UNIVERSITY GEOLOGICAL SURVEY
of
KANSAS

C. W. Gilmore
1903.

Ornithostoma. Tylosaurus. Platecarpus. Ornithostoma. Protostega. Mosasaurus. Plesiosaurs. Clidastes. Xiphactinus (fish).

REPTILES OF THE KANSAS CRETACEOUS OCEAN.

(From Popular Science Monthly, by permission.)

THE UNIVERSITY

GEOLOGICAL SURVEY

OF

KANSAS.

CONDUCTED UNDER AUTHORITY OF THE BOARD OF REGENTS
OF THE UNIVERSITY OF KANSAS.

VOL. IV.

PALEONTOLOGY.

PART I.
UPPER CRETACEOUS.

SAMUEL W. WILLISTON,
Paleontologist.

TOPEKA:
J. S. PARKS, STATE PRINTER.
1898.

MEMBERS OF THE UNIVERSITY GEOLOGICAL SURVEY

FRANCIS H. SNOW,
Chancellor, and *ex officio* Director.

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Department of Historical Geology and Paleontology.

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Department of Physical Geology and Mineralogy.

EDGAR H. S. BAILEY,
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FOR VOLUME IV.

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GEORGE I. ADAMS, Assistant Paleontologist.
ERMINIE C. CASE, Assistant Paleontologist.
CLARENCE E. McCLUNG, Assistant Paleontologist.
WILLIAM N. LOGAN, Assistant Paleontologist.

Chancellor F. H. Snow,

Ex officio Director of the University Geological Survey:

DEAR SIR—I have the honor herewith to submit to you for your approval the first part of my report upon the Paleontology of Kansas, to constitute a volume of the University Geological Survey of Kansas. That such a work, completed and now in progress, is possible is chiefly due to your zealous wisdom and foresight, whereby the rich material illustrating this field of Kansas geology has been brought together in the museum of Kansas University. I desire, also, to express to you my hearty thanks for the many facilities and constant encouragement that have been afforded me by yourself and the Board of Regents in the prosecution of the work. Respectfully,

SAMUEL W. WILLISTON.

DEPARTMENT OF HISTORICAL GEOLOGY AND PALEONTOLOGY,
UNIVERSITY OF KANSAS, FEBRUARY 1, 1898.

TO THE MEMORY

OF

PROF. BENJAMIN F. MUDGE,

The first State Geologist of Kansas,

AN EXCELLENT TEACHER, A FAITHFUL FRIEND,

AN HONEST MAN.

CONTENTS.

PREFACE.

The science of Fossils, or Paleontology, is that upon which the geological history of the earth mainly rests. Without it, geology would be but a fragmentary science, a science of the structure of the earth only. By the aid of fossils, the succession of rocks, their distribution and relations are determined. They are the key which unlocks the most difficult problems of stratification. Upon them the seeker after the economic substances of the earth must mainly depend. Until the paleontologist has deciphered the records, the geologist can only grope blindly. The study of fossils, then, needs no apology from the economist. As a pure science, paleontology is inextricably united with the science of biology, the science of living things; as an applied science, it is equally intimately related to the structure and history of the earth. In the tracing of the rocks' strata, physical characters are often deceptive and unreliable; paleontological characters are decisive and incontrovertible.

Kansas has long been a famous region for the paleontologist. Perhaps no equal area in the United States presents such varied and remarkable fossil records as does Kansas. The fame of her fossils is world-wide. The pages she has added to the geological history of the earth are already classic.

But, while the state has furnished so much of interest and of value to the sciences of geology and paleontology, the published accounts, what there are of them, have been accessible only to the specialist in scattered and abstruse papers.

Constantly is the writer in receipt of inquiries from citizens of our state, especially teachers, seeking information regarding its fossils. Invariably he has been compelled to reply that such information is accessible only to the specialist and investigator. Specimens are often sent for identification, which the senders might easily determine for themselves if only they knew where to find the information. Nothing whatever has been published by the state that will aid the student in his researches. Many of the fossils of our state have been described in scattered and voluminous reports, that can be found only in those libraries that especially collect such works. For several years past the writer has been gathering the literature concerning Kansas paleontology, either in his own private library or in the library of the University. The value of the literature consulted in the preparation of the present volume is at least $1000. No better reason can be given for the need of such reports as the present. More important still is the fact that a large part of the present volume is composed of information here published for the first time, and which must necessarily be otherwise accessible only to the investigator who has the disposition and time to devote years of study to the work. Very many high schools and other institutions of the state have specimens or collections of fossils, whose value at the present time is very slight, since a very incomplete knowledge or total ignorance of what they are prevents their use as means of education or instruction ; and it is one of the chief hopes of the writer that the present work will stimulate many of the young people of our state to an intelligent interest in its geology as based upon the study of its fossils.

The material treated in the present work is believed to be fairly complete. The work is in no sense a preliminary one, but one that is hoped will not need revision for many years to come.

The reader may find accessible in the preceding volumes of this series much of interest and value regarding the physical features of the state. The different formations have been mapped out, so far as the paleontologist has defined them. The formations and localities of the economic products have been, so far as possible, made known. But the general student wishes also to learn something himself of the facts upon which these results are largely based.

The writer has been engaged for the larger part of twelve years in the study of the geology and paleontology of the state.

His first studies began in 1874, since which time he has spent over three years in camp in field exploration within the state. For the past eight years he has been collecting the material to serve for the present work. The splendid collections of fossils made by Prof. F. H. Snow and Judge E. P. West have been so supplemented that now it is possible to give a fairly good review of the very diverse and extensive field of Kansas paleontology. As an example, it may be stated that all the material figured and described, with hardly an exception, in the present work is now the property of the University of Kansas. From this material it has been possible to add very much that is new to what had previously been known concerning the animals described.

The present work deals with the fossils of the western part of state solely for the reason that more preparatory work has been done upon them in the University in recent years. At present, Mr. J. W. Beede, a graduate student of the department of Paleontology of the University, has far advanced toward publication a work upon the Invertebrate Fossils of the eastern part of the state, and his report will form a part of the next volume of this series. The remainder of the fauna of the Upper Cretaceous is also nearly ready for publication, the Plesiosaurs and Pterodactyls by the writer; the Fishes by Mr. Alban Stewart (K. U.'96), a graduate student of the department.

Other work is already in preparation for publication, including the vertebrate and invertebrate faunas of the Lower Cretaceous, the Dakota, and the Tertiary, based upon large and valuable collections now in the University museum.

It is the aim in the present and following volumes to so picture and describe the fossils of the state that they may be understood by the ordinary reader of intelligence. But, at the same time, it is imperatively necessary that the descriptions should be accurate, and accuracy can only be obtained by the use of scientific language. The general reader will find in the introductory parts of the different chapters those portions of more general interest. The student or observer with the actual fossils in his hands will be able to follow by the aid of the figures the strictly scientific descriptions. For extended description of the Upper Cretaceous horizons, the reader is referred to papers by Mr. W. N. Logan and the writer in the second volume of this Survey reports.

The writer desires here to express his warmest thanks to Prof. E. C. Case (K. U. '93), of the Wisconsin Normal School, for the preparation of his part on the Turtles; to Dr. George I. Adams (K. U. '93) for the chapter on the Upper Cretaceous; to Mr. C. E. McClung (K. U. '96), instructor in Zoology in the University, for the chapter on the Microscopic Organisms of the Cretaceous; and especially to Mr. W. N. Logan (K. U. '96), now fellow of Chicago University, for the extensive work on the Invertebrates. Messrs. Case, Adams and Logan were former students in the department of Paleontology of the University; Mr. McClung, the writer's former assistant in Microscopic Anatomy. They have all given their careful and skilled labor wholly without remuneration from the state, and with but very slight expense.

All the drawings illustrating the vertebrates, save the first five plates, have been made for this work under the writer's immediate and constant supervision. For their accuracy he is alone responsible. Most of those of the Mosasaurs and part of those of the Turtles have been made by Mr. Sydney Prentice (K. U. '96), and thanks are due him for the fidelity, skill and zeal that he has shown in their production. The plates upon the skull, especially, have required an unlimited amount of patience on his part to insure their accuracy. The larger part of the figures illustrating the Turtles were made by Miss Mary Wellman (K. U. '92), and do not need commendation. All of the photographs used in the volume have been made either by the writer or under his immediate direction. The illustrations for the Invertebrates have been largely copied or redrawn from previous authors.

S. W. WILLISTON.

PART I.

THE UPPER CRETACEOUS OF KANSAS:

A HISTORICAL REVIEW.

By GEORGE I. ADAMS.

ADDENDA.

By S. W. WILLISTON.

Plates I–IV.

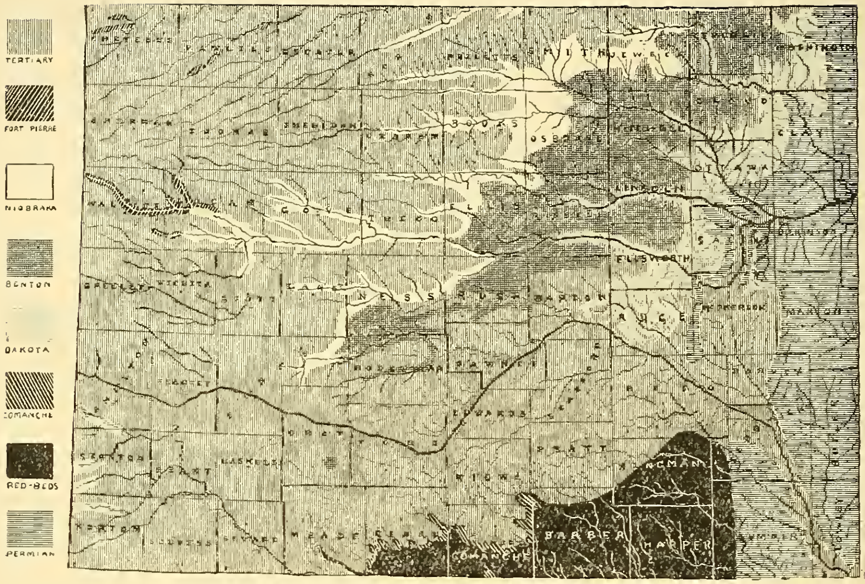

FIG. 1. MAP OF THE CRETACEOUS OF KANSAS.

THE UPPER CRETACEOUS.

By GEORGE I. ADAMS.

In 1853 Congress authorized the exploration of several lines across the western portion of the continent, for the purpose of selecting a route for a transcontinental railway. Each expedition was accompanied by a geologist. The results of their observations were published in the Pacific Railroad Reports. Among those who pushed into the western territory was Professor Hall, the veteran geologist of the New York survey. His official duties requiring his time in New York state, he employed Meek and Hayden to explore a part of the upper Missouri river region. The results of this work, mainly paleontological, were published jointly by Professors Hall and Meek.[1] This work was the beginning of long-continuing labors which they pursued jointly and separately. Their section of the Cretaceous along the Missouri river, known as the Meek and Hayden section,[2] has served as a basis for much subsequent work.

The Cretaceous formation of Kansas lies within the south interior region of the Cretaceous area of North America, as divided by White[3] for the purpose of discussion and correlation. The Missouri river section by Meek and Hayden has been used as a standard for reference in the study of this area, and is substantially still so used. It includes only formations which are referred to the Upper Cretaceous. A later nomenclature and grouping of these divisions, which was proposed by Eldridge,[4] was adopted by White. His table showing the relation of the section is given on next page.

1. Mem. Amer. Acad. Arts and Sci., 1856.
2. Proceedings Amer. Phil. Soc., 1856.
3. Bulletin No. 82, U. S. G. S., Correlation of the Cretaceous, 1891.
4. American Jour. Sci. xxxviii, 313-321, 1862.

Upper Missouri Section of Meek and Hayden.	Eldridge.
Not recognized	Laramie formation.
No. 5, Fox Hills group No. 4, Fort Pierre group	Montana formation.
No. 3, Niobrara group No. 2, Fort Benton group	Colorado formation.
No. 1, Dakota	Dakota formation.

This table does not include the Lower Cretaceous, of which the Comanche series[5] is now recognized; but, as it is the purpose of this paper to deal only with the Upper Cretaceous, the section of Meek and Hayden is wholly adequate, since the development of our knowledge of it in Kansas is largely the result of attempts to identify the members of the Missouri river section in the territory along the Smoky Hill river. The following sketch gives in chronological order abstracts of the more important papers: [6]

1855 — Doctor Schiel's Report. The series of limestones from Westport, Mo., to the Little Arkansas he considered to belong to the same formation. There he found "a white, fine-grained, non-fossiliferous limestone, and a red, ferruginous sandstone, out of which Pawnee Rock is formed. The latter was also found on Coon creek, and, from specimens brought by Captain Gunnison, he concludes that it extends up the Republican fork of the Kansas river. It supports a loose conglomerate of quartzose rock, which is seen to extend some thirty miles along the Arkansas west of Fort Atkinson. It is probable that these strata belong to the chalk formation, which, going westward, we find distinctly represented. About thirty miles further west we meet with another limestone of the Cretaceous period."

1856 — Engleman's Report.[7] This gives a general description to Fort Riley. He describes a sandstone along the Republican from above Fort Riley for forty-eight miles, that is, to eighty miles from the fort. He is inclined to think that it cannot exceed 200 or 300 feet in thickness. From Professor Hall's

5. *Vide* Prosser, vol. II, Kans. Univ. Geol. Surv. 1897, for historical summary.

6. For bibliography of Kansas Geology, see Hay, Trans. Kans. Acad. Sci. 1893–'94.

7. Geol. Ex. from Ft. Leavenworth to Bryan's Pass, 35th Cong., 1st ses., Sen. Ex. Docs. 2, pp. 489–520, Washington, 1856.

description of the route west of the Missouri in Sternberg's report, he thinks the beds may be Cretaceous. He next describes the Cretaceous formation, which was first observed seventy-four miles from Fort Riley, which is made up of chalky limestones, marls, slates, and shales. This formation extends beyond the borders of the state. He mentions some fossils. A list of fossils by Shumard accompanies the report.

1857—Hayden.[8] This article on the country bordering the Missouri river has a map accompanying it, showing the geology of northeastern Kansas, colored from information furnished by Major Hawn. In a paper immediately following, he gives a section of the rocks of northeastern Kansas above the coal measures, by Major Hawn. These beds were not seen at any one place, but their thickness and order of succession were determined in the region east of the sixth principal meridian by Major Hawn, while carrying on the lineal survey. The beds are correlated by Hayden with the New Jersey section, the Alabama section, and the Triassic and Jurassic of Marcou, from his section of Pyramid Mountain, New Mexico. The article concludes for Kansas that there is at the base of the Cretaceous series a series of beds concerning which evidence is lacking that they are not older than any portion of the Cretaceous. The section is correlated with Cretaceous, No. 1, No. 2(?), and the lower part of No. 3.

1859—Meek and Hayden.[9] In this article it was stated that No. 1 was carried too low in a previous paper (Proc. Acad. Nat. Sci. Phil., 1857). A paper by Hawn (Trans. Acad. Sci. St. Louis, I, 171) is cited in which the formation in Kansas is placed on a parallel with No. 1, but the whole is referred to the Trias. These beds were examined with care, and dicotyledonous leaves were found, proving their identity with No. 1 of the Nebraska section. Doctor Newberry is referred to as authority in the paleobotany. Between No. 1 and the beds containing Permian fossils there is a series of beds which the writer states may be Jurassic or Triassic, or both, but more probably the former,

8. Proceedings Acad. Nat. Sci. Phil. 1857.
9. American Jour. Sci., 1859.

though as yet there is no paleontological evidence. An article in the Proc. Academy of Natural Science, Philadelphia, 1859, was also published in the Transactions of the American Philosophical Society, 1863 (read 1861). The latter is accompanied by a map. These articles contain the following points of interest here: Certain beds between No. 5 of the Coal Measures and the Cretaceous are suspected of being of Jurassic or Triassic age, probably Jurassic. Reference is made to his previous discoveries of the Cretaceous age of the higher beds. Nos. 1, 2 and 3 are considered the equivalents of the Cretaceous of Nebraska, as found by Mr. Engleman. (*Vide* Rep. Sec. War, Dec. 5, 1857, p. 497.)

1866—Mudge. The First Annual Report of the Geology of Kansas, by B. F. Mudge, contains the following concerning the Cretaceous: "No unconformability has been observed from the Coal Measures to the Cretaceous. This formation, which is represented rather largely, has not been definitely studied, since it lies beyond the settlements. Chalk is said to be found in it So far as known, it appears to have a resemblance to the Cretaceous of England." Under his division Triassic, he describes fossil footprints of birds[10] found in the sandstone northwest of Fort Riley. A few miles distant, in what appeared to be the same horizon, he discovered dicotyledonous leaves. He is inclined to place the deposits in the Lias.

1866—Swallow. In his Preliminary Report of the Geological Survey of Kansas, Swallow refers No. 1 of his section, 295 feet of brown ferruginous sandstone, to the Cretaceous, but states that he saw no proofs of its age. Nos. 2 and 3, which are similar in character, he refers to the Triassic (?).

1867—Hayden.[11] This article refers to the report by Swallow, and states concerning the beds referred to the Triassic with a question, that they may be Permian, or even Jurassic, so far as any evidence yet obtained goes. He is inclined to think that they belong to the Trias.

1869—Hayden.[12] In speaking of the Cretaceous rocks (p. 13),

10. See article on Cretaceous Birds, this volume.
11. Notes on Kansas Geology, Amer Jour. Sci., 1867.
12. Preliminary Rep. U. S. G. S. of the Ters., 1869.

he says that they show five well-marked divisions, Nos. 1, 2, 3, 4, and 5, or Dakota, Benton, Niobrara, Fort Pierre, and Fox Hills. In discussing their characters, he refers briefly to the Cretaceous of Kansas at Hays City and Fort Wallace.

1872—Hayden.[13] Part I, chapter IV, by Hayden, gives a sketch of the geological formation along the Union Pacific railroad to Fort Wallace. The formation west nearly to Salina he refers to the Permo-Carboniferous series. At the 155th mile-post he says he reached the beds of doubtful age, intermediate between the Permian and the well-known Cretaceous No. 1, or those which include the rusty sandstones of the Dakota. He mentions the Dakota as occurring near Salina, at Fort Ellsworth, and as far west as Fort Harker. At Wilson he saw "the chalky limestones of the Niobrara filled with *Inoceramus problematicus.*" At the 280th mile-post he reported indications of the Tertiary. At Hays City massive rocks of No. 3 were seen sawed into blocks and used in buildings. At eight miles west of Fort Hays an exposure in a cut showed sixty feet of shale of No. 2, the Benton group, filled with concretions. On the summit of the hill he observed massive layers of yellow chalk. In concluding he says: "We have, therefore, between Salina and Fort Wallace, exposures of Cretaceous beds Nos. 1, 2, and 3. In No. 1 are well-preserved impressions of dicotyledonous leaves; in No. 2, not far from Fort Wallace, remains of gigantic reptiles have been found; while No. 3 contains invertebrates and fragments of the remains of fishes."

1876—Mudge.[14] Concerning the Cretaceous, he says that the Fort Pierre and Fox Hills groups are wanting, and that the Benton group also appears to be absent. He reports the Cretaceous as resting conformably, or nearly so, upon the Permian, and that he had found no fossils of the Jurassic or Triassic. In his description of the Niobrara, he divides it into two divisions: the Niobrara proper and the Fort Hays. The division between them is considered by him to be the bed of limestone about sixty feet thick where fully exposed. In the upper division, verte-

13. Final Rep. U. S. G. S. of Nebr., etc., with map, 1868 (printed 1872).
14. Bulletin Geol. and Geogr. Surv. of the Ters. ii, No. 3, 1876.

brates are found in abundance, while below they are rare. Of the Niobrara proper he gives a description of the physical features and areal extent, and mentions the fossils which it contains. The thickness is given as seventy-five feet in Trego county and 200 feet in Ellis county. He makes the statement that Hayden mistook exposures near Fort Wallace for Benton. He records the occurrence of seams of calc and heavy spar. He states that he discovered a bed of Baculites near Sheridan (McAllaster) and on referring specimens of them to Meek, received the following reply: "One fact in regard to your specimens, however, is curious to me. All the other forms like this that I have ever seen from any part of the far west come from Nos. 4 and 5. Can it be possible that you have found an outlier of Nos. 4 or 5?" Mudge, however, states that the beds are clearly Niobrara, since characteristic fish and saurians are found not more than fifteen or twenty feet above and not 200 yards distant. This same error was perpetuated by both Cope and Marsh in the descriptions of fossils from this region. The massive beds of stratified limestone or chalk before mentioned, together with all the deposits above the Dakota, he calls the Fort Hays. He refers to Hayden's statement, that the Niobrara limestone filled with *Inoceramus problematicus* is exposed at Wilson, and states that this rests directly on the Dakota, and all that which Hayden supposed might be Benton is above this stratum, and thus concludes that the Benton is not seen in Kansas. He remarks that the lower portion of the Fort Hays may be Benton, although there does not appear to be any line of demarcation. He says that the only persistent stratum is a buff, sandy limestone, never over ten inches thick (the Fence-post layer of Cragin), which is much used for building. He describes a bed of blue shales containing concretions (Victoria shales) above this horizon. The fossils of the formation are mentioned. The total thickness of the Fort Hays is given at 260 feet. The Dakota is made to include all the Cretaceous east of the Niobrara. No Triassic or Jurassic fossils having been discovered after ten years' search, he concludes that the Dakota rests directly upon the Permian, and is conformable with his Fort Hays group above it. The lithological characters of the limestone are mentioned, as also the occurrence of coal. Thickness, 500 feet.

1877—Mudge.[15] This paper is practically a reprint of the previous one, but gives much additional matter concerning the writer's collecting and the fossils described from the formation. Concerning the Benton he makes the same limits, but states that if he could spend a few days in the field with Hayden they might conclude that the lower portion of the Fort Hays is Benton, and therefore calls it the Fort Hays only provisionally.

1878—Mudge.[16] This repeats largely former reports. It gives a map, vertical section of the rocks of Kansas, and a horizontal section from southeast to northwest corners of the state. The Triassic and Jurassic are not represented. This allows the Dakota to rest directly upon the Carboniferous, and nearly, if not quite, in conformity. The Pierre and Fox Hills of the Cretaceous, as also the Eocene and Miocene, are reported to be wanting. The Pliocene rests upon the Niobrara or middle Cretaceous. He again repeats Meek's inquiry about beds containing *Baculites anceps*, and states that the beds are not Fort Pierre or Fox Hills. He says that in a former report he was doubtful whether the Benton is represented in Kansas. A more careful examination induces him to believe that what he called Fort Hays corresponds nearly in age to the Fort Benton. The upper portion of the Benton is formed by a bed of limestone sixty feet thick; under this is a bed of blue shale sixty feet thick, containing septaria. Below this are 140 feet of shales and layers of limestone. The total thickness is given at 260 feet. The Dakota group includes all the Cretaceous east of the Fort Benton. The principal part of the paper is composed of a discussion of the areal, geological and topographic features, and notes concerning fossils described by others.

1882—St. John.[17] The Cretaceous is laid down directly upon the Carboniferous floor, and, notwithstanding statements to the contrary, there is marked evidence of non-conformity between

15. Ninth An. Rep. U. S. G. S. of the Ters., 1875 (printed 1877).
16. First Bi. Rep. Kans. St. Bd. Agr., 1877-'78.
17. Third Bi. Rep. Kans. St. Bd. Agr., 1881-'82.

them. The Cretaceous is made up of at least three divisions—the Dakota, Benton, and Niobrara; the upper members appear to be absent. He says concerning the Benton that certain limestones, if indeed they are not to be relegated to the Niobrara, afford stratigraphical evidence upon which to base the limits of the western exposure. He estimates the total thickness at 2200 feet. He says concerning the shales at the top of the Niobrara, that they strongly resemble the "Colorado shales," *i. e.*, Fort Pierre and Fox Hills. He says that the salt springs and wells of the Cretaceous are probably supplied from the Carboniferous deposits. To the south of the Arkansas valley, horizons discovered by G. S. Chase are characterized by a molluscan fauna which indicates affinities with the Texas Cretaceous fauna.[18] He believes that the Cretaceous has been eroded progressively more deeply toward the east, so that the Tertiary rests upon successively lower beds toward the east.

1887—St. John.[19] In southwestern Kansas only the Dakota and Niobrara have been identified with certainty. Beds now known to belong to the Comanche series are here described as Dakota. Those described by him as Niobrara are referred since to the Benton.

1888—Hay.[20] From the north boundary of the state to McPherson county the Dakota sandstone rests upon the Permo-Carboniferous, an example of erosive non-conformability. From McPherson county south the Triassic beds intervene. A shorter period of erosion appears to have taken place there. The Dakota is from 300 to 500 feet thick. The passage to the Benton is without break, the beds being absolutely conformable. Total thickness probably does not amount to 400 feet. The Niobrara consists of two conspicuous strata, a succession of soft limestones, beneath which is a thick shale bed containing concretions. This shale, with occasional intercalations of limestones, is 100 to 300 feet in thickness. The limestones do not reach 100 feet. The Fort Pierre and Fox Hills appear to be ab-

18. Probably the first reference to the Lower Cretaceous in Kansas.
19. Notes on the Geology of Southwestern Kansas, Fifth Bi. Rep. Kans. St. Bd. Agr., 1885-'86.
20. Sixth Bi. Rep. Kans. St. Bd. Agr., 1887-'88.

sent. There is an outcrop in Norton county of two well-marked strata above the yellow chalk, the lower a green sand, the upper a green clay with yellow streaks. These beds are of doubtful reference.

1893 — *Williston.*[21] In this article the Niobrara is estimated to be 430 feet in thickness, and the dip to the north or northeast is shown to be greater than was previously suspected, except perhaps by St. John. The division line between the Niobrara and Benton is placed at the top of the stratified beds, following Mudge, but he is doubtful whether the Niobrara should not also include the stratified beds and perhaps also the subjacent dark blue shales. The stratified beds are called the Fort Hays, thus limiting Mudge's term. No distinction into chalk and shales is admitted for the Niobrara. He states his belief that the beds containing the *Baculites anceps*, to which Meek had referred, are Fort Pierre and not Niobrara. A similar statement was given in a paleontological paper in the Kansas University Quarterly for July, 1892, the first time that the Fort Pierre had been recognized in the state. Other paleontological matters are discussed in this paper. In 1892 Williston prepared a map of the geology of Kansas, which was published in Thomas's School Charts. This was the first time that all of the different geological epochs of the state had been given for Kansas. A modified copy of the map was published in a later paper (Kans. Univ. Quart., 1894), with the different divisions of the Cretaceous given nearly as they are at present located.

1896 — *Cragin.*[22] The rocks of the North American Interior Cretaceous are considered as belonging to two great series, the Comanche series and the Platte series, the latter including the Dakota, Benton, Niobrara, Fort Pierre, Fox Hills, and Laramie. The divisions occurring in Kansas are given as follows: The lower portion of the Benton is named the Russell formation, one horizon of which is the Downs (or Fence-post) limestone. The upper portion is called the Victoria clays, which contains the Cannon-

21. Transactions Kans. Acad. Sci., 1891–'92 (pub. 1893).
22. Colorado College Studies, March, 1896.

ball zone.[23] The lower portion of the Niobrara is named the Osborne limestones. This he states formed the upper part of Mudge's Fort Hays. The upper Niobrara is named the Smoky Hill chalk, with a lower or Trego zone, the Norton zone, and the Graham jasper horizon. The Lisbon shales named by him are supposed to be the Fort Pierre. The Arickaree shales are referred to the Fox Hills.

1897.—Logan.[24] In this paper the Upper Cretaceous is divided as follows: The Benton is divided on lithological grounds into the upper and lower groups. The lower group is subdivided into the Bituminous shale, at the base, the Lincoln marble, Flagstone, Inoceramus and Fence-post horizons. The upper group consists of the Ostrea shales and the Blue Hill shales. The Niobrara is divided into the Fort Hays and Pteranodon beds. For the Fort Pierre no divisional term is used. In a foot-note it is stated that the beds called the Arickaree shales, and referred to the Fox Hills, had been previously referred to the Fort Pierre by Hay.

1897.—Williston.[25] In this paper the line of division between the Niobrara and Benton is taken below the Fort Hays beds, following Cragin. Fort Hays is used instead of Osborne limestone. The upper portion of the Niobrara is called the Pteranodon beds (Marsh, Odontornithes, 1880). The suggestion is made that the name Pteranodon, being in all probability a synonym, should be changed to Ornithostoma beds. The Pteranodon beds are divided on paleontological grounds into the lower or Rudistes beds, and the upper or Hesperornis beds. The Fort Pierre at McAllaster is estimated at least 100 feet in thickness. The name Blue Hill is used in part for the Victoria beds. (See summary of sections, opposite page.)

From the foregoing, it will be seen that the Upper Cretaceous of Kansas is now quite well understood. The various geologists who have studied it from time to time have slightly modified

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23. The Cannon-Ball crossing of the Missouri River, illustrated in Hayden's Report, 1870, to which Cragin refers, is in the Fort Pierre.

24. Kansas Univ. Geol. Surv. II, 1897.

25. Kansas Univ. Geol. Surv. II, 1897.

SUMMARY OF SECTIONS.

	Hayden, 1872.	Mudge, 1876.	Mudge, 1882.	St. John, 1882.	Hay, 1888.	Williston, 1893.	Cragin, 1896.	Logan, 1897.	Williston, 1897.
Fox Hills. No. 5.		Reported wanting.	Reported wanting.	Reported wanting.	Reported wanting.		Arickaree shales.	Reported wanting.	
Fort Pierre. No. 4.		Reported wanting.	Reported wanting.	Reported wanting.	Norton county beds of doubtful reference.	Recognized.	Lisbon shales.	Recognized.	Recognized.
Niobrara. No. 3.	Repre-sented.	Niobrara. { Nio-brara proper.	Niobrara.	Niobrara. ?	Niobrara. { Limestone.	Niobrara. { Fort Hays limestone.	Niobrara. { Smoky Hill chalk. { Graham jasper. Norton zone. Trego zone. } Osborne.	Niobrara. { Pteranodon. Fort Hays.	Niobrara. { Pteranodon. { Rudistes beds. Hesperornis beds. } Ft. Hays.
Benton. No. 2.	Repre-sented.	Fort Hays.	Benton.	Benton.	Benton. { Shale with concretions.	Benton.	Benton. { Victoria clay with Cannon-ball zone. Russell formation, containing Downs or Fence-post limestone.	Benton. { Upper. { Blue Hill shales. Ostrea shales. } Lower. { Fence-post. Inoceramus. Flag. Lincoln marble. Bituminous. }	Benton. { Blue Hill shales.
Dakota. No. 1.	Repre-sented.	Dakota.	Dakota.	Dakota.	Dakota.	Dakota.	Dakota.	Dakota. { Saliferous. { Gypsiferous. Salt marsh. Lignite. } Ferruginous.	

the early divisions, but the tendency has been to recognize the same general groupings. There are, however, some questions of nomenclature which it may be well to mention here.

The divisions of the Dakota by Logan are the only ones so far proposed. As he remarks, there seem to be no well-marked dividing lines. The divisions were made for convenience, and may prove to be valid.

The division of the Benton into Upper and Lower is upon lithological grounds. The names used by Logan for the lower group must stand; but his division of Blue Hills is precisely identical with the Victoria shales previously proposed by Cragin, and must be given up on the ground of priority. Cragin's Russell group does not correspond with the Lower, since it does not include the Ostrea shales.

The division line between the Benton and Niobrara is in accordance with Gilbert's eastern Colorado section. (17th Ann. Rep. U. S. G. S., 1896.)

The Niobrara is divided into the Fort Hays and Pteranodon beds. The name Fort Hays was limited by Williston in 1893. The Pteranodon beds are further divided by Williston into the Hesperornis and Rudistes, on paleontological grounds. Cragin's Trego and Norton zones may correspond to these divisions, based upon lithological grounds, and scarcely recognizably characterized. Nevertheless, it is a question whether or not these terms should take precedence over Williston's.

The Fort Pierre was first reported by Williston. Cragin has since proposed the name Lisbon shales for certain outcrops, but has not in any way differentiated them or given any characters by which they may be distinguished from the rest of the Fort Pierre.

The argument for the use of the Arickaree beds rests upon similar grounds. They were first reported by Hay to be Fort Pierre. Such being the case, the names Lisbon shales and Arickaree shales may be with propriety used for the two horizons.

General Section of the Upper Cretaceous of Kansas.

Montana (Eldridge),	Fort Pierre (Hayden)		Arickaree shales (Cragin).
			Lisbon shales (Cragin).
Colorado (Eldridge),	Niobrara (Hayden),	Pteranodon beds (Marsh)	Hesperornis beds (Williston).
			Rudistes beds (Williston).
		Fort Hays beds (Mudge, Williston).	
	Benton (Hayden),	Upper group (Logan)	Victoria shales (Cragin).
			Ostrea shales (Logan).
		Lower group (Logan)	Fence-post (Cragin).
			Inoceramus (Logan).
			Flagstone (Logan).
			Lincoln marble (Logan).
			Bituminous (Logan).
	Dakota (Hayden),	Saliferous (Logan)	Gypsiferous (Logan).
			Salt marsh (Logan).
			Lignitic (Logan).
		Ferruginous (Logan).	

ADDENDA TO PART I.

BY S. W. WILLISTON.

THE first vertebrate fossil obtained from the Upper Cretaceous of Kansas was the type specimen of *Elasmosaurus platyurus* Cope, collected by Dr. Theophilus H. Turner, the physician of the garrison at Fort Wallace, and taken east by Dr. J. L. Leconte. It was described by Cope in Leconte's Notes on Geology of the Route of the Union Pacific Railroad, 1868, p. 68.

The next specimen obtained was a part of a cranium of *Tylosaurus proriger* Cope, the type, collected by Colonel Cunningham and Mr. Minor "in the vicinity of Monument station, and sent by them to Prof. Louis Agassiz." The locality is probably Monument station of the overland route, in the vicinity of Monument Rocks, in the valley of the Smoky Hill river. Other specimens were later obtained by Drs. J. H. Janeway and George Sternberg in the vicinity of Forts Hays and Wallace, and by Mr. Webb, of Topeka.

The first to make any systematic collections of fossils from the Cretaceous of Kansas was the late Prof. B. F. Mudge, at that time professor of geology in the Kansas Agricultural College. I was a student at that time under him at this college, and well remember the ardent enthusiasm that he evinced in the discoveries he made. His first expedition, as I remember, was up the Republican and Solomon rivers into the wholly uninhabited region, the home then of the bison and roving bands of marauding Indians. It was made shortly after the close of the college year in 1870. A chance acquaintance whom he met on the expedition, and who had recently come from Philadelphia, urged him to send his specimens to a young and promising naturalist in that city who was especially interested in vertebrate fossils. Although Professor Cope was then less than thirty years of age he had already achieved renown among naturalists, and it was to him that Professor Mudge wrote asking if he would be kind enough to examine the fossils and tell him what they were.

Mrs. Mudge has kindly placed in my hands a part of the correspondence that followed, and I give herewith a letter from Professor Cope, after he had received the first consignment of fossils.

It will be observed that Professor Cope speaks of a specimen found near the vicinity of Sheridan, now McAllaster. This specimen, with others, was, I believe, taken later in the season, while on a brief trip for the purpose of examining the geology in the vicinity of Wallace. He had no team or outfit, but collected the specimens from the immediate vicinity of the station.

PHILADELPHIA, October 28, 1870.

Prof. B. F. Mudge: ESTEEMED FRIEND—The fossils arrived in safety, thanks to the careful packing, and I have examined and determined most of them. The collection is a valuable one, and is an earnest of what can be done for the geological survey of Kansas under more favorable opportunities for collection.

I found portions of six species of reptilia, all of the order *Pythonomorpha*, and five species of fishes, of the new family of *Saurodontidæ*. Of the reptiles, there were two distorted vertebræ of a large *Elasmosaurus*, the species not determinable; one vertebra of a large *Liodon*, probably *L. proriger* Cope. The limb bones and accompanying vertebræ belong to a *Polycotylus* (Cope), but whether to *P. latipennis* is not yet determined. The three other reptiles are quite determinable, and new to science. I have called them *Liodon mudgei*, after the state geologist of Kansas, *Liodon ictericus* (two individuals sent), and *Clidastes cineriarum*—the last from the gray clay limestone near Sheridan.

The fishes are quite interesting, and have enabled me to define a *new family*, and correct the work of Agassiz and Leidy. They belong to the genus *Saurocephalus* of Harlan, which has been heretofore regarded as a *Sphyrænoid* fish. I find that it has not the least relationship to that order, but forms a new and interesting group near the *Ganoids* and *Characius*. In order to determine it more fully, I am exceedingly desirous of getting more complete remains, especially of the cranium and fins. The following is a list of the species:

Saurocephalus phlebotomus Cope, n. sp.
S. prognathus Cope, sp. nov.
S. napahaticus Cope, sp. nov.
S. thaumas Cope, sp. nov.

This last is the large fish eight feet long without head from 100 miles up the Solomon. Its remains were highly interesting and enabled me to determine many new points in the structure of the group. I found by means of it that the group has a vertebrated tail; also that its anal or caudal fin-ray is that which has always been referred to the *Ptychodon* genus of sharks by Professor Agassiz. The pectoral rays have just been described by Leidy as a new genus of catfish, *Xiphactinus audax!* Then there is a new genus of the same family, *Ichthyo-*

dectes ctenodon Cope, which is based on jaws and thirteen vertebræ from the yellow chalk. I hope that this species also may at some future time be more fully developed.

I hope these researches, so successfully commenced, may cover the whole vertebrate fauna of the strata. I have studied especially the mammals and birds, as well as the reptiles and fishes. If you desire any part or all of my manuscript for the annual report to the legislature, I will send it on ; in the meantime it will appear in *Silliman's Journal* and some abstracts here.

I remain, with much regard, etc., EDWD. D. COPE.

Late in the season of 1870, Professor Marsh, with an escort of United States soldiers, spent a short time on the upper part of the Smoky Hill river collecting vertebrate fossils. The material then collected served for the description of a number of interesting types by Marsh. It included the first known specimen of "Odontornithes," a foot bone brought in with other material, but which was not discovered in the material until after other specimens had been obtained later. In June of the following year Marsh again visited the same region, with a larger party and a stronger escort of United States troops, and was rewarded by the discovery of the skeleton which forms the type of *Hesperornis regalis* Marsh, together with other material.

In 1871 Prof. E. D. Cope visited the regions and made many valuable discoveries, besides giving important notes concerning the geology of the formation. "The geology of the regions marked by this formation (the Niobrara epoch) is quite simple. The following description of the section along the line of the Kansas Pacific railroad will probably apply to similar sections north and south of it. The formations referable to the Cretaceous period on this line are the Dakota, Benton and Niobrara groups, or Nos. 1, 2, and 3, etc."

In 1872 Professor Mudge made another expedition into the Cretaceous for fossils. The party accompanying him consisted of Professor Merrill, of Washburn College, Professor Felker, of Michigan Agricultural College, Professor Warder, of the Indiana Geological Survey, and seven students of the Agricultural College. They explored northwestern Kansas, traveling over 900 miles. It was on this exposition that Professor Mudge found the remarkable specimen of *Ichthyornis*, from the North Fork of the Solomon, which furnished to the world the discovery of the then startling fact of birds with genuine teeth. Under the date of September 2 of that year, Professor Marsh wrote to him inquiring about his summer collections in the Cretaceous, with the offer to "determine any reptilian or bird remains without expense," and stating that he would give him "full credit" for their discovery. Under date of September 25 he again wrote to him, acknowledging the receipt of a box of fossils, and stating that the "hollow bones are part of a bird, and the two jaws belong to a small saurian. The latter is peculiar, and I wish I had some of the vertebræ for comparison with other Kansas species." The latter is the *Colonosaurus mudgei* Marsh, which was afterwards found to belong with the bird specimen.

In the autumn of 1872, Marsh, with a small party, made another expedition into the same region. These were the only times that Marsh personally visited these regions, all of his collections being afterward obtained by parties employed by him.

In 1873 Mudge again spent some time in the exploration of the Cretaceous beds in the more northern part of the state — the only region that was at all safe from marauding Indians.

In 1874 Professor Mudge began systematic collections for Yale College, assisted by Mr. Henry Turner, of Clay Center. In July of that year his party was joined by Mr. (now Doctor) Harry A. Brous, of Manhattan, and myself, and explorations were continued into November along the Saline and Smoky Hill rivers.

In 1875 explorations for Yale College were continued by Professor Mudge, assisted by Mr. Brous and myself, from March to October.

In 1876 the party under charge of Professor Mudge consisted of Mr. Brous, Mr. E. W. Guild, who had been collecting the previous year independently, for Yale, Mr. G. P. Cooper, of Topeka, and myself. Work was continued until late in November.

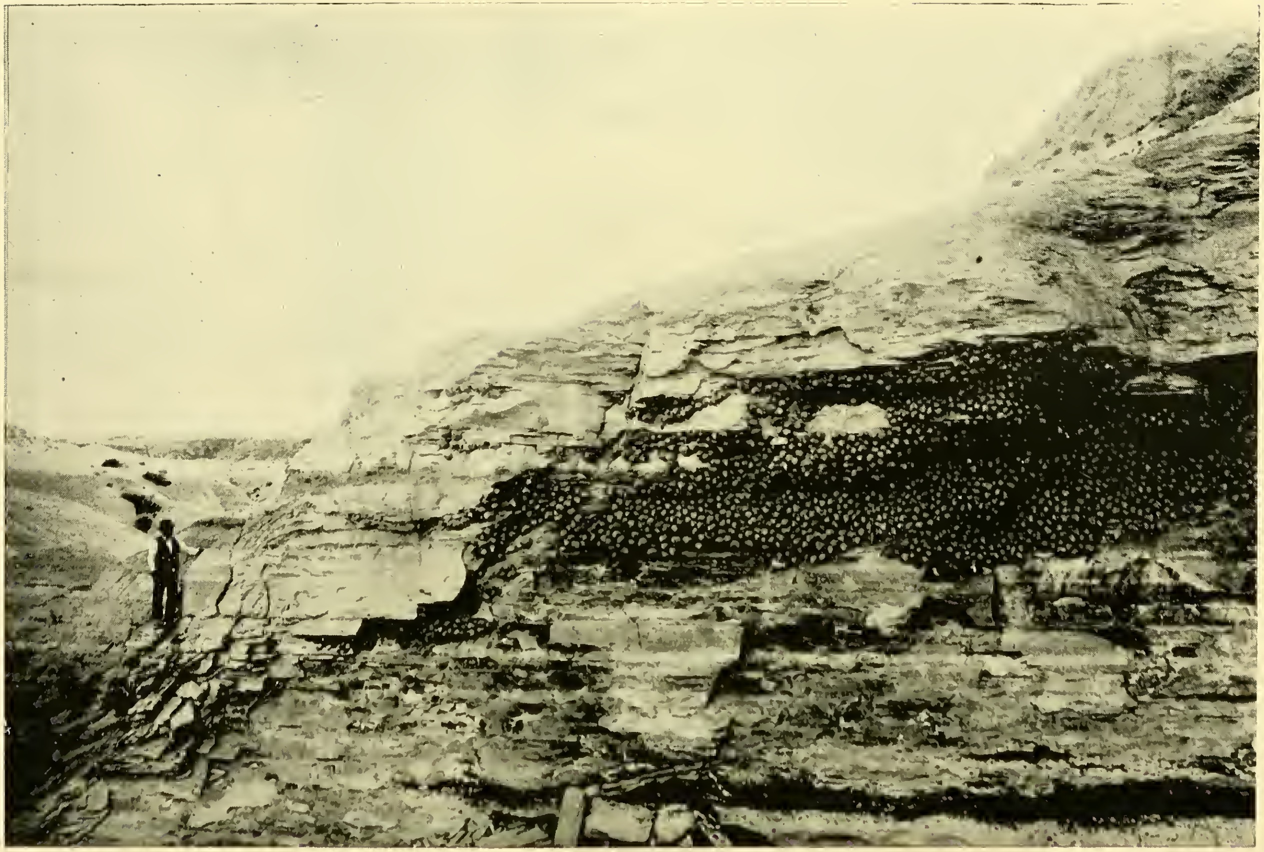
In 1877 the party (under charge of myself) collecting for Yale College consisted of Mr. Guild, Mr. Cooper, and my brother, Mr. F. H. Williston.

Meanwhile Mr. Charles Sternberg had collected by himself in these regions, during 1875, for Professor Cope. In 1877 Mr. Sternberg was in charge of a party for Professor Cope, composed of Mr. (now Dr.) Russel Hill, of Philadelphia, Mr. Wilbur Brous and Mr. Knipe, of Manhattan. For several years following Mr. Guild collected for Yale College and Mr. Sternberg made some collections for Harvard University.

In 1878 Professors Mudge, Snow and Dyche (then a student) spent some time in Gove county collecting for the University. It was on this expedition that Professor Snow obtained the specimen of *Tylosaurus* showing the skin.

For a number of years prior to 1895 Mr. H. T. Martin collected for Yale College. In 1890 Prof. George Baur collected several weeks for Professor Zittel, of Munich. In 1889 and 1890 Judge E. P. West obtained many valuable specimens for the University of Kansas. In 1891 a party under my charge, composed of Mr. (now Professor) E. C. Case, Mr. (now Professor) E. Slosson and Mr. Charles Sternberg spent about two months on the Smoky Hill river searching for specimens for the University of Kansas. Mr. Charles Sternberg, in the latter part of that year and in the following, made considerable collections for Professor Zittel. In 1895 Messrs. H. T. Martin and T. R. Overton spent the season in making collections for the University of Kansas. During the past two years collections have been made by Mr. Martin and Doctor Mathews for the American Museum, of New York city. Some additional specimens of value have been obtained by purchase for the University of Kansas from Mr. Sternberg, Mr. Martin, and others.

This in brief represents the explorational work in the Niobrara Cretaceous deposits to the present time. The few months of collecting done by Marsh and Cope was under ample protection of soldiers. While yet the danger was fully as great or greater, the various other parties spent over thirty months in the same regions with no protection other than what their own rifles and revolvers afforded. Immigrants were massacred almost within rifle shot of the parties at different times, but fortunately no encounter was had by the explorers, though at times the danger was escaped almost marvelously.



VIEW OF CHALK BLUFF IN RUSH COUNTY. With nests of swallows, *Petrochelidon lunifrons*.

CASTLE ROCK, NIOBRARA CHALK. Trego County.

NIOBRARA CHALK. Plum Creek, Gove County.

FORT HAYS BEDS, NIOBRARA CRETACEOUS.
Gove County, Smoky Hill River.

PART II.

BIRDS.

By S. W. WILLISTON.

Plates V–VIII.

BIRDS.

By S. W. WILLISTON.

Remains of birds always have been and always will be the rarest of vertebrate fossils. From the habits of the great majority of species, together with the lightness and buoyancy of their bodies in the water, it is very evident that, even where they are abundant, they will not often fall into such positions that they will be fossilized. Although, with our present evidence, they first made their appearance in geological history as far back as the Jurassic formation, scarcely two score of valid species have thus far been discovered from the Mesozoic, and all of those, with one or two exceptions, are from the Upper Cretaceous formations.

The famous *Archeopteryx*, from the Jurassic of Solenhofen, the earliest bird known, has long been renowned for its strange mingling of reptilian and avian characters. With the wings imperfectly developed, there were long reptilian fingers with claws, adapted for seizing and grasping. The jaws were provided with well-developed teeth, and the tail was elongated as in reptiles, each individual vertebra provided with a pair of long feathers.

The famous footprints of the Connecticut Triassic sandstone were, for a long time, supposed to have been made by birds. More recent discoveries of the remarkable reptiles known as Dinosaurs have shown that it was not only possible, but very probable, that all of them were made by these animals and none by birds.

From the Lower Cretaceous no bird remains are yet known. From the Upper Cretaceous, aside from the footprints noticed below, the only remains yet known in America are from the Green Sand of New Jersey, the Niobrara Cretaceous of Kansas, and the Fox Hills Cretaceous of Wyoming. *Laopteryx*, the supposed bird from the Jurassic of Wyoming, was founded upon very incomplete remains, and is, in all probability, not a bird, but a small Dinosaurian reptile.

Twenty species of birds have been described from the American Cretaceous, the larger number of which are from the Kansas Cretaceous. Not a few of these are based upon very slight material, and it is not at all improbable that future fortunate discoveries will unite some of these and at the same time add new forms to the number already known.

Bird remains, in Kansas, are, as elsewhere, among the rarest of the vertebrate fossils. One is likely to search weeks, and even months, without finding a single bone, even fragmentary. Among the thousands of specimens of vertebrates that have been collected in Kansas, not more than 175 of birds, of all kinds, have hitherto been discovered.

BIRDS OF THE NIOBRARA CRETACEOUS.

The first specimens of birds known from Kansas were obtained by the expedition of Professor Marsh in 1870. In the following year a much more complete specimen of a *Hesperornis* was obtained by another expedition in charge of Professor Marsh, and, in 1872, still other specimens.

By far the most important specimen of these early years, if not the most important of all those succeeding, as well as the one from which the discovery of the dentition was made, was one discovered by the late Professor Mudge, and sent by him to Professor Marsh. It was found by him near Sugar Bowl Mound, in northwestern Kansas, in 1872, and was first described by Marsh in October of that year under the name *Ichthyornis dispar*.

An incident related to me by Professor Mudge in connection with this specimen is of interest. He had been sending his vertebrate fossils previously to Professor Cope for determination. Learning through Professor Dana that Professor Marsh, who as a boy had been an acquaintance of Professor Mudge, was interested in these fossils, he changed the address upon the box containing the bird specimen after he had made it ready to send to Professor Cope, and sent it instead to Professor Marsh. Had Professor Cope received the box, he would have been the first to make known to the world the discovery of "Birds with Teeth." (See Addenda to Part I.)

During the succeeding years, the large collections of birds from this state were made for Professor Marsh by Mudge, Brous, Cooper, Guild, F. H. Williston, and the writer. Other bird remains have been obtained by Sternberg and Martin. In the University of Kansas museum there are portions of some twelve or more birds, including one specimen of a *Hesperornis*, much the most complete and perfect of any hitherto discovered. They apparently do not represent any new species or new forms, though not all agreeing with those described by Marsh.

In the present paper it is not worth while entering into any detailed description of these forms, inasmuch as the very complete and richly illustrated monograph of Professor Marsh[26] must remain indispensable to all those who wish to obtain more complete information.

The following list includes all the known species of birds from the Kansas Cretaceous, based upon fossil remains:

RATITÆ—Odontolcæ.

Hesperornis.

Marsh, Amer. Journ. Sci., III, 56, Jan., 1872.

H. regalis Marsh, Amer. Journ. Sci., III, 56, 1872.

This species is the best known and the most common of all the species from the Kansas Cretaceous. Practically the complete skeleton is known. See pl. VI.

H. crassipes Marsh, Amer. Journ. Sci,, XI, 509, June, 1876 (*Lestornis*).

This species was discovered by Mr. G. P. Cooper, and collected by the present writer from the yellow chalk of Plum creek, in Gove county, Kansas. It is peculiarly characterized by the presence of a rugosity on the posterior outer side of the tarso-metatarsal, above its mid-

26. Odontornithes; a Monograph of the Extinct Toothed Birds of North America. By Othniel Charles Marsh. New Haven and Washington, 1880.

dle, as though for a spur. The specimen, which comprises a considerable portion of the skeleton, was first described as the type of the genus *Lestornis*. Marsh, later, thought that the roughening might be a sexual character.

H. gracilis Marsh, Amer. Journ. Sci., XI, 510, 1876.

This species, of smaller size than the preceding, is known from the nearly complete skeleton, according to Marsh, but has never been adequately described.

Baptornis.

Marsh, Amer. Journ. Sci., XIV, 86, July, 1877.

B. advenus Marsh, Amer. Journ. Sci., l. c., 1877.

The type specimen, upon which this species and genus were based, was collected by a member of the writer's party in the yellow chalk. The generic difference is chiefly based upon the small size of the outer metatarsal.

CARINATÆ—Odontotormæ.

Ichthyornis.

Marsh, Amer. Journ. Sci., IV, 344, Oct., 1872.

I. dispar Marsh, l. c., 1872.

The type specimen of this species was discovered, as already explained, by Mudge in 1872. It is, perhaps, the most complete specimen of this group that has ever been found, and the first of any known birds that showed the presence of teeth in the jaws. The teeth were first described as belonging to a reptile, by Marsh, in the Amer. Journ. Sci. for November, 1872, under the name *Colonosaurus mudgei*. The species is at present known from nearly the complete skeleton.

I. agilis Marsh, Amer. Journ. Sci., V, 230, 1873 (*Graculavus*).

This species was based on very imperfect material discovered by Marsh in 1872, and has never yet been adequately described or figured, so that its determination, save by comparison with the type, will be more or less doubtful.

I. anceps Marsh, Amer. Journ. Sci., III, 364, May, 1872 (*Graculavus*).

The type specimen, from the North Fork of the Smoky Hill river, has never been figured.

I. tener Marsh, Odontornithes, p. 198, 1880, pl. XXX, f. 8.

Discovered by Mr. E. W. Guild, on the Smoky Hill river, in 1879.

I. validus Marsh, Odontornithes, p. 198, ff. 11, 14.

Discovered by myself on the Solomon river, in 1877.

I. victor Marsh, Amer. Journ. Sci., XI, 511, June, 1876.

The type specimen was discovered by Dr. H. A. Brous on the Smoky Hill river. Forty other specimens are referred by the author to the same species.

Apatornis.

Marsh, Amer. Journ. Sci., V, 162, Feb. 1872.

A. celer Marsh, Amer. Journ. Sci., V, 74, Jan. 1872 (*Ichthyornis*).

The type specimen was discovered by Marsh in 1872. A more perfect specimen was found later by my brother, Mr. F. H. Williston, in 1877.

The systematic position of the toothed birds from Kansas is by no means yet settled. All ornithologists are, however, agreed that they do not form a separate group, and the name Odontornithes is in consequence generally abandoned. The value of the teeth is subordinate; they do not in themselves justify a separate subclass.

Hesperornis regalis, the best-known species of the genus, was a bird measuring about six feet from point of bill to the tip of the feet when outstretched, or standing about three feet high. It was an aquatic bird, covered with soft feathers, wholly wingless, the rudimentary wing bones doubtless being inclosed under the skin, and not at all effective in locomotion. The legs were strong and moderately long; the neck long and flexible. The bill was long, and was provided with small but effective conical teeth set in the jaw firmly. Those of the upper jaws were few in number and set in the back part, while those of the mandibles formed a complete series. The jaws were united in front by cartilage only, permitting considerable mobility, which was doubtless very serviceable in swallowing their prey, which must have consisted of fishes caught by diving. The bones of the body were solid throughout, not hollow, as in almost all living birds. The sternum had no keel, as in the flying birds and those descended from flying birds, but was as in the ostrich. The vertebræ and skeleton, aside from the teeth, were not unlike those of modern birds, and, were the skull yet unknown, would be unhesitatingly referred to the subclass to which the ostrich, cassowary and rhea belong. A specimen now in the University museum, collected by Mr. H. T. Martin recently, is remarkable in showing the scuta of the tarso-metatarsal region, together with the feathers. A photographic reproduction of this part of the specimen is shown in pl. VIII. I have sketched in the tarso-metatarsal bone, to show its position. Indications of feathers are also seen on the back portion of the head, and everywhere they appear to be more plumulaceous than the ordinary type of feathers.

In pl. VI is shown the restoration of *Hesperornis regalis*, after Marsh, together with figures of the jaws and of the teeth (pl. VII). It may be added that the birds were of a low degree of intelligence, as proven by the small size of the brain.

Ichthyornis was as different from *Hesperornis* as a dove is from an ostrich. While in *Hesperornis* the wings were rudimentary and the breast-bone without a keel, in *Ichthyornis* the wings were large and powerful and the keel well developed. All the members of this group were small, none perhaps much larger than a dove. The bones were hollow, as in most recent birds. The jaws had teeth, like those of *Hesperornis*, and the birds doubtless fed upon fishes or other small animals. The most peculiar character was, however, the structure of the vertebræ. In all recent birds, as also in *Hesperornis*, the vertebræ have a peculiar articulation, which permitted ample flexure in all directions. The articulation is what is called reciprocal motion, or the saddle-shaped articulation, found, for instance, to a moderate extent in the vertebræ of the human neck. In this articulation the end of the centrum has the surface concave in one direction and convex in the other, corresponding to similar but reversed concavity and convexity in the adjacent surface of the contiguous vertebræ. In *Ichthyornis* this peculiarity was almost wholly wanting, the two ends of the centrum being nearly alike and gently concave in the middle. This concavity is not nearly so deep as in fish vertebræ, but is nevertheless of that type, which suggested the generic name from *ichthyos*, fish, and *ornis*, bird. In other respects *Ichthyornis* did not differ notably from the common flying birds of the present time. Among recent birds the tern seems to approach *Ichthyornis* most closely, due, doubtless, to similar modes of life. In pl. VII will be seen the vertebræ and jaws of *Ichthyornis*, after Marsh.

Because *Hesperornis* was a swimming bird and *Ichthyornis* a bird of powerful flight, skimming over the waters after the manner of the petrel, they have been more subject to fossilization than the strictly land-inhabiting birds were. Certainly there were many other species and genera of birds in existence at the time when these lived, since the great difference between the two forms could not have been attained without the development of many other forms. Of these, however, we have very few or no remains. Whether all birds contemporary with them were toothed or not it is impossible to say, but the probability is that they were.

In pl. V a restoration of *Hesperornis* as in life is shown, as drawn by Mr. Prentice, under my direction. Of course the coloration is largely conjectural; it is that indicated by living birds of similar habits.

BIRD TRACKS FROM THE DAKOTA CRETACEOUS.

The Dakota Cretaceous in Kansas has yielded many impressions of leaves, but no vertebrate remains of any kind have so far been discovered either in Kansas or elsewhere, save impressions or casts. A record of footprints from this formation was first made by Prof. B. F. Mudge, in 1866, and a later one by Prof. F. H. Snow. I give below the descriptions by both of these writers, in completion of the knowledge of this group of vertebrates from Kansas.

The following is by Professor Mudge:[27]

"In returning recently from an examination of the salt deposits of the Republican valley, we obtained a slab of sandstone, *in situ,* containing four impressions, and, at least, two varieties of fossil footmarks (Ornithicnites). Although the number is small, and the prints not in the best state of preservation, yet the specimens are valuable as showing a new point in the distribution of such fossils.

"The locality at which the tracks were found is on the southwesterly bank of the Republican river, about fifty miles from the mouth. The sandstone here rises from below the bed of the river in a bluff over 125 feet. The stratification is not very regular; in many cases showing an unconformable deposit, such as is frequently seen where sand is deposited in shoal water by varying currents. . . . The slab containing the tracks was found near the highest point of the bluff, on a projection within a hundred yards of the river. It is much weathered, which injures the distinctness of the footmarks.

"Species 1. *Track number C.* Divarication of the lateral toes, 65°; of the inner and middle toes, 35°; of the middle and outer toes, 35°; length of the inner toe, 3.75 inches; of the middle toe, 5.1; of the outer toe, 3.75; of the foot, 5.5; distance between the tips of the lateral toes, 4.1; projection of the middle toe beyond the others, 2.1.

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27. Discovery of Fossil Footmarks in the Liassic (?) Formation in Kansas, Amer. Journ. Sci. XLI, 174, 1866.

"SPECIES 2. *Track number A.* Divarication of the lateral toes, 65°; of the inner and middle toes, 35°; of the middle and outer toes, 35°; length of the inner toe, 2.6 inches; of the middle toe, 3.5; of the outer toe, 3.1; of the foot, 3.75; distance between the tips of the lateral toes, 3.2; between the inner and middle toes, 3.1; between the middle and outer toes, 2.2; projection of the middle toe beyond the others, 1.2 inches.

"Track number B appears to be the left foot of the bird which made number A, as the angle and length of the toes are the same; but the position of the inner toe standing so far back of the others throws some doubt upon it. Number D may be the track of still another species, or it may belong to species 1; it is so indistinct that we cannot decide upon this point." The letters refer to the four different impressions upon the slab.

Later Mudge was led to believe that these prints were the result of Indian work.

In the Transactions of the Kansas Academy for 1888, p. 3, Prof. F. H. Snow described more fully and figured a footprint from the Dakota as follows:[28]

"During the past two years Mr. E. P. West has been assisting the writer in the collection of geological specimens for the University cabinets. In the month of August, 1885, he was so fortunate as to discover, near Thompson's creek, in Ellsworth county, Kansas, a single well-marked impression, which I believe to be a genuine bird track. The piece of rock containing the impression was picked out from a pile of material which had been removed from a well excavation forty-four feet in depth. This well was sunk in the Dakota sandstone, and the geological horizon of the bird track is about 200 feet below the upper level of the Dakota rocks. The horizon of the bird track appears to be identical with that of a fine series of dicotyledonous leaves obtained on Thompson's creek, at a distance of about a mile and a half from the well.

"The impression appears to have been made by the right foot of some bird with elevated hind toe just reaching the ground at its extremity, as in the modern snipes and other wading

28. On the Discovery of a Fossil Bird Track in the Dakota Sandstone.

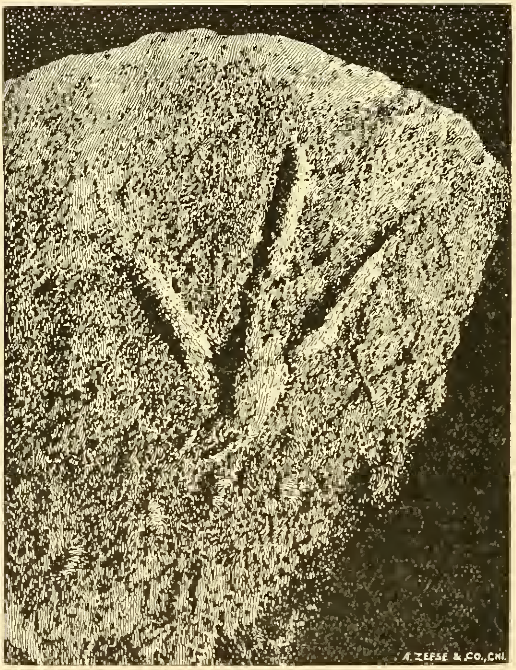


FIG. 2.
BIRD TRACK FROM DAKOTA SANDSTONE.

birds, or in the family of sea-gulls and terns. That the track is probably that of the right foot, rather than the left, is indicated by the wider separation of the outer toe from the middle toe, resulting from the greater versatility of the outer toe as compared with the inner toe, a character illustrated in many families of existing birds, and carried to an extreme in the cuckoos and the woodpeckers, in which the outer anterior toe is entirely reversed in its direction and becomes a backward-pointing member." (See opposite page.)

"It will be seen, from the accompanying cut, that our bird track exhibits the imprint of all four of the toes. The outer anterior toe is represented for fully two-thirds of its length. The middle and inner anterior toes are entirely impressed, even to the claws at their extremities — the claw being very distinctly marked upon the middle toe. The ball of the foot has left a very deep impression, and the posterior toe has made an unmistakable imprint upon the sand similar to those made at the present time by birds whose hind toes just reach the ground. That this impression is avian in character, rather than reptilian, is evident from the imprint of the hind toe, for no dinosaur or other reptile, either recent or extinct, is known to have a backwardly directed toe. . . . The small size of our Dakota track is a confirmatory indication of its avian character. It measures only two inches from anterior middle claw to claw of posterior toe, being a little larger than the foot of Prof. O. C. Marsh's *Ichthyornis victor* as restored by him in his famous monograph of the Odontornithes."

The slab on which were the prints described by Mudge was left at the Agricultural College. In the general neglect of Mudge's collection, after his connection with the institution ceased, the specimen has been lost. The specimen described by Snow is now preserved in the University of Kansas museum. The description and figure given by Snow describe the specimen sufficiently well. I agree with him in his conclusions. The print is in all probability that of a bird.

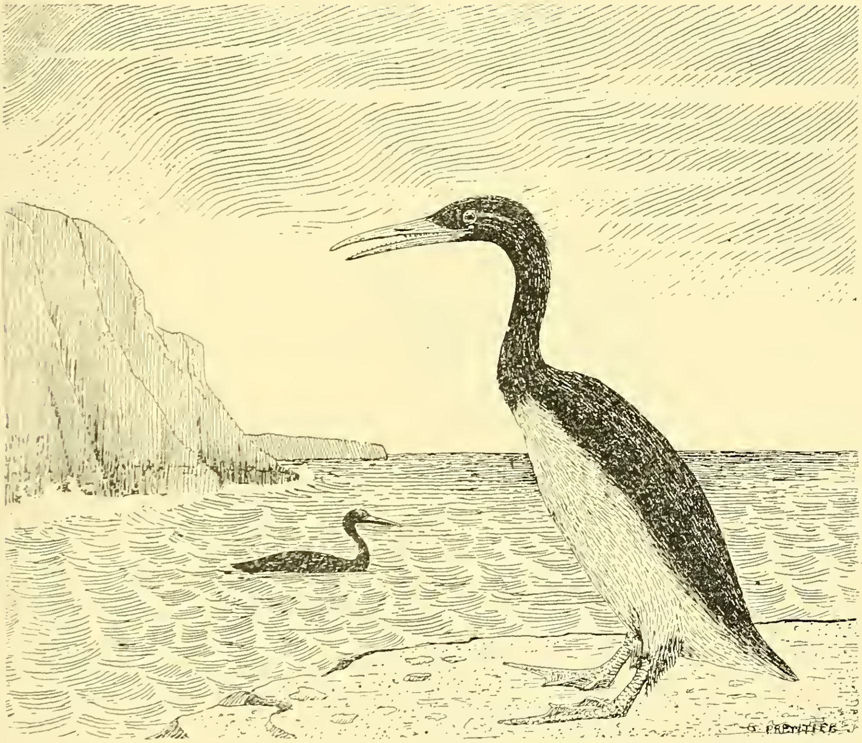
EXPLANATION OF PLATES.

PLATE V.—Life restoration of *Hesperornis regalis* Marsh. Drawn by Sydney Prentice.

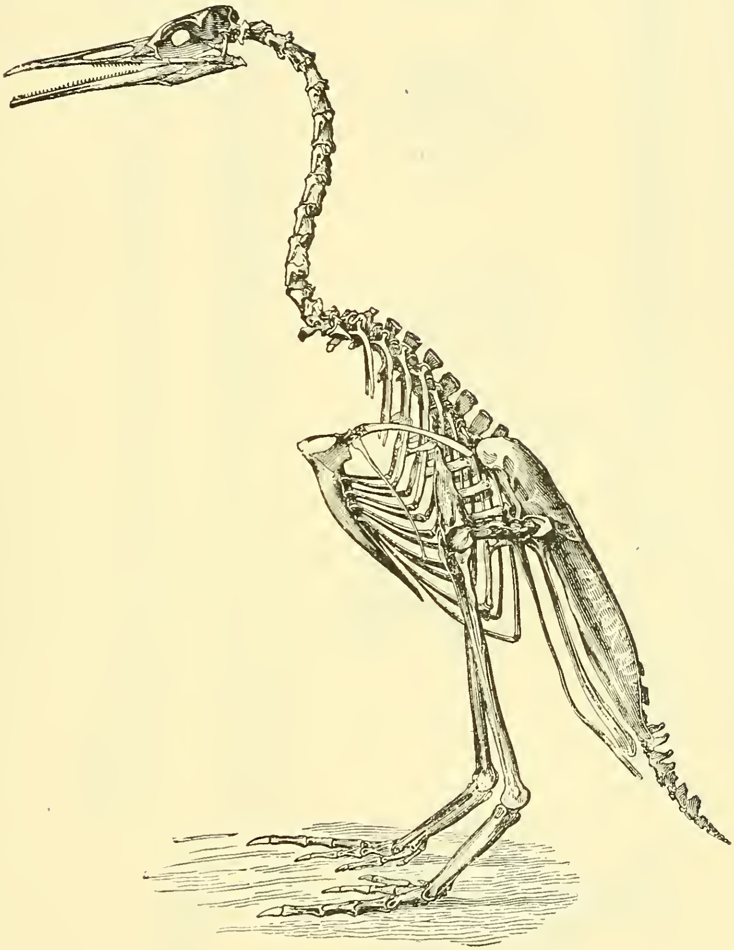
PLATE VI.—Skeleton of *Hesperornis regalis* Marsh. After Marsh.

PLATE VII.—Figs. 1, 2, jaws of *Ichthyornis dispar* Marsh, twice natural size; 3, 4, cervical vertebra of same, twice natural size; 5, 6, mandible of *Hesperornis regalis* Marsh, half natural size; 7, 8, vertebra of same, natural size; 9, tooth of same, much enlarged. All after Marsh.

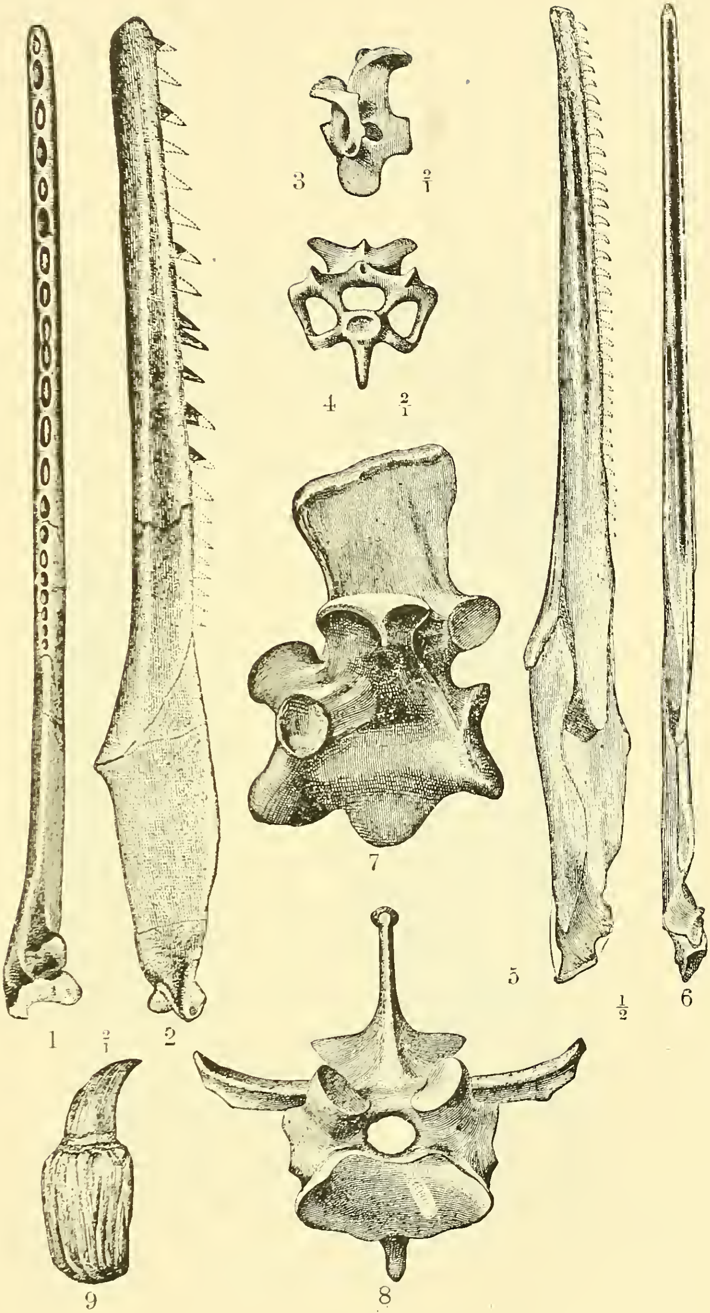
PLATE VIII.—Photograph of scutes and feather impressions of the tarsal region of *Hesperornis* species, from a specimen in the University of Kansas museum. Enlarged.



RESTORATION OF *HESPERORNIS REGALIS* MARSH.
About one-fourteenth life size.



SKELETON OF *HESPERORNIS REGALIS.*
About one-eighth life size.



HESPERORNIS, ICHTHYORNIS.

TARSAL SCUTES AND FEATHERS OF *HESPERORNIS*.
Enlarged one-fourth.

PART III.

DINOSAURS.

By S. W. WILLISTON.

Plate IX.

DINOSAURS.

By S. W. WILLISTON.

The group of Dinosaurs comprises the largest land animals that have ever existed, in some cases reaching such enormous proportions as to be almost incredible. In size and structure they are exceedingly diverse, and of course they varied also greatly in their habits. The smallest were perhaps not much larger than a cat, while the largest reached a length of over sixty feet and a height of fifteen or sixteen Unlike the reptiles of the present day, none were crawling animals; they walked erect, either on two feet, after the manner of a kangaroo, which they resembled not a little in form, or upon all four feet, as a quadruped. In all cases, however, the front legs were smaller than the hind ones, and, in the bipedal kinds were as small in proportion to the hind ones as those of a kangaroo are. It is not known what kind of a skin they possessed, but in all probability it was bare, without scales or bony plates, save in a few forms where the body was covered in a large part, perhaps wholly, by bony plates and spines. While the Dinosaurs were in many respects the most specialized of the reptiles, of a higher order of structure than any now living, they were, for the most part, animals of a low order of intelligence. In fact, in some of the very largest forms the brain was very slightly developed, an animal of twenty tons weight or more having a brain no larger than one's double fist. Some of the smaller species were exceedingly delicate in structure, having bones more hollow and light than is the case with any birds known. On the other hand, many of the larger forms were massive and heavy, with thick, solid, heavy bones. Such may have been amphibious in habit, living in marshes, lakes, and rivers, and feeding upon the succulent aquatic vegetation. They were, however, in all cases strictly land animals, never having the limbs in the least adapted for swimming. In some there are extraordinary developments of horns, plates and spines upon the body and head. A skull of one immense kind, now represented in the University museum, had a pair of horns over three feet in length on the top of the head, and another a foot long over the nose. This skull is seven feet in length, about five feet in width, and as many in height. The thigh bone of the largest species of Dinosaurs, from Wyoming, was over six feet in length, and weighed, as petrified, over 1100 pounds. The bipedal forms were usually of lighter structure, and must have been quicker and more fleet in their movements, probably progressing by long strides and leaps, and it is not at all improbable that some of the smallest, hollow-boned kinds were arboreal in their habits, living among the branches of trees, or perhaps about cliffs and promontories. Many of the bipedal forms, both large and small, were carnivorous in habit, having long, sharp and cutting teeth, which must have been exceedingly formidable weapons. The very largest were herbivorous, as were also many of the smaller ones.

The Dinosaurs ranged in time from the Triassic to the close of the Cretaceous, some of the most remarkable and extraordinary types occurring in the Laramie Cretaceous. In geographical distribution they seem to have occurred over the entire earth, with the possible exception of Australia, where none have yet been found.

Being land animals, their remains must of course occur with great rarity in marine formations, and, inasmuch as nearly all of the Kansas Cretaceous deposits are marine, they can never be expected to be found here in numbers. In fact, but one single specimen has ever been found in the state, so far as I am aware, though the animals must have lived here about the shores of the Cretaceous seas in great abundance.

In their classification there is not a unanimity of opinion among paleontologists. Many hold the opinion that they constitute a distinct subclass of reptiles, equivalent in the importance of their characters to all the other reptiles combined. Be this as it may, they are by general consent classed in three distinct groups: the Sauropoda, Theropoda and Predentata of Marsh. Other names may be eventually chosen in the place of these.

The Theropoda comprise bipedal carnivorous forms of more slender constructions and hollow bones, and were among the earliest of the known Dinosaurs. The Sauropoda were the most massive, with the fore legs only a little smaller than the hind ones, and were quadrupedal in habit. They were all herbivorous and probably amphibious. Their limb bones were solid. The Predentata were herbivorous in habit, and either bipedal with hollow bones or more or less quadrupedal and the bones solid. They included three subdivisions: The Stegosauria, with solid bones and small fore limbs, but not walking erect, the body covered with large bony plates and spines; the Ceratopsia, with solid limb bones and extensive horns on the head, their habit quadrupedal; and the Ornithopoda, animals resembling in form the Theropoda, but herbivorous, with solid or hollow bones, and without dermal armor.

The last of these subdivisions includes the only known form from Kansas. The single Dinosaur specimen known from Kansas was discovered by Professor Marsh in 1872, in the Niobrara chalk[29] of the Smoky Hill river, and named *Hadrosaurus agilis* by him.[30] Allied kinds were discovered later in the Laramie Cretaceous by Mr. J. B. Hatcher, and described by Marsh under the generic name of *Claosaurus*, which he proposed for the Kansas species in 1890.[31]

The characters he gave for the genus are as follows: "Premaxillaries edentulous; teeth in several rows, but a single row only in use; cervical vertabræ opishthocœlian; limb bones solid; fore limbs small; sternal bone parial; post pubis incomplete; sacral vertebræ, nine; femur longer than tibia; feet ungulate; three functional digits in manus and pes."[32]

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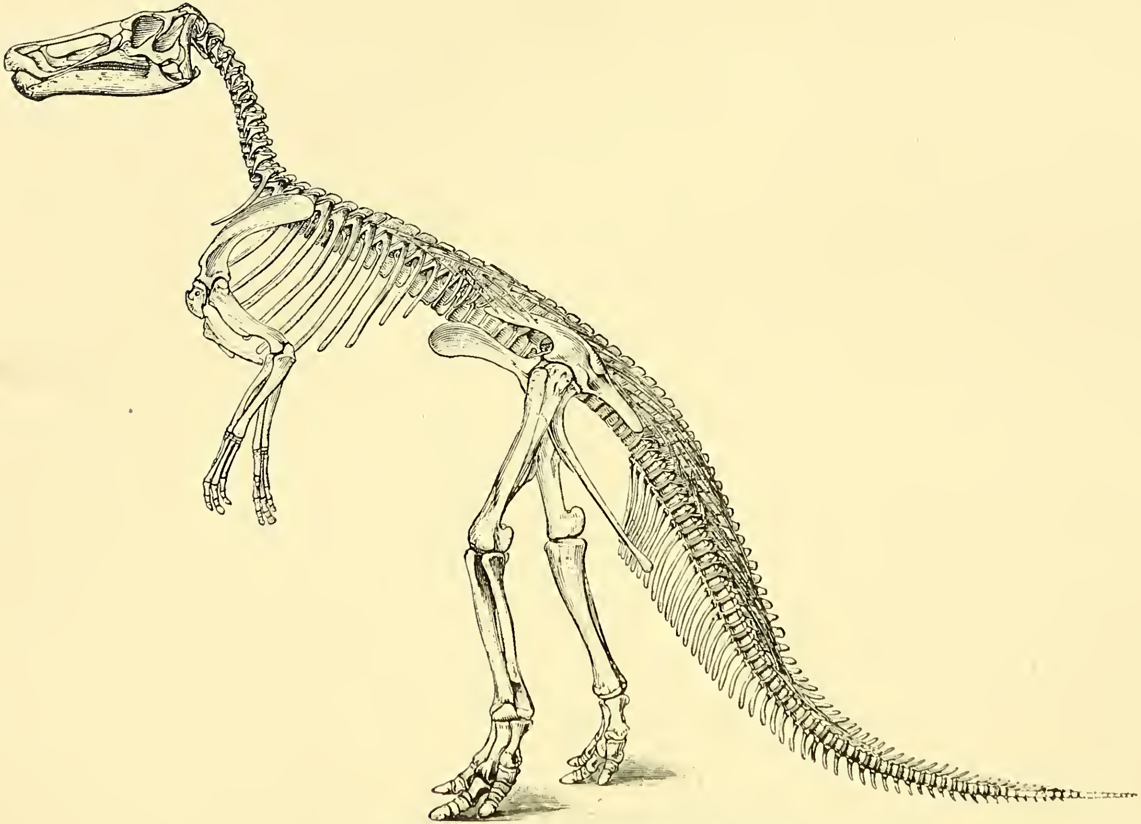
29. It is not impossible that the horizon was Fort Pierre, since the distinction between Pierre and Niobrara was not known to Marsh.

