of America and England. In the present attempt, the selachians and ganoids will be omitted, as they are beyond the scope of the foregoing paper. The species of each genus are also omitted, as the other localities are so widely separated from America as to have no great similarity in this respect. The tables of Syrian, Westphalian and English genera have been copied from the works of Davis, von der Marck, and A. S. Woodward. The list of American genera has been collected from the various government reports and scientific journals in which they have been described, and is thought to be fairly complete, although there may be a few genera which have escaped my notice.

Notwithstanding the fact that very little has been done on Cretaceous ichthyology in America during the past two decades, twenty-six genera have already been described from its deposits, and from the rich fish faunas of some of the localities we may expect that in after-years the number will be materially increased, when more carefully and systematic collections are made with this end in view.

Following is a table showing the distribution of the American genera in time, the most of which have been found in Kansas:

Cretaceous No.	2 Fort Benton.	3 Niobrara.	4 Fort Pierre.	5 Fox Hills.	Recent.
Ancistrodon.....					
Anogmius.....	—	—			
Apsopelix.....	—				
Beryx.....				—	—
Cimolichthys.....		—			
Cladocycus.....		—			
Dercetis.....		—			
Empo.....		—	—		
Enchodus.....		—			
Gillicus.....		—			
Ichthyodectes.....		—	—		
Ichthyotringa.....		—			
Ischyrhiza.....				—	
Leptecodon.....		—			
Leptichthys.....		—			
Oricardinus.....		—			
Pachyrhizodus.....		—	—		
Pelecorapis.....	—				
Protosphyraena.....	—	—	—		
Saurodon.....		—		—	
Saurocephalus.....		—			
Sardinius.....		—			
Spaniodon.....		—			
Stratodus.....		—			
Syleæmus.....		—	—		
Trienaspis.....		—			
Tetheodus.....		—			
Xiphactinus.....	—	—	—		

Pachyrhizodus is probably represented from the Fort Pierre by a fragment of a maxilla or dentary found by myself near Lisbon, Kan., during the summer of 1898; the specimen is in a very poor state of preservation, but bears a close resemblance to this genus. *Anogmius* is represented from the Fort Benton by two poorly preserved specimens, which were identified by Professor Cope as *Anogmius aratus*.

Next is given a table of genera of teleost fishes from the Upper Cretaceous deposits of Hakel and Sahel-Alma, in Syria, Baumberge and Sendenhorst, in Westphalia, England, and the United States.

Order TELEOSTEI.

Hakel.	Sahel-Alma.	Baumberge and Sendenhorst.	England.	United States.
Exocoetoides,	Istioides,	Istioides. Palaelyx. Lorenz (Esch). Telepholis.	Caturus (?).	
Xenopholis,	Osmoroides, Sardinus. Opistopteryx. Clupea.	Hololepis. Dactyloporus. Sardinoides. Sardinus.	Osmoroides,	Sardinus.
Clupea. Scombroclupea. Engraulis. Chirocentrites,	Leptosomus.	Leptosomus. Charitosomus. Microcella. Tachyactis. Brachyspondylus. Dermatopteryx. Thissopentoides. Ischyrocephalus.		Leptichthys.
Spaniodon. Eurypholis.	Spaniodon. Eurypholis. Lewisia. Pantopholis. Euryganthus.	Rhinellus. Polarorhynchus. Derectis.		Spaniodon.
Phylatocephalus. Rhinellus. Aspidopteryx.	Derectis. Angula.		Derectis.	Derectis. Trienaspis. Ichthyotringa. Leptecodon. Xiphactinus. Ichthyodectes. Gillius. Saurodon. Saurocephalus. Protosphyrena.
Derectis. Angula. Petalopteryx.			Xiphactinus. Ichthyodectes. Saurodon. Saurocephalus. Protosphyrena.	

Hakel.	Sabel-Alma.	Baumbergé and Sendenhorst.	England.	United State
Beryx.			Stratodus (?). Cimolichthys. Pachyrhizodus.	Stratodus. Empe. Cimolichthys. Pachyrhizodus. Oricardius. Anognius.
Pseudoberyx.			Tomognathus. Pomognathus. Pimthoplorus. Acrognathus. Autolepis. Beryx. Berycopsis.	Beryx.
Platax.	Pagellus. Hoploteryx. Homonotus. Enchodus.	Platycormus (Beryx). Macrolepis. Acrogaster. Hoploteryx.	Hoploteryx. Platax. Homonotus. Enchodus.	
Pycnosterinx.	Pycnosterinx. Omosoma. Imogaster. Cheithrothrix. Sphyrana. Solengnathus.	Omosoma. Mesogaster. Megapus (Cheithrothrix).		Enchodus. Tethcodus.
Vomer. Petalopteryx.			Calamopleurus. Cladocyclus. Stenopterna.	Apsopelex. Pelecorapis. Syllenus. Cladocyclus.

Besides the foregoing, the following genera are of somewhat uncertain position :

Hakel.	Sahel-Alma.	Baumberge and Sandenhorst.	England.	United States.
Spathiurus. Amphilaphurus.	Chondrostomus. Polypsephis (Microdon).	Echidnocephalus. Enchelurus.	Polypsephis (Microdon). Ancistrodon. Cœlorhynchus. Plethcodus.	Ancistrodon. Ischyrrhiza.

The following table shows the genera from the different localities which are common with the American Cretaceous :

Hakel.	Sahel-Alma.	Baumberge and Sandenhorst.	England.	United States.
Beryx.	Enchodus. Sardinius. Spaniodon. Dercetis.	Sardinius. Dercetis.	Xiphactinus. Ichthyodectes. Saurodon. Saurocephalus. Protosphyrena. Stratodus. Cimolichthys. Pachyrhizodus. Beryx. Enchodus. Cladocylus. Ancistrodon.	Xiphactinus. Ichthyodectes. Saurodon. Saurocephalus. Protosphyrena. Stratodus. Cimolichthys. Pachyrhizodus. Beryx. Enchodus. Cladocylus. Ancistrodon. Sardinius. Spaniodon. Dercetis.

In the foregoing tables, we see that there have been twenty-eight genera of teleost fishes found in the Upper Cretaceous deposits of North America, twenty-nine from England, twenty-eight from Westphalia, twenty-six from Sahel-Alma, and twenty-two from Hakel. Of these, we find that England has thirteen genera which are found in the American Cretaceous deposits, Westphalia two, Sahel-Alma four, and Hakel three.

The genus *Stratodus* has been reported from the Chalk of England by A. S. Woodward,¹⁴¹ who has described one species, *S. anglicus*, from Sussex. From the figures given in plate I, I am inclined to think that it is rather doubtful if this is *Stratodus*, as the dentary (fig. 4) is entirely different from that portion of *S. apicalis*, described in the foregoing pages. There is also hardly enough of the palatine (fig. 3a) to determine its exact relationship.

141. Proc. Geol. Assoc., vol. X, pp. 314, 315.

APPENDIX.

IN justice to Mr. Stewart, it should be said that his absence in the field during the printing of the foregoing paper has made it impossible for him to see the proof. Its correction, therefore, has devolved wholly upon myself, and I cannot hope to have done as well as would have the author. While in the printer's hands an important paper on the Kansas Cretaceous fishes was received from its author, Mr. F. B. Loomis,* too late to be recognized in the text. A brief review of this article is given below by Mr. Stewart, and the present writer has added thereto a list of the species and genera treated by Mr. Loomis in systematic sequence.—S. W. WILLISTON.

A recent article on the Kansas Cretaceous fishes, by Mr. F. B. Loomis,* reaches me while engaged in field-work, where I do not have access to the literature or the manuscript of the foregoing article on the Cretaceous fishes of Kansas, and while the work itself was rapidly going through the press. I can, therefore, make only the briefest and most general comments upon the paper. As a whole, the paper is to be commended, though I am inclined to think that the author has erred in some instances, which I may here point out briefly, reserving a more extended commentary upon the paper for a more propitious time.

On page 229 of the cited work, the author describes, under the name of *Thryptodus*, a large part of the skull of a fish which I am confident belongs to the genus *Anqgmus*, as herein described. The Kansas Museum specimen shows the top of the skull well preserved with the exception of the ethmoid and

*Die Anatomie und die Verwandtschaft der Ganoid und Knochenfische aus der Kreide Formation von Kansas, *Paleontographica*, Bd. XCIV.

nasals, and all of which are so closely associated with the mandibles, vertebræ and other bones belonging unquestionably to *Anogmius* that there can be doubt of their generic identity.

The bone figured on plate XXII (fig. 5), as a third ceratobranchial of the right side of the new genus *Pseudothryptodus*, appears to be the anterior internal portion of a maxilla of *Anogmius*. The bones shown in figures 4, 6 and 7 I have seen among our specimens in a fragmentary condition.

On page 252 and plate XXV, the author figures and described a portion of the skull of *Saurocephalus broadheadi* Steward (*sic*)*. I have described but one species of *Saurocephalus* (*S. dentatus*), which, on the preceding page, the author places as a synonym of *S. lanciformis* Harlan. It seems evident that the author has in some way got my two species, *Saurocephalus dentatus* and *Saurodon broadheadi*, badly mixed. Later I will show conclusively wherein *S. dentatus* differs from *S. lanciformis*. Under the name *Osmroides* the author describes material which I have placed in the genus *Anogmius*. Whether or not the author is right in doing so, I cannot say. I may be permitted to state, however, that Dr. A. S. Woodward, after an examination of the material in the University Museum described in the foregoing pages, expressed his opinion that the genus to which it belonged was different from anything that he knew. Possibly a more thorough examination of better material might induce Doctor Woodward to reverse this opinion. Nevertheless, the opinion of so able an ichthyologist is worthy of much consideration.

On page 265 is described "*Pachyrhizodus ferox* Steward." Evidently intended for *Pachyrhizodus velox* Stewart.

The name Enchodidæ is inadmissible on etymological grounds—it should be Enchodontidæ.

A. STEWART.

KIMMSWICK, Mo., November 3, 1900.

*Everywhere throughout this paper, and in numerous places, Mr. Stewart's name is wrongly spelled.—S. W. W.

List of Kansas Fishes Described and Figured by Mr. Loomis, cf. c.

Protospondyli.

- Protosphyraena penetrans* Cope, p. 224.
obliquidens Loomis, p. 225.
tenuis Loomis, p. 225.
nitida Cope, p. 227.

Plethodidae.

- Thryptodus* Loomis, p. 229.
zitteli, p. 234.
rotundus Loomis, p. 235.
Pseudothryptodus Loomis, p. 235.
intermedius Loomis, p. 236.

Chirocentridae.

- Ichthyodectes occidentalis* Leidy, p. 242.
hamatus Cope, p. 243.
multidentatus Cope, p. 243.
etenodon Cope, 244.
anaides Cope, p. 244.
Portheus Cope, p. 246.
Saurodon Hays, p. 247.
phlebotomus Cope, p. 248.
pygmæus Loomis, p. 248.
Saurocephalus Harlan, p. 249.
lanciformis Harlan, p. 251.
broadheadi Stewart, p. 252.

Albulidae.

- Syntegmodus* Loomis, p. 252.
altus Loomis, p. 253.

Elopidae.

- Osmeroides* Agassiz, p. 255.
polymicrodus Stewart, p. 256.
evolutus Cope, p. 257.

Salmonidae.

- Pachyrhizodus* Dixon, p. 258.
caninus Cope, p. 262.
latimentum Cope, p. 263.
sheari Cope, p. 264.
lepitopsis Cope, p. 264.
leptognathus Stewart, p. 264.
ferox (sic) Stewart, p. 265.
curvatus Loomis, p. 265.

Enchodidae.

- Cimolichthys* Leidy, p. 267.
nepaeolica Cope, p. 271.
merilli Cope, p. 272.
semianiceps Cope, p. 273.
contracta Cope, p. 273.
Enchodus Cope, p. 278.
petrosus Cope, p. 278.
dolichus Cope, p. 279.
shumardi Leidy, p. 280.
amicrodus Stewart, p. 280.

EXPLANATION OF PLATES, PART II.

PLATE XXIII.

Kansas Cretaceous Sea. (Page 234.)

PLATE XXIV.

- Figs. 1, 1a, 1b.—*Lamna sulcata* Geinitz, after Leidy, natural size.
Figs. 2, 2a.—*Scapanorhynchus rhapsiodon (texana)* Agassiz, natural size, after Leidy.
Fig. 3.—*Leptostyrax bicuspidatus* Willist., from the side, natural size.
Fig. 6.—*Scylliorhinus (Lamna?) gracilis* Willist., enlarged.
Figs. 7, 8.—*Scylliorhinus planidens* Willist., enlarged.
Fig. 5.—*Scylliorhinus rugosus* Willist., enlarged.
Figs. 9, 10.—Fragments of undetermined teeth from Kiowa shales.
Fig. 11.—*Cælodus stantoni* Willist., imperfect right splenial dentition, natural size.
Fig. 12.—*Cælodus brownii* Cope, imperfect left splenial dentition, natural size.
Figs. 13, 13a.—Amphibian atlas from Laramie Cretaceous.
Fig. 14.—Undetermined shark tooth (*Corax?*) from Benton of Colorado, enlarged.
Figs. 15, 15a.—*Leptostyrax bicuspidatus* Willist., natural size.
Middle figure of plate—Selachian verbebra (*Corax?*) from Niobrara Cretaceous.

PLATE XXV.

Ptychodus mortoni Mantell, natural size.

PLATE XXVI.

- Fig. 1.—*Ptychodus mortoni* Mantell, part of dentition of upper jaw, as preserved in the matrix, four-sevenths natural size.
Figs. 2, 4.—*Scapanorhynchus rhapsiodon* Agassiz, natural size.
Fig. 3.—*Lamna appendiculata* Agassiz, natural size.
Fig. 5.—*Isurus mantelli* Agassiz, natural size.
Fig. 6.—*Cælodus stantoni* Willist., crowns of two teeth from internal row, lower jaw, much enlarged.
Fig. 7.—*Leptostyrax bicuspidatus* Willist., enlarged.

PLATE XXVII.

Fig. 1.—*Ptychodus mortoni*, end of superior dentition, continuous with left end of fig. 1, plate XXVI, but less reduced.

Fig. 2.—*Ptychodus mortoni*, a transverse series of teeth, arranged more loosely, from near the right extremity of fig. 1, plate XXVI, about two-thirds natural size; the upper series belong one at each end of the lower series.

PLATE XXVIII.

Ptychodus martini Willist., three-fourths natural size; the teeth were discovered disassociated.

PLATE XXIX.

Figs. 1, 2, 3.—*Ptychodus*, sp. indet.

Fig. 4.—*Ptychodus occidentalis* Leidy, natural size.

Figs. 5-8.—*Ptychodus anonymus* Willist., natural size.

Fig. 9.—*Ptychodus polygyrus* Buckl., a little enlarged.

Figs. 10-15.—*Ptychodus whipplei* Marcou, nearly natural size.

Figs. 16-18, 20-22, 24.—*Ptychodus anonymus* Willist., nearly natural size.

Figs. 19, 23, 25, 26, 27.—*Ptychodus*, spp.

PLATE XXX.

Figs. 1-3.—Undetermined lamnids from Kiowa shales, Lower Cretaceous, enlarged one-half.

Fig. 4.—? *Mesodon abrasus* Cragin, enlarged one-half.

Figs. 5, 6.—*Lamna*, sp., from Kiowa shales, enlarged one-half.

Figs. 7, 8.—*Corax curvatus* Willist., from without and within, enlarged nearly two diameters.

Figs. 9-11.—? *Ptychodus janewayii* Cope, enlarged.

Fig. 12.—*Lamna*, sp., enlarged nearly two diameters. Kiowa shales.

Fig. 14.—*Ptychodus polygyrus*, from the side, natural size (the same tooth figured on plate XXIX, fig. 9).

Fig. 13.—*Ptychodus occidentalis*, enlarged nearly two diameters.

PLATE XXXI.

Figs. 1-40.—*Corax falcatus* Agassiz, about nine-tenths natural size; isolated teeth from many individuals.

Figs. 41-46, 50-52.—*Isurus mantelli* Agassiz, nearly natural size.

Figs. 47-49.—*Lamna appendiculata* Roemer, nearly natural size.

Fig. 53.—*Ptychodus*, sp., enlarged one-fourth.

PLATE XXXII.

Figs. 1-1l.—*Corax falcatus* Agassiz, from a single individual.

Figs. 2-2l.—*Isurus mantelli*, from a single individual.

Figs. 3-3c.—*Lamna appendiculata*.

Figs. 4, 5.—*Scapanorhynchus rhapsiodon* Agassiz.

Figs. 6, 7.—*Isurus mantelli*.

All six-sevenths natural size.

PLATE XXXIII.

Skull of *Xiphactinus audax* Leidy, one-third natural size: *pmx*, premaxilla; *mx*, maxilla; *den*, dentary; *dar*, dermarticlar; *eth*, ethmoid; *fr*, frontal; *pa*, parietal; *soc*, supraoccipital; *epot*, epiotic; *ptot*, pterotic; *pa*, parietal?; *prf*, prefrontal; *pfr*, postfrontal; *pal*, palatine; *sor*, suborbital; *suor*, supra-orbital; *sc*, sclerotic ring; *ps*, parasphenoid; *su*, jugal?; *hm*, hyomandibular; *pop*, preopercular; *op*, opercular; *sop*, subopercular; *q*, quadrate; *1, 2*, vertebræ; *n, n, n*, neural spines.

PLATE XXXIV.

Left mandible of *Xiphactinus audax* Leidy, external view, one-half natural size: *den*, dentary; *dar*, dermarticlar.

PLATE XXXV.

Left mandible of *Xiphactinus audax* Leidy, internal view, one-half natural size: *den*, dentary; *dar*, dermarticlar; *auar*, autarticlar; *sp*, supposed splenial.

PLATE XXXVI.

Xiphactinus audax Leidy, one-half natural size.

Fig. 1.—Sclerotic ring.

Fig. 2.—Premaxilla.

Fig. 3.—Maxilla.

PLATES XXXVII, XXXVIII, XXXIX.

Maxillæ, premaxillæ and mandibles of *Xiphactinus audax* Leidy, one-fourth natural size, showing the great individual variation in these parts.

PLATE XL.

No. 155. Maxilla, premaxilla and mandible of *Xiphactinus brachygnathus* Stewart.

PLATE XLI.

Superior maxillary condyles of *Xiphactinus audax* Leidy, one-third natural size, showing variation in the same.

PLATE XLII.

- Figs. 1, 2, 3.—Vertebrae of *Xiphactinus audax* Leidy (after Hay), one-sixth natural size; *ana*, basal piece of neural arch; *na*, neural arch; *cen*, centra.
Fig. 4.—Palato-quadrato arch of *Xiphactinus audax* Leidy, one-third natural size: *pal*, palatine; *mpg*, mesopterygoid; *mtpg*, metapterygoid; *pt*, pterygoid; *q*, quadrate; *sym*, symplectic.
Fig. 5.—Hyomandibular of *Xiphactinus audax* Leidy, one-third natural size.
Fig. 6.—Pelvic actinosts of *Xiphactinus audax* Leidy, one-third natural size.
Fig. 7.—Ceratothyal of *Xiphactinus audax* Leidy, one-third natural size.

PLATE XLIII.

Opercular bones of *Xiphactinus audax* Leidy, one-third natural size.

- Fig. 1.—Operculum.
Fig. 2.—Preopercular.
Fig. 3.—Supposed suboperculum.

PLATE XLIV.

Cranial bones of *Xiphactinus audax* Leidy, one-half natural size.

- Figs. 1, 2, 3, 5.—Bones of uncertain position.
Fig. 4.—Probably a fragmentary coracoid.

PLATES XLV-A AND XLV-B.

Shoulder-girdle of *Xiphactinus audax* Leidy, one-fourth natural size.

- Fig. 1.—External view: *cle*, cleithrum; *sc*, scapula.
Fig. 2.—Internal view of upper end of cleithrum and precoracoid, *pcor*.
Figs. 3, 4.—*Xiphactinus brachygnathus* Stewart: *pmx*, premaxilla; *max*, maxilla; *den*, dentary; *dar*, dermoticular—one-third natural size.

PLATE XLVI.

Bones of *Xiphactinus audax* Leidy.

- Figs. 1, 2, 3, 4, 5.—Fin-spines and rays, one fourth natural size.
Figs. 6, 7.—Hypural bones, one-half natural size.
Figs. 8, 9, 10.—Basiosts from pectoral fin, one-half natural size.
Figs. 11, 12.—External and internal view of neural arch from near the skull, one-half natural size.

PLATE XLVII-A.

Bones of *Xiphactinus audax* Leidy, one-half natural size.

Figs. 1a, b, c.—Superior, anterior and posterior views of first anterior vertebra.

Fig. 2.—Side view of second anterior vertebra.

Figs. 3, 4, 5.—Third, fourth and sixth anterior vertebrae, seen from the side.

Figs. 6, 8.—Hæmal arches and spines.

Figs. 7a, b.—Posterior and side views of vertebrae from near the extremity of caudal fin: *cen*, centra; *hs*, hæmal arch and spine.

Fig. 9.—Superior view of maxilla and premaxilla.

PLATE XLVII-B.

Fig. 1.—*Xiphactinus audax* Leidy, portion of caudal fin, showing the upturned condition of the vertebral centrae in this region, about one-half natural size.

Fig. 2.—Top view of skull of *Ichthyodectes hamatus* Cope.

PLATE XLVIII.

Figs. 1a, b, c.—External and internal views of maxilla and side view of prementary of *Saurodon broadheadi* Stewart, two-thirds natural size.

Fig. 2.—Dentary of *Xiphactinus lowii* Stewart, two-thirds natural size.

PLATE XLIX.

Ichthyodectes anaides Cope, one-half natural size.

Fig. 1.—Skull: *eth*, ethmoid; *fr*, frontal; *so*, supraoccipital; *epo*, epiotic; *ptot*, pterotic; *pofr*, postfrontal; *pfr*, prefrontal; *opt*, opisthotic; *pro*, prootic; *bo*, basioccipital; *v*, vertebra; *bs*, basisphenoid; *par*, parasphenoid.

Figs. 2a, b.—Maxilla and dentary.

Fig. 3.—Hyomandibular, probably belonging to this species.

Fig. 4.—Skull of *Ichthyodectes* or *Gillicus*, one-half natural size: *pa*, parietal; other lettering as in fig. 1.

Figs. 5, 6, 7.—Mandible, posterior end of maxilla and quadrate of *Ichthyodectes ctenodon* ? Cope, one-half natural size.

PLATE L.

Ichthyodectes hamatus Cope, one-half natural size.

Figs. 1a, b.—Side and top views of maxilla.

Figs. 2, 3.—Top and side views of palatine.

Fig. 4.—Preoperculum.

Fig. 5.—Quadrate.

PLATE L—continued.

Figs. 6*a, b*.—Posterior and top views of first anterior vertebra.

Figs. 7*a, b*.—Side and top views of maxilla and premaxilla *Ichthyodectes eruentis* Hay.

Figs. 8*a, b*.—External and internal views of premaxilla.

Fig. 9.—Front view of dentary bones.

Figs. 10*a, b*.—Top and side views of maxilla of type specimen from Professor Hay's collection.

PLATE LI.