30. American Journ. Sci., April, 1872.

31. American Journ. Sci.

32. Sixteenth Ann. Rep. U. S. G. S., 244.

In pl. IX is given a reproduction of *Claosaurus annectans* Marsh, a Wyoming species, but so closely allied to *C. agilis* that it will show sufficiently well the form and structure of the Kansas species. It is after Marsh.



CLAOSAURUS ANNECTANS MARSH.

PART IV.

CROCODILES.

By S. W. WILLISTON.

CROCODILES.

By S. W. WILLISTON.

The Crocodiles, inclusive of the Gavials and Alligators, are the highest type of reptilian life now existent upon the earth. It is almost impossible to state the number of species now living, since authors are not agreed as to what the valid species are, but they are found in nearly all the tropical and subtropical regions of the earth. They include three distinct types or groups: the Crocodiles, Alligators, Gavials or Gharials. The last group is confined at the present time exclusively to the rivers of the interior of India, in the hottest regions. They are distinctly more aquatic in their nature than are the other forms, and are especially characterized by the great elongation and slenderness of their snout, armed with many sharp teeth.

The Crocodiles are much more extensive in their range, occurring in India, Africa, Australia, and the tropical parts of America. The head is broad and flat, the jaws are shorter and rounded in front, and the powerful teeth are irregular in size. The Alligators are much more nearly like the Crocodiles than the Gavials. Their head is broad and flat, as in the Crocodiles. They may be distinguished by the large tooth of the lower jaw, sometimes called the "canine." It is received into a pit or socket on the upper jaw, and is not visible when the mouth is closed, while in the Crocodiles it passes in a groove on the outside and is visible when the mouth is closed. The teeth of the Alligator are received on the inner side of the upper ones instead of between them, as in the Crocodile. The Alligators, with one exception, which occurs in China, are confined to the southern part of North America and the northern part of South America.

Both the Crocodiles and Alligators are more amphibious in habit than are the Gavials, and their teeth are better adapted for the seizure of mammals than the slippery fishes that the Gavials seek.

The earliest fossil Crocodiles are found in rocks of Triassic age in both Europe and North America. These early types, however, are of a much more generalized kind than are the modern ones. These Triassic forms are more like the Gavial in shape, but the vertebræ are not concavo-convex as in the modern, but biconcave, and this peculiarity of the vertebræ continues into the Cretaceous and nearly through it, when the modern type of vertebræ takes their place.

The order is divided into three different suborders, based upon the structure of the head, especially the palatine bones and the nasal openings and the structure of the vertebræ. The first, Parasuchia, includes the earliest types, such as *Belòdon*, and had amphicœlian vertebræ. The second, the Mesosuchia, have also biconcave vertebræ, and included the Jurassic and most of the Cretaceous forms. The third, the Eusuchia, with procœlian vertebræ, is the modern type.

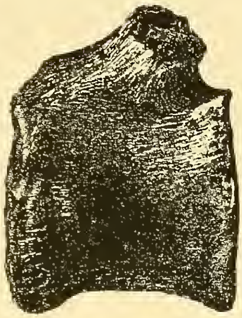
But two crocodilians have been described from Kansas, both Mesosuchian, with a long, gavial-like head. Both are known only from very scanty materials, so that it is difficult to say much about them. The older one was described — but not named — by me from the Lower Cretaceous of Clark county as follows: [33]

"A single vertebra, wanting the neural arch, but otherwise well preserved, I refer somewhat doubtfully to *Hyposaurus* or a closely allied form. It has the articular surfaces nearly flat, with the rims sharp; the body is gently concave on the sides and below, from in front back, and with striæ near each rim for about half an inch. The surface elsewhere is smooth and even, without venous foramina. A transverse section through the middle would give the greater part of an elliptical figure, with the lower side somewhat flattened. Only the base of the pedicels is present, and there is no indication of a sutural union. Springing from them, or possibly from the body itself produced above to meet the arch, there is, on each side, a stout transverse

33. Kansas Univ. Quart., III, p. 3, pl. I, ff. 4, 5.

FIG. 3.

FIG. 4.



process, the base only of which is present, but which appears to be short. In shape and appearance the centrum agrees well with one of *Hyposaurus rogersii*, from New Jersey, except in its more cylindrical shape. Its measurements are as follows:

Length of centrum	40mm.
Transverse diameter of articulating face	50 "
Vertical diameter of same face	38 "

"The upper end of a femur (f. 3) found in the same region, and from near the Red Beds, appears to belong to the same kind of an animal as does the vertebra described above. The shape is not unlike that of a human femur, with the trochanters evidently small and placed much below the level of the head. The neck is stout, the head gently convex, with an angular border. The shaft below the trochanters is somewhat flattened from before back, but becomes more transverse below. The shaft is hollow, with firm walls, not more than one third of an inch in thickness. The portion preserved measures 210mm."

From the Upper Cretaceous of Kansas there has been but a single species of Crocodile described, and I am not aware that there has ever been any other bones of these animals discovered than the single vertebra which served as the type of this species. Its horizon is the Benton, and the description by Cope is as follows:

Hyposaurus vebbii Cope.

Proceedings of the Amer. Phil. Soc., 1872, p. 310.

"An anterior cervical vertebra presents the following characteristics. It is that one in which the parapophysis occupies a position opposite the lower third of the vertical diameter. Its centrum is stout in form; the articular faces but little concave; the posterior a little more so than the anterior. The anterior is almost regularly hexagonal; the posterior subround, a little deeper than wide. The inferior surface possesses a strong, obtuse, median carina, which disappears in front of the posterior margin. Anteriorly, it terminates in a short, obtuse hypapophysis. The suture of the neural arch is very coarse. Surface of the bone smooth.

Measurements.

Length of the centrum	37mm.
Diameter of the centrum anteriorly:	
Vertical	32 "
Horizontal	31 "
Diameter of the centrum posteriorly:	
Vertical	32 "
Horizontal	31 "
Length of the surface of the parapophysis	15 "

"As compared with the *H. rogersii*, of the New Jersey Cretaceous, this vertebra is shorter and stouter, and the extremities less concave; the suture for the neural spine is much coarser.

"This Crocodile was discovered in a bluish stratum, encountered in digging a well in Brookville, Kan."

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PART V.

MOSASAURS.

By S. W. WILLISTON.

Plates X–LXXII.

MOSASAURS.

By S. W. WILLISTON.

HISTORICAL.

It is now more than a century since the first specimen of the singular group of reptiles known as the Mosasaurs was discovered, and only at the present time has our knowledge of them become at all complete. No group of extinct reptiles has been more abundantly represented as fossils, unless it be the Dinosaurs, and in no group have more skeletons and parts of skeletons been brought to light in the museums. Kansas, *par excellence*, has been the great collecting ground of the world for these reptiles. Since first a specimen was discovered by Doctor Turner, of Fort Wallace, in 1868, and taken east by Leconte, to be shortly afterwards described by Cope, many hundreds, yes thousands, of these animals have been collected. Doctors Janeway and Sternberg, at Hays and Wallace, Professors Marsh and Cope, in field expeditions, Professors Mudge and Snow, H. A. Brous, George Cooper, Charles Sternberg, E. P. West, E. W. Guild, H. T. Martin, Professor Baur, E. C. Case and the writer have at different times collected for institutions of America and Europe. A thousand or more specimens are now in the Yale museum, collected at an expense of many thousand dollars, several hundred are in the University of Kansas, and other institutions of America, and others in lesser number are in the museums of Munich and of Great Britain. Scattered publications, based often upon fragmentary material, make it difficult to obtain any connected knowledge of what the forms are in Kansas.

The present work is an endeavor to bring together clearly and distinctly all the important facts about the Mosasaurs of Kansas. The work has been the result of much careful study of the rich material now in the University of Kansas — material that is sufficient to elucidate nearly all that is to be learned about the Kansas genera and species. Little or nothing has been taken at second hand from other writers, so far as the Kansas Mosasaurs are concerned, and for nearly every statement herein contained the present writer is alone responsible. The general reader who does not care to go through the necessary mass of descriptive matter is referred to the concluding chapter, on the "Restorations of the Kansas Mosasaurs."

The first specimen of Mosasaurs of which we have historical knowledge was discovered by Doctor Hoffman, a surgeon of Maestricht, in 1780, and has been the subject of numerous descriptions and discussions by some of the most famous naturalists of the world. Its discovery, and the subsequent destination of the fossil, is the subject of the following account by M. Faujas-Saint-Fond, in his "Natural History of St. Peter's Mount":

"In one of the galleries or subterraneous quarries of St. Peter's Mount, at Maestricht, at the distance of about 500 paces from the principal entrance, and at ninety feet below the surface, the quarrymen exposed part of the skull of a large animal imbedded in the stone. They stopped their labors to give notice to Doctor Hoffman, a surgeon at Maestricht, who had for some years been collecting fossils from the quarries, and who had liberally remunerated the laborers for them. Doctor Hoffman, observing the specimen to be the most important that had yet been discovered, took every precaution to secure it entire. After having succeeded in removing a large block of stone containing it, and reducing the mass to a proper condition, it was transported to his home in triumph. But this great prize in natural history, which had given Doctor Hoffman so much pleasure, now became the source of chagrin. A canon of Maestricht, who owned the ground beneath which was the quarry whence the skull was obtained, when the fame of the specimen reached him, laid claim to it under certain feudal rights and applied to law for its recovery. Doctor Hoffman resisted, and the matter becoming serious, the chapter of canons came to the support of their reverend brother, and Doctor Hoffman not only lost the specimen but was obliged to pay the costs of the lawsuit. The canon, leaving all feelings of remorse to the judges for their iniquitous decision, became the happy and contented possessor of this unique example of its kind.

"But justice, though slow, arrives at last. The specimen was destined again to change its place and possessor. In 1795 the troops of the French republic, having repulsed the Austrians, laid siege to Maestricht and bombarded Fort St. Peter. The country house of the canon, in which the skull was kept, was near the fort, and the general, being informed of the circumstance, gave orders that the artillerists should avoid that house. The canon, suspecting the object of this attention, had the skull removed and concealed in a place of safety in the city. After the French took possession of the latter, Freicine, the representative of the people, promised a reward of 600 bottles of wine for its discovery. The promise had its effect, for the next day a dozen grenadiers brought the specimen in triumph to the house of the representative, and it was subsequently conveyed to the museum of Paris."

It is said that after peace was established the canon was reimbursed for the specimen. But it still remains in Paris.

This specimen was described and figured by Cuvier in 1808, and the generic name, *Mosasaurus*, was given to it by Conybeare in 1822; the name being derived from the river Meuse (Latin, *Mosa*), near which it was found, and *saurus*, a reptile.

In 1843 a specimen previously discovered by Major O'Fallon, an Indian agent, at the Great Bend of the Missouri, who had it taken to his home in St. Louis and placed in his garden, was most carefully and fully described by Dr. August Goldfuss,[34] and admirably figured. This description and its accompanying plates were most strangely overlooked or neglected by later authors. The parietal and jugal arches, the pterygoids and vomers, the position of the quadrate and the presence of sclerotic plates, all were clearly described or figured. Nevertheless, they

34. Der Schaedelbau des Mosasaurus, Act. Acad. Caes. Leop. Carol. Nat. Cur., XXI, 1843.

were all later announced as new discoveries. With the exception of some brief and unimportant papers on the group by Morton and Leidy, the next most important contributions to the knowledge of the Mosasaurs are due to the late Professor Cope. Aside from a number of short papers, his chief contributions will be found in his "Synopsis of the Extinct Batrachia, etc.," published in 1870, and his volume on the "Cretaceous Vertebrata of the West," published in 1875. In this last work he enumerates more than fifty species of the group from America. Meanwhile Professor Marsh had described a number of forms and published a number of discoveries concerning the anatomy of these animals, many of which, however, were rediscoveries of Goldfuss. These papers by Marsh will be found in the American Journal of Science. To him is due the discovery of the stapes, columella, transverse and hyoid, and the presence of the hind limbs, which had already been indicated by Goldfuss. Since 1882, Dollo has very materially increased our knowledge of this group, and has established the following new genera in numerous papers: *Plioplatecarpus*, *Hainosaurus*, *Prognathosaurus*, and *Phosphorosaurus*. In 1892 Baur published a complete and minute description of the skull of *Platecarpus*, illustrated by detailed drawings of the different parts, and Williston and Case gave for the first time a description of the vertebral column and more precise knowledge of the extremities and the general form of the Mosasaurs. Later papers by Williston have added to the knowledge of the Kansas forms, and the first correct restoration of any member of this group was given by him. In 1894 was published a valuable illustrated paper on the Kansas Mosasaurs, by Merriam, in which several supposed new forms were briefly described and a number of new details given of the different genera, with more complete generic differences than had hitherto been published. Other papers by Gervais, Gaudry and Owen complete the list of the more important ones on this group of reptiles.

RANGE AND DISTRIBUTION.

The Mosasaurs are at present known from four remote regions of the word—North and South America, Europe, and New Zealand. Doubtless they lived over the greater part of the earth, and may be expected wherever marine Upper Cretaceous deposits occur. Their geological range is confined exclusively to the Upper Cretaceous, from the time corresponding to the upper part of the Dakota to that of the lower part of the Laramie, or from the Upper Cenomanian to the Lower Danian. The correlation of the American Cretaceous deposits with those of Europe, or even with each other, is by no means exact, or even approximately exact. Nevertheless the equivalency of the different strata and epochs is sufficiently well determined to admit of approximate results.

The oldest Mosasaurs are apparently those described by Hector from New Zealand, which he referred to the genera *Liodon* and *Taniwhasaurus* Hector.[35] The genus *Liodon* Owen, Dollo has recently shown to be a synonym of *Mosasaurus*.[36] Whether or not Hector's species is congeneric with those placed under *Liodon* by Cope is not certain, though it is evident that it is closely allied. *Taniwhasaurus* is clearly of the *Platecarpus* type, and may possibly belong to that genus.

The most recent form is the historical *Mosasaurus giganteus* Soemmering (*M. camperi, M. hoffmani*), from the Maestricht beds in the Lower Danian. These three forms, *Tylosaurus*, *Platecarpus*, and *Mosasaurus*, represent three distinct and divergent types, which I have called the Tylosaurinæ, Platecarpinæ, and Mosasaurinæ, corresponding to the megarhynchous, microrhynchous and mesorhynchous types of Dollo.[37]

The Tylosaurinæ begin with *Liodon* (*Tylosaurus ?*) *haumuriensis* Hector in the Cenomanian of New Zealand, and continue to the Upper Senonian of Belgium as found in the genus *Hainosaurus* Dollo, from the brown phosphatic chalk of Mesvin

35. On the Fossil Reptilia of New Zealand, Trans. and Proc. New Zealand Institute, vi, 338, 1873.

36. Bulletin Soc. Belg. Geol., vii, 79, 1892.

37. Mem. Soc. Belg. de Geol., iv, 163, 1890.

Cipley. In the interior of North America the type, so far as known, begins near the lower part of the Niobrara and terminates at its close or in the beginning of the Fort Pierre ; that is, to use the European time periods, with the close of the Turonian or the beginning of the Senonian. Forms ascribed to this genus, the *Liodon* of Cope, are from the Lower Greensand or Lower Marl of New Jersey, but their positive identification is yet uncertain, if not doubtful, since the only characteristic parts, the rostrum, quadrate, and limb bones, have never yet been found. There is nothing improbable in its occurrence in these beds, but hitherto nothing decisively characteristic of *Tylosaurus* has been found there. The genus *Hainosaurus* is clearly of the *Tylosaurus* type. In fact, the two genera are so nearly related that decisive distinctional characters are not yet forthcoming, unless they be found in the paddles.

The Platecarpinæ have a very similar distribution. Beginning in the Cenomanian of New Zealand, in *Taniwhasaurus*, if the deposits of New Zealand are really contemporaneous with this epoch in Europe, they terminate in the closely allied *Plioplatecarpus* Dollo from the Lower Maestrichtian of Belgium. In North America the species upon which the genus *Platecarpus* has been chiefly based are known nowhere outside of Kansas and Colorado, and are here restricted exclusively to the Niobrara. The type species of this genus, *P. tympaniticus* Cope, is from Mississippi, and is in all probability congeneric with the Kansas species, but this has not yet been satisfactorily proven, though it certainly belongs in the Platecarpinæ.

From the Fort Pierre only one species can be referred to this group, and this with doubt. *Brachysaurus* described by myself may belong here, but I believe that its affinities are more close with the Mosasaurinæ. It is certainly closely related to *Prognathosaurus* Dollo,[38] from the Upper Senonian of Belgium, and I should have had little hesitancy in identifying it with that genus had not Dollo stated that the chevrons are free in *Prognathosaurus*.[39]

38. Mem. Soc. Belg. de Geol., III, 193, 1889.
39. Mem. Soc. Belg. de Geol., IV, 163, 1890.

Of the Mosasaurinæ, including the two genera *Mosasaurus* and *Clidastes*, the lowest horizon is the upper part of the Niobrara in Kansas. *Clidastes* ranges into the Fort Pierre, as previously stated by myself. In the eastern Atlantic region this genus is represented by forms closely allied to those from Kansas. Its range, then, is from the upper part of the Turonian through the larger part of the Senonian.

The typical *Mosasaurus* is confined exclusively to the Senonian and Danian. Its distribution in North America is reputed to be from New Jersey, Alabama, and Dakota, but some of the determinations may be incorrect. The species from the Fort Pierre are, however, clearly congeneric with one or more from New Jersey. In Europe, *Mosasaurus* is known only from the Upper Senonian and the Danian (upper chalk and Maestrichtian); that is, apparently, from later horizons than those in which the genus occurs in America.

The two genera *Mosasaurus* and *Clidastes* are nearly related, though perhaps sufficiently different to justify their independent existence.

From the known distribution of the Mosasaurs, Dollo has concluded :

"Que la Nouvelle-Zéland (ou, mieux, les terres australes) est le centre d'irradiation des Mosasauriens, qui en seraient partis à la fin de l'époque cénomanienne, auraient vécu uniquement en Amérique durant l'époque turonienne, auraient émigré en Europe à l'époque sénonienne et s'y seraient éteints avec l'époque maestrichtienne."

The fact that Mosasaurs have been reported from the Amazonian Purus, corresponding to the Maestrichtian, would certainly indicate that they had not become at all restricted in distribution in the latter part of their existence.

The distribution of the Mosasaurs, so far as now known, seems to be of little value in the correlation of the Cretaceous epochs. Only a single genus seems to be of wide distribution, and the nearly related ones may be widely separated in geological range. Two, perhaps three, distinct types appear suddenly in the Cenomanian, and have continued side by side in the same waters throughout the greater part of the time during which the group has been in existence. Some minor divergent forms have appeared, such as the singular *Phosphorosaurus* Dollo, *Prognathosaurus*, and *Brachysaurus*, and, perhaps, *Baptosaurus* Marsh, which, by the way, is one of the latest American forms, from the Upper Greensand or Marl of New Jersey, and occurring, also, if Merriam's determination is correct, in the Niobrara of Kansas.

The common aquatic ancestor of the three types must be sought for in a much earlier period, certainly in the Lower Cretaceous. The rudimentary or possibly functional zygosphene among the Platecarpinæ, or some members of it, and the complete zygosphene in *Clidastes*, together with the shortened muzzle and more fully ossified paddles, indicate a much closer relationship between the Platecarpinæ and Mosasaurinæ than between either and the Tylosaurinæ. In the last we find, in some forms at least, that the fifth finger is actually longer than the fourth, with as many phalanges, and that the carpus and tarsus are almost wholly unossified. If we assume with Dollo that the zygosphene is a primitive character, (and it must be unless it had an independent origin among the Mosasaurs,) then *Clidastes* would be the most generalized and *Tylosaurus* the most specialized of the Mosasaurs. In the paddles and skull, *Tylosaurus* is, with hardly a doubt, more specialized than any other genus. However, although *Clidastes* may retain some of its primitive characters, it certainly shows in many other respects a high degree of specialization.

I give below a tabular review of the known genera of the Mosasaurinæ arranged in systematic sequence, using the European time epochs for comparison's sake. Of course it is understood that the exact equivalency of these time periods is yet a matter of uncertainty.

TYLOSAURINÆ.

Tylosaurus Marsh.

Cenomanian of New Zealand (*Liodon haumuriensis* Hector).
Upper Turonian of Kansas and New Mexico (Niobrara).
? Senonian of New Jersey (Greensand).

Hainosaurus Dollo.

Upper Senonian of Belgium (brown phosphatic chalk of Cipley).

PLATECARPINÆ.

Platecarpus Cope.

Upper Turonian of Kansas and Colorado (Niobrara).

? Senonian of Mississippi.

Plioplatecarpus Dollo.

Lower Maestrichtian of Belgium (Danian).

Prognathosaurus Dollo.

Upper Senonian of Belgium (brown phosphate of Cipley).

? *Brachysaurus* Williston.

Senonian of Dakota (Fort Pierre).

Sironectes Cope, and *Holosaurus* Marsh.

Upper Turonian of Kansas (Niobrara).

Taniwhasaurus Hector.

Upper Cenomanian of New Zealand.

MOSASAURINÆ.

Mosasaurus Conybeare.

Lower Danian of Belgium and England (Upper and Lower Maestrichtian and Upper Chalk).

Upper Senonian of Belgium (brown phosphate of Cipley).

Senonian of New Jersey and Dakota (Greensand and Fort Pierre).

? Senonian of Alabama and North Carolina.

Clidastes Cope.

Uppermost Turonian or lowermost Senonian of Kansas and Colorado (Niobrara and Fort Pierre).

Senonian of New Jersey, Alabama, and Mississippi.

INCERTÆ SEDIS.

Baptosaurus Marsh.

Upper Senonian of New Jersey (Upper Greensand).

Upper Turonian of Kansas (Niobrara).

Phosphorosaurus Dollo.

Upper Senonian of Belgium (brown phosphatic chalk of Cipley).

CRETACEOUS EPOCHS OF THE UNITED STATES AND EUROPE.

		Atlantic border.	Gulf border.	Southern interior.	Northern interior.	Pacific border.	France.	England.
Upper Cretateous.	1	Wanting.	Wanting.	Wanting.	Denver.		Danian.	
	2	Upper Greensand.	Wanting.	Laramie.	Laramie.			
	3	Middle and Lower Greensand.	Ripley. Upper Rotten Limestone.	Glauconitic. Ponderosa Marls.	Montana. { Fox Hills. Fort Pierre.	Chico.	Senonian.	Upper, Middle and Lower Chalk.
	4	? Clay Marls.	Lower Rotten Limestone.	Austin Limestone. Eagle Ford Shales.	Colorado. { Niobrara. Benton.		Turonian.	
	5	Raritan.	Upper Eutaw. Tombigbee.	Lower Cross-timber Sands.	Dakota.		Cenomanian.	Upper Greensand.
Lower Cretaceous.	1	Potomac.	Tuscaloosa.	Comanche.	Kootanie.	Shasta.	Albian. Aptian. Neocomian.	Gault. Lower Greensand. Wealden.

SYSTEMATIC POSITION.

There has been much controversy regarding the systematic position of the Mosasaurs. By many they are considered to be a suborder of the Squamata, coequal with the Lacertilia and Ophidia, and this view has the support of Cope, Boulenger, and Dollo, all eminent herpetologists. On the other hand, Owen, Marsh and Baur contend that they belong among the Lacertilia. If one accepts the division of the Lacertilia into Lacertilia, Rhiptoglossa, and Dolichosauria, then I believe that the suborder Mosasauria should find an independent place with them. But otherwise I believe that they should be included among the Lacertilia in the wider sense as a distinct tribe. Surely the natatory character of their limbs, and the absence of sacrum, together with important differences in the skull, are sufficient to entitle them to a position of their own, distinguished from all other lizards. But, in any event they do not present any distinct relationships with the Ophidia, and the name Pythonomorpha in consequence must be given up.

The history of the controversy between Professor Cope and the various authors who have contended for the subordinate position of the group is of sufficient importance to warrant a brief review here, with references to the literature concerned, to which the reader may turn, should he desire to pursue the subject further.

Cuvier, who was the first to publish a scientific discussion of the nature and structure of the Mosasaurs, contended that they were nearest allied to the Monitors and Iguanas.[40]

Goldfuss, who published an excellent and extended paper on an American form of the group,[41] expressed his views of their relationship as follows: "The depressed, elongate form of the anterior part of the head, the narrow, long nares, the structure of the lower jaw and the presence of the palatal teeth, affirm Cuvier's claim that this genus of animals finds its systematic position between the Monitors and Iguanas. If we follow the

40. Sur le Grand animal fossile des cariere de Maestricht, Ann. Mus. Hist. Nat., XII, 145, 1808.
41. Der Schaedelbau des Mosasaurus, Act. Acad. Caes. Leop. Carol. Nat. Cur., XXI, 1843.

structure of the skull in its details, we are surprised to find here a middle ground in which not only the peculiarities of the above named genera, but indeed also those of most other saurians are united, together with others which are peculiar to them and distinguish them from all others" (p. 179). "From the foregoing it is seen that the genus *Mosasaurus* has only the teeth alveolæ in common with the crocodilians and the bony sclerotic ring with the fish-like saurians, but on the other hand is related to the living lizards, and especially agrees with the Monitor" (p. 188).

In 1869[42] Professor Cope proposed for the reception of the Mosasaurs the erection of a special order, which he called Pythonomorpha, and for which he gave the following characters :

"1. The teeth have no fangs. 2. There is merely a squamosal suture between the maxillary and premaxillary. 3. The opisthotic bone projects free from the cranium, and is the suspensorium of the os quadratum. 4. There is no columella. 5. There is no symphysis mandibuli. 6. The parietal is decurved posteriorly and unites with the alisphenoid, forming the cranial wall in front of the prootic. 7. The subarticular and splenial elements of the mandible are connected by articular faces. 8. The vertebræ are very numerous, much exceeding 100, and frequently present the zygosphene articulation. 9. The abdominal cavity is long and surrounded by many short curved ribs, which have simple heads and a free antero-posterior movement on vertical articulating surfaces, and which commence close behind the axis vertebræ. 10. The pterygoids are elongate and bear numerous teeth, and in one type are free, except at the extremities. 11. The brain-case is not fully ossified anteriorly. 12. Scapula and coracoid elements are present. 13. The caudal vertebræ are furnished with chevron bones. 14. The squamosal bone is present. 15. The angular bone is distinct. 16. The os quadratum is movably articulated to the opisthotic. 17. The os quadratum embraces and incloses the meatus auditorius externus. 18. The opisthotic is supported by a pedestal projecting from the cranial walls, composed of the

42. Proceedings Bost. Soc. Nat. Hist., XII, 253.

prolonged prootic in front and the exoccipital behind, which embraces the suspensorium for much of its length. 19. The anterior limbs are fins, with all the elements in a single plane; the radius incapable of rotation; the humerus broad and flat. 20. There are probably no hind limbs. Of the above characters, the first eight are those of serpents; the five characters following the ninth are lacertian; while the seventeenth is peculiar, and not found in any existing order of reptiles. The eighteenth is characteristic of the Sauropterygia."

In 1875[43] he defined the order Pythonomorpha as follows:

"1. The quadrate bone is attached to the cranium by a ginglymoid articulation, admitting of free movement. 2. The ribs are attached by simple articulations to single articular facets, or diapophyses, springing from the bodies of the vertebræ. 3. There are two pairs of limbs, which form paddles, having the elements arranged in one plane, and incapable of rotation or flexure on each other. 4. There is no sternum. 5. The scapular arch consists of scapula and coracoid only. 6. There is no sacrum. 7. The pelvis consists of slender elements, of which the inferior are nearly transverse, and meet, without uniting, on the middle line below. 8. The opisthotic bone projects free from the cranium as the suspensorium of the quadrate bone, and is supported and embraced by a pedestal projecting from the cranial walls, composed of the prootic in front and the exoccipital behind. 9. The stapes lies in a groove on the posterior side of this suspensorium, and is produced to the os quadratum. 10. There is no quadratojugal arch. 11. The parietal is decurved posteriorly, forming the cranial wall in front of the prootic. 12. The brain chamber is not ossified in front. 13. The squamosal bone is present, merely forming the posterior part of the zygomatic arch. 14. The mandible is composed of all the elements characteristic of reptiles: the articular and surangular distinct; the angular represented by its anterior portion only; and the coronoid present. 15. The atlas consists of a basal and two lateral pieces only; the odontoid is distinct, and is bounded by a free hypapophysis, besides the hypa-

43. Cretaceous Vertebrata, p. 112.

pophysis of the axis. 16. The caudal vertebræ support chevron bones. 17. The teeth possess no true roots."

In 1877 Professor Owen[44] criticized these views of Cope, contending that the supposed ophidian characters do not really exist in the Mosasauria, summing up his conclusions with the statement that "The fossil evidences of the Mosasaurians hitherto made known do not yield a single character peculiar to and characteristic of the ophidian order." He contended that the Mosasaurs are aquatic Lacertilia, holding a position similar to that of the pinnipeds among the true carnivora.

In his reply to this paper Professor Cope[45] gave the following characters as essential in the definition of the order, which he still contends is valid: "1. The parietal bones are decurved on the sides of the cranium, and are continuous with the alisphenoid and prootic elements. 2. The opisthotic is largely developed, and extends upwards and forwards to the walls of the brain-case. 3. A distinct element connects the squamosal with the parietal bone above the opisthotic. 4. The teeth have no roots. 5. There is no sacrum. 6. There is no sternum. 7. The bones of the limbs possess no condylar articular surfaces.

"Of the preceding seven characters, the decurvature of the borders of the parietal bone at the margins, and their continuity with the margins of the prootic bones, is of importance as a character not found in the Lacertilia and universal among Ophidia. The opisthotic has a greater development than in lizards, where it does not reach the brain-case upward. In the serpents, its contact with the brain-case is well known. The existence of another element lying on the opisthotic, first pointed out by Marsh, is an important character. The anterior extremity of this bone enters into the side wall of the cranium below the parietal, occupying much the position of the pterotic, and resembling, even more than the opisthotic, the suspensorium of the Ophidia. Should this be the true homology, the affinity to the Ophidia is not strengthened; and should it prove

44. On the Rank and Affinities in the Reptilian Class of the Mosasauridæ, Gervais, Quart. Journ. Geol. Soc., 1877, 682.

45. Cope, E. D., Professor Owen on the Pythonomorpha, Bull. U. S. Geol. and Geogr. Surv. Ters., IV, No. 1, Washington, 1878, pp. 299-311.

to be a distinct element, not found in either Ophidia or Lacertilia, the claims of the new order to existence are maintained. In either case it is clear that the ophidian suspensorium is not the squamosal bone.''

Unfortunately in these characters given by Cope there are several errors. There is no distinct element connecting the ''squamosal'' (prosquamosal) with the parietal bone above the opisthotic. There is the same kind of a sternum present as in the Lacertilia. The characters then left are the decurvature of the parietal bone, the absence of true roots to the teeth, and the absence of a sacrum. The last character is also incorrect, since in some of the forms, at least, there are as distinct articular condylar surfaces as in the Lacertilia. To the decurvature of the parietal bone no great importance can be attached. The absence of a sacrum and the natatory character of the limbs are really the most important of all the characters adduced, and, I believe, certainly entitle the Mosasaurs to an independent group among the Lacertilia. Among the last to criticize the classification of Professor Cope is Baur,[46] who reviewed the whole history of the controversy, described and figured the bones of the skull in an excellent way, and gave the following classification :

PLATYNOTA.

Superfamily **Varanoidea.**
Families ***Varanidæ.***
Mosasauridæ.
Superfamily **Helodermatoidea.**
Family ***Helodermatidæ.***

'' I see no difficulty in assuming that the Mosasaurs developed from unguiculate Lacertilia, which were very close to the Varanidæ. To express this affinity, I placed the Varanidæ and Mosasauridæ in a superfamily, the Varanoidea. By this I wanted to say that the Mosasauridæ cannot be separated from the true Lacertilia, to which the Varanoidea belong ; in other words, that they cannot be placed as a suborder of the Squamata, but have to be placed among the suborder Lacertilia. In this opinion I have nothing to change.''

46. Science, Nov. 7, 1890, and Journ. of Morph., VII, p. 1, 1892.

Baur does not insist upon uniting the Mosasaurs in the same ultimate division as the rest of the Lacertilia, or any of the living forms, but does insist that they be placed under the Lacertilia.

In criticizing the first of these papers by Baur, Boulenger, the distinguished herpetologist, took the position, with Cope, that the Pythonomorpha constitute a distinct suborder of the Squamata, basing his views chiefly upon the limbs. He says: "Does this mean that limbs as strongly modified as those of the Monitors can have been modified into the paddles of the Mosasaurs? A glance at the figures suffices to refute such a theory." He defined the Pythonomorpha as having "nine or ten cervical vertebræ. Extremities paddle shaped, with hyperphalangy." In the three Kansas genera of the Mosasaurs described in the present work there are never more than seven cervical vertebræ. While hyperphalangy does occur among the Mosasaurs, there are some forms in which this is so in only a slight extent or not at all. In all the forms the "fifth metatarsal is reduced in length and strongly modified," another lacertilian character given by Boulenger.[47]

The latest definition of the Pythonomorpha given by Cope[48] is as follows:

Alisphenoid modified as epipterygoid or wanting, leaving brain-case open; parietals flat; an interclavicle and clavicle; teeth with dentinal roots, *Lacertilia.*

Epipterygoid present; parietals decurved, partially inclosing brain-case; no clavicle nor interclavicle; teeth with osseous roots...... *Pythonomorpha.*

No epipterygoid; brain-case inclosed in front; no clavicle nor interclavicle; no fore limbs; teeth rootless.................................... *Ophidia.*

Dollo has recently affirmed the presence of a distinct interclavicle in the Mosasaurs, first discovered by Marsh. I have never seen such a bone in the material that has been accessible to me.

Following the foregoing papers and discussions appeared a paper by Dollo,[49] in which he summed up his views as follows:

"En résumé, je suis donc d'accord avec M. Boulenger pour regarder les Mosasauriens comme un sous-ordre distinct des *Squamata.*

47. Boulenger, Notes on the Osteology of *Heloderma horridum* and *H. suspectum*, with Remarks on the Systematic Position of the Helodermatidæ and on the Vertebræ of the Lacertilia, Proc. Zool. Soc. Lond. 1891, pp. 109–118.

48. Syllabus of Lectures on Geology and Paleontology, pt. III, 45, 1891.

49. Bulletin Soc. Belg. de Geol., VI, 251, 1892.

"Je pense, comme lui, que les Lacertiliens *actuels* (même les *Varanidæ*) sont trop spécialisés pour representer la souche des Mosasauriens.

"Je crois, comme mon collegue du British Museum, que cette souche nous est fournie par les Dolichosauriens.

'Mais je ne puis admettre que ceux-ci soient les ancêtres des Lacertiliens, des Ophidiens, et des Rhiptoglosses."

Of course no one can for a moment suppose that the Mosasaurs have not descended from terrestrial fissiped reptiles. The great variations in the type of the limbs among the Mosasaurs do not permit such exact comparisons as M. Dollo makes.

The latest discussion on the affinities and systematic position of the Mosasauridæ will be found in the papers cited below[50] by Professors Cope and Baur, dealing especially with the elements supporting the quadrate. This controversy in brief was, on the part of Cope, that the paroccipital was a distinct element, and not fused with the exoccipital, which did not support the quadrate at all. Baur contended that the paroccipital was fused with the exoccipital, and that the separate element called the paroccipital by Cope is in reality the squamosal. Further, Baur contended that the exoccipital of Cope, his paroccipital, did not at all support the quadrate, in the Iguanidæ, while Cope asserted that such was always the case. It is true that in *Varanus* the exoccipital of Cope does, in a measure, support the quadrate to a greater degree than I have ever observed among the Moasaurs. It is also true that the exoccipital (Cope) does in many cases help form the quadrate articular surface in the Mosasaurs.

The more important cranial differences from *Varanus* are as follows: The premaxillary of *Varanus* is flattened, and the conjoined nasals are united by a distinct suture. There are eight premaxillary teeth. The nares are much larger, the prefrontals smaller, the palatines smaller, and its anterior process longer. The lachrymal bone is larger. There is a supraciliare present, wholly wanting in all Mosasaurs. The frontal bones are united

50. Cope, Amer. Nat., Sept. 1895; Nov. 1895, p. 1003; Febr. 1896, p. 147.
Baur, Amer. Nat., Nov. 1895, p. 998; Febr. 1896, p. 143; Apr. 1896, p. 327.

by suture. The jugal is incomplete. The transverse bone unites with the maxillary and jugal. The pterygoids are without teeth. The basipterygoid processes are longer and the pterygoids, hence, much more widely separated. The basioccipital processes are much smaller; the exoccipital elements larger. The quadrate is more slender and has no suprastapedial process. The splenial and presplenial interdigitate and do not unite by a distinct articulation, the presplenial extending much further proximally and articulating with the coronoid. The sides of the parietal bone are not decurved to form the sides of the brain case anteriorly. There is a frontal subrhinencephalic bridge.

COMPARATIVE ANATOMICAL DESCRIPTIONS.

The skull, in the Kansas forms of the Mosasaurs, is elongate, wedge-shaped, and flattened. The external nares are elongated slits, with an anterior dilatation, and separated from each other by the slender prolongation of the premaxillary and the co-ossified nasals, and, at the posterior narrowed extremity, by the anterior end of the frontals. Externally they are bounded by the prefrontals and maxillæ. The orbits are irregular in outline, broader from in front back than from above downward. Their plane is outward, with a superior and anterior obliquity. Their free margins are composed of the prefrontals, usually the frontals for a short distance, the postfronto-orbitals, the jugal, and the lachrymal. In *Clidastes*, and, in a less degree, in *Mosasaurus*, the upper part of the orbital cavity forms part of the superior plane of the skull, covered over, in life, by membrane, and supported by the projecting prefrontals, which here functionally replace the supraciliare of *Varanus*. The frontal bone is nearly plane and is unpaired, though there is an indication in all, but especially in *Tylosaurus*, of the original division into two bones, anteriorly. The supratemporal fossæ, directed upwards, are large, bounded externally by the postfronto-prosquamosal arch, posteriorly by the parieto-squamosal arch. A pineal foramen is always present, is usually large, and situated near the anterior end of the unpaired parietals. The jugal arch is complete in all the known forms, forming the posterior and inferior border of the orbit. Below, on the inner side, it is suturally attached to the transverse bone, which does not reach forward to the maxilla, or so only to a very slight extent. The parietal sends down on each side a flattened, wing-like process for union with the petrosals and supraoccipital, bounding the brain cavity externally in part.

The posterior aspect of the skull presents an elongated opening below the parietal arch, bounded below by the conjoined exoccipital and paroccipital and above by the parieto-squamosal arch. The teeth exist in a single row on the maxillæ, mandibles, and pterygoids, and in a double row of four on the conjoined premaxillary. The vomers are elongated bones of the palate attached anteriorly to the premaxillary and maxillary, posteriorly to the anterior elongation of the palatines. The crowns of the teeth are simple, conical, and recurved, sometimes nearly round in cross-section, at other times flattened oval with a posterior and anterior cutting carina, the surface elsewhere smooth, or narrowly faceted and striated. The crown is attached to a spheroidal mass of ostein, which is not, however, a true root, and which projects beyond the margin of the bones in which they are inserted in a cavity. This base is an ossification of the tissue surrounding the blood-vessels and nerves, and is frequently dislodged entire from the jaw. On the inner side posteriorly of this base there is usually a smaller excavation, in which the young tooth may be found. Rarely is a jaw seen in which all the teeth are complete. Some will be lost, showing only the empty cavity of the socket, while others will be found in different stages of growth. The crown is covered with enamel. The teeth of the pterygoids are smaller, sometimes much smaller, than those of the jaws, and are usually more curved.

The posterior flattened portion of the palatines articulate closely with the posterior end of the maxillæ on the outer side, the anterior thinned portion of the pterygoids on the inner, the vomers anteriorly, and the descending process of the prefrontal on the superior side posteriorly. Between the anterior process and the maxilla, on either side, there is a long, narrow vacuity, situated in part below the external nares. The palatines curve downwards to articulate with the pterygoids, so that the teeth of the latter are in a lower plane than those of the maxillæ.

The pterygoids are elongate, curved bones with four processes. The anterior, obliquely flattened process articulates with the inner side of the palatines and is separated narrowly from its mate at the extremity. The ectopterygoid process, thicker and stouter, is directed somewhat upwards, its rugose and dilated extremity attached to the transverse bone. The dentigerous portion is prolonged into a small, flattened process, which lies under the basipterygoid process of the basisphenoid, nearly in contact with that of the opposite side and close to the under surface of the basisphenoid. The long, flattened, involute posterior process is curved outward and downward to articulate with the inferior inner angle of the quadrate. Its roughened end fits closely to a corresponding surface on the quadrate, and, while the union may not be rigid, it cannot admit of much motion.

In the following detailed descriptions I have used for comparison skulls of *Clidastes velox, Platecarpus coryphæus, Mosasaurus horridus, Tylosaurus proriger*, and an incomplete one of *Brachysaurus overtoni* :

Premaxillo-nasals.

Clidastes velox. The premaxillary is characteristic of the genus. The anterior, expanded portion is about as long as wide, forming a broad, short cone, extending only a short distance in front of the teeth, with the apex rather sharp. The borders for articulation with the maxillæ pass inwards obliquely, the width of the superior surface between the maxillæ to the anterior end of the nares being nearly equal throughout, the sides almost parallel. The surface is lightly and delicately sculptured above, with an obtuse, low, median convexity. At the beginning of the nares, the superior surface rapidly narrows to form a vertical plate separating the openings. At the posterior extremity the conjoined nasals dilate to overlap the narrow anterior projection of the frontal. On the under side there are four teeth, the anterior pair smaller than the maxillary teeth and approximated. A median ridge separates the teeth, and is continued into a stronger one back of them. Between the two narial openings the inferior border is thin, and is wholly or largely hidden by the approximated vomers. The bone articulates with the maxillæ, vomers, and frontal.

Mosasaurus horridus. The tip of the rostrum is rather more obtuse than in the previous species, but not as much so as in the following, projecting a short distance beyond the teeth. The portion in front of the maxillæ is about as long as wide, nearly semicircular in cross-section, with a shallow longitudinal groove in the middle above, in place of the obtuse carina. This groove reaches to about the beginning of the nares. The lateral margins above are very long and oblique, resembling in this respect *Tylosaurus* more than *Clidastes.* The opening of the nares is opposite the fifth maxillary tooth.

Platecarpus coryphæus. Pl. xxvi, ff. 2, 3. The premaxillary is short and obtuse, differing markedly from the other genera in not projecting at all beyond the teeth, the tip often with a distinct depression, instead of a convexity or cone. It is smoothly convex above, without median ridge or convexity. The sutural union for the maxillæ runs nearly obliquely from the dental border back to the anterior end of the nares, very unlike what it is in *Clidastes.* The internarial process is narrow and oval in cross-section for a short distance before the middle of the nares. Posteriorly it widens uniformly into a thin, flattened plate, the conjoined nasals, which overlie the anterior prolongation of the frontal, the suture nearly opposite the posterior end of the nares. The nares are much shorter relatively than in *Clidastes.*

Tylosaurus. The premaxillo-nasal in *Tylosaurus* is one of the largest elements of the skull, and is very characteristic of the genus. It forms a long, obtuse projection in front of the teeth, the edentulous portion being considerably longer than the dentulous. It is smooth and rounded, nearly circular in cross-section in front of the teeth, the tip obtuse. The teeth are relatively smaller than in the other genera. Just back of the posterior pair the sutural border runs a short distance rectangularly upward. From this angle, the sides run obliquely backward to the anterior angle of the nares. The intermaxillary portion is very broad and long, more than twice as wide in front as behind. The surface above throughout is convex and smooth, without carina or depression. Posteriorly, to the anterior end of the nares, the internarial portion narrows rapidly, but is much thicker and stronger in the narrowest part than is the case in either of the other genera. The conjoined nasals broaden as in the other genera to overlap the anterior end of the frontal, but extend much further back, beyond the nares. The free internarial portion of the conjoined bone is only a trifle longer than the intermaxillary portion. On the under side the ridge separating the anterior teeth divides at their posterior part into two branches, between which are inserted the thin, vertical and contiguous anterior ends of the vomers. The thin plate or ridge continues on each side into a tongue-like process, vertically flattened and suturally united in a shallow groove on the outer side of each vomer as far back as the posterior part of the second tooth, articulating on the inner side of the maxilla at the base of the first tooth.

Vomers.

The vomers in *Mosasaurus* are very slender, and are in apposition throughout, or for the most part. Near the front end, the short, vertical, articular face unites with the maxilla opposite the second tooth. Just back of the articular surface there is a small elongate oval opening left on each side between the constricted vomer and the emargination of the horizontal plate of the maxilla. The vomers, as far back as the eighth or ninth teeth, are very narrow below, the surfaces somewhat obliquely placed. Posteriorly they seem to join by a long, squamous suture with the anterior prolongation of the palatines.

The vomers in *Clidastes* are evidently quite like what they are in *Mosasaurus*. They articulate with the premaxilla to a very slight extent only at the tip. The suture between them and the palatines is indistinguishable.

In *Platecarpus* the vomers resemble those in the two preceding genera. A view of the anterior outer side is shown in pl. xix, f. 4, giving the articulation with the maxilla. In none of the three genera is there any indication of the long, tongue-like process of the premaxillary, as described below, and no distinct surface for union with the premaxilla. The emargination back of the articular face is longer and deeper in the horizontal maxillary plate of this genus.

The vomer in *Tylosaurus* is very much elongated, as in *Mosasaurus*. Anteriorly it ends in a thin vertical plate lying contiguous with its mate and inserted between the two plates of the premaxilla on the under side, as described for that bone. On the outer side, as far back as the middle of the second maxillary tooth, it has a shallow longitudinal groove for articulation with the thin, vertical, tongue-like plate of the premaxilla. The articulation with the maxilla extends back of this as far as the middle of the fourth maxillary tooth, presenting an elongated sutural surface. Posterior to this articulation the bone is constricted as in the other genera to form the anterior palatine foramina, which lie below the anterior end of the nares, and thence gradually widens, standing nearly vertically. The union with the palatines is so close that it cannot be distinguished, the bones continuing in the same line and in apposition nearly as far back at the anterior end of the dilated portion of the palatines. In the posterior part the bones slope outward from the middle line, where they are in close contact, inclosing a long, slender, oval opening between them and the maxillæ, in large part below the external narial opening. Just back of the maxillary articulation the bones diverge a little for a short distance to show the inferior border of the premaxillary, and the under surface here shows an oblique groove running backwards and outwards, as though for the passage of a nerve or blood-vessel.

Maxillæ.

Clidastes velox. The maxillæ have fifteen or sixteen teeth, the last one in the latter case small. The inner side has a strong longitudinal ridge, emarginate anteriorly, for the anterior palatine foramen, with a groove or cavity above it, arched over by the flattened upper part of the bone. The borders for union with the premaxillæ, back of the vertical part, are nearly parallel to each other in the skull. The narial openings are elongated and narrow, the maxillary border thin, with a deep emargination in front. Posteriorly here is a small, flattened process overlapping the prefrontal on the upper surface of the skull. The posterior end terminates in a slender, pointed projection, partly covered over above by the jugal. On the outer side there are fifteen dental foramina above the teeth, and some smaller ones anteriorly. The bone articulates with the premaxilla, vomer (turbinate?), palatine, prefrontal, jugal, and lachrymal. The border for the palatine is thinned, beveled, and roughened, extending as far forward as the fourth tooth from the end. The border for the jugal is straight and thin, reaching as far forward as the antepenultimate tooth. Below this border on the inner side there is a narrow and deep excavation. The articular surface for the vomer is short and small, very near the anterior end of the bone, on the front extremity of the inner ridge and above the first two teeth. Just above this surface posteriorly there is a small, smooth depression.

The maxillæ of *Mosasaurus horridus* have fourteen teeth. The bone is narrower than in *Clidastes.* The beginning of the nares is opposite the sixth tooth. The nares are much elongate, reaching beyond the posterior end of the nasals.

Platecarpus. Pl. xxv, ff. 1, 2. The maxillæ are stouter and shorter than in *Clidastes.* The border for the articulation with the premaxillæ runs nearly straight and obliquely to an obtusely rounded point, which is separated by only a short space from the one of the opposite side, just before the beginning of the nares. The free border back of this is thickened, rounded, and deeply emarginate anteriorly. From the posterior end of this emargination the inner upper part of the bone overlies broadly the sides of the prefrontal. Posteriorly this border ends in a small, tongue-like projection on the prefrontal, outside of which the margin is continuous with the pointed posterior extremity of the bone. There are twelve teeth. The articular surface for the vomer is situated further back than in *Clidastes*, nearly over the third tooth, and the emargination for the palatine foramen is much larger, reaching to beyond the fourth tooth. The surface for union with the palatine is shorter.

Tylosaurus. The maxilla of *Tylosaurus* is intermediate in length and breadth between those of *Clidastes* and *Platecarpus*. The maxillary suture extends as far back as the sixth tooth, and is much longer than in either of the other genera. Back of this the emargination for the anterior part of the nares is less deep than in *Platecarpus*. The prefrontal process is rather larger than in *Platecarpus*, the posterior extremity more slender. The sutural surface for the vomer is situated further back than in *Platecarpus;* that for the palatine is nearly the same. There are thirteen teeth.

Brachysaurus overtoni. Pl. XXII, f. 1. The maxilla in *Brachysaurus* is very massive and stout. The border for the premaxilla is very short, extending back as far as the third tooth only, the vertical portion only a little shorter than the oblique portion. There are ten, probably eleven, teeth, implanted on prominent, broad bases.

Prefrontals.

Clidastes. The prefrontal is the most characteristic bone of the *Clidastes* skull, varying somewhat in the different species. It is elongate and flattened on the upper surface, with striations and markings like those of the frontal on whose plane the horizontal portion is. It projects strongly over the orbits in front, serving functionally in place of the supraciliare of the *Varanus* skull. The inner border is concave to correspond with the border of the frontal. The outer border is free, nearly straight, and lightly rugose for nearly half its length, protruding horizontally. On the inner side anteriorly the bone forms a short part of the free border of the nares, anterior to which the thin expansion is overlapped by a flattened process of the maxillary. The maxilla also overlaps the outer part of the bone on the anterior third. The horizontal part is considerably thickened posteriorly, with the under side of the hind border beveled and slightly concave. A broad, flattened process at the posterior interior part underlaps the frontal, being received in a pit or depression of that bone. A thick, curved, wing-like process is sent down on the outer side, curving inward to form the very convex anterior border of this orbit, and articulating below with the jugal, lachrymal, and, on the inferior surface, with the posterior end of the palatine. It articulates with the frontal on the inner side, the maxilla in front and on the side anteriorly, the lachrymal and jugal behind, and the palatines below.

Mosasaurus horridus. The prefrontal of *Mosasaurus* is quite as peculiar as that of *Clidastes.* The horizontal part, or wing, over the anterior part of the orbit, is semicircular in shape, with lightly crenulated edges. In front of this there is an emargination or groove with rounded border connecting the superior and lateral faces. This semicircular supraciliary plate served the same purpose as the posterior flattened part in the *Clidastes* bone. Were it removed the bone would not be unlike what it is in the two following genera. Between this supraciliary plate and the postfrontal there is a rather sharp triangular notch, evidently filled in with membrane in life. The bone touches the postfrontal behind.

Platecarpus. Pl. xxv, f. 3. The prefrontal, as seen in the articulated skull of *Platecarpus,* sends a long, slender process on the inner margin of the maxilla as far as the posterior end of the anterior emargination, its thin narial border being straight or gently concave. Posteriorly it has a thickened, irregular, very narrow horizontal projection along the frontal orbit, corresponding to the semicircular plate of *Mosasaurus* or the broad one of *Clidastes.* Behind this it reaches back nearly or quite as far as the postfrontal, though scarcely visible from above. Inferiorly it sends down a much smaller process for union with the palatines.

Tylosaurus. In *Tylosaurus* the superior surface of the prefrontal is elongate triangular in shape. The anterior end is overlapped broadly by the broad, tongue-like process of the maxillary, which may even reach to the frontal, wholly excluding the prefrontal from participation in the nares. Posteriorly it reaches, narrowly, quite to the anterior prolongation of the postfrontal. Outwardly it reaches downwardly, broadly, to the thin margin of the maxilla, leaving a triangular space posteriorly in which the lachrymal is articulated. In front of the orbit the nearly vertical surface turns inward, broadly, as in the preceding, to the margin of orbits. In the horizontal development of the posterior part of the prefrontal, the greatest is that of *Clidastes*, the least of *Tylosaurus*, with *Mosasaurus* and *Platecarpus* respectively intermediate.

Lachrymal.

The lachrymal bone is present in the different genera, but seems to differ slightly. It is least distorted in a specimen of *Clidastes*, where it is a small, somewhat irregular, pointed bone, with an articular surface along the sides, and at the larger extremity is grooved along one side ; it is smooth above, and is slightly roughened on the outer side. It is attached in the interval between the jugal and the prefrontal, and articulates in part with the maxilla. It enters into the lower part of the anterior border of the orbit.

Frontal.

The frontal bone in *Clidastes* is elongate and slender in comparison with that of the other genera. The lateral borders have a long and deep concavity from near the posterior angles of the bone to near the anterior third, whence the sides approach each other more rapidly, or wedge-like, to near the posterior ends of the narial openings. The posterior border is transverse, with an undulatory or zigzag outline, the middle not being appreciably emarginated for the parietal bone. The upper surface is flattened, gently convex in the middle, and with a low, rather obtuse median carina on the anterior third. The free orbital border is short, obtusely edged, and forms a part of the lateral concavity of the bone. On the under side there are two prominent ridges, bounding the cavity for the olfactory lobes. On the anterior part this cavity is separated into two by a median ridge; nearly opposite the posterior extremity of the maxilla the ridges bounding the cavity approach each other, the excavation continuing as a narrow, deep groove to about opposite the middle of the orbital margin. At the outer side of these ridges the bone is excavated for the sutural union of the prefrontals. At the beginning of the narial opening the bone rapidly narrows and is thinned for union with the nasal. In this part the bone is imperfectly united in the middle. The nasals reach no further than the posterior end of the narial openings. The bone articulates with the parietal, postorbital, prefrontal, and nasal.

Mosasaurus horridus. The frontal bone in *Mosasaurus* is much broader than in *Clidastes.* Posteriorly it has two slender processes inclosing the narrow anterior projection of the parietal, in which is the pineal foramen. The sides are nearly straight, and gently convergent to a strong and sharp emargination for the prefrontal anteriorly. Its connection with the nasal cannot be made out with certainty, but it is evidently not posterior to the narial openings. The bone is nearly plane, sloping gently, and with a low, obtuse carina in the middle anteriorly.

Platecarpus. Pl. XVI, ff. 2, 3. The frontal bone is broader than in *Clidastes.* Posteriorly it is broadly and deeply emarginate for the parietal, outside of which the margins are nearly straight to the angles. From near the angles the lateral margins are concave for nearly half their distance to the nares, somewhat thickened on the orbit, which is thickened for a short distance, as seen from above. Beyond, the sides are irregular and gently convex to unite with the prefrontals. From a little back of the middle of the bone there is a thin, sharp, median carina, highest in its middle portion; on either side of the carina the bone is shallowly concave. On either side in front there is a small, tooth-like process underlying the posterior process of the maxilla, the notch between it and the inner border forming the posterior angle of the nares. This process is wholly wanting in *Clidastes.* On the under side the prefrontals are more widely separated and the olfactory groove more gradually widened. The bone is considerably wider at posterior end.

Brachysaurus overtoni. The frontal bone in this species is remarkably broad and stout.

Tylosaurus proriger. In *Tylosaurus*, the frontal is broader relatively than in *Platecarpus;* the sides above the orbits are nearly straight and parallel, and wholly excluded from the orbits. From the posterior third the sides gradually converge in nearly a straight line to the tooth-like process at the posterior end of the nares. In front of the middle the bone is convex in the middle part but is not carinate. Anteriorly the two halves of the bone are unossified, the division represented by a median groove above. Posteriorly the deep median emargination for the parietal is wanting. In shape the bone is more nearly triangular than in the preceding species. On the under side the prefrontals are more narrowly separated than in *Platecarpus.*

Postfronto-orbitals.

Clidastes. The postfrontal and orbital are closely united, without trace of suture. It extends along the outer border of the frontal for a short distance, its outer border curving outward and downward to the jugal process. The stout, thickened process for lateral union with the parietal extends only a little inwards, forming the outer anterior angle of the supratemporal fossa. The jugal process is broad and flat and is directed nearly downwards. Back of the process the bone narrows to a flattened oval shape in cross-section, the under side of which is inserted into a groove in the prosquamosal. The bone extends nearly to the articular surface for the quadrate. The broad squamosal plate underlies the frontal, articulating for nearly a third of its width. It articulates with the squamosal (sometimes), the prosquamosal, parietal, jugal, and frontal.

Mosasaurus. The postorbito-frontals in *Mosasaurus horridus* extend forwards to touch the posterior end of the prefrontal, leaving a triangular notch in the roof of the orbit. The posterior process is wedge-shaped, and, posteriorly, instead of being inserted in a groove in the squamosal, it divides that bone in two, one part of which lies on the inner and the other on the outer side below.

Platecarpus. Pl. xxiv, f. 4. In this genus the postfrontal touches, or nearly touches, the prefrontal, instead of being separated by a considerable space as in *Clidastes.* The jugal process is longer and flatter. The posterior projection, lodged in a groove on the upper part of the prosquamosal, extends back to beyond the anterior end of the articulation for the quadrate. The bone does not articulate with the squamosal at all, and the prosquamosal reaches as far forward as the descending process for the jugal.

Tylosaurus. In *Tylosaurus* these elements are nearly as in *Platecarpus,* except that the bone extends forward, quite to the prefrontal, forming a very narrow margin to the orbit posteriorly. The jugal process is rather shorter, and the articular surface for the prosquamosal reaches quite to that for the jugal, the two bones touching each other, which does not occur in *Clidastes.* The bone underlaps the frontal broadly, forming a subtriangular surface.

Jugal.

Clidastes. The jugal is a slender, curved rod, with an articular surface at either extremity. It is nearly circular in cross-section posteriorly and flattened anteriorly. The curvature begins near the middle, and is nearly regular. The anterior half is only slightly concave on the upper border. The excavation for the maxilla is on the inferior inner side, and reaches nearly a third of the length of the bone. At the anterior dilated extremity the bone articulates with the lachrymal above. The posterior extremity is somewhat thickened, though not much dilated, and unites with the short jugal process of the postfrontal. The bone has no tubercular process on the posterior border, as is found in the following forms. There is usually a small articular surface situated far back on the inner side, at the margin of the greater concavity, for union with the ectopterygoid.

Platecarpus. Pl. XXIV, f. 5; pl. LXIII, f. 3. In this species the jugal is a stouter bone than in *Clidastes*, but not as stout as in *Tylosaurus.* It is somewhat L-shaped in form, with the horizontal arm slender and curved downward. The upright arm is flattened obliquely, and deeply excavated above on the outside for the jugal process of the postfrontal, the excavation reaching more than half the distance to the angle of the bone. Its posterior superior angle is thickened, and unites with the prosquamosal. Where the bone begins to curve forward there is a prominent tubercle on the outer hind margin, as if for ligamentous attachment, and the bone is channeled obliquely inward in front of it. The anterior branch is dilated and flattened at the extremity, and excavated into a groove on the under side for articulation with the posterior end of the maxilla. At the posterior end of the horizontal arm in front of the angle, on the inner side, there is a depressed sutural surface, of variable length, for union with the ectopterygoid.

Tylosaurus. In *Tylosaurus* the jugal is a stouter bone than in either of the other genera. It is bent more nearly in a right angle than in *Platecarpus*, and the anterior prolongation is less slender, the end less dilated. The upper ramus is broader and flatter, and less deeply excavated for the jugal process of the postfrontal. The angle below is broadly rounded, the margin is thinner, and not produced into a tubercular process; instead of which, there is, on the outer side, a roughened depression of considerable size for the insertion of a strong ligament or tendon. The vertical arm is set more obliquely and the surface is concave transversely. On the inner border there is a roughened, elongate spot for the transverse bone. The horizontal arm is flattened and much stouter than in *Platecarpus.* The beveled and grooved articular surface for the maxilla is on the inferior inner side, and extends far back. The bone runs to a narrow extremity anteriorly, different from the expanded and flattened extremity in *Platecarpus*. Altogether, the jugal, as already stated, is a stronger element, with stronger muscular attachments, than in either of the other genera. Judging from the differences which these three forms present, it is not at all unlikely that in some forms of the group the jugal may exist in a rudimentary condition, as in *Varanus*.

Pterygoid.

Clidastes. The pterygoid is an elongate bone, with four, more or less elongated, processes. The posterior process is broad, flattened, and nearly vertical, with a short, emarginate articular surface at the extremity, for union with the inferior, anterior inner part of the quadrate. Its under border is markedly convex distally, the upper border thicker and concave. From the base of this process the ectopterygoid process is directed outward and upward, its posterior border continuous with the superior border of the quadrate process. The process is flattened, oval in the middle, and somewhat dilated at the extremity for union with the ectopterygoid ; it is placed obliquely, so that the anterior superior border is continuous with the upper inner border of the body of the bone. Directed nearly backward and a little outward is a short, pointed process, which I will call the basisphenoid process, inclosing between it and the quadratal process a deep notch for the articulation of the basipterygoid process of the basisphenoid. On the upper side, at the anterior extremity of this notch, there is a small pit for the inserting of the lower end of the epipterygoid. The anterior process is thin and flattened and unites with the posterior inner angles of the palatines, the free margin continuing on the inner side to a point which is less broadly separated from that of the opposite side than the bones are posteriorly. The teeth are twelve in number — greater than in any other genus of the group.[51] The anterior ones are larger than the posterior, and they are all rather closely crowded together. They are moderately flattened, with a distinct carina. They are bordered internally by

51. Merriam gives the number at twelve to fifteen, but I have never seen more than twelve.

a more or less sharp ridge, but they are never pleurodont or protected by a parapet, a character that has been given for distinguishing the genus *Edestosaurus* from *Clidastes*, but which is of no value whatever.

Mosasaurus horridus. The pterygoids in the type specimen of this species are in position and undistorted, while those of *Clidastes* are invariably more or less distorted. They are evidently very closely alike, and present characters that readily distinguish the bone from the same in the other subfamilies. The anterior end terminates in a broad plate on the inner side, which slopes markedly toward the middle. There are eight teeth in a single curve, whose concave side is internal and reaching from before the posterior end of the palatine, and opposite the last maxillary tooth, to the base of the basisphenoid process. The teeth back of the palatine stand very nearly on the outer edge of the bone on a convex surface, and are not all pleurodont. The basisphenoid process is longer than in *Clidastes*. The ectopterygoid process is placed like that of *Clidastes*; that is, obliquely. Its posterior border is continuous with the inferior border of the quadrate process, while the anterior is continuous with the superior interior border of the body of the bone, inclosing a long, shallow groove between its base and the part on which the teeth are inserted. In *Platecarpus* and *Tylosaurus* the process is nearly horizontal, and its anterior border is continuous with the outer border of the bone, or nearly so. The bone differs from that of *Clidastes*, in the lesser number of teeth (eight) and in the less expanded inner side anteriorly.

Platecarpus. Pl. XXIV, f. 1. The pterygoid of *Platecarpus* has ten teeth arranged in the form of a reverse curve. The teeth extend into the base of the basisphenoid process, which lies closely in the depression on each side of the lower surface of the basisphenoid. The quadrate process is nearly vertically flattened or gently concave on the inner side, narrower and stouter at the base, obliquely truncate and roughened at the tip for union with the quadrate. The under border of the dilated portion is strongly convex. Nearly opposite the base of the ectopterygoid process on the upper side in front of the notch between the quadratal and basisphenoid process there is a rounded pit for the epipterygoid. The ectopterygoid process is much dilated obliquely at its extremity, sometimes dilated near its base in front so as to constrict the inclosed notch. The palatine process is flattened, ending in a narrower extremity. The teeth begin posterior to the end of the palatine. The teeth are small, much curved, somewhat flattened and striate.

Tylosaurus. In *Tylosaurus* the pterygoid resembles that of *Platecarpus.* The anterior dentigerous portion is stouter and less flattened, the part in front of the teeth for union with the palatines thinner and less broad. The teeth begin further forward, as in *Clidastes*, and not back of the palatines. The ectopterygoid processes are relatively stouter and less contracted at the base. The basisphenoid process is broader and shorter, and the teeth do not extend as far as its base, while in *Platecarpus* they reach two-thirds of the distance to its tip. The quadratal process is less expanded distally, and is relatively shorter than in *Platecarpus.* The bone altogether is less slender. There are ten teeth.

Parietal.

Clidastes. The coossified parietals have a broad, anterior, transverse border, concave sides, limited by sharp margins, the parietal crests, and long, thin, flattened parieto-squamosal processes, reaching outward and backward from the posterior angle to the outer part of the suspensorium. Posteriorly, on either side, the upper surface is continued into a pointed projection, which forms the upper margin of the base of the parieto-squamosal process. The margin in the middle behind is thinned, rugose, beveled, and with a notch in the middle. Anteriorly the stouter lateral processes or wings pass outward to form the anterior lateral border of the supratemporal fossæ, connecting with the postfrontals. They are convex from above downwards, and limited on the inner part by a sharp overhanging ridge, the beginning of the parietal crests. The pineal foramen is small, and situated a short distance back of the front margin of the bone. On either side, the bone sends down a broad, deep wing to form the upper part of the sides of the brain-case. At the most inferior part the border is projected into a thin, triangular process, the tip of which shows sutural roughening; their posterior margins are thin, with an S-shaped undulation. From the sides this thin margin shows an obtuse angle near the middle, the upper part for union with the supraoccipital, the lower for the petrosals, or rather for the cartilage that completes the union between these two bones. The thin margin superiorly, is inserted in the groove of the supraoccipital, as described below. Between the upper extremities of these thin margins the under surface of the bone is more or less roughened, or with spinous sutural projections for attachment to the crest of the supraoccipital. The posterior processes are thin, flattened, and arch outwards, backwards and downwards to unite with the long process of the squamosal by a long suture on the under side. The superior surface between the crests has nearly parallel sides. The bone articulates with the frontal, postfrontal, petrosal, squamosal, and supraoccipital.

Mosasaurus. The superior surface of the parietal continues back more narrowly than in *Clidastes*, with a divaricated process on either side of the posterior notch.

Platecarpus. Pl. XXVI, f. 1; pl. LXIII, f. 1. The parietal fits into a broad emargination of the frontal. From the posterior angles of this emargination, the sharp borders of the superior surface, or the parietal crests, run nearly straight to an apex a little beyond the middle of the bone, a character peculiar to the genus. The moderately large parietal foramen is situated a little back of the line of the suture, and usually wholly within the parietal bone. The lateral processes, forming the anterior boundary of the supratemporal fossa, reach out transversely to unite with the postfrontal a little within the angles of the frontal bone. The bone is narrowest opposite the apex of the superior surface.

Tylosaurus. The parietal in *Tylosaurus* is characteristic. Its upper flat surface has its sharp, lateral crests convergent to beyond the middle, and then parallel or gently divergent, the posterior end terminating to divergent points, as in *Clidastes*. The anterior lateral wings do not extend as far outward, and the lateral margins, especially toward the front, are thinner and more projecting than in either of the other forms. The pineal foramen is rather small, and is usually wholly inclosed in the parietal, though it may border the anterior suture.

Supraoccipital.

Platecarpus. The supraoccipital is a little longer than wide, with a ridge upon the upper surface, terminating in a sutural surface for union with a median tooth or tongue-like projection of the parietal bone. In the region of the semicircular canals the brain cavity is narrowed by a swollen projection on either side, into which is continued, from the exoccipital, a small, round canal. Anteriorly the sutural surface for union with the petrosal continues as a straight, flat surface, inclosing, between the two, a broad cavity for the cerebrum. The upper border, meeting at an angle a little greater than a right angle with that of the petrosal, is a little shorter, and has a deep longitudinal groove, with the margins thin; the thin posterior margins of the descending wings of the parietal fit into these grooves. The bone articulates with the exoccipital, petrosal, and parietal, with the latter directly, in the middle, by the intervention of connective tissue on the descending part. It forms the superior margin of the foramen magnum, and extends outward, as a broad, flattened squama, for about an inch on the upper side of the base of the exoccipital.

Basisphenoid.

Clidastes. The basisphenoid, longer than broad, as seen from below, has the margins deeply concave, the ends nearly transverse. In front are three processes, the middle small and short, ending abruptly and transversely; two lateral ones truncate, flattened oval, and obliquely placed to the long axis of the bone. The former is the presphenoid, and has near its base on either side above a small, rounded surface, for cartilage, precisely as in *Varanus*. I have never seen the presphenoid bone in this genus, but in *Platecarpus* one similar to that of *Varanus* is sometimes found, and in all probability it occurs in *Clidastes.* The lateral processes, the basipterygoid, are much shorter than in *Varanus,* and evidently are completed by cartilage, as they do not extend to the bottom of the notch for their reception in the pterygoids in the articulated skull. The posterior, basioccipital processes are squamous, underlying and closely united with the hypapophyses of the basioccipital, reaching nearly to their extremity. From above, the narrow, concave brain cavity is seen lying between the oblique, broad, sutural surfaces for the petrosal. On either side, under these overhanging sutural projections, there is a deep longitudinal groove, at the bottom of which, in front and behind, is the opening to the longitudinal canal. From the anterior opening of the canal a groove is continued anteriorly to near the tip of the presphenoid process. In front of the pituitary fossa the cerebral surface is narrowed to a slender groove, continued to the tip of the presphenoid process. The bone articulates posteriorly with the basioccipital, superiorly with the petrosals, and anteriorly with the pterygoids, the latter of course non-sutural in character.

Basioccipital.

Clidastes velox. The occipital condyle is moderately separated from the basioccipital processes by a distinct neck, and is chiefly formed by this bone. The neural surface is narrow, of moderate depth, with a depression near the middle, the "fossa mediana." The hypapophysial processes are stout, trihedral, directed downward and outward, and are overlapped on their whole anterior surface by the thinned posterior process of the basisphenoid. There is no median canal in any specimens of this or the other genera in the University collection. The bone articulates above with the exoccipitals, which extend downward on the outer side nearly to the extremity of the basal processes. In front the bone articulates with the basisphenoid, the anterior broadly rounded border of the inferior processes fitting into a depression on the posterior part of the basisphenoid. On the upper anterior angles there is a small surface for articulation with the petrosals.

In *Platecarpus* the exoccipital reaches to the margin of the cartilaginous surface of the basioccipital processes on the outer side anteriorly, and is broader here than in *Clidastes.*

In *Tylosaurus* the exoccipital reaches only a short distance downward on the sides of the hypapophyses, while the basisphenoid extends much further back on the inner side. The cartilaginous surface at the extremity of the hypapophysial processes seems to be more elongated.

Exoccipital.

Exoccipital and *paroccipital* of Baur; *exoccipital* of Cope. There has been not a little controversy over this element, or the distal part of it, by Professors Baur and Cope, which the reader may follow, if he chooses, in the references given below.[52] Baur holds that the bone called exoccipital by Cope, and which never shows a trace of division in this group, is in reality composed of the conjoined exoccipital and paroccipital. To avoid confusion, it will be desirable to give here the different names by which the elements of the cranial bar have been called by different authors in the Lacertilia:

Paroccipital. Baur.
  Exoccipital, Cope.

Squamosal. Gegenbaur, Baur (1892), Merriam.
  Mastoid, Cuvier, Owen.
  Supratemporal, Parker, Baur (1887).
  Opisthotic, Cope (1871).,
  Paroccipital, Cope (1892).

Prosquamosal. Baur.
  Quadratojugal, Gegenbaur, Baur (1889, 1892), Merriam.
  Squamosal, Owen, Huxley, Parker, Cope (1871), Baur (1887).
  Supratemporal, Cope (1892).

The element under discussion, whatever be its composition, is usually closely united with the petrosal (prootic), the two rarely being found disassociated. The stout suspensorium, composed of these two bones and the squamosal, is directed outwards, somewhat upwards, and backwards, articulating with the squamosal and quadrate. The line of union between the

52. Baur, Amer. Nat., 1896, pp. 143, 327; Anat. Anzeiger, x, 327. Cope, Amer. Nat., 1895, pp. 855, 1003; 1896, p. 147.

exoccipital and petrosal begins at the angle of the basioccipital bone, curves backward through the meatus auditorius, and thence toward the posterior margin of the distal extremity, lying on the front margin of the stapedial groove for nearly its whole length. The upper surface of the suspensorium is composed chiefly of the exoccipital. The bone unites broadly with the squamosal at its anterior surface side distally and sometimes helps form a part of the quadrate articular surface. As regards the relation which the exoccipital or paroccipital bears to the quadrate, Baur says: "The Mosasauridæ agree with the Iguana, etc., in not having any part of the articular face for the quadrate on the paroccipital"; Cope, that "the articulation of the quadrate in the Pythonomorpha is exclusively with the paroccipital [*i. e.*, squamosal] and the squamosal [prosquamosal]." The fact is, that in some Mosasaurs both the paroccipital and squamosal of Baur, or the exoccipital and paroccipital of Cope, articulate with the quadrate, though the articular surface for the former is always less extensive than that for the latter.[53]

In *Platecarpus*, at least, there is an elongate, conical or pyramidal process intercalated between the exo-paroccipital and the petrosal, reaching nearly to the brain cavity. In nearly all of the rare cases in which the squamosal is separated from the suspensorium, this process is broken off from the body of the bone at the extremity of the petrosal, the strongly roughened surfaces appearing as though the bone terminated there, which is not the case. The elongated portion that is thus intercalated between the two bones is entirely excluded from the exterior, received in a depression on the anterior superior face of the exoccipital and completely overlapped by the petrosal. Internally, above, the suture of the supraoccipital extends outward in a thin, rounded plate, as far as the lateral margins of the condyle. The process extending downwards on the sides of the basioccipital hypapophyses is broad and long, reaching as far as the margin of the distal surface. Above, the short sutural surface for the petrosal, between that for the supraoccipital

53. This fact is also stated by Baur: "The lower and distal part of the paroccipital process joins the quadrate." Journ. Morph., VII, 12, 1892.

and the basioccipital, is largely excavated for the semicircular canals. The sutural surface for the petrosal extends narrowly along the upper side of the squamosal, and more narrowly below it, thus inclosing in a long, conical cavity the inner process of the squamosal.

Are not these relations of the *squamosal*, wedged in between the petrosal and the exo-paroccipital, anomalous among reptilia?

Petrosal *(prootic).*

Platecarpus. The petrosal unites by a short, flattened, sutural surface with the exterior part of the basioccipital and by a longer, similar one, with the basisphenoid. The thickened anterior margin is emarginate near its middle for the trigeminal nerve, a protuberance superiorly sometimes partly inclosing the notch into a foramen. Just back of this emargination, on the inner side, is the opening for a small foramen. On the outer side, near the posterior margin, there is an elongated slit covered by a thin scale of bone, having a small foramen at its bottom The surface for union with the parietal is shorter than that for the supraoccipital, which it meets in nearly a right angle. The groove for the stapes is dilated somewhat beyond the foramen leading into the semicircular canals. These openings are chiefly excavated from the petrosals, with a smaller excavation upward into the supraoccipital and another into the exoccipital. The sutural surface for the parietal is flatly truncated, and was evidently covered with cartilage for union with the thin, decurved margin of the descending wing of the parietal. The anterior part of this surface, continuous with the anterior border as far as the trigeminal notch, is markedly roughened for ligamentous attachments. The petrosal in general is triradiate in form, of which the stouter branch is for articulation with the basioccipital and basisphenoid, the longest for union with the exoccipital, covering the process of the squamosal, as described in that bone. The smallest process is for the union with the supraoccipital and parietal. The external branch is flattened distally, lying upon and in front of the exoccipital and reaching nearly to its distal extremity. Rarely is the bone found separated from the exoccipital. The bone articulates with the parietal, supraoccipital, exoccipital, basioccipital, basisphenoid, and squamosal.

Squamosal.

Clidastes. The squamosal is a small bone, firmly wedged in between the prosquamosal and paroccipital, as also the petrosal. It articulates broadly on the outer side with the prosquamosal, sending a more or less elongated process along the upper inner side of that bone, which may touch the posterior end of the postfrontal. A long, thinned and curved process is directed upwardly and inwardly to unite with the distal extremity of the parietal process, completing the parieto-squamosal arch. Internally it is broadly and firmly united with the exoccipital of Cope, the paroccipital of Baur, extending inward on the anterior face. In none of the specimens in the museum is the petrosal separated from the exoccipital, so that it cannot be said with certainty that the relations of the parts in this genus are like those of *Platecarpus*, but such is doubtless the case. Below, it forms the middle, antero-posterior, elongated portion of the quadrate articular surface, which is completed on the outer side by the prosquamosal, and, to a very slight extent, in some cases at least, by the paroccipital. The bone articulates with the paroccipital, petrosal, parietal, prosquamosal, and, in some cases to a limited extent, with the postfrontal.

In *Platecarpus* the squamosal closely resembles that of *Clidastes.* The internal process on the paroccipital extends very nearly to the semicircular canals, forming a long, slender, pyramidal process firmly wedged in between the exoparoccipital and the petrosal, and completely excluded by them from the external surface. The parietal branch is rather longer, and there is no process extending on the prosquamosal.

In *Tylosaurus* the internal process is probably like what it is in *Platecarpus*, but this cannot be determined. There is sometimes a slender process on the prosquamosal, as in *Clidastes*, though never reaching the postfrontal.

Prosquamosal *(quadratojugal, squamosal).*

Clidastes. The prosquamosal is an elongate bone, dilated posteriorly. The posterior end is turned downward, with an excavation on the lower side for the outer part of the articulation for the quadrate bone. On the inner side distally it articulates with the squamosal, the anterior process of which extends forward as described below. The anterior end forms the inner and upper part of the arch, extending nearly to the anterior end of the arch, but not reaching the jugal. It is deeply grooved on the outer superior side for the postfrontal, which extends to a point nearly as far back as the surface of the quadrate. It articulates with the quadrate, squamosal, and postorbital.