Ichthyodectes acanthicus (?) Cope, one-half natural size.

Figs. 1, 2.—Superior and side views of maxilla.

Figs. 3, 4.—External and internal views of mandible: *den*, dentary; *aut*, autarticular; *der*, dermarticular.

Figs. 5*a, b*.—External and internal views of premaxilla.

Fig. 6.—Portion of scapula.

Fig. 7.—Palatine seen from side.

Fig. 8.—Side view of vertebræ.

Figs. 9*a, b, c, d*.—Pectoral fin-spines and rays.

Fig. 10.—Pelvic actinosts.

Fig. 11.—Portion of caudal fin, probably of this species.

Fig. 12.—*Ichthyodectes ctenodon* Cope, ceratohyal.

Fig. 13.—Bone of uncertain position.

PLATE LII.

Gillicus arcuatus Cope, one-half natural size.

Fig. 1.—Skull: *eth*, ethmoid; *fr*, frontal; *pa*, parietal; *so*, supraoccipital; *epo*, epiotic; *ptot*, pterotic; *pofr*, postfrontal; *hmnd*, hyomandibular; *pfr*, prefrontal; *sc*, sclerotic ring.

Fig. 2.—Maxilla, external view.

Figs. 3, 4, 5.—External and internal views of mandibles.

Fig. 6.—Ceratohyal.

Fig. 7.—Quadrate.

Fig. 8.—Palatine and mesopterygoid.

Fig. 9.—Preoperculum.

Fig. 10.—Fragment of sclerotic ring.

PLATE LIII.

Palato-quadrate arch and opercular bones of *Gillicus arcuatus* Cope, about seven-tenths natural size: *q*, quadrate; *mtpg*, metapterygoid; *pg*, pterygoid; *pop*, preoperculum; *op*, operculum.

PLATE LIV.

Gillicus arcuatus (?) Cope. Caudal fin, slightly under one-half natural size.

PLATE LV.

Saurodon xiphirostris Stewart, about three-fifths natural size: *pden*, pre-dentary; *den*, dentary; *dar*, dermarticlar; *max*, maxilla; *pmax*, premaxilla; *eth*, ethmoid; *fr*, frontal; *pfr*, prefrontal; *pa* and *ptot*, pterotic; *spot*, sphenotic; *hm*, hyomandibular; *qu*, quadrate; *na*, nasal; *prop*, preoperculum; *op*, operculum; *pal*, palatine; *sc*, sclerotic ring; 1, 2, 3, vertebrae.

PLATE LVI.

Saurodon ferox Stewart.

Fig. 1.—Upper and lower jaws, one-half natural size: *max*, maxilla; *pmax*, premaxilla; *den*, dentary; *pden*, pre-dentary; *dar*, dermarticlar.

Fig. 2.—A small toothed element, the exact location of which is not known, natural size.

Fig. 3.—Right quadrate, one-half natural size.

Fig. 4.—Ceratothyal, one-half natural size.

Fig. 5.—Centra of first anterior vertebra, natural size.

Fig. 6.—Glenoid portion of scapula, natural size.

Figs. 7, 8.—Portions of pectoral fin-spines.

PLATE LVII.

Saurodon ferox Stewart.

Fig. 1.—One-half natural size: *max*, maxilla; *pma*, premaxilla; *den*, dentary; *pden*, pre-dentary; *dar*, dermarticlar; *auar*, autarticlar.

Figs. 2, 3.—Internal view of right quadrate and hyomandibular.

Figs. 4, 5.—*Saurodon phlebotomus* Cope, external view of right maxilla and mandible.

PLATE LVIII.

Figs. 1*a*, *b*.—Premaxillae of *Protosphyraena occidentalis* Stewart, natural size.

Figs. 2*a*, *b*.—Outline and external markings of rostrum of *Protosphyraena bentoniana* Stewart; the first natural size, the second one-fourth natural size.

Figs. 3*a*, *b*.—Maxilla, premaxilla and dentary of *Saurocephalus dentatus* Stewart, one-half natural size.

Figs. 4*a*, *b*.—Internal view of maxilla, premaxilla and dentary of same.

PLATE LIX.

Empo nepæolica Cope, one-third natural size.

Fig. 1.—Top view of skull: *eth*, ethmoid; *fr*, frontal; *po*, postorbital; *so*, supraoccipital; *eo*, exoccipital.

Fig. 1*a*.—Pectoral fin-rays.

Fig. 2.—Inferior view of skull.

Fig. 3*a*.—Palatine.

Fig. 3*b*.—Mandible: *den*, dentary; *art*, articular.

Fig. 4.—External view of dentary.

Fig. 5.—Ethmoid seen from below.

Figs. 6*a*, *b*, *c*.—Hyoid bones.

Fig. 7.—Quadrate.

Fig. 8.—Preoperculum.

Fig. 9.—Operculum.

PLATE LX.

Stratodus apicalis Cope, slightly over one-half natural size: *sk*, top of skull; *pmx*, *den*, dentary; *pal*, palatine.

PLATE LXI.

Stratodus apicalis Cope.

Fig. 1.—Top view of skull, one-half natural size: *fr*, frontal; *pa*, parietal; *pt*, pterotic; *eo*, exoccipital.

Empo nepæolica Cope, one-half natural size.

Fig. 2.—Vertebrae seen from the side.

Fig. 3.—Ethmoid seen from below.

Fig. 4.—Hyomandibular.

Fig. 5.—Premaxilla (?).

Empo semianiceps Cope, one-half natural size.

Figs. 6*a*, *b*.—Palatine, inferior and side views.

Fig. 7.—Mandible.

Fig. 8.—Ceratohyal.

Fig. 9.—Posterior view of cotylus of articular.

Empo lisbonensis Stewart.

Figs. 10*a*, *b*.—Inferior and side views of palatine.

PLATE LXII.

Protosphyraena gigas Stewart, slightly under one-third natural size.

PLATE LXIII.

Fin-spines of *Protosphyraena penetrans* (?), slightly under one-half natural size.

PLATE LXIV.

Anogmius polymicrodus Stewart, one-half natural size: *den*, dentary; *art*, articular; *mx*, maxilla; *pmx*, premaxilla; *q*, quadrate; *ch*, ceratohyal; *sc*, sclerotic ring; *a, a, a, a*, dermal plates; *op*, operculum; *pop*, preoperculum; *iop*, interoperculum; *sop*, suboperculum; *or*, supposed orbital bones.

PLATE LXV.

Anogmius polymicrodus Stewart.

Fig. 1.—Top view of skull, one-half natural size: *fr*, frontal; *po*, postorbital; *pa*, parietal; *pt*, pterotic; *hmd*, hyomandibular.

Fig. 2*a, b*.—First anterior vertebra, posterior and superior views.

Fig. 3*a, b*.—Abdominal vertebrae, top and side views.

Fig. 4.—Premaxilla.

Fig. 5.—Condyle of quadrate.

Fig. 6.—Superior view of cotylus.

Anogmius evolutus Cope.—Superior view of cotylus.

Figs. 8, 9, 10.—Opercle and other bones, probably of *Enchodus*.

PLATE LXVI.

Anogmius polymicrodus Stewart.—Caudal fin, about one-half natural size.

PLATE LXVII.

Anogmius evolutus Cope, slightly under natural size: *den*, dentary; *pal*, supposed palatine; *mx*, fragmentary maxilla; *phar*, supposed pharyngeal bone of *A. polymicrodus* Stewart; *a*, bone of uncertain position.

PLATE LXVIII.

Pachyrhizodus latimentum? Cope, one-half natural size.

Fig. 1.—Right mandible: *den*, dentary; *art*, articular.

Fig. 2.—Premaxilla.

Fig. 3.—Maxilla.

Fig. 4.—Quadrate.

Fig. 5.—Condyle of quadrate, seen from below.

Figs. 6*a, b, c*.—Bones of uncertain position.

Fig. 7.—Vertebrae.

Fig. 8.—Glenoid portion of scapula.

PLATE LXIX.

Fig. 1.—*Pachyrhizodus leptognathus* Stewart, natural size: *den*, dentary; *art*, articular; *q*, quadrate; *pop*, preoperculum; *op*, operculum?; *a*, bone of uncertain position.

Fig. 2.—*Pachyrhizodus velox* Stewart, one-half natural size; *mx*, maxilla; *den*, dentary; *art*, articular; *hy*, bone of uncertain position, probably a ceratohyal, natural size.

PLATE LXX.

Fig. 1.—*Pachyrhizodus leptopsis* Cope.—Internal view of dentary, one-half natural size.

Fig. 2.—Superior view of dentary of *Pachyrhizodus caninus* Cope.

Fig. 3.—Premaxilla.

Fig. 4.—Bone of uncertain position.

Figs. 5, 6.—Superior and posterior views of vertebra.

Figs. 7, 8.—Posterior and side views of basioccipital of *Pachyrhizodus latimentum* ? Cope.

Figs. 9, 10.—Superior and posterior vertebrae of same.

Fig. 11.—Palatine of *Enchodus petrosus* Cope.

Fig. 12.—Palatine of *Enchodus dolichus* Cope.

Fig. 13.—Dentary of *Enchodus*, sp.

Fig. 14.—Internal view of dentary of *Enchodus dirus* Leidy.

PLATE LXXI.

Shoulder-girdle and pectoral fin of *Pachyrhizodus*, about one-half natural size.

PLATE LXXII.

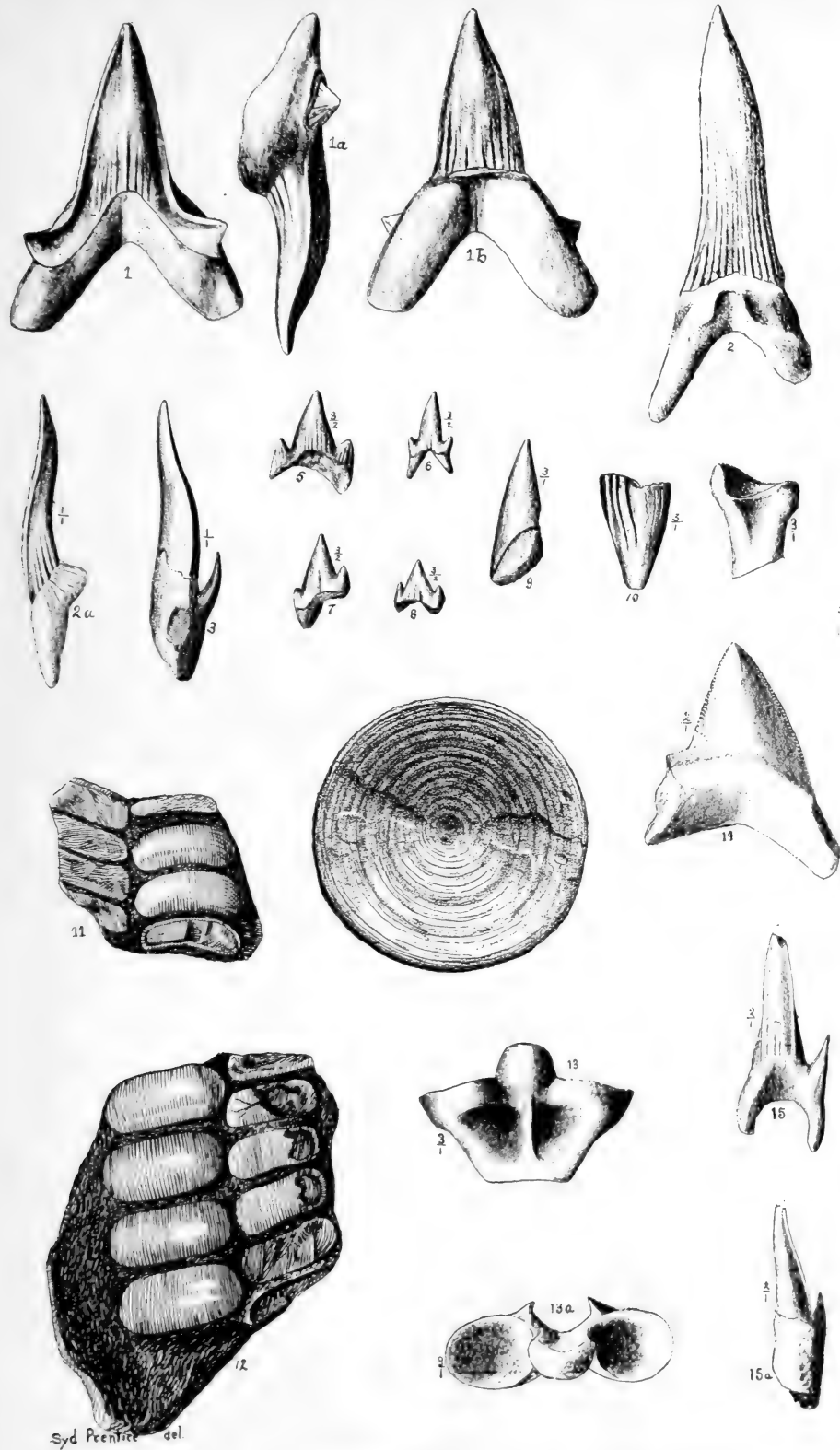
Fig. 1.—*Leptichthys agilis* Stewart, about one-half natural size.

Fig. 2.—*Sylæmus latifrons* Cope, slightly under one-half natural size.

PLATE LXXIII.

Leptecodon rectus Williston, about three-fifths natural size.





Syd Prentice del.

LAMNA, 1.

SCAPANORHYNCHUS, 2.

LEPTOSTYRAX, 3, 15.

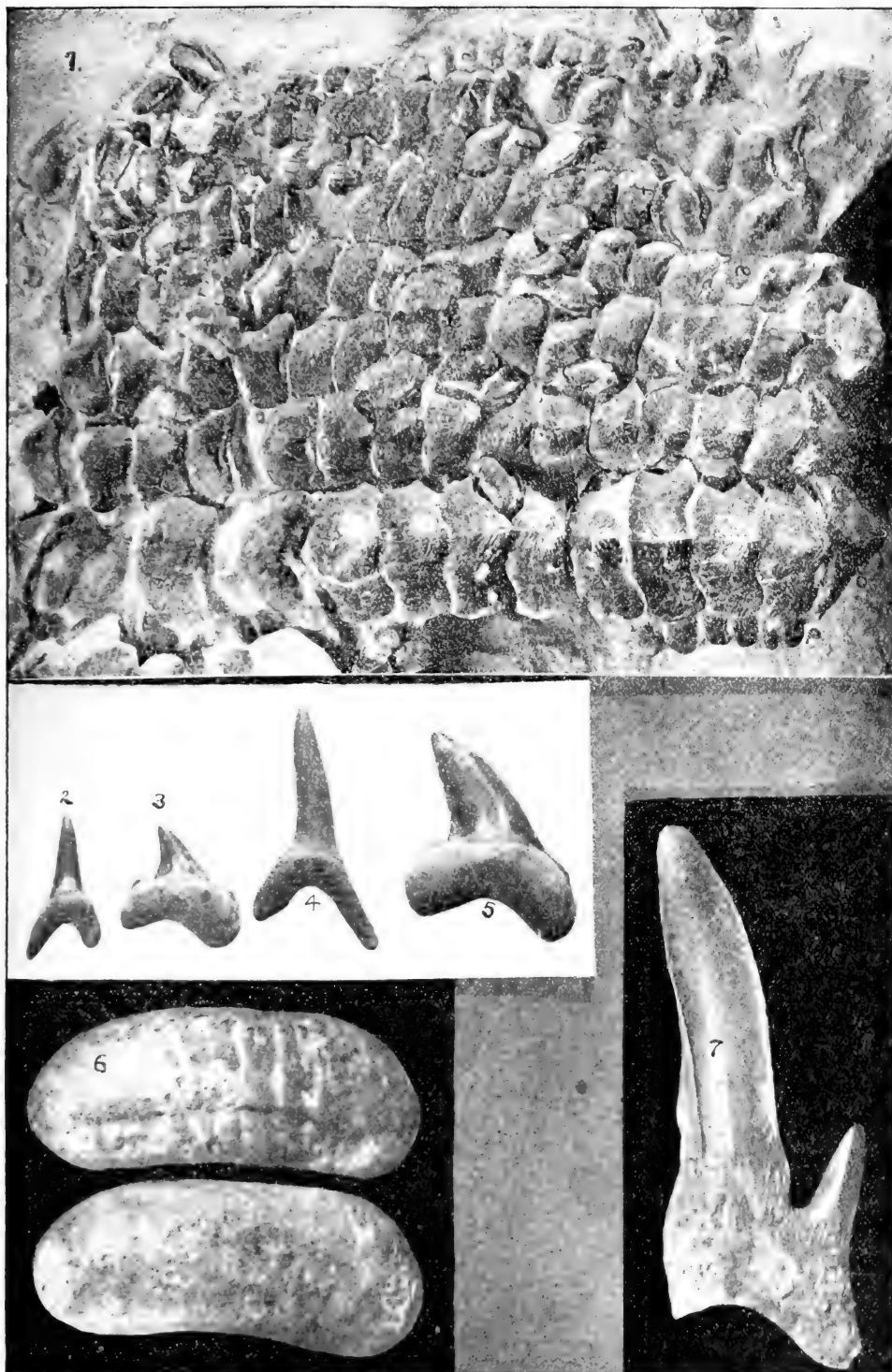
SCYLLIORHINUS, 5-8.

CŒLODUS, 11, 12.





PTYCHODUS MORTONI.



PTYCHODUS, 1.

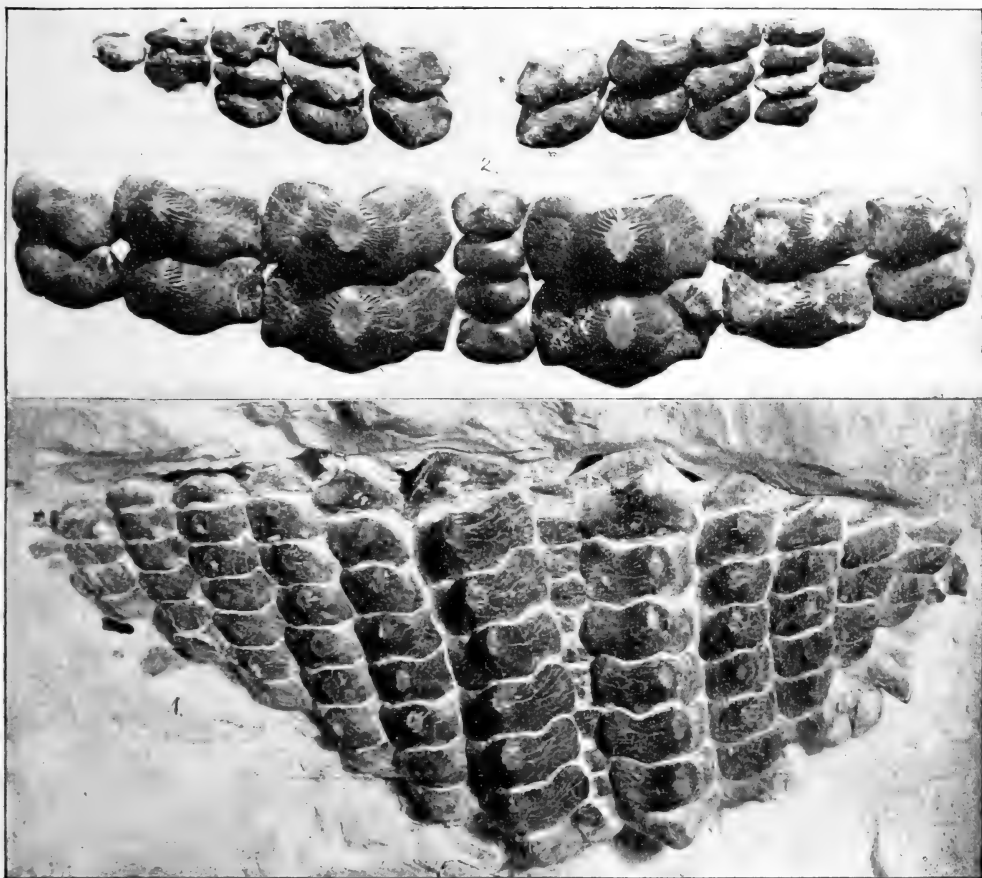
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LAMNA, 3.

ISURUS, 5.

CŒLODUS, 6.

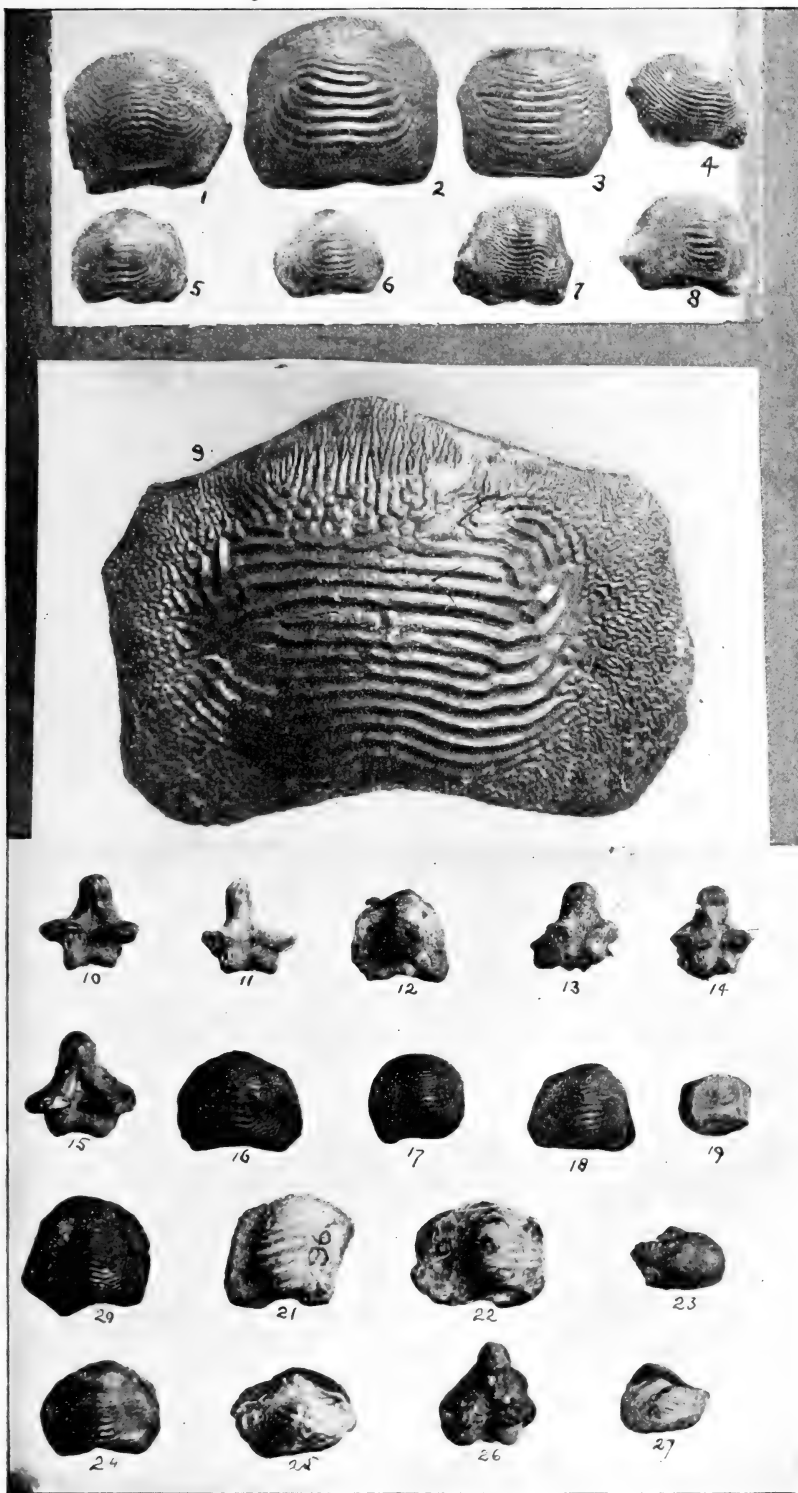
LEPTOSTYRAX, 7.