Platecarpus. Pl. xxvi, f. 4. The prosquamosal differs from that of *Clidastes* in its relations to the squamosal. In *Clidastes* the upper border of the posterior end is convex and scarcely elevated above the body of the bone, or, if so, only slightly. In *Platecarpus* there is a flat process on the upper part, uniting with the squamosal, which does not send a process forward. The bone anteriorly reaches as far forward as the jugal process of the postorbital, and touches the jugal.

Tylosaurus. The prosquamosal in this genus articulates with the jugal, as in *Platecarpus.* It differs from *Platecarpus* in the more rounded, wing-like process on the upper side distally, which is pointed in the former and scarcely at all projecting in *Clidastes.* The bone, also, is more curved downward at the posterior end in this genus.

Ectopterygoid (or *transverse bone).*

The ectopterygoid has never been found in *Clidastes,* and in all probability it is very incompletely ossified in this genus, since the slender jugal shows only a small articular surface for it, or none at all.

In *Platecarpus* (pl. xxv, ff. 4, 5) the bone varies considerably in shape in different individuals, the jugal branch being longer or shorter. It is somewhat L-shaped, with the shorter branch broad, and with an oblique sutural surface on the under side for union with the expanded end of the ectopterygoid process of the pterygoid. The anterior branch is slender and more or less pointed. Its outer surface is flattened and roughened for sutural union with the jugal. It does not reach to the maxilla.

In *Tylosaurus* the bone differs only in being a little more slender; the pterygoid end less broad. It articulates with the jugal in same way as in *Platecarpus*, not reaching the maxilla.

Quadrate.

Clidastes. Pl. XXIV, f. 7. From below, the articulation of the quadrate is a little longer from side to side than antero-posteriorly. In the former direction it is somewhat concave, with a median convexity. From without, the rim of the ear cavity forms a nearly complete circle, the diameter a little greater from above downward, and extending to the tip of the suprastapedial process. Its lower margin terminates in a small, roughened process, nearly opposite the tip of the suprastapedial process, but external to it, and the articular surface of the lower end of the bone is beveled so that its upper margin nearly coincides with the lower border of the ear cavity. At the upper extremity the articular surface is convex in both directions, more strongly so antero-posteriorly. Anteriorly the articular surface divides into two processes, of which that on the upper border of the ala, the alar process, is the longer and narrower. Back of the junction, the sides of the surface are nearly parallel to opposite the top of the auditory notch, where it is narrowed at the expense of the outer side, which is depressed and roughened. The suprastapedial process is directed downward and somewhat inward, reaching a little below the middle of the bone. On the inner side the suprastapedial process is excavated above, and toward the tip there is a smooth, oval, articular surface looking inward. The inner border is nearly straight from above downward, with a raised, narrow ridge beginning below the meatal pit and continuing nearly to the inferior extremity. In front and slightly below the pit there is a distinct roughening on the convex border. The roughened projection on the posterior side below is confined to the outer side at the extremity of the alar ridge, the surface at its inner side being smoothly convex. The superior surface has the internal process much elongated and narrow, the cavity between it and the alar process deep.

There are two, perhaps more, distinct types of quadrates in the genus *Clidastes*, corresponding to the emarginate and non-emarginate coracoid. To the first type belongs *C. velox*, and *C. pumilus*, if it be distinct; while in the second are included *C. tortor*, *C. propython*, *C. dispar*, *C. westii*, and probably all the others now known. All of these last-mentioned species have quadrates so nearly alike that they do not offer trustworthy specific differences. Differences there are among them, but it is yet to be determined whether any of them are of more than individual importance. The accidental distortions to which the Kansas specimens are liable render it hard to determine which are adventitious and which are structural. The quadrate of *C. tortor* differs from that of *C. velox* as follows: The internal border between the superior and inferior angles is deeply concave, instead of being nearly straight. The border is smooth and rounded in the concavity, and is more or less sinuous. In *C. velox*, it is nearly straight, and has a distinct rugosity just in front of the meatal pit, and a distinct ridge below it, both of which are wanting in *C. tortor*. The articular surface of the suprastapedial process is more narrowed on the upper part, the lower end more dilated. Below the end of the process, near the inner side, there is a more or less strong tubercular rugosity, wanting in *C. velox*, where the rugosity is toward the posterior side, and is represented by a strong rugose ridge in *C. tortor*, extending from the tubercular rugosity obliquely to the outer inferior angle. The posterior surface is nearly plane from side to side, and convex from above downward to near the lower part. In *C. velox* there is a deep and broad channel, and the surface is strongly concave from side to side as well as longitudinally. The ala is somewhat less dilated and more elongated vertically. The upper articular surface is much more deeply concave between the anterior and alar processes in *C. velox*, while the inner border at the base of the suprastapedial process is much more concave in *C. tortor*. The inferior surface appears to be broader from side to side in *C. tortor*.

Quadrate No. 1119 (pl. LXIV, f. 4) is in a measure intermediate between that of *C. tortor* and *C. velox*. The internal posterior rugosity is smaller, the anterior border above more concave, and the anterior surface somewhat channeled. The quadrate of *C. westii* closely resembles that of *C. tortor*.

The quadrate of *Mosasaurus horridus* agrees best with that of *C. tortor*, though very different. The interior border from above downward is slightly convex in the middle, projecting beyond the plane of the ends, instead of being concave. The infrastapedial rugosity is very much larger than in *C. tortor*, and situated higher up. Between it and the anterior border there is a strong channel, terminating near the thin inferior border of the stapedial pit. The ridge limiting the inferior border of the ear cavity posteriorly is sharper, though less prominent. The suprastapedial process is much shorter, terminating almost exactly opposite the middle of the bone. It is much broadened below from side to side. The superior inner process of the articular surface is very short and obtuse, with only a short concavity between it and the alar process. The anterior surface is nearly straight from side to side in the middle and only moderately convex longitudinally. The stapedial pit is of large size, oval and vertial, its upper end reaching only a little above the upper end of the meatal notch. The inferior articular surface is much elongated from side to side and only a little broader on the outer part. In *Clidastes* its breadth is much greater on the outer part.

The quadrate of *Brachysaurus* (pl. XLVI, f. 2) is, in several respects, very remarkable. Its inner side from above downward is very deeply concave, the border sinuous. The border to above the middle is thin and sharp, the face including a deep channel that terminates on the anterior side of the meatus. On the upper part, as the deep channel turns backward to the opening, the border is broader, but limited posteriorly by a rather sharp edge that runs to the inferior part of the stapedial pit. The stapedial pit is situated very high up, almost wholly above the meatus, and is more rounded. Its lower border behind is low and thin, and forms at the same time the upper margin of the meatal orifice. The suprastapedial process is very stout and broad, descending a little below the middle, and broadly and firmly coossified below with the very large and stout process. Its inner side is excavated and roughened, with a sharp, thin ridge separating it from the meatus. The posterior surface is moderately channeled from side to side in the middle, more deeply so above. The ala seems to have been only moderately broad. Externally the ear cavity is very deep and small, ending in the very large opening inclosed by the suprastapedial process and the tubercle below. The vertical diameter of the rim is only a little greater than the transverse one, and is distinctly less than half the height of the bone, the floor being more nearly horizontal, and not extending nearly so far toward the inferior angle as in all the other quadrates described in the present work. The superior articular surface has a broad and prominent anterior process, with a long concavity between it and the alar process, and a broad upper surface of the suprastapedial process, which, however, is placed for the most part very obliquely. The outer side, below the ear cavity, is very broad and rugose. The lower articular surface is elongated from side to side, and moderately dilated externally.

Platecarpus. Pls. LX, LXI. The quadrate of *Platecarpus* differs very markedly from that of *Clidastes* in the greatly elongated suprastapedial process. On the inner side, the large, oval, stapedial pit is situated higher up. It is larger and more oval, situated nearly as in *Brachysaurus;* that is, with its long axis very oblique, its thin posterior border forming the upper margin of the meatal opening. The prominent internal border is formed of a broadly rounded ridge, slightly convex longitudinally, ending below in the flattened inner surface of the articulation for the pterygoid. Between this ridge and the inferior rugosity there is a shallow pit or channel, very much as in *Mosasaurus*. The internal angle above is much less prominent than in *Clidastes.* The inferior anterior angle is acute and the border for a short distance is thin and sharp. The anterior surface is only moderately convex longitudinally, but has a distinct channel, concave from side to side. The alar process of the upper articular surface is not as long or slender as in *Clidastes;* that for the suprastapedial process broad and not constricted. This process is long, reaching much below the middle of the bone, and arches far backward. It is stout, only a little expanded distally, and incloses a large, broad notch between it and the body. Its inner side above is beveled or excavated much as in *Brachysaurus,* leaving a free rounded border next the opening. About midway in the process there is a rather large, rounded, smooth articular surface on the inner side, posteriorly. The ala is very large, broad, and thin. Its border is continuous from the end of the suprastapedial process to the rugosity below the process, and is everywhere thin and prominent, and nearly all on one plane. At the lower part, there is a much deeper concavity than in the other forms, behind and above the very prominent ridge or plate that continues the border to the rugosity. This rugosity is in the shape of a small tubercle. The inferior articular surface is small — very small in proportion to the size of the bone — and has a prominent articular projection in the middle in front. The bone is very large in proportion to the size of the skull, as compared with that of the other genera.

Tylosaurus. Pls. LX, LXI. As is the case with *Clidastes* and *Platecarpus,* the quadrate of *Tylosaurus* is very characteristic of the genus, resembling, however, that of *Clidastes* more than that of *Platecarpus.* Anteriorly the shape is much like that of *C. tortor,* the inner margin less concave, the outer less convex, the shape being more like that of a parallelogram, with the two articular ends beveled outwardly. The surface is less convex from above downward, and there is a distinct longitudinal channel, the surface transversly in the middle not being plane as in *C. tortor.* The internal face is much like that of *C. tortor,* the concavity and sinuosity less. The stapedial pit is moderately oblique and extends for about half its length above the upper end of the meatal notch. The suprastapedial process is very short and broad, and its posterior face only a little constricted above. It extends only about a third of the length of the bone. On the posterior surface there is a strong rugosity a little below the middle of the bone, continued into an oblique low ridge that runs to the outer inferior angle. The ear cavity is more shallow and much longer from above downward than from side to side; the outer border but little convex. Its wall is thicker than in *Platecarpus*, where the bottom of the concavity is very thin. The inner angle above is stout and much produced, but the concavity between it and the alar process is long and not very deep. The inner border of the articular surface is rather deeply concave.

Mandible. (Pls. XXII, XXII.)

The mandible is one of the most peculiar parts of the Mosasaurian skull. It is proportionally very large and stout, and exceeds the skull proper in length. Back of the middle there is an imperfect joint between the splenial and presplenial bones. This joint admitted motion in both lateral and vertical directions, though chiefly in the former. The motion, even laterally, could not have been great, since a thin plate of the angular extends forward within the cavity of the presplenial. Doubtless this thin extension was elastic, permitting some inward flexion of the dentary, and helping to restore extension. The extension of the articular back of the cotylar cavity was never great, but the broad, stout posterior part of the mandible evidently indicated powerful muscles for the seizure and holding of the prey. The following descriptions of the different elements is from a jaw of *Platecarpus coryphæus*, a figure of which from the inner side is given in plate XXII.

The *articular* forms part of the cotylar cavity — a little less than half — the sutural line running obliquely from before backwards and outwards. The surface in this part is concave from side to side. The portion back of the cavity, separated by an obtuse ridge, is placed obliquely, though in most specimens it is crushed flat so as to lie vertically, while in reality it is more nearly horizontal at the extremity. Its upper margin is convex, running to the obtuse inferior angle. This much of the bone is the chondrogenous element of the Testudinata and Rhynchocephalia known as the articular. The anterior portion, according to Baur, is the co-ossified angular. "What is the articular of the Lacertilia? A consideration of its relations to the other elements of the mandible teaches that it is nothing else than the chondrogenous articular plus the dermogenous angular of the Testudinata and Rhynchocephalia. The so-called angular of the lacertilians is the splenial, and the so-called splenial is the presplenial of the Chelyoidea."[54] If these conclusions are correct, it becomes necessary to revise our nomenclature of the elements of the lacertilian mandible. That the nomenclature here used may be readily homologized with that hitherto used I give the correlative terms, as follows:

Articular	Articular plus angular (articulo-angular).
Angular	Splenial.
Surangular	Supraangular.
Coronoid	Complementary.
Splenial	Prespenial.
Dentary	Dentary.

That portion of the bone that would be the angular of Baur shows no separation whatever in any of the forms from the articular proper. The suture separating it externally from the surangular proximally and splenial distally runs obliquely downward from the posterior part of the cotylus, and then nearly parallel with the lower border of the bone. Internally it forms a long, thin tongue, extending forward beyond the articulation, to be inclosed within a cavity of the presplenial. It is very thin where it crosses the articulation, but is here undoubtedly capable of bending; otherwise the joint between the two segments of the jaw would be immovable. Below on the inner side, the anterior projection, the angular proper, is slightly overlapped by the margin of the splenial. Above, it meets the ridge-like convexity of the surangular below the coronoid, inclosing between it and the surangular a long, flattened cavity.

54 Anatom. Anzeiger, xi, p. 412, 1895.

Just below the proximal end of the coronoid an elongated foramen leads into the upper part of this cavity.

The surangular forms the outer anterior three-fifths of the cotylus, the surface strongly concave antero-posteriorly, gently convex from side to side. Posteriorly on the outer side, the bone unites obliquely with the articular, and from back of the middle with the splenial, which forms the inferior border of the mandible here. The upper border, as far as the coronoid, is thin and sinuous. The extremity is broad and oblique, fimbriated or roughened. On the anterior half, the lower border is narrowly and deeply grooved for the reception of a tongue from the splenial. Posteriorly and internally to this groove, there is another for the reception of the margin of the articular. On the inner surface, below, the bone is excavated for the reception of the flattened part of the articular, its upper margin being an angular margin or ridge reaching about midway. Above this process a groove leads down into an excavation, which is broader in front, forming a foramen leading into the cavity between the articular and surangular. The upper border in front is thickened and rounded for the reception of the coronoid, with a sharp, thin, sinuous margin on the outer side posteriorly. Just below the surface for the coronoid near the anterior margin, there is a groove leading into a foramen. The lower margin of the bone is suturally united with the splenial and the angular, as already described.

The *splenial* of Baur, the angular of authors, forms the thickened and rounded lower border of the bone for more than half the distance back of the articulation. At its distal extremity it has an oval, vertical, articular surface, convex in both directions, for union with the presplenial. The bone is U-shaped in cross-section, the outer lip with a narrow tongue for insertion into the surangular, the inner one thin and overlapping the angular, but not reaching to the coronoid. In the cavity between the two the plate-like process of the articular is received. See plate LXIII.

The *coronoid* has its upper border deeply concave antero-posteriorly, convex and rounded from side to side. It is U-shaped in section. Posteriorly on the outer side it has a free curved margin, inclosing a groove or fossa, which is narrowed and shallow below, deeper and broader above, and which looks downwards, outwards, and backwards. Its upper border is thinned, roughened, and irregularly U-shaped. The anterior end of the bone is irregularly roughened.

The *presplenial* lies on the inner inferior side of the dentary, extending as far forward as the fourth tooth. It appears on the outer side at the inferior posterior part, where it is stout and rounded on the lower margin. For a large part of its extent it forms a deep groove or channel; that is, it is somewhat U-shaped in section, with the inner side longer and each with a thin margin. At the posterior extremity the large articular surface for union with the splenial is placed at right angles to the long axis of the bone. It is rather deeply cupped, oval or subcrescentic in outline, with the long diameter vertical. Anteriorly the bone is thin, covering up the narrow, deep groove for Meckel's cartilage.

The *dentary* comprises more than one-half of the entire length of the mandible. It is widened gradually behind, the upper border straight or gently concave, the lower border somewhat convex. Anteriorly it projects a short distance beyond the first tooth, ending obtusely. On the inner side in this region the groove for Meckel's cartilage begins a little distance before the first tooth, the surface below flattened as far back as the second for apposition with its mate. There are eleven teeth in the dentary of this species, with eight or ten foramina in a row below them exteriorly. Posteriorly the jaw projects a short distance back of the last tooth, ending in a short, striated process. From without, the jaw in front of the articulation is composed almost wholly of the dentary, the presplenial showing only at the posterior and lower part, the separating suture appearing nearly opposite the fourth tooth from the end and running back nearly parallel with the upper border. On the inner side the presplenial reaches to in front of the middle of the bone, opposite the fourth tooth. In front of this bone the groove is partially closed by its thin margins. The articulation back of the presplenial is not a complete one, though, as already stated, undoubtedly admitting of a little lateral motion. Above the shallow ball-and-socket joint the border of the dentary slopes obliquely forward, and is denticulated or fimbriated with outer and inner laminæ interdigitating with similar processes of the coronoid and surangular.

In *Clidastes tortor* (pl. XXIII) the arrangment of the bones on the inner side of the posterior part of the mandible is very different from what it is in *Platecarpus*. The coronoid is much longer and more prominent, and sends down a broad internal plate to overlap the upper part of the splenial, completely inclosing, in this region, the anterior part of the articular. The surangular is narrower, the anterior end more pointed. The dentary is more slender and there are eighteen teeth.

In *Tylosaurus* the structure is much more like that of *Platecarpus* than that of *Clidastes*. The coronoid and splenial are broadly separated, the angular exposed. The coronoid is longer and more prominent relatively than in *Platecarpus*. The dentary projects more in front of the first tooth. There are thirteen teeth.

In *Brachysaurus* (pl. XXII) the mandible is stouter and broader. The coronoid is more prominent than in *Platecarpus* and *Tylosaurus*. The dentary is extraordinarily concave on its upper border. It is remarkably short and stout and has twelve or thirteen teeth.

Vertebræ.

The vertebræ in the known forms of the Mosasaurs vary in number from one hundred and seventeen to possibly one hundred and fifty, though none are known from the Kansas Cretaceous with more than one hundred and twenty. It is not at all improbable that the number of the caudals, or even of the precaudals, may vary to a slight extent in different individuals of the same species. Much reliance has been placed upon the form of these bones in specific classification, but I doubt very much whether such characters are generally reliable, largely for the reason that most of the Kansas specimens from the Niobrara Cretaceous show more or less distortion from pressure changing the shape of the centra. The vertebræ of *Clidastes* may always be readily distinguished from those of the other genera by their greater slenderness, and especially by the presence of a more or less complete zygosphene. The vertebræ of *Platecarpus* and *Tylosaurus* do not present any very tangible differences from each other, and it is often difficult, if not impossible, to distinguish them generically, unless considerable series are examined.

Only three divisions can be distinguished: cervical, dorsal, and caudal, and even the cervical do not show clear distinctions from the dorsal. For convenience, however, the true thoracic vertebræ — that is, those bearing long ribs — may be distinguished from the posterior dorsal or lumbo-dorsal vertebræ, or those bearing short ribs. The vertebræ themselves, however, will not enable one to place them correctly in their series, except by direct comparison with others of the series. In the posterior lumbo-dorsals the zygapophyses are weaker and less developed, and the transverse processes smaller. At the beginning of the caudal series there is an abrupt change, the short costiferous processes giving place to flattened, elongate processes that are non-costiferous. The non-chevron-bearing vertebræ with these simple processes vary in number in our genera from five to seven, and have been called pygial by the writer and E. C. Case. The distinguished paleontologist, Doctor Dollo, has expressed a doubt of the nature of these vertebræ, contending that some or all of them are true lumbar vertebræ, as they had all been previously considered. I feel yet more assured that they are true caudal vertebræ — that is, situated back of the pelvis — and have so described and figured them in the restoration of the animals. In *Varanus*, for instance, where there is a true sacrum, the stout ilia are directed upward and backward to unite by synchondrosis, extending nearly as far back as the posterior part of the ischium. This places the ischial symphysis below the sacrum and in front of the chevron-bearing caudals, and leaves the opening for the pelvis entirely unrestricted. The number of the vertebræ back of the sacrum without chevrons in *Varanus* is but two, as more are not needed, in reality corresponding to four in the Mosasaurs, since there is no sacrum in these animals. I know of no reptile, as I have previously stated, in which this arrangement of the non-costiferous vertebræ is not the rule, and it seems strange that the error of confounding the non-costiferous and non-chevron-bearing vertebræ with the mammalian lumbar vertebræ should have persisted so long. In the Mosasauria there is never a sacrum; the rod-like ilia are directed, not backward, but forward, ending without attachment, but doubtless lying in contiguity with the most anterior of the pygals. The symphysis of the ischia is thus thrown below the fourth or fifth vertebra succeeding. If these vertebræ bore chevrons it will be immediately seen they would have protruded into the pelvic cavity, obstructing the outlet. Not less than five or six pygial vertebræ are necessary in these marine lizards to leave space for the free exit of the cloaca.

The relative lengths of the thorax and tail vary in the different genera. While in *Clidastes velox* there are as many as forty-two precaudal vertebræ, in *Tylosaurus* and *Platecarpus* there are not more than thirty, with seventy-seven caudal vertebræ in the first and eighty-six or more in the last two.

Atlas.

Clidastes velox. The intercentrum is a small bone with its three principal sides of nearly equal extent; the two upper articular surfaces are gently concave, and meet in a transverse obtuse border. The anterior margin is thin and sharp, the articular surface behind it for the condyle more concave than that for the odontoid. The inferior surface is convex, both antero-posteriorly and from side to side, with a roughened longitudinal prominence in the middle on the posterior part for muscular insertion. The posterior articular surface is limited by a narrow groove below on the margin of the bone. The bone articulates broadly behind with the atlantar hypapophysis, reaching above to the surface for the odontoid, and, on the ends, to those for the lateral pieces. The lateral pieces have distinctly separated articular surfaces for union with the condyle, intercentrum, odontoid, and axis. The facet for the intercentrum at the inferior part of the bone is smallest, looking nearly inwards. That for the condyle is flattened, looks nearly forward, and is vertical in position. The superior facet, oblique in position vertically and transversely, is for union with the axis, and is more or less confluent with the internal triangular surface for the odontoid. On the outer side the bone is strongly convex from above downward, with a flattened process on the posterior upper part, directed upwards and forwards, and expanded obliquely at its distal extremity. The inner side of the top margin is beveled and striated, and is probably contiguous or approximated with its fellow of the opposite side. Directed downwards and backwards from the posterior inferior side, there is a stout styliform process. Above it there is a small tubercular process on the posterior margin of the upper process, directed backward.

In *Platecarpus* and *Tylosaurus* the intercentrum resembles the same bone in *Clidastes*, being a little broader antero-posteriorly. The lateral processes have the upper process somewhat broader, and the styliform process is very much shorter.

Axis.

Clidastes velox. The neural spine of the axis is elongated antero-posteriorly, its length above equal to that of its proper centrum. It is thin on the anterior portion, the border sloping upward, the posterior border thickened, stout, and oblique in position. The transverse processes are flattened and horizontal, the smallest of the costiferous series, and with only a small articular facet for the rib. The stout postzygapophyses have their faces looking obliquely ventrad and laterad. The zygosphenal articular surfaces are wholly wanting on the inner side of the triangular cavity between the borders leading to the two articulations. The articular surface of the centrum behind is smoothly convex, a little broader from side to side than from above downward, and only faintly emarginate above. The hypapophysis is the largest of the series, and is suturally united with the stout exogenous process of the centrum, which is directed almost directly ventrad, its posterior margin close to the articular border. The hypapophysis is directed obliquely backward. The atlantar hypapophysis forms the cephalo-ventral part of the centrum, articulating anteriorly with the intercentrum of the atlas, and above suturally with the axis. It bears on its inferior surface a small process directed caudad and ventrad. Between this process and the anterior border of the exogenous projection of the centrum behind there is a deep emargination, the two hyapophyses being separated by a considerable interval. The odontoid process is united to the body of the axis by suture. Its upper surface is nearly horizontal and shallowly concave. The articular surface for lateral pieces and the occipital condyle is oblique and slightly concave from above downward, the upper margin rounded and semicircular from side to side.

The axis in *Platecarpus* differs from that of *Clidastes* in the spine being more prominent in front, in being thicker behind, and in the ball being not at all emarginate above. The hypapophysial protuberance is shorter or nearly sessile. The postzygapophyses stand out more freely, the ridges above them are less prominent. The hypapophysis is entirely free.

Third to Seventh Cervical Vertebræ.

Clidastes velox. The third cervical vertebra shows a well-developed zygosphenal articulation posteriorly. The transverse processes are small, only a little larger than those of the axis, but, unlike them, they are strengthened by a ridge running obliquely ventrad and caudad from the under side of the anterior zygapophyses. The hypapophysial projection is rather longer and stouter than that of the axis, the hypapophysis itself of about the same size, or a little smaller, and directed, like that, backward. The spine is a stout rounded, or trihedral projection, with a sharp carina on the anterior side, less oblique on its margin. The spine is directed rather more obliquely than in the following vertebræ.

The fourth cervical vertebra has stouter transverse processes, the anterior portion, turned downwards and then forwards to the rim of the cup, is stronger, the oblique ridge leading to the under side of the zygapophyses stouter, and the hypapophysis is directed rather more directly ventrad. The spine is less stout than in the preceding, and is rather more vertical in position and the anterior thinned part above is more dilated.

The fifth cervical vertebra differs from the fourth in the broader spine, the stouter transverse processes, and the smaller hypapophysis.

In the the sixth cervical vertebra the hypapophysis is reduced to a small ossification in some cases, always distinctly smaller than that of the preceding vertebra, and it is directed wholly ventrad. The spine has reached nearly the full width of that of the following vertebræ, though it is somewhat stouter above. The transverse processes are yet stouter.

In the seventh or last cervical vertebra the hypapophysis is wanting, or is the merest rudiment. The hypapophysial projection of the centrum is reduced in size, and the centrum in front of it has gradually assumed the shape of an obtuse carina.

Dorsal Vertebræ.

In *Clidastes velox* there are thirty-five vertebræ between the last cervical and the first non-costiferous vertebra, to which the pelvis was, evidently, related. The distinction between the cervicals and thoracics cannot be made out from any inherent character, as the last cervical does not bear a distinct hypapophysis. In a series of vertebræ referred to *C. pumilus*, a species doubtfully distinct from *C. velox*, the seventh vertebra bears a short rib. In a specimen of *C. velox* the eighth post-cranial vertebra has a long rib attached to it, evidently articulating with the sternum. From this it is evident that there are seven true cervicals. Posteriorly, also, there is no distinction between the thoracic vertebræ and those of the lumbar region. All the vertebræ anterior to the pelvic region bear ribs, and all should be considered as dorsal vertebræ, the true thoracic vertebræ being restricted to those in which the ribs are elongated and inclosing the thoracic cavity, whether connected with a sternum or not. In the anterior dorsal vertebræ the centra are subcarinate below, the obtuse, rounded keel becoming less and less apparent until no indications of it can be seen, before the middle of the series. The transverse processes reach their maximum in the first thoracic vertebra. On the anterior cervicals, the articular surface is nearly rectangular and the two arms of nearly equal length, the anterior one reaching nearly to the rim of the cup, the other thicker, vertical and uniting near its upper end with the stout, rounded ridge from the anterior zygapophysis. In the posterior cervicals the anterior arm assumes a more oblique position, the included angle being more obtuse; it is shorter and does not reach as near to the rim of the cup. In the first thoracic the vertical branch is nearly twice the length of the other. In the third or fourth the anterior arm has become a short, curved, pointed projection, directed more downwards than forwards. The upper posterior angle is curved backward in the whole series to a moderate extent, giving, in the anterior dorsals a curved articular surface resembling the italic letter *S*. The zygapophyses have nearly the same position throughout. They are much the stoutest and the longest in the cervical and anterior dorsal region, showing evidently a greater range of downward curvature in this region. They immediately become shorter, and the oblique ridge connecting them with the upper part of the transverse process is weaker and more slender.

In the most anterior thoracic vertebræ the plane of the articular surface for the transverse process lies only a little exterior to the outer border of the zygapophyses, but posteriorly the process stands widely beyond the zygapophyses, being absolutely and relatively longer, and the transverse process is somewhat constricted before the end. The spinous processes increase very slightly in length and breadth, and are only slightly and nearly uniformly oblique throughout. The centra increase very slightly in length to beyond the middle of the series, the posterior ones being distinctly more slender, and, as already stated, have more protuberant transverse processes. The vertical diameter of the ball increases slightly, while the transverse diameter remains more nearly the same.

Caudal Vertebræ.

Immediately following the thirty-fifth costiferous vertebra in *Clidastes*, the tubercular rib-process gives place to an elongated non-costiferous process. There are seven such vertebræ in this species — with elongated flattened process and without chevrons. A distinctive name for them is needed, and in a previous paper [55] the name *pygial* was proposed. These pygial vertebræ, or pygals, are seven in number in this species. The under surface is somewhat flattened, and, as in the preceding vertebræ, is gently concave antero-posteriorly. The transverse processes are elongate, flattened, with a thin rounded extremity, and are directed gently downward. In the anterior vertebræ the processes spring from the anterior part. As the centra become shorter they arise from near the middle. In the last of the series there are minute indications of chevrons. The centra, which had already begun to decrease in length in the posterior part of the lumbo-dorsal series, diminish rapidly, the last being only three-fourths the length of the first. The transverse processes are of nearly the same length throughout, their expanse being fully four times the length of the first centrum.

The centra of those vertebræ which bear chevrons do not differ much in shape. They become less constricted, and, back of the middle of the series, are smoothly cylindrical in shape. The transverse processes decrease gradually in length and size, and ascend somewhat on the centrum, disappearing entirely on the twenty-fifth or twenty-sixth. The spinous processes are now much narrower than in the precaudal series, though of nearly the same length, increasing gradually in this respect for the first twenty of the series, and are markedly oblique, with the posterior border stout, and the anterior border alate. With the twenty-sixth, where the transverse processes cease, the spines begin to increase rapidly in length, and have become more vertical in position, with both borders thinner. In the thirty-fifth or thirty-sixth they attain their greatest length, and are here directed slightly forward. Thence to the end of the tail the spines decrease gradually and they become more and more oblique

55 Kansas Univ. Quart., I, 22.

backward. Towards the end of the tail, the length of the centra decreases more rapidly than in the anterior parts, finally terminating in a mere nodule of bone. In the well-preserved specimen described there are seventy-seven vertebræ with chevrons, all continuous, except in one place. The last one is less than a fourth of an inch in diameter, and shows that there had been yet another, possibly several more. The entire series was not less than seventy-eight and probably not more than eighty. The chevrons are strongly oblique throughout, and are firmly coossified with the centra. They are much more slender and longer than in the other genera.

The tail of *Clidastes*, as is thus seen, has a broad, vertical, fin-like extremity, and doubtless aided very materially in the propulsion of the animal through the water.

In *Platecarpus* the cervicals are less slender than in *Clidastes*. There are no zygosphenes, or the merest rudiments of them; the centrum is more transverse. The centra are transversely oval in the dorsal region, more pear-shaped in the pygal, and vertically oval in the caudal. There are six pygals, and their transverse processes are stouter and flatter than in either of the other genera. The vertebræ bearing transverse processes behind the pygals are fewer in number than in either of the other genera. The precise number of the vertebræ bearing chevrons cannot be determined, though in all probability the tail does not differ in this respect from that of *Tylosaurus*. The spines are all regular, there being no dilatation of the tail as in *Clidastes*, and the obliquity is apparently also not irregular. The chevrons are longer than in *Tylosaurus*, but not nearly so slender and elongate as in *Clidastes*. They are all articulated by a rounded head into a small cup-like depression on the under side of the centra back of their middle.

In *Tylosaurus* the dorsal vertebræ are yet more transverse in outline and the pygals more pyriform. In fact, in most specimens of the pygals the centrum is found almost triangular in shape, the exaggerations due to the crushing, which almost always occurs from above downwards in these specimens, owing to the transverse processes fixing the position of the vertebræ in the sediment. The caudal vertebræ are distinctly vertical oval. The spines and chevrons are stouter and shorter in proportion to the centra than in *Platecarpus*. The former, also, show a marked degree of irregularity in their obliquity, as will be seen in the restoration of this species. Probably this irregularity is not constant in all the different individuals of the same species. The number of the pygals is somewhat indefinite. In a specimen in the museum in which the vertebral column is complete there are five typical ones and two more with rudimentary tubercles for the chevrons. In others these tubercles are somewhat larger. The number is not less than five, and may be seven.

Below is given a comparison of the different regions of the vertebral column in the three typical species that have been discussed in this work.

Number of vertebræ.

	Clidastes.	Platecarpus.	Tylosaurus.
Cervical	7	7	7
Dorsals	35	22.	23
Pygals	7	5	6
Chevron caudals	70	80?	80
	118	115?	116

Lengths of the different regions.

	Clidastes.	Platecarpus.	Tylosaurus.
Skull	0.420	0.512	0.816
Neck	.226	.240	.360
Trunk	1.360	1.345	2.000
Tail	1.460	2.160?	3.165
	3.466	4.257	6.341

Proportionate lengths of the different regions of the body.

	Clidastes.	Platecarpus.	Tylosaurus.
Skull	12.1	12.0	13.0
Neck	6.5	5.6	5.6
Trunk	39.2	31.3	31.5
Tail	42.2	50.7?	49.9
	100.0	100.0	100.0

Extremities.

In all the known Mosasaurs there are four functional limbs, varying not a little in the different genera in size and structure. The arm and leg bones are short and broad, the articular surfaces not conspicuously differentiated, and evidently capable of great dorso-ventral flexibility. The carpus and tarsus in some forms are well developed, with closely interlocking bones; in others the number may be decreased to a single one, a mere nodule set in a broad plate of fibro-cartilage. The metapodials cannot, in many instances, be distinguished from the phalanges, save by their greater size. They are all elongated, hour-glass shaped, somewhat flattened at either extremity, and constricted into a cylindrical or flattened shaft. In *Tylosaurus*, the thin membrane supporting the digits has been found quite to the extremity and there can be no question but that the digits in all were webbed throughout.

Scapula.

Clidastes velox. The scapula is a thin flattened bone, with the lower portion thickened and stout. Its superior border is long and thin, somewhat thicker on the posterior half. The margin is squarely truncated for the attachment of a plate of cartilage, which extends up on the sides of the thorax, as in recent lizards. This cartilage is often preserved in a semiossified condition. The convexity is greatest near the middle of the superior border and near the anterior end — the margins more nearly straight between these points. Posteriorly the angle is acute, whence the posterior border, reaching nearly midway to the glenoid articulation, is straight, thinned, and nearly vertical, ending in a thin angle. Below this angle the border is concave, rounded and thickened below. The anterior inferior angle is nearly rectangular, the border below in front of the coracoid thin and sharp and concave, ending in a thickened, triangular, much-roughened process, just in front of the coracoid union, looking downward, for ligamentous attachment. The head of the bone is divided by an oblique ridge into unequal facets, meeting each other in an obtuse angle. The anterior one, the larger, is roughened for union with the coracoid. The posterior one is smooth, concave in front, convex behind, looking downward, backward, and outward. The outer surface of the bone is nearly flat, the inner more concave, the head being formed chiefly at the expense of this side. The glenoid margin on the outer side is produced into a sharp, prominent lip.

Mosasaurus horridus. An imperfect scapula of this species apparently closely resembles the same bone in *Clidastes.* It is less distorted and crushed, so that the neck is less flattened, and the lip of the glenoid articulation is produced into a sharp, prominent ridge.

Platecarpus coryphæus. The scapula in *Platecarpus* has greater vertical height than in *Clidastes* and less antero-posterior elongation. The superior border is much more strongly convex, the greatest convexity being at the uppermost part. The posterior part is not as strongly produced, the angle not as acute. The free, thin upper border is much shorter or reduced to a short convexity, the concave border below it much longer and thicker. The anterior inferior border is concave as in *Clidastes*, ending in a sharp margin somewhat deflected on the inner side, the thinning due to a broad groove on the outer surface. In some specimens the border is concave, in others straight from the anterior angle to the smaller roughening in front of the coracoid articulation. Around the lip of the coracoid articulation there is a considerable ligamentous roughening, as in *Clidastes.*

Tylosaurus dyspelor. The scapula of *Tylosaurus* closely resembles that of *Platecarpus*, but is, relatively, both to the size of the coracoid and to the skeleton, a much smaller bone, its size in *T. proriger*, of twenty-four feet in length, being absolutely smaller than in *P. coryphaeus*, of thirteen feet in length. The bone in *Tylosaurus* is less expanded vertically and antero-posteriorly than in *Platecarpus.* The posterior emargination is shorter, the superior border thicker.

Coracoid.

Clidastes velox. The coracoid is a broad, thin, fan-shaped bone, flattened on the exterior surface, concave on the inner. The head, like that of the scapula, is divided by an oblique ridge into unequal facets, meeting in an obtuse angle. The anterior and large one for the scapula is concave, and directed obliquely inwards. The outer posterior one, forming about one-half of the glenoid fossa, is largely concave, and is produced into a prominent ridge outwardly. The posterior inferior border is thickened, concave, and roughened immediately back of the glenoid margin, straight and thin distally, ending in a rounded angle. The anterior superior border is nearly straight or gently convex on the outer three-fifths, moderately thickened and ending in a rectangle. Proximally it is beveled convexly at the expense of the outer surface, terminating in a thin, sharp, prominent ridge, extending from the apex of the roughened triangular space in front of the scapular surface to the inner side of the superior border, a little before the middle. The inferior border is thin and convex throughout from before back, the convexity being greater on the posterior part. The border is lipped for cartilage, and is a little thicker near the posterior end. Just back of the anterior fourth of the border there is a deep emargination, with very thin margins. In front of this emargination the border of the bone is thicker, especially on the posterior half, where the border is swollen. Just back of the emargination the border is also a little thickened. About midway between the bottom of the emargination and the margin of the scapular articulation the small coracoid foramen pierces the bone from above downwards.

In most specimens of Mosasaurs from Kansas the bones are flattened, from pressure. The present specimen has, however, the two bones but little changed, so that the angle between the scapula and the coracoid is shown nearly as in life. Their relationship will be clearly seen in plate XXXI, figure 6, which shows the two bones as articulated, from behind.

Platecarpus. The coracoid of *Platecarpus* resembles that of *Clidastes* rather closely. The bone is longer and less expanded distally, the neck longer and proportionally narrower, the posterior margin longer and concave throughout.

In *Tylosaurus*, the coracoid is very large in proportion to the scapula. The anterior border is nearly straight, the posterior concave, the inferior strongly convex. There is no emargination.

Humerus.

This bone is characterized by the absence of a distinct neck, by its constrictions and transverse dilatation distally. There appear to be two distinct types, characterized by the tuberosities of the distal end.

Mosasaurus horridus. The humerus in this species is a massive bone, agreeing best with the humerus of *Clidastes.* The greater diameter of the proximal articular surface is anteroposterior, instead of transverse. The slightly pitted, transversely gently concave surface is crescentric in outline, with the concavity facing the radial border. At the ulnar side proximally, there is a stout, massive tuberosity, directed upward and inward, and rising about an inch above the articular surface. It is subovate in cross-section, its end convex, and the surface cartilaginous. The stout pectoral ridge is scarcely differentiated from the body of the bone, being very broad. It is situated nearly in the middle of the bone, its proximal end forming the inferior end of the large crescent already described. The distal border has the broad, thickened surface for articulation with the radius placed obliquely, looking to the radial side and also dorsally. At its outer end there is a stout, styliform, flattened process directed outwards in the horizontal plane of the bone, its oval extremity showing a cartilaginous surface. The ulnar condylar process is stout and projects on the palmar side of the bone. Its distal surface looks inward and somewhat downward.

Clidastes velox. In this species the proximal end of the bone is transverse, but less regular in outline than in the following genera. The glenoid articular surface is situated near the middle transversely, its surface concave in both directions. The articular or cartilaginous surface is continuous to the inner angle of the bone. This portion of the bone, which in *Mosasaurus* is raised prominently into a tuberosity, is only a little prominent in *Clidastes,* forming the inner two-fifths of the margin of the bone, and ending in a thin border. Possibly in life the resemblance between the two genera in this part may have been somewhat greater, but the differences are nevertheless very marked. On the distal border, the thickened, smooth and nearly flat articular border for the radius looks very obliquely outward, more so than in any other form ; it meets the surface for the ulna in a rounded angle. At the proximal (outer) rounded margin of the articulation begins the prominent, styliform radial process, directed outward in the plane of the bone ; it is flattened from above downward, and its tip was covered with cartilage. The ulnar condylar process is stout and thick, its surface subtriangular in outline, looking downwards, inwards and distad. The surface of the bone on the outer (radial) side is roughened. The free ulnar border of the bone is much longer than the radial, and more deeply concave. The radial border forms a short notch between the upper angle of the bone and the radial process. The pectoral process is more distinctly differentiated than in *Mosasaurus*, is situated nearer to the radial side of the bone, and has, at its upper part, a distinct cartilaginous surface, separated from that of the head of the bone and looking more downward. The dorsal surface of the bone is convex transversely, and gently concave along the middle longitudinally. A humerus of *Clidastes westii*, from the Fort Pierre, in the collection, has not been subjected to compression or distortion. The shapes of the two ends are shown in plate XXXIX. It is probable that these outlines represent the general *Clidastes* type.

Brachysaurus overtonii. The humerus of *Brachysaurus* differs markedly from that of all the other forms. It is stout and broad. Its proximal end is angulated near the middle, both sides sloping away from the angle, much as in *Tylosaurus*. The ulnar side is the longer and thinner of the two. The distal border is much elongated, and more convex from side to side than in the other genera. Its greater thickness is on the radial side, whence the border turns proximad to near the middle of the bone, leaving only a very short, moderately deep notch between it and the superior angle. There is no radial process. The ulnar side of the distal margin is considerably thickened as far as the place where it is reflected downward, where it is continued as a thin margin into the stout ulnar condyle, whose surface looks downwards and distad. The pectoral process is very small, is oblique in position, as in *Platecarpus*, and is situated close to the radial side of the bone ; its ridge is thin. The dorsal surface is markedly concave from side to side ; the palmar surface, flattened and concave. The specimen described, like that of *Mosasaurus* has not been subject to the compression so common among the Kansas specimens. Its resemblances are apparently greater to *Platecarpus*, though very different in the convexity and angularity of the proximal end. See plate LXII.

Platecarpus coryphæus. The humerus in this genus is the most expanded of any of the forms known to me, its width distally being nearly as great as the length. The proximal border is nearly straight, transversly or gently concave along the middle, the margins thinner and rounded. The distal border is much expanded and broadly convex, forming nearly the half of a circle. The thickened articular surface for the radius looks a little obliquely outward ; proximad to the thickened portion the border forms a gently convex outline, its chord nearly parallel to the longitudinal axis of the bone ; this portion is thinned and the surface covered with cartilage. In no other form, save *Brachysaurus*, is the structure similar here. The ulnar side is more expanded than the radial, its convex border nearly longitudinal. The surface here, however, is thickened to form the tuberosity, which looks downward. The tuberosity is not very stout, and is connected with the ulnar articular border by a thinner margin, which is not emarginated. Both the radial and ulnar borders of the bone are deeply emarginated, the bone being much constricted above the middle. The ulnar border is a little, though not much, longer than the radial. The pectoral process is situated more nearly in the middle of the bone than in any of the other forms. It is obliquely inclined toward the radial side, and compressed from side to side, the ridge blending with the surface a little below the middle of the bone. Its cartilaginous surfaces reaches through more than half of its extent, and is either entirely separated from the cartilaginous surface of the head or is only narrowly connected. The process is gently inclined toward the radial side. On the dorsal surface, a little distad and laterad of the middle, there is a small roughening for muscular attachment. The same process seems to be apparent in most of the genera, and may be called the deltoid tubercle.

Tylosaurus proriger. The humerus of *Tylosaurus* is the most elongate and least expanded of any of the Kansas forms, and is relatively the smallest. Its proximal end, unlike that of the other genera, save *Brachysaurus*, is not transverse, but strongly angulated a little to one side of the middle, its thinned border sloping sharply away to meet the radial border in a rounded angle about opposite the proximal fourth of the bone. The ulnar side of the proximal border is moderately thinned and slopes gently, and is more expanded than the radial side. The distal border is much thicker on the radial side, the ulnar side being thinner and only moderately expanded. The radial angle is thin and very slightly produced; it has no projecting process. The ulnar angle, though more prominent, has no thickened process. The free radial border is long and gently concave between the proximal and distal rounded angles; that of the ulnar side is longer and deeper, but, like the other, is nearly uniform in curvature, much more so than in the other genera. The pectoral process is less projecting than in the other genera, its cartilaginous surface smaller and situated more nearly the proximal end. The rounded ridge which it forms is situated nearly in the longitudinal axis of the bone, and in line with the radial thickening of the distal end.

Radius.

Mosasaurus horridus. The radius in this species, as in all the other species of the group, is much the larger bone of the forearm. It is very stout at the proximal end, broadly expanded at the distal. In the single specimen of this species known to me the outer part of the bone is missing. The inner part differs from the corresponding bone of *Clidastes* in the distal angle being more produced.

Clidastes velox. In *Clidastes velox* the radius is almost fan-shaped. The proximal end is thickened, ovate in shape, the greater thickening on the outer side. The articular surface is smooth and gently concave for close union with the humerus. Beyond the head, at about the proximal third, the bone is much contracted, the width here being about one-third of that in its widest place. On the distal end the bone is much expanded, forming more than half of a circle, with the carpal articular border a chord. The outer margin is short and deep, the border thinned. The inner border is thicker and about a half longer than the outer, its distal end forming an acute angle with the inner end of the carpal surface. The carpal border forms more than a third of the distal periphery. It is thickened, concave and smooth on the surface, and placed very obliquely to the axis of the bone — about forty-five degrees. The remainder of the distal border is thin, and gives attachment to cartilage. I can give no rule by which the bones of the two sides may be distinguished, save perhaps that the thickening of the proximal end seems to be less uniform on the dorsal side, its greatest convexity in cross-section being on the outer side.

Platecarpus. In *Platecarpus* the shape of the radius is much more like that of *Clidastes* than of *Tylosaurus.* The bone is broader and flatter, the proximal portion less constricted, the distal border more uniformly a half circle — that is, the carpal border is not so distinctly a chord of a circle — and the curvature transversely is less strong. The articular part of the distal extremity is only a little thicker than the free cartilaginous border. The whole surface of the border is, moreover, coarsely roughened, showing an intervening attachment of fibro-cartilage.

Tylosaurus. The radius of *Tylosaurus*, like the other paddle bones of this genus, is elongate and narrow. The proximal end has an oval articular face at right angles to the long axis of the bone, for articulation with the humerus. The shaft is only moderately narrowed to near the middle of the bone. The distal extremity is about a half wider than the proximal. On its inner side it is thickened for more than half its width; the outer part is thin and moderately concave, and reaches the full length of the bone, from the thickened proximal to the distal angle. The bone has no articulation distally, the single carpal bone being set in a plate of fibro-cartilage, which is attached to the roughened border of the forearm bones.

Ulna.

Mosasaurus horridus. The ulna in *Mosasaurus* is a less broad bone than is the radius, but is rather stouter in its proportions. The proximal end is stout, thick, transverse, and rectangular, the surface somewhat cupped and smooth; in outline subtriangular, with the inner angle produced more than the outer. The distal extremity is less expanded than the proximal, and shows three facets for close union with carpal bones, separated from each other by slight angles, that on the outer side the most angulated. The middle facet, the largest, is nearly transverse to the long axis of the bone. The inner border is thicker than the outer and more deeply concave, the greatest concavity a little beyond the middle of the bones; the border extends from the sharp angle of the carpal articulation to the slightly rounded angle of the humeral. On the inner side the border is shorter, thinner, and less deeply concave, extending from the angle for the surface of the sesamoid bone to the rounded, thinned, olecranon expansion on the inner side of the proximal end. The shaft of the bone is twisted somewhat, so that the inner border at the proximal end is turned downwards. The dorsal surface of the bone is markedly concave longitudinally and transversely throughout the most of its extent, the plane of the proximal end twisted dorsally on the inner side. On the palmar surface the bone is strongly convex transversely and but slightly concave from end to end.

Clidastes velox. The ulna in this species differs only in minor details from the same bone of *Mosasaurus horridus.* It is more slender and less stout, the proximal articulation is placed a little more obliquely to the long axis of the bone, the olecranon process is smaller, and the corresponding inner border longer. The distal articulation is more oblique outwardly and there are but two facets for articulation with the carpal bones. The outer one is straight and cupped and reaches over nearly the whole extent of the distal surface, that for the pisiform inwardly being merely a notch-like opening between the ulna and the ulnare carpal.

Platecarpus coryphæus. The ulna of *Platecarpus* is more nearly like that of *Clidastes* than of *Tylosaurus*. Both the proximal and distal articular surfaces are placed more obliquely to the axis of the bone and the distal expansion is greater. The olecranon expansion is not rounded, but angulated, the roughened cartilaginous surface meeting the free border in a right angle. In *Mosasaurus* the cartilaginous surface extends out a moderate distance on the projection, but in *Clidastes* the expansion from the edge of the humeral articulation is rounded and smooth. The distal extremity shows a large, thickened, roughened border on the outer side for the carpal bone; the outer part thinner, less roughened, and meeting the free border in a right angle. The bone, as in *Clidastes*, is concave above transversely, convex below.

Tylosaurus proriger. The ulna in *Tylosaurus* is the most slender of the arm bones of any genus. Its proximal extremity is a little wider than the distal, and placed obliquely outwards to the axis of the bone. The distal extremity is transverse and but little expanded, its border gently convex. Both the inner and outer free borders are long and gently concave, the greatest narrowing of the bone occurring a little beyond the middle. The olecranon expansion is thin, its border gently convex. The bone is convex from side to side, both above and below.

Carpus.

The carpus in *Mosasaurus* and *Clidastes* is composed of seven bones, closely articulating, forming a firm and but slightly flexible wrist. In *Platecarpus* there are four bones, the inner part of the wrist, between the radius and the first and second metacarpals, remaining cartilaginous. In *Tylosaurus* the carpals exist as a mere rudiment in a single, rounded ossicle, situated at the inner end of the radius and surrounded on all sides by cartilage.

Mosasaurus horridus. There are four carpal bones in the proximal row, which may be designated the radiale, mediale, ulnare, and pisiform. The radiale is trapezoidal in shape, the inner end narrower than the outer. Its proximal articulation is the longest and thickest; it articulates closely with the radius, but does not extend quite to the inner end of the distal border of that bone. The distal border, nearly as long and thick, is straight and turned somewhat more outwards; it articulates with the broad first metacarpal. The outer, free border is rounded and thinner than any of the others. The inner border, less thick than the long borders, meets the distal border in a rounded rectangle, and articulates with the rounded bone of the second row. Between this and the upper border the margin is rounded, where it meets the mediale for a short distance. The mediale is the next in size of the carpal bones, but is thinner than either the radiale or ulnare. It has a free, thin, concave, proximal border, extending from the distal, opposing angles of the forearm bones. The distal border, nearly parallel with the chord of the free border, is for articulation with the middle bone of the second row. Its outer border has three articular surfaces in this species; the two proximal ones rounded and indistinctly separated, for articulation with radiale and radius; the distal one, as long as the other two together, is for articulation with the third of the distal row. On the ulnar side there are two articulations, the proximal one the thickest of all, but short, for union with the ulnar; the other, long one, for union with the ulnare. The ulnare is a stout, nearly square bone, nearly or quite as large as the mediale. Its outer border, for union with the thinned mediale, is abruptly thinned. Its proximal and distal borders are very thick; the former slightly convex from above downwards, the latter gently concave. The distal one is a little the longer, and articulates with the third distal carpal; the proximal with the ulna. The outer side is rounded and has two small articular facets, the proximal one, the larger, forming an entering angle with the ulna, for the pisiform; the distal, smaller one, for articulation with the fifth metacarpal. In the distal row there must have been three carpals, only one of which is preserved in this specimen. The outer one is subround or subquadrate, and articulates with the following bones, there being no free border: radiale, mediale, medial distal carpal, first and second metacarpals.

Clidastes velox. The carpals of *Clidastes* are seven in number, situated in two rows, and firmly articulated with each other and the adjacent bones. They very much resemble the bones of *Mosasaurus.* The largest is the radiale, an irregularly shaped bone, and thicker than any of the others. Its thickest facet is for articulation with the radius. Its rounded outer angle is free. Its longest face, directed obliquely outward, is for articulation with the first metacarpal. On the inner side there are two facets, indistinctly separated, the proximal for articulation with the mediale, the more distal one for the outer distal carpal. Between the mediale and the angle of the radius there is a short, free, rounded border. The mediale is five-sided. Its shortest side articulates with the radiale; the longest, at the opposite end, with the ulnare. Between these faces distally there are three articular facets for the three distal carpals, the outer one the longest, and meeting the middle in an angle. Proximally, between the radial and ulnar facets, the border is free, concave, and thinned, continuing the curve from the radiale to the angle of the ulna, which the bone slightly touches. The ulnare is indistinctly five-sided, and is the second largest bone of the carpus. The largest and thickest face articulates with the ulna; the shorter face, on the outer side, with the mediale. Internally, the broad, rounded end has two facets, indistinctly separated, for articulation with the pisiform and the fifth metacarpal. The pisiform, an elongate bone, is inserted into the entering angle between the ulna and the ulnare; of the two proximal faces, that for the ulnare is a little the longer. The distal extremity is transversely convex, and is tipped with cartilage. The two sides are parallel and free, the distal one shorter and thinner than the proximal one. The distal carpals, three in number, are all of nearly the same size and shape, the inner one a little the largest. They are irregularly four- or five-sided. The inner one articulates with the ulnare, the mediale and the second distal carpal, and with the first and second distal carpals. The middle one articulates with the mediale, the other two of the distal row, and the third metacarpal. The outer one articulates with the radiale, the mediale, the middle distal carpal, and the fourth metacarpal. These three bones are thinner than the others, save the mediale.

Platecarpus. The carpal bones of *Platecarpus* are four in number, articulating rather closely together, and situated on the ulnar side of the wrist. They are the ulnare and mediale of the proximal row, the first and second of the distal row. The radiale, pisiform and outer distal carpal are wanting. This structure in connection with the absence of the condylar process of the distal extremity of the radius and the much weaker first digit, shows a decided inferiority in this part of the paddle as compared with *Mosasaurus* and *Clidastes.* The ulnare, the largest, articulates with the ulna, fifth metacarpal, and the other three carpals. The mediale articulates with the ulnare, radius, and outer distal carpal. The two distal carpals articulate with the second and third metacarpals respectively.

Tylosaurus. In *Tylosaurus* there is but a single carpal, a small, rounded bone, situated opposite the end of the ulna, and doubtless corresponding to the ulnare. It does not articulate with any bone, but was surrounded on all sides by cartilage.

Metacarpals.

Clidastes velox. Of the five metacarpals in *Clidastes*, the first is the broadest, the fifth the shortest, and both much flattened. The other three are more slender, with expanded extremities and constricted shaft. The first is much expanded on the proximal extremity, the broadly convex end articulating with the radiale, and, together with the next three, permitting very free lateral movement. The distal extremity is less expanded than the proximal, the end squarely truncate for close union with the phalanx. The inner border, thicker than the outer, has a shape somewhat like a fish-hook, terminating in an acute distal angle of the bone. The outer border is much shorter and has a slight convexity at the bottom of the con cavity. The outer distal angle of the bone is broadly rounded. The second, third and fourth metacarpals have the proximal extremity broadly convex transversely and much expanded; the shaft is constricted beyond the middle into a flattened cylinder. The distal extremity is moderately expanded and squarely truncate. The third is a little shorter than the second, the fourth distinctly shorter than the third. The fourth may be recognized by the less symmetrical proximal extremity and a shallow emargination of the inner border distally. The fifth metacarpal is short and flattened. The proximal extremity is nearly transverse to the long axis, and but little convex. Its position and mode of articulation with the carpus indicate less lateral movement than exists in the other metacarpals. The distal extremity is much broader, the longer border for the articulation of the phalanx placed obliquely to the axis of the bone. The inner border is straight or gently concave; the outer border is shorter and deeply concave.

Platecarpus. The metacarpals of *Platecarpus* are less differentiated than in *Clidastes* or *Mosasaurus*. The first is somewhat flattened and is more expanded proximally than the others, its proximal articular surface being placed somewhat obliquely to the long axis of the bone. The fourth has a slight sigmoid curvature, and the fifth is shaped somewhat like the corresponding bone of *Clidastes*, with the broader extremity distal. The second, third and fourth are more expanded proximally than distally, but the discrepancy is not as great as in *Clidastes*. The proximal extremities are not as convex transversely, and all the bones are separated more widely by cartilage.

Tylosaurus. The metacarpals are more slender in *Tylosaurus* than in the other genera. The first is the broadest and stoutest, and as long as the second. It is more expanded proximally than distally, but not much. The ends are nearly transverse to the long axis, and but slightly convex. The inner border is more deeply concave than the outer. The second, third and fourth metacarpals are slender bones, scarcely distinguishable in shape from the proximal phalanges. They are only moderately constricted, and the proximal extremity is but little more expanded than the distal, and both but slightly convex. The fifth is a broader and shorter bone than the others, divaricate, as in the other genera, but with the broader extremity proximally. Its proximal articular border is oblique, and the inner border is shorter and more deeply concave than the outer.

Phalanges.

Clidastes. The phalanges of *Clidastes* offer distinctive characters from those of the other genera, which will usually permit them to be referred to this genus without trouble. They are smoother and more sharply truncate at the extremities, the ends being flat or even concave. In the first finger there are four, more flattened and expanded than in the next three fingers. The first is broadly expanded proximally to correspond with the distal extremity of the metacarpal. The remaining three of the first may be distinguished from those of the next three fingers by the outer distal angle being thinned and rounded. In the fifth finger there are three; the first is flattened and much expanded proximally, but is shorter than the corresponding bone of the first finger. The second is not three times the length of its proximal extremity, and all, like those of the first finger, have a distal angle rounded. In the second, third and fourth fingers there are four or five phalanges, all of which are rather slender, markedly constricted, and with their extremities nearly symmetrical.

Platecarpus. In *Platecarpus* the phalanges resemble those of *Clidastes* more closely than those of *Tylosaurus*, and seem to be the same in number or but one or two more in the middle fingers. The bones of the first and fifth fingers are more flattened and unsymmetrical than in the other fingers, but less so than in *Clidastes.* In plate XLIV is shown a paddle of *P. ictericus* drawn by myself many years ago, as the bones lay in position.

Tylosaurus. In *Tylosaurus* the phalanges are more slender than in either of the other genera, and much more numerous. A specimen in the museum of *T. proriger*, from which the characters of the paddles have chiefly been derived, has the front paddle almost absolutely complete and all the bones, or nearly all, in their natural relations. A photograph of the specimen is shown in plate XLVIII, and in the accompanying figure is given the outline of the bones there concealed, as determined from an excavation on the opposite side of the slab. The number of phalanges were apparently as follows: I, 6; II, 9; III, 10; IV, 11; V, 11. The distal one is preserved only in the fifth finger, and is, as is seen, very small and imperfect. I am rather inclined to the opinion that the number of phalanges is not always absolutely uniform in different individuals, though probably varying only within small limits. It will be observed that the fifth finger is longer by far than in either *Platecarpus* or *Clidastes*. It is this specimen in which the remains of the skin are preserved, described in the chapter on the restoration. Between the phalanges, even to their extremities, traces of the skin are found, from which it is evident that the membrane connecting them was very thin and pliable and extended fully to their tips. Small, scale-like scutes are found as far as the metacarpals, beyond which they are wanting everywhere.

In the plates cited above will be seen what are evidently the natural positions of the digits of the front paddles in *Platecarpus* and *Tylosaurus*. The restorations of the paddles given by Marsh are certainly unnatural and unlifelike. There is a gentle curvature of the fingers away from the radial side. While in life the fingers were probably less approximated, it is certain that the fingers were never spread, fan-like. The first finger appears to have been closely approximated to the second, and incapable of much divarication, giving support and strength to the side of the paddle. In the structure of the paddles especially, *Tylosaurus* is the most specialized of the Mosasaurs, and the least lizard-like. The paddles are the most slender, most flexible, and relatively smaller and less strong than in the other genera.

Pelvic Girdle and Extremity.

The pelvic girdle presents more characteristic generic differences than do the bones of the pectoral girdle, though in all the structure is of the same plan. The rod-like ilium ends in a free, flattened extremity, directed obliquely upwards and forwards in life. Its union with the vertebral column is very weak, if there is any union at all. The end probably lies in relation with the first non-costiferous transverse process, though probably without any connection, inasmuch as none of these processes shows any special indication of ligamentous attachments. The pubis is flattened spatulate at the distal extremity, and, if it meets the fellow of the opposite side, the union must be slight. The ischium, on the other hand, shows a broad and somewhat flattened distal extremity of considerable thickness, especially in *Platecarpus*. Doubtless there is a true symphysis here, forming a complete pelvic girdle. The pelvis is, relatively to the pectoral girdle, the weakest in *Clidastes* and strongest in *Tylosaurus*. It is, however, absolutely the strongest and best developed in *Platecarpus* of any of the three genera.

Ilium.

Clidastes velox. The ilium in this species is a slender, somewhat flattened, rod-like bone, gently concave along the upper border, for most of its length, and correspondingly convex below. The extremity is flattened, thin, and somewhat roughened. At the acetabular end the bone is expanded into a thickened head, the anterior border curving suddenly downward, while the posterior or upper is gently convex. It has two facets of nearly equal length, the posterior one for union with the ischium, the anterior for the pubis; a third cupped surface forms part of the acetabulum. The side to which the bone belongs may be determined by the outward direction of this face. The articulations are more roughened, as they are in all the bones of the girdles and extremities, indicating a thicker covering of cartilage.

Platecarpus coryphæus. The ilium in this species is more thickened and stout than in *Clidastes*, and the facets at the proximal extremity less well marked. The upper or posterior border is gently convex, and not sinuous, the convexity greater near the acetabular end.

Tylosaurus proriger. In this species the shaft of the ilium is nearly straight throughout, there being a downward convexity toward the acetabular end. The acetabular end is relatively stout and broad, and the bone more flattened.

Pubis.

Clidastes velox. In *Clidastes* the pubis is the broadest of the pelvic bones. The acetabular end is broadly expanded, with three facets, one on either end of the border, uniting in a slight angle, for ilium and ischium, the third for the acetabulum near the middle and directed outwardly. Below the thickened end there is a moderately constricted, flattened neck, in front of the middle of which is the small pubic foramen. Below this, and directed forward, there is an obtuse, flattened process. Below this process the narrow, flattened shaft of the bone is directed downward into a flattened, somewhat spatulate blade, moderately expanded and slightly thickened at the extremity. The bone is shorter than the ilium and of about the same length as the ischium.

Platecarpus. The pubis in *Platecarpus* is intermediate in shape between that of *Clidastes* and that of *Tylosaurus*. The anterior process exists as a thicker and slightly prominent projection close to the head of the bone. The shaft is placed less obliquely to the long axis of the bone, is thicker and longer, and is considerably expanded distally. The anterior border is thinner than the posterior, nearly straight below the process. The posterior border is thick and concave, the thickened portion of the shaft lying on this side. The distal extremity is thinned on the front part, considerably thickened for the ventral symphysis on the posterior. Internally the bone is flattened longitudinally. Externally it is concave on the upper part transversely. The thickened head for articulation with the ischium is directed upward and backward, the acetabular surface back of the middle is turned outward. The pubic process anteriorly is thickened at its extremity, its oval elongate face for cartilage turned somewhat outward and connected with the cartilaginous surface of the upper part by a narrow neck.

Tylosaurus proriger. The pubis of *Tylosaurus* may be at once distinguished from the same bone in the other genera by the entire absence of the pubic process. The bone also is relatively shorter and less expanded distally. The front border has a gentle convexity from the iliac angle to beyond the middle, whence the margin is more nearly straight to the extremity. The iliac and ischiac borders occupy each about half of the upper end and meet in a slight angle. The posterior border is gently concave or nearly straight throughout nearly the whole extent.

Ischium.

Clidastes velox. The ischium of *Clidastes* has a moderately constricted neck, placed at a strong angle with the long axis of the bone; a prominent, thinned tuberosity directed directly backward, near the upper end of the bone, and separated by a shallow concavity from the acetabular surface; and a stout, thickened and expanded symphysis below. The articular surface for the pubis is nearly parallel with the long axis, and nearly at right angles with that for the ilium.

The *Platecarpus* ischium differs markedly from that of either of the other genera. The ischial tuberosity is small, the pubic face is more oblique to the long axis, and the distal extremity is greatly dilated into a long, angular projection anteriorly. The distal extremity when seen from the end presents a shallow, V-shaped figure, with the pubic border much longer and thinner, the posterior border very stout and thick. The bones evidently meet in a very firm and broad symphysis. From without the bone presents a long, obtuse ridge with the sides shallowly concave. On the inner side there is a corresponding depression.

Tylosaurus proriger. In *Tylosaurus* the bone is less stout than in *Platecarpus*, and resembles that of *Clidastes* more nearly, differing chiefly in the broader blade below, with a broader extremity and less constricted shaft above. The spinous process is more pronounced and is tipped with cartilage. A rather pronounced ridge runs from the uppermost, posterior angle downwards on the inner side, to become continuous with the inflected anterior border of the bone on the lower half. Back of this the surface is concave above, more strongly so below. The blade of the bone below on the outer side is correspondingly convex.

Femur.

Clidastes. The femur of *Clidastes* is a relatively small, rather slender bone. The head is moderately expanded, transverse, with an oval, convex, articular surface. The trochanter, situated on the tibial side, is stout, prominent, directed nearly upward, with the large oval extremity tipped with cartilage, and narrowly separated from the articular surface of the head by a slender neck. The stout, rounded ridge of the trochanter extends below the middle of the bone. The distal extremity is more expanded than the proximal. It has a broad, thickened articular surface for the tibia, and a smaller, thinner and oblique one for the fibula. The tibial border is thickly rounded and gently concave throughout. The shorter and thinner fibular border ends in the thinner rounded lateral expansions above and below.

Platecarpus. The femur in *Platecarpus* is much like that of *Clidastes.* The trochanter is hardly as large, the extremities a little more dilated, the fibular angles a little less rounded. The distal extremity is more expanded.

Tylosaurus proriger. In *Tylosaurus* the femur is more slender than in either of the other genera, but the differences from *Platecarpus* are not great. The lower extremity is more expanded and convex, the sides more deeply concave, of nearly equal depth and length. The sides meet the lower border in an acute angle, lacking the slight convexity of *Platecarpus* and the marked convexity of *Clidastes.* The head of the trochanter stands a little lower down on the bone, and its coarse pitting for cartilage is less distinctly separated from the articular surface of the head by the smooth neck. The bone is nearly bilaterally symmetrical, except the lateral position of the trochanter. In both *Clidastes* and *Platecarpus* the bone is markedly unsymmetrical, the greater flattening and deeper concavity being on the fibular side.

Tibia.

Clidastes velox. The tibia is a moderately stout bone, articulating proximally by a thickened, oval face with the thickened articular facet of the femur. It is more flattened and expanded distally than proximally. The outer border is thick and rounded, and concave longitudinally from near the proximal angle quite to the distal articular face, which it meets in an acute angle. The outer border is thin and moderately deeply concave near the middle, the proximal end convex in outline, the distal end meeting the long convexity of the distal border in an obscure angle. The thickened face for the tarsal is on the inner third of the distal border, and is placed obliquely to the long axis. The articular surface is cupped and oval in outline.

Platecarpus. The tibia of *Platecarpus* resembles that of *Clidastes* more than that of *Tylosaurus.* It is more flattened than in *Clidastes*, less than in *Tylosaurus.* Its outer border is less deeply concave than in *Clidastes;* the articular facet for the tarsal is smaller, the inner border is longer and less deeply concave, almost wholly lacking the convex flattened expansion proximally. The curvature of the distal border does not extend as far proximally.

Tylosaurus proriger. The tibia in *Tylosaurus* is an exceedingly broad, flattened bone, the width of the distal extremity being nearly as great as the length. The outer border is gently concave throughout, while the free, inner, thin border is confined to a shallow notch on the proximal half. The outer distal angle is broadly rounded, as in *Clidastes*, the proximal less so. The proximal border is nearly straight transversely, while the distal is gently convex. There is no facet for a tarsal bone.

Fibula.

Clidastes. The fibula in *Clidastes* is characteristic. It is a small slender bone, with the distal extremity expanded fan-shape. The outer border is the thicker, concave throughout, the concavity deepest beyond the middle, the border meeting each end in nearly a rectangle. The inner side is also concave, the concavity deepest near the middle. The distal extremity is transverse in the middle, rounded on either side. The inner part has a short, thickened facet for articulation with the large tarsal bone. The middle portion is somewhat thinner and has a facet for union with one of the smaller tarsals. The outer part of the border gives attachment to cartilage and meets the lateral border in an obtuse angle. The proximal end is oval in cross-section, the articulation placed obliquely to the long axis, with the inner angle rounded.

Platecarpus. The fibula of *Platecarpus* is not unlike the corresponding bone of *Clidastes*, but is less expanded distally and more symmetrical. The outer border is moderately and nearly evenly concave throughout. The inner border is more deeply concave, with its end slightly convex. The proximal end of the bone is about two-thirds the width of the distal and is nearly transverse. The distal end is somewhat oblique, the inner angle expanded. There is a small facet near the outer end of the border for the tarsal.

Tylosaurus proriger. The fibula in this genus is very small in proportion to the tibia, its extremities but little expanded. The lower extremity is expanded more than the upper; the sides are concave, with the greater concavity on the inner side.

Tarsus.

Clidastes. Of *Clidastes velox* there is but a single tarsal bone preserved. Of *C. westii* there are three or four. The largest is the one articulating with tibia and fibula. The broader tibial extremity has in the proximal side a large oval facet for the tibia, immediately internal to which the bone is directed proximad, with a free oval border to the distal external angle of the fibula. Nearly at right angles to this free border there is an oval articulating facet for the fibula. The outer and distal border is rounded and apparently articulates with no bones. On the inner side there are two articular facets, indistinctly separated for the smaller tarsal bones. These two bones, in *C. westii*, resemble very much the distal carpals. They are irregularly four- or five-sided, the proximal one articulating with the fibula, the outer and distal tarsals, and in part with the fifth metacarpal.

The distal one, a little smaller, articulates with the two tarsals and the metatarsal. The structure of the hind paddle in *Clidastes* is undoubtedly like that of *Mosasaurus*. See pl. XXXI, f. 8.

Platecarpus. The three tarsals preserved in *Platecarpus* show much resemblance to those of *Clidastes*. The largest is more nearly circular, with a short, deep, free notch separating the tibial and fibular faces, that of the tibia the larger and thicker. The outer border is thickened and rounded; the distal and inner side shows two or three facets for the smaller bones. These bones are proportionately smaller than in *Clidastes*. The proximal one, articulating as in *Clidastes*, is the smaller, and is broader from side to side than the length; the other is irregularly five-sided and its diameters nearly equal; its articulations are as in *Clidastes*.

Tylosaurus proriger. In *Tylosaurus* there is but a single tarsal bone, small and rounded. It probably represents the largest of the bones of *Clidastes* and *Platecarpus* and is set in cartilage opposite and between the ends of the two leg bones.

Metatarsals.

No part of the Mosasaur skeleton is known so imperfectly as the digits of the hind extremity. Of *Clidastes*, all that is known with certainty are the first and fifth metatarsals and isolated phalanges. *Platecarpus* and *Tylosaurus* are better known, still not completely.

Clidastes. The first metatarsal in *C. velox* is broadly and obliquely expanded proximally, the angles rounded. The distal extremity is much narrower and the border rectangular, with the outer angle rounded. The inner border is thicker than the outer and more deeply concave, ending more or less acutely. The fifth metatarsal in *C. westii* is a somewhat disk-shaped bone, with one side concave. The proximal and distal ends are thickened for articulation or cartilage. The proximal border is thin and semicircular. The distal border is thickened and rounded and concave. The bone evidently articulates proximally with the two smaller tarsals. Whether there is a phalanx articulating with it distally is not known, but probably not.

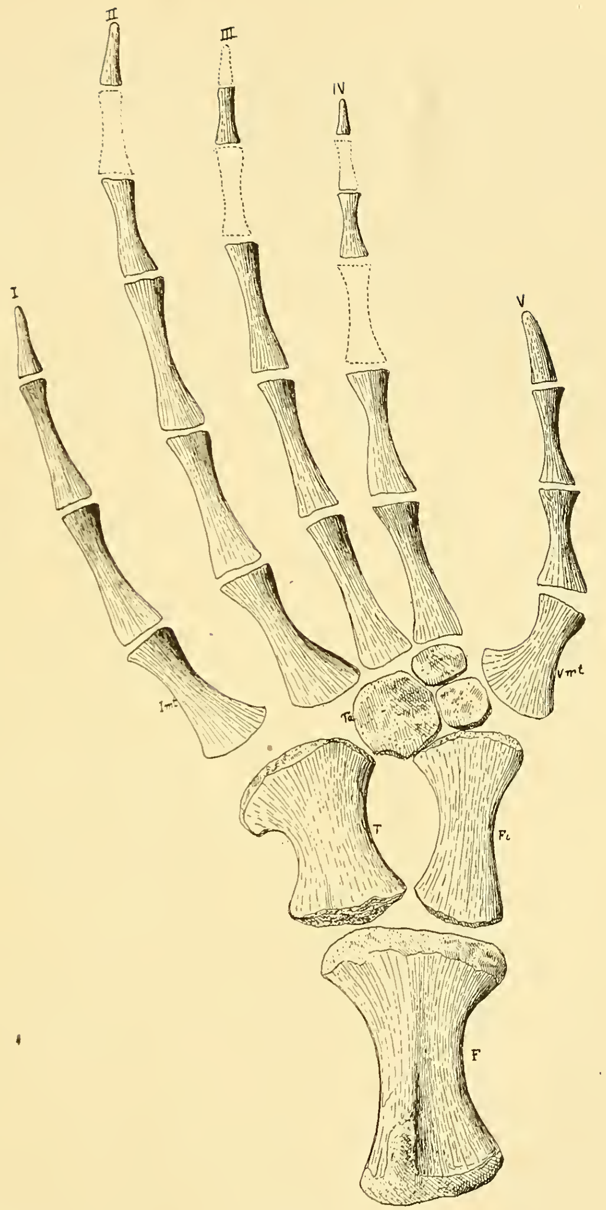

Fig. 5.

Hind paddle of *Platecarpus coryphæus*, in part after Marsh. *F*, femur; *T*, tibia; *Fi*, fibula; *Ta*, tarsals; *Imt–Vmt*, first–fifth metatarsals; *I–V*, first–fifth digits.

Platecarpus. The metatarsals of *Platecarpus* are better known than those of *Clidastes.* The first is the most expanded at the base; the second, third and fourth less so, resembling the phalanges. The fifth is most characteristic; it is thin and flattened, with the proximal extremity much expanded, gently convex and a little oblique. The distal or outer border is more thickened than the opposite, and is concave throughout. The inner or proximal border is thin and slightly concave from the prominent flattened rounded proximal angle. The distal extremity is less than half the width of the proximal, and is only moderately thickened. It is slightly oblique to the long axis of the bone.

Tylosaurus proriger. In *Tylosaurus* the first and apparently the fourth metatarsals are nearly symmetrical bones, with the base broadly expanded and convex in outline. The fifth is very much smaller—smaller relatively than in *Platecarpus,* which it resembles. It is shorter than in that genus, the extremities more oblique. The proximal articular surface is placed at an angle of about forty-five degrees with the long axis of the bone. The outer border is short and deeply concave, and thicker than the inner border. The latter is thin, short, and shallowly concave between the broadly rounded angles. The distal extremity is only a little narrower than the proximal; it is gently convex, and nearly transverse to the long axis of the bone. The bone is not twice as long as wide.

Phalanges.

Clidastes. The phalanges in this genus are of the same general character as those of the hand. Nothing is known of their number and arrangement. In all probability the digits are of a length similar to that in the hand.

Platecarpus. The number of phalanges in the first and fifth toes is probably four, and in the other toes five or six. In their general character they resemble those of the front foot.

Tylosaurus. The best information we have concerning the hind paddle of this genus is the specimen of which a photographic illustration is given (plate L). In all probability there were about five phalanges in the first and fifth toes, and eight or nine in the others. The phalanges are more slender in this form than in the others, and somewhat less constricted. The fifth digit is evidently divaricated, and undergoing reduction, in both of which characters it differs from that of the front foot. A restoration of the paddle, as I think it should be, will be found in the restoration of *Tylosaurus*.

SYSTEMATIC DESCRIPTIONS.

For the sake of completeness and clearness I give herewith the group and generic descriptions of the known European and American Mosasaurs, rather briefly, however, save for the Kansas forms.

The determination of the species described by early authors is in large part clearly impossible in the absence of the type specimens. Species after species have been named, based largely or entirely upon mechanical distortions and mutilations. The conditions of petrifaction in the Niobrara seas were such that the bones of these animals are rarely preserved in their natural shape. Vertebræ are almost invariably flattened, and, if preserved in a vertical position, the bones are depressed; if in a horizontal position, compressed. This distortion is not readily perceived in many specimens, as cracks and breaks are usually wanting, the bones having yielded, as though of a plastic material. For this reason, very little or no dependence can be placed upon the shape of the centra. In fact, the centra in all the forms appear to have greatly resembled each other in shape during life—a rounded or slightly depressed shape in the cervical region, a more depressed or transversely oval in the dorsal, a subpentagonal or pyriform shape in the pygal, and a vertical oval in the caudal region. Just what is the norm of each genus or species it is difficult to say, and will always remain more or less of a problem. For this reason I have entirely ignored this character in the specific determinations.

In the restoration of the skull of the different genera a vast deal of study has been necessary to correct the malformations due to fossilization, the skulls fossilized in different positions having been thoroughly studied, and all compared with the positions of the different bones in the perfectly preserved and undistorted skull of *Mosasaurus horridus* from the Fort Pierre. That all errors have been avoided in the restorations I cannot hope for; I am confident, however, that they have been reduced to a minimum. The limb bones are invariably flattened, and rarely agree exactly. If one takes into account these differences, scarcely ever will any two specimens be found alike; if one ignores them four-fifths of all the described species must be abandoned.

MOSASAURIA.

Pythonomorpha Cope, Proc. Bost. Soc. Nat. Hist., 1869, p. 253.

Large marine reptiles, varying in length between five and forty feet. Limbs wholly natatory, webbed to the extremity of the digits, and without claws, the phalanges often numerous, the arm and leg bones short and broad, and incapable of rotation upon each other, or so to a limited extent only. Pectoral girdle composed of scapula, coracoid, and (in some cases) an interclavicle, the clavicle never present. Sternum, when present, calcified. No sacrum; the anteriorly directed, rod-like ilium feebly or not at all united to the vertebral column. Pubes and ischii united in a ventral symphysis. Vertebræ procœlous, from 115 to 150 (?) in number. Cervical vertebræ seven in number, the first five or six with an articulated hypapophysis. Thoracic ribs not more than fifteen in number, single headed, attached to a stout diapophysis springing from the centrum. All the precaudal vertebræ, except the atlas, costiferous. Zygapophyses stout and strong anteriorly, becoming obsolete at the beginning of the tail, Tail elongate, as long as the precaudal series of vertebrae, more or less compressed, with elongated chevrons, save at the basal part, and with diapophyses anteriorly. Premaxillaries united with each other and with the coossified nasals. Frontal and parietal bones unpaired. A large pineal foramen present. Parietal with decurved, winglike processes for union with petrosal and supraoccipital. Jugal arch complete. Temporal arch composed of squamosal, prosquamosal, and post-frontal. A complete parieto-squamosal arch present. Paroccipital united with exoccipital (?). Quadrate large, free, with a large suprastapedial process, articulating proximally with prosquamosal, squamosal, and sometimes with the exoccipital (paroccipital). Transverse bone small, articulating with pterygoid and jugal only. Pterygoids elongate, approximated in front and behind, but not contiguous, united by ligament to the quadrate, and provided with numerous teeth. Palatines small, without teeth. A ball-and-socket joint between splenial and presplenial. Skull elongated and narrow.

Mosasauridæ.

Mosasauridæ Gervais, 1853.
Clidastidæ Cope, Proc. Bost. Soc. Nat. Hist., 1869.
Tylosauridæ Marsh, Amer. Journ. Sci., XII, July, 1876.
Edestosauridæ Marsh, Amer. Journ. Sci., XXI, p. 55, 1878.

TYLOSAURINÆ.

Tylosaurinæ Williston, Kans. Univ. Quart., VI, A, 180, 1897.

Hind feet functionally pentedactylate. Trunk short, the tail proportionally long, not dilated distally. Tarsus and carpus almost wholly unossified, the phalanges numerous. Vertebræ wholly without zygosphene, or, at the most, very rudimentary. Premaxillary projecting into a long rostrum in front of the teeth. Quadrate with a short suprastapedial process.

Tylosaurus.

? *Macrosaurus* Owen, Journ. Geol. Soc. Lond., 1859, 380.
? *Lesticodus* Leidy, Proc. Amer. Phil. Soc., VII, 10, 1859.
? *Nectoportheus* Cope, Proc. Amer. Phil. Soc., 1868, 181.
Rhinosaurus Marsh, Amer. Journ. Sci., III, 461, June, 1872 (preoc.)
Rhamphosaurus Cope, Proc. Acad. Nat. Sci. Phil., 1872, 141 (preoc.)
Tylosaurus Marsh, Amer. Journ. Sci., IV, 147, 1872.

Moderate to large sized species. Rostrum much produced, the nares situated far back. Facial surface of the parietal produced to the posterior part in the middle, the sides nearly parallel. Postfrontal and prefrontal meeting on the superior orbital border. Prefrontal not expanded on the facial plane over the orbit. Quadrate with a short suprastapedial process. Humerus not broad, the proximal end angulated, the distal end without radial process. Ulna and radius slender. A single carpal or tarsal bone present, not articulating with the adjacent bones. Phalanges very numerous, the fifth finger not reduced. Hind limbs as large as the anterior. Spines of caudal vertebræ not elongated before the distal end. Thoracic vertebræ twelve to thirteen in number, the lumbo-dorsals about ten, the pygal caudals five; whole number of vertebræ not exceeding 120; no zygosphene. Coracoid not emarginate.

The rightful name of this genus cannot be determined until more is known about the forms described from incomplete material from New Jersey. It is altogether likely that *Nectoportheus* is the same, and it is possible that *Macrosaurus* and *Lesticodus* are. In this uncertainty *Tylosaurus* may be retained for the present.

Macrosaurus lævis Owen, was proposed for a genus and species represented by two dorsal vertebræ from the Green sand of New Jersey. Leidy (Cretaceous Reptilia, 75) referred other remains to the same species, but with the remark, "I cannot avoid the suspicion that both the specimens in question and those described by the high authority just mentioned [Owen] really appertain to a dorsal series of *Mosasaurus*." The vertebræ figured by Leidy seem to resemble those Kansas forms referred to *Tylosaurus*, but inasmuch as the genus is distinguished with difficulty by the vertebræ alone it would be hazardous to say with any degree of certainty that they are really the same. Cope, in 1870 (Extinct Batrachia, etc.), referred certain bones to this same species under the name *Liodon*. In the plates of the same work he figured two or three vertebræ over the name of *L. validus*, referred to *L. lævis* in the text, and to *Clidastes antivalidus* in the explanation of the plates. The different names that he used are sufficient evidence of his uncertainty.

In the Proceedings of the Boston Society of Natural History for 1869, p. 260, Cope says of *Macrosaurus:* "This genus has undoubted relationships to *Clidastes;* I have observed in a few of its vertebræ traces of a notch, which, in the latter, separate the zygosphene from the zygapophyses. Unfortunately other portions of the genus are unknown."

Lesticodus was given by Leidy to a species (*L. impar*) represented by teeth and portions of the jaws, and was afterwards abandoned by him. Cope evidently believed that the genus was the same as *Liodon* Cope.

Nectoportheus Cope was based upon *Liodon validus* (olim *Macrosaurus*) and was characterized by him as follows (Extinct Batrachia, etc., 208): "The posterior dorsals are so much more depressed than in *Liodon lævis*, that future discovery may justify the generic separation of the genus *Nectoportheus*, which I originally applied to this animal." In his Cretaceous Vertebrata (p. 160) he says: "The typical species of this genus (*Liodon anceps* Owen) is very little known, but few remains having been obtained from the English Chalk, its locality and horizon. Numerous North American species resemble it in the forms of the crown of the teeth, and it is probable, though uncertain, that they agree in other respects also. Several names have been proposed for our species, the earliest of which is *Macrosaurus* Owen. This name applies to species with compressed dorsal vertebræ, as *L. lævis* and *L. mitchelii*, both from the New Jersey Greensand. For species with the depressed dorsal vertebræ, as *L. validus* from New Jersey, *L. perlatus* from New Jersey, and *L. proriger* from Kansas, the name *Nectoportheus* was proposed and briefly characterized."

The definition of *Tylosaurus* (*Rhinosaurus*) was explicit and exact, leaving no doubt of the genus to which it was intended to apply.

Tylosaurus proriger.

Macrosaurus proriger Cope, Proc. Acad. Nat. Sci. Phil., 1869, p. 163; Ext. Batrachia, etc., pl. XII, ff. 22–24.

Liodon proriger Cope, Ext. Batrachia, etc., 202, Cret. Vert., 161, pl. XXVII, ff. 8, 9; XXX, ff. 10–13; XXXVI, f. 2; XXXVII, f. 6.

Rhinosaurus proriger Marsh, Amer. Journ. Sci., June, 1872.

Rhamphosaurus proriger Cope, Proc. Acad. Nat. Sci. Phil., 1872, p. 41.

Tylosaurus proriger Leidy, Ext. Vert. Fauna West. Terr., 274, 344, pl. XXXV, ff. 12, 13; XXXVI, ff. 1–3. Merriam, Ueber die Pyth. der Kans.-Kreide, 14. Williston, Kans. Univ. Quart., VI, 98, pls. IX–XII; 107, pl. XIII; 177, pl. XX.

This species was the first of the Mosasaurs described from Kansas. "The original description was based upon material in the Museum of Comparative Zoology, Cambridge, Mass., brought by Prof. Louis Agassiz from the Cretaceous beds in the neighborhood of Monument, Kan., and near the line of the Kansas Pacific road." The locality thus given by Cope is not exact. The specimen was undoubtedly found in the vicinity of Monument Rocks, the old overland stage station, which is not near the railroad, while the station, Monument, is not near any Cretaceous outcrops. The species is the most common of this genus, and has been found at nearly all horizons in the Niobrara beds. The characters of the species have been fully given in the preceding descriptions, and need not be repeated here.

Tylosaurus dyspelor.

Liodon dyspelor Cope, Proc. Amer. Phil. Soc., 1870, p. 574; 1871; Cret. Vert., 167, pls. XXVIII, ff. 1–7; XXIX, XXXIII.

Rhinosaurus dyspelor Marsh, Amer. Journ. Sci., June, 1872.

Tylosaurus dyspelor Leidy, Ext. Vert. Fauna West. Terr., 271, pl. XXXV, ff. 1–11; Merriam, Ueber die Pyth. der Kans.-Kreide, 14.

This species, the largest of the Kansas Mosasaurs, was originally described from a specimen obtained from the Niobrara chalk near Fort McRae, N. M. It is the only species of the group found in Kansas that is known to occur elsewhere.

The differences that Cope gives for the species are as follows: "The palatine bones are more slender anteriorly, and the outer edge descends lowest in a ridge; in *L. proriger*, the inner is produced downward as a longitudinal rib. In this species there are eleven teeth; in that one, nine. The quadrate bone of *L. proriger* presents a longer internal angle, and more prominent internal ridge, with smaller space inclosed by the basis of the great ala." These characters are not correct. The "palatines," *i. e.*, the pterygoids, are quite alike anteriorly. In a specimen of *T. dyspelor* I count eleven teeth, as stated by Cope; in two specimens of *T. proriger* I find ten teeth, and I do not doubt but that in others there may be eleven, or that in specimens of *T. dyspelor* there may not be more than ten. This variation is also affirmed by Merriam. The following specific differences are given by Merriam :

(1) The mandible, which is not truncated at the tip, but rounded and narrow. (2) The basioccipital, whose hypapophyses are not so strongly compressed, and, parallel to the longitudinal axis of the head, are scarcely half as broad as in *T. proriger* and *T. micromus.* (3) The pterygoids send out the transverse process in the vicinity of the sixth tooth. (4) The maxillary teeth, which are rounder, with almost no facets on the outer side or striations, while the inner side shows a strong striation.

(1) In two pairs of mandibles of each species I can distinguish no differences in the front end. (2) I can distinguish no differences in the shape of the hypapophyses that are not due to post-mortem origin. (3) In the pterygoids of *T. dyspelor* the two bones of one skull send off the transverse process opposite the seventh and eighth teeth, precisely where they are in *T. proriger.* (4) The teeth of *T. dyspelor* seem stouter, and possibly the characters given may be correct, but I am in doubt. I cannot find characters about which I feel assured. Nevertheless, there can be no doubt but what the two species are distinct. At present, however, this distinction must rest chiefly upon the very much greater size of *T. dyspelor*, rather than upon structural characters. Here, as so commonly elsewhere, the specific characters have been generally obliterated by the compression and distortion of the bones. The skull of *T. dyspelor* measures forty inches in length from the tip of the rostrum to the condyle, and the mandible is forty-eight inches long. The quadrate has a length of seven inches.

Tylosaurus micromus.

Rhinosaurus micromus Marsh, Amer. Journ. Sci., June, 1872, pl. XIII, ff. 1, 2.
Liodon micromus Cope, Cret. Vert., 271.
Tylosaurus micromus Merriam, Ueber die Pyth., etc., 24, pl. I, f. 3.

Scarcely any of the original characters given by the author of this species are valid. In *T. proriger*, "which is three or four times larger than the present species, the cervical vertebræ have vertically ovate articular faces," while in *T. micromus* "the cervical vertebræ have the articular faces but slightly transverse." As the cervical vertebræ of all the species have the faces "slightly transverse," this character is not good for much. Merriam, l. c., who believed that he had identified this species, says that it is distinguished from *T. dyspelor* and *T. proriger* "by its smaller size, by the more lightly formed bones of the skeleton, and by the shape of the quadrate, which has a somewhat longer suprastapedial process, and a larger stapedial groove, and on the upper, inner angle is not so acute."

Tylosaurus nepæolicus.

Liodon nepæolicus Cope, Hayden's Bull. U. S. Geol. Surv. of the Terr., 1874, p. 37; Cret. Vert., 177, 271, pl. xxxv, ff. 11–13.

This was based upon the mandible and parts of the maxilla and premaxilla, the quadrate, a dorsal vertebra, etc. "It is about the same size as *T. micromus* Marsh, but is much more like the *T. proriger* in character. As compared with *T. micromus*, this species differs in the much less attenuated premaxillary and maxillary bones, the anterior nostril, and absence of facets on the crowns of the teeth; from *T. proriger*, in the absence of narrow concave facets on the anterior teeth, and anterior position of the nostril; from *T. dyspelor*, in the less compressed or less knife-shaped dental crowns, and totally different form of the condyle of the quadrate. The total length of the jaw was twenty-six inches — the length of the quadrate about three inches and a half."

The characters given — such as may be valid — are altogether too slight to distinguish the species, and I do not believe that *T. nepæolicus* is entitled to recognition.

There is a very small specimen of a *Tylosaurus* in the museum collection, which may possibly belong to either this or the preceding species, but I believe that it is only the young of *T. proriger*. The humerus measures but three inches in length, the pubis five. The shape of various bones, especially the pelvic ones, is different from those of the other specimens, and, were one to depend upon such characters, it would be easy to construct a species. The bones show much compression; they were evidently more largely composed of organic matter than are the bones usually — a condition expected of young animals.

Hainosaurus.

Hainosaurus Dollo, Premiere Note sur le Hainosaure, mosasaurien nouveau de la craie brune phosphatee de Mesvin-Cipley, Bull. Mus. Roy. Hist. Nat. Belg., 1885, II, p. 297.

Rostrum much prolonged in front of the teeth. Suprastapedial process of quadrate short. Frontal broad, the prefrontal and postfrontal touching each other. Carpals reduced in number. Typical species, *Hainosaurus bernardi* Dollo, *loc. cit.*

This genus is very closely allied to *Tylosaurus*. The phalanges of the front feet are not as numerous, and the paddle is relatively larger. There are, apparently, more numerous dorsolumbar vertebræ. Like *Tylosaurus*, it includes some of the largest species of the Mosasaurs.

PLATECARPINÆ.

Platecarpinæ Williston, Kans. Univ. Quart., VII, A, 181, 1897.

Hind limbs functionally pentedactylate. Trunk short; the tail proportionally long, not dilated distally. Carpus and tarsus imperfectly ossified. Vertebræ with rudimentary or functional (?) zygosphene. Premaxillary not projecting beyond the teeth, very obtuse. Quadrate large, with a long suprastapedial process, not united to infrastapedial process.

Platecarpus.

Holcodus Gibbes, Smiths. Contr., II, p. 9, 1850.
Platecarpus Cope, Proc. Bost. Soc. Nat. Hist., XII, 1869, p. 264.
Lestosaurus Marsh, Amer. Journ. Sci., June, 1872.

Medium-sized Mosasaurs. Premaxillary short and obtuse, projecting very slightly beyond the teeth. Teeth slender, and recurved, faceted upon the outer side and striate on the inner. Nares much dilated anteriorly, situated forward. Frontal emarginated in the middle behind; pineal foramen large, situated near the frontal suture. Facial surface of parietal small, triangular in shape, the apex not extending beyond the middle of the bone. Prosquamosal with a dilated wing-like process above. Quadrate large, with a large suprastapedial process, reaching below the middle of the bone. Expanded portion of palatine short. Coronoid short and not prominent. Zygosphenes of vertebræ rudimentary. Cervical vertebræ seven in number. Thoracic vertebræ not more than fifteen in number, lumbo-dorsals nine or ten; pygial caudals five or six; chevrons large, articulated; spines of caudals regular in length. Limbs relatively large; arm and leg bones short and expanded; three or four carpal or tarsal bones present, closely articulating; pollex and hallux shorter than the fourth digit, divaricated. Coracoid with a deep emargination. Pelvic bones large; ischium much expanded distally; pubis without antero-proximal process.

The genus *Holcodus* Gibbes was proposed for the reception of a species supposed by him to be represented by three teeth from Alabama, South Carolina, and New Jersey. Two of these were figured in his work (pl. III, ff. 6–9), with the following description: "They are solid, and resemble in their pyramidal form those of *Mosasaurus hoffmani* antero-posteriorly, the dividing ridges making the anterior and posterior surfaces equal, and they are both convex. They are also acutely pointed. In *Mosasaurus* the outer surface is plane or nearly so, and both have longitudinal narrow planes near the base. . . . In the teeth under notice, on the outer half are many planes, almost grooves, and also on the inner face, which is peculiarly striated toward the base. As the striated character is a structural distinction, the name *Holcodus* is given to the genus, and that of *acutidens* to the species." Professor Leidy afterward[56] showed that only the tooth from Alabama belonged to a Mosasauroid, the one from New Jersey being that of a crocodile (*Hyposaurus*). He describes Gibbes's type as follows (*op. cit.*): "The specimen has the enameled crown three-fourths of an inch in length. The base is elliptical in transverse section, and measures five lines antero-posteriorly, and four lines transversely. The crown is nearly equally divided by acute ridges, which are imperfect in the specimen, but appear not to have been denticulated. The surfaces are subdivided into narrow, slightly depressed planes, and the inner one is strongly striate

56. Cretaceous Reptiles of the United States, p. 32, foot-note.

at the base." He is inclined to refer the tooth to *Mosasaurus*, a view in which Marsh coincides after examination of the type.[57]

I cannot agree with these authors. Whatever the tooth may be, it is not that of a *Mosasaurus*. Professor Cope erected the genus *Platecarpus* for a species which Leidy had previously referred to *Holcodus*, under the name *tympaniticus*. The specimen which he described was from Mississippi. Later Cope applied the name *Holcodus* to two species from Kansas (*H. coryphæus and H. ictericus*), but which he later placed in *Platecarpus*, after the name *Lestosaurus* had been given to the genus represented by them. In his Cretaceous Vertebrata (p. 141) he says: "The teeth of the Kansas species referred to it are somewhat similar in character to those described by Gibbes; but it is evident that the latter belonged to a different animal more nearly allied to the true *Mosasaurus*." Of *Platecarpus tympaniticus* very little of the skeleton has been described, and the tail is not yet known. At one time (Ext. Batr., etc.) Cope stated that the tail vertebræ of *Platecarpus* had coossified chevrons, upon what authority I cannot learn. Marsh based the distinction of *Lestosaurus* largely upon that character, apparently following Cope. The quadrate of *P. tympaniticus*, as figured by Cope, certainly looks very much like that bone of the Kansas species, and the quadrate in this genus is a very characteristic bone. These questions then, are to be settled before the name *Platecarpus* can be finally accepted for the Kansas forms: First, is the typical *Platecarpus* identical with the *Holcodus?* I believe that it is. The teeth of the Kansas forms agree perfectly with Leidy's description and figure of the type specimen of *Holcodus*. Second, is *P. tympaniticus* congeneric with the Kansas species placed in this genus? This also appears to be true, but it is by no means yet proven. If both propositions are true, our species must be known as *Holcodus*. If the latter only is true, *Platecarpus* will be retained; while if the former is alone true, the name *Lestosaurus* will take precedence. It is a pity that little or nothing has been added to our knowledge of the southern and eastern species of this

57. American Jour. Sci., June, 1872.

group within the last twenty years. Perhaps we may expect more definite knowledge concerning them in the immediate future. There is no inherent improbability that the Alabama or Mississippi species are not congeneric with the western ones, inasmuch as we know positively that one genus at least, *Clidastes*, does occur in all these regions, and it does not seem at all unlikely that all of them are common to the different horizons.

? Platecarpus crassartus.

Liodon crassartus Cope, Proc. Amer. Phil. Soc., 1871, 168.
Platecarpus crassartus Cope, Cret. Vert., 153, 268, pl. XXVI, ff. 4, 12.

This species is known only from Cope's description. Its locality is given from Eagle Tail, in Colorado. The fact is, however, that the locality whence it was discovered is within the borders of Kansas. I visited the precise place of its discovery in company with Professor Mudge, who discovered it many years ago. The horizon is not Niobrara, but clearly Fort Pierre. The species does not belong in the genus *Platecarpus*; of that I feel confident. It evidently has strong relationships with *Brachysaurus*, and I would have referred it to that genus save for the free chevrons. As it is, I am not sure but that it may belong there, or perhaps better in *Prognathosaurus* Dollo.

The peculiar robust condition of the bones is not, however, the most characteristic peculiarity of the species. Bones wherever found in the Fort Pierre invariably have a solidity and thickness never seen in the specimens from the Niobrara. I am confident that the limb bones of the various forms known from the Niobrara had the general robustness seen in this, but have always been flattened and compressed in fossilization. Better characters are found in their shape. Especially is the relative size of the limb bones and vertebræ different from that in *Platecarpus*, the limbs being evidently much smaller. Copies of the principal figures given by Cope are reproduced in plate XLV, which will enable the species to be again recognized. I have no doubt but that future discovery will bring to light much better specimens of this species from the Fort Pierre outcrops in Colorado. The measurements given by Cope are as follows:

"Length of humerus	100 mm.
Proximal diameter of same	95
Distal diameter of same	102
Length of femur	80
Proximal diameter of same	65
Length of a centrum of a dorsal vertebræ without ball	61
Transverse diameter of cup	60
Vertical diameter of cup	53
Length of a pygal vertebra	55
Transverse diameter of ball of same	60
Length of caudal	41
Depth of ball	52
Width of ball	52

"The vertebræ are as much distinguished for their shortness as those of *P. latispinis* are for their elongation. The articular faces are but little broader than deep, and their planes are slightly oblique. The inferior face is somewhat concave in the longitudinal direction. The zygapophyses are stout, and there are no distinct rudiments of zygosphene. The pygals and anterior caudals have round articular surfaces. One of the latter with strong diapophyses, but posterior, is subpentagonal in outline of cup."

? Platecarpus latispinis.

Liodon latispinis Cope, Proc. Amer. Phil. Soc., Dec. 1871.
Platecarpus latispinis Cope, Cret. Vert., 156, pl. XXVIII, ff. 1–4.
? *Platecarpus latispinis* Cope, *op. cit.* 368.

This species is also from the Fort Pierre, and very doubtfully belongs in this genus. There is not enough of the type specimen preserved and described by Cope to locate it definitely. It will, however, some time be recognized, I am confident, and for that reason I give Cope's description fully.

"The remains representing this species consist of seven cervical and dorsal vertebræ; five of them being continuous and inclosed in a clay concretion. The type specimens were found by Prof. B. F. Mudge, one mile southwest of Sheridan, near the 'Gypsum Buttes.' These display the elongate character seen in *Liodon lævis*, etc., but the transverse surfaces are transversely oval, thus resembling the *P. ictericus*. The cup and ball of the penultimate cervical are a little more transverse than those of the fourth dorsal, and none of them are excavated above for the neural canal. The last cervical is strongly keeled on the middle line below, and with a short, obtuse hypapophysis marking the beginning of the posterior third of the length; the median line of the first dorsal has an obtuse ridge. There is no keel on the fourth dorsal, but the lower surface is concave on the antero-posterior direction. The diapophysis on the last two cervical and first three dorsal vertebræ have great vertical extent; the articular surface for the rib is not bent at right angles on the first dorsal. Neural arches and spines are well preserved in most of the specimens. There is no trace of a zygantrum. The neural spines are flat, and have considerable antero-posterior extent on cervical as well as dorsal vertebræ, and are truncate above. First dorsal bears a long, strong rib."

"Transverse diameter of cup of penultimate cervical vertebra..........	51mm.
Length of centrum of fourth dorsal, without ball.....................	72
Vertical diameter of the ball...	45
Transverse diameter of same...	65

Platecarpus glandiferus.

Liodon glandiferus Cope, Proc. Amer. Phil. Soc., Dec. 1871.
Platecarpus glandiferus Cope, Cret. Vert., 156, 168, pl. xxvi, ff. 13, 14.

This species was based upon very slight material. Nevertheless it is possible that it may again be recognized. The two cervical vertebræ upon which it is based were collected from "lower Butte creek" and "one mile southeast of Sheridan." If the locality is accurately given, the second specimen was assuredly from the Fort Pierre. The other specimen must have been in the Niobrara. Unfortunately it is not stated which of the vertebræ was from the North Fork and which from Butte creek. I doubt that the vertebræ are sufficiently characteristic to positively determine the species, but they may be. I give Cope's description and a reproduction of his figures:

"One is an anterior, the other a posterior cervical vertebra. The articular sufaces are transversely elliptic, and completely rounded above; that is, neither truncated nor excavated for the neural canal. This shorter axes are oblique, *i. e.*, make less than a right angle with the long axis of the centrum ; and the articular surface of the ball is thus carried forward on the upper face to much nearer the base of the neurapophysis than usual, in the anterior vertebra nearly touching them. The ball is, likewise, more convex than in any other species, having a slight central prominence in the posterior vertebra. There is no annular groove around the ball. In both, the articular surface of the hypapophysis is truncate and bounded by an elevation in front, a peculiarity not observed in any of the species above described. There is no trace of a zygosphene in either. In the anterior vertebra the diapophyses are nearly horizontal; the posterior portion slightly thickened and oblique. The anterior portion is thinned out, and very rugose above and below, and does not continue its margin into the rim of the cup. In the second vertebra the diapophyses are very large, vertical, and with a horizontal portion rising in a curve to join the middle of the lateral margin of the cup. Neural spine narrowed above and keeled behind.

"Length of centrum of anterior vertebra	64 mm.
Vertical diameter of ball	30
Transverse diameter of same	39
Length of posterior vertebra	64
Vertical diameter of ball	30
Transverse diameter of same	43
Expanse of the anterior zygapophyses	55

Platecarpus tectulus.

Holcodus tectulus Cope, Proc. Amer. Phil. Soc., Dec. 1871.
Platecarpus tectulus Cope, Cret. Vert., 159, 269, pl. XXI, ff. 3–6; XXVII, ff. 5–10.

"Established on a number of cervical and dorsal vertebræ of smaller size than those characteristic of the other species of the genus. The centra have not suffered from distortion under pressure. The articular surfaces are depressed transverse-elliptic in outline with a slight superior excavation for the neural canal. A well-marked constriction surrounds the ball.

"There is a rudimental zygosphene, in the form of an acute ridge rising from the inner base of the zygapophysis, and uniting with its fellow of the other side, forming a production of the roof of the neural canal. The combined keels become continuous with the anterior acute edge of the neural spine. Thus the form is quite different from that seen in *P. mudgei*, and constitutes a lower grade of rudiment. The fact that this zygosphenal roof is separated on each side from the zygapophyses by an acute groove gives the former a distinctness more apparent than real:

"Length of median cervical	43mm.
Diameter of the ball of a median cervical, vertical	20
Diameter of the ball of a median cervical, transverse	33
Length of the anterior dorsal	42
Width of the cup	32

This species was from Butte Creek, "fourteen miles south of Fort Wallace." If this locality is correctly given it may be that the horizon is Fort Pierre. The author speaks of the species as the "smallest known *Platecarpus*." A second specimen, discovered by Mudge from the vicinity of Sheridan, must necessarily be of the Fort Pierre. The material is so very fragmentary from both of these localities that I cannot venture an opinion as to the exact affinities of the species. If a *Platecarpus*, it is probably distinct from any others.

Platecarpus ictericus.

Holcodus ictericus Cope, Proc. Amer. Phil. Soc., 1870, 577; ibid., Dec. 1871.
Lestosauras ictericus Marsh, Amer. Journ. Sci., June, 1872.
Platecarpus ictericus Cope, Cret. Vert., 149, 267, pl. XIV, f. 4; XV, f. 2; XVII, ff. 3, 4; XVIII, f. 6; XIX, f. 9; XX, f. 1; XXV; XXXVI, f. 7; XXXVII, f. 6.

This species was the first of the genus described from Kansas. Several specimens in our collection may be referred to it with tolerable certainty. Just what the essential specific characters are I am not prepared to state. The size, however, which is materially greater than any other, is apparently constant.

In pl. XLIV is given a figure of the front paddle, reproduced from a drawing made in the field by myself in 1875. I cannot say at this time that the drawing is accurate in all details, but from the care taken in its production I believe that it is. It was made natural size, and bears the following in my own writing: "Found by Prof. B. F. Mudge, South Fork Solomon river, Graham county, Kansas, May 27, 1875. Under surface of right fore paddle, sketched in original position, natural size. Size of head, twenty-three inches from tip of snout to occipital condyle. Scapula opposite sixth cervical vertebra (measurements accurate). No. 68." The specimen is at present preserved in Yale museum under the above number, and the accuracy of the drawing may be determined whenever the material in that collection is studied. Measurements of every bone, and the distances between the adjacent ones were given in the drawing.

The drawing is especially valuable as showing the natural position of the digits and their relations to each other. The carpal bones have been partially dislodged, and the four inner metacarpals somewhat disturbed. At the tip of the third finger there was a small oval ossicle, and at the end of the radius a small nodule which was marked "sesamoid?". It was evidently cartilaginous.

By comparison with Marsh's figure of his *Platecarpus simus*, distinct differences will be seen in the shape of metacarpals. These shapes are observed in the material in our collection referred to *P. coryphæus*. It seems evident from the drawing that there were at least four phalanges in the first finger, six in the second and third, five in the fourth, and four in the fifth.

The size of the head, as compared with the paddle, it is seen is very small. The length of the paddle as drawn was twenty-nine inches, and it was at least two inches longer; that is, the proportion was as twenty-three to thirty. In *Platecarpus coryphæus* it was as twenty-one to about twenty-three; in *Clidastes velox*, as fifteen to about ten; in *Tylosaurus proriger*, as thirty-six to twenty-four.

The following measurements of the types by Cope agree with the specimens in our collection:

"Quadrate greatest length	99 mm.
Anterior dorsal, length of centrum	59
Posterior dorsal, length of centrum	55
Scapula, length	145
Humerus, length	154
Radius, length	115

Characteristic differences, other than those of size, absolutely and relatively, are hard to find. Nevertheless I believe that the species will be recognized.

Platecarpus coryphæus.

? *Liodon mudgei* Cope, Proc. Amer. Phil. Soc., 1870, p. 581.
Holcodus coryphœus Cope, Proc. Amer. Phil. Soc., Dec. 1871.
? *Lestosaurus gracilis* Marsh, Amer. Journ. Sci., June, 1872.
? *Lestosaurus simus* Marsh, Amer. Journ. Sci., June, 1872.
Platecarpus coryphœus Cope, Cret. Vert., 142, 267, pl. XIV, f. 3; XV, f. 1; XVI, f. 1; XVII, f. 6; XX, f. 4; XXI, ff. 1, 2; XXXVI, f. 6; XXXVII, f. 9: Baur, Journ. Morph., VII, 1; Merriam, Ueber die Pyth. der Kans.-Kreide, 30; Williston, Kans. Univ. Quart., VI, pl. X.

This species is the best known of the Kansas Mosasaurs, and the most common. Possibly this is due to the fact that it was the best described. "The specimens upon which this species rests were discovered by Prof. B. F. Mudge, formerly State Geologist of Kansas, now professor of geology in the State Agricultural College of Kansas, on the north bank of the Smoky Hill river, thirty miles east of Fort Wallace, Kan."

The description of the species will be found in detail in the comparative anatomical description, and numerous figures and the restoration will be found in the plates.

I believe that I recognize at least three synonyms, *P. mudgei* Cope, *P. gracilis* and *P. simus* Marsh. From the inadequacy of the descriptions of these species I may be in error. Nothing but an examination of the type specimens will determine the matter. Should *P. mudgei* be found identical, the name must supersede *coryphæus*.

I give, however, the descriptions of all three of these species quoted from their authors.

Platecarpus mudgei.

Liodon mudgei Cope, Proc. Amer. Phil. Soc., 1870, 581.
Holcodus mudgei Cope, l. c., 1871, December.
Rhinosaurus mudgei Marsh, Amer. Journ. Sci., June, 1872.
Platecarpus mudgei Cope, Cret. Vert., 157, 268, pl. XVI, f. 3; XVII, f. 5; XXVI, f. 3; XXXVII, f. 7.

"The characters distinguishing this saurian are the following: Vertebræ without rudimental zygosphene; quadrate bones with plane surfaces from the proximal articular surface and the external obtuse-angled ridge to the meatal pit; the latter, therefore, not sunk in a depression, as in the other species.

"The determination of this species rests on a series of specimens from the yellow chalk at a point six miles south of Sheridan, Kan. They consist of three vertebræ and fragments of atlas, with numerous portions of cranium and proximal extremity of scapula."

The determination of this species may be doubtful, but, as only one species in the genus from Kansas antedates it, *P. ictericus*, the name, fortunately, must be eventually acknowledged as of a valid species, should it not be identical with *H. ictericus*. I suspect that the species is identical with *P. coryphæus*.

Platecarpus gracilis.

Lestosaurus gracilis Marsh, Amer. Journ. Sci., June, 1872.

"A marked feature in this skull of this species is the superior surface of the parietals, which is small and subtriangular in outline, with the sides incurved. The internal angle of the proximal end of the quadrate is much less than a right angle, although the great ala is nearly in the same plane as the outer margin of the hook. This leaves a deep, broad notch between the alar process and the internal angle. There is a deep groove below the meatal pit. The articular ends of the cervical and dorsal vertebræ are transversal oval, with a distinct excavation on the superior margin. Rudimentary zygosphene present. Smoky Hill river.

"Length of parietal on median line	46mm.
Width in front	80
Length of quadrate	76
Length of centrum of axis	53

Not a single character is given in the above description to distinguish the species, except possibly the smaller size. It may be referred to *P. coryphæus* with safety. The position of the trochanter of the femur was doubtless due to post-mortem distortion.

Platecarpus simus.

Lestosaurus simus Marsh, Amer. Journ. Sci., June, 1872.

"There are eleven teeth in the maxilla, and thirteen in the mandible. The teeth have their external faces faceted, and marked with irregular striæ, and the inner side strongly striate. The quadrate is large, with a stout elongated hook. The internal angle is nearly a right angle. The distal articular face is prominently convex, with its anterior margin but slightly inflected. There is a large tubercle on the inner margin of the hook opposite the meatal pit, but no articular button. The cervical and dorsal vertebræ have transverse, broadly oval articular faces, slightly emarginated above for the neural canal.

"Length of alveolar portion of dentary	275 mm.
Length of quadrate	93
Length of axis with odontoid	98
Length of centrum of first dorsal vertebra	58
Length of humerus	141
Length of radius	99
Length of ulna	104
Length of ilium	153
Length of ischium	138
Length of pubis	175
Length of femur	116
Length of tibia	56

"This species may be distinguished from *Liodon curtirostris* Cope, perhaps its nearest known ally, but a smaller species, by the number of teeth in the maxillary, which are eleven instead of ten, by the more anterior nareal expanse, and by the supraoccipital keel, which is inclined obliquely forward. The two latter characters separate it also from *Holcodus coryphæus* Cope, from which it likewise differs in its large quadrate. Smoky Hill river." All utterly worthless characters.

Platecarpus planifrons.

Clidastes planifrons Cope, Hayden's Bull. U. S. Geol. Surv., No. 2, p. 31, 31, 1874; Cret. Vert., 135, 265, pls. XXII, XXIII, ff. 1–13; XXXV, f. 16.

? *Sironectes anguliferus* Cope, Bull. U. S. Geol. Surv., No. 2, p. 34; Cret. Vert., 139, 267, pls. XXXIII, ff. 16–18; XXXIV, 1–15, 1875.

The material upon which this species was based is "a large part of the cranium, including the quadrate bone, cervical and dorsal vertebræ and fragments of other elements, all belonging to one individual." Notwithstanding the apparently functional zygosphene, the species evidently belongs in *Platecarpus*, and doubtless would have been located there or in *Sironectes* had the caudal vertebræ been preserved in the type specimen. This is apparent from the parietal bone, which, though incomplete, was evidently of the peculiar *Platecarpus* type; from the shape of the frontal, prefrontal, coronoid and vertebral bones. The vertebræ differ in no important respect from those of *Sironectes anguliferus*, apparently, and the presence of the zygosphenes makes it evident that the species are very closely allied if not identical.

Platecarpus felix.

Lestosaurus felix Marsh, Amer. Journ. Sci., June, 1872.

The larger part of the description of this species is drawn from illusory characters—characters due to the amount of pressure and distortion the specimen has received. In no species of the order does the supraoccipital keel, for instance, incline obliquely backward, to project beyond the basioccipital condyle.

"There are eleven teeth on the maxillary, and twelve in the mandible. The great ala of the quadrate is nearly in the same plane as the external margin of the hook, and hence the inner angle is much greater than a right angle. There is a broad, shallow depression on the front face of the ala near the middle, and below this a deep pit on the inner face above the internal angle at the distal end.

"Width of maxillary at anterior nareal expanse	33mm.
Width of frontal at posterior margin	115
Length of quadrate	81
Length of axis without odontoid process	48
Length of anterior dorsal vertebra	60

Platecarpus latifrons.

Lestosaurus latifrons Marsh, Amer. Journ. Sci., June, 1872.

"The frontals in this species are broad, especially anterior to the orbits, where there is a lateral expansion. Eleven maxillar, twelve mandibular and ten pterygoid teeth. The quadrate has an elongate depression on the back of the ala near the middle, and a deep semicircular excavation under the hook and behind the meatus. The cervical vertebræ are small, their articular ends elliptical, with no superior emargination. Rudimentary zygosphene present. Distinguished from *L. curtirostris* and *H. coryphæus* Cope by the number of teeth in the jaws, or palatines. Smoky Hill river.

"Width of frontals between posterior angles	115 mm.
Width in front of orbits	85
Length of quadrates	77
Length of axis with odontoid process	68

Platecarpus clidastoides.

Platecarpus clidastoides Merriam, Ueber die Pyth. der Kans.-Kreide. 30.

"This species is based upon a parietal, the entire occiput, the quadrato jugal [prosquamosal], the atlas, some dorsal and three caudal vertebræ. It is characterized by the peculiar parietal, that shows anteriorly a low, three-cornered field, in whose middle is the comparatively small, round pineal foramen, which is situated remote from the coronal suture. The parietal is vertically flattened at its posterior end, and shows much resemblance to that of *Clidastes*. The entire appearance of this bone is different throughout from that of other species of *Platecarpus*. That the species belongs to this genus is shown by the perforate basioccipital, and the *Platecarpus*-like lateral piece of the atlas. The vertebræ are so much crushed and weathered that they can be distinguished neither as belonging to *Clidastes* nor *Platecarpus*." Translation from Merriam, l. c. The specimen was collected by Sternberg on the Smoky Hill river, though whether from the Niobrara or Pierre is not certain.

Platecarpus oxyrhinus.

Platecarpus oxyrhinus Merriam, Ueber die Pyth. der Kans.-Kreide, 30.

"This species is based upon two maxillæ, a premaxilla, fragments of a dental, transverse, femur, and ulna. The character by which it is strongly distinguished from all other species, is the elongation of the rostrum, as in *Clidastes*, only the elongation is not as great." Translation from Merriam, l. c. The locality and the collector are the same as of the preceding species.

Plioplatecarpus.

Plioplatecarpus Dollo, Note sur l'osteologie de Mosasauridæ, Bull. Mus. Roy. Hist. Nat. Belg., I, 1882, p. 62.

Oterognathus Dollo, Premier Note sur les Mosasauriens de Mesvin, Bull. Soc. Belg. Geol. Pal. Hydr., III, 1889, 286.

Premaxillary obtuse, not projecting beyond the teeth. Teeth long and slender, faceted and striated. Suprastapedial process of quadrate long; ear cavity large. Mandible slender, the coronoid rudimentary. Chevrons free, not large. Coracoid emarginate. An interclavicle present. Humerus stout. Zygosphenes rudimentary. Type species, *P. marshii* Dollo, l. c. Maestrichtian.

This genus was originally made the type of a new family, based upon the supposed union of vertebræ to form a sacrum. This was afterwards found to be an error by the author and the family withdrawn. The genus certainly belongs in the vicinity of *Platecarpus*, though abundantly distinct, especially in the peculiar shape of the limb bones, as figured, in the mandible, etc.

Prognathosaurus.

Prognathosaurus Dollo, Premiere Note sur le Mosasauriens de Mesvin, Mem. Soc. Belg. Geol., III, 293, 1889.

Premaxillary short, not projecting beyond the teeth. Frontal large and triangular. Prefrontal and postfrontal touching each other. Sclerotic ring conical. Pterygoid with very large teeth. Quadrate with the suprastapedial process strong, coossified with the infrastapedial process below, inclosing an oval auditory meatus. Mandible strong, more or less campylorhynchous,[58] with a large coronoid process. Parietal foramen of moderate size. Hypapophyses of cervical vertebræ free. No zygosphene; chevrons articulated. Coracoid without emargination. Typical species, *P. solvayi* Dollo, l. c. Brown Phosphatic Chalk of Cipley, Upper Senonian.

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58. That is, curved, with its upper border concave.

Brachysaurus.

Brachysaurus Williston, Kans. Univ. Quart., VI, 1897.

Premaxillary probably obtuse. Frontal large and broad. Suprastapedial process of quadrate united with infrastapedial process. No median basioccipital canal. No zygosphene; chevrons coossified.

This genus is yet in large part unknown. As will be seen, there are many striking points of resemblance to *Prognathosaurus*, and I am inclined to suspect that the two genera may yet be found to be identical. The chief distinction, and which, if true, will certainly distinguish the genera, is the union of the chevrons. In *Prognathosaurus* they are free, while in *Brachysaurus* they are coossified, or at least some of them are. The entire chevrons are not preserved in any specimen, but the broken ends indicate clearly that the union was not by articulation. Dollo states, on page 298 of the work cited, that the chevrons are coossified in *Prognathosaurus*, but on the following page that they are free. In a later publication, however, he says that they are free, as determined from additional specimens. If the bone I identify as a part of the pterygoid is really that, the teeth are very large, thus agreeing with the most striking character of the genus *Prognathosaurus*. The species has been described in the foregoing papers, and will be found figured in plates XXX and LXII. Typical species, *B. overtonii* Williston, Kans. Univ. Quart., III, 169, 1895. Geological horizon, Fort Pierre Cretaceous of South Dakota.

Holosaurus.

Holosaurus Marsh, Amer. Journ. Sci., Jan. 1880.

Nothing further is known of this genus than the original description by Professor Marsh. Whether it is a good genus or not cannot be stated with any degree of certainty. The only essential character given by the author to separate it from *Platecarpus* is the non-emargination of the coracoid. As this same character is disregarded in *Clidastes*, it would hardly seem to be of value in this, if there are no other characters.

I give the original description, as follows:

Holosaurus abruptus Marsh, l. c. "The type specimen on which the present genus is based is one of the most complete skeletons of the Mosasauroid reptiles yet discovered. This genus is most nearly related to *Lestosaurus* [*Platecarpus*], and agrees with it in the form and general characters of the skull. It may be readily distinguished by the coracoid, which is entirely without emarginations, as well as by other points of difference. From *Tylosaurus* it is separated widely by the premaxillaries, mandibles, and the palatines.

"The present species was one of the shortest in proportion to the bulk hitherto described, the skull and tail being both abruptly terminated. The entire length was about twenty feet. There are ninety-eight vertebræ preserved between the skull and a point in the tail where the caudals have a diameter of one inch. Many of these vertebræ are in position. The caudals preserved all have articulated chevrons.

"Some of the dimensions of the present specimen are as follows:

"Length of entire lower jaw (two feet)	610 mm.
Length of dentary bone on lower border	342
Length of twelfth vertebra	71
Transverse diameter of ball	50
Length of twentieth vertebra	85
Length of humerus	146
Width of distal end	136
Length of radius	102
Length of ulna	88
Length of femur	141
Width of distal end	85
Length of fibula	117
Width of distal end	100
Length of tibia	99
Width of distal end	76

This specimen was found by myself in the yellow chalk of Butte creek, Kansas, in the summer of 1877.

The estimate of the length is clearly too great. If the proportions are as in the species of *Platecarpus* it would not be over sixteen feet in length. The vertebræ do not vary a great deal in length to the base of the tail, or about the thirtieth vertebra.

The average length of these, according to the measurements, is about three inches each, making ninety inches. The bones of the tail decrease in length rapidly in the tail, the length of the entire tail never being as great as the trunk in front of it. Sixteen feet, it is thus seen, is a large estimate of its length. If the specimen is greater than that, the proportions would furnish sufficient generic difference from *Platecarpus*. The type specimen is now on exhibition in the Yale Museum, and it will be an easy matter to determine the characters.

Cope has believed that this genus is identical with *Sironectes*. The last genus, if genus it be, differs from *Platecarpus* in the functional zygosphenes. If *Holosaurus abruptus* has such zygosphenes, and it is not at all improbable that it may, the synonymy would be extremely probable. It is thus not at all impossible that *Clidastes planifrons* Cope, *Sironectes anguliferus* Cope, and *Holosaurus abruptus* Marsh, are all identical.

Phosphorosaurus.

Phosphorosarus Dollo, Mem. Soc. Belg. Geol., III, 280, 1889.

Suprastapedial process of quadrate much elongated and united below with the infrastapedial process, inclosing an elongated auditory meatus; tympanic cavity extended and shallow. Frontal bone very narrow, with nearly parallel sides, and forming a part of the superior border of the orbits. Parietal bone small, with a triangular superior surface and a very large pineal foramen, bordering upon the frontal. Prefrontal not projecting into a horizontal plate. Type species, *P. ortliebii* Dollo, Brown Phosphatic Chalk, of Mesvin, Belgium.

Although this genus is yet incompletely known, the parts now known present very distinct and important differences from the corresponding ones of any other known genera. The genus is, seemingly, one of the most singular yet described, and further knowledge concerning it will be looked for with much interest. Just what are its nearest relationships, one cannot now say, but I believe that it will be found to be a member of the Platecarpinæ.

MOSASAURINÆ.

Mosasaurinæ Williston, Kans. Univ. Quart., VI, A, 181, 1897.

Hind limbs tetradactylate. Carpus and tarsus fully ossified, and with not more than six phalanges in any digit. Trunk relatively long, the thorax short, the tail much compressed distally, the chevrons coossified wth the centra. Zygosphenes rudimentary or functional. Humerus with a strong radial process at the distal end. Prefrontal more or less dilated into a horizontal plate posteriorly. Coronoid large, articulating with splenial on the inner side. Rostrum short, obtusely conical. Quadrate small, with a suprastapedial process of moderate length.

Mosasaurus.

Mosasaurus Conybeare, in Parkinson, An Introduction to the Study of Fossil Organic Remains, 198, 1822.[59]

Zygophenes rudimentary or wanting.

This character, slight as it is, seems to be the only one that is applicable for the differentiation of the species from those of *Clidastes*. Possibly future knowledge of the forms now known as *Mosasaurus* may determine other characters that will be of generic value either in the separation of this, or for the erection of others. The genus includes the largest of the known Mosasaurs, while those of *Clidastes* are either very small or of moderate size.

Clidastes.

Clidastes Cope, Proc. Acad. Nat. Sci. Phil., 1868, p. 233.
Edestosaurus Marsh, Amer. Journ. Sci., I, p. 417, June, 1871.

Small to medium sized, elongated, and slender. Premaxillary short, projecting but little beyond the teeth, obtusely conical. Teeth faceted upon the outer side, smooth on the inner, or smooth throughout; fifteen or sixteen in number in the maxillæ, seventeen or eighteen in the dentary, and twelve to fifteen in the pterygoids. Nares moderately dilated, situated anteriorly. Frontal not emarginated in the middle posteriorly. Pineal

59. "Mosasaurus, the Saurus of the Meuse, the Maestricht animal of Cuvier. As Cuvier has not yet given it a name, this name is suggested by Mr. Conybeare until he has done so."

foramen of moderate size, situated within the parietal bone. Facial surface of parietal elongate, the sides nearly parallel, emarginate posteriorly. Quadrate relatively small, the suprastapedial process reaching to about the middle of the bone. Expanded portion of the palatine elongate. Vertebræ with functional zygosphenes. Vertebræ from 117 to probably not more than 125 in number. Thoracic vertebræ eleven or twelve, lumbo-dorsals twenty-four or more, pygal caudals seven. Chevrons long, coossified with the centra. Tail much compressed, the spines elongated posteriorly. Limbs small; arm and leg bones short and expanded. Phalanges not more than six in number in any digit. Fifth finger divaricate and shorter than the fourth. Hallux rudimentary or wanting. Hind limb much smaller than the anterior one. Coracoid emarginate or entire. Ischium but little expanded distally, pubis with a proximal anterior process.

These characters are based upon a nearly complete specimen of *C. velox* and the larger part of one of *C. tortor*. The complete tail is known only in *C. velox*, and hence it is possible that the dilatation may not be present in other species.

The genus *Clidastes*, as first described by Cope, was based upon two dorsal vertebræ of *C. iguanavus*, the type species, from New Jersey. Shortly afterward, however, he gave a full generic description, as derived from an unusually good specimen of an allied species, *C. propython*, from Alabama. Only a little later, Marsh described a genus, which he called *Edestosaurus*, from Kansas, but without giving any really distinctive characters from *Clidastes*. The genus *Edestosaurus* has now been rejected by all writers on the Mosasaurs, save its author. It seems hardly necessary to point out the identity. The only distinctive character the author gave for his genus was the insertion of the pterygoid teeth, and even this character he modified later—"Palatine [*sic*] teeth more or less pleurodont."[60]

The genus is certainly very closely allied to *Mosasaurus*, but, I believe, shows sufficient distinctive differences to justify its existence. The form of the animal is elongated, as in that

60. American Journ. Sci., III, June, 1872.

genus, the paddles are of the same structure, and the skull shows very strong resemblances. The presence of functional zygosphenes will at once distinguish the known species.

Three species of *Clidastes* have been described from other regions than Kansas: *C. iguanavus* Cope, from New Jersey; *C. propython* Cope, from New Jersey; and *C. intermedius* Leidy, from the Rotten Limestone of Alabama. Only *C. propython* is well known of these, and a comparison of the published figures and descriptions by Cope (Extinct Batrachia, etc.) will convince one of the very strong relationships with *C. tortor*, especially from Kansas. Indeed, I half suspect that a careful comparison of the specimens may reveal the identity of the species. A specimen discovered some time ago at Flagler, Colo., which I have examined, probably from the Fort Pierre, may indicate another species.

Clidastes stenops.

Edestosaurus stenops Cope, Proc. Amer. Phil. Soc., 1871, p. 330; Marsh, Amer. Journ. Sci., III, p. 264, June, 1872.

Clidastes stenops Cope, Cret. Vert., etc., pp. 133, 266, pl. XIV, ff. 4, 5; XVII, ff. 7, 8; XVIII, ff. 1, 5; XXXVI, f. 3; XXXVIII, f. 3.

This species is very peculiar in lacking the expansion of the prefrontal over the orbit anteriorly, its shape being more nearly as it is in *Platecarpus*. In all other respects, however, it is true *Clidastes*. "The prefrontal is of peculiar form, and displays the greatest difference from that of *C. tortor*. Instead of being a horizontal bone, it is so oblique as to be nearly vertical. From this follows an alteration of the relation of all the parts. The squamosal suture with the frontal, which is marked by peculiar concentric rugosities in both species of this genus, instead of being on the upper, is nearly on the under surface, though oblique to both. The lateral margin is subinferior and plicate; the crest of the inner side bounding the maxillary projects far below it in front. The characters are similar to those of *C. tortor;* but all the bones are more massive, though of the same dimensions."

Nothing is known of the extremities.

Clidastes cineriarum.

Clidastes cineriarum Cope, Proc. Amer. Phil. Soc. 1870, p. 583. Cret. Vert. etc., pp. 137, 266; pl. XXI, ff. 14–17. Bull. U. S. Geol. Surv., Hayden, III, p. 583.

"The type specimen of this species consists of vertebræ and pterygoid teeth. There are two anterior dorsals, three lumbars [pygals] and one caudal. The articular faces of the caudals are broad vertical ovals." This practically is all that is given to distinguish the species, a character that is more or less illusory and unsatisfactory, and in this present case wholly insufficient. "The centrum of the anterior dorsal is much compressed." Collected by Professor Mudge, six miles south of Sheridan.

Clidastes velox.

Edestosaurus velox Marsh, Amer. Journ. Sci., I, p. 450, June, 1871.
Edestosaurus pumilus Marsh, l. c., p. 452.
Clidastes affinis Leidy, Rep. U. S. Geol. Surv., Hayden, p. 283, 1873.
Edestosaurus dispar Marsh, Amer. Journ. Sci., XXIX, pl. I, Jan. 1880.
Clidastes velox Williston and Case, Kans. Univ. Quart., I, 15, pls. II, III, 1892. Williston, Kans. Univ. Quart., II, p. 83, pl. III. Merriam, Ueber die Pyth., etc., p. 31, pl. III.

This species has been used in the foregoing pages as typical of the genus, and a description of the different parts is given in detail, as based upon an unusually perfect skeleton discovered by myself in the summer of 1891 and now mounted in the museum. See plate LXII.

The diagnostic characters of the species are found in the structure of the quadrate, as described on a preceding page, in the emarginate coracoid, and in the structure of the front paddles, especially the forearm and carpal bones.

Marsh has figured a specimen of *Clidastes* with emarginate coracoid under the name of *C. dispar*, but, from my memory of the specimen, which was collected by myself, I am quite sure that he was wrong in its determination. The quadrates of the two species are readily distinguishable, and the figure of the type of *C. dispar* shows that it cannot possibly be the same as this. Cope expressed the opinion to me that the presence or absence of an emargination in the coracoid is sufficient for generic separation. I am not inclined to agree with him, in the absence of other important differences. Should it be deemed sufficient, however, the name *Edestosaurus* cannot be used for this genus to include *C. velox*, since *C. dispar* is the type of *Edestosaurus*.

Of the identity of *C. affinis* Leidy, I have no doubt. The figures and descriptions given by Leidy agree perfectly, except that he describes the back teeth of *C. affinis* as having the enamel strongly striated, with the surface presenting evidences of subdivision into narrow planes. The differences from the actual condition of our specimens in this particular are so slight that I do not think the character has any weight.

In the paper cited above, Williston and Case expressed the opinion that *C. pumilus* Marsh is identical with *C. velox*. Merriam, who has examined specimens since then, would accept the species as distinct. "*C. pumilus* Marsh, zeichnet sich besonders durch seine geringe Grösse aus, welcher Eigenschaft wohl einer specifischer Werth beizulegen ist, weil man sonst annehmen müsste, das Individuen mit der geringen Schädellänge von 22 cm. zu derselben Species gehören wie die grossen Exemplare von *C. velox*."[61]

Nevertheless, it is a question of considerable moment how much specific weight can be placed upon size alone. Not a single character given by Marsh (the structure of the quadrate, basioccipital, etc.) is constant for the species. The only difference is size, so far as I can ascertain, after the most careful scrutiny of the various specimens in the museum. Possibly the jaws are more slender, and the articulation more oblique, but, if so, there must be other species which are intermediate in these characters, yet unnamed. Leidy (l. c., *supra*) expressed his views of the specific value of size as follows: "It is a question of some importance how far difference in size among the Mosasauroids may be a test of difference of species. Among the numerous remains of these animals which have been discovered, I have never yet observed any which presented any

61. Paleontographica, Ueber die Pythonomorphen, etc., XLI, 35.

relative to age. . . . In this view of the case, some of the many species of Mosasauroids may have been founded on different ages of the same."

This statement I can corroborate. I have seen altogether not far from 2000 specimens of Mosasaurs, and have collected with my own hands not less than 400. But I have never seen one that could unhesitatingly be pronounced to be that of a young animal. And certainly the Mosasaurs did not all die of old age. One suspects the youth in some cases from the distorted condition of the bones, due probably to less well-ossified conditions. The neural sutures are never found unclosed, and rarely do we find the bones of the skull macerated and separated. It is certain, then, that size cannot have a very great specific value.

The smallest specimen of a Mosasaur in our collection has the mandibles 250 mm. in length; that is, indicating an animal a little over six feet in length. These mandibles are more slender than are those of the specimen of *C. velox* used for description, but no more slender than in another specimen of larger size that should be referred to *C. velox*. In this specimen the jaws have a length of 365 mm. In the smallest specimen the coronoid projects much beyond the proximal end of the presplenial, while in all the other specimens the dentary projects much further back.

Marsh has given certain characters for the quadrate of *C. pumilus* which do not exist in the smallest specimen under examination. The quadrates in this specimen measure but thirty-three mm. in length, with the distal articular face twenty mm. in extent, precisely that of the type. The two quadrates agree exactly with those of the *velox* described in the foregoing pages, and *C. velox* has perhaps the most characteristic quadrate of any species of the genus. The inner face is not concave longitudinally on the anterior border, as it is in all those that I know of or that have been figured, but is nearly straight. The sharp ridge beginning just below and to the anterior side of the stapedial pit and extending towards or to the anterior inferior angle is present, and always wanting in the quadrate of the other species. Just anterior to the pit, on the border, there is a small roughening, as in *C. velox*, and of which there is no sign in the specimens of other species at my command. The rugosity below the stapedial process is confined to the outer side, as in *velox*, and the length of the process is the same. The shape of the distal articular face presents no tangible differences. Furthermore, *C. velox* and the present are the only species of the genus now known in which the coracoid is emarginate; the two species agree in the paddles quite, and no two other species do. Finally, there are specimens in the museum which are intermediate in size between the two.

Taking all these facts into consideration, I am still of the opinion that there is but a single species.

Clidastes tortor.

Edestosaurus tortor Cope, Proc. Amer. Phil. Soc., Dec. 1871. Marsh, Amer. Journ. Sci., III, 264, April, 1872.

Clidastes tortor Cope, Cret. Vert., etc., pp. 48, 265, pls. IV, f. 1; XIV, f. 2; XVI, ff. 2, 3; XVII, f. 1; XIX, ff. 1–10; XXXVI, f. 3; XXXVII, f. 2. Bull. U. S. Geol. Surv. Hayden, III, p. 583. Williston and Case, Kans. Univ. Quart., I, 25.

Edestosaurus dispar Marsh, Amer. Journ. Sci., June, 1871; June, 1872, pl. I, ff. 1, 3.

Edestosaurus rex Marsh, *op. cit.*, June, 1872, pl. II, f. 1.

Clidastes medius Merriam, Ueber die Pyth. der Kans.-Kreide, 35.

The material referred to this species in the University of Kansas consists of one nearly complete skeleton and the incomplete remains of five others. The descriptions given are taken almost exclusively from the complete specimen, which was collected by the late Judge E. P. West. The species appears to be the most common of this genus in the Kansas chalk. I believe that I recognize three synonyms of the species in those previously described.

Edestosaurus dispar was the type of the genus. Its characters, both generic and specific, were given together, as is the custom of the author. The essential characters given by him, that is, those not common to other species, are as follows:

"In the cervical and anterior dorsals the cup and ball are somewhat inclined: in the posterior dorsals and lumbars [pygals] less so, and in the anterior caudals they are nearly, but not quite vertical. The articular faces in the cervicals are a broad, transverse oval, faintly emarginate above for the neural canal. The quadrate has the same general form as in *C. propython*, but the external angle is situated further back, and has a notch in its posterior margin directly above the meatal pit. The posterior superior process is shorter, with a compressed free end. The teeth are curved and somewhat compressed. The enamel is smooth and shows faint indications of broad facets on the basal half. There were at least fifteen pterygoid teeth." In plate I, June, 1872, the author figures the coracoid, scapula, quadrate, and pelvis. The coracoid, though incomplete, shows the absence of the emargination, as in fact the author explicitly states ("There is certainly no emargination in the coracoid of *Clidastes, Edestosaurus*, and *Baptosaurus*, as specimens in the Yale museum conclusively prove"). It is true that Marsh in a later paper [62] figured a specimen with emarginate coracoid under the name of *Edestosaurus dispar*, but it is certain that his identification of his own species was wrong, since no species but *C. velox* (and *C. pumilus*) is yet known to have an emarginate coracoid. The specimen figured was collected and prepared by myself, and I have no hesitation in saying that the species is *C. velox*.

That the emargination was overlooked by the author seems strange, since he separated *Holosaurus* at the same time from *Platecarpus* (*Lestosaurus*) upon that very character. If this character is of generic value, then *C. velox* must receive a new name, since *E. dispar* is the type of *Edestosaurus*, and hence perfectly synonymous with *Clidastes*.

The paddles and quadrate agree quite with the corresponding bones of *C. tortor*. The notch in the margin of the upper border of the quadrate of *C. dispar*, upon which Marsh places much importance, is an individual character only, and of slight importance.

Edestosaurus rex, Marsh described essentially as follows:

"The skull is elongate, the frontal converging very regularly in front. The palatines have fourteen teeth. The shaft of the

62. American Journ. Sci., XIX, pl. I. f. 1, Jan. 1880.

ilium is less sigmoid than in *E. dispar*, and the ischium more expanded distally. The pubis appears to have had a more prominent anterior process. The articular ends of the anterior caudals are vertically oval."

The species differs, according to the author, from *C. tortor* and *E. dispar*, in "the less number of the pterygoid teeth and in other characters." The absence of one tooth in the pterygoids is not of specific importance. If the other characters had been of any importance the author would have stated them. The shape of the pelvic bones, by reference to his figures, one will see to be of trivial importance, and all might easily have been the result of imperfect preservation. Until these "other characters" are forthcoming, it will be quite safe to consider *C. rex* as a synonym of *C. tortor*.

Clidastes medius Merriam was based upon the shape of the prefrontal bone. "Die meisten knochen stimmen mit den entsprechenden von *C. velox* und *C. tortor* überein," but the prefrontal "nicht so weit in der Entwickelung zu einer einfachen horizontal Platte vorgeschritten ist."

In the absence of further differences and figures, I think it may be safely assumed that the difference of the prefrontal bone has been due to imperfect preservation rather than to a specific structure.

Clidastes wymani.

Clidastes wymani Marsh, Amer. Journ. Sci., June, 1872, plate ii, f. 1.

This species was based upon two specimens — one including the chevron caudal vertebræ; the other, parts of the skull and anterior vertebræ. It is, of course, not at all certain that the two skeletons belonged to the same species.

"The specimens indicate a small reptile, very near *C. propython* in size, but differing from that reptile in several important particulars. One of the most noticeable of these is the form of the muzzle, which in the present specimen has a short and obtuse extremity, not unlike that of *Liodon proriger* Cope (*Tylosaurus*). The basioccipital has the condyle deep vertically, and only a shallow groove on the upper surface for the neural canal. The quadrate has the postero-superior process free at its lower extremity. Just below this there is a prominent rugose knob, with a deep pit under it entering from the external border.

"In the cervical vertebræ, the outline of the articular faces is transverse cordate, the ball of the axis showing a marked difference in this respect from that of *C. propython*, where it is subpentagonal. The centra of the anterior dorsals are elongate, and much constricted behind the diapophyses. The cup here becomes broader, and the emargination deeper. In the anterior caudals the articular faces are a broad vertical oval. There are eighty-one caudal vertebræ preserved, the last fifty being continuous. The terminal ones are less than one-twelfth of an inch in transverse diameter.

Measurements.

"Length of axis with odontoid process	39 mm.
Width between diapophyses	35
Length of sixth cervical without ball	27
Width of cup	18
Distance from end of muzzle to center of first tooth	12

North Fork of Smoky river."

Clidastes liodontus.

Clidastes liodontus Merriam, Ueber die Pyth. der Kans.–Kreide, Pal., XLI, p. 35, 1895.

"This species is represented in the Munich collection by the nearly complete, though very fragmentary upper jaw, premaxillary, and dentary. The premaxillary is drawn out into a sharp point and possesses four teeth, which are rounded at their base and which show anteriorly a tolerably strong, on the distal third of the outer side a very weak carina. The maxillæ have the border for the premaxillary oblique as far as the fifth tooth. The maxillary teeth, like those of the dentary, are rounded at the base and compressed toward the apex, with a strong carina anteriorly and a somewhat lateral one posteriorly. Toward the hind end of the jaw the teeth are more strongly compressed and at the end strongly so. All the teeth are quite smooth, and may be compared with those of *Liodon* Owen, from which they are scarcely or not at all different."

The teeth are unknown in *C. cineriarum* and *C. westii*, either of which may be the same.

Clidastes westii.

Clidastes westii Williston and Case, Kans. Univ. Quart., I, p. 29, 1892.

The specimen upon which this species was based consists of a complete lower jaw, quadrate, fragments of the skull, the larger part of the vertebral column, and the incomplete hind and fore paddles. The vertebræ preserved are in two series, the one, numbering thirty-three, continuous with the skull; the other, sixty-three in number, all chevron caudals. The terminal caudals preserved indicate that there were several more in life, perhaps eight or ten; the first of the series was evidently among the first of those which bore chevrons. Altogether, the tail may have had seventy-five chevron caudals. The length of the two series are respectively seventy-one and seventy-two inches. Assuming that there was the same number of precaudal vertebræ as in *Clidastes velox*, the entire vertebral column would have measured in life fifteen feet and four inches. The lower jaw shows the skull to have been very nearly twenty-four inches in length, giving a total length for the animal when alive of seventeen and one-half feet. It is thus seen that the species is one of the largest of the genus.

While the skeleton was only about one-half longer than that of *C. velox* described in the foregoing pages, or of about the same length as a very complete specimen of *C. tortor* in the museum collection, the proportions of the animal were very much stouter. The figures given in plate LIII of the twenty-fifth, or eighteenth dorsal, vertebra will show the proportions between length and breadth. It is upon these remarkably stout proportions, and the shape of the articular faces as indicated by the figures and the measurements appended, that the species is chiefly distinguished from those previously known. The articular surfaces of the basal caudal vertebræ are remarkably triangular in shape, with the angles rounded and the sides of nearly equal length. This triangular shape is persistent for the first twenty of the series as they are preserved. The paddles, as shown in plates XXXV and XXXVI, show much stouter proportions than in any other known species.

The coracoid is rather more transversely expanded than in *C. velox*, with the posterior border more convex. There is no emargination whatever. The scapula is not unlike that of *C. velox*. The humerus differs slightly only in that the radial border is more nearly the length of the ulnar, and that the distal facets for the radius and ulna are more obliquely placed to each other. The radius is very distinctly different in the much shorter free outer border, which is shorter than the articular surface of the proximal articular surface. The articulation for the radius is placed less obliquely to the long axis and more nearly at right angles to the outer cartilaginous border, which is here less convex and more nearly parallel to the long axis of the bone. The ulna shows only slight differences; on the outer side of the distal articular surface there is a distinct facet for the medial carpal, wanting in *C. velox*.

Of the carpals, the radial is broader on its outer side, removing the first metacarpal further from the radius. Its proximal inner angle is not at all emarginate to help form the free border between the radius and ulna. The medial is rather broader from side to side, the free border more concave and extending from the radius to the ulna; on the inner side the bone articulates for a short distance with the ulna, which is not at all the case in *C. velox*. The ulnare and the bones of the distal row resemble those of *C. velox* closely. Of the metacarpals the fourth is peculiar in having the proximal inner angle much produced, so that the proximal articular surface is sinuous, and very oblique to the long axis of the bone.

Measurements.

Length of dentary	400 mm.
Depth opposite the first tooth	20
Depth opposite last tooth	62
Entire extent of mandible	630
Greatest depth at coronoid process	95
Length of axis with odontoid process	80
Length of axis without odontoid process	70
Vertical diameter of ball	24
Transverse diameter of ball	33
Length of fourth cervical vertebra to rim of ball	49
Expanse of diapophyses	82

Length of fifth cervical to rim of ball	49 mm.
Transverse diameter of ball	35
Expanse of diapophyses	90
Length of fourteenth vertebra to rim of ball	54
Transverse diameter of ball	40
Vertical diameter of ball	33
Length of eighteenth vertebra to rim of ball	50
Transverse diameter of ball	40
Vertical diameter of ball	36
Length of thirtieth vertebra to rim of ball	54
Transverse diameter of ball	46
Length of quadrate	65
Length of humerus	92
Length of radius	68
Length of ulna	65
Length of femur	95
Length of tibia	70

The specimen upon which this species is based was collected by Chas. Sternberg, from near McAllaster, in the Fort Pierre.

GENUS INCERTÆ SEDIS.

Baptosaurus.

Halisaurus Marsh, Amer. Journ. Sci., XLIII, Nov. 1869 (preoc.)
Baptosaurus Marsh, Proc. Phil. Acad., XXIII, Jan. 1870.

This genus was based upon a New Jersey species, represented "by a posterior cervical and an anterior dorsal vertebra; the right splenial bone with its concave articular face, and a small portion of the base of the skull." Another species (*H. fraternus* Marsh) from the same region was established on an anterior dorsal and two posterior dorsal vertebræ, found not far from each other, and probably part of the same series." The characters given for the type species (*H. platyspondylus* Marsh) are as follows: "This species is especially characterized by the great depression of the centra of the vertebræ, which gives the articular ball and cup a very transverse elliptical outline, exceeding in this respect apparently those of any other reptile. The vertebræ, so far as known, are also elongate, and without the zygosphenal and zygantral articulation." The coossification of the cervical hypapophyses is also given as a distinctive character. —

Baptosaurus onchognathus.

Baptosaurus onchognathus Merriam, Ueber die Pyth. der Kans.-Kreide, 36, 1894.

"Among the material collected by Mr. Sternberg there was, in one of the boxes, some vertebræ and parts of a skull of like appearance. They belong, apparently, to the same individual. The single fragment of a jaw [pl. xxv, f. 6, after Merriam] agrees, except the abnormal articular, with *Platecarpus* or *Tylosaurus*, distinct, however, in that the upper border of the articular, immediately behind the cotylus, instead of being directed downwardly at an angle of about forty degrees, is turned vertically upwards into a high process, from which the hind end of the lower jaw has a hook-like appearance. Also at the posterior inferior angle, where in *Platecarpus* and *Tylosaurus* there is an elongated thickening, the border is thickened suddenly to more than twice the thickness behind this place, and then becomes suddenly thinner below the posterior end of the cotylus. There is a much crushed quadrate present, which possesses a supracolumellar [suprastapedial] process very much like that of *Platecarpus*." In a note he says: "Since the completion of the manuscript I have seen the original of Professor Marsh's *Baptosaurus*, and am convinced that the remains in the Munich museum really belong to the genus *Baptosaurus*." See, also, pl. XLI, f. 3.

The lower jaw is so extraordinary that there will be no trouble in referring a similar structure to the same genus, notwithstanding the absence of other information concerning the species. The type species appears to have been much distorted from pressure, which may render the specific recognition somewhat difficult.

The absence of all information concerning the genus, except, practically, what is given above, prevents much if anything being said about its proper position. The types of the genus are from a much higher horizon than the Kansas species (which may be, however, from the Pierre) and it would be remarkable if the genus should be found to really occur in both places. It would seem strange that, in all the many hundreds of specimens of Mosasaurs taken from the Kansas chalk previously and since, no other specimen has been found, I believe, that can be referred to this genus. The species remains as a problem which I fear will not be fully solved soon.

RESTORATION OF THE KANSAS MOSASAURS.

In plate LXXII are given restorations of the three well-defined types of Mosasaurs from the Kansas Niobrara Cretaceous—*Clidastes*, *Platecarpus* and *Tylosaurus*. They are based exclusively upon the material in the University of Kansas museum, and have been drawn with the greatest care. But very little about them is in any ways conjectural.

Clidastes is restored from a single specimen, discovered by myself on Butte creek, in Logan county, in the summer of 1891. It is, I believe, the most perfect specimen of a Mosasaur in any museum of the world. Another specimen, nearly as complete, of *Clidastes tortor*, collected by the late E. P. West two or three years previously, has offered some suggestions in the arrangement of the bones. The specimen of *C. velox* lacks some of the terminal phalanges of the front paddle, and many of the hind paddle; it is, therefore, not certain that these parts are correct in all details. That there could have been many more or less phalanges than what are figured, is impossible, since the ones preserved largely determine the number that are missing.

Platecarpus is based chiefly upon a single specimen, comprising the nearly complete disarticulated skull and a connected series of the vertebræ to beyond the middle of the tail, the sixty-fifth, together with the pectoral and pelvic girdles and many of the bones of the limbs. All the limb bones are present in other specimens of the same species. The position of the digits of the front paddle has been determined by the paddle of *P. ictericus* figured in plate XLIV; that of the hind paddle by the figure given by Marsh.[63] As in *Clidastes*, some of the digits may have

63. American Journ. Sci.

had a few phalanges more or less, but certainly not enough to perceptibly modify the general form. The only parts conjectural in the restoration are the number of the thoracic ribs and the precise number of the caudal vertebræ with chevrons. There are no characters present in this or any other genus by which the number of thoracic ribs may be determined save by their actual preservation *in situ*. That they were materially different from what is figured, is impossible, since many of the short ribs are preserved in some of the specimens. Isolated caudal vertebræ and partly connected series are present in other specimens, from which it is evident that the tail agrees in its general characters well with that of *Tylosaurus*. They may have been a few more or less of the small vertebræ, but certainly not enough to perceptibly modify the length in the restoration.

Tylosaurus is based almost wholly upon three specimens in the museum, one with the posterior part of the head and the absolutely complete series of vertebræ, connected from head to tip of tail, collected by E. P. West; the second, with the skull and cervical vertebræ equally complete, obtained from Mr. H. T. Martin; the third, with the paddles nearly complete, together with many ribs and vertebræ. This last specimen is the one collected by Professor Snow, in which the skin is preserved as figured in plate LXX.

Each of the three animals thus restored has its own peculiar characters, representing three distinct types of the group, which I have already defined. The skull of *Platecarpus* is the broadest; that of *Tylosaurus* the slenderest. The jaw teeth are most numerous in *Clidastes;* the fewest and most powerful in *Platecarpus*. The pterygoid teeth, on the other hand, are the strongest in *Tylosaurus;* smallest and least effective in *Platecarpus*. Correlated with these dental peculiarities are the large size of the paddles in *Platecarpus*, and the small size in *Tylosaurus*. The skull of *Platecarpus* has a more rounded contour posteriorly, and the striking size of the quadrate is conspicuous.

In *Clidastes* the slenderness of the body, the shortened and small thorax, the much greater length of the lumbo-dorsal region, and the proportionally shorter tail are all noticeable. The preterminal dilatation of the tail, together with the more elongate chevrons and their rigid coossification with the centra, all show a more powerful propelling organ than is the case with either of the other genera.

The differences in the paddles in the three genera are also conspicuous, those in *Platecarpus* being the largest, and those of *Tylosaurus* the smallest. The hind paddles in *Tylosaurus* are the largest and the least reduced. Hyperphalangy is carried to the greatest extent in *Tylosaurus*, where the fifth digit of the front paddle, also, is not at all reduced. On the other hand, the phalanges are least numerous in *Clidastes*. The flexibility is greatest in *Tylosaurus*, where mobility is obtained at the expense of strength. In *Clidastes* the opposite extreme is seen. In the one, control over the different movements through the water was due chiefly to the tail; in the other, to the limbs. In *Clidastes* the bones of the limbs are all closely articulated, and the tarsus and carpus are fully ossified. In the other genera, and especially in *Tylosaurus*, the limb bones had a greater amount of cartilage between them and the joints were correspondingly less well formed and less perfect. In *Clidastes* the ossification of the bones is more complete; their texture is finer and more solid, and the bones are less liable to distortion or compression.

Upon the whole, *Platecarpus* combined the greatest flexibility with the greatest strength, and was, for its size, the most powerful and most pugnacious of the Kansas Mosasaurs. In later geological times its prowess was doubtless contested by the species of *Mosasaurus* proper. In the Kansas seas, however, *Platecarpus ictericus* was, I believe, the king of the Mosasaurs, though neither the largest nor the most fleet in its movements.

In size, the maximum among the Kansas Mosasaurs was reached in *Tylosaurus dyspelor*, which may have attained a length of thirty-five feet, with a head measuring four feet in length. The smallest and most graceful of all was *Clidastes pumilus*, which had a length of about six feet. A few species larger than *T. dyspelor* are known from New Jersey, some possibly attaining a length of thirty-seven or thirty-eight feet, and some species yet larger are, I believe, reported from Europe. I am confident, however, that there never has been a Mosasaur in existence—certainly none whose remains are now known—whose length was greater that forty-five feet. The text-books and popular descriptions place the length of these animals at from 75 to 100 feet.

The habits of the animals when alive are not hard to conjecture. They were marine lizards, living for the most part in shallow waters, though, often, especially the largest species, venturing far out to sea. That they did not usually frequent deep water, as did the Plesiosaurs, is probable. There are pebbles from the stomach of a Plesiosaur in the University museum which must have been brought to Kansas from hundreds of miles away—longer journeys than I believe the Mosasaurs ever made. Perhaps this fact will account for the entire absence, so far, of the Mosasaurs in the Benton rocks, while they do occur most abundantly in the shallower water deposits of the Niobrara in Kansas, especially towards the close of the epoch.

While the flexibility and loose union of the jaws doubtless permitted animals of considerable size to be swallowed, the structure of the pectoral girdle would never have permitted any such feats of deglutition of which the python and boa are capable. It has been supposed that the lower jaws were capable of an anterior prolongation in swallowing their prey, but such must have been very slight, since the union with the pterygoid is too firm to permit much, if any, motion here. In the pictures of the skull, the remarkable, though incomplete, ball-and-socket joint back of the middle of the jaw is conspicuous, differing in this respect from all other reptiles, ancient or modern. That there was any degree of vertical motion here is scarcely possible, since the union of the jaw above was too close. As has been described, a thin plate of bone passed across the joint and was ensheathed within the presplenial, permitting probably a small amount of lateral bending, but little or none of vertical. The animals living in the water, with no solid objects to aid in deglutition, the body not serpentine enough to coil about the prey and hold while being forced down the gullet, and the limbs non-prehensile and small, it is seen that, without some peculiar modification of the jaws, food would have been swallowed with difficulty. This peculiar modification is seen in the structure of the joint in the jaws. It has been supposed that the prey, after seizure, was pulled down the throat by the alternate protrusion and fixing of the separated jaws. This, however, could not have been true. The mandibles in front, while not rigidly connected, yet show ligamentous union, and, as we have seen, the quadrates were largely fixed by the pterygoids posteriorly. The jaws, acting together, pulled the prey backward by the lateral bending at the articulation, and then both were disengaged after the upper jaw teeth and the pterygoid teeth had been inserted. Possibly a saurian of the largest size might have swallowed entire an animal as large as a two year-old-calf, but I doubt the possibility. Their food was evidently the numerous small fishes that swarmed the seas with them, with perhaps an occasional animal of their own kind. Possibly this will account for the fact that young Mosasurs are almost unknown as fossils.

"The habit of swallowing large bodies between the branches of the under jaw, necessitates the prolongation forward of the mouth of the gullet; hence, the throat in the Pythonomorpha must have been loose and almost as baggy as a pelican's. Next, the same habit must have compelled the forward position of the glottis or opening of the windpipe, which is always in front of the gullet. Hence these creatures must have uttered no other sound than a hiss, as do animals of the present day which have a similar structure, as, for instance, the snakes. Thirdly, the tongue must have been long and forked, and for this reason: its position was still anterior to the glottis, so that there was no space for it, except it were inclosed in a sheath beneath the windpipe when at rest, or thrown out beyond the jaws when in motion. Such is the arrangement in the nearest living forms, and it is always in these cases cylindrical and forked." The above, by Cope, was written under some misapprehensions of the true nature of these animals. Still I believe that he was correct for the most part. The skin of the neck was not necessarily more bagged than that of *Varanus*, and the sounds uttered by the animals must have been practically such as are uttered by *Varanus*, since the structure of all the parts here was doubtless the same in both animals. *Varanus* has a long, forked tongue, and I do not doubt but that the Mosasaurs had such also.