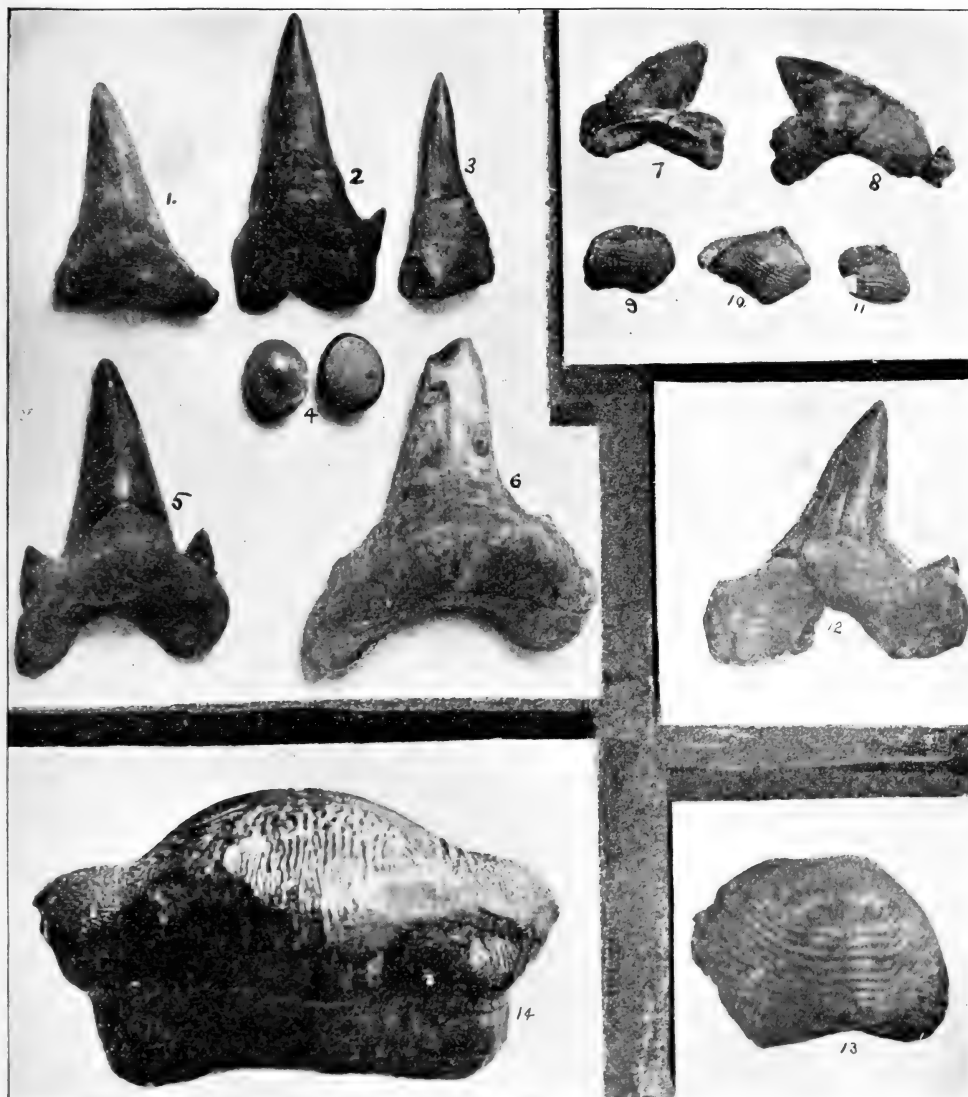
PTYCHODUS MORTONI.



PTYCHODUS MARTINI.

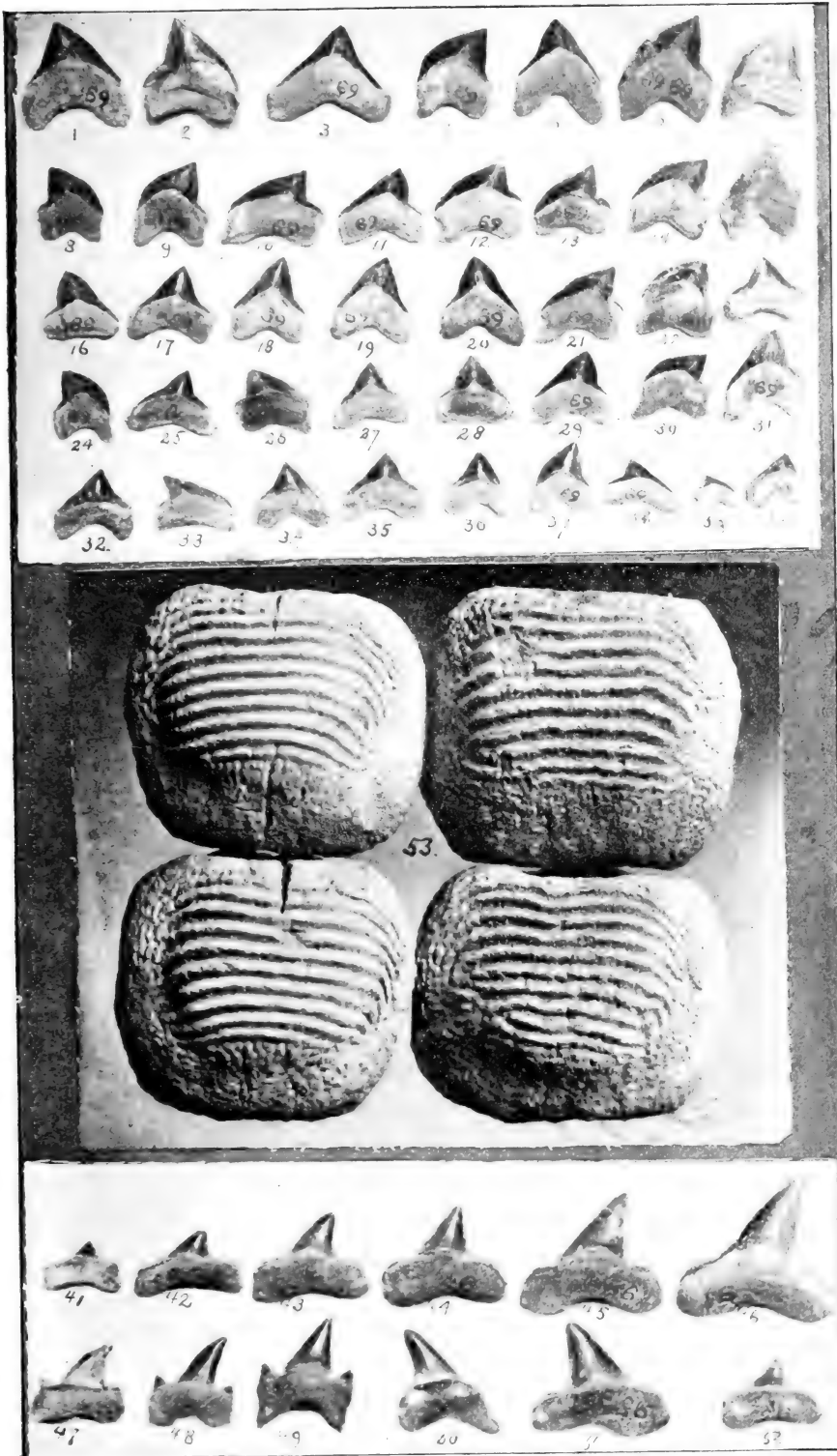


PTYCHODUS.



LAMNA, 1-3, 5, 6, 12. MESODON ?, 4. CORAX, 7, 8. PTYCHODUS, 9, 10, 11, 13, 14.

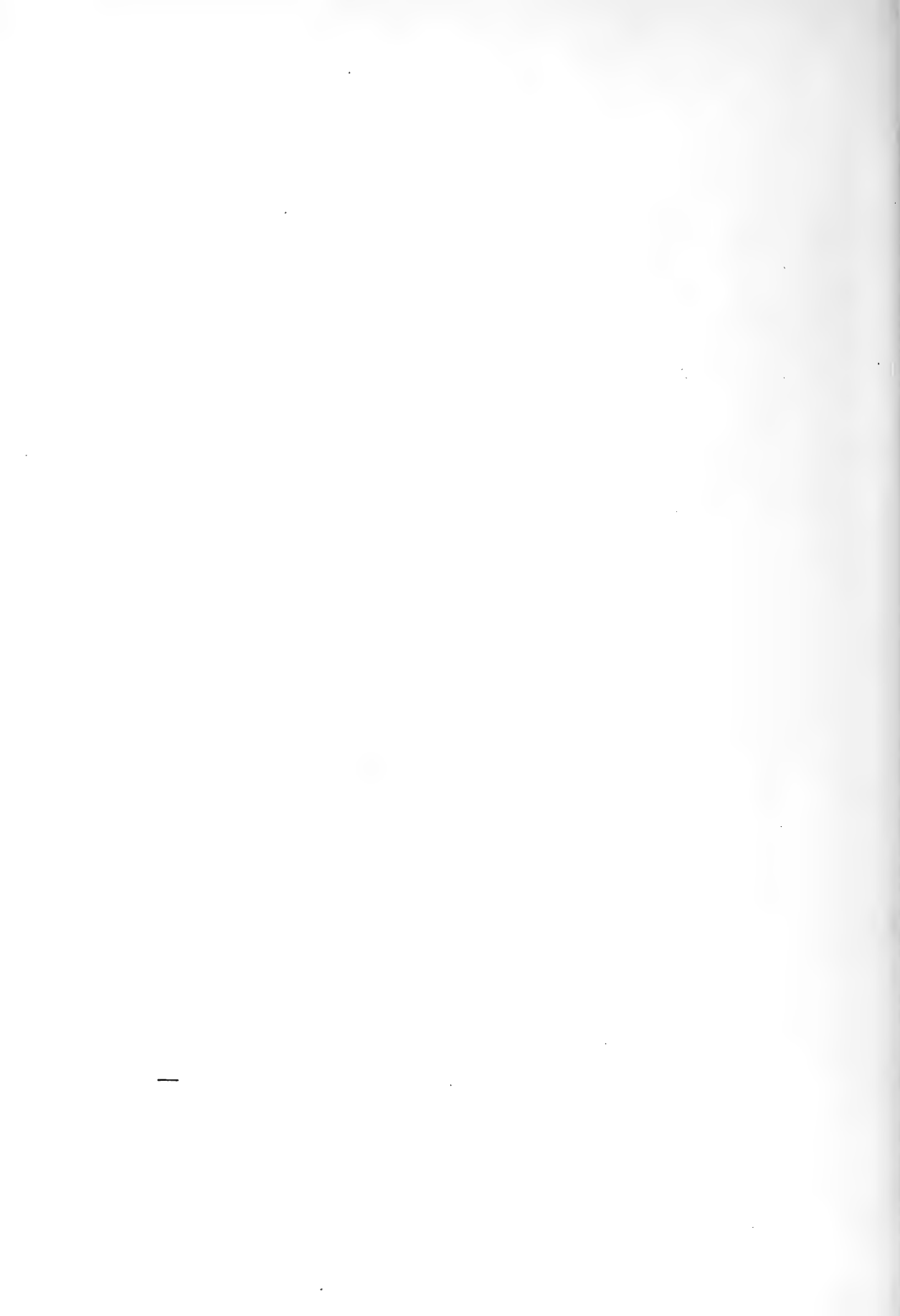


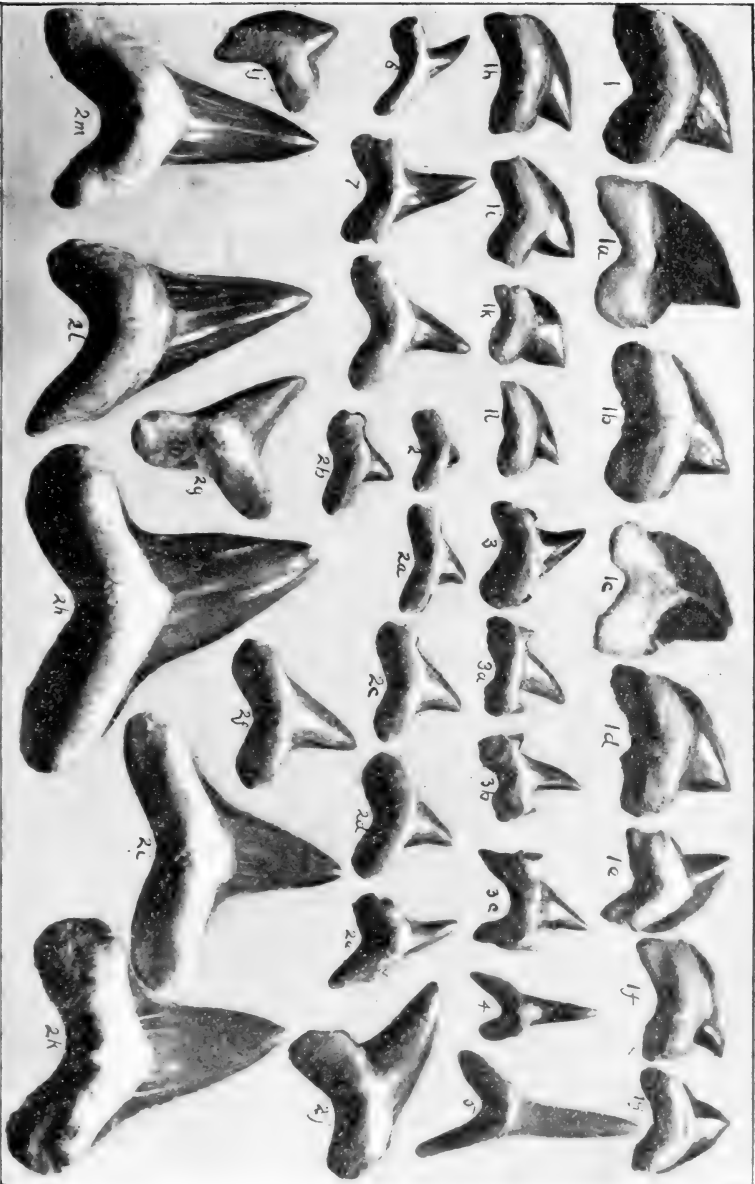


CORAX, 1-40.

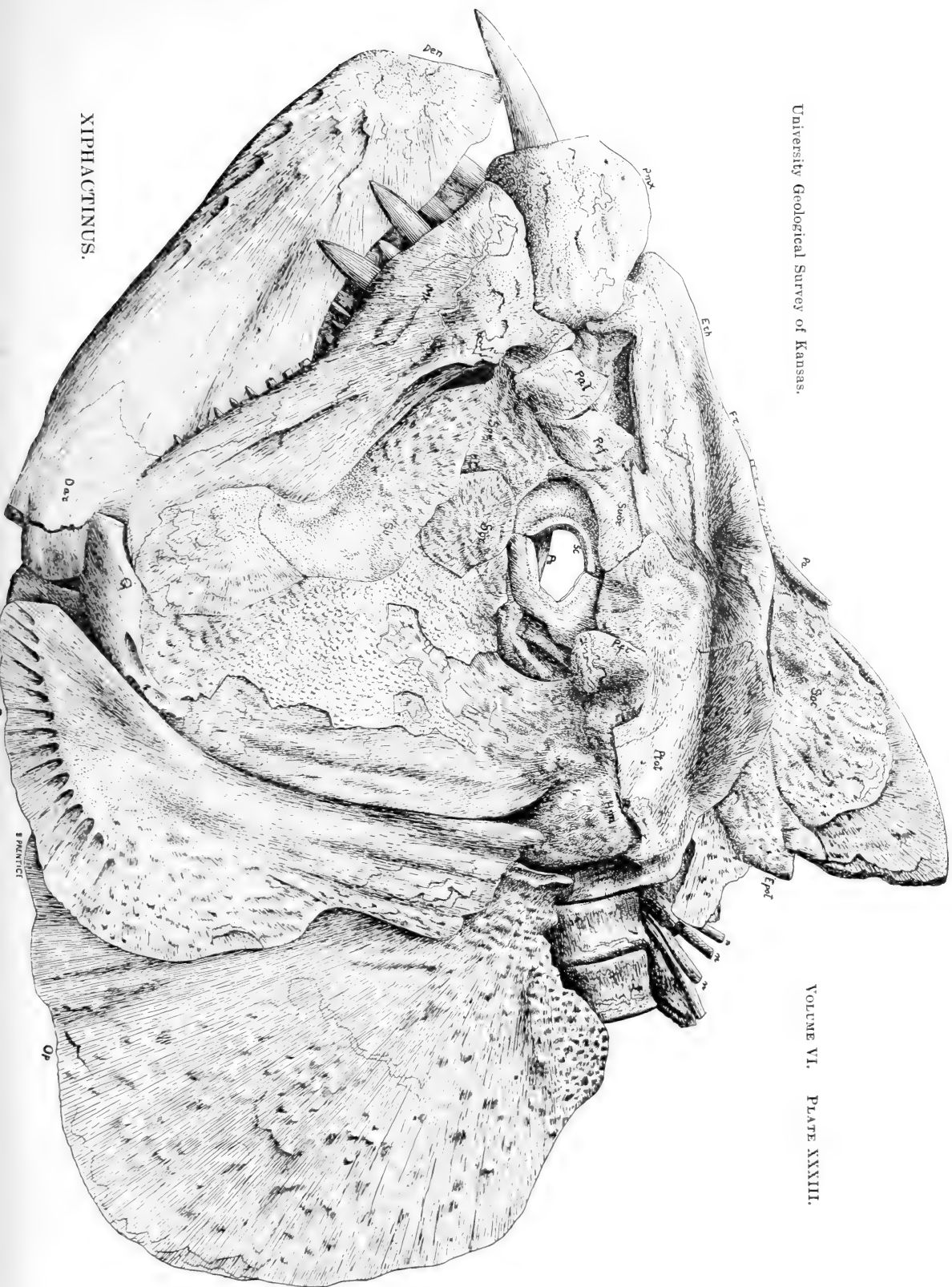
ISURUS, 41-46, 50, 52.

PTYCHODUS, 53.

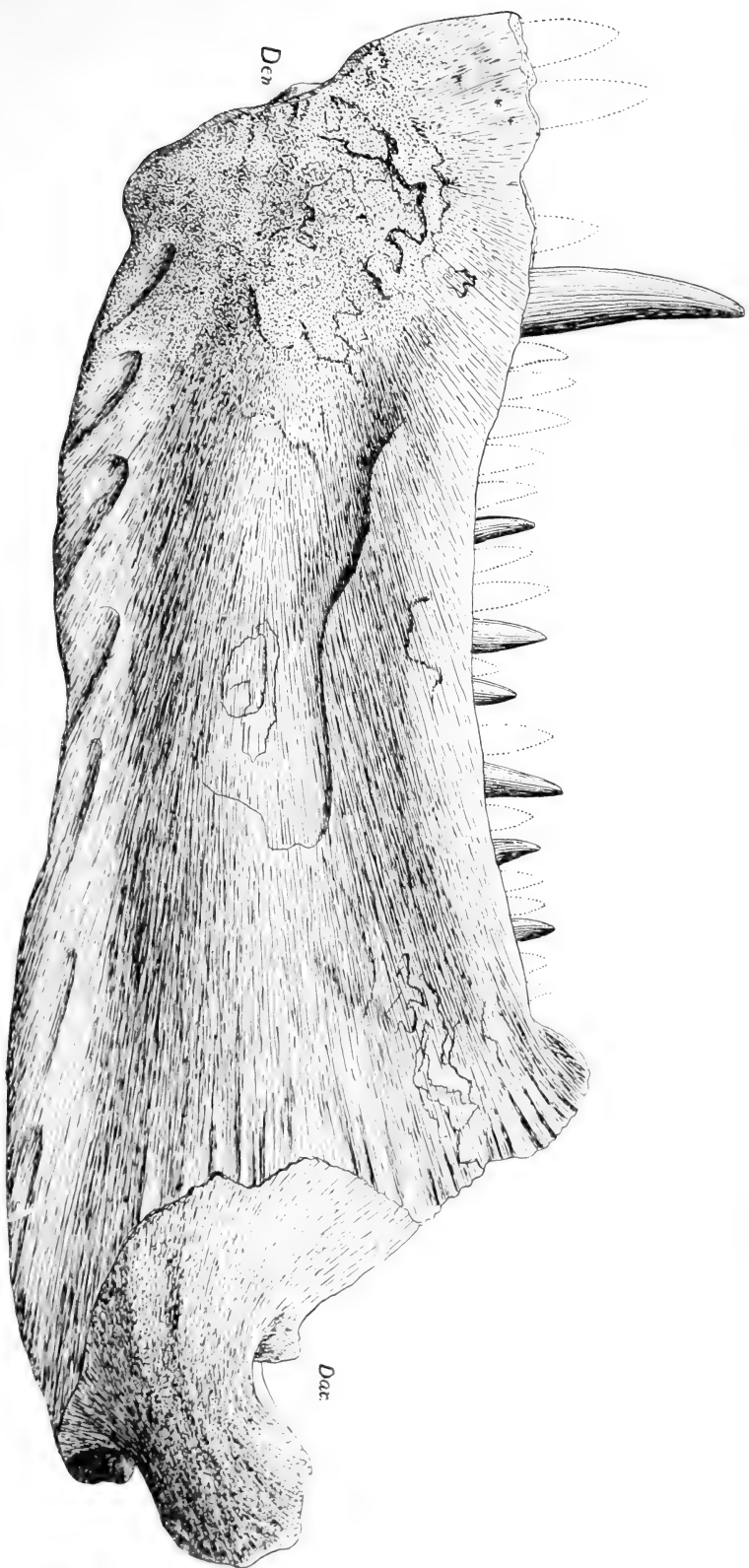




CORAX, 1. ISURUS, 2, 6, 7. LAMNA, 3. SCAPANORHYNCHUS, 4, 5.

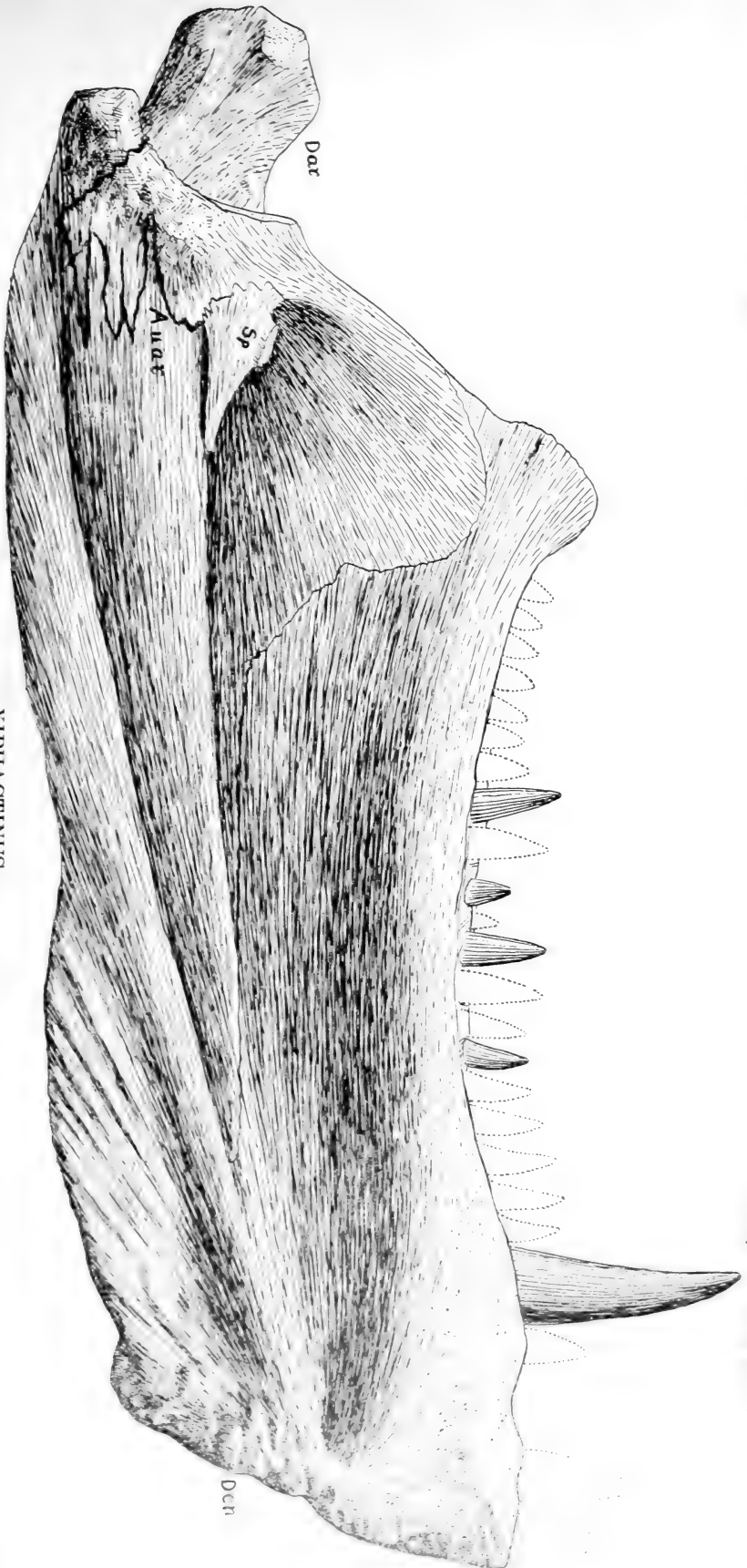






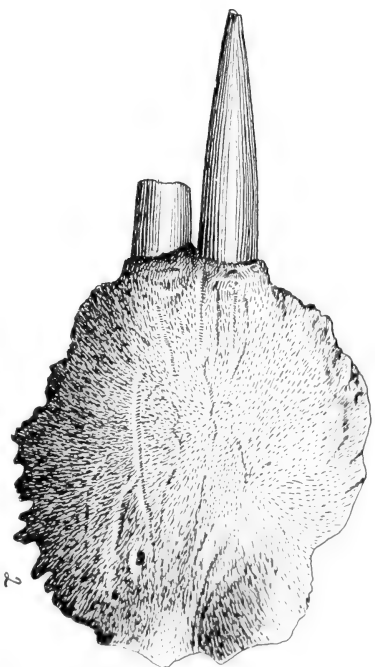
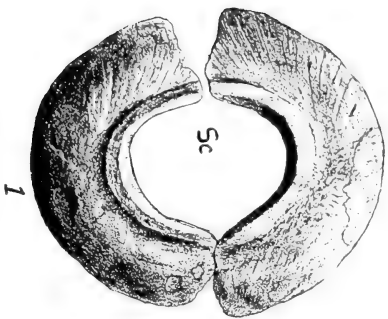
XIPHIACTINUS.



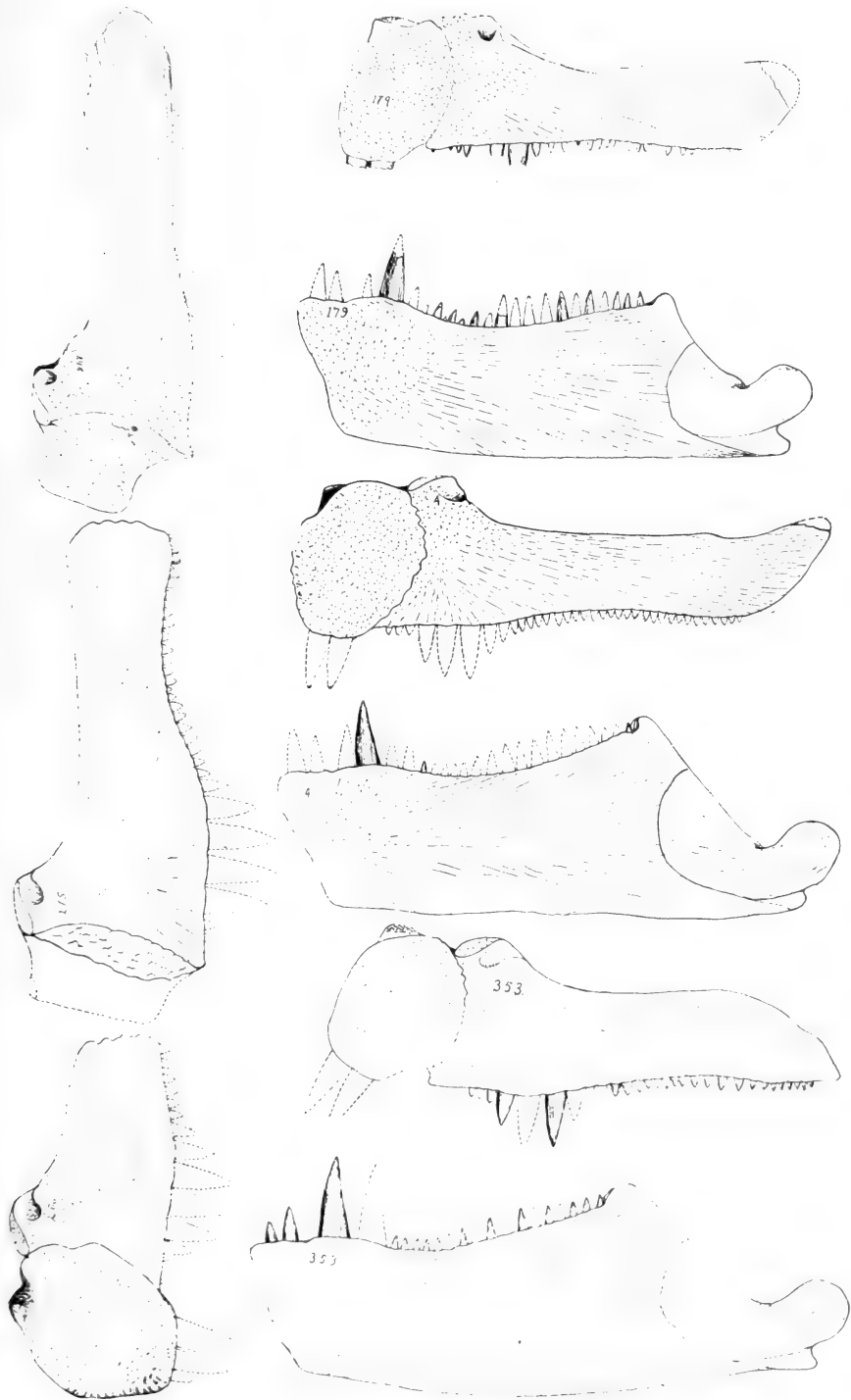


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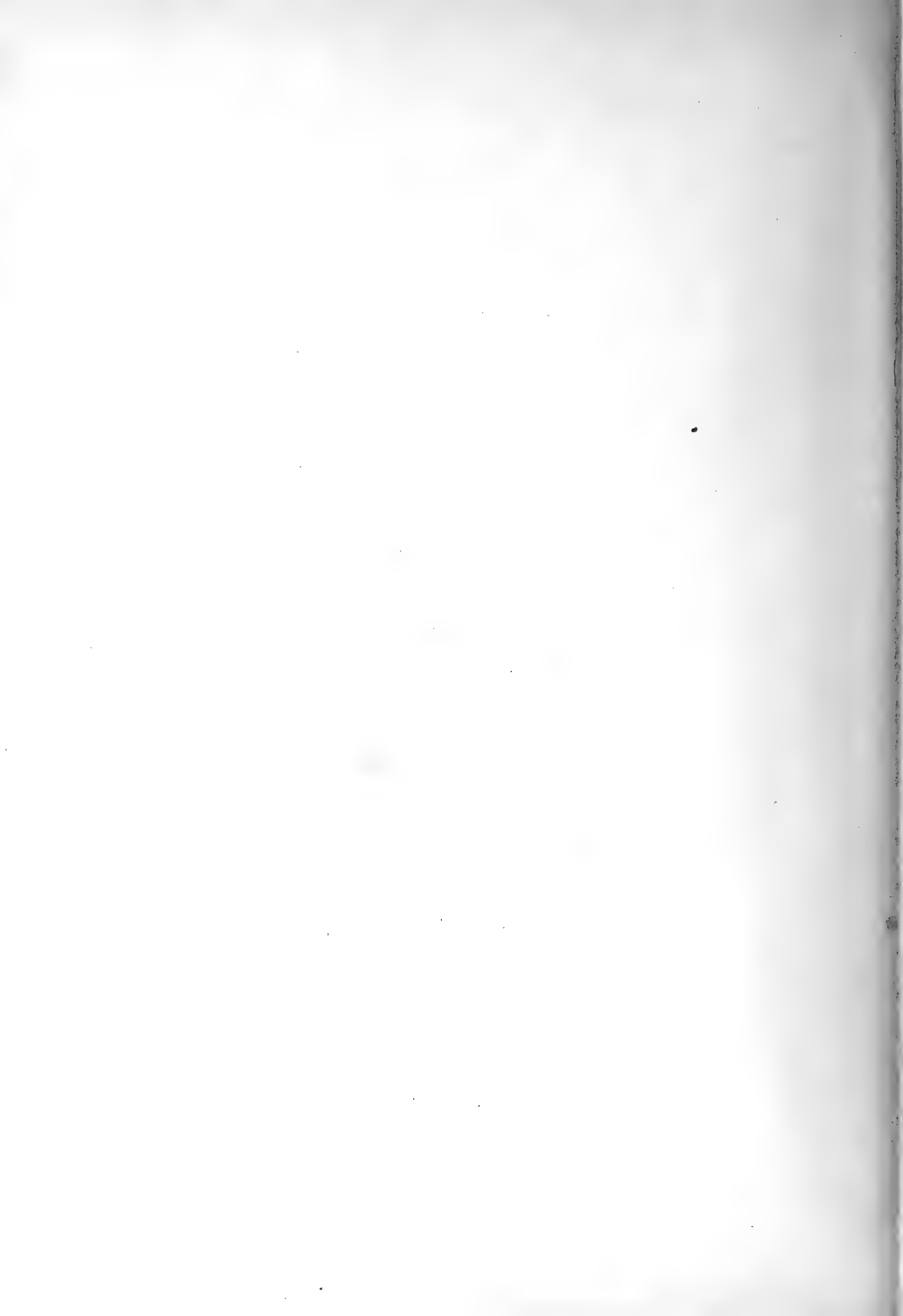


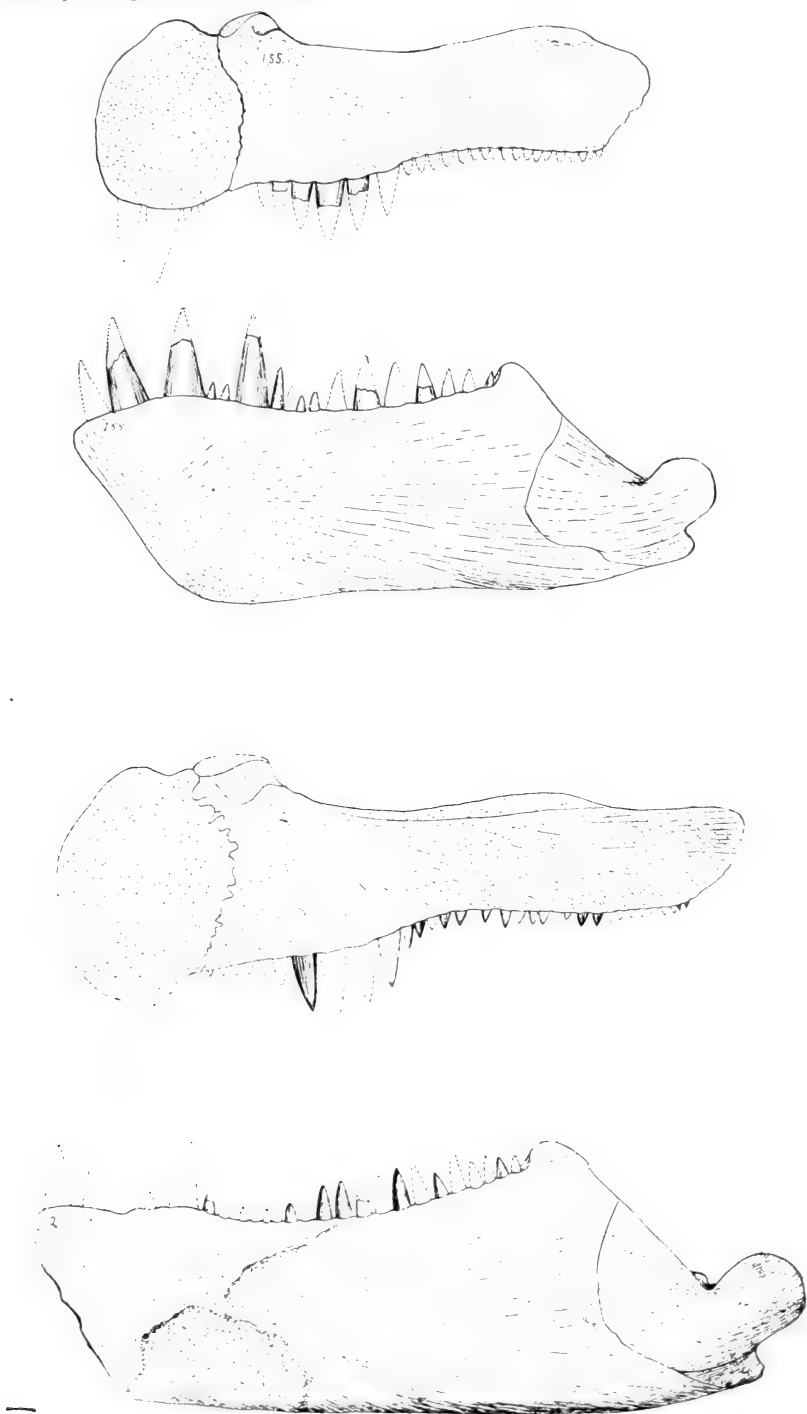


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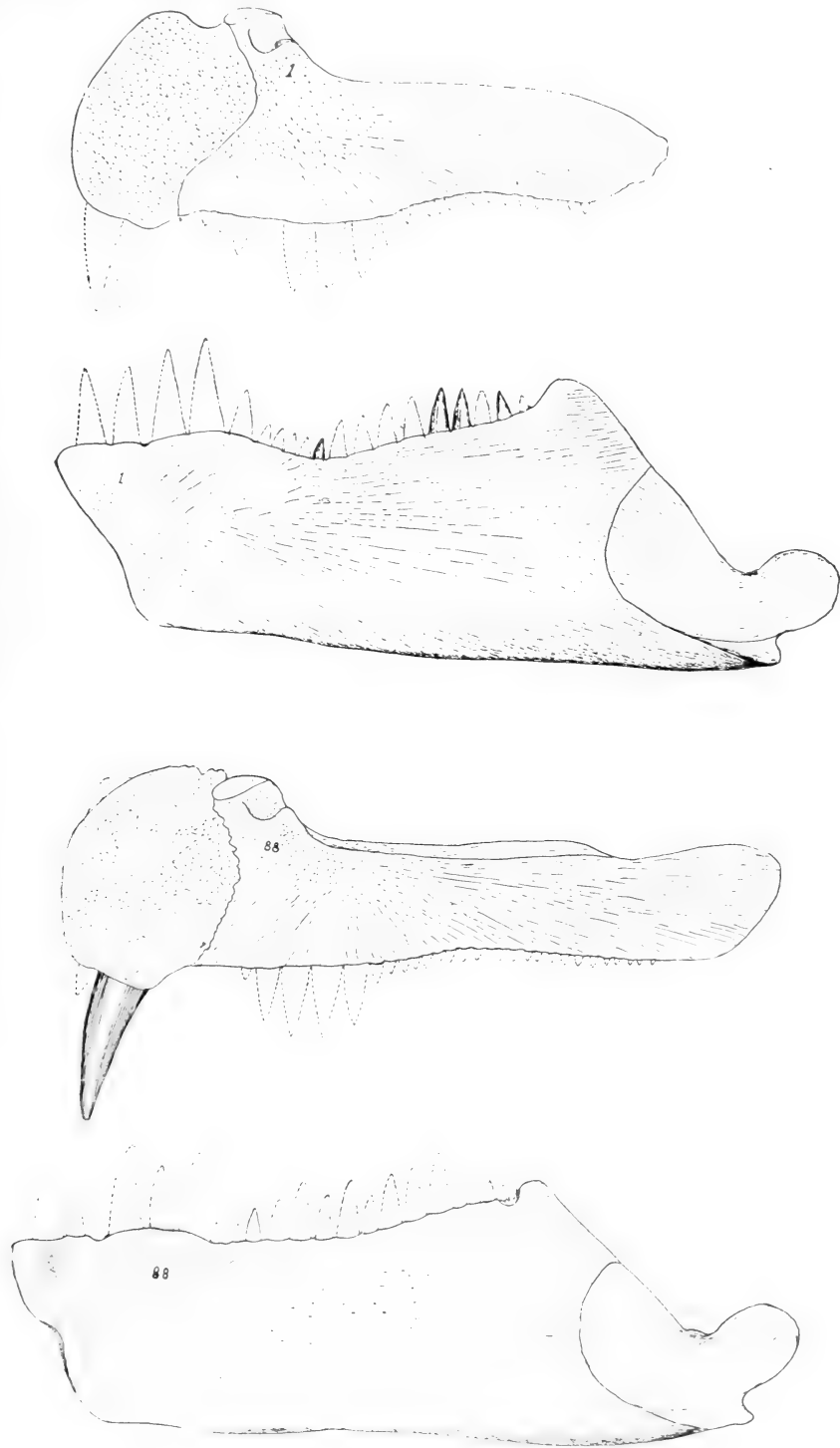


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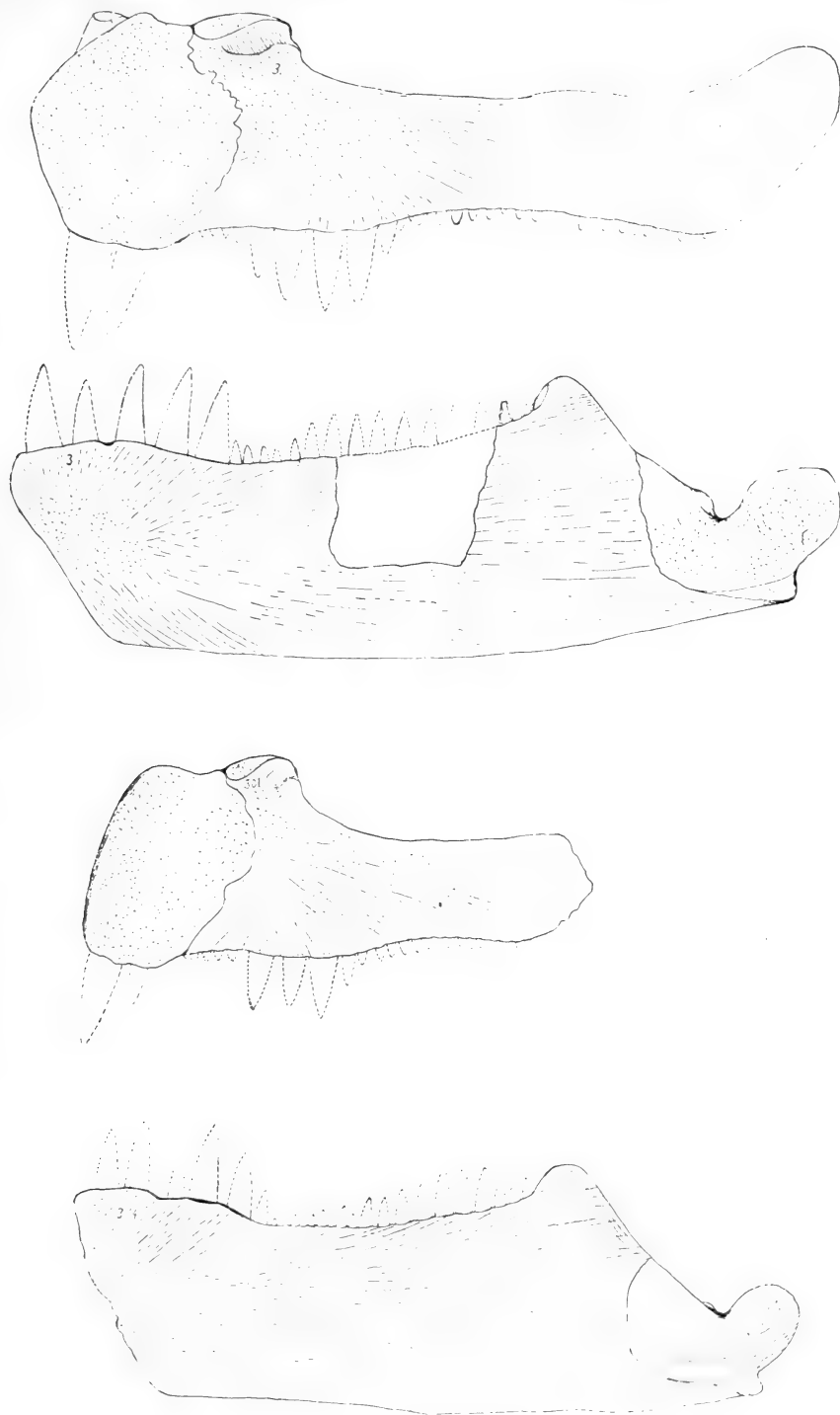