The Mosasaurs must have been practically helpless on land. They were not sufficiently serpentine, especially *Tylosaurus* and *Platecarpus*, to move about on *terra firma* without the aid of limbs, and these were not at all fitted for land locomotion. That they may have frequented the beaches for the purpose of depositing their eggs is probable, though not certain. They were certainly not viviparous.

That they were pugnacious in the extreme is very evident from the many scars and mutilations which they suffered during life. I have observed exostosial growth in their lower jaws, the vertebræ, especially those of the tail, and the paddles, especially the digits. In some the mutilations have been extensive. One tail of a *Platecarpus* has the spines of the distal half of the tail broken off and false joints produced. Never have I known of a case where there has been evidence of ante-mortem loss of the tail, or any part of it. A paddle of another specimen, figured in part in plate LVI, has the bones of the forearm, carpus and metacarpals all united by exostosis.

Coprolites which I have always had reason to believe were from these animals are in some places very abundant, weighing from an ounce or two up to a half pound or more. They are ovoidal in shape, with sphincter or intestinal impressions upon them, and contain very comminuted parts of fish bones, fish scales, etc.

Whether or not they are Mosasaurian in origin, I doubt not that the food of the Mosasaurs consisted almost exclusively of fishes, living or dead, and such small animals as drifted upon the water. Their bones frequently bear the impression of teeth, of post-mortem origin, and in many cases I have found the teeth of small sharks imbedded in them. Invariably, after long experience, I have learned that a missing part of a specimen could never be found in the immediate vicinity. A distance of a single foot without a bone always means that no more of the skeleton may be found in extensive excavations.

And yet, some disturbances of the bones took place after falling to the bottom ; vertebræ are dislocated and paddle bones almost always separated. The skull is always attached firmly to the vertebral column. When one finds a cervical vertebra joined to its mate, he may confidently expect that the head will be uncovered by further excavation.

Bones of the hind paddles are always much less common than those of the front, and such bones in position are among the greatest of rarities.

The animals were covered completely by a scaly skin, the scales in size and shape so closely resembling those of a large monitor that a further description is unnecessary. But a single specimen showing these scales is known, that of the *Tylosaurus* which has furnished the best paddles of the genus yet known. The specimen was discovered by Chancellor Snow many years ago on Hackberry creek in Gove county, and the large slab with the bones was safely transported to the museum. Plate LXIX is made from the electrotype originally used by Chancellor Snow in the description of the skin.[64] In plate LXX is given a reproduction from the photograph which was used in the production of the wood engraving. The two together will convey a most perfect idea of the skin. The impression, or rather the carbonized scales themselves, are from the anterior part of the body, from the region over or just back of the scapula.

In plate LXXI is given a restoration of *Clidastes velox* as it is believed it appeared in life, based upon all the evidences given in the foregoing pages. It is not possible that the picture can be very far from the real truth. Whether or not the animal had colorational markings, it is of course impossible to say, but that its shape was nearly like what the artist has depicted is fairly certain. Possibly the abdominal region was larger than is shown, but I believe not.

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64. Transactions Kans. Acad. Sci., VI, 54.

The frontispiece, from a painting by Mr. J. Carter Beard, the well-known artist, has been for the most part based upon the restorations of the present volume, and others published elsewhere by myself. It is, I believe, as nearly correct as it is possible for such an ideal representation of extinct animals to be. The Petrodactyls and Plesiosaurs, not treated in the present volume, will be fully described and figured in the next one of this series, I trust. It is not at all probable that the saurians were often upon land, as they are represented, though possible.

EXPLANATION OF PLATES.

(Pages 223–347.)

The following abbreviations apply to all the plates of the skull:

Ang, angular.
Art, articular.
Bo, basioccipital.
Bs, basisphenoid.
Cor, coronoid.
Dn, dentary.
Eo, exoccipital.
Fr, frontal.
Jug, jugal.
L, lachrymal.
Max, maxilla.
Na, nares.
Oc, occipital condyle.
P, parietal.
Pal, palatine.
Pet, petrosal.
Pfr, prefrontal.
Pmx, premaxillary.
Po, postorbitofrontal.
Prs, prosquamosal.
Prsp, presplenial.
Ptg, pterygoid.
Q, quadrate.
S, squamosal.
So, supraoccipital.
Spl, splenial.
St, stapes.
Sur, surangular.
Tr, transverse.
V, vomer.

PLATE X.—Skull of *Clidastes velox* Marsh, from the side.

PLATE XI.—Skull of *Clidastes velox* Marsh, from above.

PLATE XII.—Skull of *Clidastes velox* Marsh, from below.

PLATE XIII.—Skull of *Platecarpus coryphæus* Cope, from the side.

PLATE XIV.—Skull of *Platecarpus coryphæus* Cope, from above.

PLATE XV.—Skull of *Platecarpus coryphæus* Cope, from below.

PLATE XVI.—Skull of *Tylosaurus proriger* Cope, from the side.

PLATE XVII.—Skull of *Tylosaurus proriger* Cope, from above.

PLATE XVIII.—Skull of *Tylosaurus proriger* Cope, from below.

PLATE XIX.—Skull of *Mosasaurus horridus* Williston, from the side.

PLATE XX.—Skull of *Mosasaurus horridus* Williston, from above.

PLATE XXI.—Skull of *Mosasaurus horridus* Williston, from below.

PLATE XXII.—Upper figure, maxilla and mandible of *Brachysaurus overtonii* Williston (the articular and splenial bones are shown from the inner side, the other bones from without); lower figure, left mandible of *Platecarpus coryphæus*, from the inner side.

PLATE XXIII.—Upper figure, left mandible of *Clidastes westii* Williston, from the outer side; lower figure, right mandible of *Clidastes tortor* Cope, from the inner side.

PLATE XXIV.—Fig. 1, right pterygoid of *Platecarpus coryphæus*, from below; fig. 2, premaxilla of same, from below; fig. 3, the same, from above; fig. 4, postorbitofrontal of same, from within; fig. 5, left jugal of same, from without; fig. 6, sternum of *Clidastes velox* Marsh, after Marsh; fig. 7, left quadrate of same, from without.

PLATE XXV.—Fig. 1, left maxilla of *Platecarpus coryphæus*, from without; fig. 2, the same, from within; fig. 3, prefrontal of same; figs. 4, 5, transverse bones of same; fig. 6, posterior part of mandible of *Baptosaurus onchognathus*, after Merriam.

PLATE XXVI.—*Platecarpus coryphæus.* Fig. 1, parietal, from above; fig. 2, frontal, from above; fig. 3. frontal, from below; fig. 4, left prosquamosal, from without.

PLATE XXVII.—Upper figure, posterior view of skull of *Platecarpus coryphæus;* fig. 1, radius of *Clidastes westii*, 1a, ulna; fig. 2, radius of *C. tortor*, 2a, ulna of same; figs. 3, 4, radii of *C. velox;* 3a, 4a, ulnæ of same.

PLATE XXVIII.—Fig. 1, quadrate of *Clidastes velox*, from within; fig. 2, the same, from without; fig. 3, the same, from in front; fig. 4, the same, from behind; fig. 5, pterygoid tooth of *Platecarpus coryphæus*, enlarged; fig. 6, mandibular tooth of *Clidastes tortor*, enlarged; fig. 7, mandibular tooth of *Platecarpus coryphæus*, enlarged; fig. 8, radius of *Platecarpus coryphæus.*

PLATE XXIX.—Fig. 1, mandibular tooth of *Tylosaurus proriger*, from within, showing socket of successional tooth, enlarged; fig. 2, posterior cervical vertebra of *Clidastes tortor*, from behind, showing zygantrum; fig. 3, sclerotic plates of *Platecarpus coryphæus*, enlarged; fig. 4, anterior end of vomer of *Platecarpus coryphæus*, from without, enlarged; fig. 5, undetermined bone of *Platecarpus coryphæus*, enlarged.

PLATE XXX.—*Brachysaurus overtoni.* Fig. 1, mandibular tooth, natural size; fig. 2, frontal bone, from above; fig. 3, left quadrate, from within; fig. 4, posterior cervical vertebra, from behind; 4a, the same from below; fig. 5, median caudal vertebra, from behind; fig. 6, humerus; fig. 7, undetermined paddle bone. Except fig. 1, one-half natural size.

PLATE XXXI.—Figs. 1, 2, 3, hyoid bone of *Platecarpus*, natural size, after Marsh; figs. 4, 5, pygal vertebra of *Platecarpus coryphæus*, from behind and from the side; fig. 6, coracoid and scapula of *Clidastes velox*, from behind; fig. 8, part of hind paddle of *Mosasaurus lemoinii*, after Dollo, much reduced. Other figures one-half natural size.

PLATE XXXII.—Left figure, part of left paddle of *Mosasasurus horridus*, one-third natural size; *h*, humerus; *R*, radius; *U*, ulna; *I*, first metacarpal; right figure, right quadrate of *Mosasaurus horridus*, from within, two-thirds natural size.

PLATE XXXIII.—Incomplete left front paddle of *Clidastes velox: C*, coracoid: *S*, scapula: *Hm*, humerus: *I*, first digit; *V*, fifth digit.

PLATE XXXIV.—Pelvis and part of left hind paddle of *Clidastes velox: Il*, ilium: *P*, pubis: *Is*, ischium: *F*, femur: *T*, tibia: *Fi*, fibula; *Ta*, tarsal *Imc*, first metatarsal. Three-fourths natural size.

PLATE XXXV.—Pectoral girdle and part of right front paddle of *Clidastes westii: S*, scapula: *C*, coracoid; *H*, humerus; *R*, radius: *U*, ulna; *I*, *II*, and *IV*, first, second and fourth metacarpals.

PLATE XXXVI.—Part of right hind paddle of *Clidastes westii:* femur, tibia, fibula, tarsals, and first metatarsal.

PLATE XXXVII.—Right scapula and coracoid of *Clidastes tortor*, from without: *S*, scapula; *C*, coracoid.

PLATE XXXVIII.—Part of left front paddle of *Clidastes tortor: h*, humerus: *r*, radius; *u*, ulna: *ue*, ulnare: *re*, radiale; *o*, third carpal of distal row; *Imc*, first metacarpal.

PLATE XXXIX.—Upper two figures: proximal and distal ends of humerus of *Clidastes westii;* right-hand figure, right pelvic bones of *Clidastes tortor*, the upper element the ilium, the lower right one the pubis, the lower left one the ischium; lower left-hand figure, the left pelvic bones of *Clidastes dispar* Marsh, after Marsh.

PLATE XL.—*Tylosaurus proriger.* Fig. 1, femur, from below; fig. 2, ilium; fig. 3, right ischium, from without; fig. 4, left ischium, from within; fig. 5, femur, from above; fig. 6, radius; fig. 7, metacarpal; fig. 8, ulna; fig. 9, radius; figs. 10 and 11, indeterminate bones of *Brachysaurus overtonii.*

PLATE XLI.—Fig. 1a, left ilium of *Tylosaurus proriger*, from without: 1b, pubis of same; 1c, ischium of same; fig. 2, pubis of *Platecarpus;* fig. 2a, ischium of same; fig. 3, posterior cervical vertebra of *Baptosaurus onchognathus*, from behind, after Dollo; fig. 4, posterior cervical vertebra of *T. dyspelor*, from behind; fig. 5, the same, from the side.

PLATE XLII.—Fig. 1, Pygal vertebra of *Tylosaurus dyspelor*, from behind; fig. 2, the same, of another specimen, from in front; figs. 3, 4, median dorsal vertebra of *Platecarpus coryphæus*, from the side and from behind; figs. 5, 6, posterior cervical vertebra of *Clidastes tortor*, from behind and from the side.

PLATE XLIII.—*Platecarpus ictericus: S*, scapula, from without; *C*, right coracoid, from without.

PLATE XLIV.—Right front paddle of *Platecarpus ictericus*, from above, after a drawing made *in situ* by the author: *H*, humerus; *R*, radius; *U*, ulna; *MC*, metacarpals; *I* and *II*, *III*, *IV*, *V*, first to fifth digits.

PLATE XLV.—Fig. 1, radius of *Platecarpus*, side and end views; fig. 2, tibia (?) of *Platecarpus*, side and end views; fig. 3, humerus of ? *Platecarpus crassartus*, after Cope; fig. 5, dorsal vertebra of same, from below; fig. 4, indeterminate paddle bone of same.

PLATE XLVI.—Left humerus of *Platecarpus coryphæus*, from below; fig. 2, distal end of same; fig. 3, the same, from above; fig. 4, proximal end of same; *s*, scapula of *Tylosaurus dyspelor*, from without; *c*, coracoid of same, from without; *s*, right scapula of *T. dyspelor*, from without; *c*, coracoid of same.

PLATE XLVII.—Left-hand figure, frontal bone of *Clydastes tortor*, from above; right-hand figure, right pelvic bones of *Platecarpus simmus*, after Marsh, from without: *a*, ilium; *b*, ischium; *c*, pubis; *d*, femur.

PLATE XLVIII.—Coracoid and front paddle of *T. proriger*, as imbedded in the chalk, the left-hand figure, outlines of the bones as determined from the two sides of the slab.

PLATE XLIX.—Left pelvic bones of *T. proriger*, as imbedded in the same slab as the preceding; the lower right element is the pubis; the left, the ischium.

PLATE L.—Hind paddle of *Tylosaurus proriger*, in matrix: *f*, femur; *f'*, fibula; *t*, tibia; *ta*, tarsal; *mc*, metatarsal; *Vm*, fifth metatarsal.

PLATE LI.—*Platecarpus coryphæus*, in matrix: fig. 1, right humerus, from below; fig. 2, left coracoid, from without; fig. 3, right scapula, from within; fig. 4, left humerus, from above; fig. 5, carpal; fig. 6, radius; fig. 7, cervical hypapophysis; figs. 8, 9, cervical ribs; figs. 10, 11, 12, thoracic ribs; fig. 13, cartilage.

PLATE LII.—*Platecarpus coryphæus:* fig. 1, left humerus, from below; fig. 2, ulna; fig. 3, right lateral piece of atlas, from within.

PLATE LIII.—Fig. 1, thirty-eighth vertebra of *Clidastes westii*, from behind; fig. 2, the same, from below.

PLATE LIV.—Pygal vertebræ, from behind: fig. 1, *Tylosaurus* sp., from Fort Pierre; figs. 2, 3, *Platecarpus coryphæus;* fig. 4, *Clidastes tortor;* fig. 5, anterior caudal vertebra of same.

PLATE LV.—Bones of *Tylosaurus proriger*, in matrix: fig. 1, radius; fig. 2, humerus; fig. 3, coracoid; fig. 4, cartilage.

PLATE LVI.—Figs. 1, 2, 4, femora of *Platecarpus coryphæus;* fig. 3, radius; fig. 5, radius, carpus, and part of metacarpus, showing exostosial growth.

PLATE LVII.—Figs. 1, 2, radii of *Platecarpus* sp.?; fig. 3, tibia of *Clidastes* sp.; fig. 4, tibia of *Platecarpus coryphæus;* fig. 5, fibula of same; fig. 6, metatarsal of same; fig. 7, fifth metatarsal of same; figs. 8, 9, 10, tarsals of same.

PLATE LVIII.—Figs. 1, 2, 3, radii of *Platecarpus coryphæus;* figs. 4, 5, 6, ulnæ of same; fig. 7, radial carpal of same; fig. 8, ulnar carpal of same; figs. 9, 10, distal carpals of same.

PLATE LIX.—*Tylosaurus dyspelor:* fig. 1, humerus; fig. 2, radius; fig. 3, ulna; figs. 4–8, metacarpals and phalanges.

PLATE LX.—Fig. 1, right quadrate of *Tylosaurus proriger*, from behind; fig. 2, left quadrate of same, from within; fig. 3, left quadrate of *Platecarpus coryphæus*, from without; fig. 4, right quadrate of *Clidastes westii*, from in front; fig. 5, right quadrate of *Clidastes tortor*, from without; fig. 6, right quadrate of *Clidastes velox*, from behind; fig. 7, left quadrate of same, from within.

PLATE LXI.—Figs. 1, 2, quadrates of *Tylosaurus dyspelor*, from without and within; fig. 3, right scapula of *Platecarpus coryphæus*, from without; fig. 4, left quadrate of *Clidastes tortor*, from within.

PLATE LXII.—Fig. 1, humerus of *Brachysaurus overtonii;* fig. 2, coracoid of same; fig. 3, skeleton of *Clidastes velox*, in matrix.

PLATE LXIII.—*Platecarpus coryphæus:* fig. 1, parietal bone, from below; fig. 2, petrosals, from behind; fig. 3, left jugal, from within; fig. 4, left prosquamosal, from within; fig. 5, odontoid; fig. 6, atlantar intercentrum; figs. 7, 8, lateral pieces of atlas, from within and without; fig. 9, coronoid; fig. 10, surangular, from within; fig. 11, articulo-angular, from within.

PLATE LXIV.—Fig. 1, left quadrate of *Clidastes tortor*, from behind; fig. 2, left quadrate of *Platecarpus coryphæus*, from without; anterior caudal vertebræ of *Platecarpus coryphæus*, in matrix; quadrates of same.

PLATE LXV.—Posterior thoracic and anterior dorsolumbal vertebræ and ribs of *Tylosaurus proriger*, in matrix.

PLATE LXVI.—Posterior caudal vertebræ of *Tylosaurus proriger*, in matrix.

PLATE LXVII.—Terminal caudal vertebræ of *Tylosaurus proriger*, in matrix, continuation of those in plate LXVI, the proximal ones showing ante-mortem injuries.

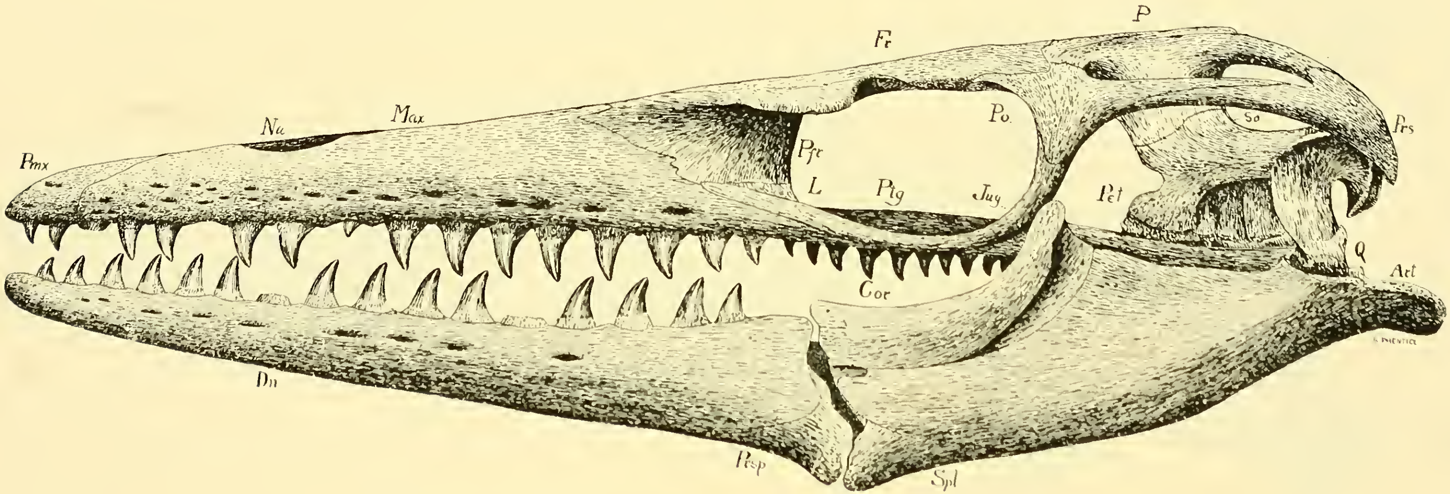
PLATE LXVIII.—Slab with specimen of *Tylosaurus proriger*, on which imprints of skin occur; the impressions are at the left side below the vertebræ and ribs.

PLATE LXIX.—Skin impression of *Tylosaurus proriger.*

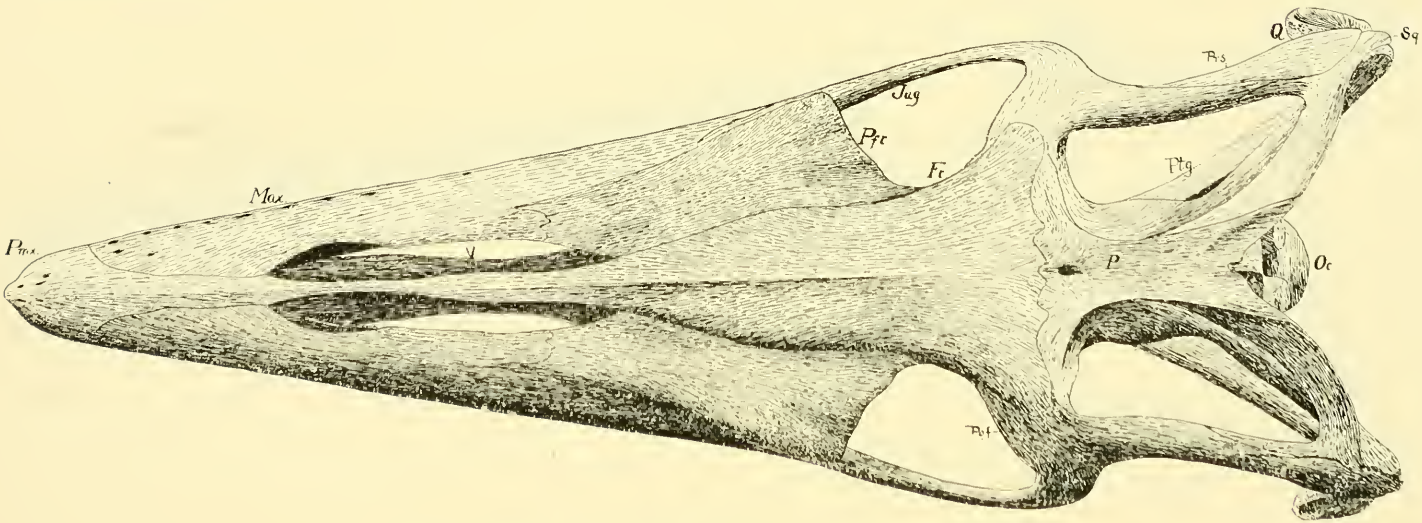
PLATE LXX.—Photographic reproduction of part of plate LXIX, reversed.

PLATE LXXI.—Restoration of *Clidastes velox*, as in life, the middle figure; restoration of *Uintacrinus socialis* at left; restoration of *Ornithostoma ingens* at right.

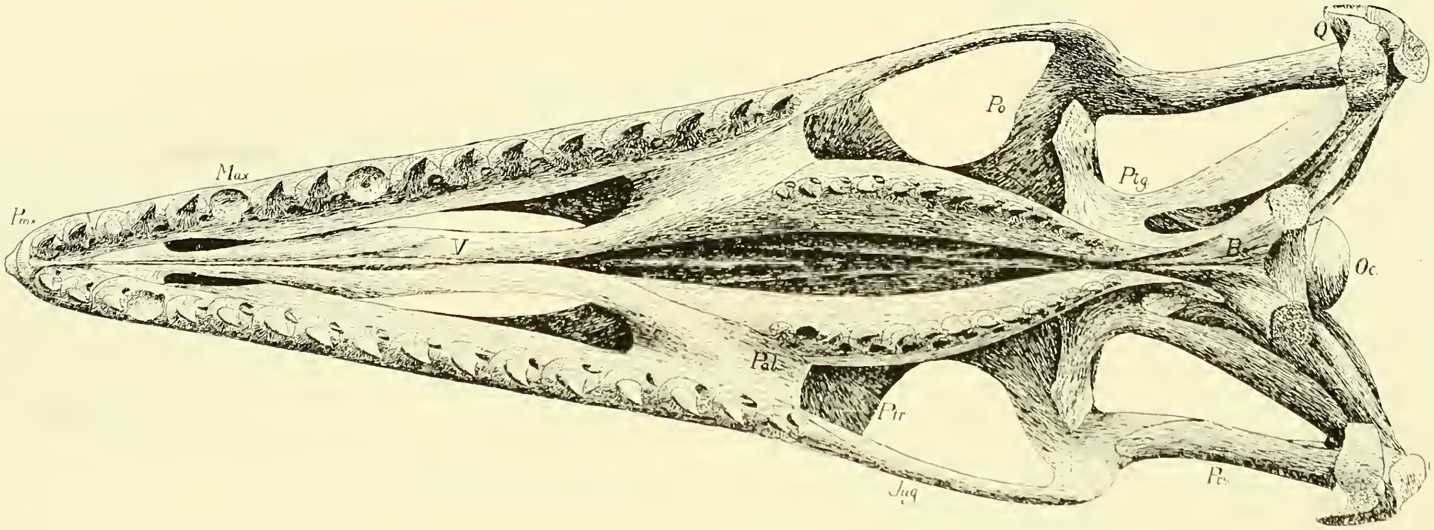
PLATE LXXII.—Restoration of the skeletons of Kansas Mosasaurs: fig. 1, *Clidastes velox*; fig. 2, *Platecarpus coryphæus*; fig. 3, *Tylosaurus proriger.*



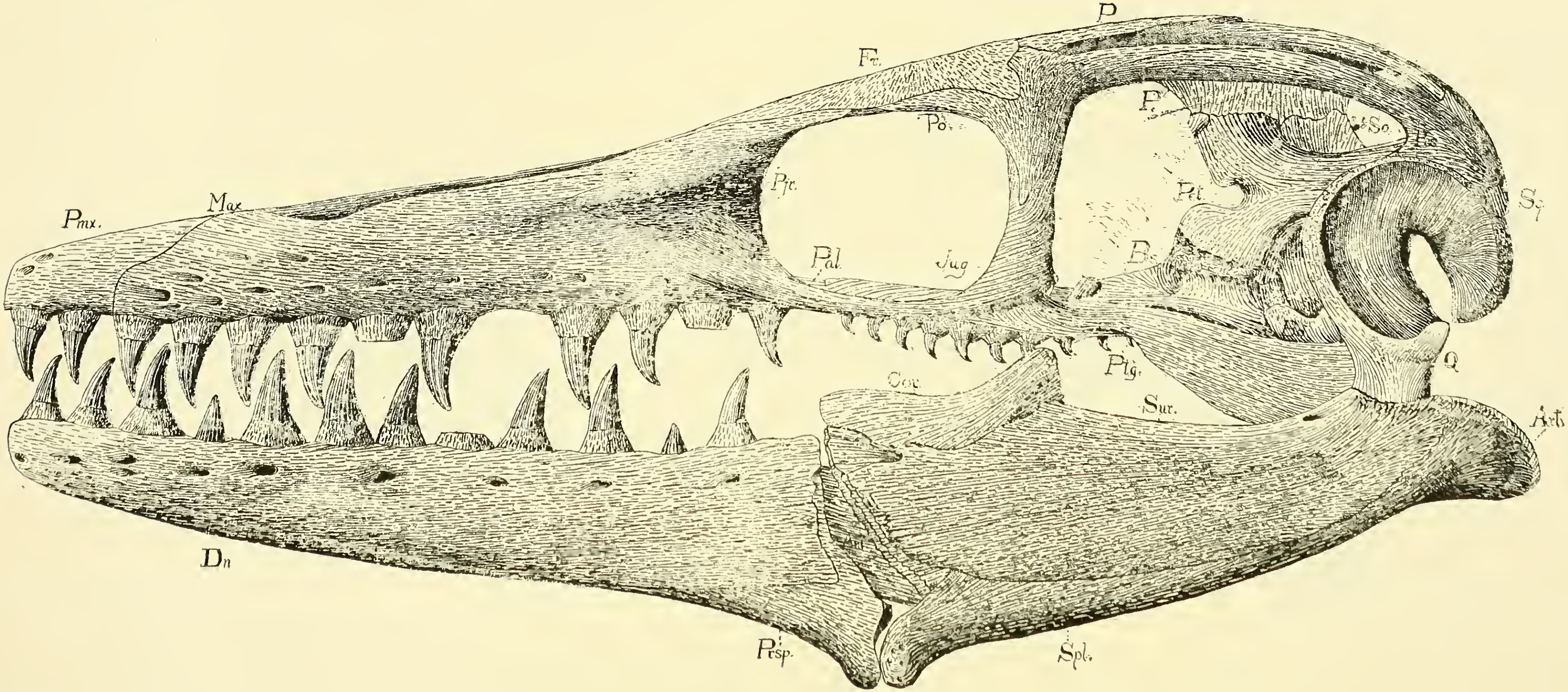
CLIDASTES VELOX MARSH, × three-eighths.



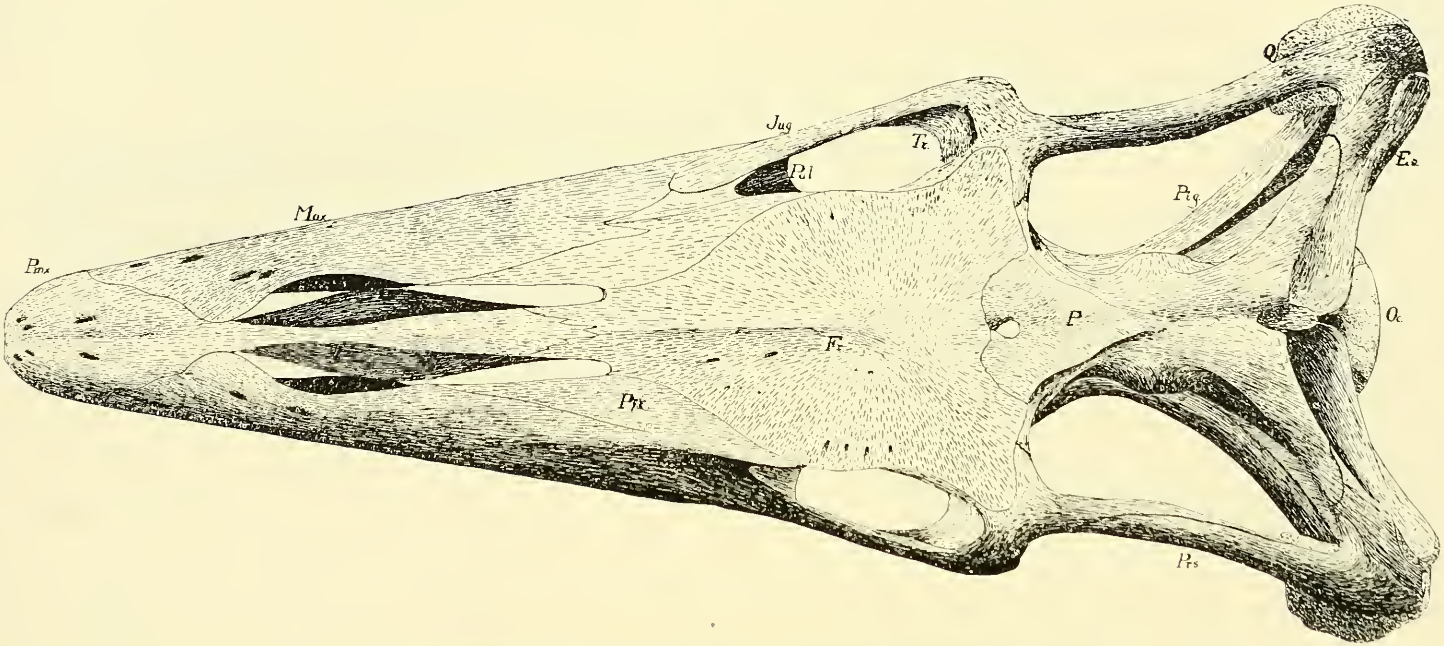
CLIDASTES VELOX (from above), × three-eighths.



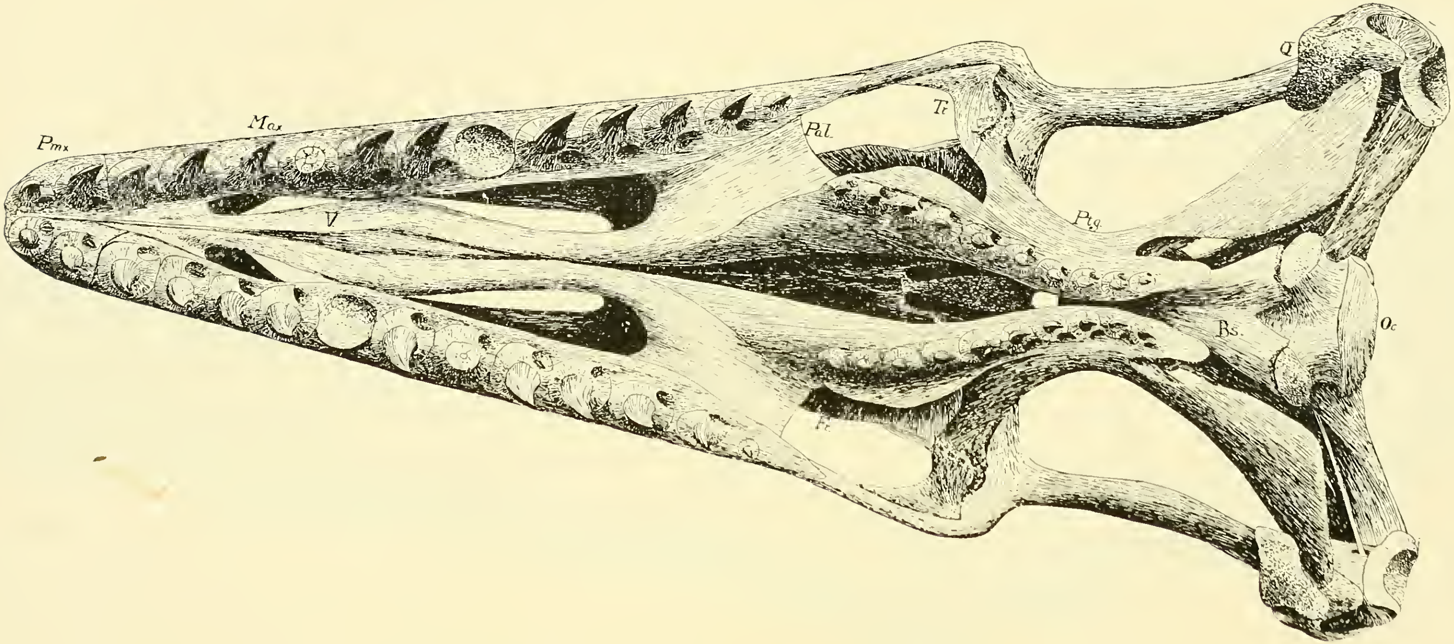
CLIDASTES VELOX (from below), × three eighths.



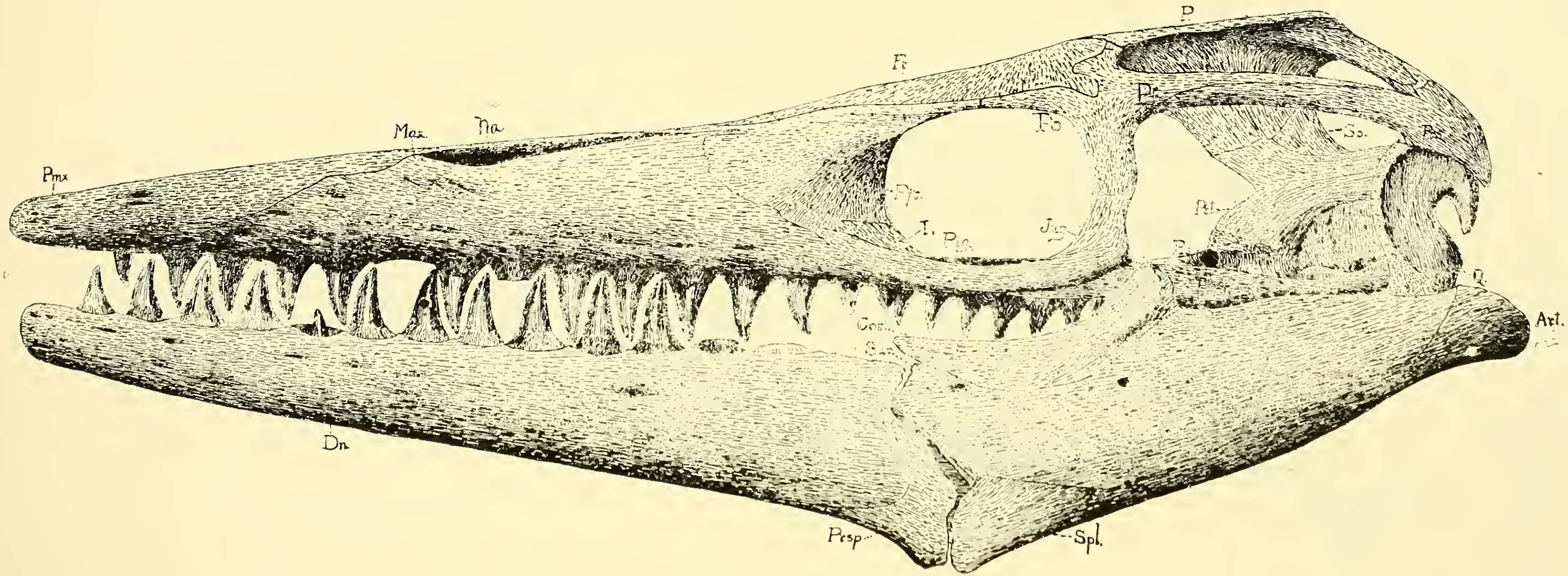
PLATECARPUS CORYPHÆUS Cope, × two-fifths.



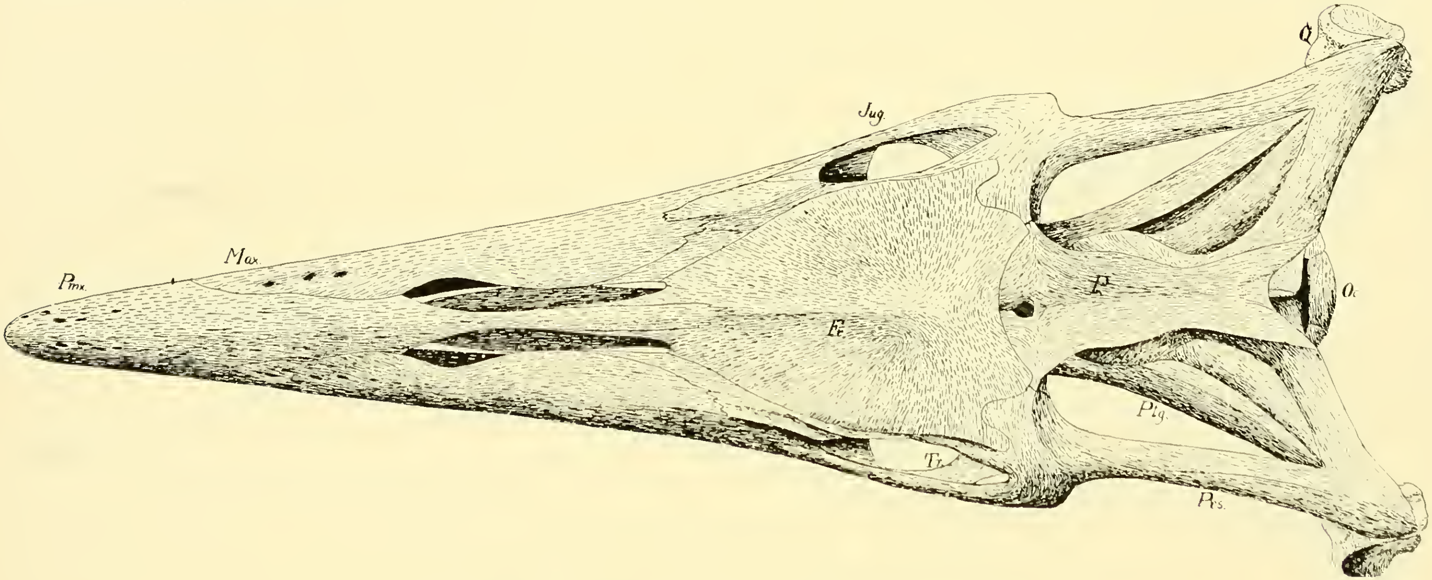
PLATECARPUS CORYPHÆUS (from above), × one-third.



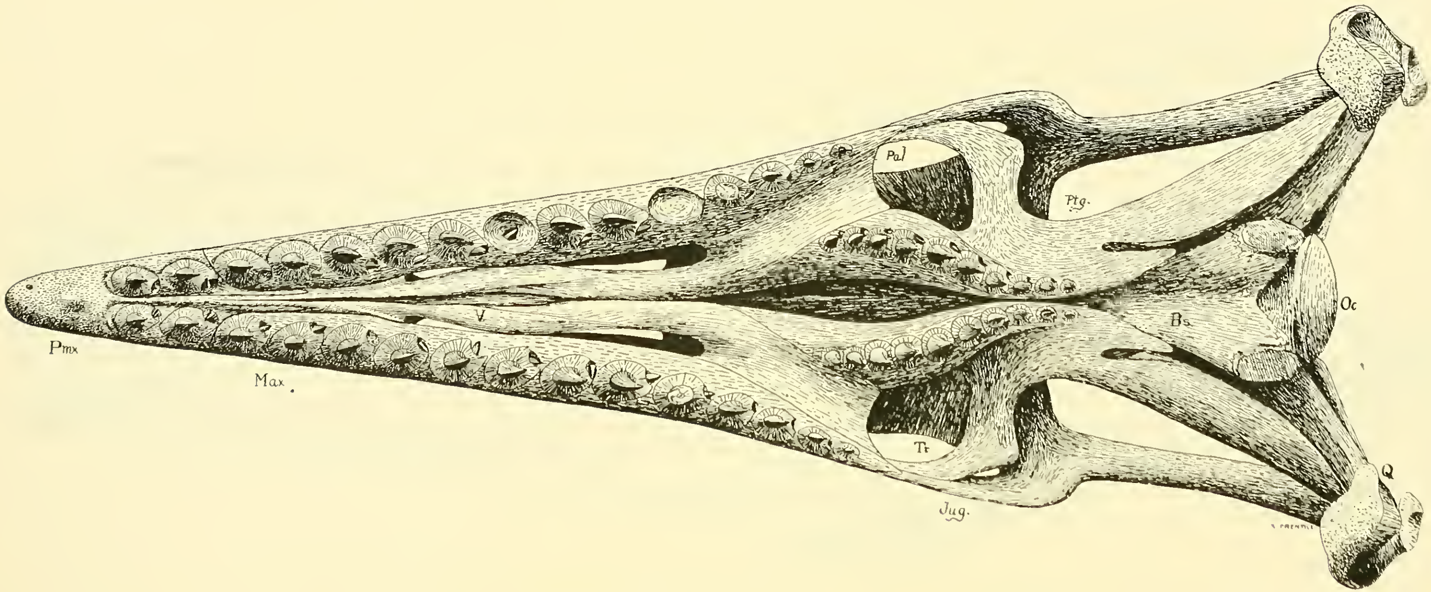
PLATECARPUS CORYPHÆUS (from below). × one third.



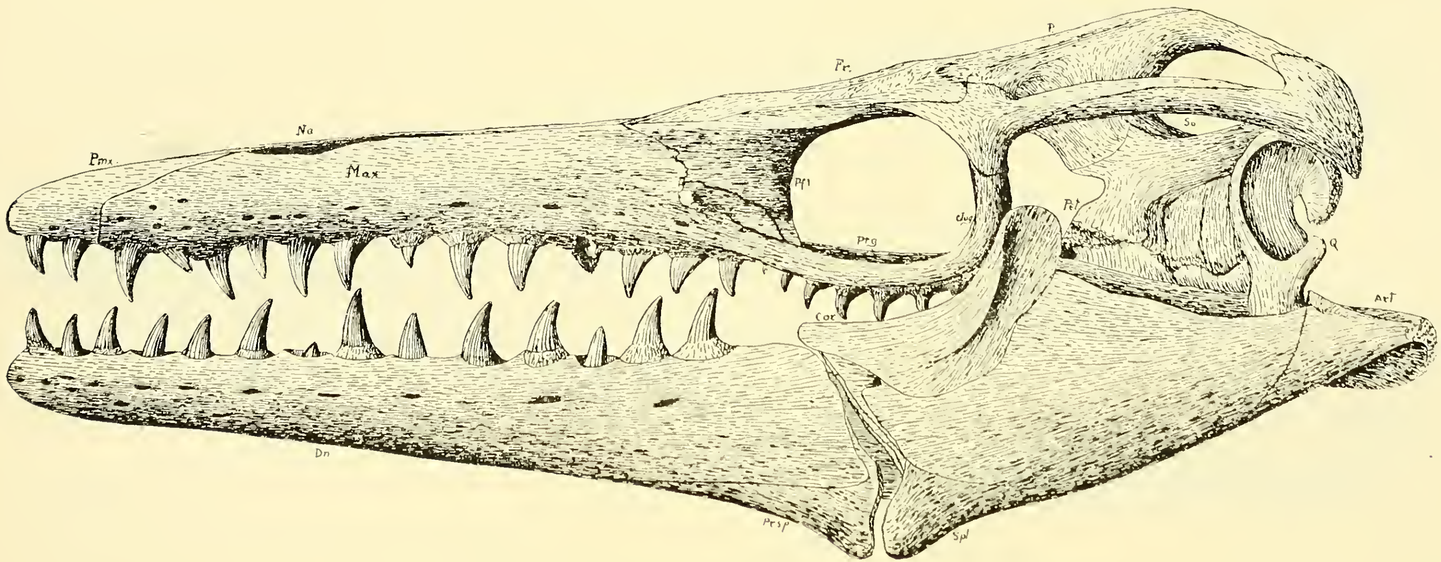
TYLOSAURUS PRORIGER Cope, × two-ninths.



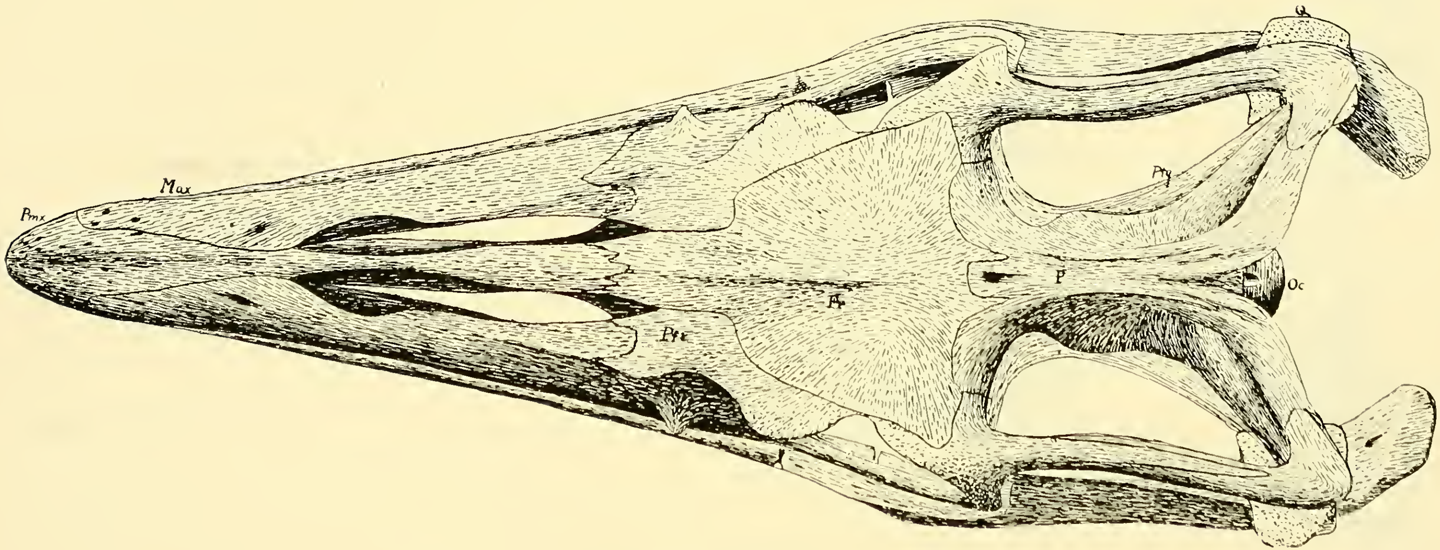
TYLOSAURUS PRORIGER (from above), × one-fifth.



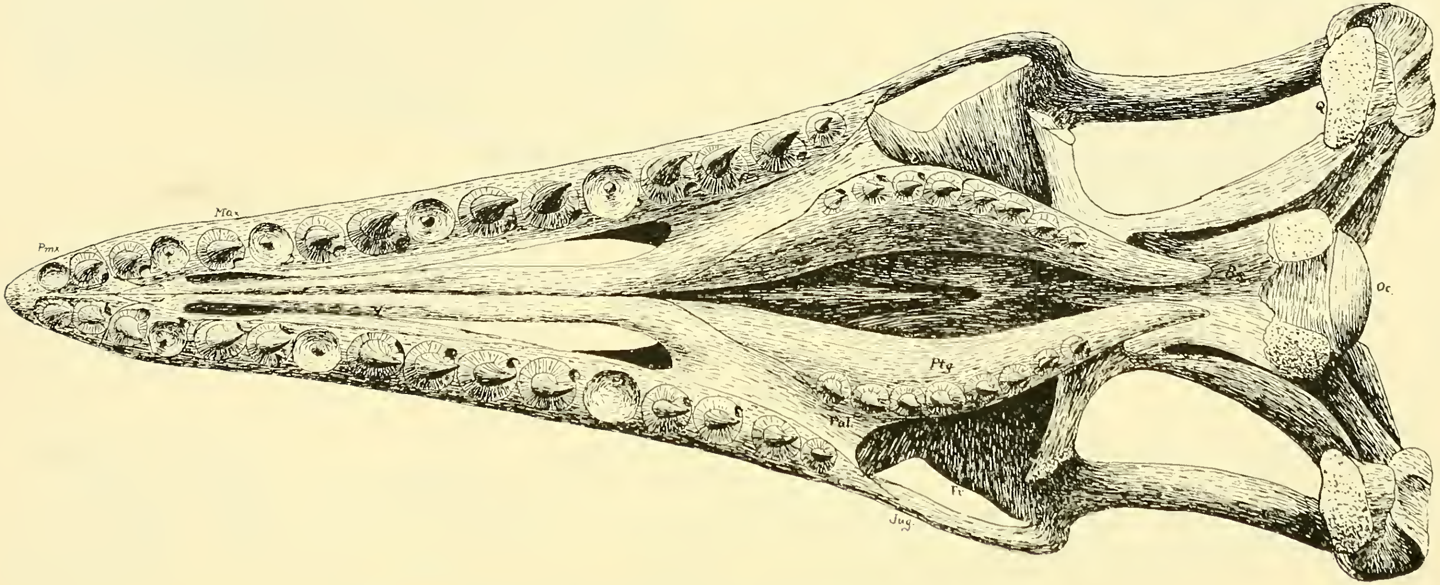
TYLOSAURUS PRORIGER (from below), × one-third.



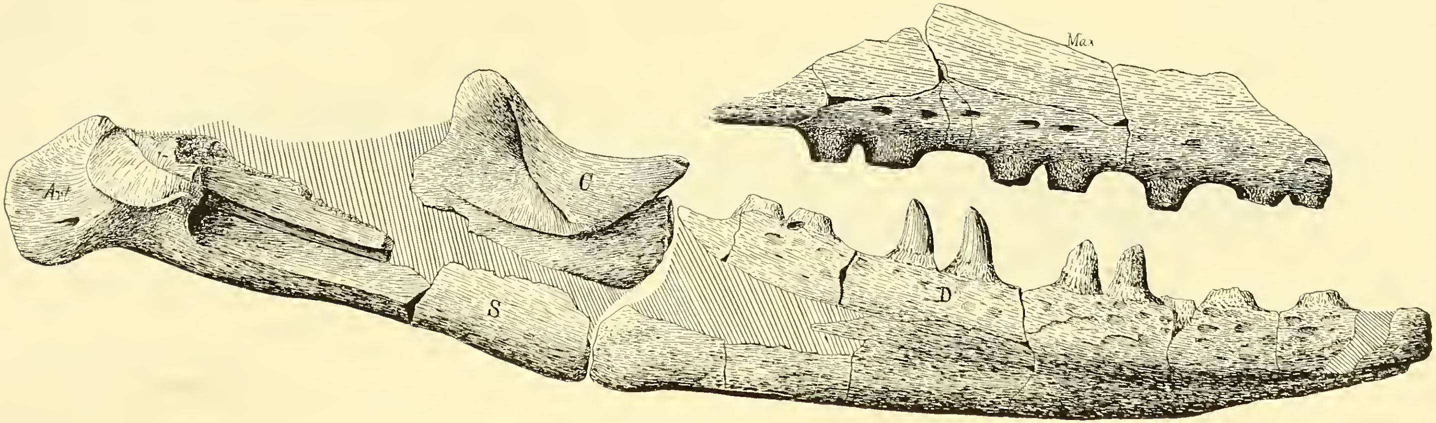
MOSASAURUS HORRIDUS WILLISTON, × three-sixteenths.



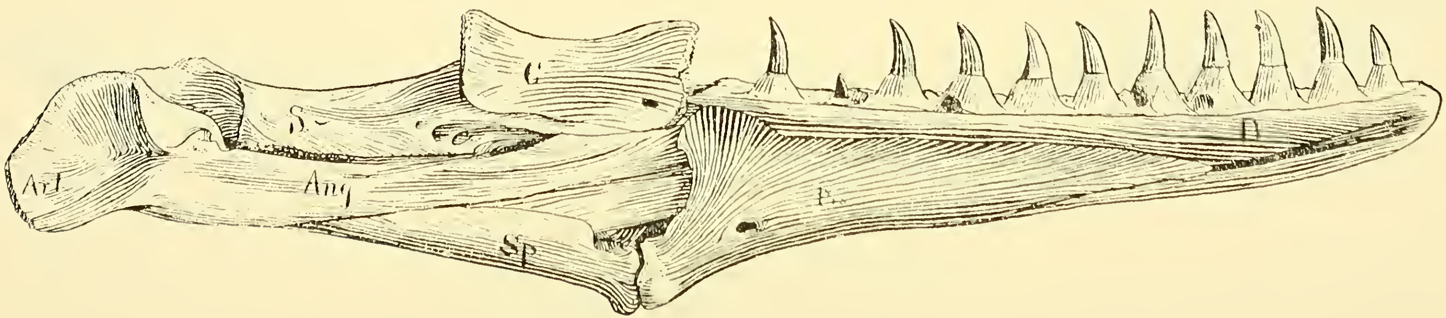
MOSASAURUS HORRIDUS (from above), × three-sixteenths.



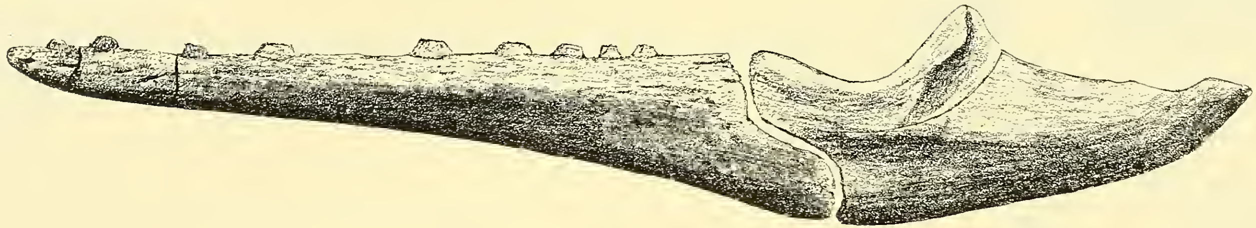
MOSASAURUS HORRIDUS (from below), × three-sixteenths.



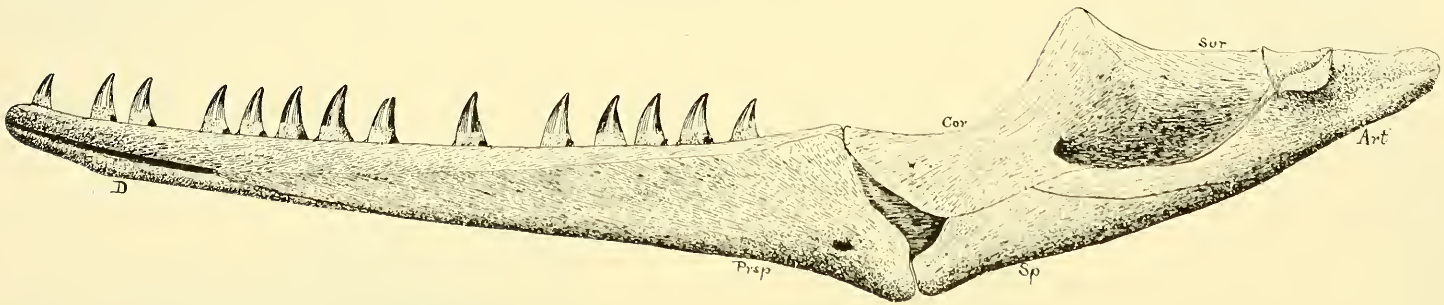
BRACHYSAURUS OVERTONII WILLISTON, × one-sixth.



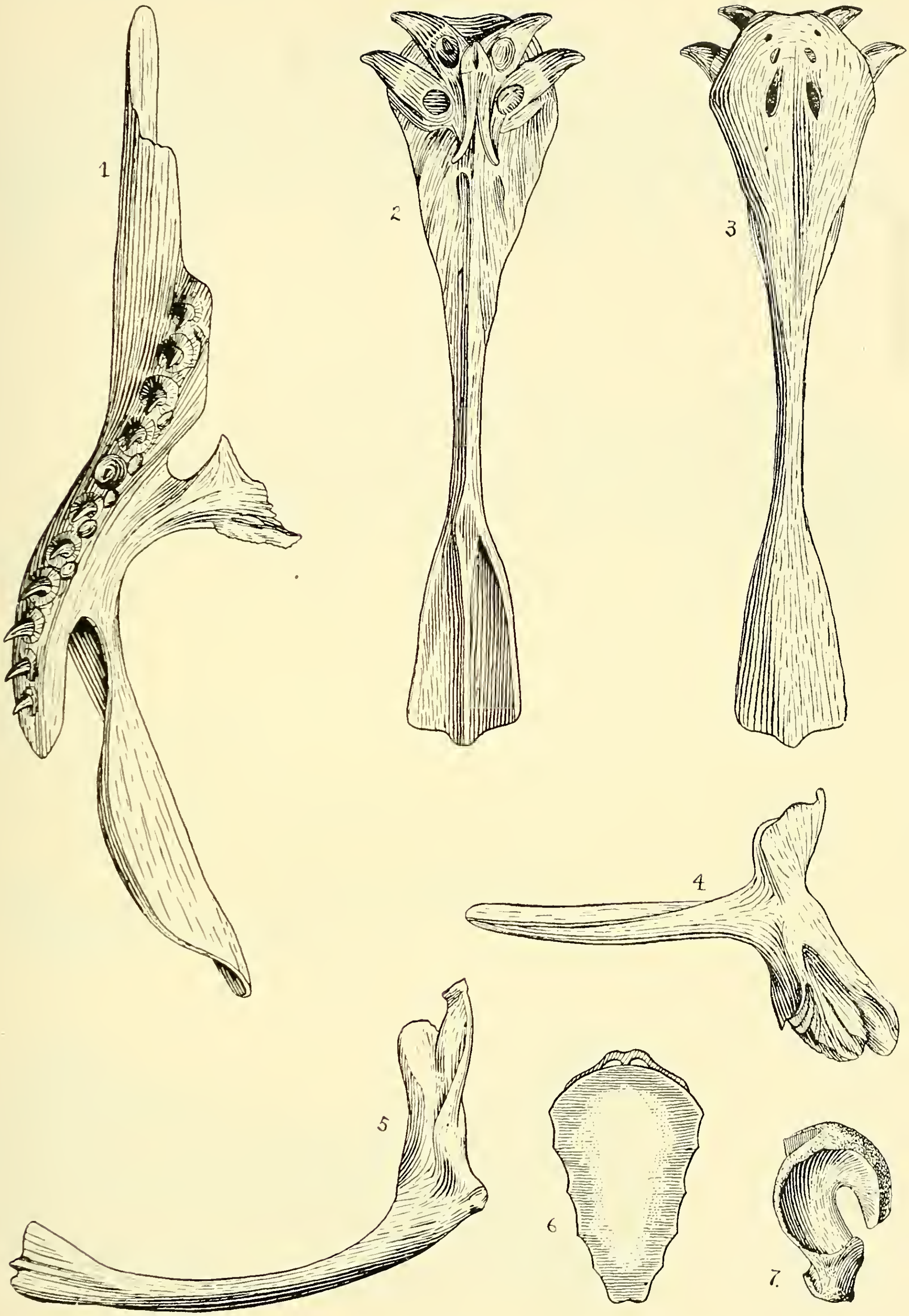
PLATECARPUS CORYPHÆUS COPE, × one-third.



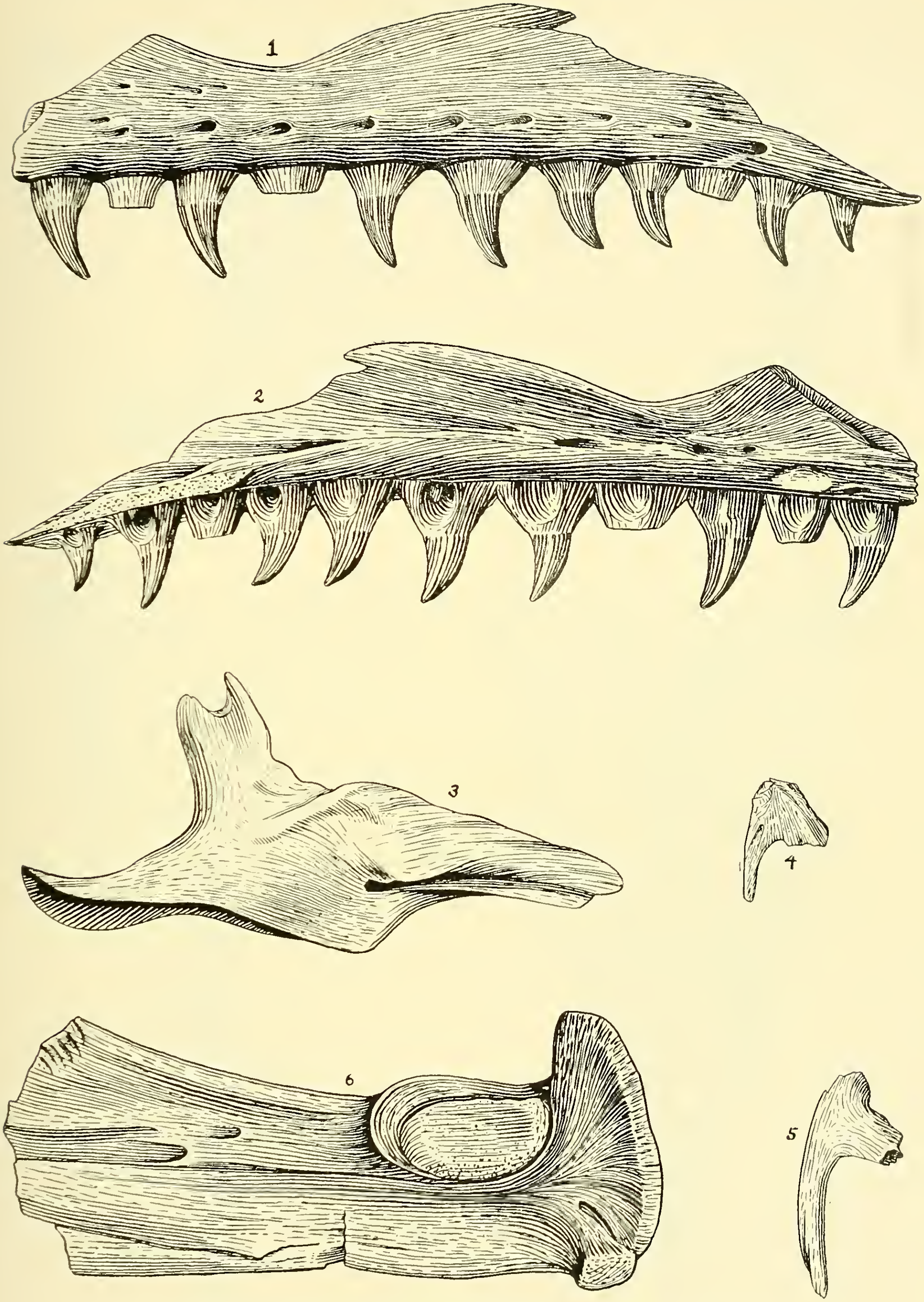
CLIDASTES WESTII Williston, × one-fourth.



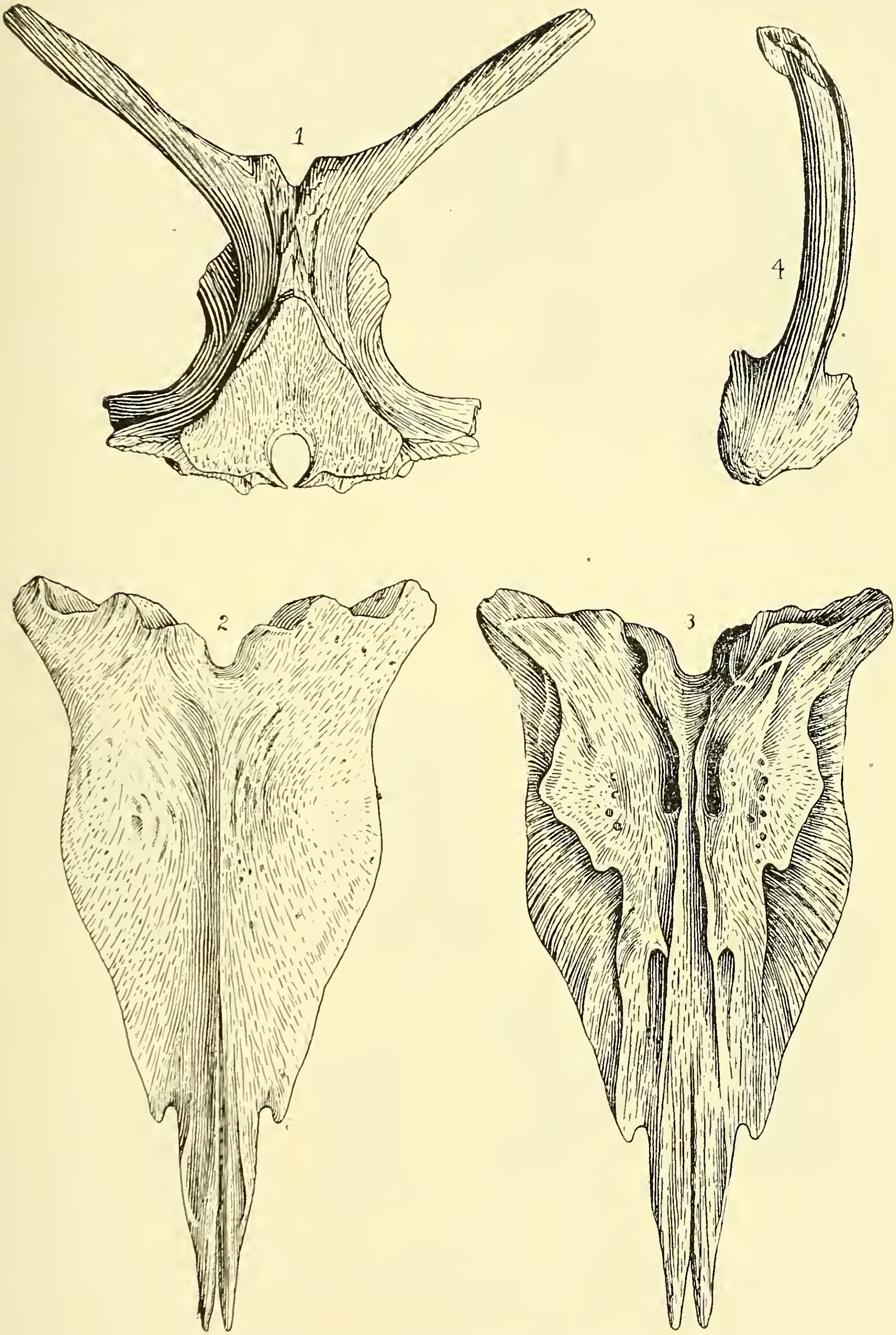
CLIDASTES TORTOR Cope, × one-fourth.



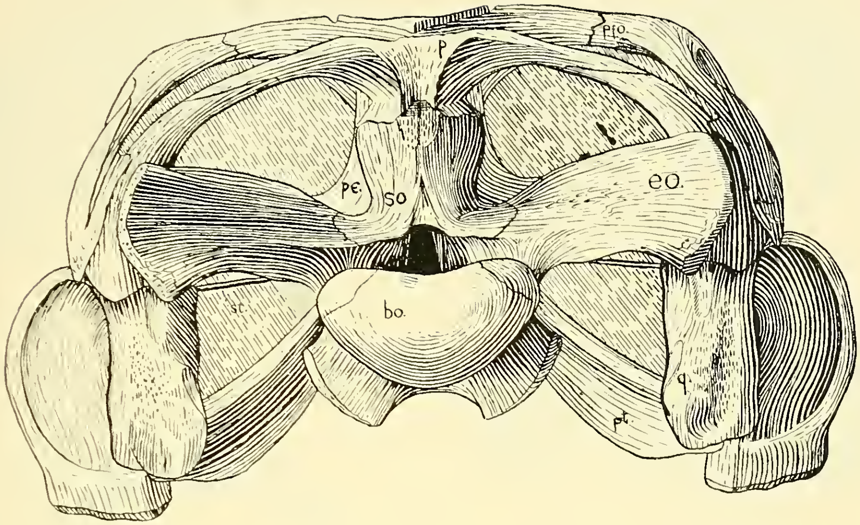
PLATECARPUS CORYPHÆUS—1, 2, 3, 4, 5. } × one-half.
CLIDASTES VELOX—6, 7.



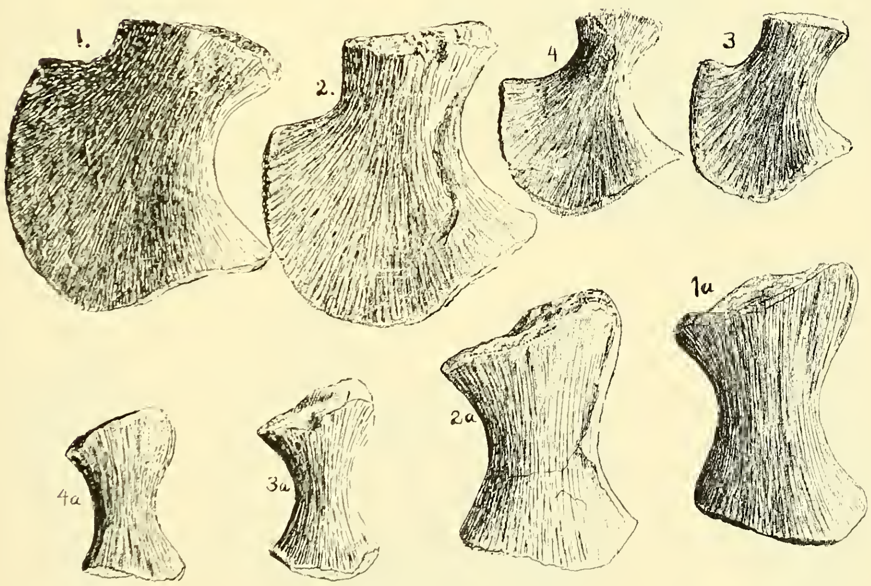
PLATECARPUS CORYPHÆUS—1, 2, 3, 4, 5. } × one-half.
BAPTOSAURUS ONCHOGNATHUS—6.



PLATECARPUS CORYPHÆUS, × one-half.

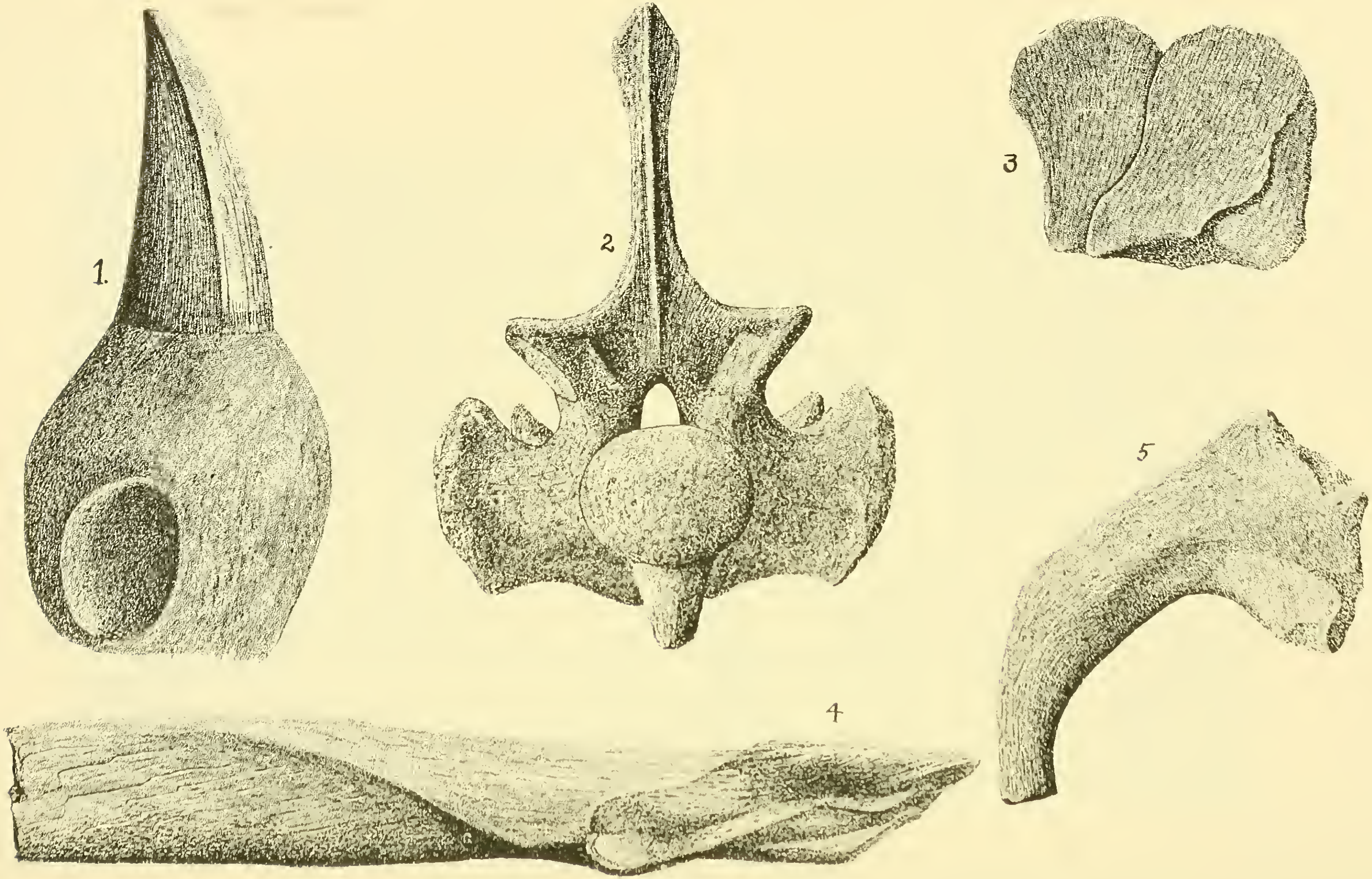


PLATECARPUS CORYPHÆUS. × one-half.

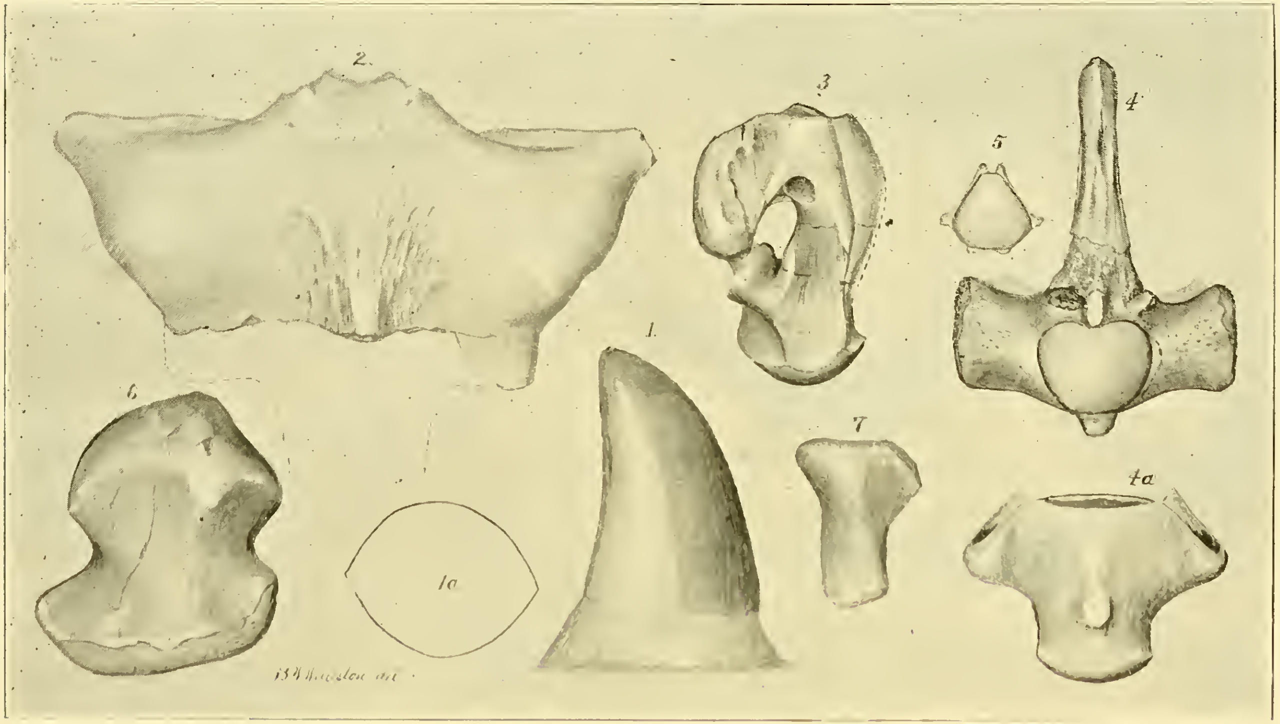


CLIDASTES { WESTII — 1, 1a, TORTOR — 2, 2a, VELOX — 3, 4, 3a, 4a, } × one-half.

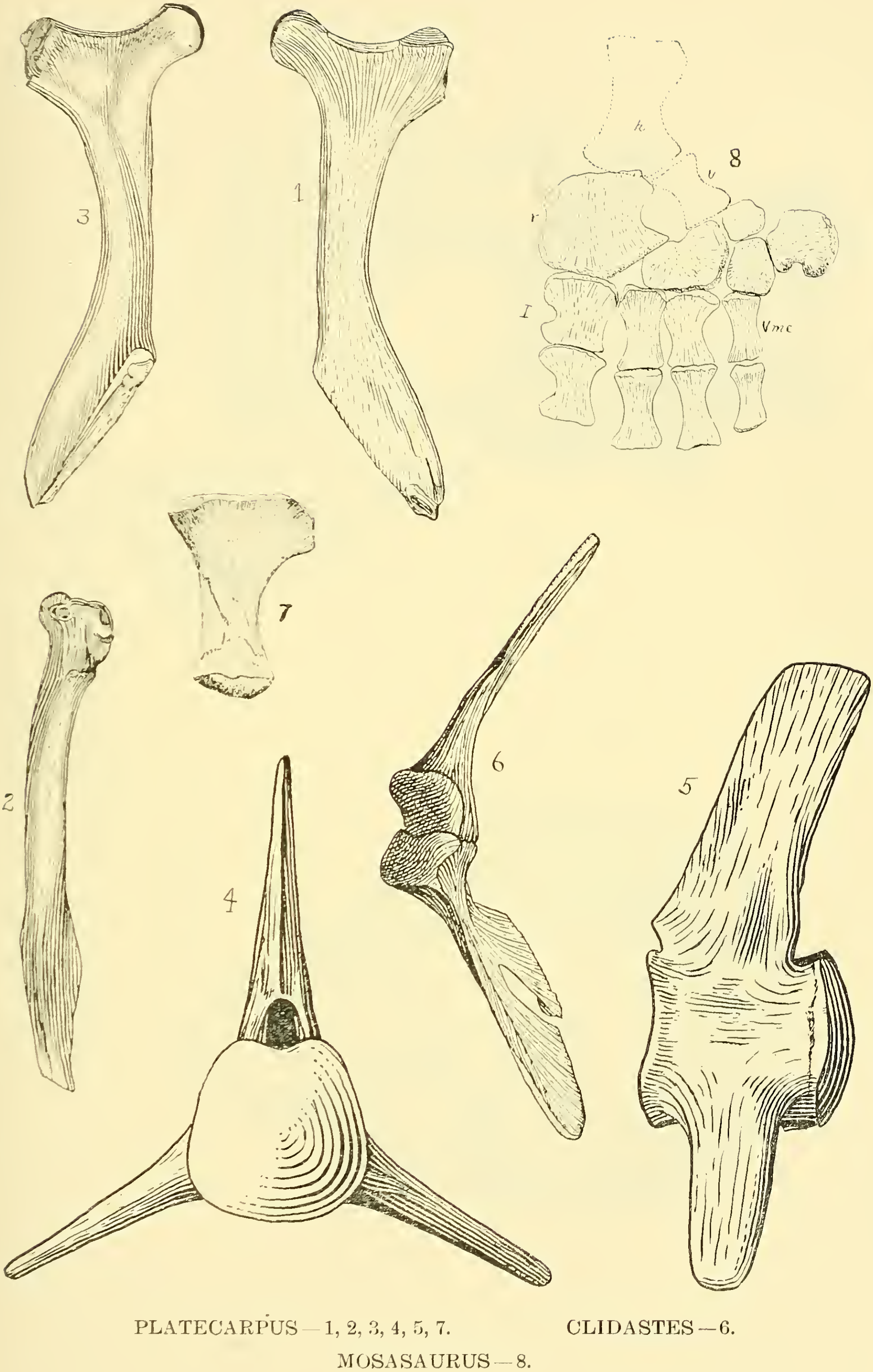
PLATECARPUS — 5, 6, 7, 8. CLIDASTES — 1, 2, 3, 4.



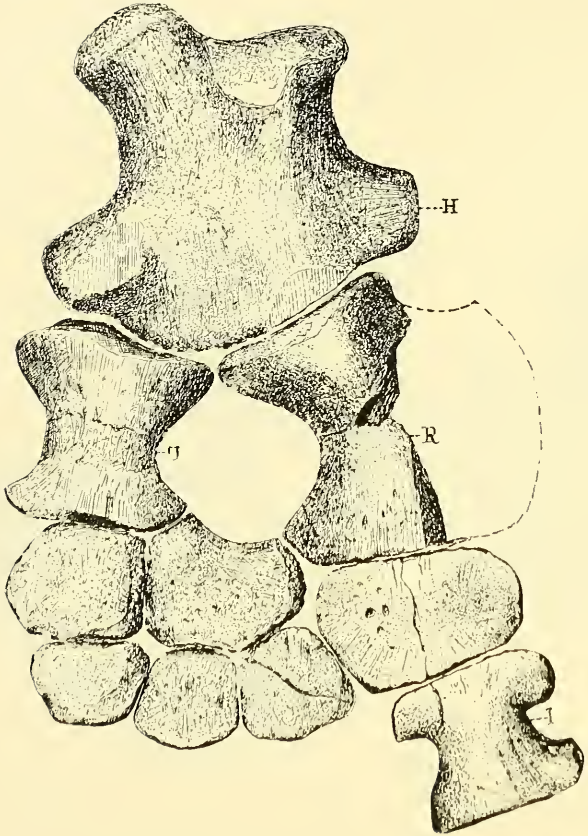
TYLOSAURUS—1. CLIDASTES—2. PLATECARPUS—3, 4, 5.

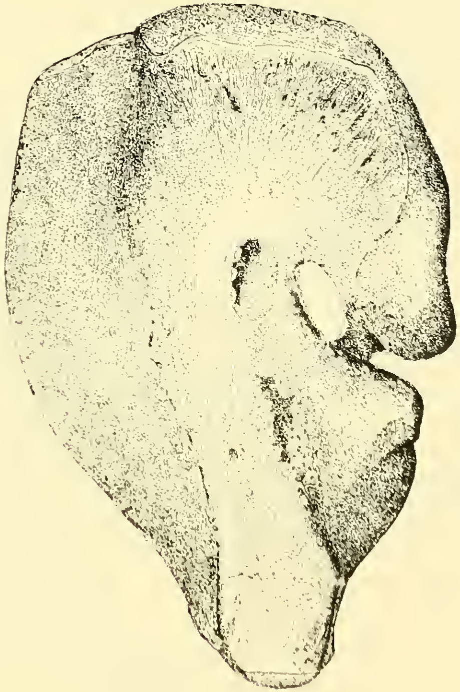


BRACHYSAURUS OVERTONII.

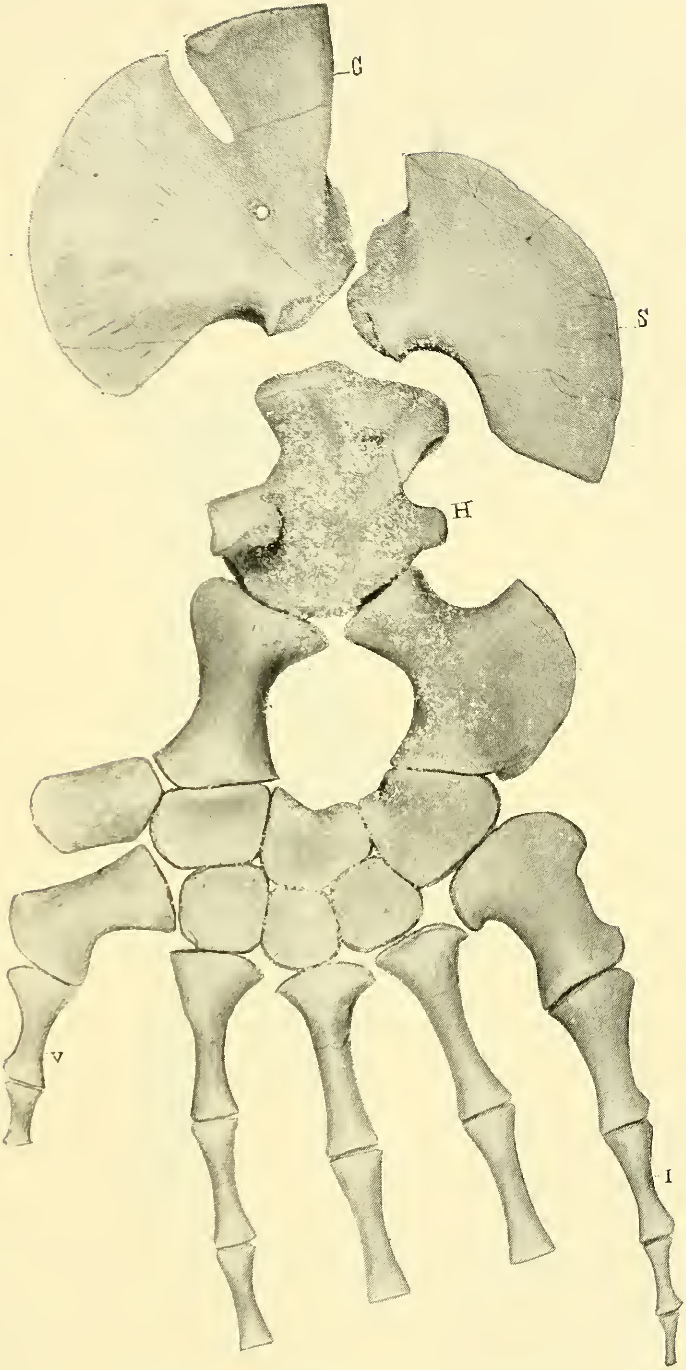


PLATECARPUS — 1, 2, 3, 4, 5, 7. CLIDASTES — 6.
MOSASAURUS — 8.

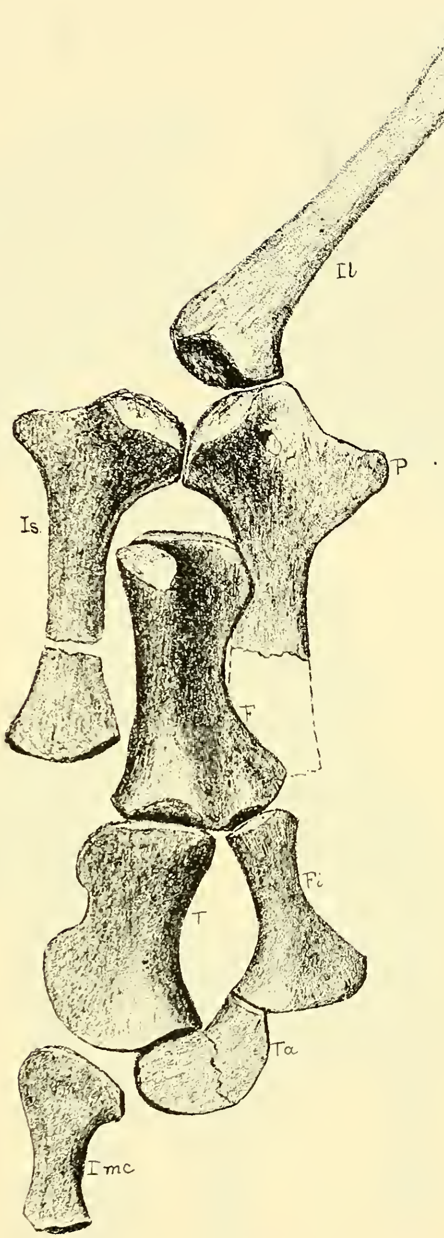




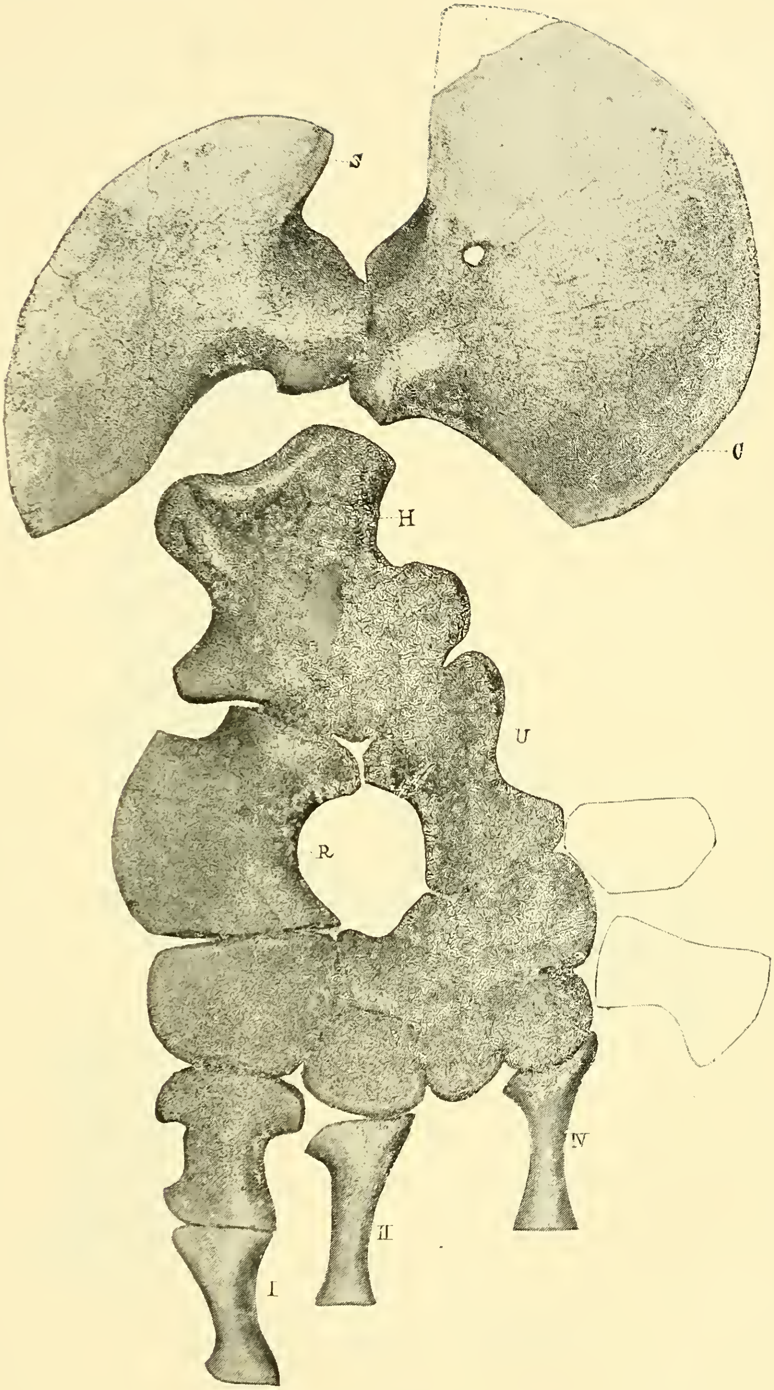
MOSASAURUS HORRIDUS.



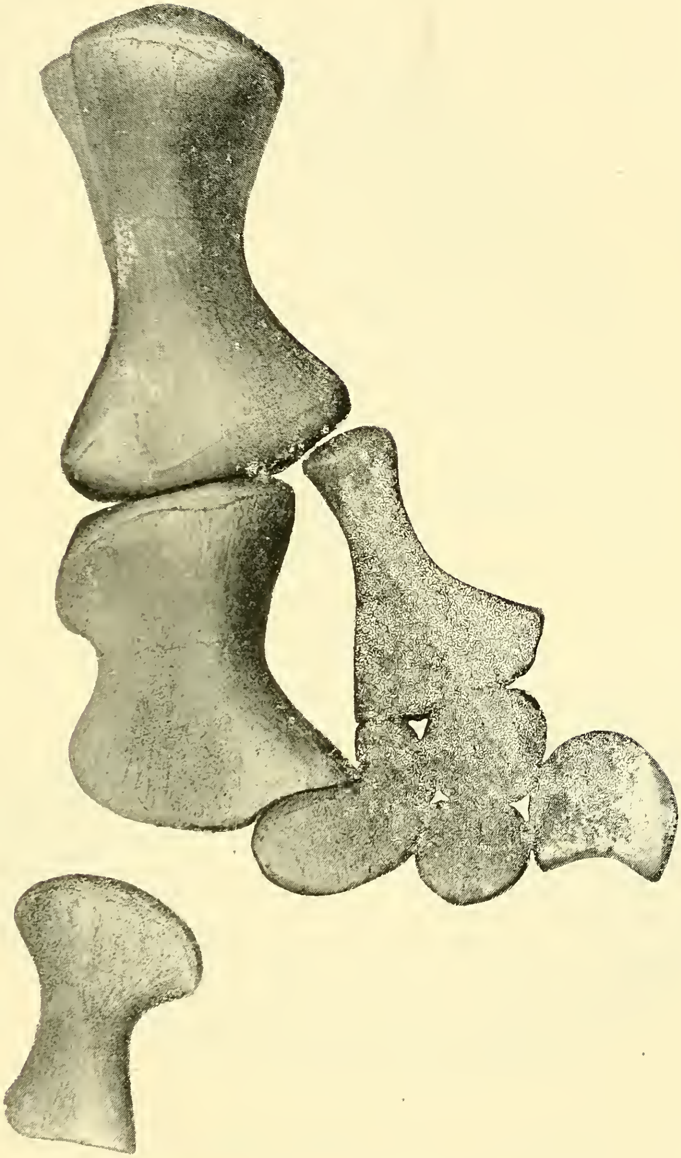
CLIDASTES VELOX, × two-thirds.



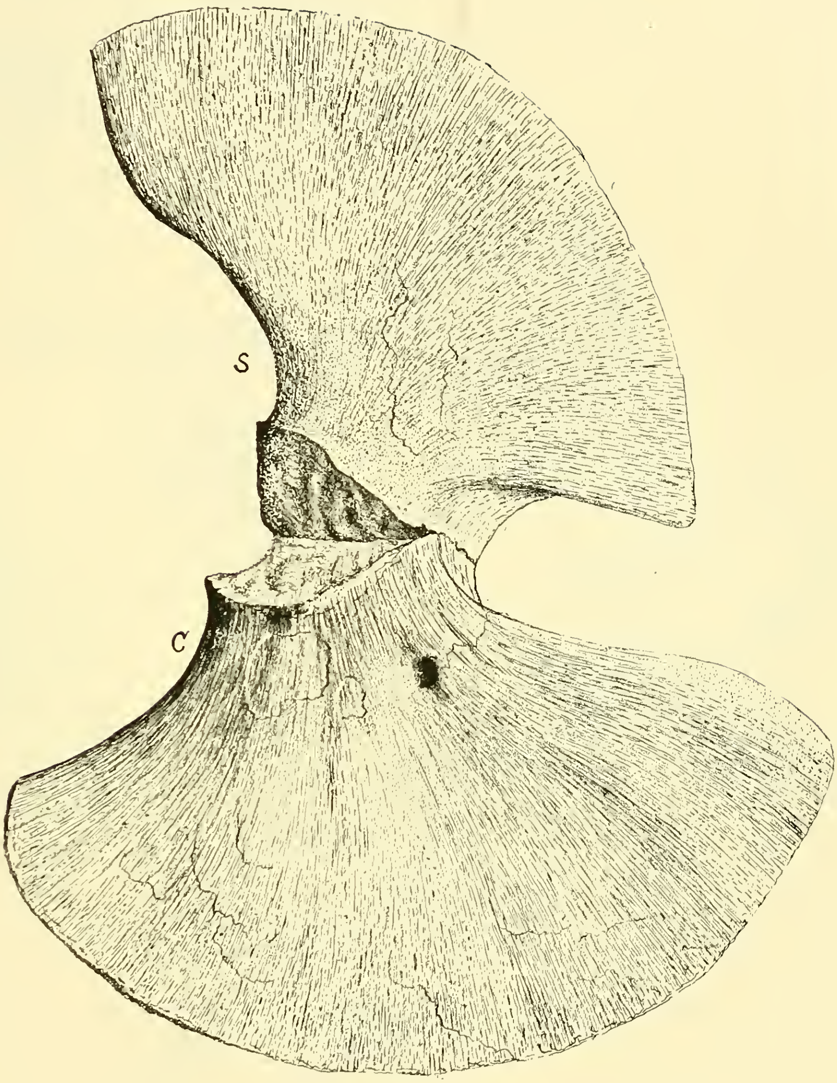
CLIDASTES VELOX, × two-thirds.



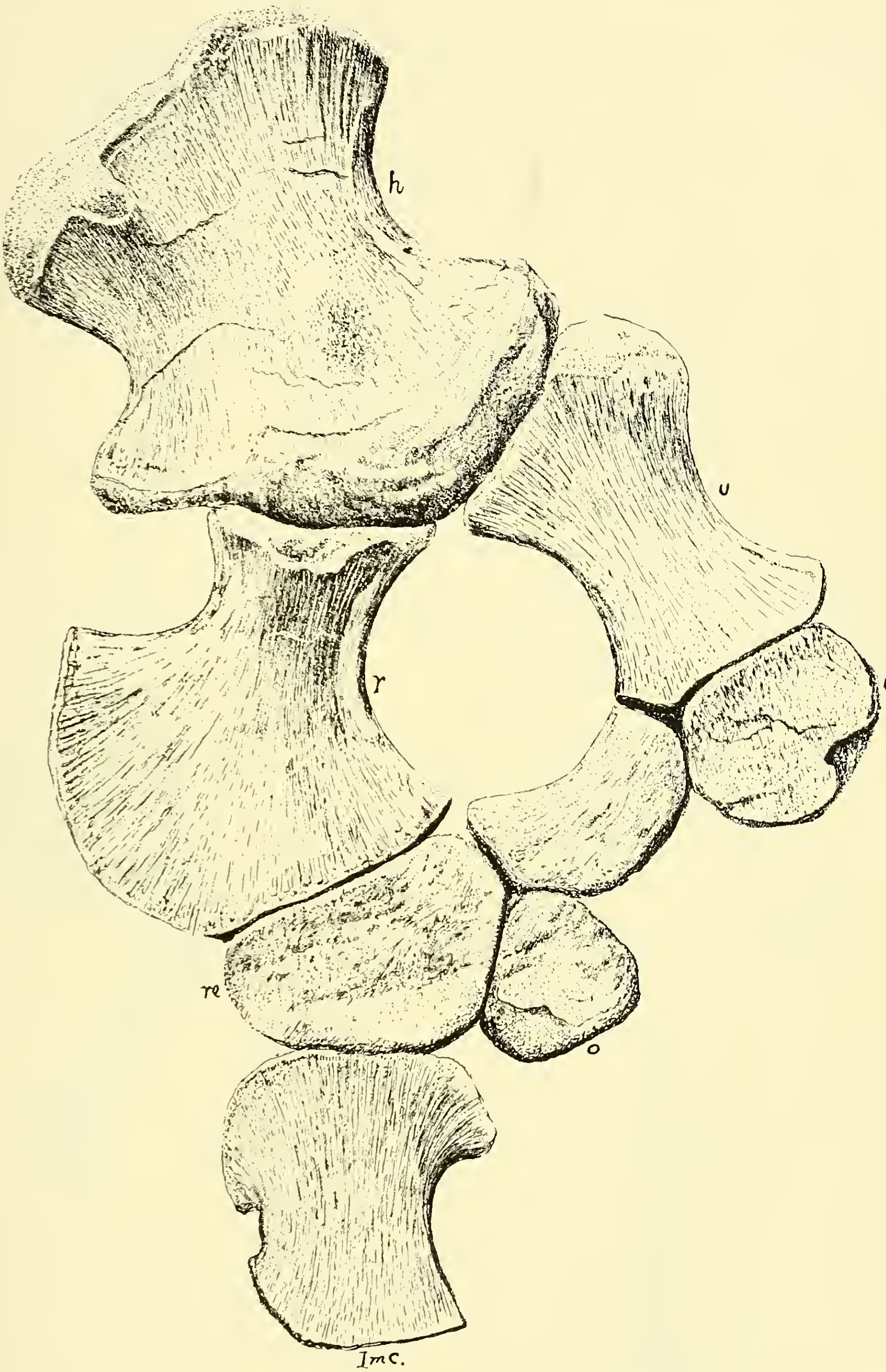
CLIDASTES WESTII, × one-third.



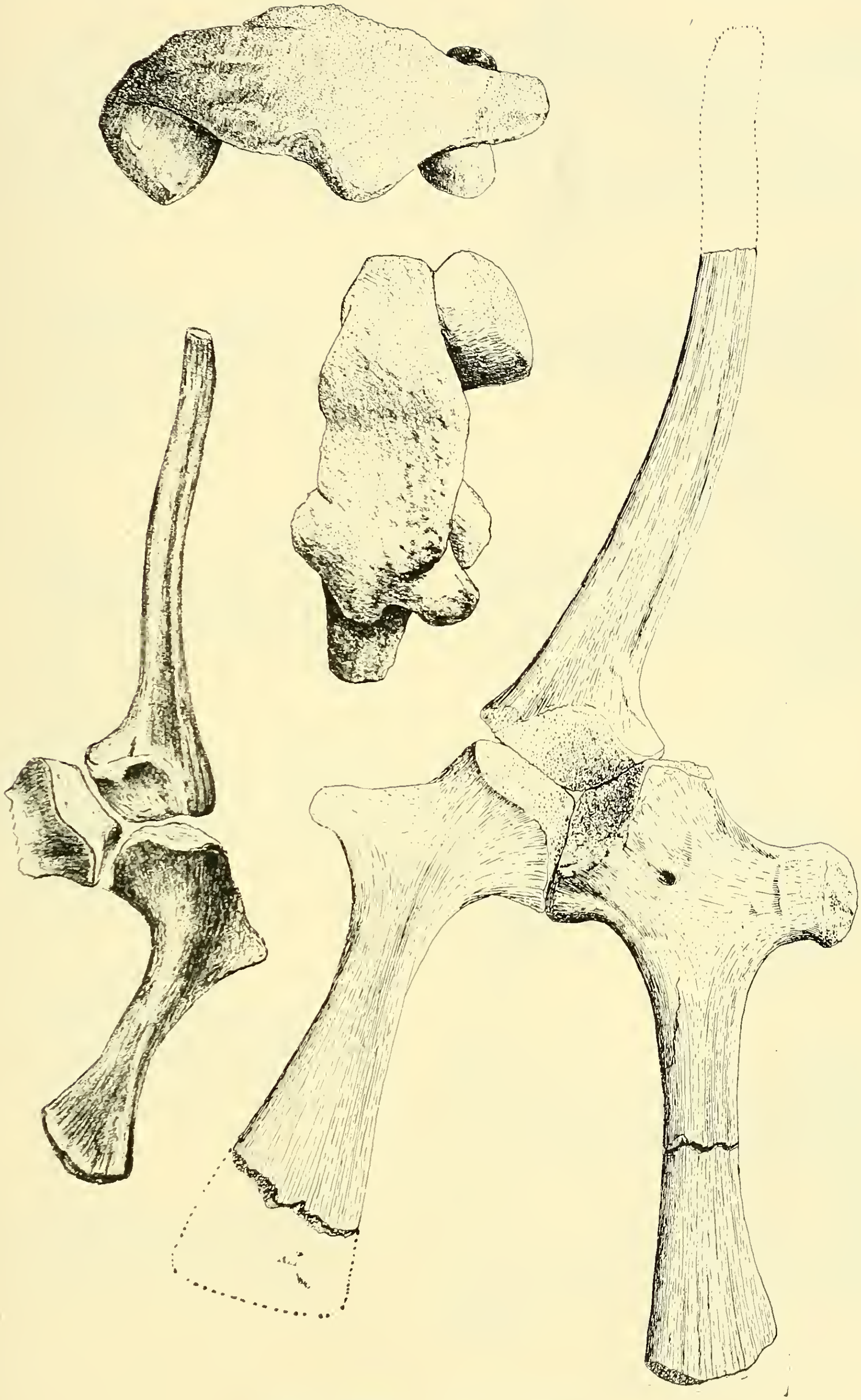
CLIDASTES WESTII, × two-thirds.



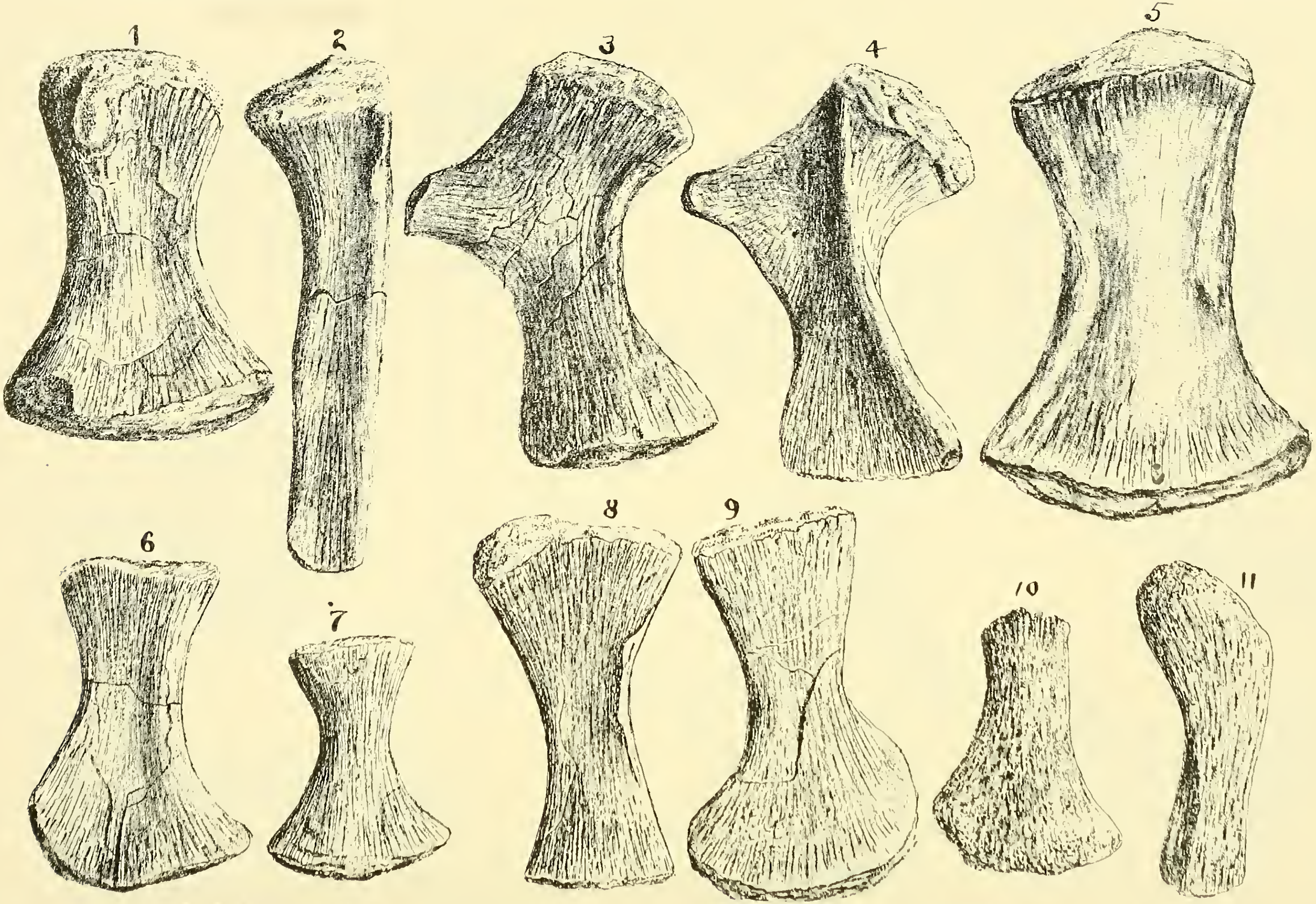
CLIDASTES TORTOR, × two-thirds.



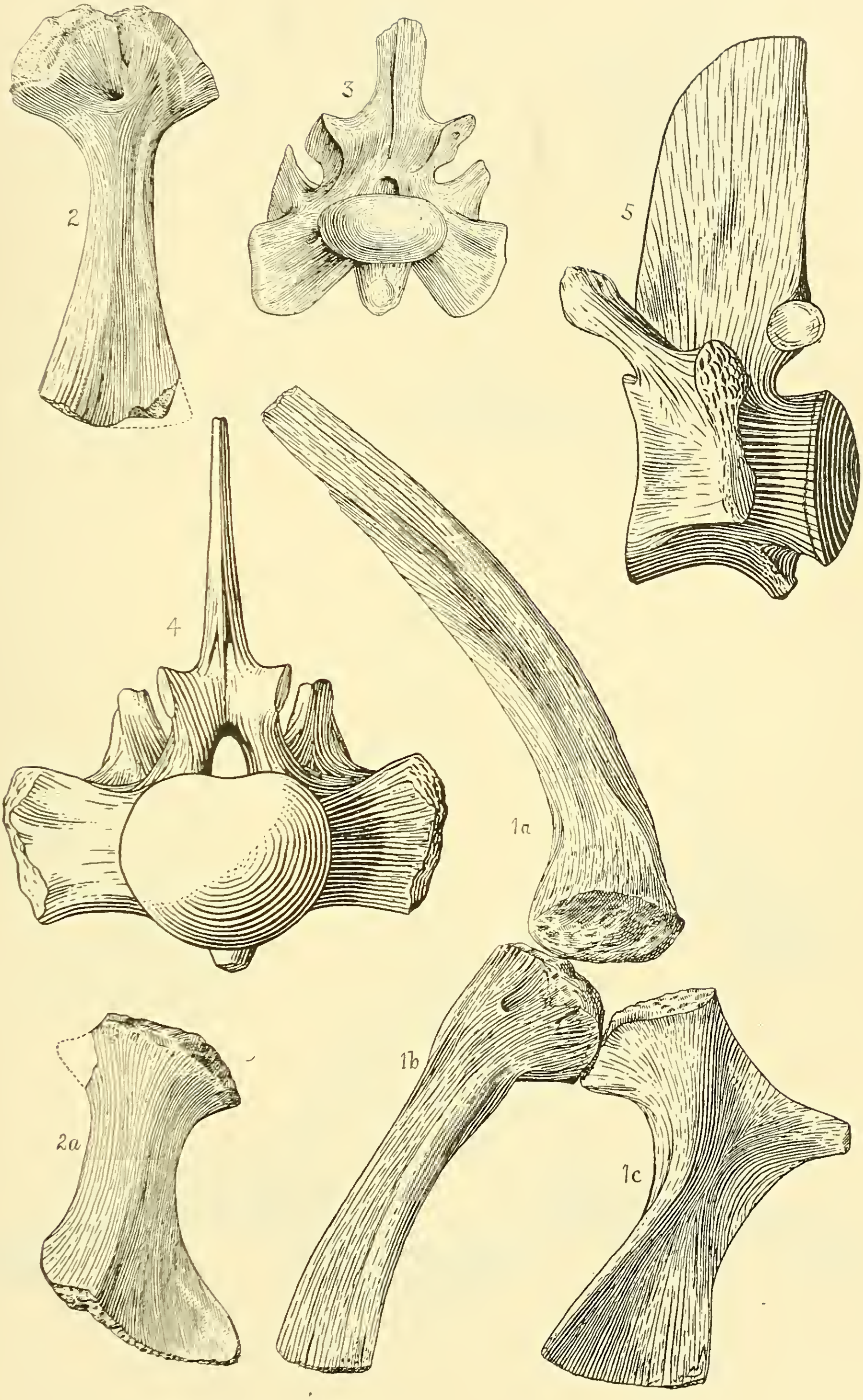
CLIDASTES TORTOR, × four-fifths.



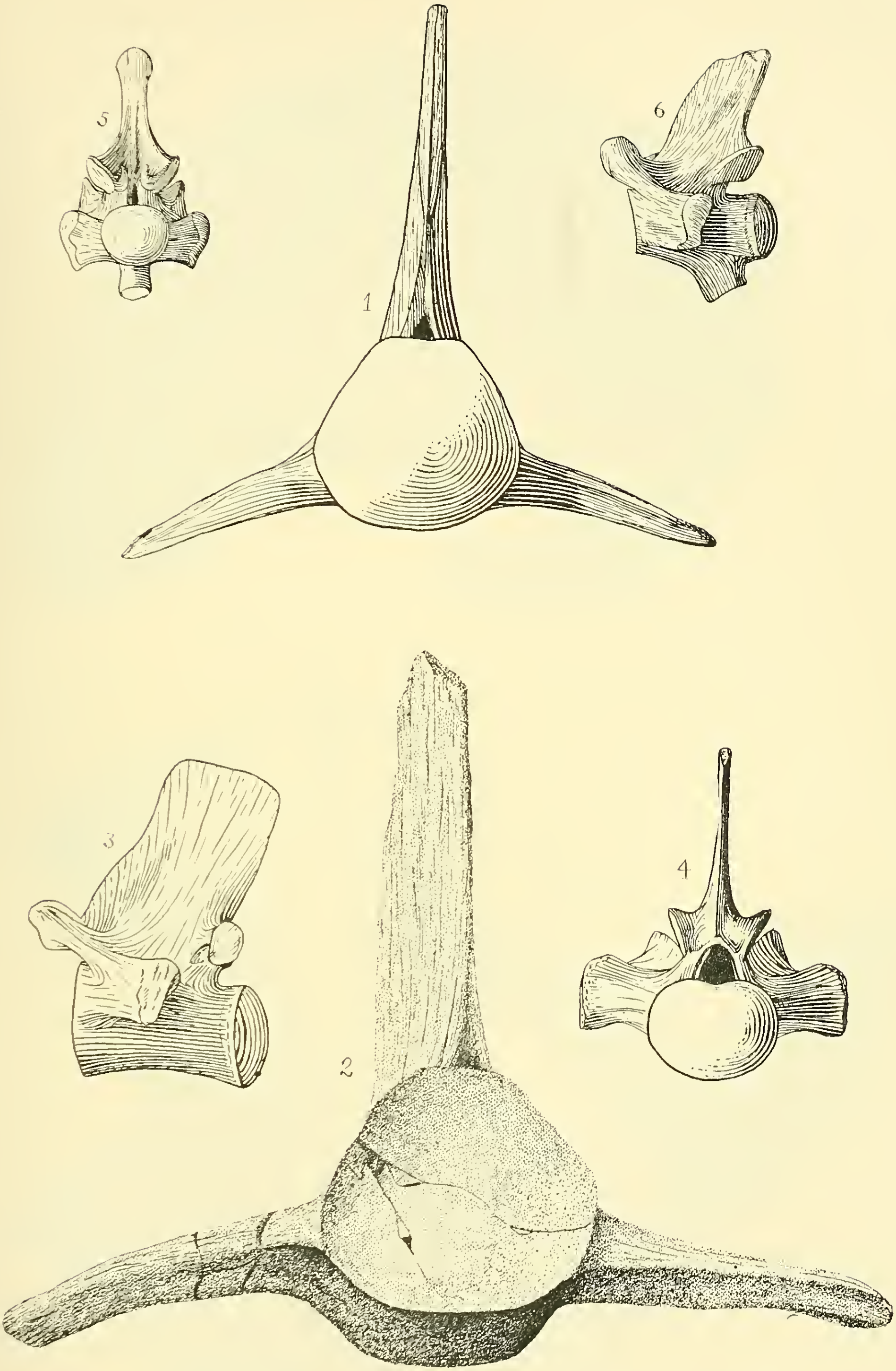
CLIDASTES, × three-fourths.



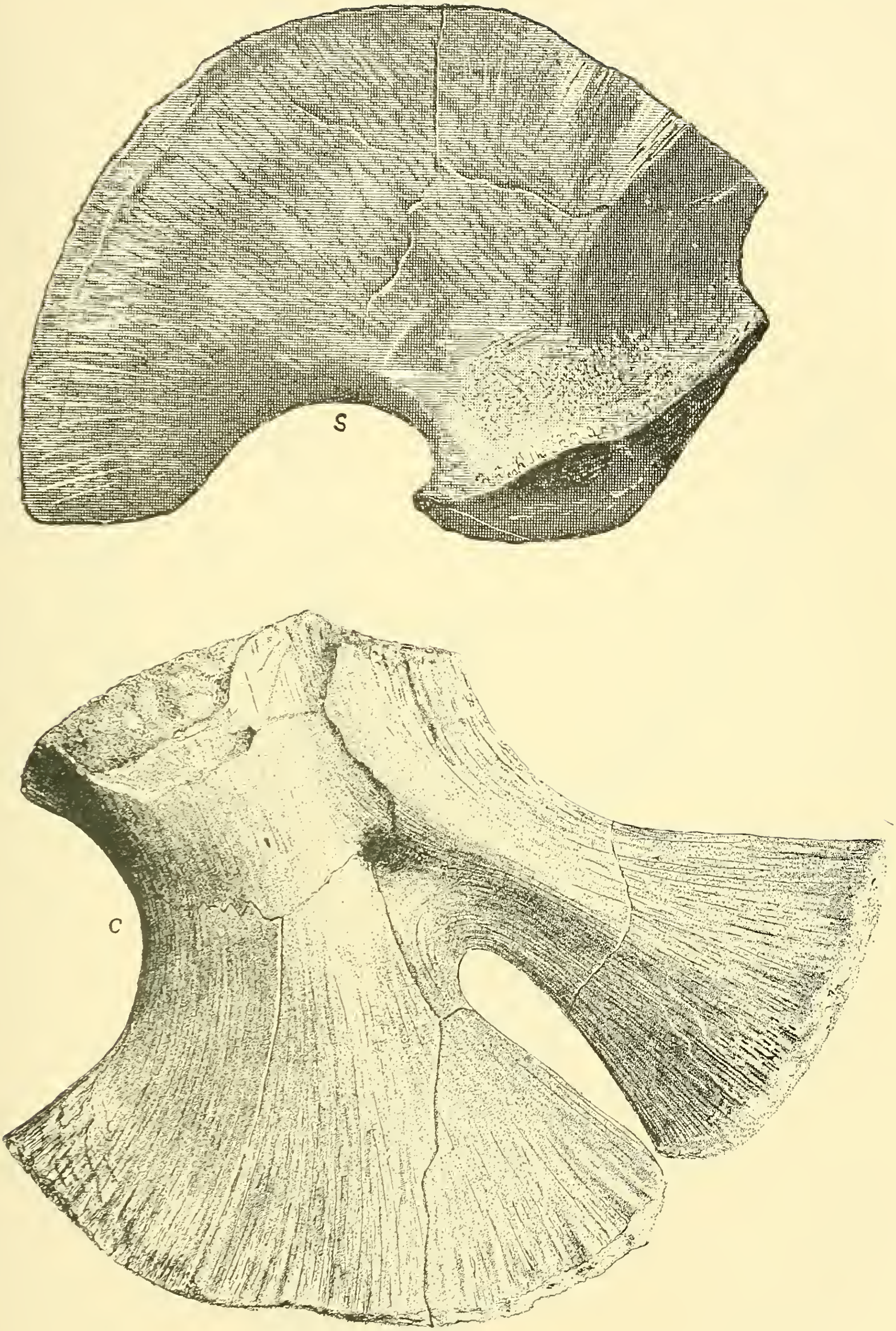
TYLOSAURUS PRORIGER — 1 to 9, × one-half. BRACHYSAURUS OVERTONII — 10. 11, × one-half.



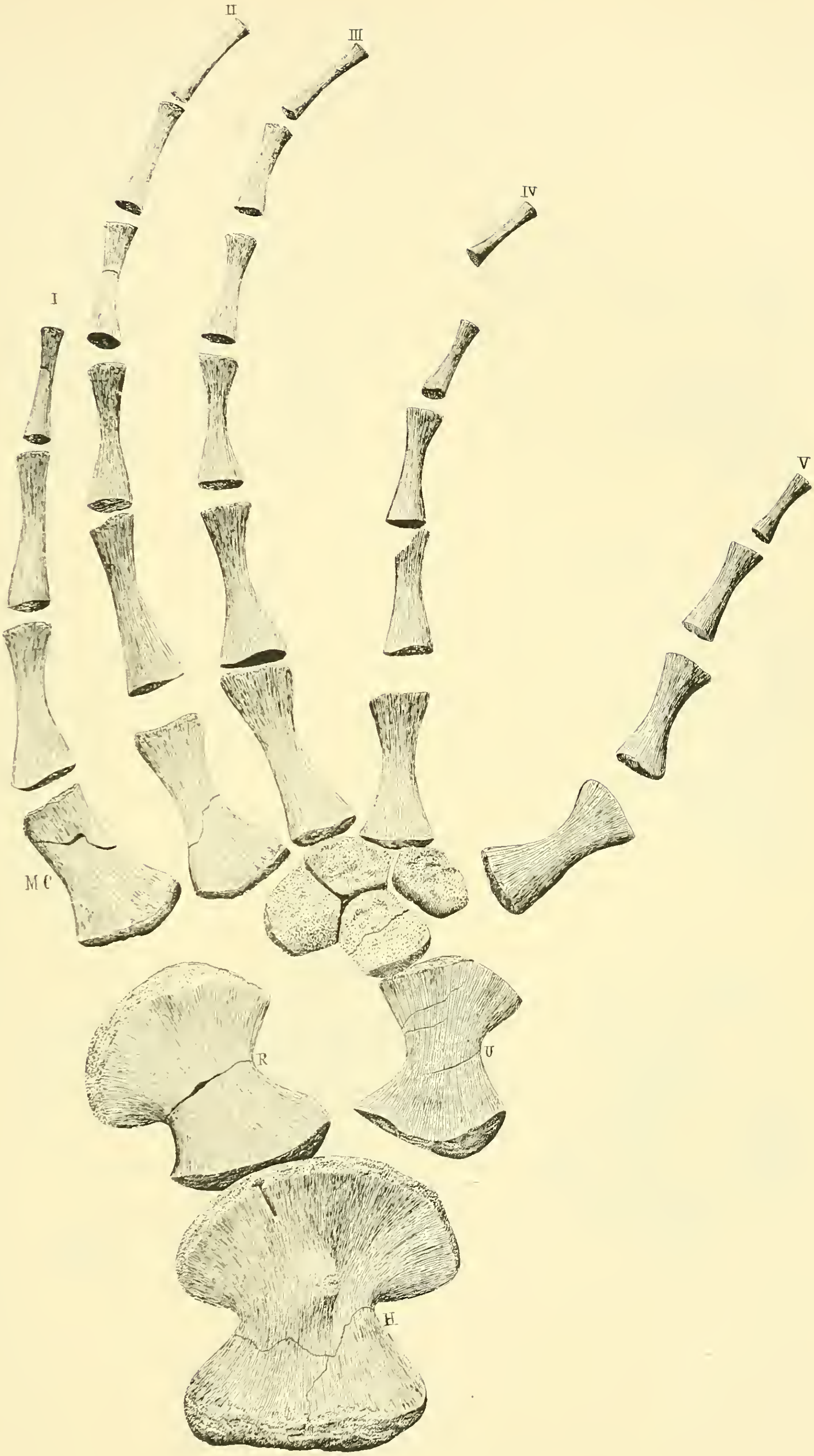
TYLOSAURUS—1a, 1b, 1c, 4, 5,
PLATECARPUS—2, 2a,
BAPTOSAURUS ONCHOGNATHUS—3,
× three-eighths.



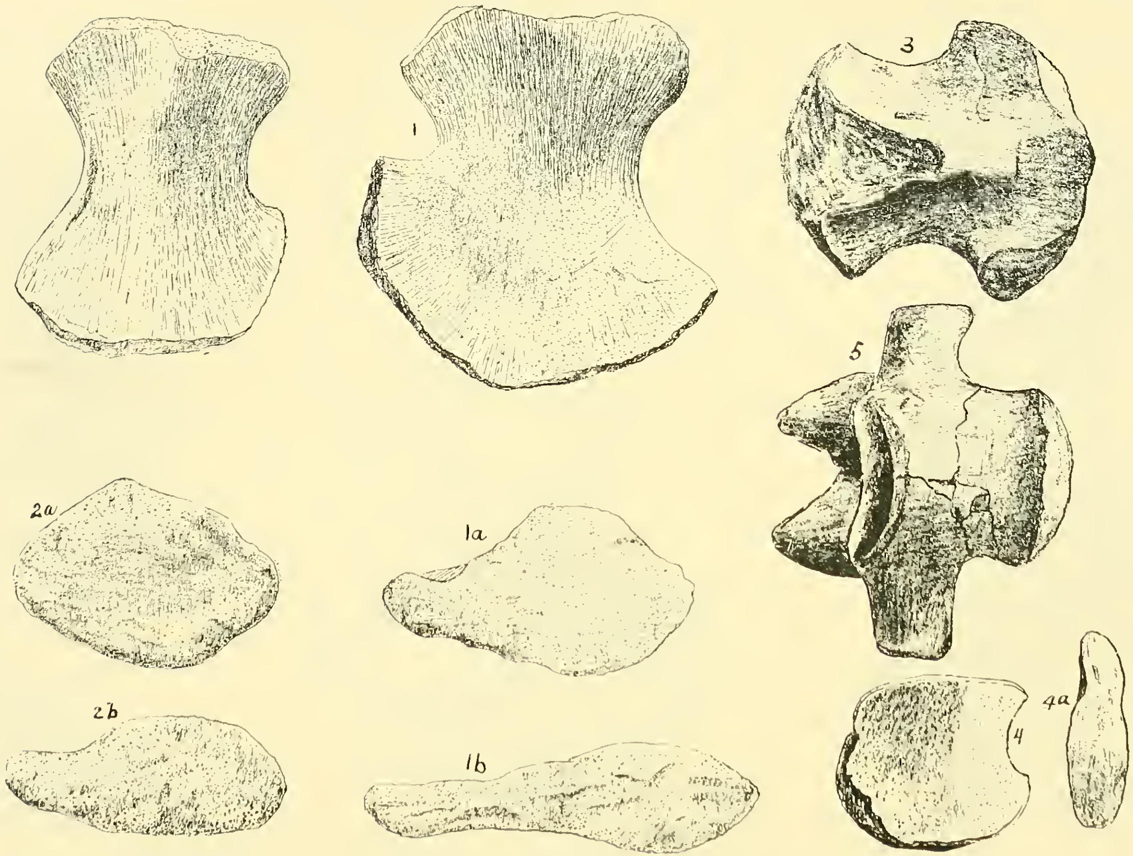
TYLOSAURUS DYSPELOR—1, 2,
PLATECARPUS CORYPHÆUS—3, 4, } × three-eighths.
CLIDASTES TORTOR—5, 6,



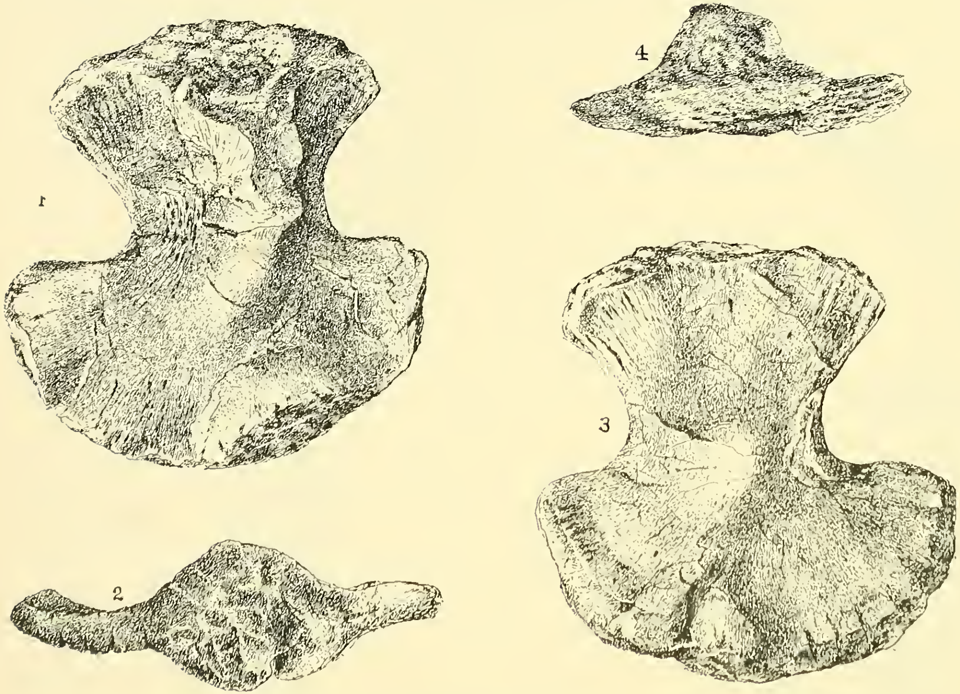
PLATECARPUS ICTERICUS, × five-sevenths.



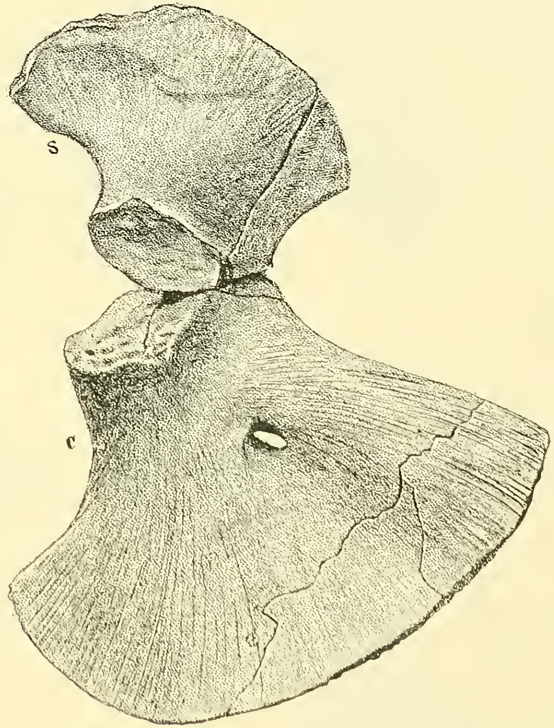
PLATECARPUS ICTERICUS, × one-third.



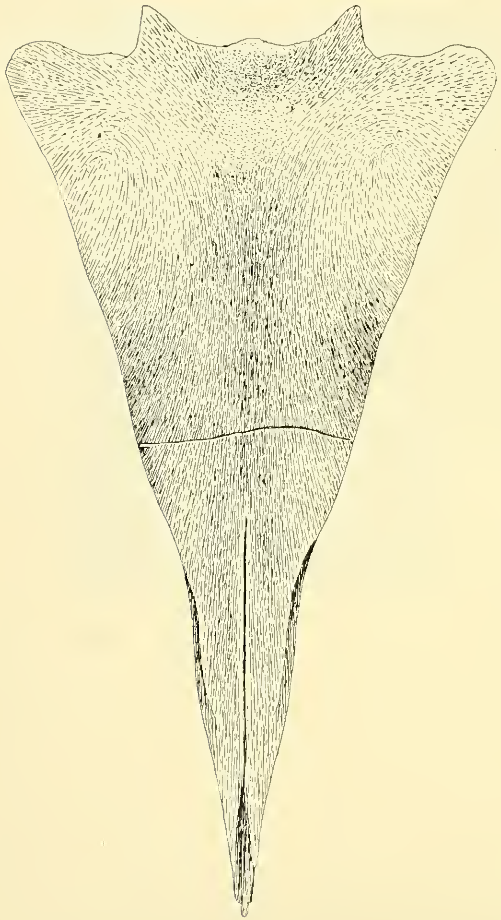
PLATECARPUS.



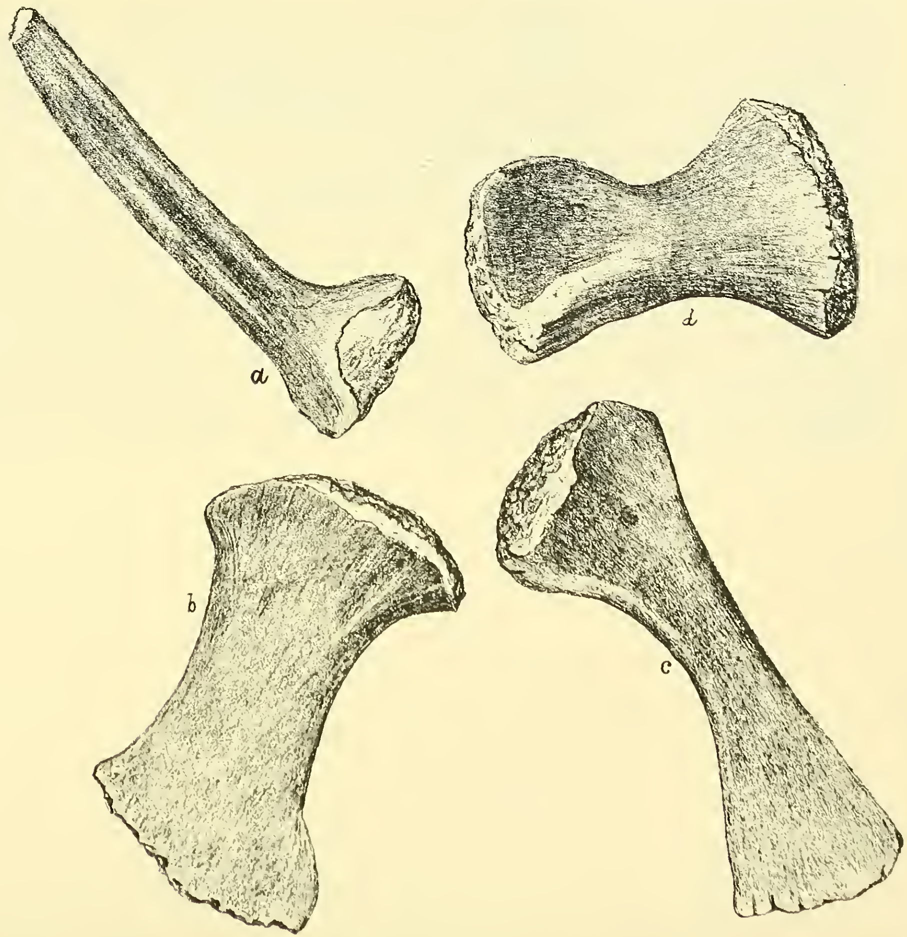
PLATECARPUS CORYPHÆUS — 1, 2, 3, 4, × two-thirds.



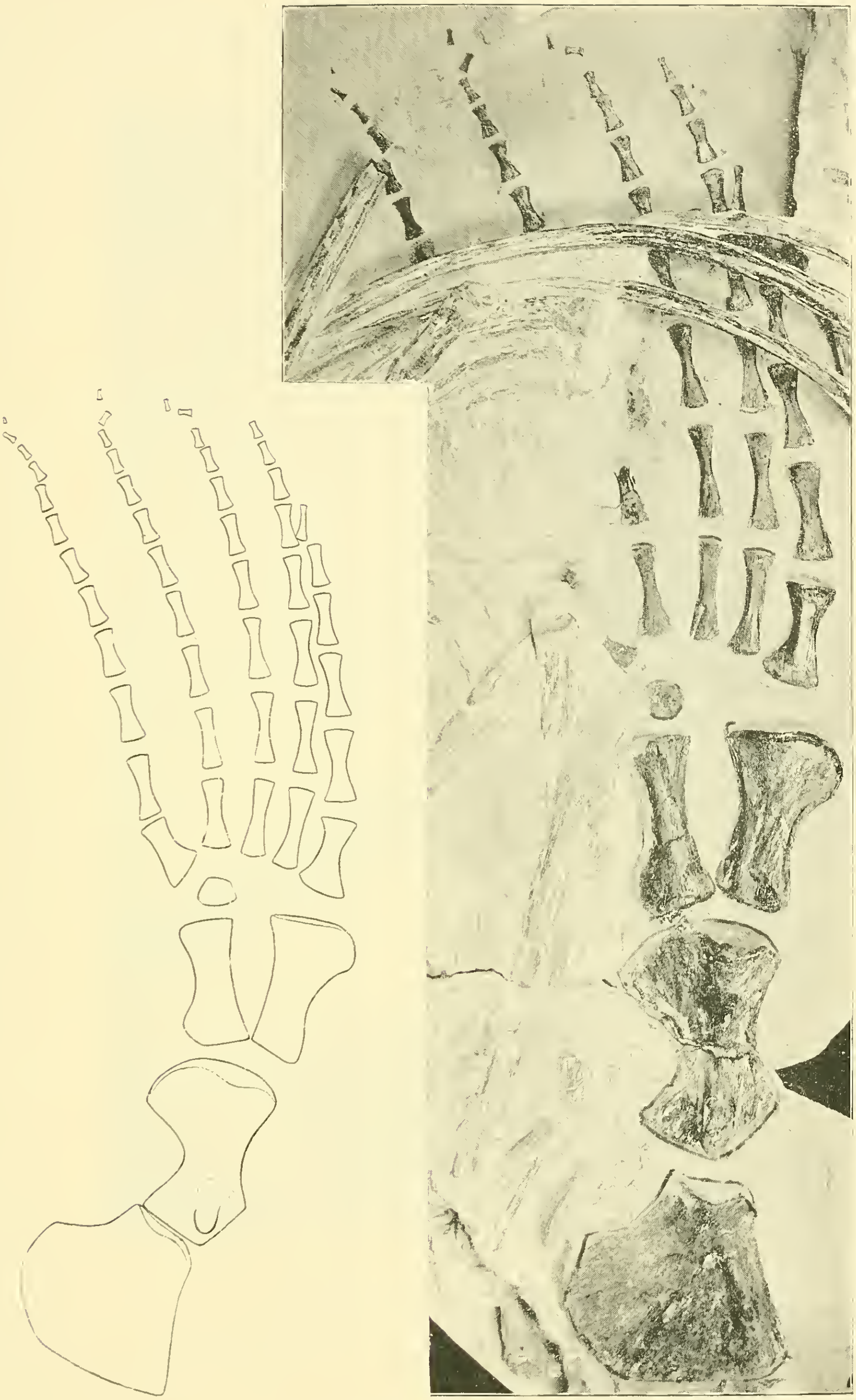
TYLOSAURUS DYSPELOR — s, c, × one-third.



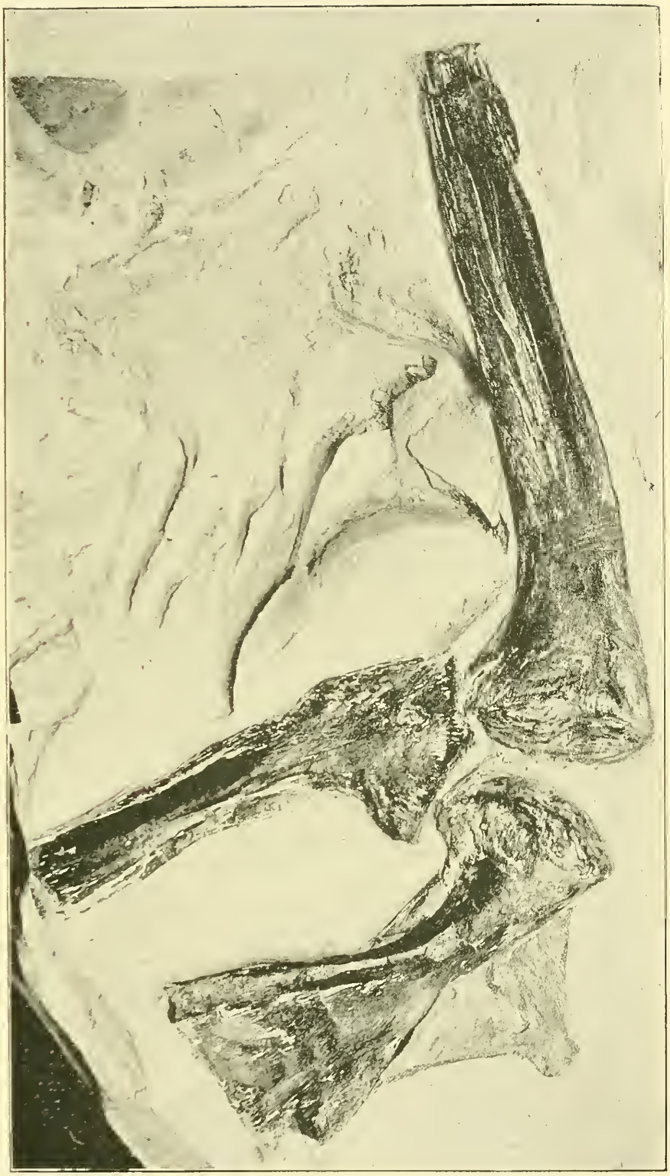
CLIDASTES TORTOR, × one-half.



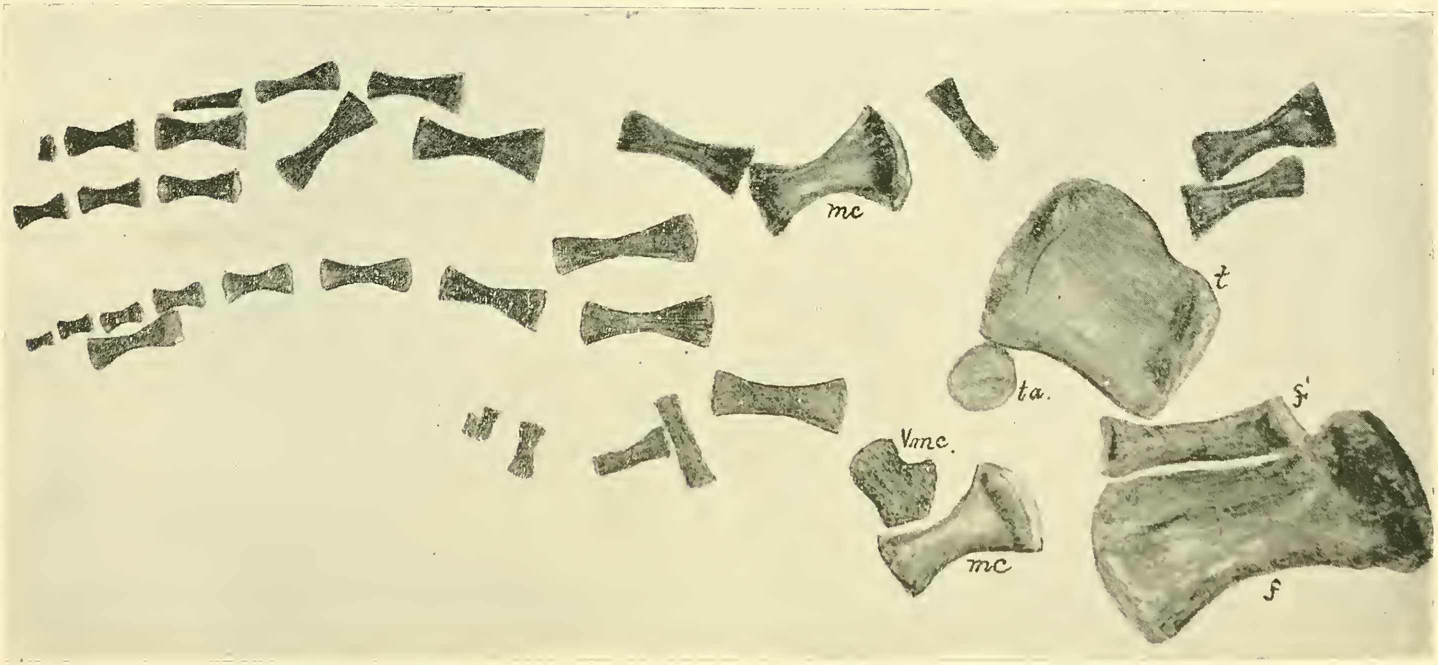
PLATECARPUS SIMUS, × one-half.



TYLOSAURUS PRORIGER.

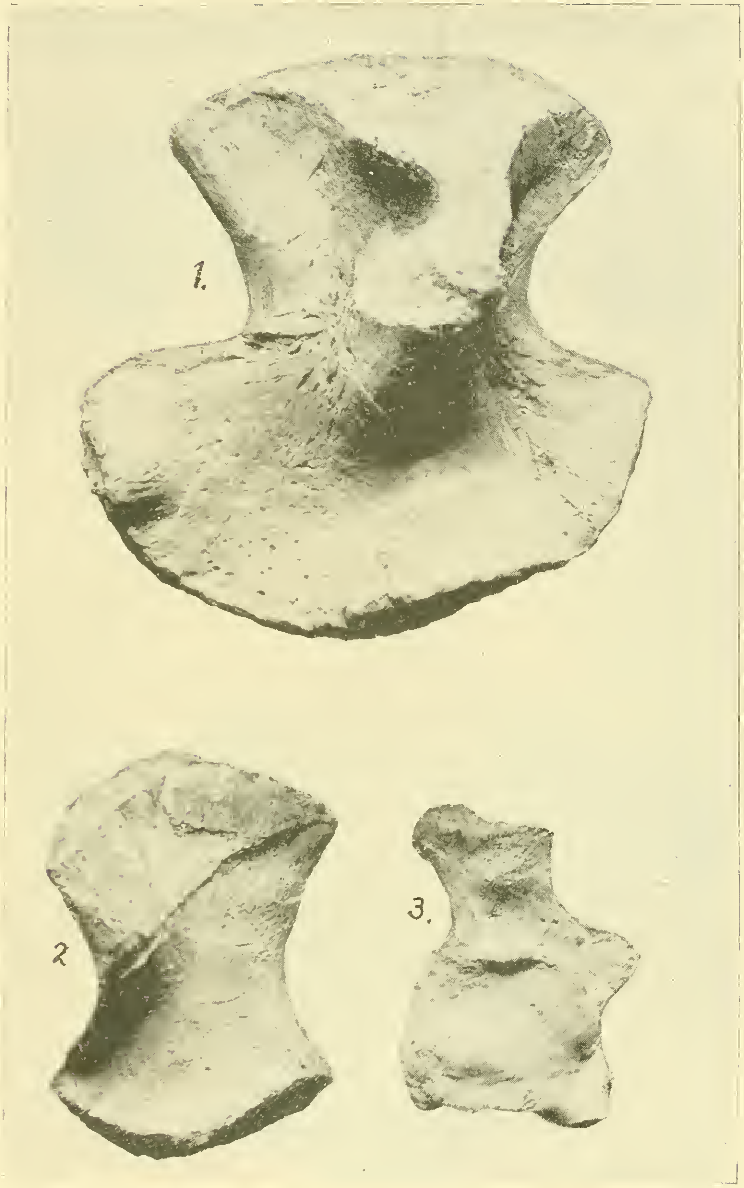


TYLOSAURUS PRORIGER.



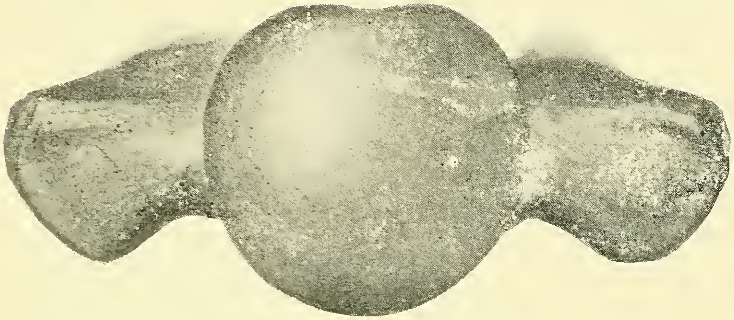
TYLOSAURUS PRORIGER, × one fourth.

PLATECARPUS CORYPHAEUS × three-sevenths.

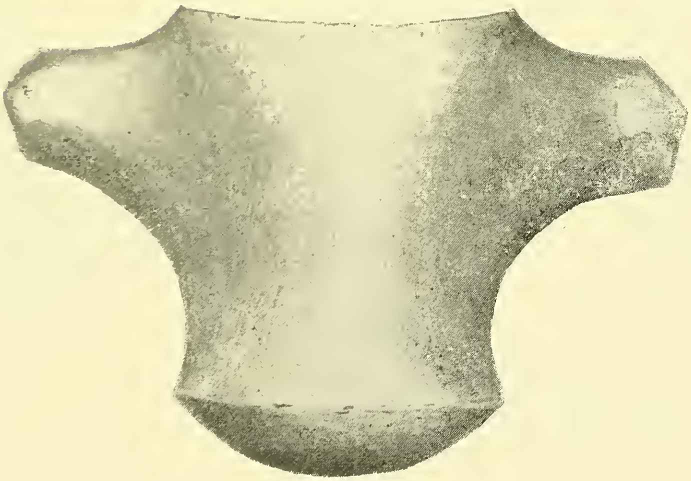


PLATECARPUS CORYPHÆUS, × two-thirds.

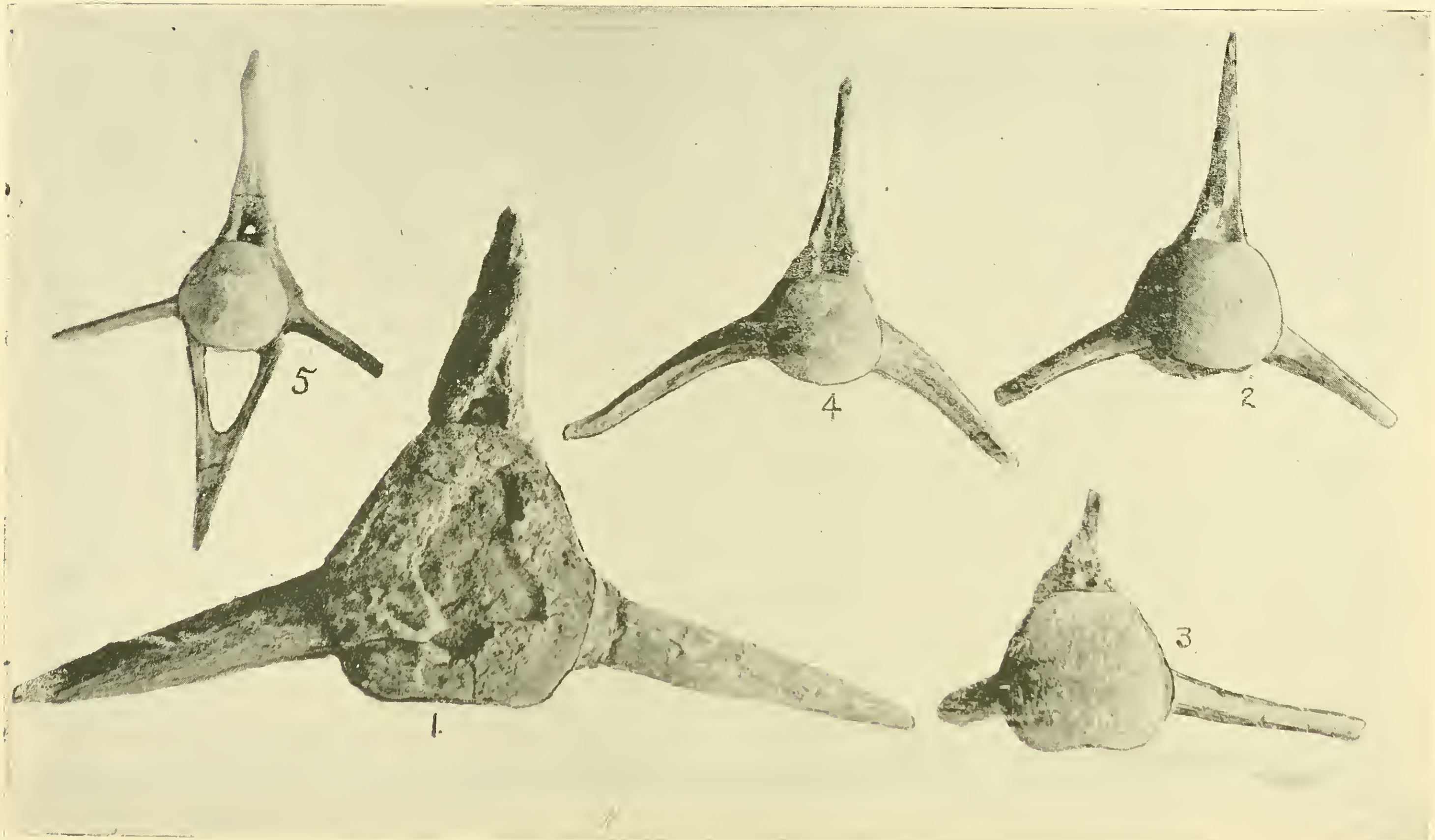
1.



2.

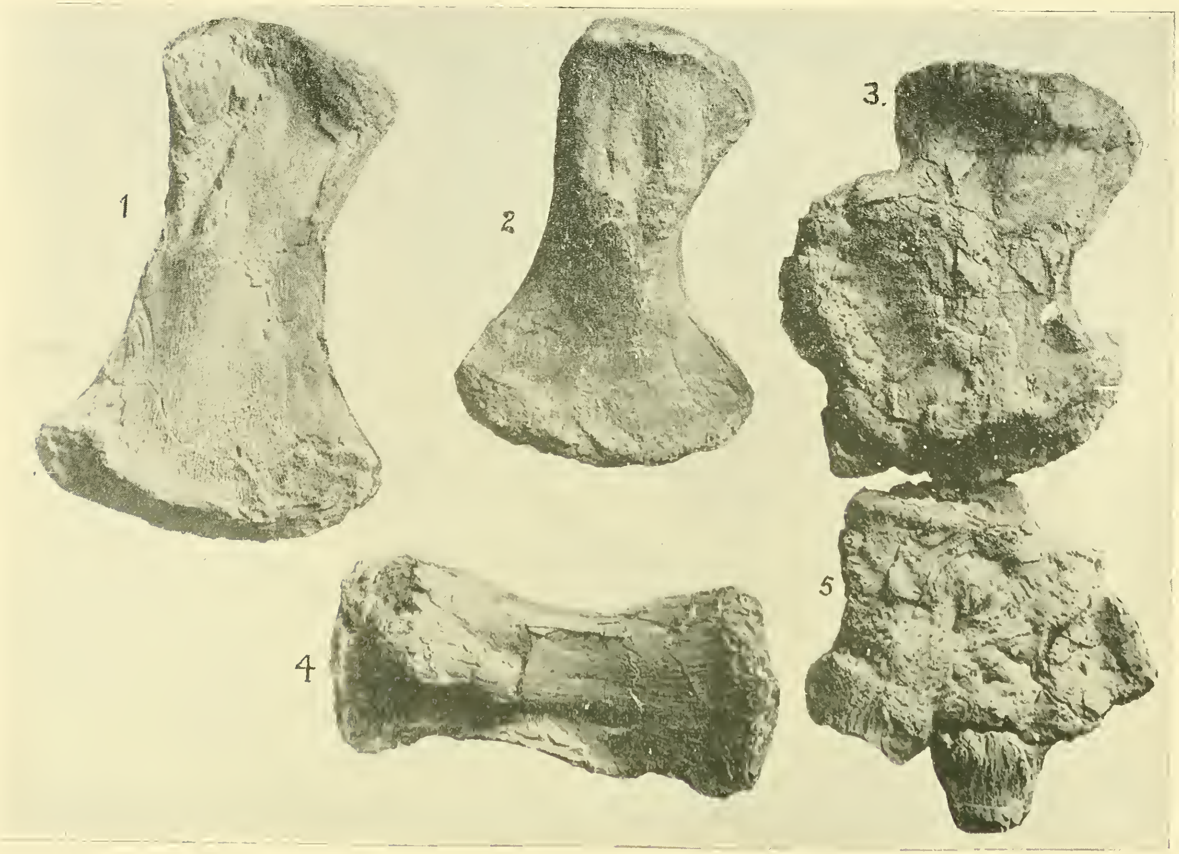


CLIDASTES WESTII, natural size.