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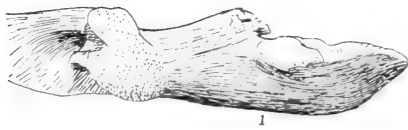
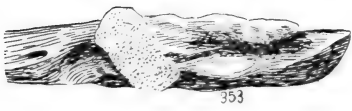
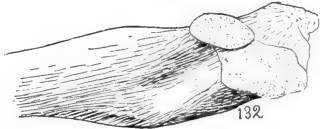
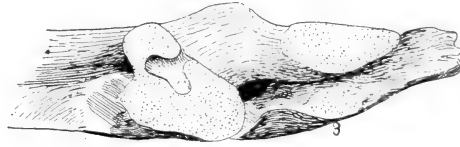
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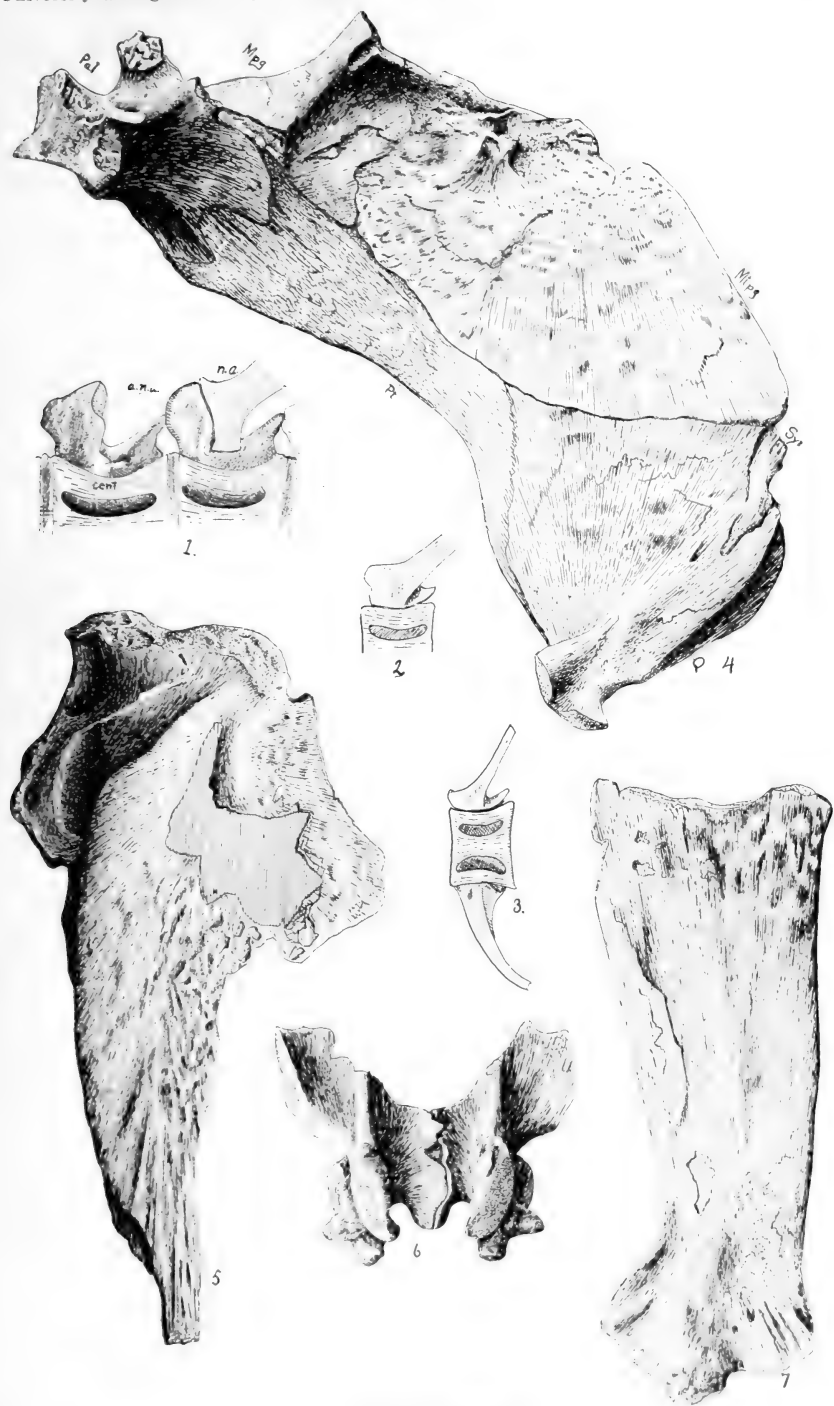


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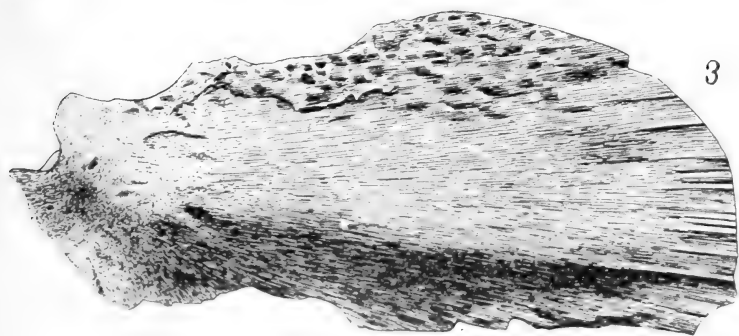
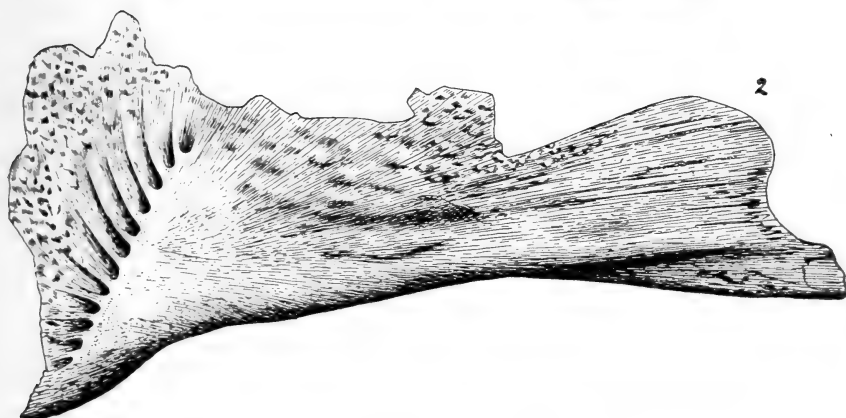
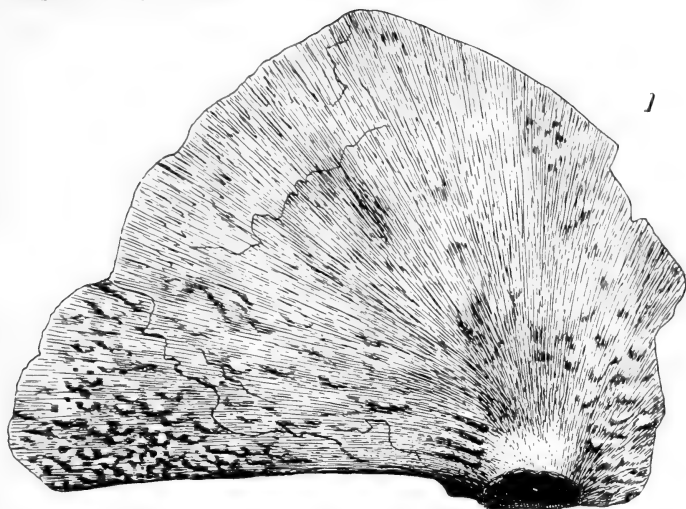


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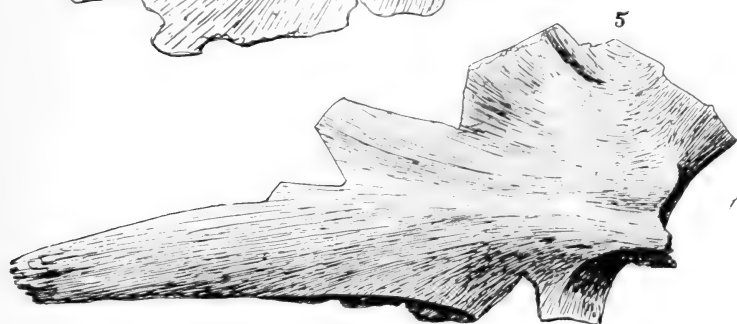
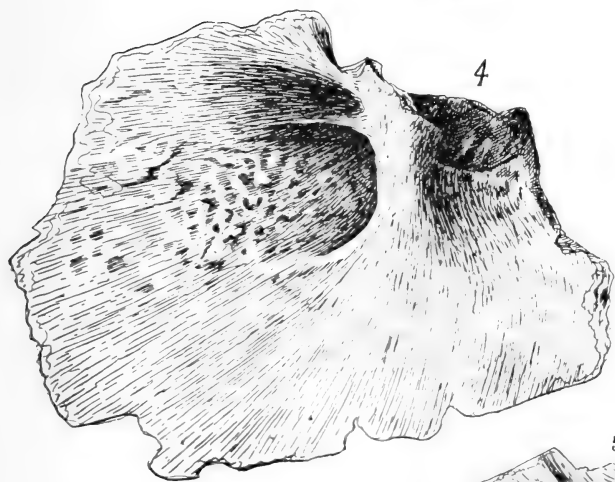
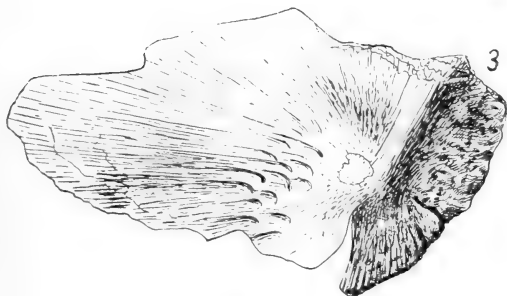
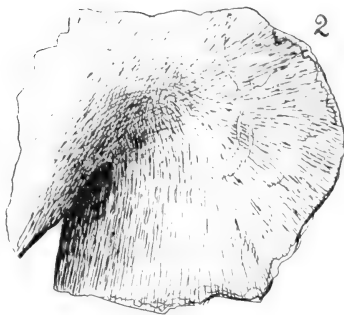
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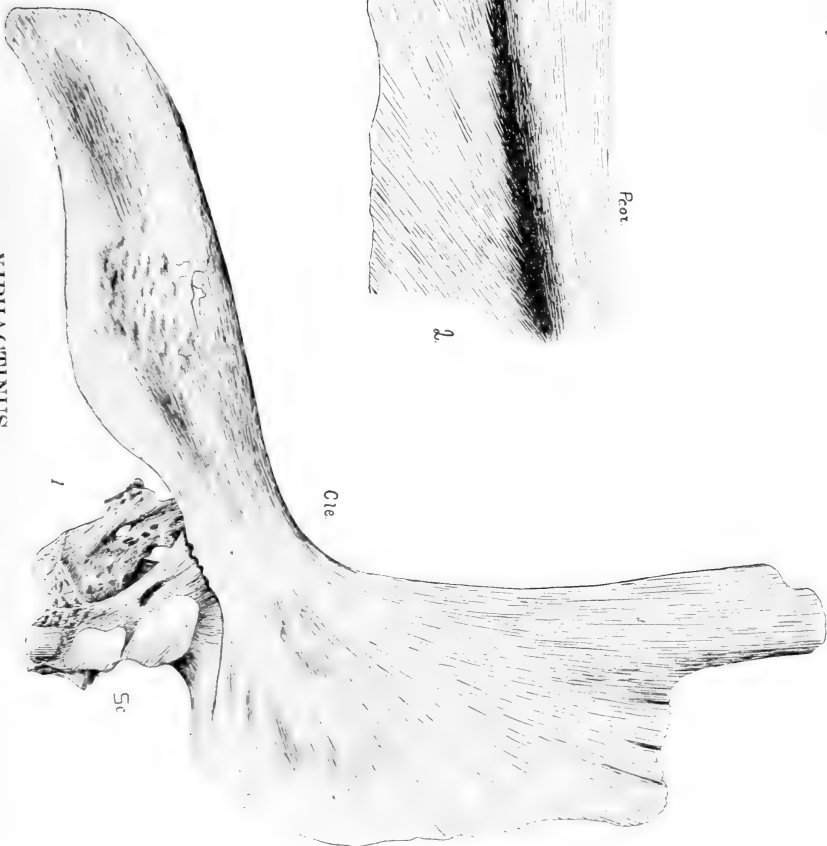
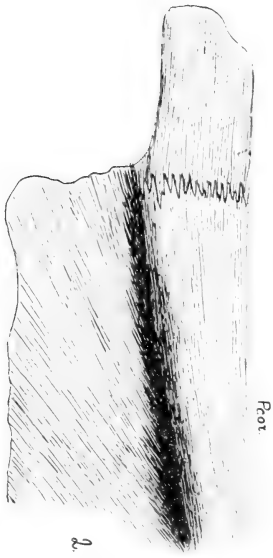
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XIPHACTINUS.



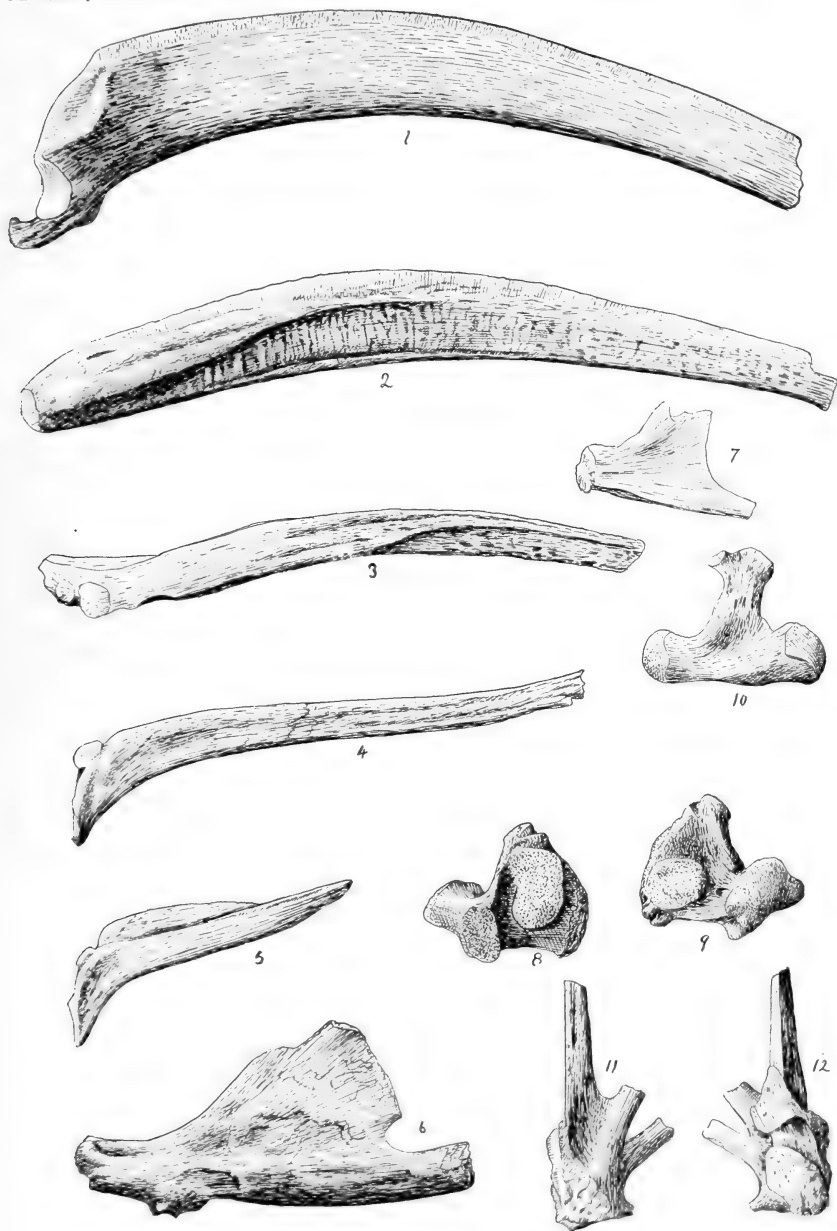


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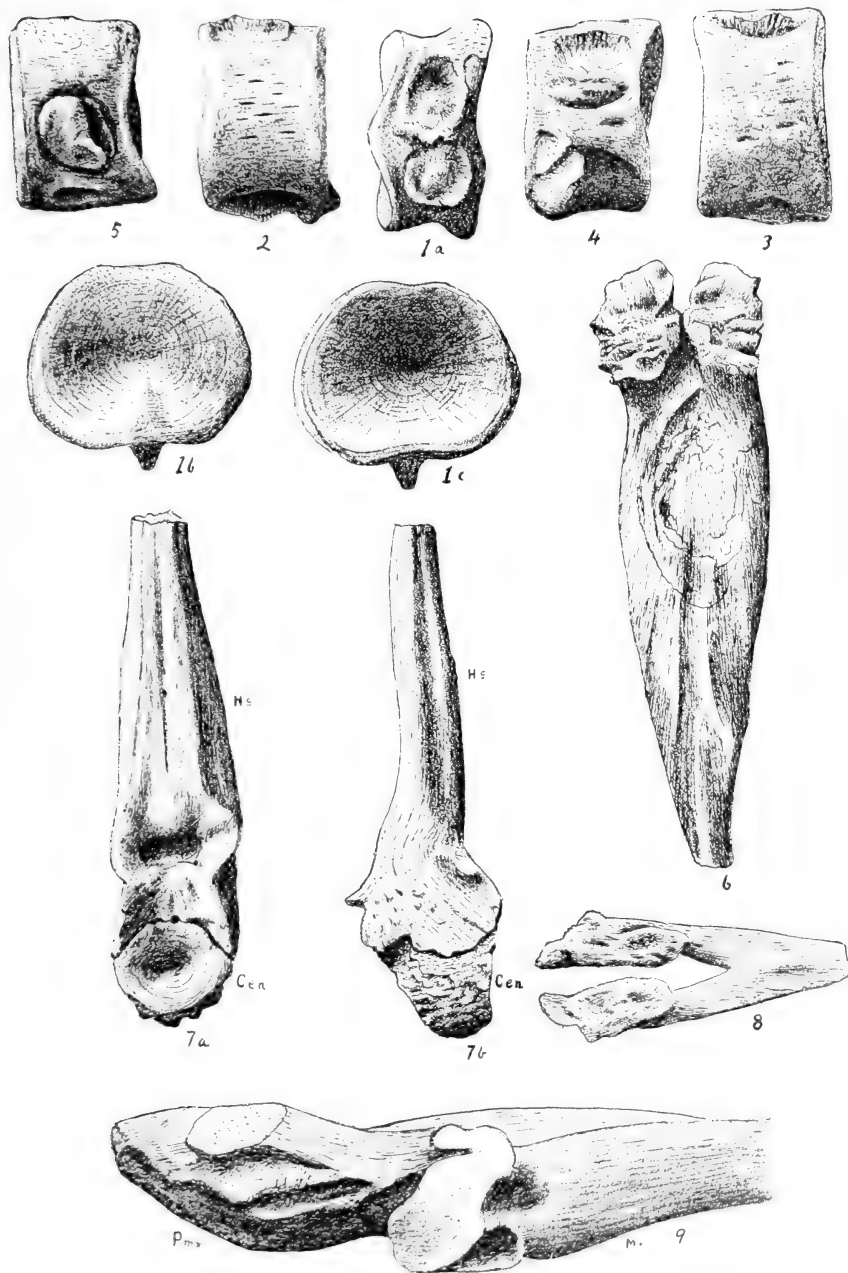


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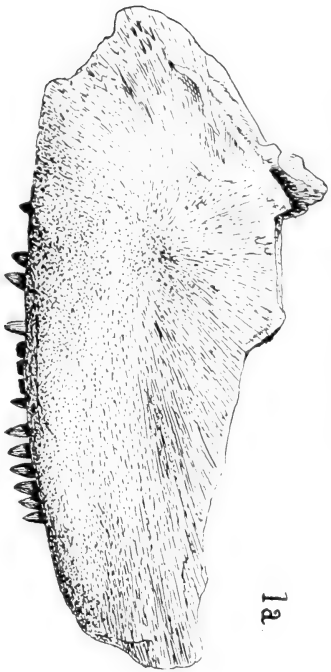


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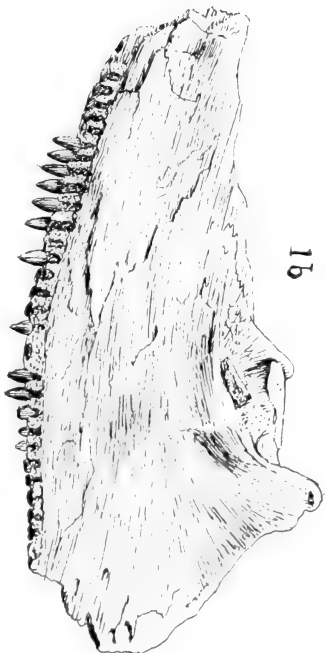


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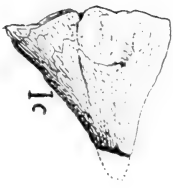
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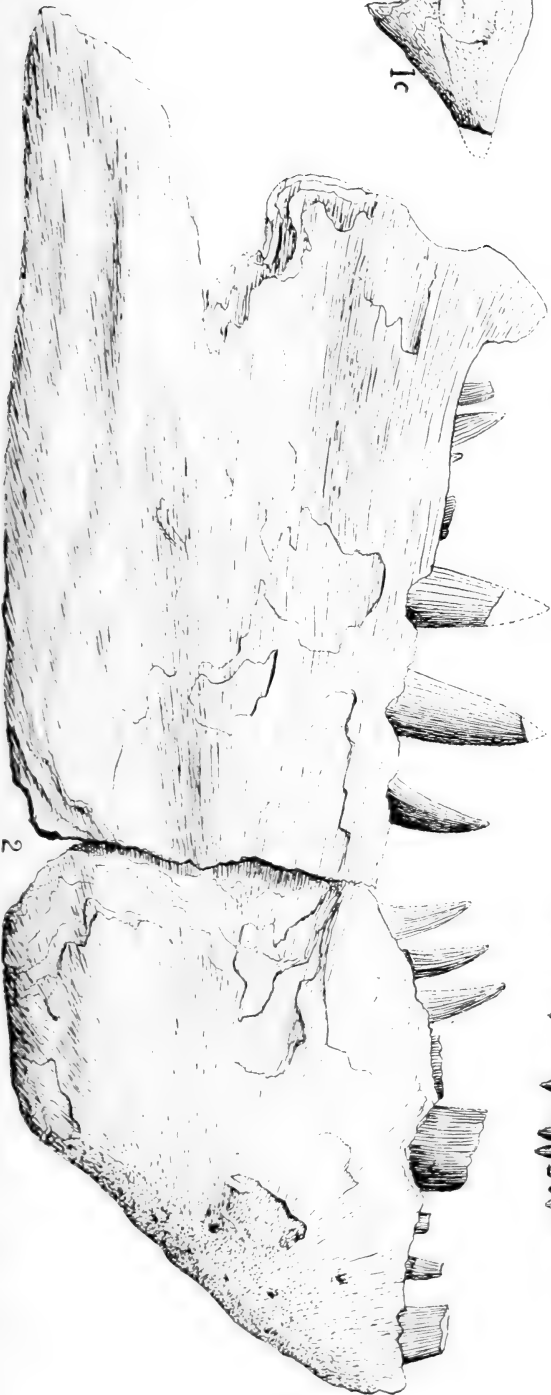
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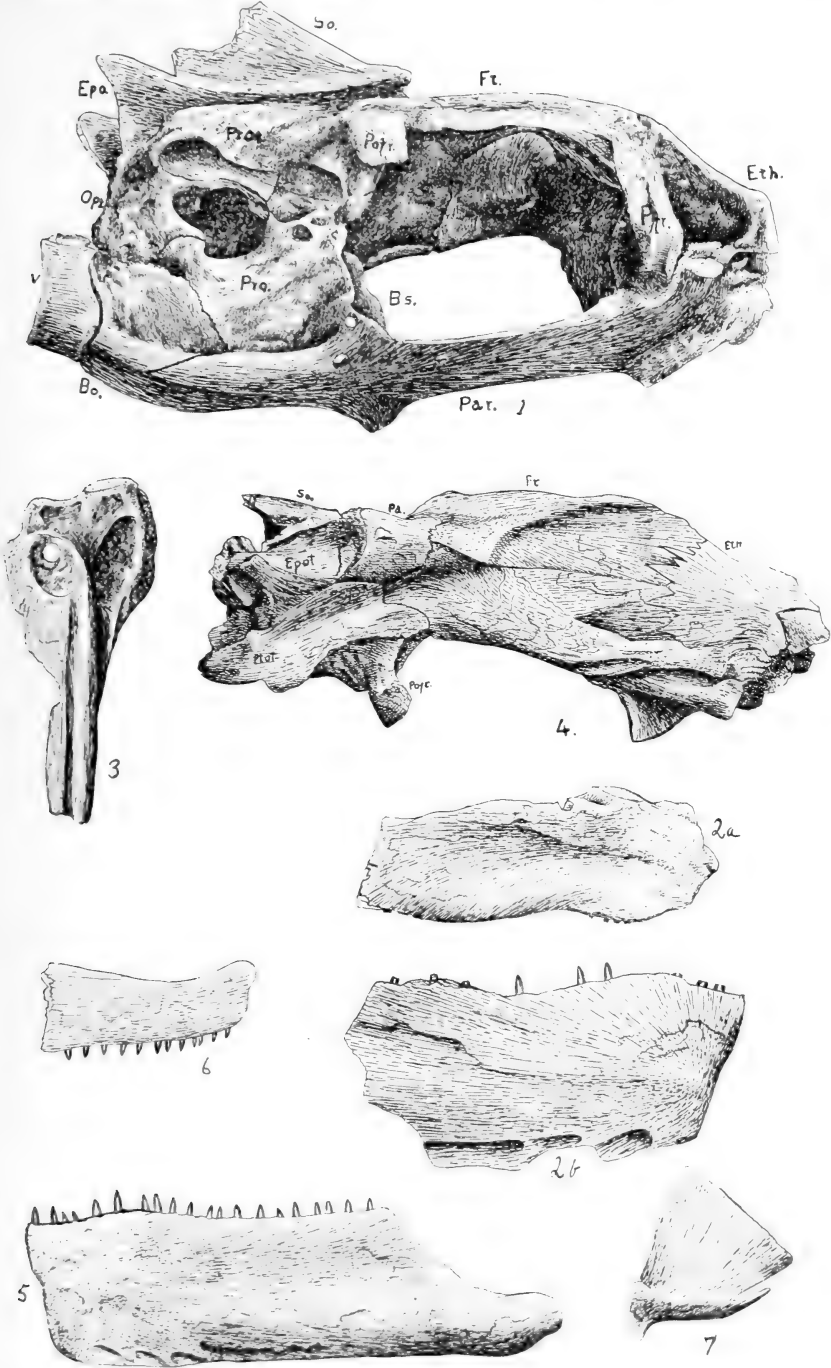
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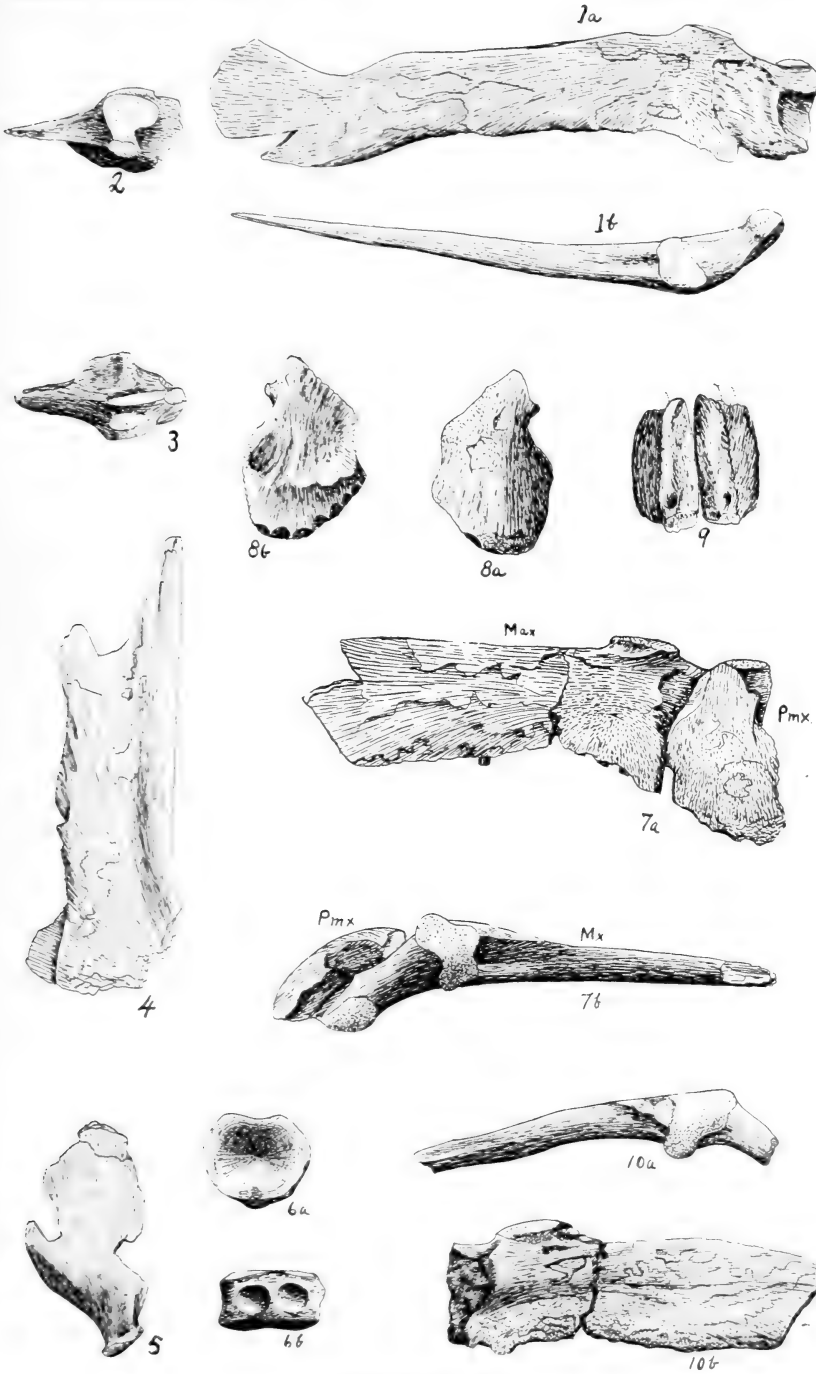
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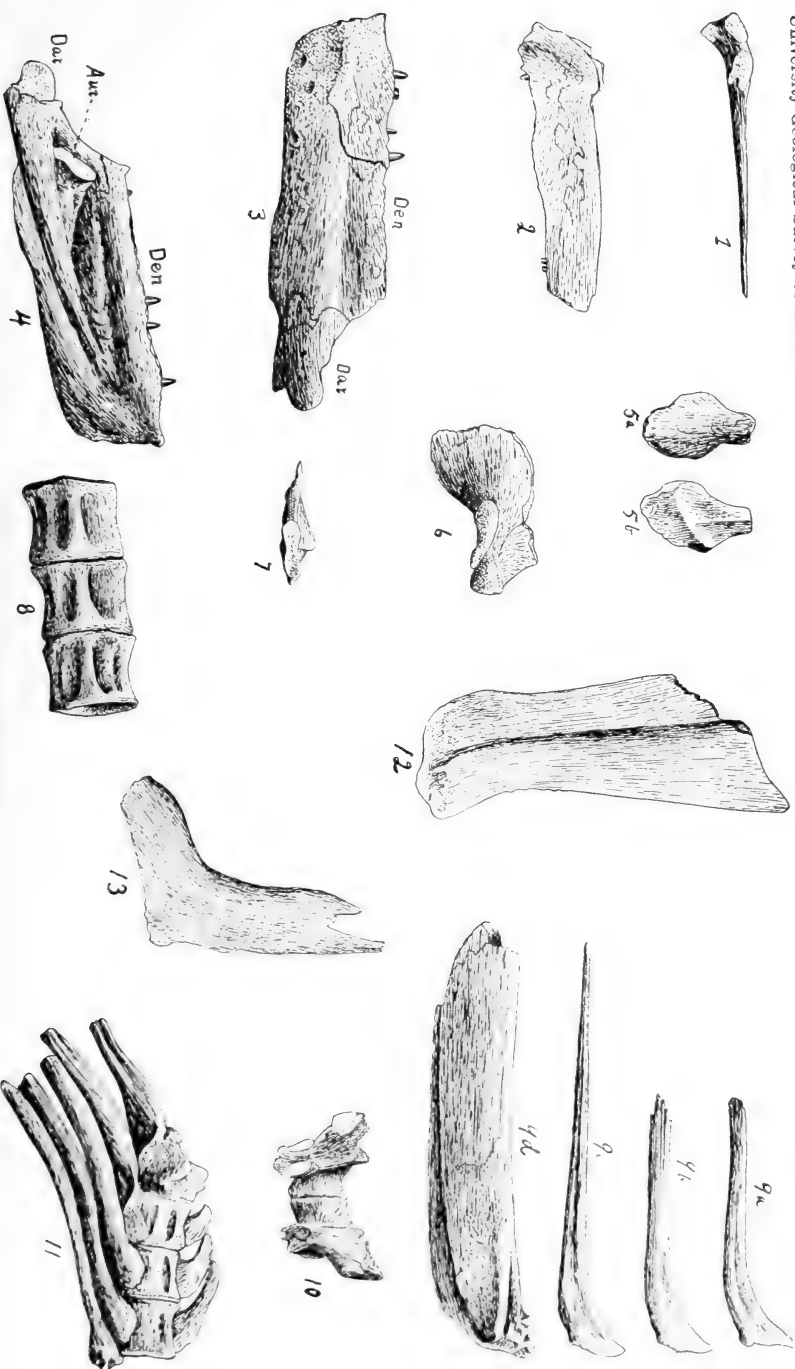


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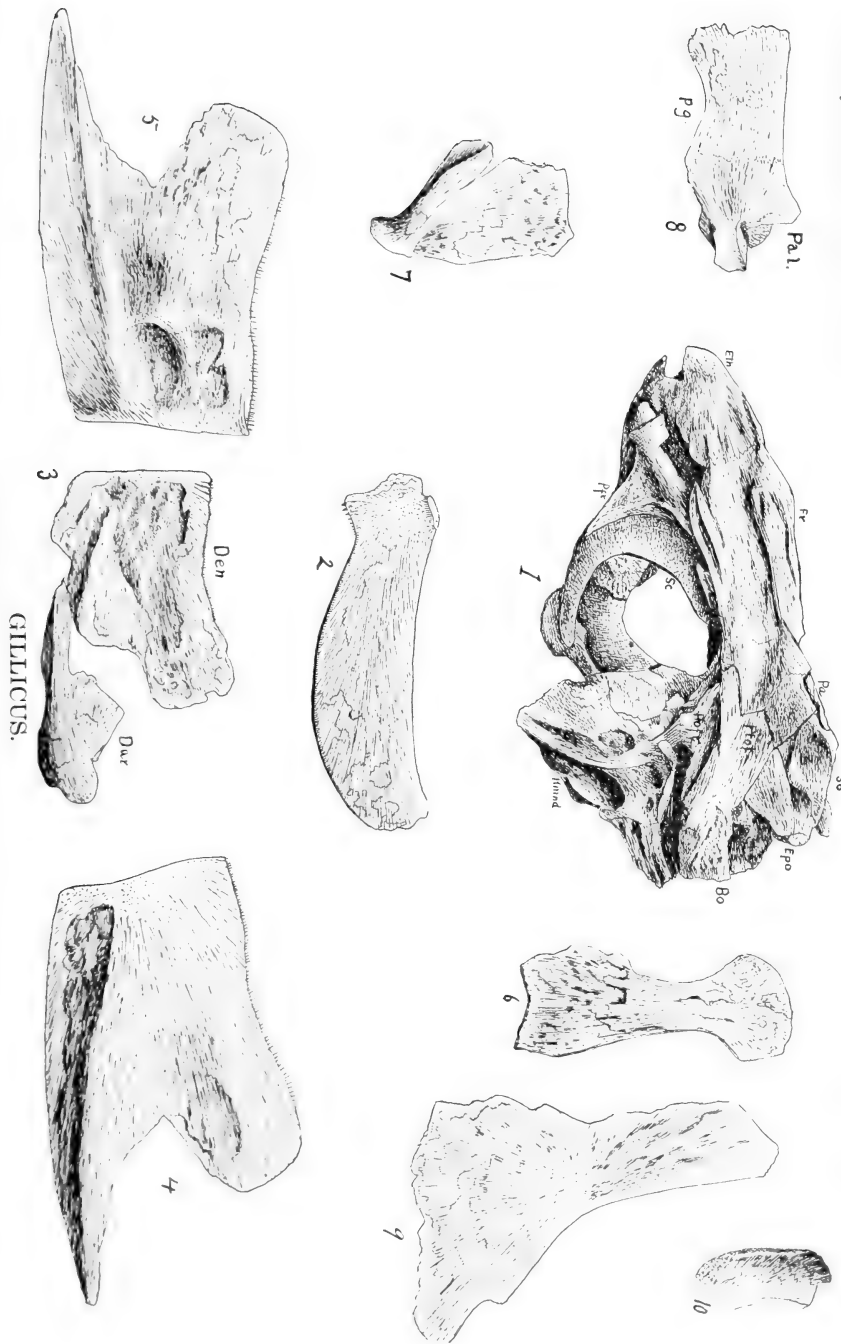




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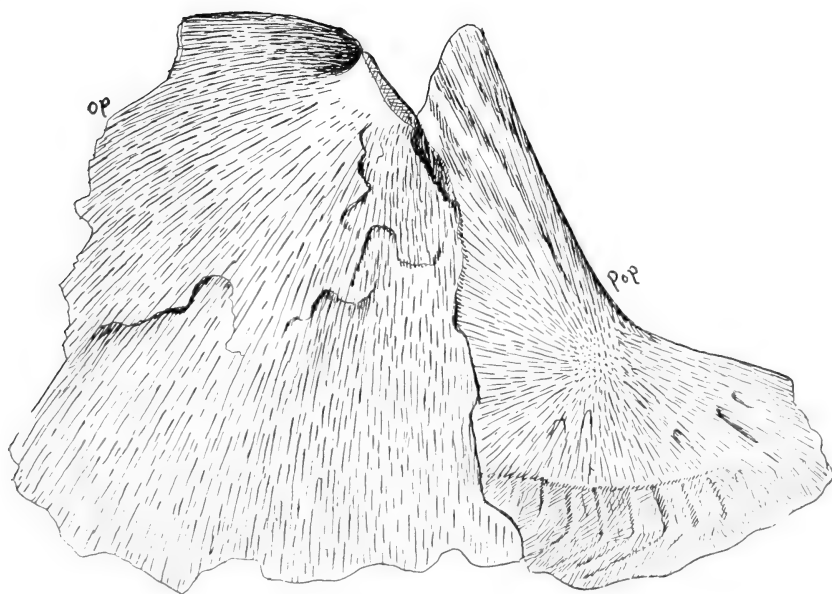
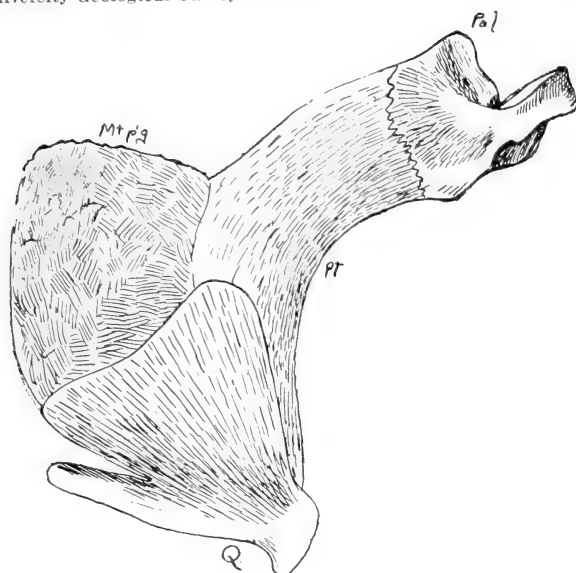






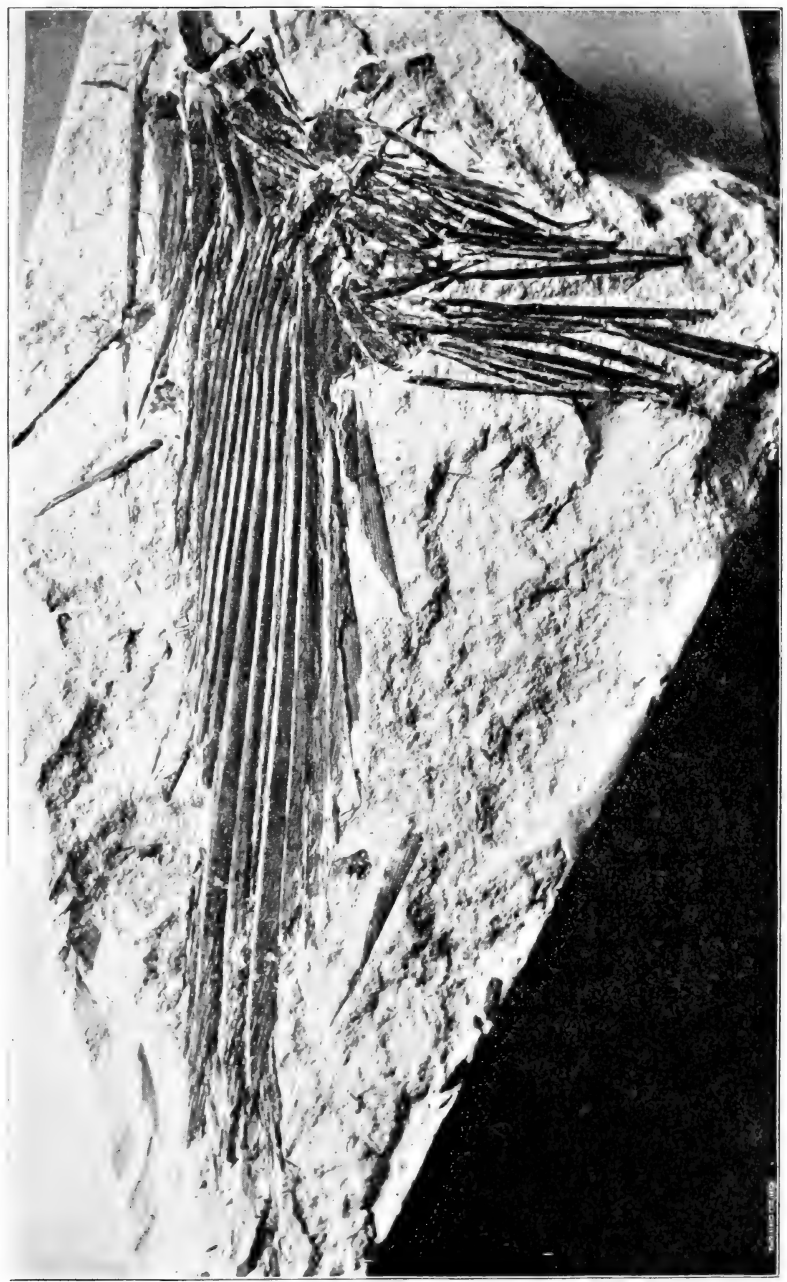
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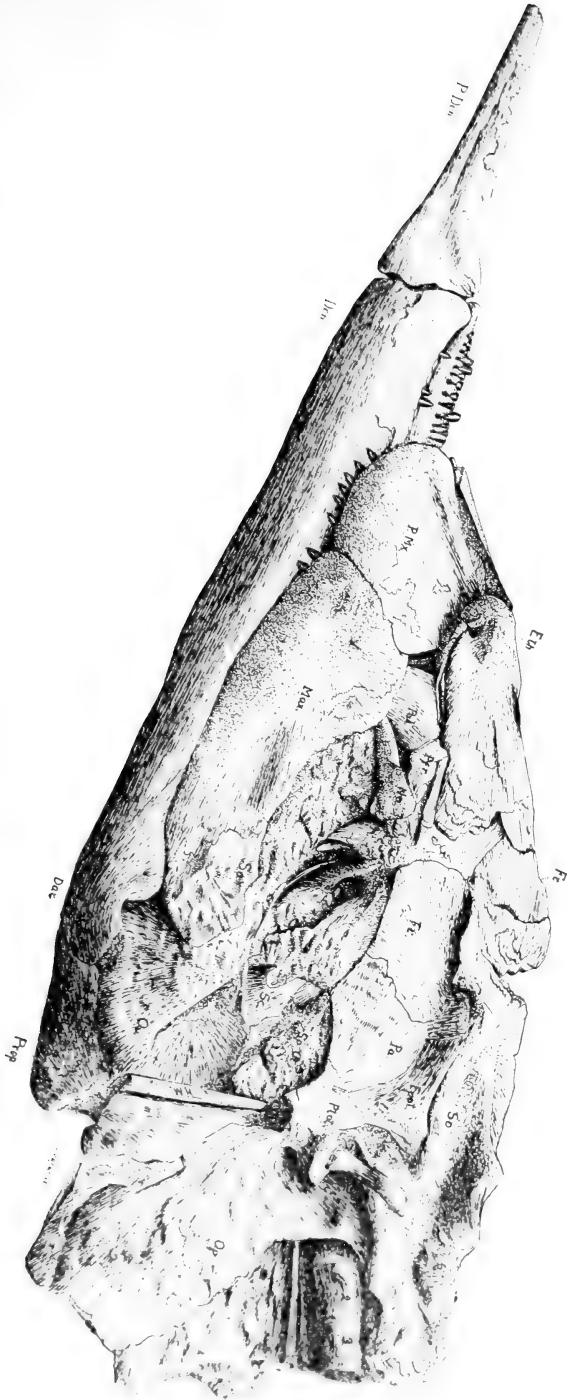
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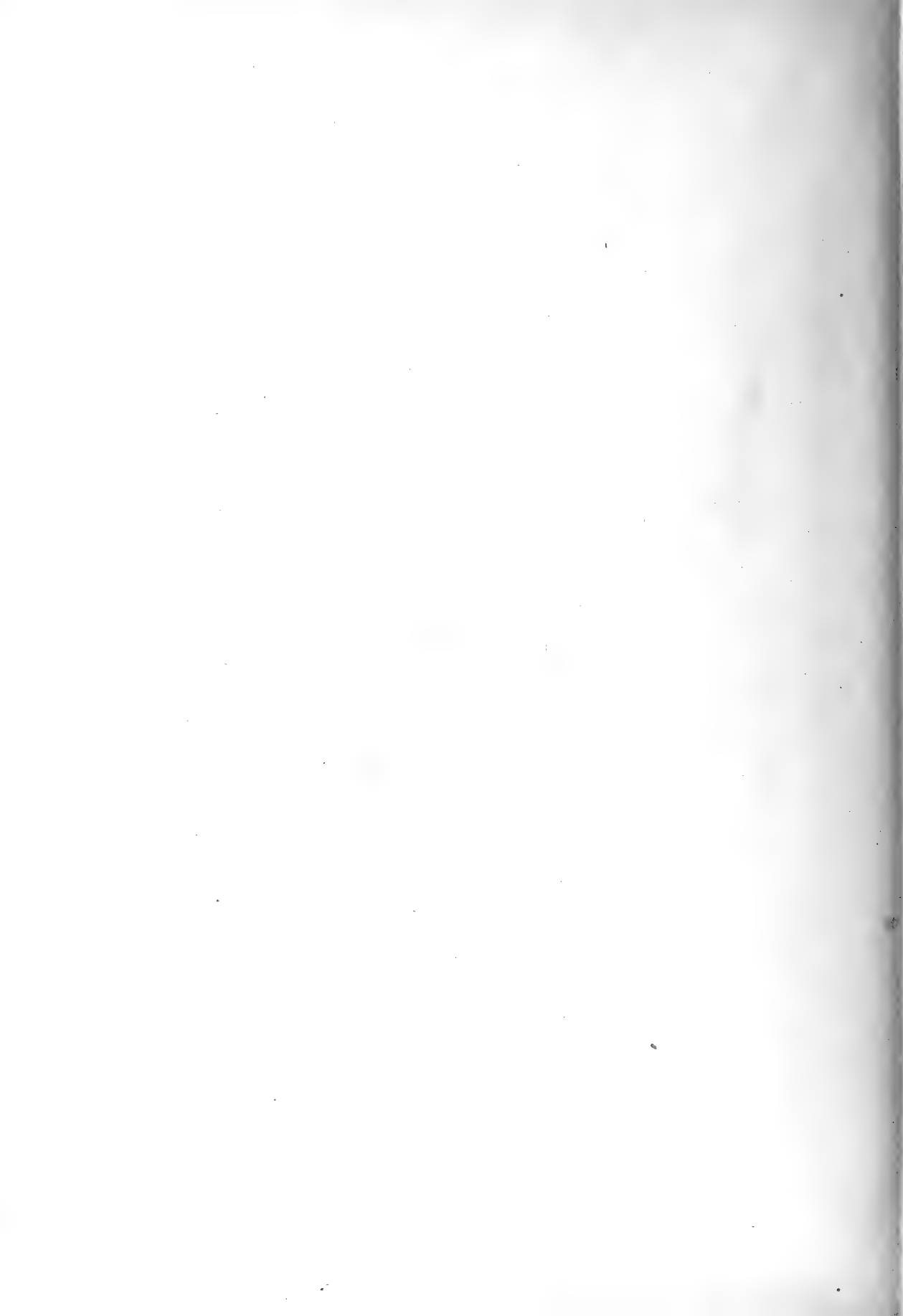