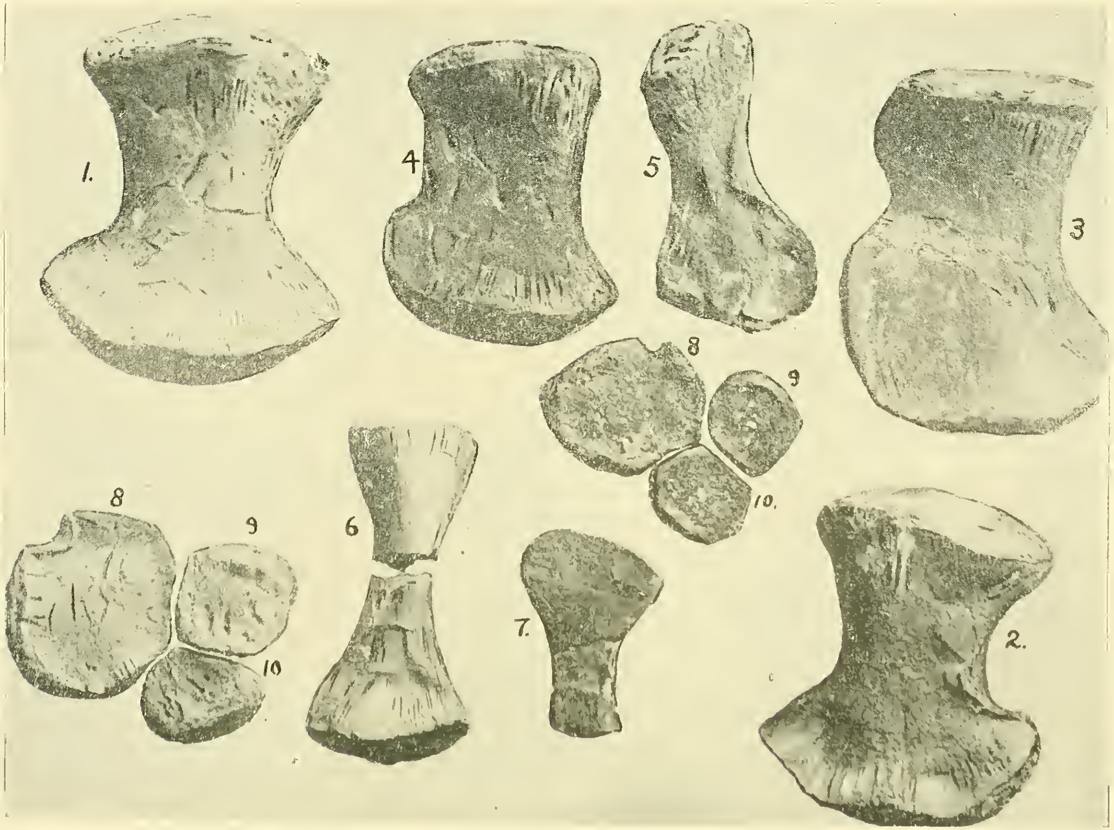


TYLOSAURUS sp.?—1. PLATECARPUS CORYPHÆUS—2, 3. CLIDASTES TORTOR—4, 5.

TYLOSAURUS PRORIGER, × one-half.



PLATECARPUS CORYPHÆUS, × one-half.



PLATECARPUS sp.?—1, 2. CLIDASTES sp.—3.

PLATECARPUS CORYPHÆUS—5 to 10, × three-fifths.

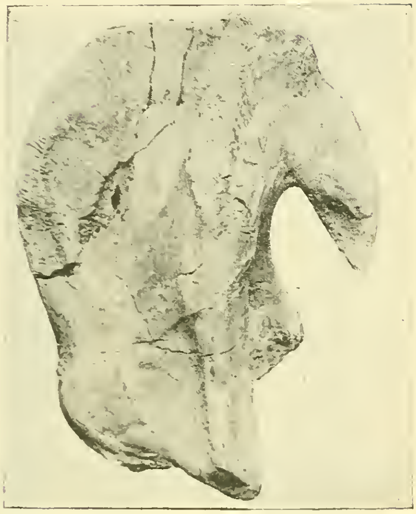
PLATECARPUS CORYPHÆUS, × three-fifths.

TYLOSAURUS DYSPELOR, × two-fifths.

All × seven-twelfths.

TYLOSAURUS PRORIGER — 1, 2.
PLATECARPUS CORYPHÆUS — 3.
CLIDASTES WESTII — 4.
C. TORTOR — 5.
C. VELOX — 6, 7.

1.



2.

TYLOSAURUS DYSPELOR—1, 2, × one-third.

3.

4.

PLATECARPUS CORYPHÆUS—3, × one-half.

CLIDASTES TORTOR—4, × two-fifths.

3.

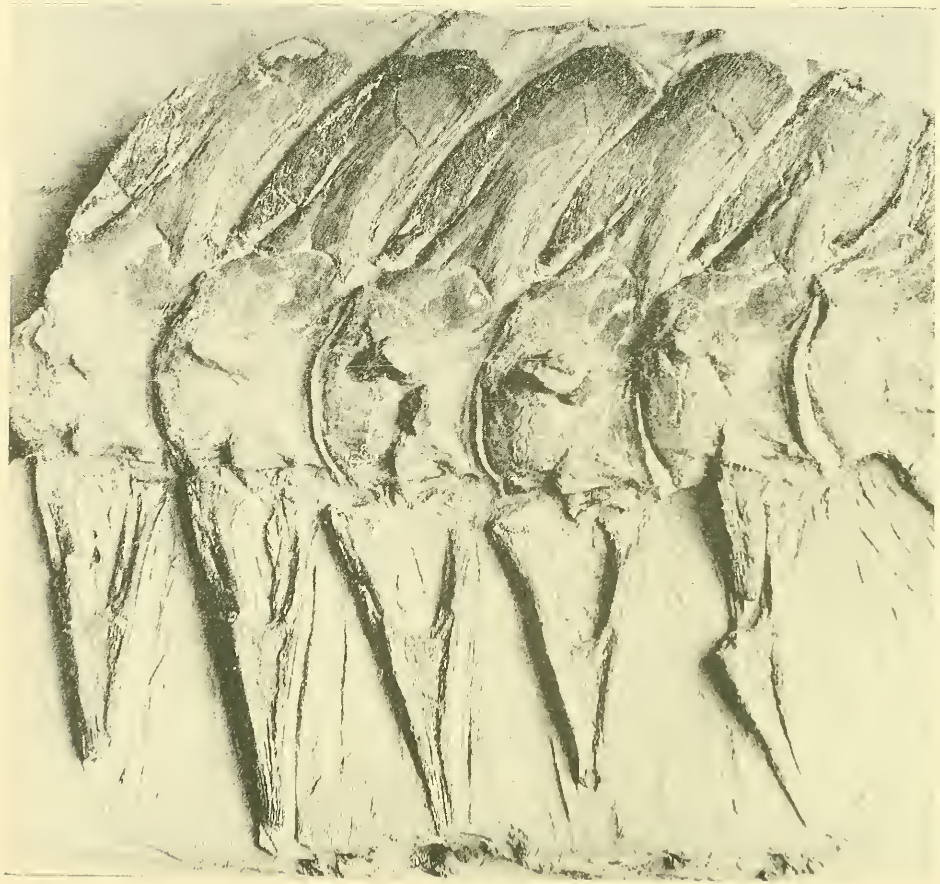
1.

2.

BRACHYSAURUS OVERTONII—1, 2, × two-fifths.
CLIDASTES VELOX—3, × one-seventeenth.

PLATECARPUS CORYPHÆUS, × one-half.

3.

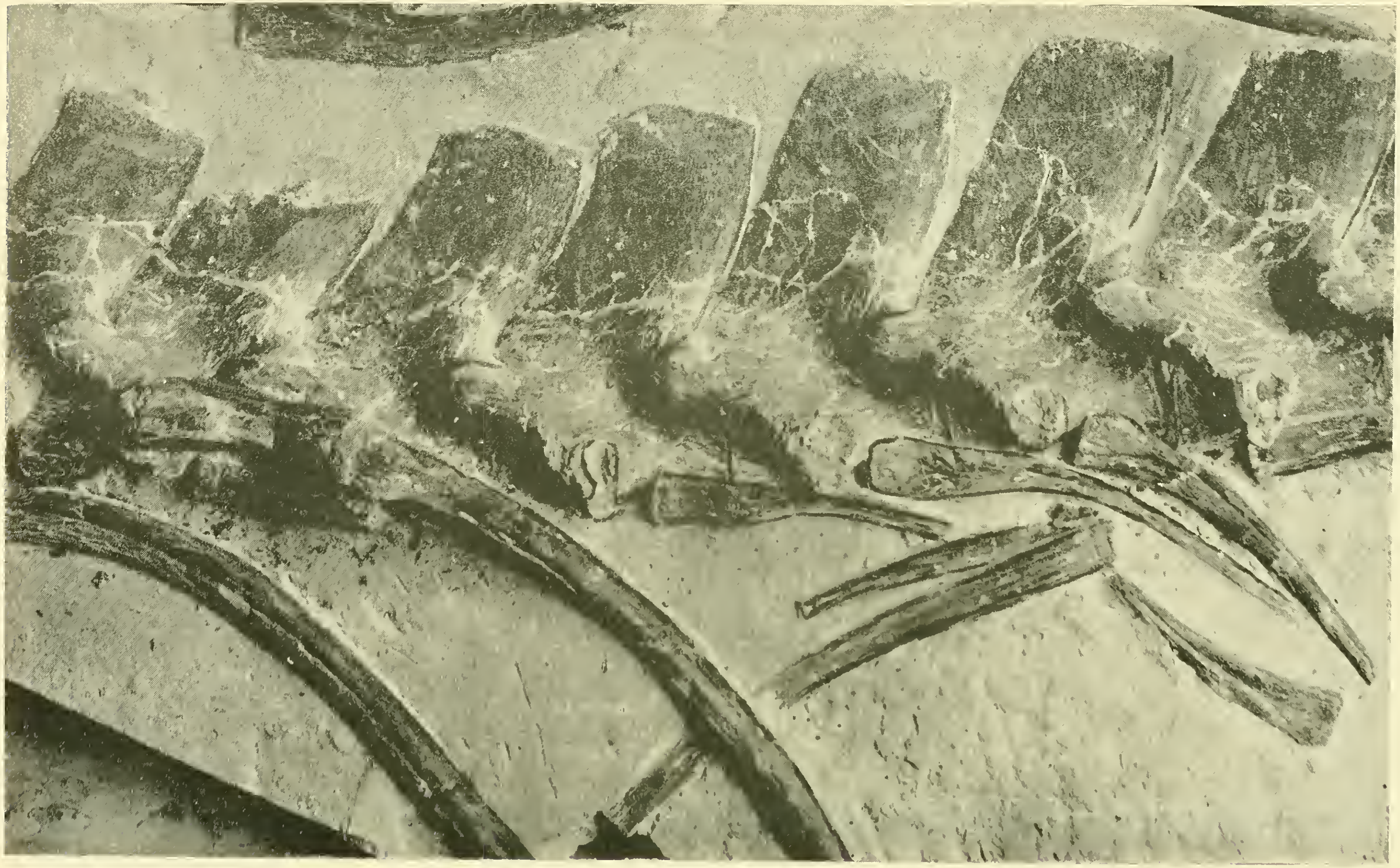


1.

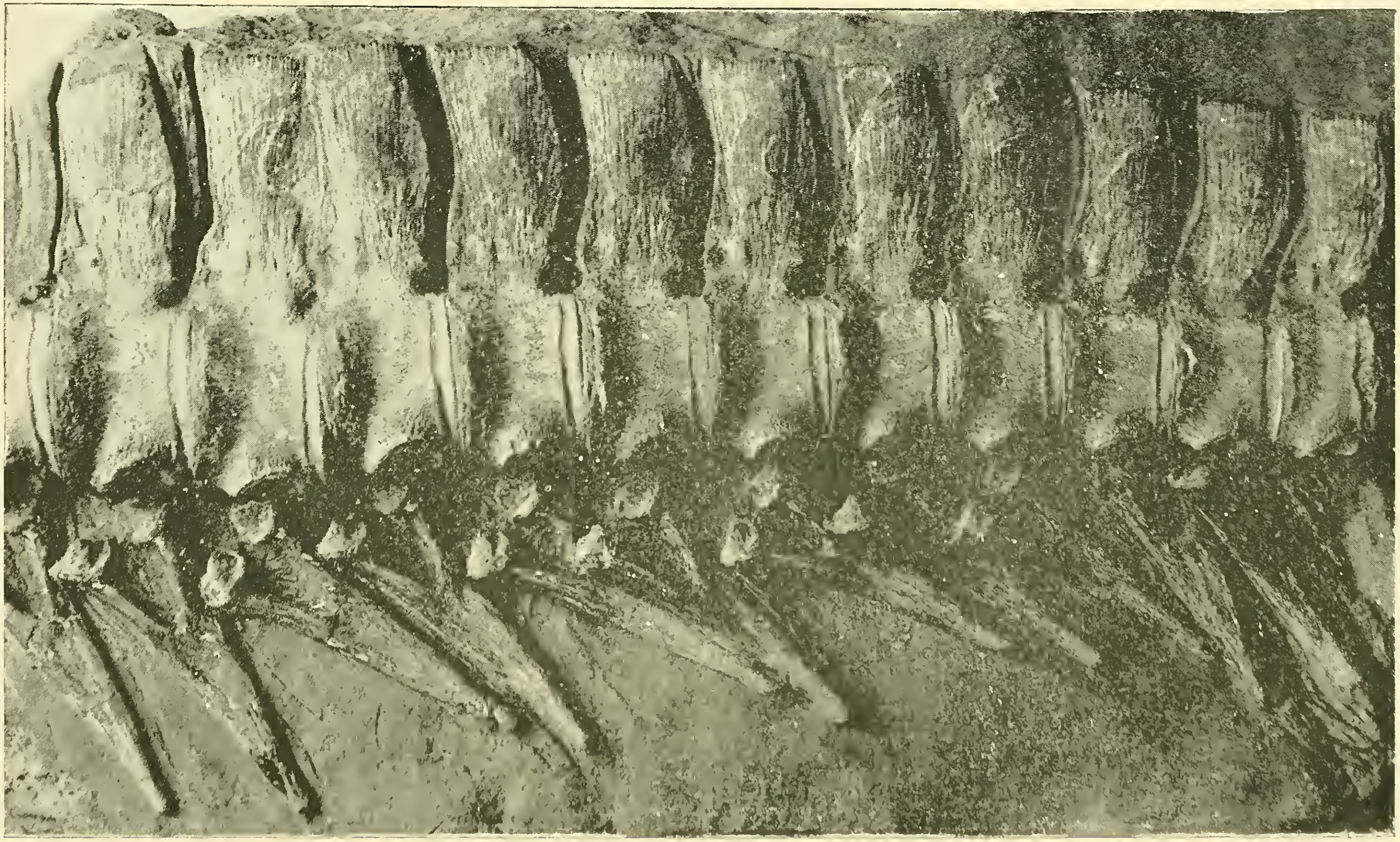
CLIDASTES TORTOR, × two-fifths.

2.

PLATECARPUS CORYPHÆUS—2, 3, × one half.

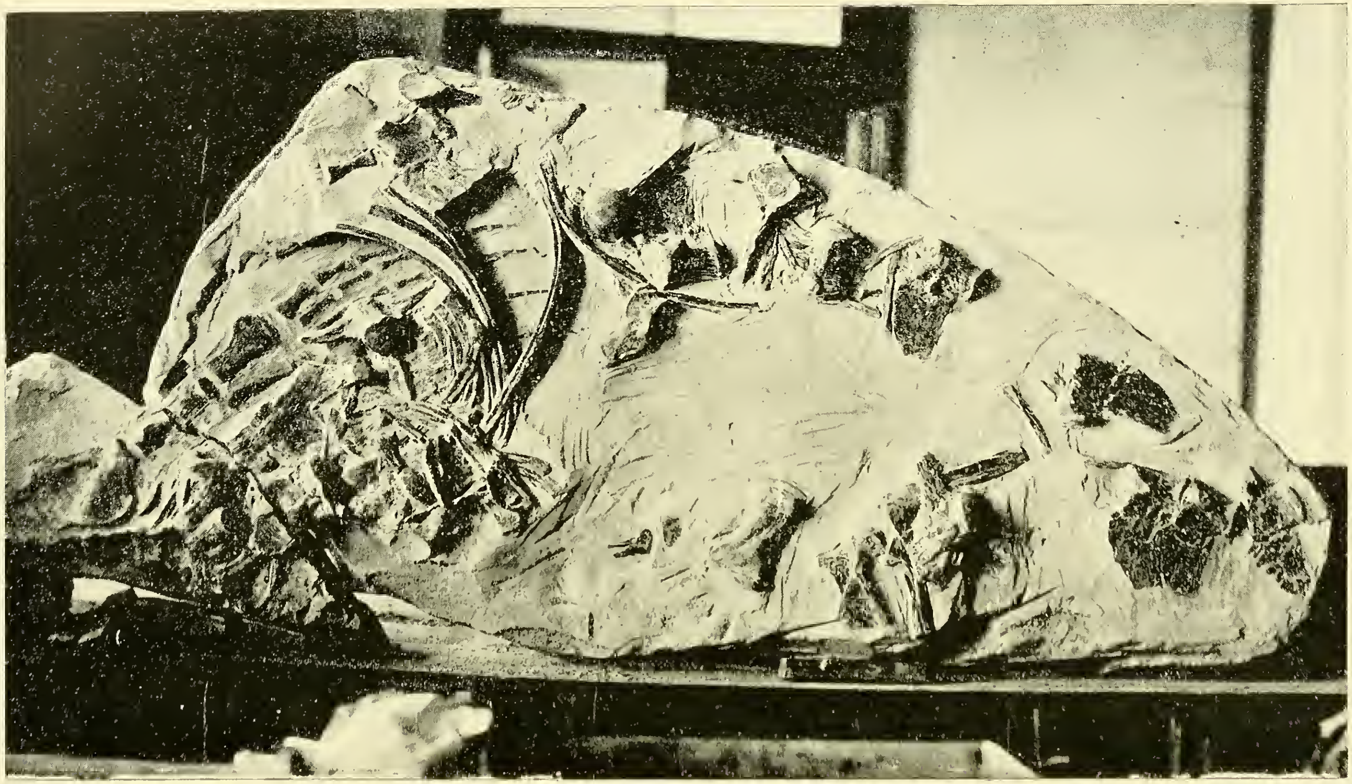


TYLOSAURUS PRORIGER, × one-half.

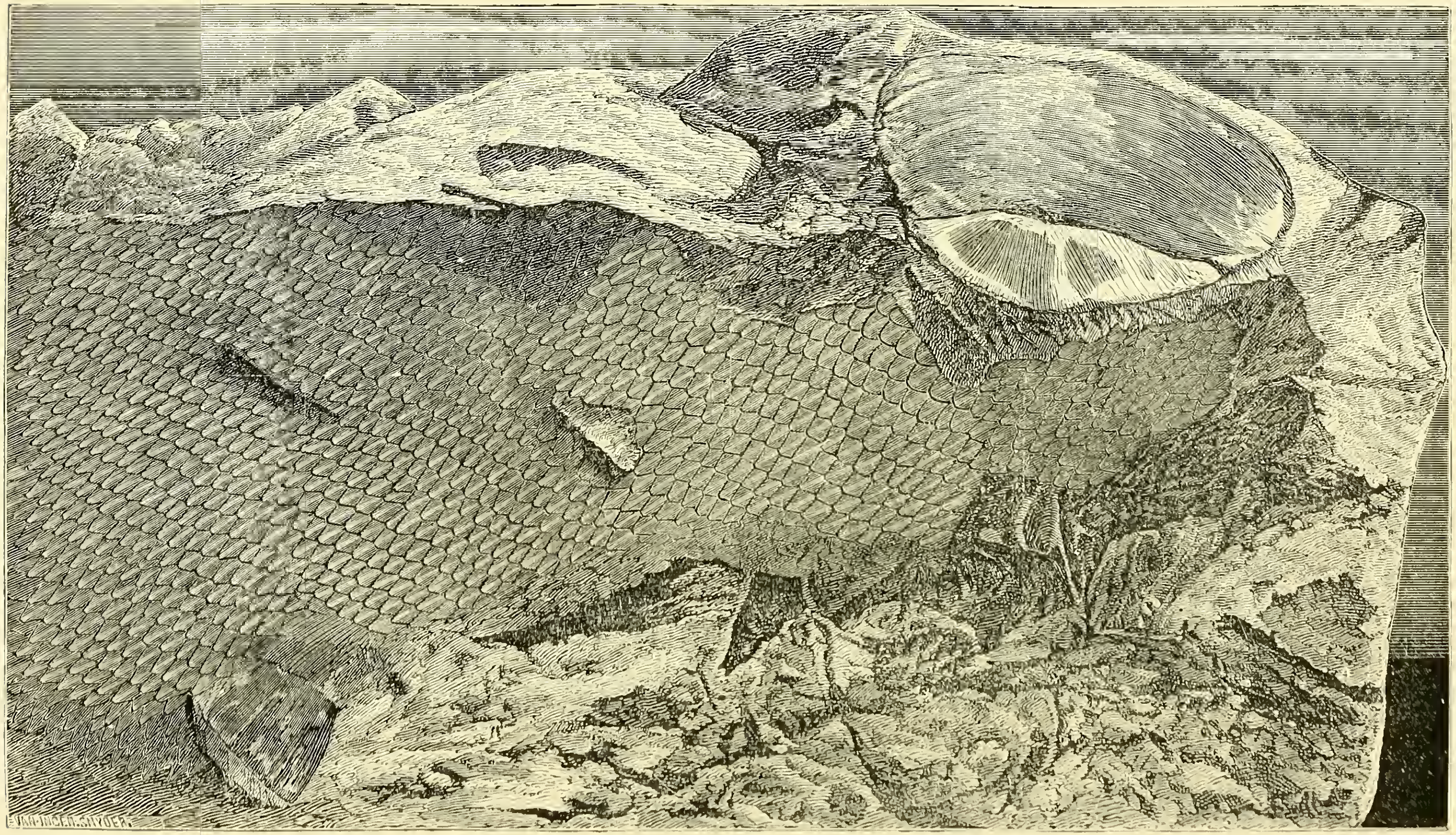


TYLOSAURUS PRORIGER.

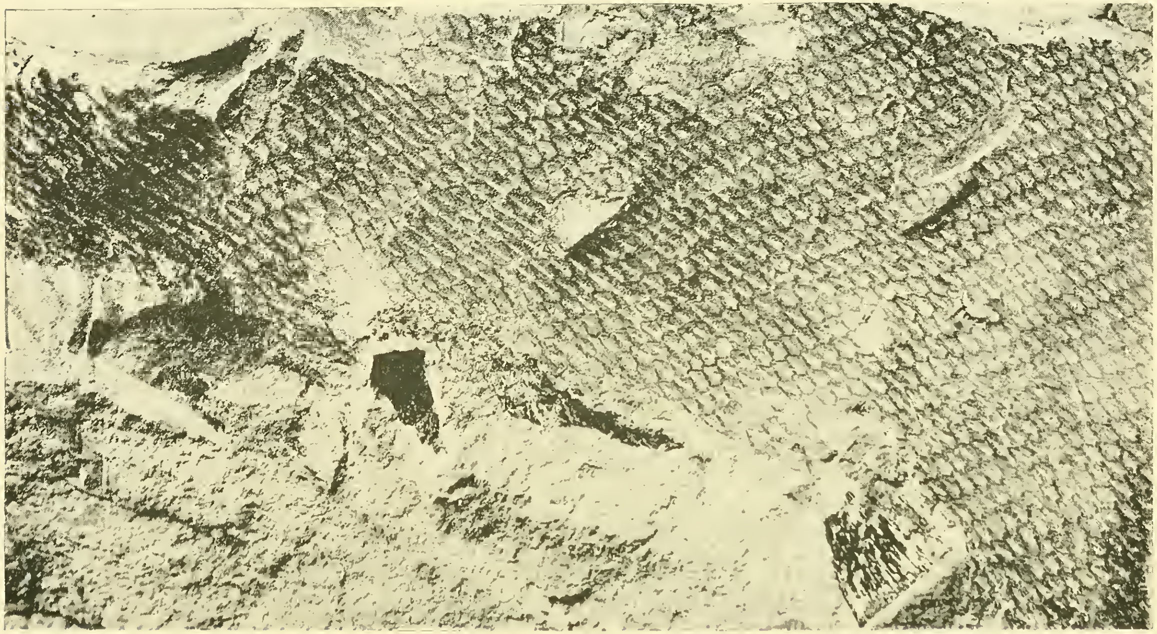
TYLOSAURUS PRORIGER.



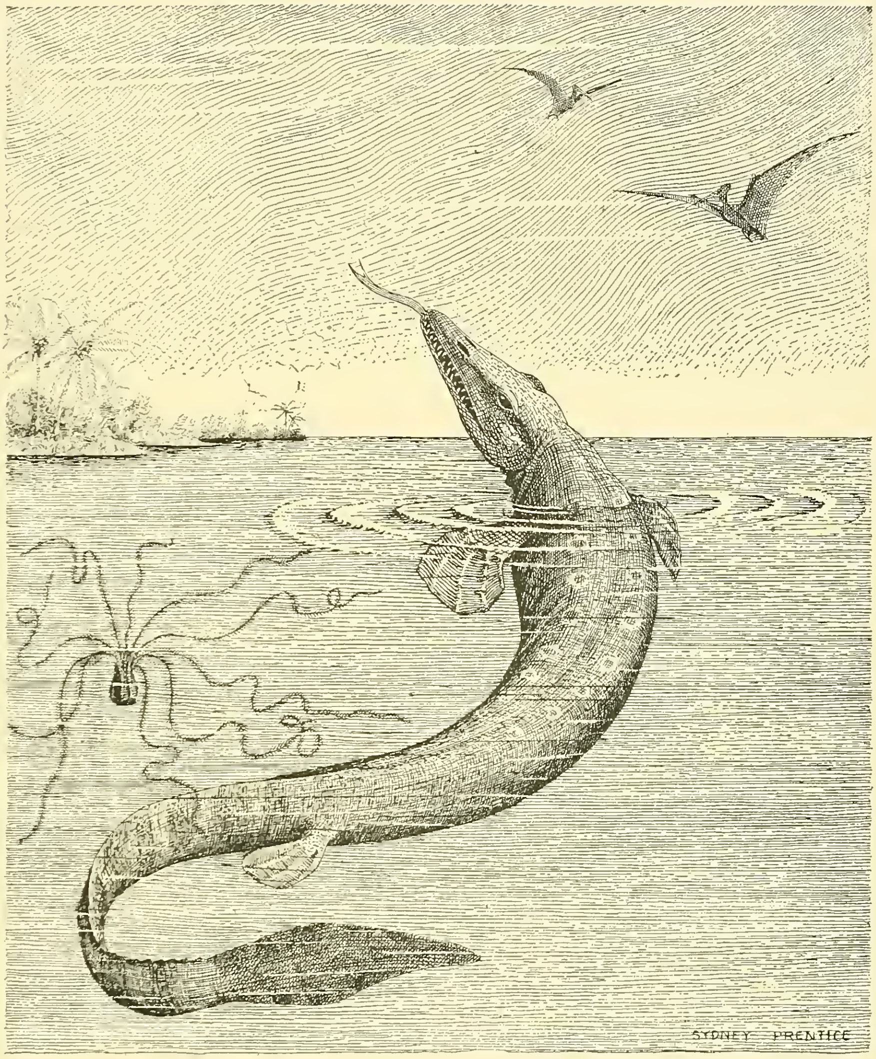
TYLOSAURUS PRORIGER, × one-eighth.



TYLOSAURUS PRORIGER, natural size.



TYLOSAURUS PRORIGER, natural size.



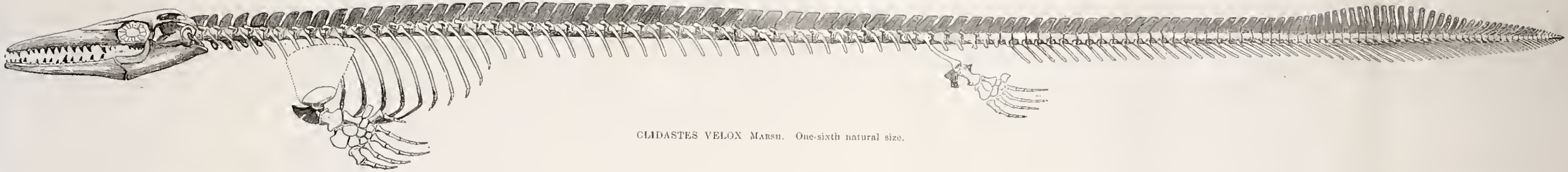
Uintacrinus socialis. *Clidastes velox.* *Ornithostoma ingens.*

LIFE RESTORATION OF KANSAS CRETACEOUS ANIMALS.

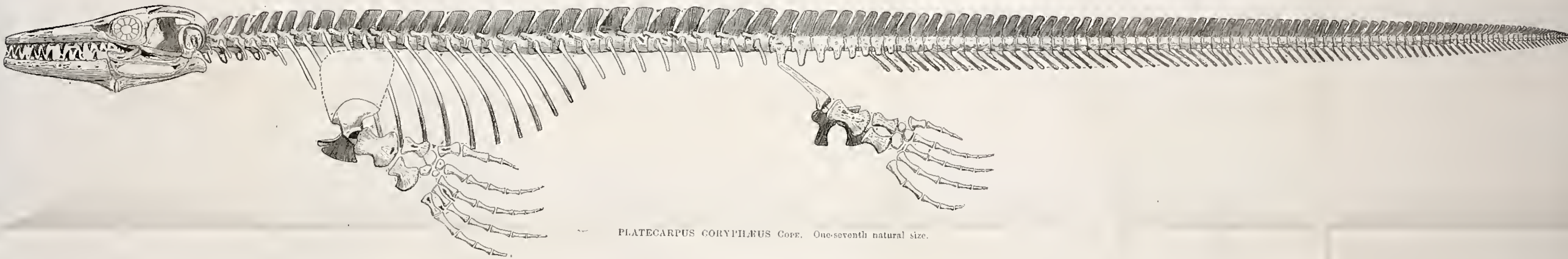
AT

RESTORATIONS OF KANSAS MOSASAURS.

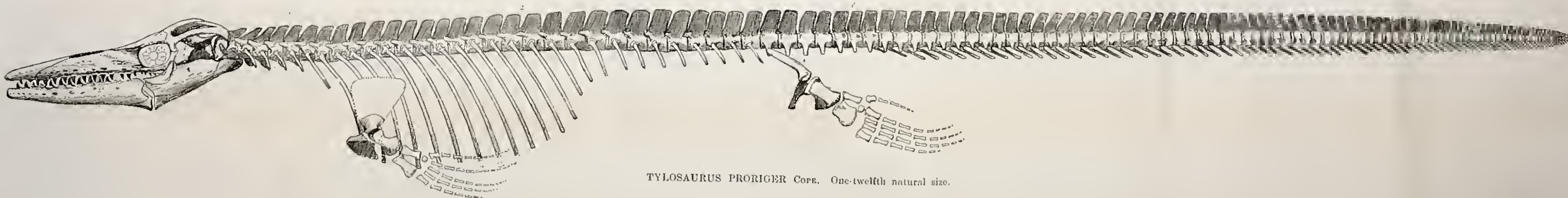
PLATE LXXII.



CLIDASTES VELOX Marsh. One-sixth natural size.



PLATECARPUS CORYPHÆUS Cope. One-seventh natural size.



TYLOSAURUS PRORIGER Cope. One-twelfth natural size.

PART VI.

TURTLES.

INTRODUCTION AND DESMATOCHELYS.

By S. W. WILLISTON.

TOXOCHELYS.

By E. C. CASE.

Plates LXXIII-LXXXIV.

CRETACEOUS TURTLES.

INTRODUCTION.

From the Upper Cretaceous of Kansas four genera and six species of turtles, or Testudinata, all marine, are now known — one from the Benton and the others from the Niobrara. The largest of these, and in many respects the most remarkable of all fossil turtles, is the gigantic *Protostega*, an animal that may have reached a length of twelve or more feet. The others are much smaller, probably never more than five or six feet in length. *Toxochelys* is by far the most common of them all, its remains being found, especially in the upper or yellow chalk of the Niobrara, often in abundance. *Protostega* has recently been fully described and figured,[65] chiefly from the material in the University of Kansas museum, by Professor Case, and the description it is not thought desirable to reproduce here. The *Toxochelys* remains of the museum have been thoroughly described for the present work by Professor Case, whose studies in this group have well fitted him for the task.

Desmatochelys occurs in the state, though the type specimen came from Fairbury, Neb., near the Kansas line, in the Benton.

Remains of turtles are among the most frequent of vertebrate fossils in nearly all the formations from the Triassic to the present time. Unfortunately, while their distribution has been very general, indicating wide-spread abundance, the remains are usually fragmentary, complete or even approximately complete specimens being comparatively rare. For this reason our knowledge of the fossil forms is yet far from satisfactory in many of the formations. Many genera and species have been proposed, but not a few of them are known so imperfectly that

65. Journal Morph., June, 1897.

their relationships or validity are yet more or less problematical.

The first known Testudinata are from the Upper Trias. Singularly enough these first turtles are as distinctly specialized as those of the present time. The extraordinary specialization which this branch of reptiles has undergone, whereby the ribs have been transformed into a bony shell, and the shoulder and pelvic girdles inclosed within the bony case, instead of being outside the ribs, as in all other vertebrates, had been completed by the close of the Trias. Undoubtedly we may expect the early ancestors of the turtles, the more generalized forms with incomplete carapace and with teeth in the jaws, at least as early as the beginning of the Trias, if not in the Permian. So far, however, all such evidence is wanting.

In the Jurassic formation, turtles are very abundant and of varied organization. In the Cretaceous, turtles have been found in less abundance, yet they are not at all rare. The turtles of the early Tertiary offer only slight differences from the Cretaceous Testudinate fauna. In the Eocene and Miocene lake deposits of America the remains of often gigantic turtles are very abundant.

There is nothing in the history of the turtles that is of startling interest. None have lived that were much larger than some in existence. *Protostega*, from the Kansas Cretaceous, is probably the largest. This form is peculiar in having a very imperfectly ossified carapace, the ribs being separated and not uniting into a solid bony plate.

The classification of the turtles is by no means yet clearly solved. The usual grouping is into three suborders — the Trionychia, Cryptodira, and Pleurodira, The Trionychia include turtles with a leathery skin, and not with horny shields, the carapace poorly ossified and the body flattened. The soft-shelled turtle of the Kansas rivers is an example. The Cryptodira include the great majority of turtles, such as the snapping turtle, the tortoise, etc. The carapace and plastron are more or less perfectly ossified, the head is withdrawn under the shell by a vertical flexion, etc. All of the known forms from the Kansas

Cretaceous belong to this suborder. The Pleurodira include a much smaller number of living turtles, all of which are confined to the southern hemisphere. The carapace is always fully ossified; the head is brought into the shell by turning sidewise, and not by a vertical flexion. The earliest known turtles are Pleurodira.

The large green turtle of the West Indies sometimes attains a weight of five hundred pounds.

DESMATOCHELYS LOWII.

BY S. W. WILLISTON.

In November of 1893 I received from Mr. M. A. Low, general attorney for the Chicago, Rock Island & Pacific railroad, a skull of a turtle, of unusual interest, which had been obtained by Mr. Schrantz, roadmaster of the Rock Island road, near Fairbury, Neb. From the matrix yet adhering to the specimen I recognized its age as that of the Benton Cretaceous.

Mr. Low, with his usual generosity towards the University, enabled me shortly afterward to visit the locality whence it had been obtained. I found, as I had suspected, the formation to be the Benton, and probably from the horizon named the Ostrea Shales by Mr. Logan. An associated fossil was *Xiphactinus lowii* Stewart, recently described. The late Doctor Eaton, of Fairbury, kindly assisted me in the examination of the region, and, by his intervention, I obtained various other parts of the skeleton. The animal had been fossilized nearly entire, but had unfortunately suffered loss and mutilation in its collection and preservation. It nevertheless permits nearly all of the essential characters to be made out with considerable certainty. It represented a new species, which I have named in honor of Mr. Low, as a slight appreciation of the many favors that he has done to the University and indirectly for science, and a new genus, which I have called Desmatochelys, and a new family, Desmatochelyidæ.

While this type specimen, from which the following description has been drawn exclusively, was obtained from just across the line in Nebraska, the species also must occur in Kansas, and has actually been reported from this state by Cragin. For that reason the description has been included with the other Cretaceous vertebrates of this state.

Desmatochelyidæ.

Desmatochelyidæ Williston, Kans. Univ. Quart., III, 5, July, 1894.

DESMATOCHELYS.

Desmatochelys Williston, Kans. Univ. Quart., l. c.

Desmatochelys lowii.

Desmatochelys lowii Williston, Kans. Univ. Quart., l. c.

Skull.

The skull was originally complete and in wonderful preservation, having suffered but little from compression. Unfortunately the posterior inferior portion has been so injured that its characters are mostly obliterated.

The *parietals* are elongate, narrow, gently arched bones, separated from each other by a distinct suture, and extending back over the supraoccipital for a considerable distance. Taken together, the two bones, exclusive of the supraoccipital projection, form an elongated parallelogram, with a rounded boss or eminence in the middle in front. They send down a rather narrow fore-and-aft plate to join the pterygoids.

The *frontal* bones are irregular in shape, though their entire form cannot be made out with certainty, owing to the obliteration of a part of the suture between them and the prefrontals. Posteriorly they unite by a nearly transverse, somewhat concave suture with the parietals, and, by an oblique suture running to near the middle of the superior orbital margin, with the postfrontals. The free orbital border is short and gently emarginate. In front, the transverse suture separating them from the prefrontals is very distinct on the outer two-thirds, but obliterated on the inner part. A very careful examination here shows, apparently with certainty, that the suture is not continued inwardly on the same line, but seems to turn forward and a little outward to join the nasal suture, as is indicated in the drawing, thus excluding the prefrontals from meeting in the middle line.

With this interpretation, the *prefrontals* are small, and have an irregularly four-sided shape. Their orbital margin is even shorter than that of the frontals.

The *nasal suture* is transverse; the maxillary suture oblique and gently concave. The superior aspect of each bone is on one plane, sloping outward and forward.

The *nasals* are united by well-marked sutures, and are subquadrate in shape, the maxillary and prefrontal sutures, which are nearly of the same length, meeting in an acute angle. There may have been a slight notch in the middle in front. The bones together form a very gentle arch.

The *premaxillaries* show distinct sutures, both median and lateral, the latter nearly at the outer margin of the narial opening and all parallel.

The *postfrontals* form an extensive arch, together with the parietals, covering the temporal fossæ. Their union with the jugals is not evident, but seems to be above the middle of the posterior orbital margin. The postfronto-squamosal suture is likewise not distinct.

The lower margin of the *maxillaries* forms a rather thin, somewhat sinuous edge. The junction with the jugal it is impossible to trace. On the posterior part, from near the middle of the orbital margin, there was evidently a thin expansion downward, but the edge has been broken off, so that one cannot say to what extent. Its ascending process to join the prefrontals is about one inch in width between the nares and orbits.

The *external nasal opening* is cordate in shape, with a rounded anterior angle. The plane of its margins looks upwards and forwards at an angle of about thirty-five degrees from the perpendicular.

The posterior margin of the *orbits* is almost exactly in the middle of the anterio-posterior diameter of the skull. Their shape is irregularly oval, the greater diameter being from before back. Their superior margin, as far back as the frontopostfrontal suture, is parallel with the median line of the skull; it then turns obliquely outward, with a gentle convex border, to the middle of the hind margin. The plane of their margins is not more than ten or twelve degrees from the vertical, and is turned outward and forward at an angle of about thirty-five degrees. The margins are everywhere thin.

The *mandibles* have been firmly compressed upon the maxillaries, and are posteriorly somewhat flattened. They are stout and heavy, with a thin inferior margin throughout most of their extent. The genial margin is gently convex and considerably receding. The superior margin was evidently thin, like that opposing it. The articulating surfaces cannot be clearly made out, as the quadrates have been crowded upon them. They appear, however, to be slightly convex. The two sides show no trace of a suture between them.

The *palate* is remarkable for its extreme concavity and the anterior position of its choanæ. All posterior to the pterygoids has been so crushed that it is impossible to determine the characters.

The *pterygoids* are short and narrow, concave on the sides, extending out in front to form a rounded, vertical, ectopterygoid process, just in front of which is the distinct, transverse, palatine suture. The palatines continue the full width of the pterygoids in front, and are gently concave, with a rounded margin on the sides as far as the process. These processes curve outward and forward nearly horizontally to unite with the maxillaries, which do not send a distinct process out to meet them. Near the posterior border of the process, well out towards the extremity, there is a small palatine foramen, leading up into the floor of the orbit at about its middle, and vertically below, or a little to the inner side of the innermost part of the superior margin of the orbit. On the left side there appear to be two foramina. Almost from the posterior margin of the palatines the surface begins to ascend obliquely forward, forming a deep channel, which in the anterior half is divided into two by a strong median ridge. Unfortunately, the suture with the vomer cannot be made out. The posterior narial openings are extraordinarily large, and situated far forward, almost immediately below the anterior openings. Each opening is large, and its plane looks upwards, forwards, and inwards.

General Characters of the Skull.

The skull is elongate, narrow, and high. It tapers on the sides from near the quadrates to the front margin of the orbits, whence the muzzle forms an acute, somewhat convex cone. The superior surface from the front margin of the nasals is only lightly arched, but with a rounded boss back of the middle. The surface is nearly smooth, or with delicate striæ, except near the front end, where it has numerous small, rounded pits. The orbital and nasal margins are sharp.

The principal dimensions of the specimen are as follows:

Extreme length	205 mm.
Width through quadrates	145
Height	95
Length of mandibles	155
Width between orbits above	58
Greatest width between the orbits posteriorly	105
Antero-posterior diameter of orbits	60
Width of orbits	42
Transverse diameter of nares	31
Antero-posterior diameter of same	31
Least width of pterygoids	22
Width through the ectopterygoid processes	46
Least width of the palatines	43
Antero-posterior diameter of posterior nares	24
Transverse diameter of same	18
Distance between choanæ	16
Width between palatine foramina	48
Width of mandible through symphysis	43
Width of mandible below orbit	24

The skull, as will be seen from the description and the figures, has a great resemblance to that of the sea turtles, the rostrum being somewhat less narrow than in *Chelone*, but from which it differs conspicuously in the presence of free nasals, the presence of palatine foramina, the structure of the palate and the anterior position of the choanæ, and the convexity of the maxillary condyle. Its resemblance to *Rhinochelys*, from the Cambridge Greensand, seems greater, so far as I can judge by the figures given by Lydekker. Like that, it has free nasals; the pterygoids narrow and emarginate, the palatines probably meeting in the middle line; the prefrontals separated; the jugal continuing the line of the alveolar border to the quadrate; mandible with the interdentary suture obliterated, and with a prominent oral margin. From it there seem to be ample generic differences. There are no indications of epidermal shields in the present skull.

Cervical Vertebræ.

The specimen, as I received it, showed crowded into the posterior temporal opening three cervical vertebræ. With much labor one of these has been removed; it presents important characters, all distinctly Pleurodiran. The anterior surface of the centrum is markedly convex, but much broader from side to side than from above downward, being subtriangular in shape. The posterior zygapophyses are elongated and evidently arched downward. The arch above is gently convex. Near the posterior part of the centrum on each side is a very stout transverse process. The posterior articular surface of the centrum has been injured, but is convex.

The measurements of this vertebra are as follows:

Length of centrum from rim to rim	26 mm.
Width of anterior articular surface	26
Vertical diameter of the same	15
Width through transverse processes	64
Thickness of transverse processes	17
Diameter of neural canal, transverse	13
Diameter of neural canal, vertical	14

Caudal Vertebræ.

Several caudal vertebræ are preserved, one of the largest of which is shown in pl. LXXVIII, f. 4. They are all small, and indicate a small and short tail. The centrum is moderately elongated, with well-developed zygapophyses and rudimentary transverse processes. The anterior end of the centrum is concave, the posterior convex. Its measurements are as follows:

Length of centrum	17 mm.
Height of vertebra	22
Vertical diameter of cup	12

Pectoral Girdle and Extremity.

The bones of the pectoral girdle and extremity preserved were found so little distorted from their natural position that their mutual relationships are assured. The scapula and coracoid were found between the carapace and plastron, near together. A part of the coracoid has been lost, but the inner end was lying in apposition to the inner end of its mate. There is one nearly complete humerus preserved and close to the lower end of both were the bones of the forearm and the metacarpal bones which are figured. Unfortunately, the single bone figured as carpal or tarsal had been separated from the matrix and its position is unknown. The four bones of the metacarpus were lying nearly in position, the two inner ones crossed over each other. Lying across them, and undoubtedly belonging with them, is the fifth bone.

Scapula.

The scapula-proscapula is preserved complete, and shows but little distortion or compression. The humeral neck is moderately constricted, and is longer relatively than in *Protostega*. The two extremities are flattened oval in cross-section near the base, with rounded margins. The proscapula is shorter than the scapula, and is flattened and a little dilated at the distal extremity. The scapula is slightly widened distally, and ends in an obtuse point, with two shallow emarginations before the tip on the inferior border, and one on the upper border, separated by rounded prominences. The angle of the scapula with the proscapula a little less than a right angle.

Width of neck	42 mm.
Width of articular extremity	56
Length of proscapula to inferior border of scapula	82
Width of proscapula distally	34
Length of scapula to inferior border of proscapula	158
Greatest width of scapula distally	32
Least width of scapula	27
Distance between extremities of scapula and proscapula	175
Thickness of proscapula at proximal end	9

Coracoid.

The coracoid is a remarkably short bone for so large a turtle. The single bone preserved, of the right side, lies immediately above the proscapula and below the carapace. Its articular end is thickened, with a thinner expansion for articulation with the scapula. The scapular border is deeply concave, the distal extremity thin and moderately expanded. The outer border, except proximally, is wanting, but, from the thinness of the border at the extremity, it appears to have been nearly straight.

Length	100 mm.
Width at proximal end	35
Width of shaft (approximately)	18–20

Humerus.

The humerus is a very large, flat bone, intermediate in some respects between that of *Protostega* and that of *Chelone*, but with a narrower shaft than in either. Both bones were originally present, but unfortunately the left one is represented only by fragments. The distal end is shaped very much as in *Chelone*, save, as already stated, that it is more constricted above, below the radial process. The radial process is even larger than in *Protostega*, though not reaching as far down the bone. The ulnar process, on the other hand, is even more elongated than in *Chelone*, and is apparently even longer than I have represented it in the drawing. The bone is in all respects the humerus of a sea turtle.

Length from top of articular surface	202 mm.
Extreme length, about	260
Greatest diameter of a scapular articular surface	44
Least width of shaft	40
Width through lower part of radial crest	67
Greatest width distally	80
Thickness of shaft	17

Radius.

Lying nearly in connection with the portion which is preserved of the left humerus, are the nearly complete radius and a portion of the ulna. The radius has been but little compressed, and it is in excellent preservation, save for the part that is lost. Both extremities are expanded, apparently about the same. The upper end is thicker than the lower, and has slight striate markings near the border of the articular surface. About twenty-five mm. from the upper extremity, near the inner border, there is a roughened protuberance, the bicipital tuberosity. The shaft is quite smooth and oval.

Carpal ?

A single bone, which from its size I take to be a carpal and not a tarsal, is very thin and flat, nearly smooth, and oval in shape. It measures fifty-two mm. in its greatest and thirty-eight mm. in its opposite diameter, and is nowhere over five mm. in thickness. It has some very inconspicuous markings near the articular margin.

Metacarpals.

The four bones represented in pl. LXXVI, figs. 8, 8c, were lying upon the end of an ulnar fragment, and almost over the radius, and nearly in the position in which they are figured, the two inner ones being crossed. That they belong to the manus I have no doubt, and that they are metacarpals and not phalanges seems evident from the shape of their articular ends. Their measurements are as follows :

Length	48 mm.
Width of distal extremity	9
Length	87
Width proximally	19
Width distally	18
Length	55
Width distally	20
Length	55
Width proximally	15

Another finger bone, lying across the end of the radius is shorter than any of the foregoing, and may be a phalanx. One end is wanting, but the end which is present and the shaft are stouter than any of the foregoing. The width at the end is twenty-two mm., and in the narrowest place of the shaft twelve. Yet another digital bone (fig. 10) seems to be a phalanx, but whether of the fore or hind foot cannot be said, as it was misplaced. Its measurements are as follows:

Length	36 mm.
Width at extremities	11, 12
Least width of shaft	9

Pelvic Girdle and Extremity.

The three pelvic bones of the right side are lying with their articular surfaces nearly contiguous, the upper end of the ilium in apposition with the end of the transverse process of the sacrum. On the left side, the ischium and a part of the ilium, also in position are alone represented. Unfortunately of those of the right side the outer end of the ilium and a part of the anterior border of the pubis have been lost. The ilium is an irregular rod of bone, stout and not very broad with a pointed sacral extremity. Its anterior border is deeply concave, smooth and rounded, and not very thick. Its posterior border is dilated into a thinner expansion below, which is turned outward. Near the extremity, however, the bone again forms one plane and is moderately thick.

Greatest width of ilium	35 mm.
Width before the acetabular articulation	26

On the inner margin near the tip, there is a slight roughening, lying in apposition to the tip of the transverse process of a sacral vertebra.

Ischium.

The ischia have a smooth, paddle-shaped extremity, a long tooth-like tuberosity, and a dilated articular extremity which shows facets for the ilium and pubis. The symphysial end is broad, nearly straight on its margin, with rounded angles, and moderately thick. The tuberosity, which is situated about the middle of the bone, is conical, pointed and curved toward the acetabulum.

Length	84 mm.
Width of symphysial end	43
Width of acetabular end	35
Width of shaft on the proximal side of the tuberosity	21
Length of tuberosity	25

Pubis.

The pubis is much thickened at the acetabular end, expanded and thin at the symphysial end. The side exposed, the inner, shows two facets separated by a distinct angle. The ischial border is deeply concave, and for the most part thin. The bone is narrowest midway, and the whole lower part is evidently thin. Unfortunately, the anterior inferior portion has been lost. The surface exposed is nearly plane throughout, though it probably had some curvature. There are no indications on either pubis or ischium of union with the plastron.

Width of acetabular extremity	37 mm.
Length of ischial facet	25
Length of bone as preserved	108

Femur.

The only bone of the hind extremity preserved is an incomplete femur, which lies directed backwards, with the great trochanter immediately below the sacral end of the ilium. Its great trochanter is flattened, high, and broad, with distinct rugosities on the outer side. The head is a small, oval articular surface surmounting a rather thin, small plate placed nearly at right angle to the plane of the trochanter and at one side. Just back or below the head is a distinct depression or "digital" fossa, with a muscular rugosity near it. On the outer, or dorsal convex surface, near the narrowest part of the shaft, there are two roughened surfaces, one on the border opposite to that of the head forming a rounded tubercle about half an inch in diameter. The lower part of the bone is expanded and quite thin.

Width of trochanter	32 mm.
Height of trochanter above the head	25
Height of head above plane of trochanter	20
Length of articular surface of head	10
Width	7
Width of shaft	25
Thickness of shaft	12
Width near lower extremity as figured	40
Thickness	6

Carapace.

The carapace must have been originally nearly complete, but much has been lost and other portions have been injured in removing the hard matrix. It was evidently narrow in proportion to its length, and was pointed posteriorly. The bone everywhere is very thin — from two to three millimeters in thickness — and shows numerous small or minute pits; no other evidence of shields, however, is present. The sutures in some places between the pleuralia and neuralia are distinct, but for the greater part obliterated. The lateral plate corresponding to the third presacral vertebra has a length of 135 mm., but the very thin end is wanting, and may have been prolonged to the marginal. Its width proximally is forty, toward the outer part five or six millimeters more. The neural for this vertebra has its front and lateral sutures distinct; at its broadest part behind it measures thirty-two mm. in width.

The dorsal vertebræ are stout and cylindrical, with moderate expansions at the extremities. The rib processes are stout, situated near the anterior part of each vertebra, and the ribs articulated with one centrum alone in the posterior vertebra at least. The processes and heads of the ribs are stout, and are united by a free suture. The ribs of the three presacral vertebræ exposed are directed very obliquely upward; the transverse processes of the sacrum are nearly horizontal, slender, and the first pair directed a little obliquely backward.

Length of second sacral vertebra	21 mm.
Length of first sacral vertebra	24
Width through the articular surfaces for the transverse processes	31
Width of transverse process at base	17
Width of transverse process distally	11
Length of transverse process	45
Length of first presacral vertebra	29
Width of centrum anteriorly	22
Width through rib processes	25
Length of second presacral vertebra	40
Width of centrum anteriorly	24
Width through rib processes	29
Distance between inferior margin of same vertebra and the top of the carapace	40

Eight marginal bones are present, including the pygal. Whether they are all from the same side or not I do not know; but all are different. Lying in position, with the anterior projection touching nearly the posterior end of the united carapace, is the pygal which is figured, the surface which is represented being the upper one, and the attached marginal belonging to the right side. Lying beneath it, near the margin, were two small caudals, one of which is shown in the plate. The pygal and adjacent marginal are very flat bones, very thin on the outer margin, somewhat roughened on the anterior part. A fragment of the attached left marginal is present, but is not shown in the figure. The sutural union, here as elsewhere, is firm.

Length of pygal	97 mm.
Width at the ends	42
Width across the middle	61
Thickness near anterior border	6
Length of adjacent marginal	64
Width	45
Thickness	5

Lying in contact with a hyo- or hypoplastron is one complete marginal, and portions of two others partly detached. The bones here are elongate and narrow, with interdigitated sutural ends. On the lower side of the one exposed they are flat, with the inner margin thin, but somewhat thickened on the outer part.

Length of lateral marginal	130 mm.
Width at one end	35
Width at other end	27
Width of contiguous marginal	37
Thickness near middle	6

The half of two contiguous marginals lying over the left scapula shows the outer part thicker, from nine to eleven mm. in thickness; the inner part very thin, and, near the middle, below the thin border a shallow horizontal pit, which may have been for the reception of a rib. The greatest width of these bones is thirty-nine mm.

Plastron.

All the plastron was originally preserved, but part has been lost, and some has been necessarily injured or destroyed in getting at the bones lying between it and the carapace in the hard matrix. Lying contiguous with the upper end of the right humerus is a large, thin, flat bone which is evidently the epiplastron. The bone had sustained injuries or decomposition before fossilization, or was of a partly cartilaginous nature. Its thicker, rounded border in gently concave and measures a little over 200 mm. in length. Lying upon it and impressed as though partly pressed into its substance, is evidently another bone, which agrees better with the epiplastron of *Chelone.* It is gently convex on the outer, concave on the inner border, tapering to a point from the flat blade, and with well-marked longitudinal grooves upon it. It measures 180 mm. in length and has a width on the outer part of nearly thirty mm. If this is the real epiplastron, I do not know what the broad bone is.

A number of fragments of the hyo- or hypoplastron are present, but, unfortunately, the portion figured cannot be united to the remainder, through the loss of intermediate portions. That they all belong to one bone, seems evident from the marked peculiarities in the surface, color, and markings. The anterior (?) denticulate margin has a width of ninety mm.; the posterior hypoplastral border (?) is incomplete, was not more than sixty mm. in width and could not have had a close union with the hypoplastron, if it touched it at all, as the extreme length in this direction is only about 200 mm. The bone is thicker and of firmer texture than is the carapace. The posterior end of the xiphiplastron lies under the sacrum. It is only thirty mm. in width, is thin and has four elongated denticulations. The whole structure of the plastron appears to have been something like that in *Protosphargis veronensis.* Whether the other elements of the plastron were present or not, I cannot now say.

SYSTEMATIC POSITION.

All things considered, I believe that the genus *Desmatochelys* must be located among the Cryptodira, in a distinct family of Baur's Chelonioidea. But this will necessitate revision of the characters hitherto attributed to both suborder and group. These may best be expressed by giving the characters in detail, as Baur[66] has expressed them, with the emendations shown in italics.

CRYPTODIRA.

Free nasals sometimes present; a parieto-squamosal arch present or absent; descending process of prefrontals connected with vomer; stapes in an open groove of the quadrate or covered by the quadrate behind; pterygoids narrow in the middle, without winglike lateral expansions, separating quadrate and basisphenoid; epipterygoid free or not free; dentary bones united. *Cervical vertebræ rarely with stout transverse processes;* the posterior cervicals with double or *single* articular faces; sacral ribs well developed and connected with centrum and neuroids; pelvis free from plastron and carapace. Epiplastra in contact with hyoplastra; entoplastron oval rhomboidal or T-shaped; a more or less complete series of peripheralia, more or less connected with the ribs.

Chelonioidea.

A parieto-squamosal arch; articular faces between sixth and seventh cervical vertebræ plane, nuchal with a distinct process on the lower side for the articulation with the neuroid of the eighth cervical; no lateral processes of nuchal. One biconvex cervical vertebra.

1.—*Desmatochelyidæ.* Palatine foramina present; a descending process of the parietals; free nasals present; limbs paddle-shaped. *Desmatochelys.*

2.—*Cheloniidæ.* Palatine foramina not present; a descending process of the parietals; no free nasals; limbs paddle-shaped; claws one or two. *Chelone*, etc.

3.—*Dermochelyidæ.* No free nasals, no palatine foramina;

66. Note on the Classification of the Cryptodira, Amer. Nat., July, 1893, p. 672.

no descending process of the parietals ; no claws ; limbs paddle-shaped. Bony carapace dissolved into numerous mosaic-like pieces. *Dermochelys.*

Of course a more perfect knowledge of *Desmatochelys* may necessitate a further revision of the different group characters.

CYNOCERCUS.

Cynocercus Cope, Proc. Amer. Phil. Soc. 1872, 308; Cret. Vert., 96, 1875.

Nothing further is known concerning this genus than what is given by the author of it. There is no material in the University of Kansas which can be with certainty referred to it. I therefore reproduce the original figures by Cope and give the most essential portion of his description.

"Established on a metapodial bone and caudal vertebræ of a tortoise of uncertain, but in any case peculiar, affinities. The caudal vertebræ are not anterior ones, almost lacking diapophyses, but are long and slender, and the articular faces singularly incised. The form had a tail more elongate than the snapping turtle, and different from it in details of composition, especially in being of a procœlian type."

Cynocercus incisus.

Cynocercus incisus Cope, l. c., pl. VIII, ff. 3-5.

"The centrum is elongate and depressed. The inferior surface at the cup is flat; it is then arched upward, descending again to the rim of the ball. The posterior two-thirds has a median groove, which terminates in a deep notch of the ball, which involves one-third of its vertical diameter, and widens backward. The ball is transverse oval, and only moderately convex; near its upper margin a small, deep pit interrupts its surface, having the appearance of an unusually large ligamentous insertion; its border lightly excavates the border of the ball. The cup is transverse oval, wider below. Its inferior and superior margins are so deeply (but openly) emarginate as to reduce the concavity in the vertical direction very much.

From the superior emargination, a deep groove descends to below the middle, probably for ligamentous insertion. The neural canal is subtrilateral.

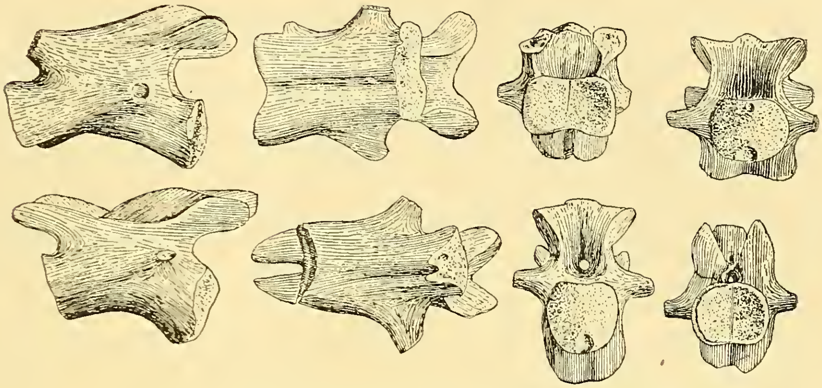


FIG. 6. Caudal vertebræ of *Cynocercus incisus* Cope.

"The neural arch is, as usual in this group, deeply emarginate in front, and much prolonged behind. The zygapophyses project beyond the ball, and the arch is contracted in front of them. Its upper surface has neither process nor keel, but is rugose for ligamentous and muscular insertion. The diapophyses have a wide base, and are sub-cylindric.

"Another vertebra differs in being rather more slender, and in having an obtuse keel of the neural arch. The pit of the ball is wanting and the inferior emargination. The chevron articulations are larger; and the groove of the cup occupies its middle, instead of its upper half."

The locality is not given, but is probably Niobrara.

TOXOCHELYS.

BY E. C. CASE.

Toxochelys is the single well-established genus of the sea turtles from the Cretaceous of Kansas comparable to the living Cheloniidæ. In habit of body the species were very similar to those of the genera *Chelonia* and *Thalassochelys*. The head was low and flat, roofed posteriorly by the bones of the skull, and provided with the large orbits characteristic of the family. The limbs were modified as swimming organs, especially the front pair, which were developed into long, powerful flippers. It is probable that these turtles spent the larger part of their time in the open seas, seeking the beaches only to deposit their eggs. The different species of the genus varied in size from about two feet in *T. serrifer* to five or six in *T. latiremis*.

The genus was founded upon the characters of the lower jaw, the coracoid, and phalanges. In a second description of the genus Cope says (Cret. Vert. 98): "The mandibular ramus is slender, and has a narrow, flat, alveolar surface. The coronoid process is moderately elevated, and is excavated behind by the anterior extremity of the elongated and deep dental foramen. The cotylus is depressed, and the articular bone ossified. The angle is not produced. The coracoid bone is long and spatuliform, like that of the marine turtles."

"The slenderness of the mandibular rami resembles the form in *Chelydra*, but it differs in the absence of the alveolar cutting edge of the latter. The phalanges are broad and flat and not unlike those of *Protostega*."

While primitive in many of its characters, *Toxochelys* was already well advanced in the line towards the modern Cheloniidæ. Cope believed that it was related to this family and to the Chelydridæ. Hay thought that it is "related both to the Chelydridæ and the Cheloniidæ, but that the relationship is much closer to the last-named family, and with the carnivorous division of this family, *Thalassochelys*." [67]

67. Hay, O. P., Field Columbian Museum Publications, 12 and 13, Zool. Series, vol. I, 101, pls. XIV and XV.

TOXOCHELYS.

Toxochelys Cope, Proc. Phil. Acad. Nat. Sci., 1873, p. 10.

Toxochelys latiremis.

Toxochelys latiremis Cope, Proc. Phil. Acad. Nat. Sci., 1873, p. 10; Cret. Vert., p. 98, pl. VIII, ff. 1–2; Proc. Amer. Phil. Soc., 1877, p. 176.

The skull of this species is the best known part of the skeleton. The *maxillaries* are broad posteriorly, with the alveolar surface slightly concave from side to side. Near the posterior end the cutting edge of the maxilla is scarcely developed, but begins about a centimeter from the end and rises rapidly until in the middle and anterior portions of the bone it is deep and strong. The base of this edge is marked internally by several deep pits. The posterior end of the bone shows a broad articular face for the jugal. The middle part of the internal edge joins the palatine, and, anteriorly, it unites with the vomer and premaxillary. The posterior part of the upper edge is rounded to form the lower portion of the orbit.

The *premaxillaries* are longer than broad, with a deep cutting edge. At the base of this edge, the lower surface of the premaxillaries are excavated, forming a rather deep pit on the median line perforated by a foramen. Externally, the surfaces of the premaxillaries are rugose and pitted. They form the lower surface of the anterior nares, the edge of the jaw formed by the maxillaries and premaxillary being the lowest part of the arc.

The *prefrontals* are strong and thick. They are united on the median line for the anterior two-thirds of their length, and rapidly separate to inclose the anterior ends of the frontals. United with the ascending process of the maxillaries, they form the upper and lateral edges of the anterior nares, which are completed by the premaxillaries below. The nares are large and a little broader than high. Posteriorly the outer edge of the prefrontals form the anterior portion of the upper border of the orbit. The frontals narrow anteriorly, to be inserted between the prefrontals, and far forward beneath them, appearing much further forward on the inferior than on the superior surface. They expand rapidly posteriorly, and join the parietals by an almost straight suture. The external edges become quite thin, and are concave from in front backwards. They form the upper rim of the orbit for about two centimeters. The lower surface of each bone shows a sharp ridge near the middle running antero-posteriorly. This ridge is highest and sharpest near the anterior edge, and the two include between them a deep groove, broadest at the two extremities, and slightly contracted in the middle.

The *parietals* are incomplete posteriorly. Anteriorly they join the frontals, and then diverge laterally. They form a part of a very complete temporal roof. From the under side of each bone, a thin vertical plate descends as in *Chelonia*, and was probably joined to the pterygoids by a slender epipterygoid.

There is no trace remaining in the specimen described of the postorbito-frontals. In a second specimen of a different species they show much the same outlines as in the modern *Chelonia*, uniting with the parietal above and malar below. They form the posterior edge of the orbit.

The *jugal* joins the posterior end of the maxillary with the quadrato-jugal behind; it is narrow vertically, with a concave lower border, so that the lower line of the skull rises posterior to the maxilla. The upper edge is thin and sharp anteriorly, and forms the posterior part of the lower border of the orbit. The posterior part of the superior margin joins the postorbito-frontal, and a broad process from the inner side joins the pterygoids.

The *orbit* was rather large, roundly ovate in outline, and somewhat broader posteriorly than anteriorly.

The *squamosal* joins the upper part of the quadrates laterally, and the quadrato-jugals and postorbito-frontals anteriorly. The internal margin unites with the parietal. The bone is thin and plate-like, somewhat triangular in outline, broad externally and narrower internally, where it is wedged in between the parietal and postorbito-frontal. The posterior margin is quite concave, and is continuous with a similar concavity of the posterior margin of the parietal, forming a deep emargination in the posterior border of the temporal roof, much deeper than in *Chelonia.*

The *supraoccipital* is comparatively short and stout. It extends well forward under the parietals, and has a short, strong, posterior process, with a deep groove on its inferior face. The superior surface of the process is nearly straight, and presents no trace of the strong convexity shown in *T. serrifer.*

The *vomer* is broad and strong anteriorly, with a concave inferior face. This expanded anterior portion, together with the maxillaries, forms the anterior edge of the posterior nares. At the anterior end of the nares the bone contracts sharply, and sends back a long, flat process to reach the posterior end of the palatines. On this process is developed a strong ridge, becoming obsolete as it approaches the posterior end, which separates the posterior nares. These nares are oval in outline, and lie well forward. There is no tendency towards a cover for these on the lower surface by an expansion of the vomer or palatine, as in the recent sea turtles.

The *palatines* are broad, thin plates of bone, attached by the anterior part of their lateral edges to the maxillaries. Just internal to this suture there is a strong antero-posterior rugosity, which does not rise above the level of the alveolar surface. From the edge of this rugosity the bone bends upward sharply, and is excavated to form the posterior nares. Posteriorly the bone expands and becomes thin and plate-like. Above the vomer, the posterior border of the palatines clasps the anterior margin of the pterygoids. The external margin of the posterior portion is excavated, to form with the maxillæ a large foramen — the palatine foramen — which is completed by the pterygoids and jugals behind. This foramen is about two centimeters long by one broad.

The *pterygoids* are firmly united on the median line on their anterior half. The anterior extremity is underlaid, and prevented from appearing on the roof of the mouth by the vomer. From near the anterior extremity, they send out lateral processes to join the jugals. Posteriorly each sends a broad and long process to articulate with the quadrate. The distal end of this process is perforated by a large foramen. Between the posterior end of the pterygoids there is a small triangular space into which is wedged the basisphenoid; this, as in all the sea turtles, appears very slightly on the lower surface of the skull. This triangular surface of the basisphenoid is very rugose.

The *basioccipital* presents a broad, slightly concave, lower surface, on a somewhat higher plane than that of the basisphenoid, so that there is a sharp offset of about a half a centimeter at the junction of the two. Near the posterior end, the bone turns sharply upward. Near the center of the bone, two small tuberosities are seen on the angle thus formed, on each side of a slight concavity in the median line. The occipital condyle is distinctly tripartite; the lower portion is formed by the basioccipital and has an antero-posterior length of about one centimeter.

The *exoccipitals* form the lateral thirds of the occipital condyle. They extend for some distance laterally and apparently separate the basioccipital from any contact with the opisthotic. They form the sides of the foramen magnum, which is completed above by the supraoccipital. Each bone is pierced on the lower side by a large foramen.

The *opisthotic* joins the supraoccipital and petrosal in front, the exoccipital behind, and runs outwardly to join the posterior border of the quadrate. Near the posterior edge, a strong, sharp ridge extends the full length of the bone. At the distal extremity there is developed on the posterior margin a prominent rugosity just before the bone unites with the quadrate. This gives to each side of the cranial region a concave posterior outline, corresponding somewhat to that of the temporal roof.

The *quadrates* have the sides of the stapedial notch closely approximated, but not so much so as in *T. serrifer*. The whole bone is inclined somewhat backwards, so that the lower extremity was the most posterior. The articular face is rather broad, and is divided into two parts, an outer and an inner, by a deep notch. The alæ are short, and show articular surfaces all around the convex edges for the squamosal and quadrato-jugal. From the outer extremity of the articular face a strong ridge runs far inward toward the brain-case, and receives the distal end of the pterygoid bone. Below the opening of the stapedial notch, the posterior margin of the bone is swollen and rugose. The petrosal is somewhat distorted; it is elongate, and joins the supraoccipital, opisthotic and pterygoids internally, and the quadrate by a strong sutural area externally. Between the proximal extremity of the petrosal and the pterygoid is a large oval foramen. Just proximate to the junction with the quadrate there is a strong, rugose area for attachment of the masseter. The lower surface of the skull is seen in plate LXXIX.

The *mandible* has a flat alveolar surface, with the outer border scarcely raised above the surface. There is no beak, and the symphysis is quite short. The specimen described is incomplete, terminating at the posterior end of the dentary bone. The jaw at this point is very low; much lower, proportionally, than in *T. serrifer*. The inner surface of the dentary is marked by a shallow groove. Plate LXXXI, figures 4, 5.

The head of *T. latiremis* as a whole is broad behind, becoming gradually narrower anteriorly, to about the hind termination of the maxillæ, where the jaws rapidly approach each other to form a rather blunt point, which is completed by the premaxillaries. The skull is somewhat flattened from above downward, giving a general appearance of that of *Thalassochelys*.

The *scapula* has the form characteristic of the sea turtles. The neck is comparatively long, and supported by a rather thick extremity, which bore two articular faces. One, the upper, or rather the outer, is supported on a prominent ridge arising from the base of the scapular portion; it is triangular in outline, and afforded attachment to the proximal end of the coracoid. The second face is the scapular face of the glenoid cavity; it is somewhat oval in outline, and joins the coracoid face at a little less than a right angle. The margins are thickened and rugose. Behind the expanded portion of the bone bearing these two faces the neck is much contracted, and then expands rapidly to form the body of the bone, from which spring the scapula proper and the proscapular process. These were slender and elongate, slightly expanded, and rugose at the extremities, for ligamentous attachments. The two processes join each other at an angle of ninety degrees. The scapular process is about one-third longer than the proscapula and is a little thicker. Plate LXXX, figure 1.

The *coracoid* is comparatively short, being less in length than the scapula proper. It presents an expanded end, divided into a scapular and a humeral face. The latter is the larger, equaling in size the humeral face of the scapula. The glenoid surface as a whole is large, wide open, and shallow. Behind the head, the shaft of the bone becomes contracted and then gradually expands to a broad, spatulate extremity, marked by rugose striæ. The shortness of the bone and its broad distal extremity are its characteristic features. Plate LXXX, figure 2.

The *humerus* is represented by a fragment of the proximal end only of a large specimen, which shows that it was not divided into two parts, one for the head and the other for muscular attachment, as in *Protostega* and the existing sea turtles, but was covered by a single articular surface, which is broader on the inner side. The same feature is shown in a nearly perfect humerus of a smaller specimen. Plate LXXXI, figures 3, 6, 7.

The *radius* and *ulna* are unknown. The front foot, or manus, as shown by a few bones from this region, was modified to form an elongate flipper, with short carpus and long, slender digits, much as in the modern loggerhead turtle. Plate LXXXII, figures 1, 2.

The *pelvis* is represented by the ilia and a single ischium. The *ilium* is a strong bone, indicating an animal of considerable size. The proximal end shows three faces, two for the ischium and pubis, and the third for a part of the acetabulum. The first two are nearly equal in size, meet at an obtuse angle, and are separated from each other by a sharp ridge. The acetabular face lies on the outer side of the bone, nearer the posterior than the anterior side. The ridge that separates the ischial and pubic faces meets a little in front of the middle of the inner border of the face. The iliac face shows that the acetabulum was nearly circular in outline and moderately deep; the rim is sharp, and elevated above the rest of the bone. At about its upper third, the bone turns sharply backwards, and is roughened. Plate LXXXI, figure 8.

The *pubis* of this form could not have been very different from the same bone of *Chelonia*, broad and flat anteriorly and contracted behind.

The *ischium* is broad and flat, constricted in the middle, the anterior border being strongly concave, as is the posterior border above and below the ischial spine. On the upper part of the iliac end are the two facets for the ilium and pubis, which meet about in the middle. Both facets are elongate oval, slightly concave. The ischial portion of the acetabulum is narrow. The symphysial facet is long, slender, and crescent-shaped. The iliac spine extends backward nearly at right angles to the axis of the bone, immediately below its middle. It is rather large; its end is broken away in the single specimen examined. The upper surface of the ischium, near its edge, from the ischial spine to the central symphysis, is distinctly rugose; along the symphysis the rugosity is less pronounced. Plate LXXXII, figure 6.

The *femur* is rather long and slender, weaker than the humerus, and evidently supported a much less powerful limb. The proximal end shows a well-developed head, oval in outline and supported on a distinct neck. On either side of the head are two tuberosities; the larger and internal one is separated from the head by a distinct notch and stands well out from the body of the bone. It is rugose, for muscular attachments. The anterior tuberosity is smaller, and seems to be only a small expansion of the external part of the head. These tuberosities give to the proximal end of the bone a tripartite appearance, of which the head is the middle, and is situated almost entirely in the internal side of the bone. Behind the head, on the external side, there is a deep concavity, which is in part due to crushing in the described specimen. The middle portion of the bone is contracted into a slender, regular shaft in the middle third. The bone expands into a broad, spatulate distal end, which shows no distinct division into facets for the tibia and fibula.

The distal end is nearly as broad as the proximal, but this may be largely due to post-mortem compression. Plate LXXXI, figures 1, 2.

The *tibia* and *fibula* are unknown.

The hind foot is represented by an incomplete specimen. The first digit was shorter than the others, and terminated in a strong claw. There were four phalanges, all short and strong. The first one, longer than the others, had slightly expanded proximal and distal ends and strong articular faces, for the tarsus and the succeeding phalanx. The next two phalanges are shorter than the first, and have a pit for muscular attachment on each side of the distal extremity. They are flattened on the posterior side and convex on the anterior. The terminal claw is strong and much curved. The phalanges of the remaining digits are longer and more slender. The terminal one is not developed into a claw, but is long and slender, and thin at the extremity. In all probability it did not penetrate the skin of the foot.

Certain bones of the tarsus are preserved, but are so badly crushed that their true shape and position cannot be determined.

Toxochelys brachyrhinus, sp. nov.

A nearly complete skull seems to indicate an undescribed species. The individual bones are very similar to those described as *T. latiremis*, but the proportions of the whole skull are so very different that one is warranted in considering it as the representative of a yet undescribed species. Instead of the broad posterior end rapidly contracting anteriorly, the sides are much more nearly parallel, and the anterior end, instead of terminating in a sharp nose, with much divergent maxillaries, is so blunt as to give an almost square appearance. The quadrates are nearly equal in height to those of a specimen of *T. latiremis*, though the skull is shorter and much narrower. The upper surface of the roofing bones show a strong sculpture of deep pits and rugose lines, not observed in the specimens of other species. An upper view of the skull is shown in plate LXXXIV.

Toxochelys serrifer.

Toxochelys serrifer Cope, Cret. Vert., p. 299.

The skull of this species is represented in the University collection by the anterior portion, the quadrates, the basisphenoid, the pterygoids, the supraoccipital and petrosal, and the anterior part of the mandible.

The *maxillaries* have a flat, broad, alveolar space posteriorly, the cutting edge evidently rising sharply, though quite low. Anteriorly the edge becomes deeper, and the face of the alveolar space is quite concave. Posteriorly there is a broad suture for the jugal, and anteriorly the maxillaries unite with the palatines and premaxillary. The union with the palatine is marked by a prominent rugose ridge, much stronger than in *T. latiremis.*

The *premaxillaries* are short, deeply concave on their lower surface, with a deep cutting border. Posteriorly they unite with the palatine and vomers, laterally with the maxillaries, externally they form the lower margin of the external nares.

The *palatines* are incomplete posteriorly. Anteriorly they are thickened and rugose, forming the prominent margins mentioned. They are united with the vomer on the median line. The anterior border of the vomer is excavated by a deep groove, from the posterior extremity of which a ridge extends posteriorly along the median line separating the choanæ. These are oval in outline, and extend almost directly forward. There were probably palatine foramina at the posterior end of the palatines, but they are not indicated in the specimen.

The *prefrontals* are elongate antero-posteriorly, and join in the middle line in front, where they form the upper border of the external nares. Posteriorly they diverge, leaving a V-shaped area, which clasps the anterior part of the frontal. The prefrontals extend backward to near the middle of the upper border of the orbit. They are joined to the vomer below by descending processes from their anterior part.

The *external nares* are formed by the premaxillaries below, the ascending processes of the maxillaries laterally, and the prefrontals above. They have a much greater vertical than horizontal extent, being a high, narrow opening, and differing materially from what they are in *T. latiremis*, where the opening is broader than high.

The *frontal* is elongate antero-posteriorly, joined with that of the opposite side. Anteriorly the two become narrowed and pass between the divergent ends of the prefrontals. The middle portion of the outer border is concave, and forms the upper part of the orbital rim. The posterior end is the broadest part of the bone, and presents a semicircular articular margin for the parietals and postorbito-frontals. On the inferior surface of each bone there is a sharp ridge, running antero-posteriorly. These ridges inclose between them a deep groove, which becomes wider at the posterior end.

The *parietals* are wanting in the material at my command. Cope says in describing the type specimen: "The free border of the parietal on one side, though not well preserved, indicates that the temporal fossa is partly roofed, as in *Chelydra*."

The *postorbito-frontals* are not preserved.

The *orbit* was large, oval in outline, with the greatest diameter antero-posterior. The superior and inferior borders are "subparallel for a short distance."

The *squamosal* and petrosal are indicated by fragments attached to one of the pterygoids, but are too imperfect for description.

The *supraoccipital* is represented by the posterior median process; this is very large, with considerable vertical, as well as antero-posterior extent. The lower edge is straight, and the upper strongly convex, forming nearly a semicircle.