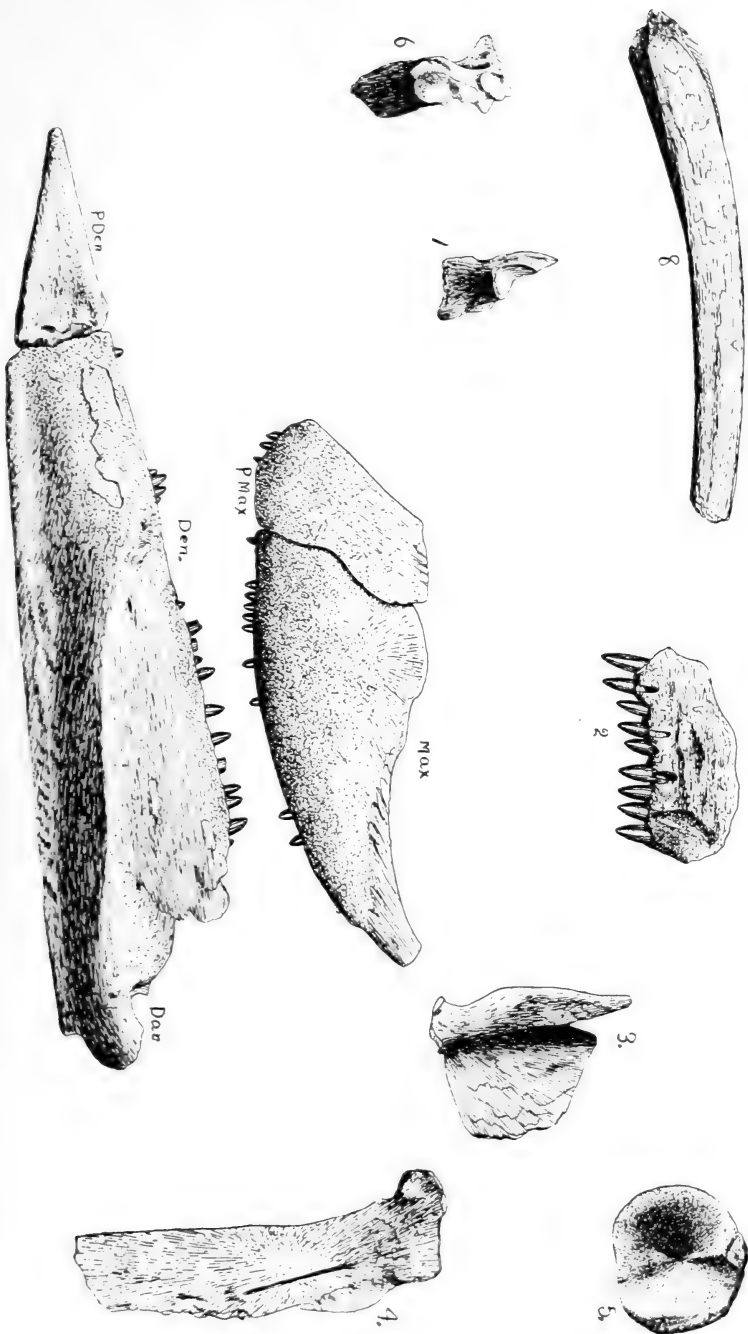
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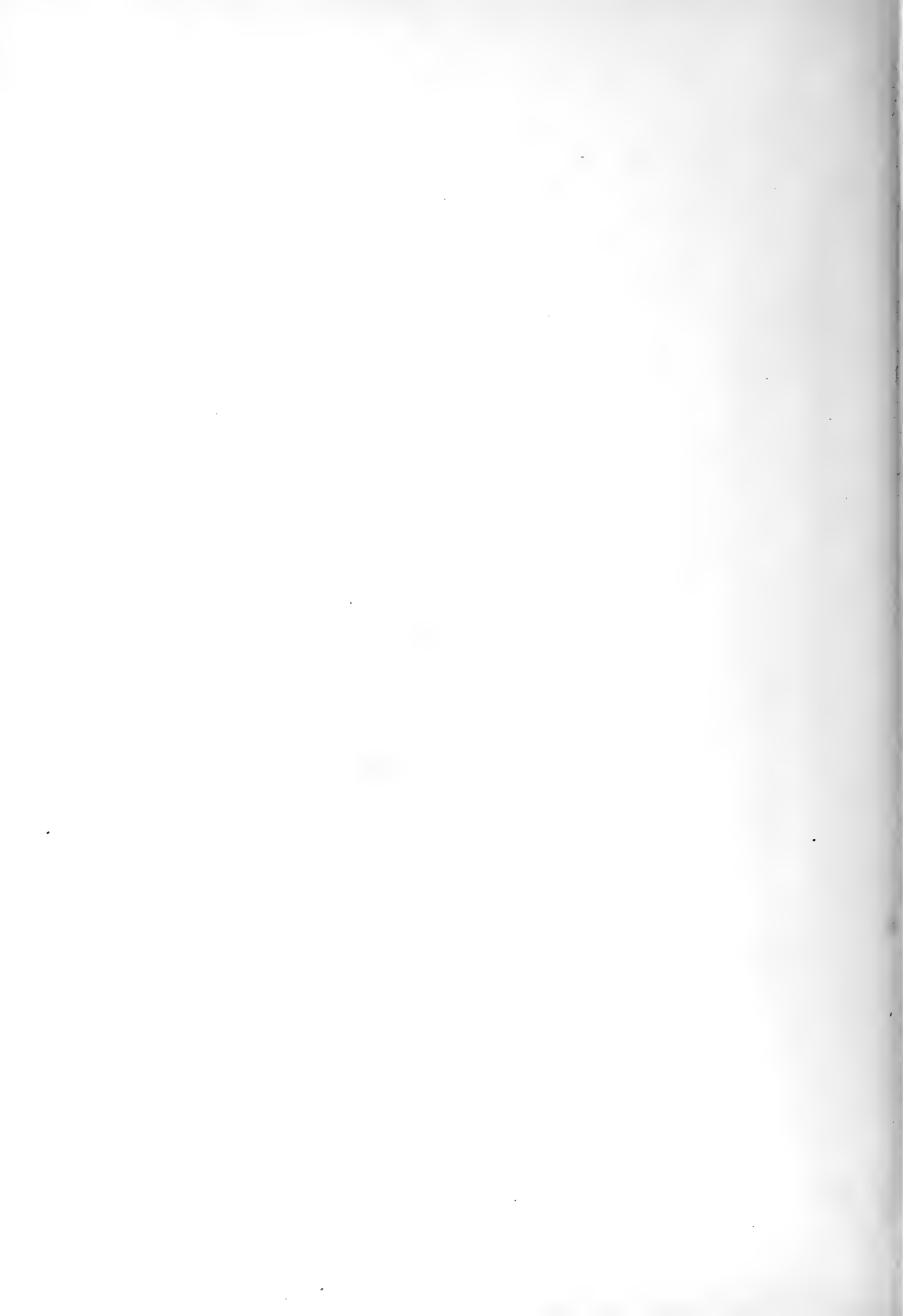


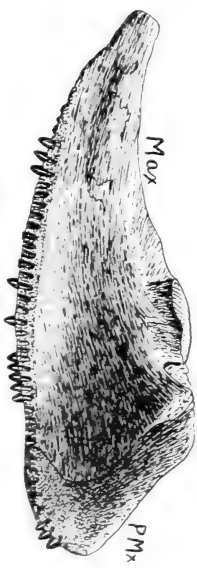
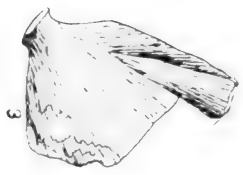
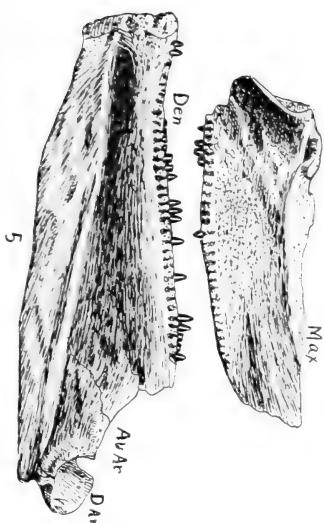
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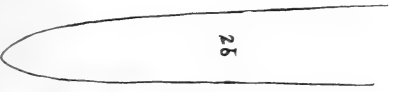
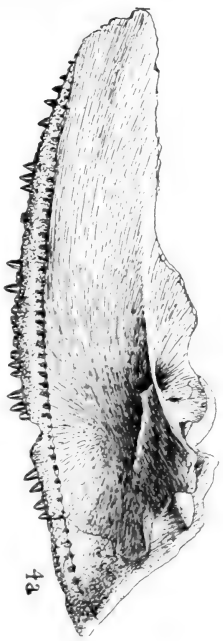
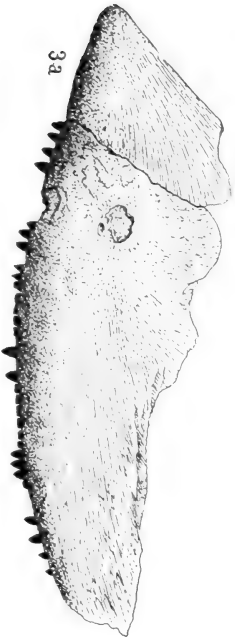
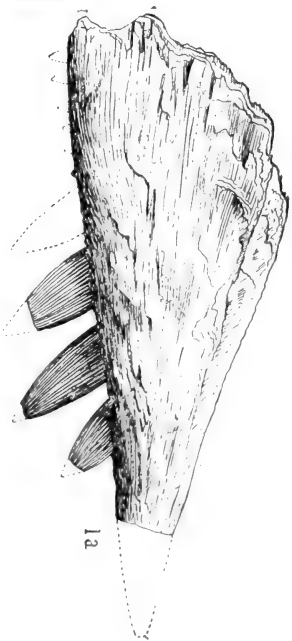
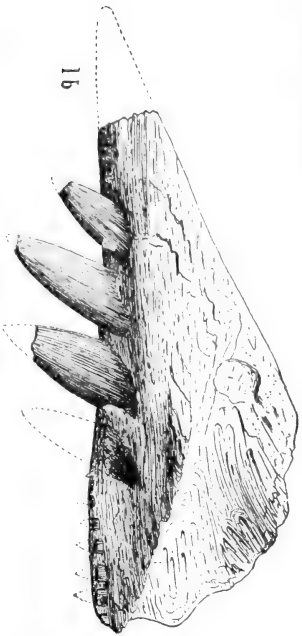
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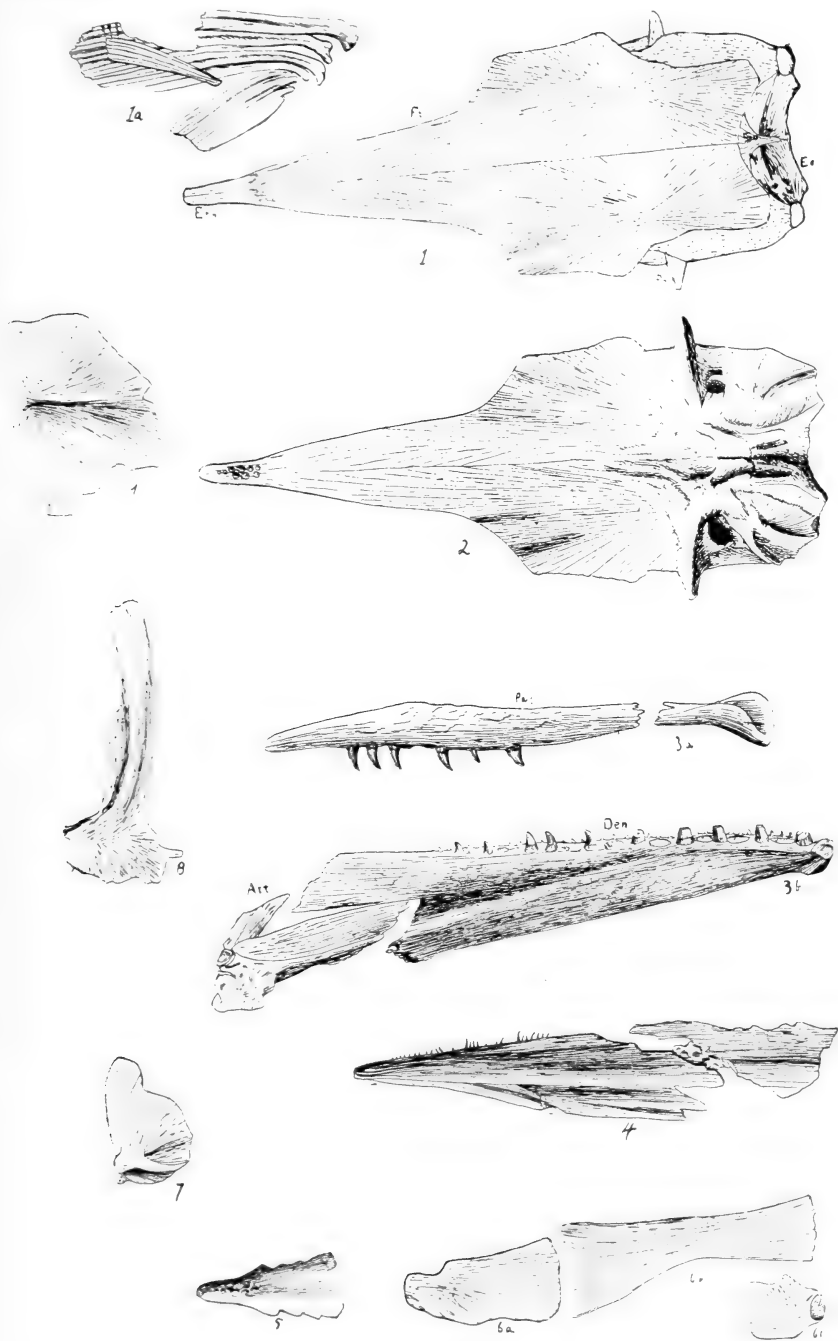


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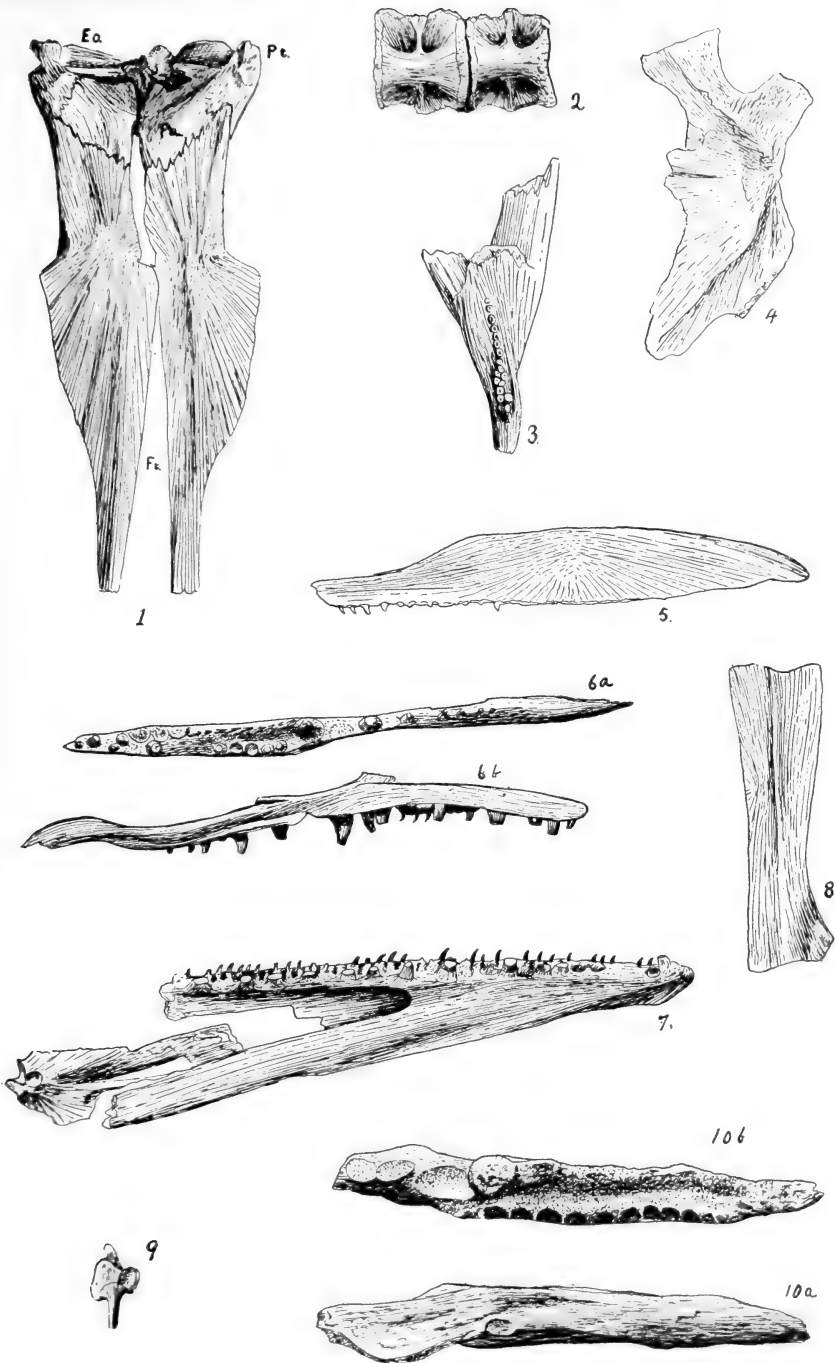




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PROTOSPHYRENA.

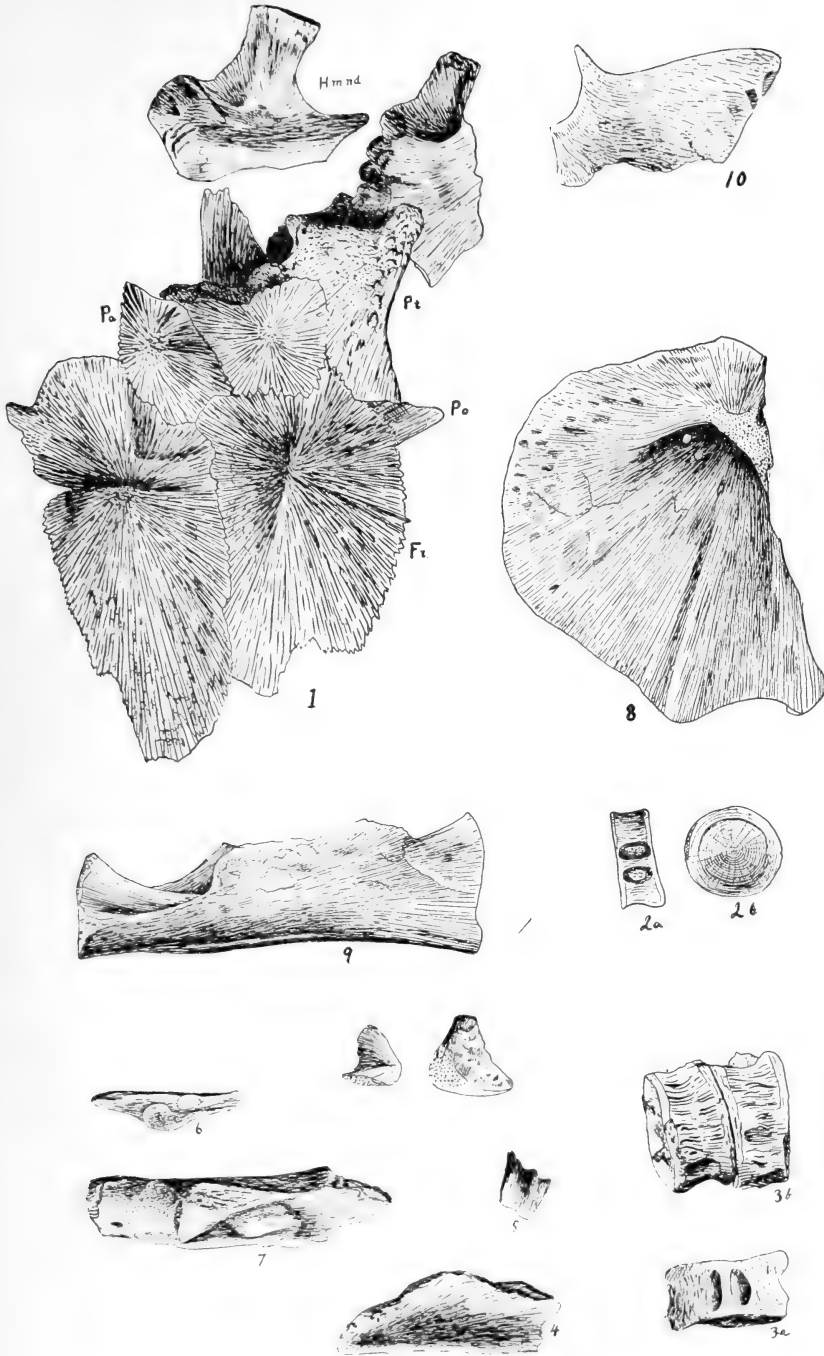




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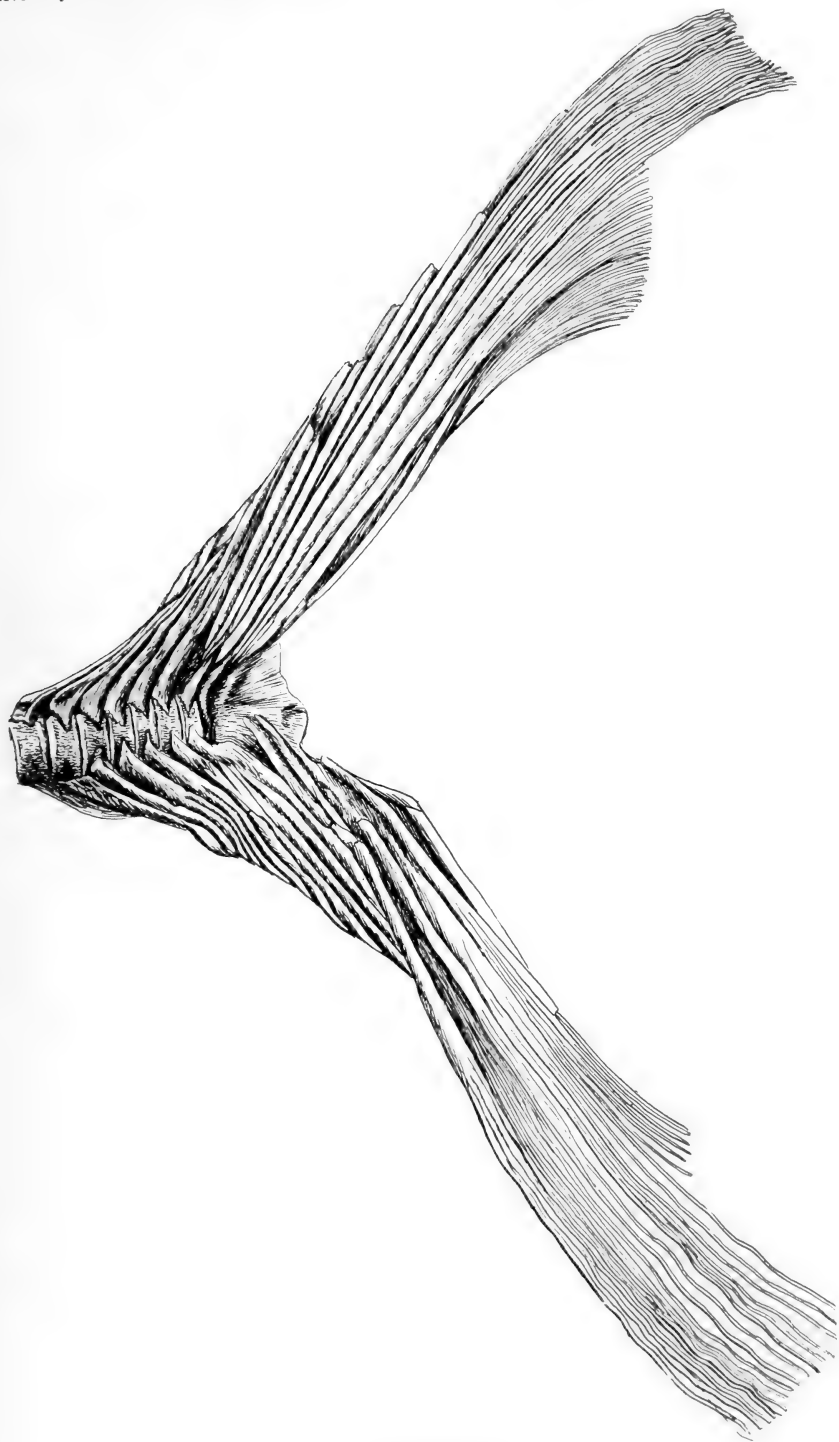


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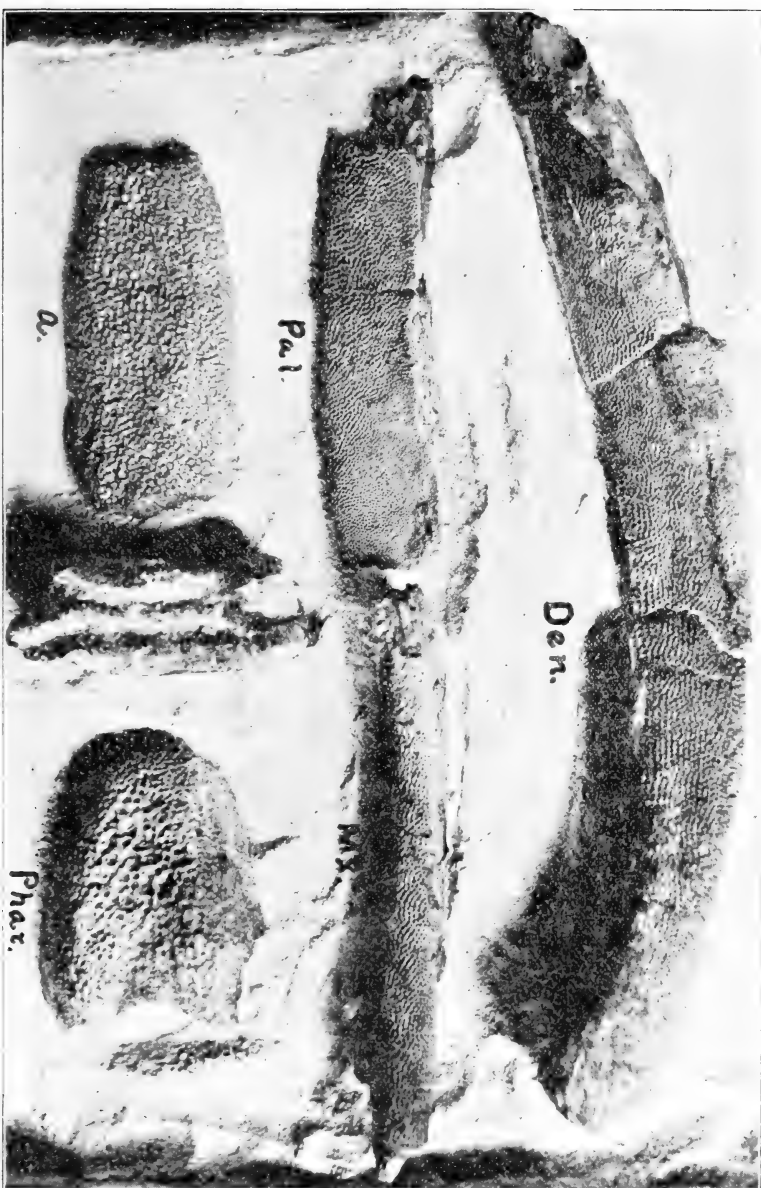
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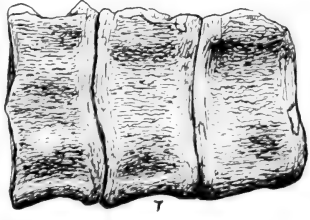
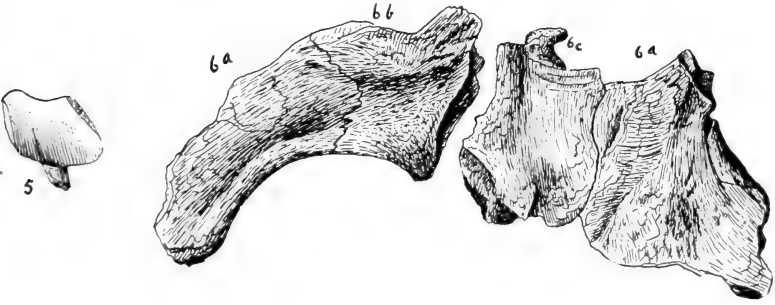
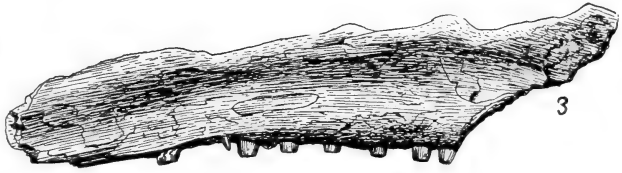
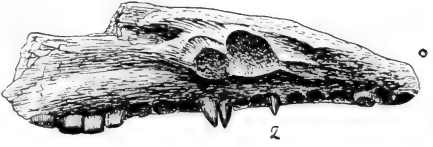


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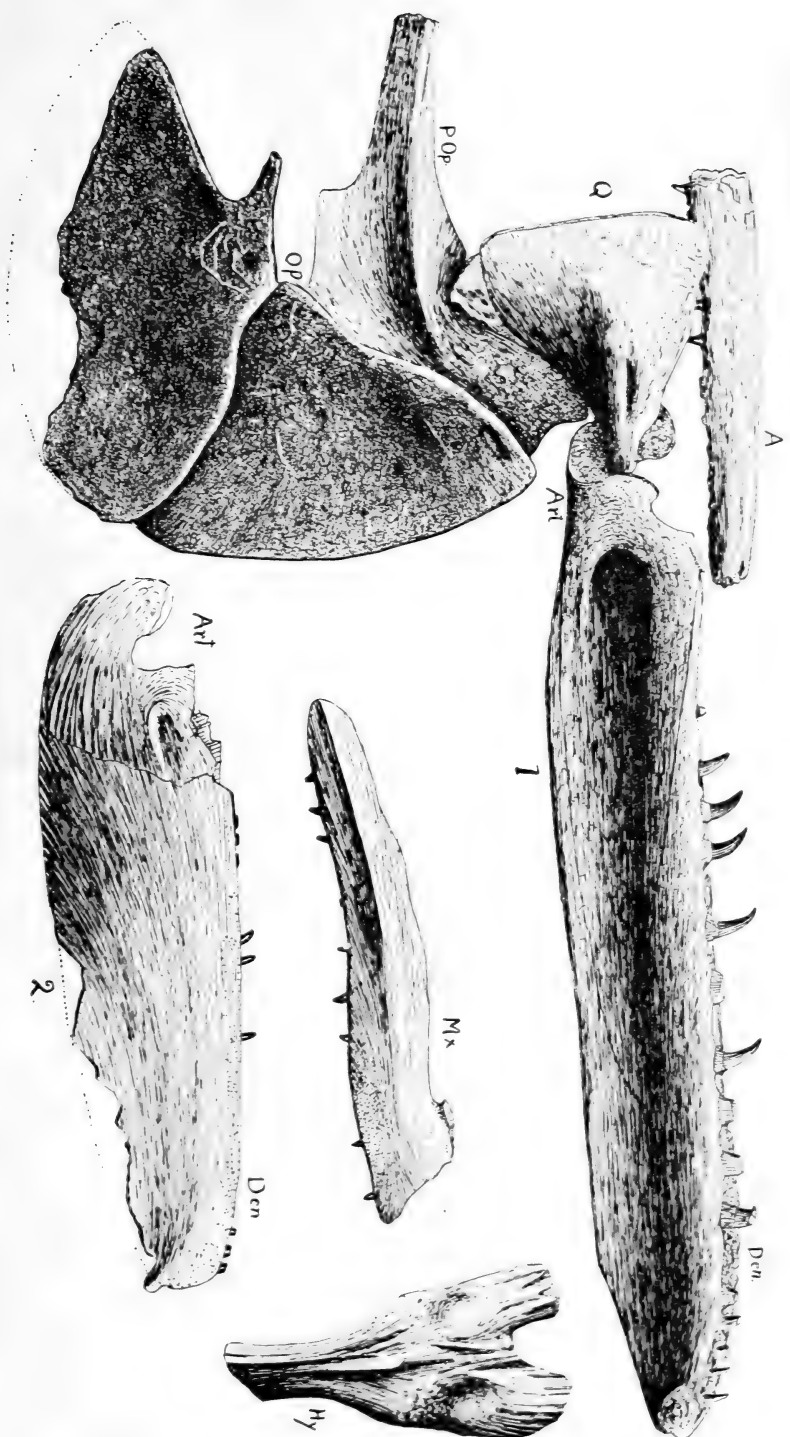


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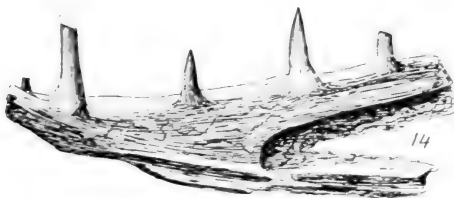
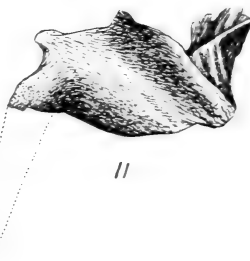
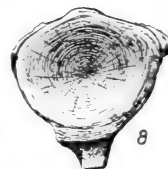
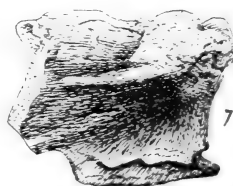
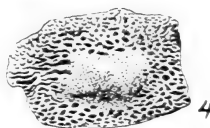
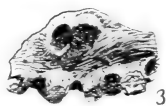
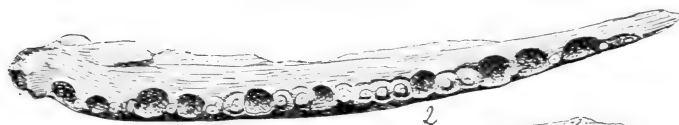
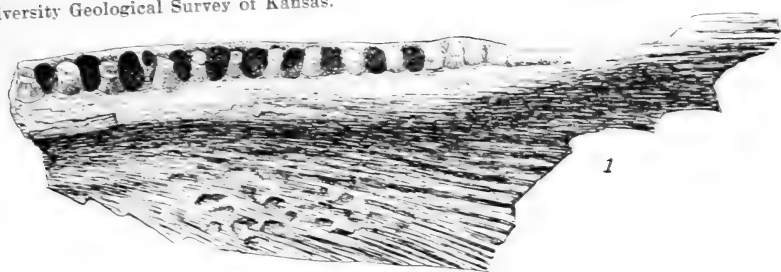


PACHYRHIZODUS.





PACHYRHIZODUS.



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PACHYRHIZODUS.



LEPTICHTHYS, 1. SYLLEMUS, 2.





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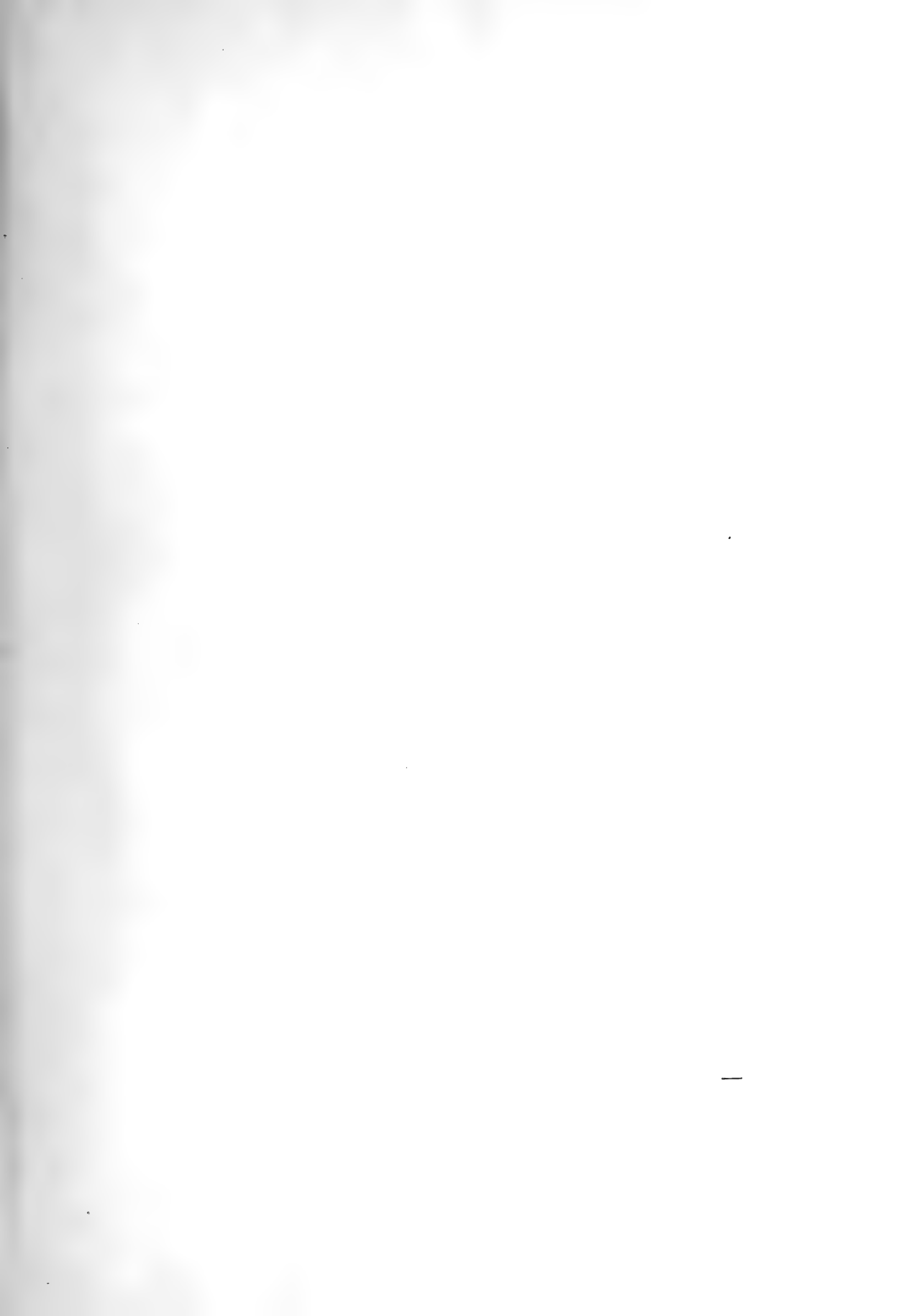
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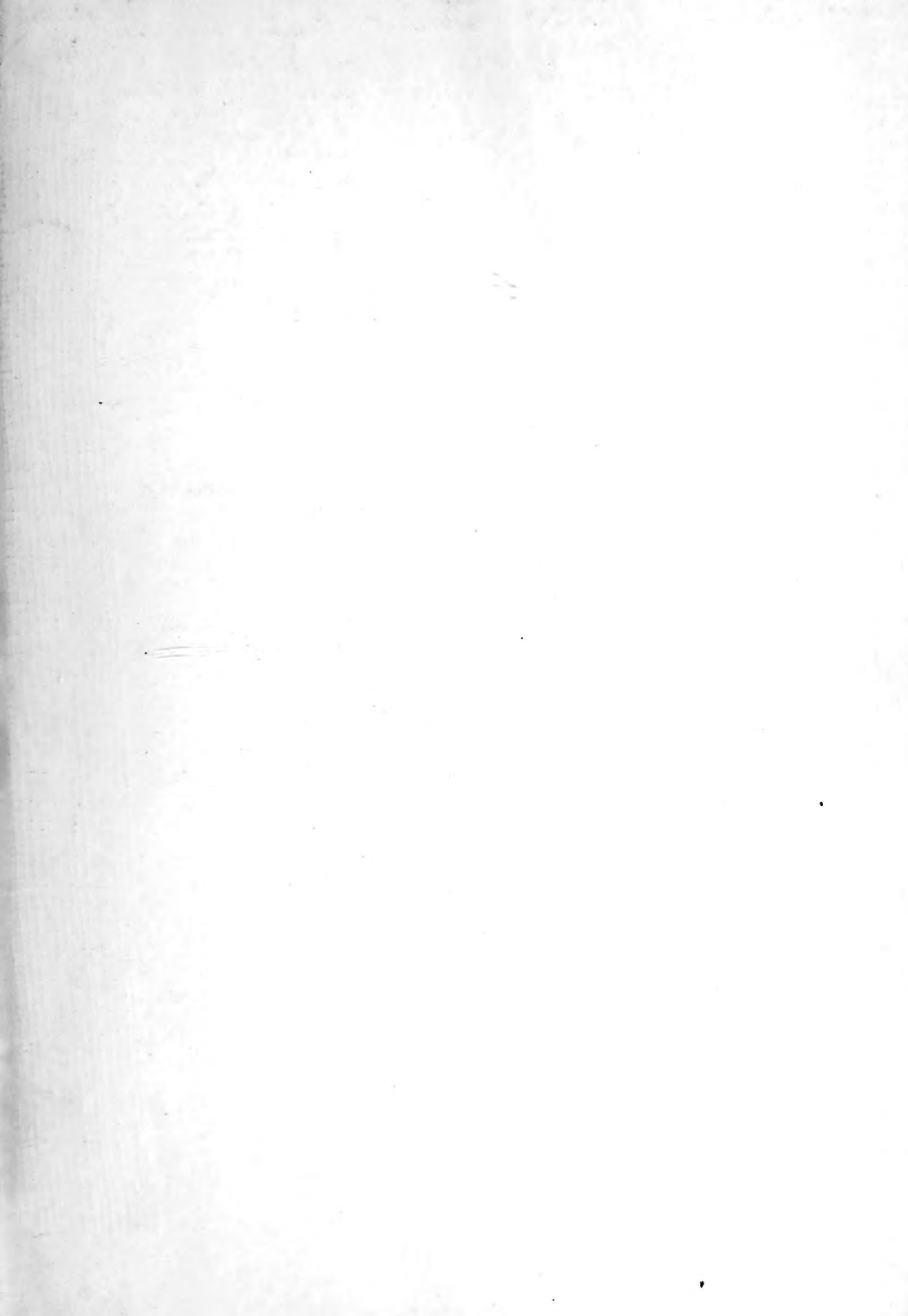
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