The *pterygoids* are closely united in the median line, and extend forward to join the palatines. They are slightly contracted before the lateral process is given off to join the quadrate. Posteriorly the pterygoids are separated by the basisphenoid, which is wedged in between them, and appears on the lower surface a rugose, triangular, somewhat concave surface.

The *quadrate* is short and strong. The sides of the stapedial notch are so closely approximated that it may be best described as a fissure. The alar portion is small and not expanded. Just opposite the stapedial fissure there is a small, but strong articular surface for the petrosal. The superior end is very broad and rough, and was probably overlain by the squamosal. The borders of the alar portion show traces of sutural connection with the quadrato-jugal throughout its length. The lower articular surface is almost flat, somewhat constricted in the middle portion, and looks a little forward as well as downward.

The *mandible* is thus described by Cope: "The dentary bone is stouter, but not as large as in *T. latiremis*, and is flattened concave on its superior alveolar face, whose outer border, though sharp, is not elevated above the level of the inner border. The symphysis is short and there is no beak. The inner face of the dentary is a broad, shallow groove." The groove on the inner side of the dentary is rather deep to be described as broad and shallow. The symphysial portion is extended into a slight but unmistakable beak.

The *carapace* was formed much as in the existing sea turtles. The ribs are expanded, and suturally united for about their proximal third on the anterior part of the carapace, and for rather more than half of their length on the eighth and ninth. The expanded portion contracts rapidly, leaving the slender portion to join the peripherals. Proximally the expansion extends beyond the head of the rib and articulates closely with the neurals, leaving no opening in the carapace in the middle. The head of the rib extends well away from the flattened plate, bending downward to articulate between the vertebræ. The plates are suturally united with two neurals, the dividing suture dividing the neurals meeting the rib plate at about its middle. The proximal portion of the superior surface of the ribs shows no sculpturing, other than a slight pitting, but, on the under side, lines radiating from the origin of the head extend to the distal end. Only the posterior part of the carapace is preserved, showing five of the eight functional ribs, and the proximal part of the tenth. The anterior of these are the longest, becoming gradually shorter posteriorly, indicating a blunt, heart-shape outline for the carapace. The last three ribs are turned backwards with a marked obliquity; the anterior ones pass directly outwards. The *neurals* are known only from the posterior part, the last four being preserved. The seventh and eighth, the first two preserved, are rather longer than broad and are V-shaped in section, the two sides meeting in rather a sharp ridge above. The upper part extends posteriorly to articulate with the following bone by an overlapping joint. The ninth is small and closely connected with the tenth, which is the largest of the series. This is rather narrow anteriorly, but expands rapidly posteriorly, to near the end, and then contracts abruptly, forming sharp, flat wings upon the sides. The expanded proximal ends of the tenth ribs articulate with the anterior margin of these wings. Posteriorly the tenth neural terminates in a rounded process elevated above the rest of the bone, which extends backward to join a similar process on the anterior face of the pygal. The posterior end of the ninth neural does not overlie the adjoining portion of the tenth, but the two are connected by a separate, thin overlying ossicle of bone which rises above the general level of the carapace and forms an imbricating joint. The anterior border of this ossicle rises gradually and then terminates abruptly posteriorly, making a very prominent elevation.

The *peripherals* are represented by a nearly complete series. The pygal has a greatly thickened anterior border, from which springs a rounded process to join the tenth neural. The posterior margin is very thin, giving the bone a triangular form in cross-section. There is a deep notch on the hind margin at the end of a short groove, which begins at about the middle of the upper surface. The peripherals joining the pygal are not so thick in the middle; the internal border is, however, much thicker than the external. There is no groove or pit for articulation with the rib. The next three, probably the ninth, tenth, and eleventh, have much the same characters as that adjacent to the pygal, except that the internal border becomes progressively thicker. There is a slight sculpture formed by radiating lines from the middle of the upper surface of the bone.

The next four—probably the fifth, sixth, seventh, and eighth—have a very thick internal border, rapidly contracting externally to form a sharp edge. The internal surface of each of these is marked by a deep, round pit, which received the end of a rib. The anterior members of the series are represented by two or three short, slender and almost cylindrical elements, which show no trace of articulation with the ribs. The nuchal is a rather thin flattened bone, with a rounded, concave anterior margin. The whole bone is convex from side to side. Its outline is much the same as in *Protostega.* There are two large, wing-like lateral expansions, becoming very thin at their posterior and lateral margins; and a posteriorly extending process from the center of the hind margin. Plate LXXXII, figure 3; plate LXXXIII, figure 1.

The *plastron* is represented by the hyoplastron, hypoplastron, and xiphiplastron. There is no trace of the entoplastron or the epiplastron. The anterior end of the hypoplastron is still interlocked and held in position by one of the neurals that has been pressed down upon it from above. The two sides are slightly displaced in the antero-posterior direction.

The *hyoplastron* is joined to the hypoplastron by a comparatively broad area and suture closely resembling the condition in *Chelonia.* The anterior process extends well forward and inward, and interlocks by a strong digital process at its posterior and middle portion with the corresponding bone of the opposite side. At the anterior part the digitations are weaker and more slender. The lateral process does not start from the posterior margin of the bone, but from a point about a centimeter anterior to it. It extends outward and a little forward quite to the peripherals, and terminates in strong digitations. On the underside there is a short, rugose elevation, about a centimeter long, running antero-posteriorly, located near the base of the anterior process.

The *hypoplastron* is quite similar to the hyoplastron in outline, and of nearly the same size. The posterior process is shorter antero-posteriorly, and extends inward and backward and is interlocked with the hypoplastron of the opposite side, as in the case of the hyoplastron. Near the internal border it articulates strongly by an overlapping joint with the xiphiplastron.

The lateral process starts a little posterior to the articulation of the hyo- and hypoplastra, thus leaving quite a space between the two processes. It extends outward and slightly backward and terminates in strong digitations, as does the lateral process of the hyoplastron. There is a rugosity on the lower surface similar to that on the hyoplastron, and located in about the same position.

The *xiphiplastron* is elongate antero-posteriorly, rounded on the outer border, and broken into deep serrations on the inner.

There was a fontenelle of considerable size, as shown in the figure.

The *ilium* of the right side is all that is preserved of the pelvis. It is short and rather strong. The proximal portion is slightly expanded, with the usual three faces. The posterior border of the acetabulum is raised and is much thicker here than elsewhere. Anteriorly it is thinner, and there is no pronounced rim to the acetabular cavity. Above this end the shaft contracts slightly, and then expands to form the broad and thin distal end. This end is extended forwards so that it lies at almost a right angle to the remainder of the bone. Plate LXXX, figure 9.

Two small bones, slightly curved, with elongated shaft, and slightly expanded extremities, may belong in the forearm. There are several phalanges of the front foot present, showing that it was developed into a long swimming organ, as in *Chelonia*.

A single caudal vertebra from near the middle of the series is about a centimeter long. It presents well-defined transverse processes. The body is contracted in its middle part, and shows a slight groove on its lower surface. There is no trace of facets for chevron.

The *humerus* presents an unbroken proximal articular surface. In this it differs from the existing sea turtles, where the head is separate from the radial crest. The articular surface is semicircular near its middle, is expanded, and extends on the outer surface of the bone, which is the head proper. The part representing the radial crest is lower than the remainder and bent inward, so that it stands at an angle to the rest of the bone. The whole proximal end is thin and convex externally. Below the expanded portion the shaft of the bone is contracted and thicker, but does not become cylindrical. The distal end is thin and expanded, with the articular surface thin and continuous. There is a groove on the internal side of the distal end, indicating the position of the entepicondylar foramen. Plate LXXX, figure 7.

The *coracoid* has a rather small head, with two articular faces. Back of the head the bone is much contracted to form a shaft somewhat triangular in outline, and is then gradually expanded into a broad, spatulate extremity. The bone is a little shorter than the humerus. Plate LXXX, figure 6.

EXPLANATION OF PLATES.

(Pages 389 to 411.)

PLATE LXXIII.—Skull of *Desmatochelys lowii* Williston, from above. *pm*, premaxillary; *ma*, maxillary; *pfr*, prefrontal; *n*, nasal; *pa*, parietal; *fr*, frontal; *pof*, postfrontal.

PLATE LXXIV.—Skull of *Desmatochelys lowii* from below. *ima*, mandible; *ch*, choana; *ma*, maxillary; *plf*, palatine foramen; *pal*, palatine; *pt*, pterygoid.

PLATE LXXV.—Right humerus of *Desmatochelys lowii.*

PLATE LXXVI.—Fig. 1, right marginal and adjacent plastral bone of *Desmatochelys lowii;* fig. 2, pygal and contiguous right marginal of same; figs. 8, a, b, c, metacarpals of same; 9, 10, 11, undetermined bones of front limb.

PLATE LXXVII.—*Desmatochelys lowii.* Fig. 1, coracoid; fig. 2, radius and ulna, a, (?); fig. 3, scapula-proscapula.

PLATE LXXVIII.—*Desmatochelys lowii.* Fig. 1, right pelvic bones, inner side: 1, ilium, 1a, ischium, 1b, pubis; fig. 2, femur; fig. 3, carpal; fig. 4, caudal vertebra.

PLATE LXXIX.—Skull of *Toxochelys latiremis* Cope, palatal view: *pmx*, premaxillary; *mx*, maxillary; *p*, palatine; *pt*, pterygoid; *bo*, basioccipital; *exo*, exoccipital; *so*, supraoccipital; *q*, quadrate; *ju*, jugal.

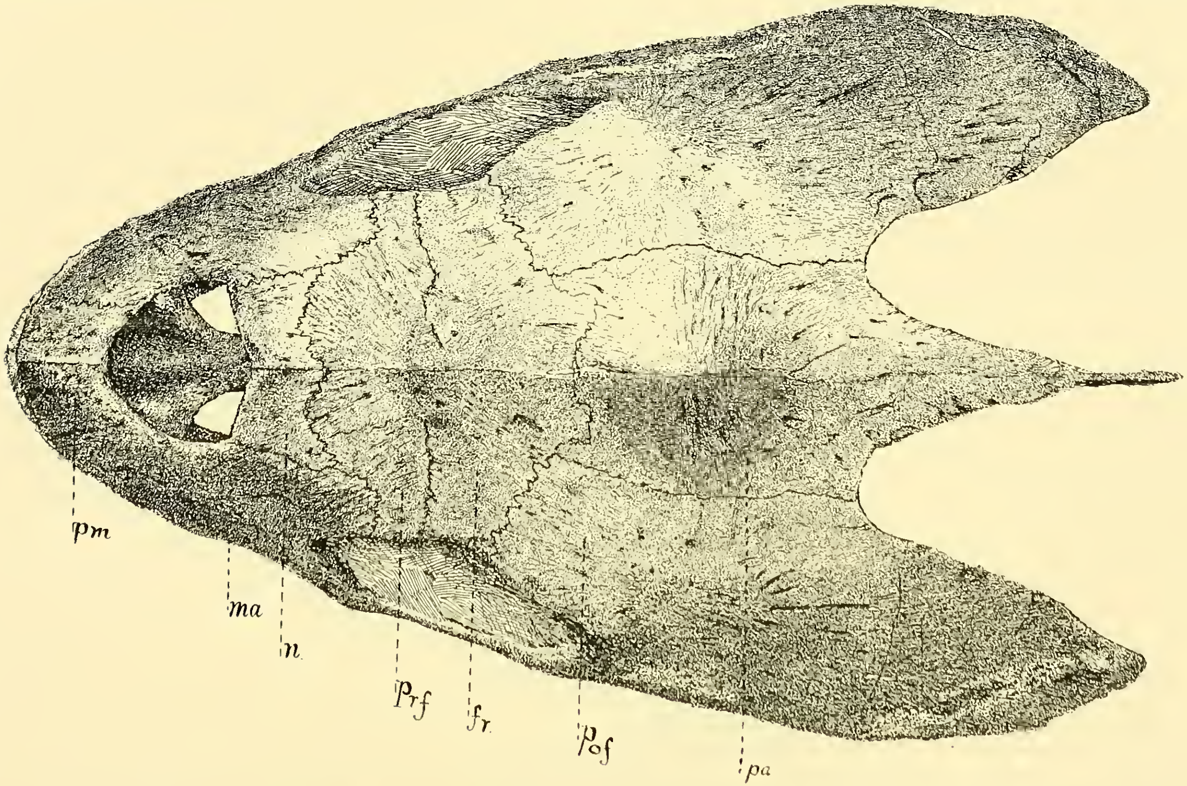
PLATE LXXX.—*Toxochelys.* Fig. 1, scapula, right side; fig. 2, right coracoid; fig. 3, left hyoplastron; fig. 4, left hypoplastron; fig. 5, left xiphiplastron; fig. 6, coracoid of a small specimen; fig. 7, humerus of same; fig. 8, femur of same; fig. 9, ilium of same. Figs. 1, 2, *T. latiremis;* others, *T. serrifer.*

PLATE LXXXI.—*Toxochelys latiremis.* Figs. 1, 2, femora; fig. 3, upper end of same; fig. 4, lower jaw, from above; fig. 5, inner side of lower jaw; figs. 6, 7, upper ends of humeri; fig. 8, right ilium; fig. 9, outline of pelvis of *Chelonia;* figs. 10 to 13, carpal bones.

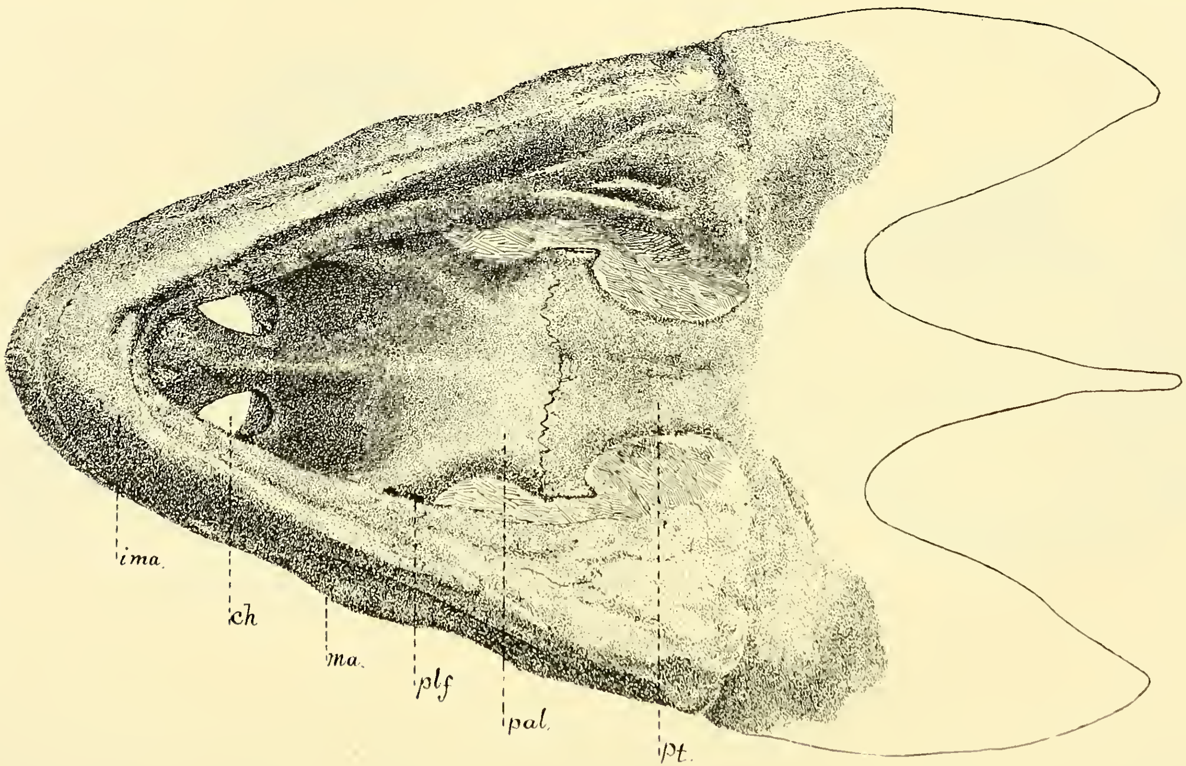
PLATE LXXXII.—Fig. 1, fourth or fifth finger of *Toxochelys latiremis;* fig. 2, first finger of same; fig. 3, nuchal plate of same; fig. 4, under view of anterior part of skull of *Toxochelys serrifer* Cope; fig. 5, the same, upper view; fig. 6, ischium of *Toxochelys latiremis.*

PLATE LXXXIII.—Fig. 1, posterior portion of carapace of *Toxochelys serrifer;* figs. 2, 3, 4, cervical vertebræ of *T. latiremis.*

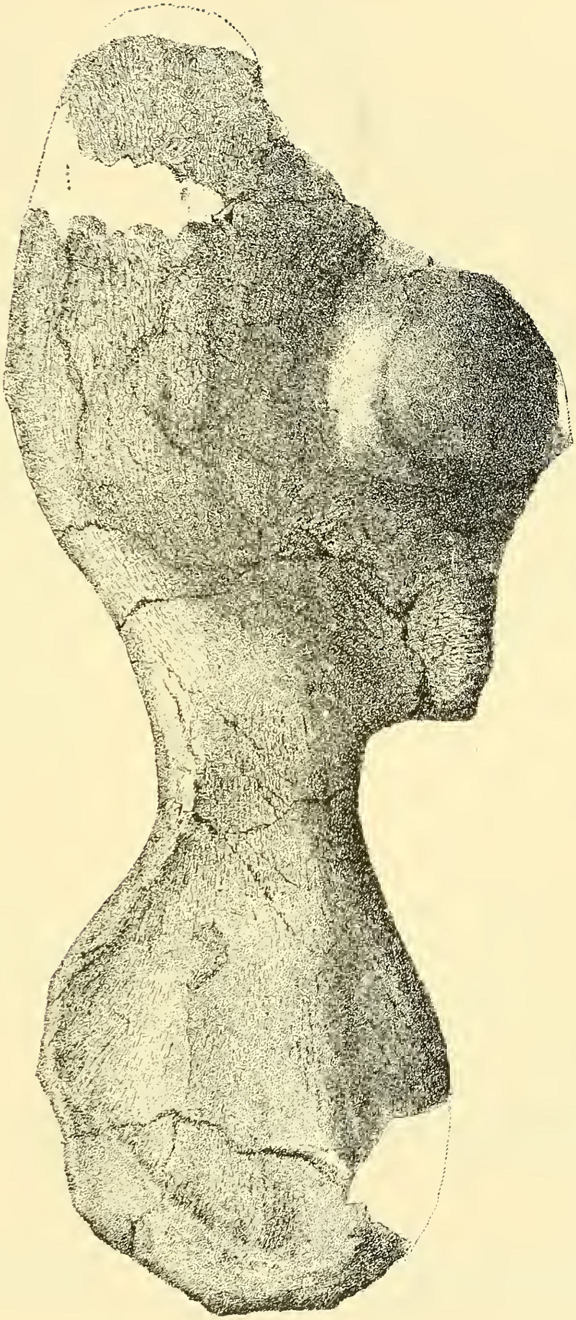
PLATE LXXXIV.—Fig. 1, upper view of skull of *Toxochelys brachyrhinus* Case, reduced; fig. 2, the same, restored, natural size.



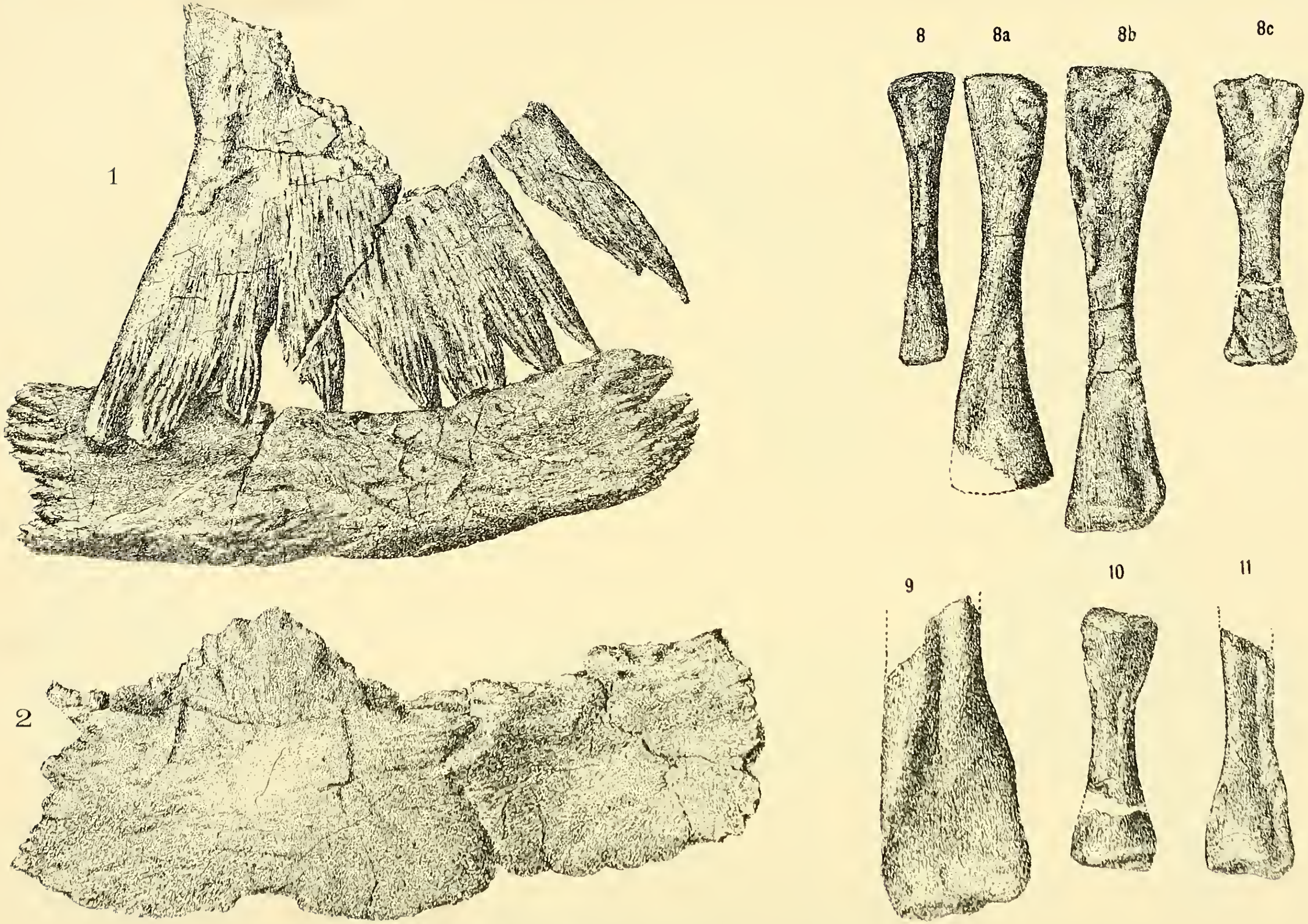
DESMATOCHELYS LOWII (from above), × two-thirds.



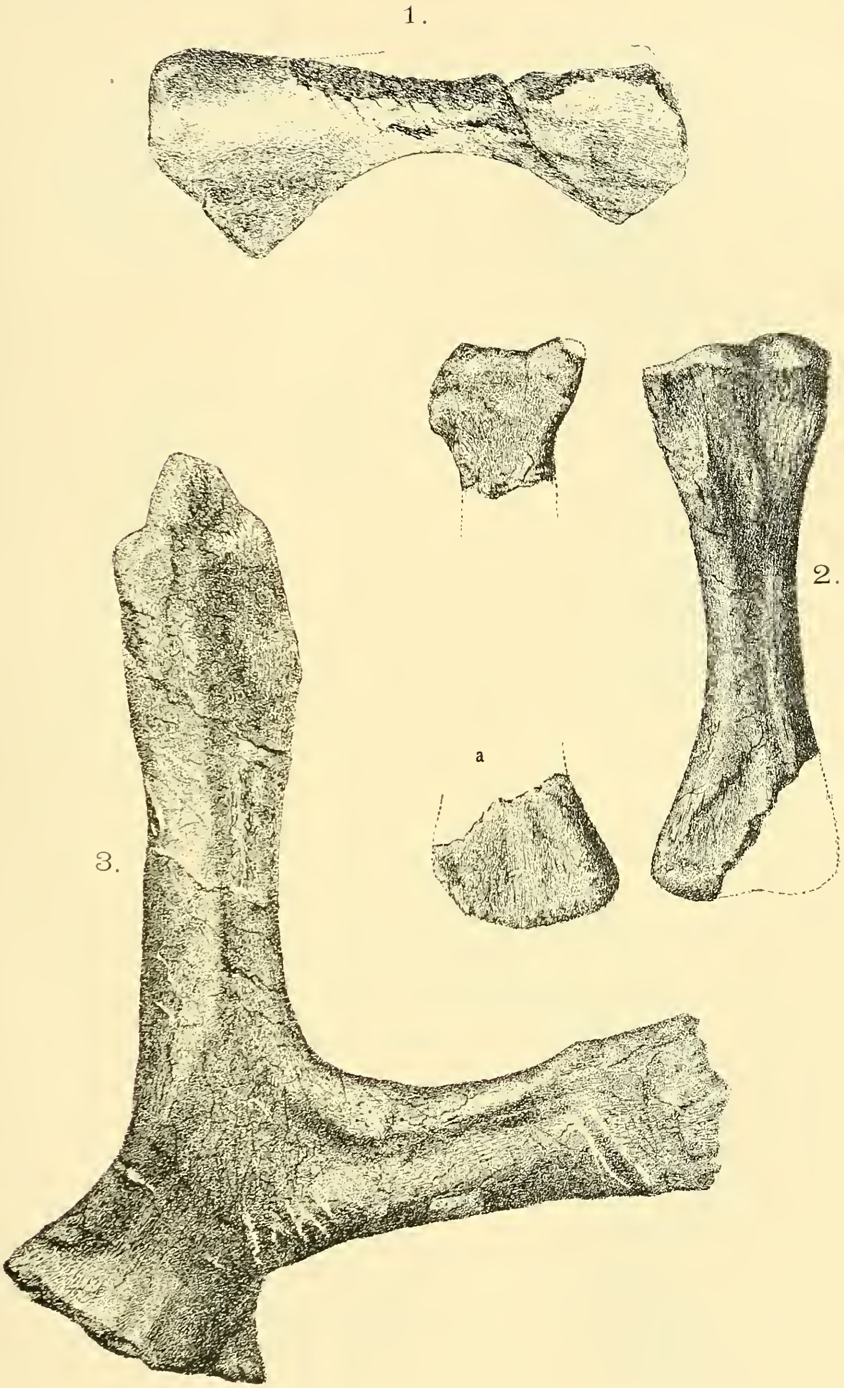
DESMATOCHELYS LOWII (from below). × two-thirds.



DESMATOCHELYS LOWII, × two-thirds.



DESMATOCHELYS LOWII. × two-thirds.



DESMATOCHELYS LOWII, × two-thirds.

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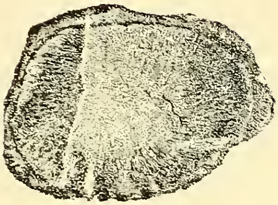

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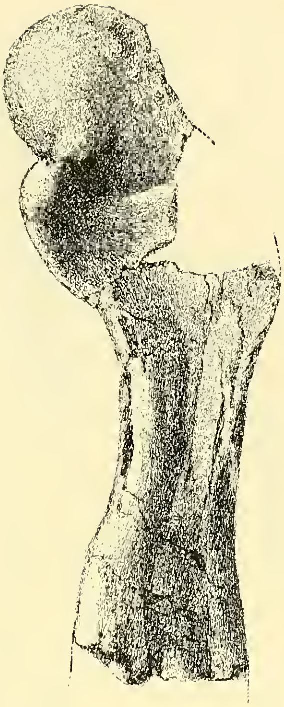

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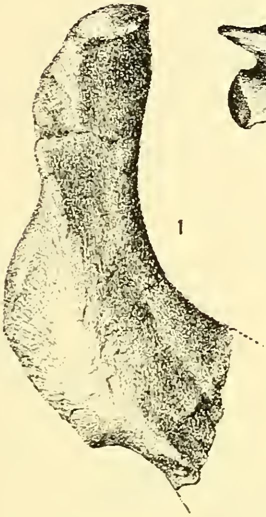

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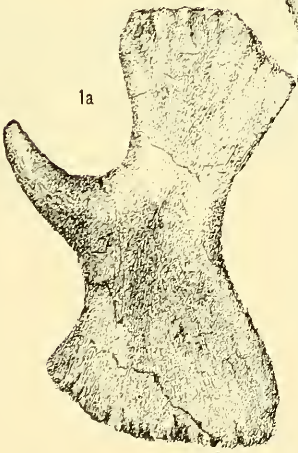
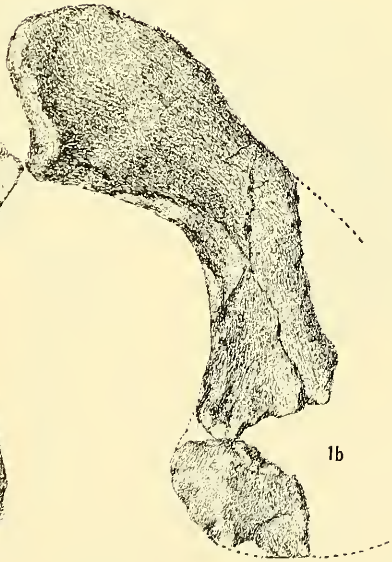
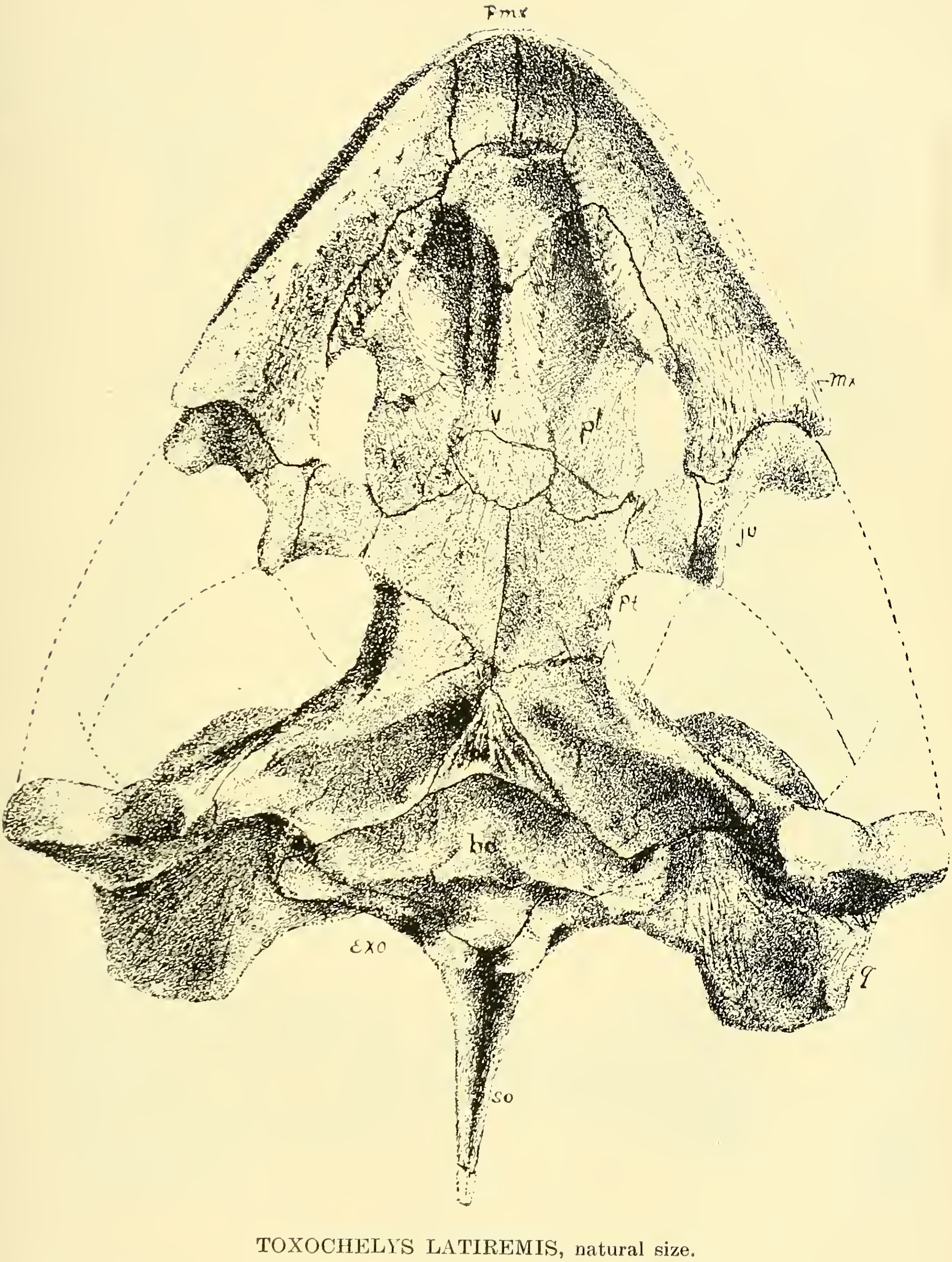


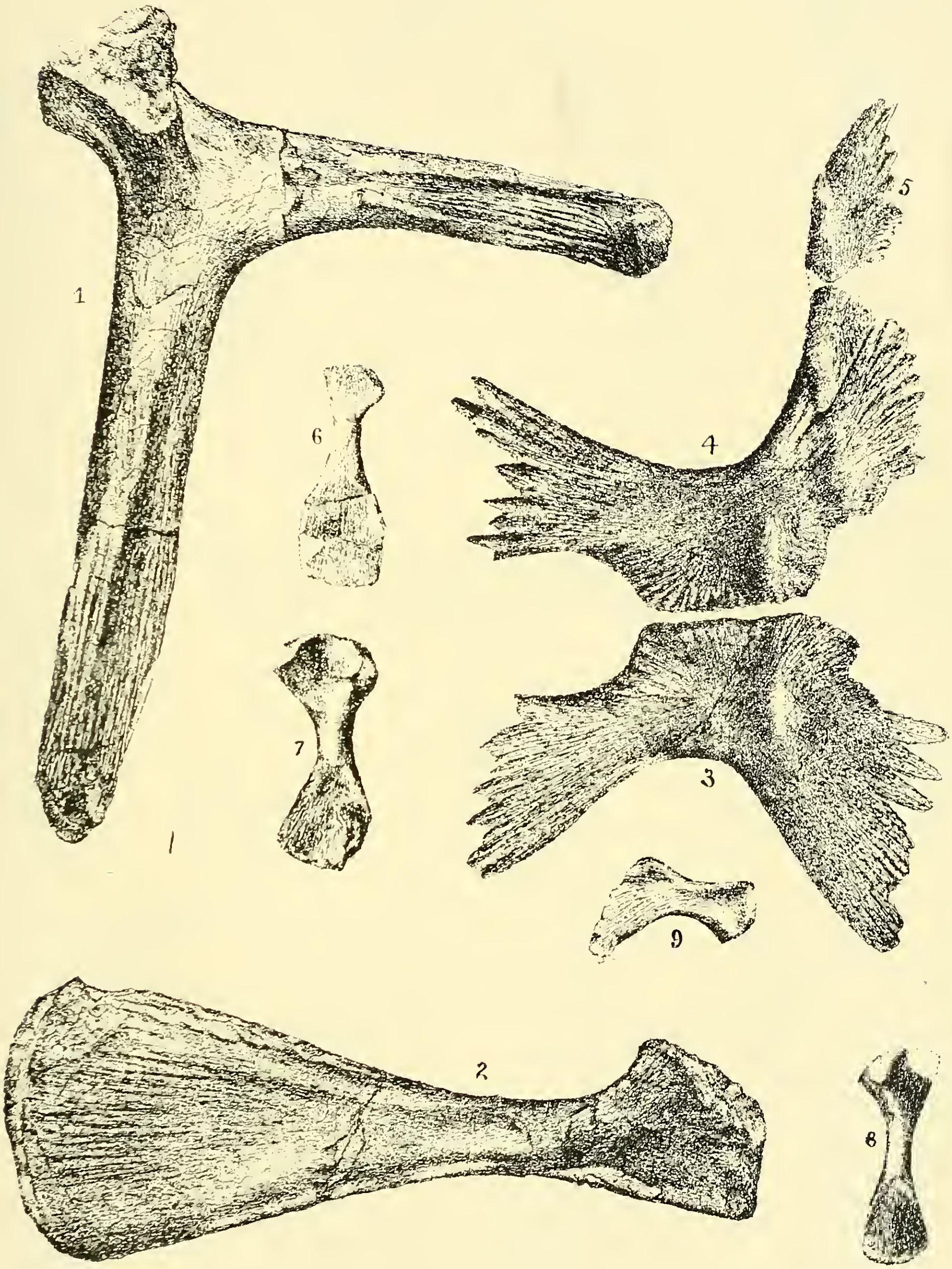
1b



DESMATOCHELYS LOWII, × two-thirds.



TOXOCHELYS LATIREMIS, natural size.



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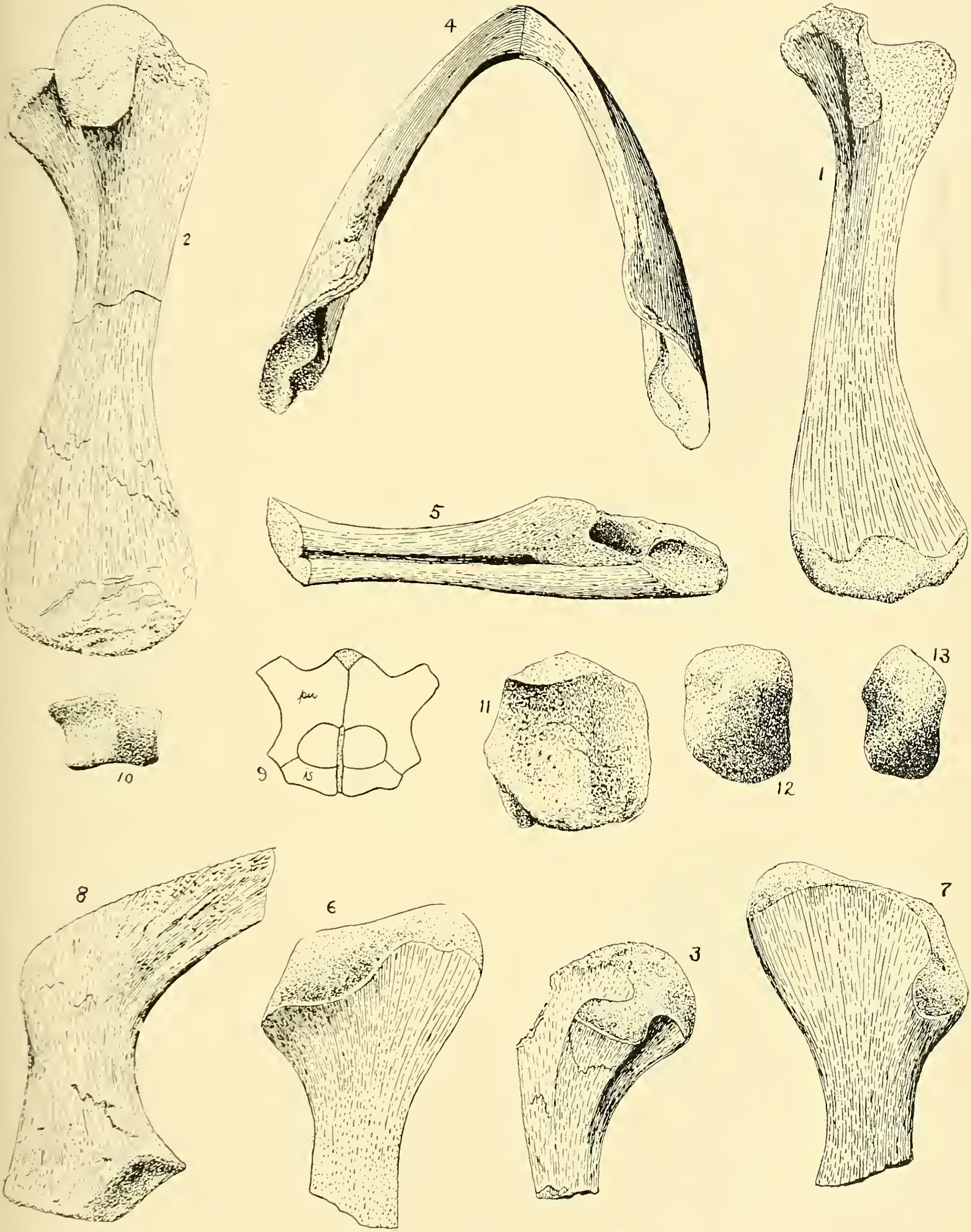

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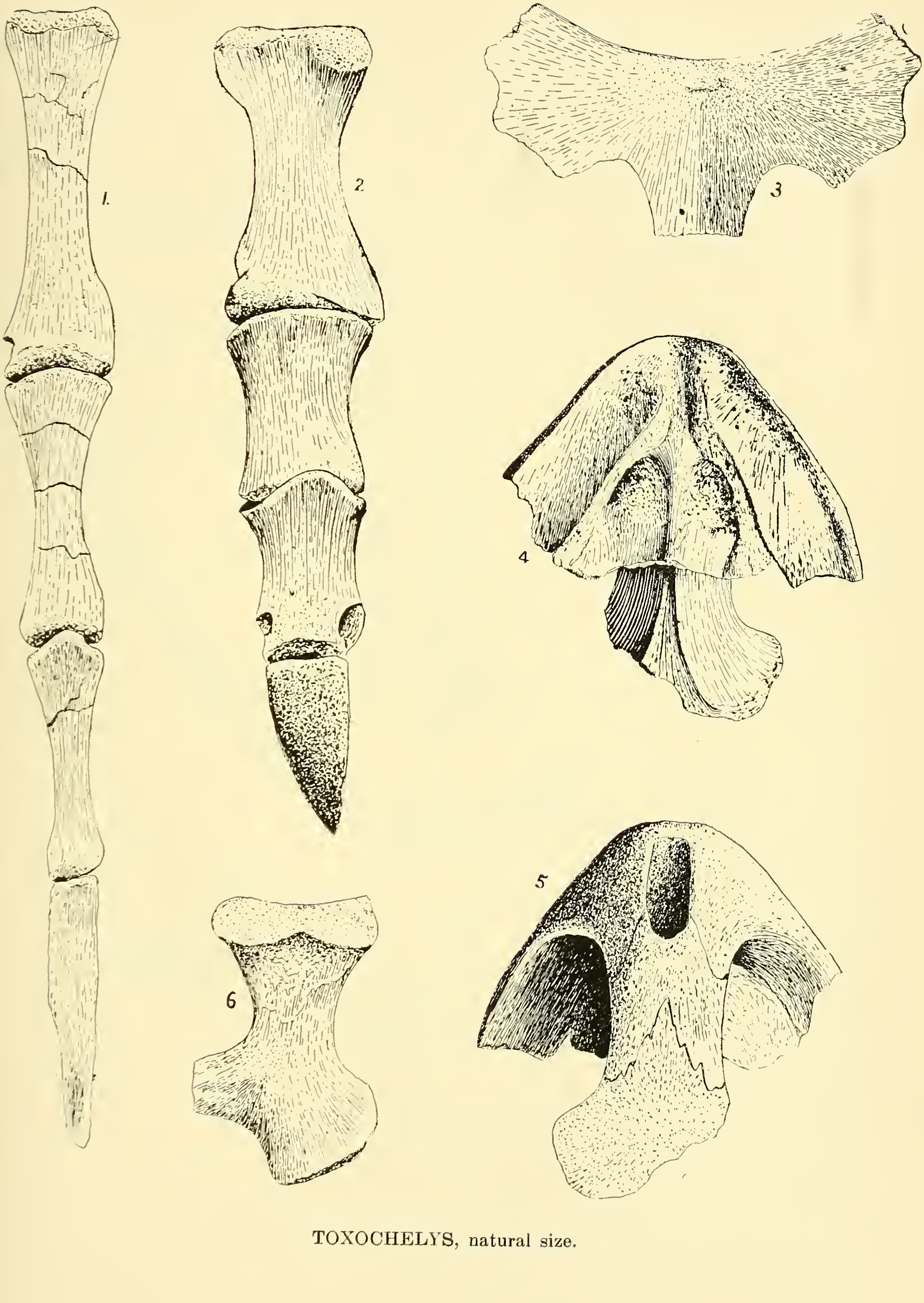
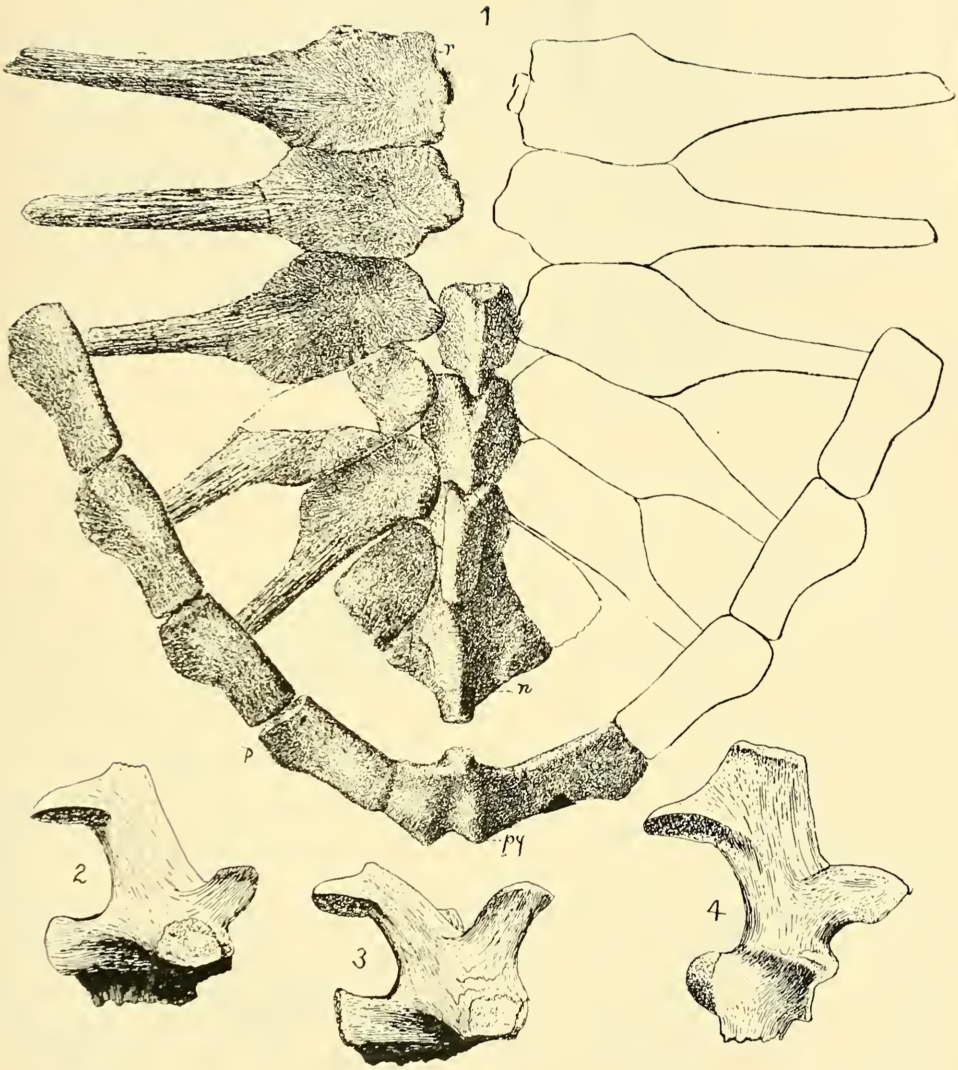
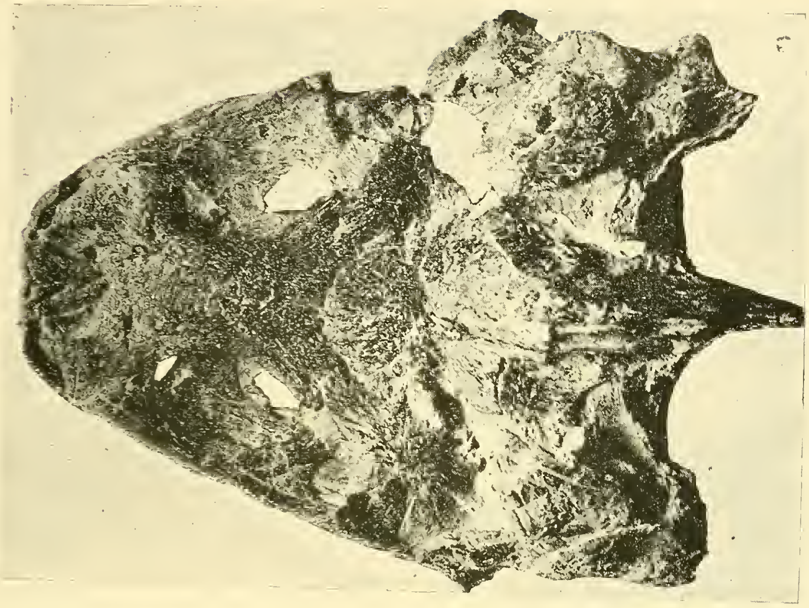


TOXOCHELYS, natural size.



TOXOCHELYS, × two-thirds.



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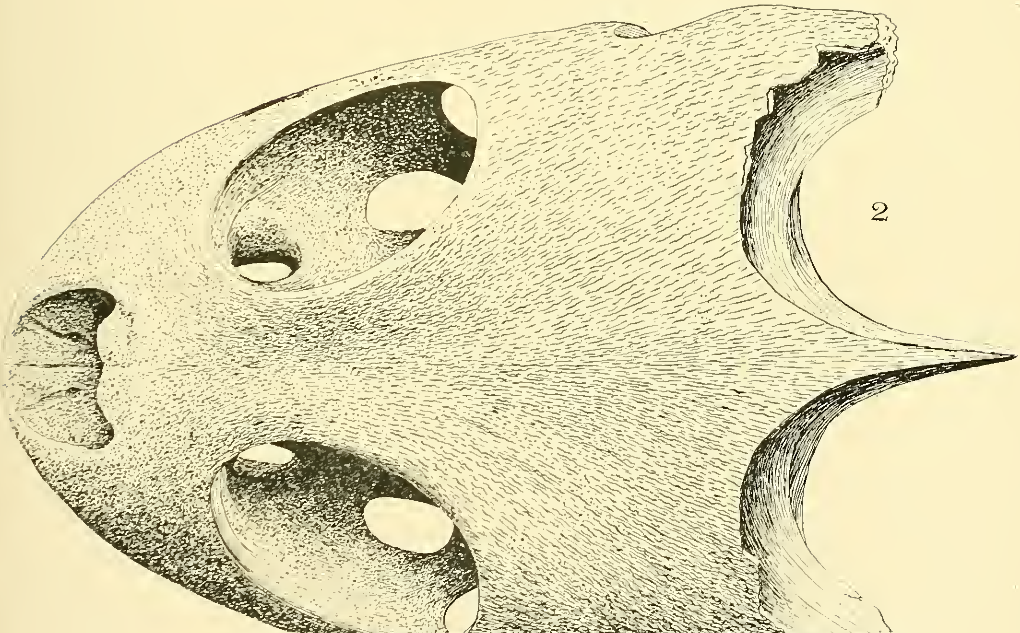


2

TOXOCHELYS BRACHYRHINUS CASE.

(Fig. 2 natural size.)

PART VII.

MICROSCOPIC ORGANISMS OF THE UPPER CRETACEOUS.

By C. E. McCLUNG.

Plate LXXXV.

MICROSCOPIC ORGANISMS OF UPPER CRETACEOUS.

BY C. E. McCLUNG.

AMONG the numerous organic remains occurring in the Upper Cretaceous of Kansas, the microscopic organisms are not the least interesting and important. In the study of the minute forms of life here found, an interesting field for investigation presents itself, concerning which the present paper gives account of merely a brief incursion therein. This would have been more complete were it not that the material for study was only such as had been collected for other purposes, and so the opportunity was lacking. However, representative samples from six of the thirteen beds were obtained and carefully studied. Of these, five have rewarded the writer with evidences of their organic origin. Those represented were the Lisbon shale, Hesperornis, Rudistes, Fort Hays, Inoceramus and Lincoln marble beds. All of these except the first mentioned exhibited well-preserved fossil remains, and this, perhaps, might have done so had more of the material been at hand for study.

Particular interest centers around the beds of the Niobrara group, for here we find the Kansas chalk which has been more thoroughly investigated and has been more discussed than any of the other deposits.

English chalk, as is known, is composed almost wholly of foraminiferal remains, imbedded in a matrix consisting of inorganic particles, and the curious discs and rods known as Coccoliths and Rhabdoliths. From the method of chalk formation, it would naturally be supposed that all similar Cretaceous rocks would have a like structure, but for a long time it was denied that there is any true chalk in America, such a statement being found in the text-books of Leconte and Winchell. It was not until 1875 that proof was forthcoming necessary to establish beyond a doubt the presence of chalk in America. This was furnished by a specimen from Kansas and reported as Kansas chalk. In the same year Professor Patrick, of the State University, presented a paper upon the subject before the Kansas Academy of Science, in which he asserted his belief that organic remains were not present, the deposit being formed merely by the chemical precipitation of calcium carbonate.

Later, in 1882, W. S. Bunn, a student in the University, found, under high magnification, definitely formed bodies. This led Professor Patrick to withdraw from his former position, and to ascribe the formation of Kansas chalk to the same agencies as were instrumental in the production of English chalk. At the meeting of the Kansas Academy of Science in 1882, Professor Patrick again spoke upon the subject, and described in detail the appearance of the forms first observed by Mr. Bunn. By the use of a higher power than any formerly employed by him, he was able to make out the structure of the different forms. These he described as circular and oblong bodies, marked by dark spots variously arranged, and as long rod-like bodies, having no apparent structure. Remains of Foraminifera were probably not observed, as no mention was made of them.

The next account of the subject appears in a paper by Dr. S. W. Williston, read before the Kansas Academy of Science in 1890. By him the true character of the forms described by the other investigators was recognized, and in addition he detected the presence of Foraminifera and sponge spicules. The most abundant variety of the Foraminifera was ascribed to the genus *Textularia*, but no specific determinations were made. The purpose of the present paper is, so far as possible with the material at hand, to complete the researches thus begun; to determine specifically the organisms represented in the deposits; and to ascertain if there is any variation in the number or species of the different beds.

Since the character of the results depends very much upon the methods of investigation, a brief account of those employed in the present research may not be inappropriate. Heretofore, microscopical examinations of the deposits have been made by triturating the substances to a moderately fine powder, and by elutriation, separating the desired forms from the rest. So far as the smaller remains, Coccoliths and Rhabdoliths, are concerned, this method is entirely satisfactory, but a few trials of it in search for Foraminifera convinced the writer that it is anything but a desirable process. This much might be inferred from the results obtained by the early investigators who discovered the minute Coccoliths and overlooked the large Foraminifera. The delicate tests of these creatures are almost invariably broken in the crushing of the specimen, and but little conception of their forms and none of their number can be obtained.

Evidently the only proper way to study them is in sections, where their form and relation to each other are preserved undisturbed. Some difficulty arose at first in the preparation of sufficiently thin sections of such a soft and friable substance as the chalk, which becomes a mere paste when rubbed on the stone with water. As a means of overcoming this obstacle, infiltration with shellac was tried, and proved all that could be desired. Fragments of the substances were ground or pared down to the required size, and the tablets thus formed were allowed to absorb all of an alcoholic solution of shellac that they would take up, and were then baked in an oven until dry. Thus prepared, they were quite hard and tough, and submitted readily to grinding upon a stone, or upon a glass plate charged with fine emery powder and water.

Two or three hours usually suffices to drive off the alcohol from the shellac, and then the specimens are ready to be reduced to sections. First, one surface is carefully worked down on the stone until it is perfectly plane and smooth. Then some hard balsam is melted upon a glass slip and the smooth surface of the specimen pressed down upon it and held there until the balsam becomes cold and hard. By this means it is firmly fastened to the glass, and can be rubbed down upon the stone until a section of sufficient thinness has been obtained. It is then carefully washed off in water, dried in air, and mounted under a cover glass with balsam. Specimens thus prepared show clearly, not only the form of the imprisoned shells, but also their arrangement and the number in a given area. Surface markings are as plainly apparent as in the isolated tests, for at one or more places the abrasion has occurred in such a way as to exhibit the shell free from the matrix. Above all, everything existing in the space occupied by the section is present and visible, and is not dependent upon chance for discovery.

FORAMINIFERA.

Subkingdom.......**PROTOZOA.**
Class..............**RHIZOPODA.**
Order..............**Foraminifera.**

Suborder A: CHITINOSA Schwager.

Test chitinous, imperforate, occasionally incrusted with agglutinated particles; pseudopodial opening at one or both ends.

Family.—*Gromiidæ.* Not found fossilized.

Suborder B: AGGLUTINANTIA Schwager.

Test of agglutinated silicious particles, held together by an argillaceous or silicious cement.

Family 1.—*Astrorhizidæ* Brady. Paleozoic to Recent.
* Family 2.—*Lituolidæ* Brady. Carboniferous to Recent.
* Family 3.—*Orbitolinidæ* Zittel. Through Cretaceous.

Suborder C: PORCELLANEA Schwager.

Test calcareous, porcellaneous, imperforate.

Family 1.—*Nubecularidæ* Brady. Triassic to Recent.
Family 2.—*Peneroplidæ* Schwager. Triassic to Recent.
* Family 3.—*Miliolidæ* Carpenter. Triassic to Recent.

Suborder D: VITRO-CALCAREA Schwager.

Test calcareous, vitreous, perforate, sometimes silicious, finely perforate.

* Family 1.—*Lagenidæ* Carpenter. Silurian to Recent.
* Family 2.—*Textularidæ* Schultze. Carboniferous to Recent.
* Family 3.—*Globigerinidæ* Carpenter. Triassic to Recent.
* Family 4.—*Rotalidæ* Carpenter. Silurian to Recent.
Family 5.—*Fusulinidæ* Möller. Carboniferous.
Family 6.—*Numulinidæ* Möller. Carboniferous to Recent.

The Foraminifera belong to the subkingdom Protozoa in the class Rhizopoda. They form an order characterized by their immense numbers, great variety of forms, and long geological history. In size they vary from 1-100 of an inch to three inches in their longest diameter, not taking into consideration the problematical *Eozoon* which covers an area a foot square. In their distribution they are almost omnipresent, being found in nearly every body of water, salt or fresh, and at all depths. Although usually small in size, so numerous have they been in the past that extensive strata of rocks are composed to a great extent of their remains. At present their numbers show little, if any, sign of decrease; multitudes of them still inhabit the seas, and as they die add their skeletons to the abyssal sediment that represents the strata of rocks now in the process of formation. Over 2000 species have been noted, and of these one-third are now living. Their geological range, so far as known, is from the Silurian to the present time.

In general the Foraminifera may be described as minute, nucleated, protoplasmic bodies, invested with a shell, through which the body substance, or sarcode, is protruded at one or more points. So far as the living substance, the animal itself, is concerned, there is little difference between the species; indeed, even between them and their shell-less fellow Rhizopods belonging to different classes. Motion, limited as it is, and prehension are accomplished by the protrusion and retraction of thread-like, anastomosing pseudopodia through the numerous foramina in the shell, or through the mouth opening in the imperforate forms. Digestion takes place at any point in the body of the animal, and excretion of waste material proceeds merely by the ejection of the undesirable material from any convenient area at the surface. Reproduction occurs by a process of budding, the resultant individuals being separated off as independent organisms, but more frequently remaining attached to the parent, thus forming the "composite" animal.

Because of this similarity existing between the living matter of the Foraminifera and the other Rhizopods, no particular interest attaches to this part of their organization. It is the shells secreted that are noteworthy. These are remarkable for their great variety and beauty of form. Their structural relationships also furnish the basis of classification and are of added interest on that account.

Morphological difference here, as elsewhere, is merely the expression of differences in physiological activity, the form of the shell registering the growth habit of the organism. In modern methods of classification this fact is recognized, and where formerly distinctions were made upon the plan of growth, now they depend largely upon the results of functional processes. Therefore separation of the order of Foraminifera into the different suborders is based upon the character and use of the materials chosen for the shell, and there results, accordingly, the Chitinosa, the Agglutinantia, the Porcellanea, and the Vitro-calcarea.

Under the CHITINOSA are found species that enclose themselves in a soft chitinous shell and extrude the protoplasm through one or two comparatively large mouth openings. These forms are almost exclusively of fresh-water habit, and because of the character of the shell, are never found fossilized. In the present instance, therefore, little interest attaches to them.

The suborder AGGLUTINANTIA is distinguished from others by the fact that members of it have tests built up from particles of foreign matter fastened together with a cement. These constituent fragments are usually silicious in character, but, in the absence of the desired material, minute bits of calcareous or other substances are used. The resulting shells are naturally thicker and rougher than those formed of a homogeneous substance, but otherwise they bear a general resemblance to members of the other suborders. The geological range is from the Silurian to the present time.

The PORCELLANEA are so named because their homogeneous, imperforate, calcareous shells resemble porcelain in reflected light. Protrusion of the sarcode usually occurs through a simple opening, called the oral aperture, or mouth. Range is from the Triassic to the present time.

The VITRO-CALCAREA differ from the Porcellanea in having minute perforations in the glassy, transparent shell, through which the protoplasm is extruded instead of through an oral aperture only. The material from which the shells are built up is of the same calcareous nature in both suborders. Occasionally there may be added an external, Agglutinantia-like layer of silicious particles by some of the Vitro-calcarea. Range is from the Silurian to the present time.

In all the suborders the unit of growth is the unilocular test, represented by such forms as *Orbulina*. If, in the process of reproduction, the offspring separate from the parent shell, then there results the monothalamous or unilocular forms; should they adhere to the parent in a series, there is formed the polythalamous or multilocular tests. These may be of various shapes, depending upon the direction and sequence of the "budding" process. If this occur in a linear series, forms such as *Lagena* result; if in one plane and in two or more alternate rows, genera such as *Textularia*. When the growth assumes a circular form and expands as a helix, there are produced forms like *Rotalia;* where the circular form is elongated into a spiral by the addition of new chambers, there results *Globigerina*-like structures. A number of other plans of growth are to be found, but these are the most common, and the only ones found in the Kansas Cretaceous deposits.

Following are the descriptions of the species here represented, all of which belong to the suborder Vitro-calcarea.

Textularidæ.

Textularia globulosa. (Pl. lxxxv, ff. 1–4.)

Textularia globulosa Ehrenberg, 1838, Abhand. Akad. Berlin.
Textularia americana Bailey, 1841, Amer. Journ. Sci., vol. xli, p. 401.
Textularia missouriensis Meek, 1864, Smiths. Inst. Check-List.

"*Textularia globulosa;* test microscopic, with smooth surface in the adult longer than wide; chambers globular."—Ehrenberg.

This species is one of the most common forms of the Foraminifera. The shell substance is usually of a calcareous nature, and, in the young forms, appears very clear and homogeneous, but, in the older specimens, becomes opaque and rough, owing to the agglutination of sandy particles on the surface. By this means considerable variation in appearance may be produced, although the general form and structure is not altered. The plan of growth is indicated in figures 1 and 3. Budding from the primordial chamber takes place in such a manner as to add alternately to the two rows, a fact that is suggested by the means of communication between the chambers of the two series. Sections through a single row may occasionally be found (f. 2), which simulate in appearance *Nodosaria*. The absence of communication between the chambers, however, disposes of this superficial resemblance.

Textularia was found universally present in all the horizons where Foraminifera were represented, except in the Inoceramus beds. It was particularly numerous in specimens from the Hesperornis beds. Both the typical form (f. 3) and the pigmy form (f. 4) were found.

Globigerinidæ.

ORBULINA UNIVERSA. (Pl. LXXXV, f. 9.)

Orbulina universa d'Orbigny, 1839, Foram. Cuba, p. 3.
Miliola spherula Ehrenberg, 1854, Mikrogeologie.
Globigerina universa Owen, 1867, Journ. Linn. Soc., vol. IX.

Shell unilocular, spherical, hollow. Walls thin, perforated by numerous, minute foramina, and provided usually with an oral aperture, as in *Globigerina bulloides*, but this is sometimes lacking. Variable in size and in thickness of shell.

The synonymy of the name applied to this species throws considerable light upon its relationships. The resemblance to *Globigerina bulloides* is so close as to lead many investigators to the conclusion that it is merely the unilocular form of this species — a belief that the present writer's brief study supports. Add to this the almost invariable presence of the two together, and the case in favor of identity becomes a strong one. Distribution about the same as that of *G. bulloides*.

Globigerina bulloides. (Pl. lxxxv, ff. 5–8.)

Globigerina bulloides d'Orbigny, 1826, Ann. Sci. Nat., vol. vii.
Globigerina depressa Ehrenberg, 1854, Mikrogeologie, pl. xxvi, f. 92.
Rotalia rudis Ehrenberg, 1854, ibid., pl. xxiv, ff. 35, 36.

"Test spiral, subtrochoid; superior face convex, inferior more or less convex, but with deeply sunken umbilicus; periphery rounded, lobulated; adult specimens composed of about seven globose segments, of which four form the outer convolution; the apertures of the individual chambers opening independently into the umbilical vestibule. Diameter sometimes 0.36 mm. but oftener much less."—Brady.

Among the most widely distributed and oldest species of the Foraminifera is *G. bulloides*. It is now present in such abundance in the deep-sea ooze as to compose ninety-seven per cent. of it. In the past it was equally as important an agent in the formation of the great chalk beds. Being so universally distributed, it is subject to considerable variation in form and size. In general, however, it may be stated that the chambers number from eight to sixteen, each being approximately spherical in shape. The spiral, formed in the process of growth, consists of groups of four, disposed in as many planes as there are groups. In this respect the species was found to differ from the description of Brady given above. Coarse perforations pierce the shell for the extrusion of the sarcode, and some forms have spinous processes over which the body substance is extended. Each chamber has a mouth opening placed in close relation to those of the other chambers at the umbilicus, a point near the center of the lower group of four. The shell may be thin and transparent or thick and somewhat opaque, depending upon the size of the organism and its habitat. A pigmy form also exists that resembles the typical in everything except size.

Globigerina spinosa, sp. nov. (Pl. lxxxv, f. 7.)

Shell composed of about eight markedly globular segments, the union between which is so slight that they appear as almost independent chambers; the last formed much larger than the primordial one and the others of the first group of four. Wall thick, coarse, and closely beset with strong, stout spines over the entire surface. Size variable, but on the whole much larger than that of *G. bulloides*, the diameter being two or three times greater. Lack of any description of such a form has led to the provisional application of the term *spinosa* to the species. It is very common, appearing abundantly in the Fort Hays of the Niobrara, and in the Lincoln marble of the Lower Benton. The specimens are well preserved and quite distinctly apparent in the sections, with all the details of structure exhibited.

Coccoliths and Rhabdoliths. (Pl. LXXXV, f. 10.)

Mention has several times been made concerning the coccoliths and rhabdoliths found in the different rocks. These curious and puzzling forms constitute a large part of the real chalk, and become plainly visible in properly prepared specimens. In the beginning it may be stated that nothing new was learned regarding the true character of these organisms, if such they are. Reference to the figure (pl. LXXXV, f. 10) will show, however, that the usual conception of simplicity of structure is hardly sufficient in the way of explanation.

The Coccoliths were observed in some six or eight different varieties, but they offered no variation in connection with their derivation from different localities. The "cup and saucer" form, described as so characteristic of the recent specimens, was not observed at all. On the contrary, the elementary form seems to be a ring, circular or oval, spanned by two bars, either at right angles to each other or sometimes at a greater angle in the oval variety. Frequently only one bar is present, and at other times three cross the center of the disc. That these are true projections, is shown by the fact that remnants of them remain attached to fragments of the rim in broken specimens. Occasionally, in entire forms, the bridging rods are represented by imperfect septa of irregular contour that do not reach the entire distance across the space inclosed by the rim. Less frequent modifications are those in which the rim incloses a solid center, which may be merely granular or be perforated by numerous small, round openings.

The peripheral rim, in the majority of cases, is merely a simple, homogeneous band, but in some specimens it is perforated by from fifteen to twenty oval apertures placed radially, or is crossed by numerous radial striæ. The substance of the rim and the cross-bars appears to be continuous.

Just as remarkable and less well defined than the Coccoliths are the Rhabdoliths. In form these vary considerably, the most common types being a small cross, with arms of variable length, and a flat, funnel-like form. In the specimens examined, the latter was the more common, and was plainly visible in all the details. The narrow part representing the neck of the funnel was always broken, and there is no way of knowing how long it may originally have been. On the whole, the appearance is very suggestive of spinous fragments from some comparatively large organism.

With regard to the true character of the Coccoliths and Rhabdoliths, little definite knowledge exists. The former were named in 1858, by Huxley, and the latter by Dr. O. Schmidt, in 1872. Huxley considered that the Coccoliths were formed by the agency of a protoplasmic substance of indefinite size and uncertain composition, named by him *Bathybius*. This gelatinous substance was supposed to be found at great depths in the ocean, and was observed to inclose numerous Coccoliths within its confines. Since, however, the *Bathybius* has been produced artificially by the deposition of sulphates from solutions on the addition of alcohol, this origin of the Coccoliths had to be dispensed with. Therefore, at the present time it may be said the question of origin stands about where it did at the time the forms were discovered. A similar statement may be made concerning the Rhabdoliths.

But four species of Foraminifera were discovered in all the rocks of the Upper Cretaceous. These were subject to no little variation, such as might have been made the basis for the establishment of other species or varieties, but in the opinion of the writer these are merely modifications due to the conditions of growth. This view receives the support of A. Goes, who, in his work, "The Reticularian Rhizopods of the Caribbean Sea," inveighs very strongly against the practice of naming species on such insufficient grounds as slight differences in shell composition. His opinion is expressed in the following words: "Those who have been engaged in the laborious task of throwing light upon the nomenclature of this class, may in many instances have been struck at finding their list of synonyms swelled to hundreds by different names having been conferred on forms without even varietal distinction, founded upon quite accidental or individual diversity, or on no differentiating characters whatever."

The real chalk from the Pteranodon beds bears a close resemblance to the English variety, but has fewer and better preserved remains. Here the *Textularia globulosa* and *Globigerina bulloides* abound, but no trace of *G. spinosa* is apparent. The forms are beautifully preserved and show every detail of their structure. The matrix is, to a great extent, composed of Coccoliths and Rhabdoliths. Crystals of calcite fill most of the tests. Aside from the color, therefore, the chalk from the Hesperornis and Rudistes beds of Kansas may be said to differ but little from the true English chalk.

From the Inoceramus beds, hardly as clear an indication of the organic origin was obtained as from the others. Instead of the clearly marked shells of the Foraminifera are found regular spaces filled with a crystalline deposit. These, however, are of such a character as to lead to the belief that the rocks were originally made up, to a considerable extent, of Textularian and Globigerine remains, which, at a later time, became replaced by obliterating crystalline deposits. Occasional well-preserved remains are found and their appearance lends support to the opinion just expressed.

Specimens from the Fort Hays beds, as represented by rocks from Coolidge, are found to contain comparatively few organic remains, the matrix constituting the greater part of the bulk. *Globigerina spinosa* appears most prominently, while *G. bulloides* is absent. A few *Textulariæ globulosæ* may be found.

Perhaps the most remarkable of any of the rocks are those that come from the Lincoln marble deposits. On examination these are found to consist almost exclusively of Foraminiferal remains — all well preserved. The most prominent representative is *Globigerina spinosa*, which exists in some places to such an extent as to almost entirely exclude the other forms. *Globigerina bulloides* is also found in considerable quantities, as is likewise *Textularia globulosa*. *Orbulina universa* is less prominently represented than the other species. In addition to these known forms there were in considerable numbers the remains of another, which, for the lack of suitable literature, could not be identified. Its resemblance to *Gyroporella annulata* was very close, but the size of the specimens was much less. On this account no name has been assigned to the form.

In conclusion, brief mention may be made of the fact that there are remains present in the rocks aside from the Foraminifera, such as would be expected. Among these the most prominent are sponge spicules. For the sake of completeness, notice may be given of certain round, yellowish bodies that were occasionally seen in the empty tests of the Foraminifera. No conception of their character could be formed. The yellow color of the chalk may be in part or perhaps altogether due to this substance.

EXPLANATION OF PLATE LXXXV.

(Drawings by the author.)

Fig. 1. A section of *Textularia globulosa*, showing the arrangement of the chambers and the means of communication between them. × 150.

Fig. 2. A section through one row of chambers in *Textularia globulosa*, indicating a superficial resemblance to *Nodosaria*. × 150.

Fig. 3. Surface view of *Textularia globulosa*, showing globular form of the chambers. × 150.

Fig. 4. Pigmy form of *Textularia globulosa*. × 330.

Fig. 5. Appearance of *Globigerina bulloides* in section, showing arrangement of chambers, surface markings, thickness of wall, and crystalline contents. × 150.

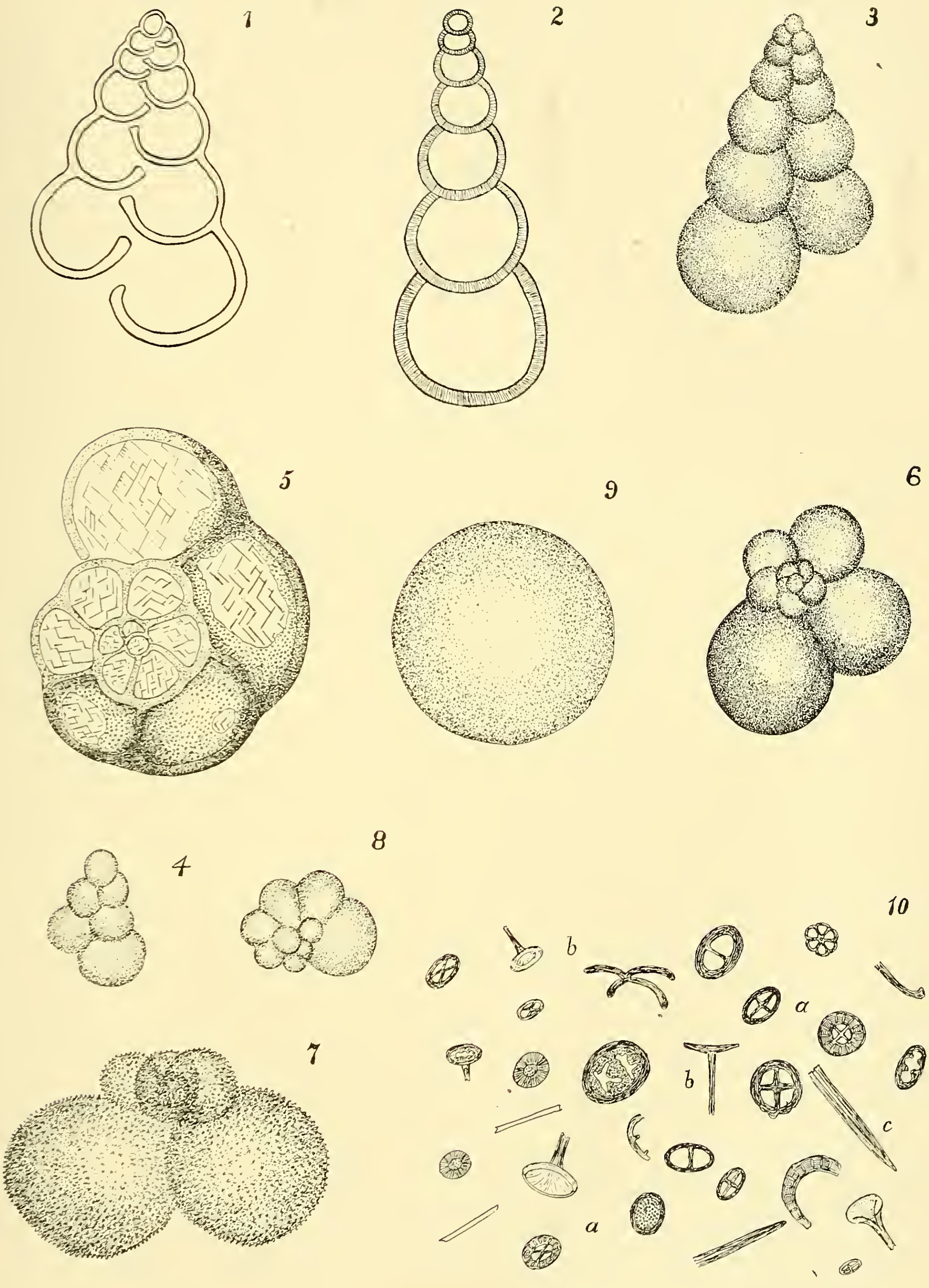
Fig. 6. Surface view of *Globigerina bulloides*, exhibiting the arrangement of chambers and their shape. × 150.

Fig. 7. Lateral view of *Globigerina spinosa*, indicating the number and arrangement of the chambers, and the surface markings of the shell. × 100.

Fig. 8. Pigmy form of *Globerigerina bulloides*. × 330.

Fig. 9. Test of *Orbulina universa*. × 330.

Fig. 10. Typical forms of Coccoliths, Rhabdoliths, etc. *a*, *a*, Coccoliths of various forms; *b*, *b*, Rhabdoliths; *c*, *c*, Sponge spicules. × 1000.



FORAMINIFERA, etc.

PART VIII.

THE INVERTEBRATES OF THE BENTON, NIOBRARA AND FORT PIERRE GROUPS.

By W. N. LOGAN.

Plates LXXXVI-CXX.

CONTENTS.

INTRODUCTION.

Although the Upper Cretaceous beds of Kansas have been the object of much attention from paleontologists and collectors, yet until recently but little consideration has been given to their invertebrate faunas. The discoveries of such a large list of vertebrate forms as the Kansas Upper Cretaceous has produced have had a tendency to overshadow the importance of its invertebrate forms.

The following review and classification of the invertebrate faunas of three of the Upper Cretaceous divisions of Kansas contain the descriptions and figures of nearly seventy-five forms, embracing seventeen believed to be new to science. It is the direct result of the study of the invertebrate fossils already belonging to the Kansas State University collection, those collected by the writer while working on the stratigraphy of the Upper Cretaceous of Kansas under the direction of the University Geological Survey, and those collected by Doctor Williston and the writer during the summer of 1897. In this classification I have attempted to combine, together with the purely scientific, information that may be utilized by the general reader. This attempt has led to a general rather than a strictly scientific discussion of the subkingdoms of Invertebrata. In order, however, that its value to the scientist may not be impaired, the customary order of scientific description has been retained for both the already-described and the new species. In all species already described the original descriptions and figures, as far as practicable, have been retained.

In the preparation of this report the writer desires to acknowledge his indebtedness to Dr. S. W. Williston for valuable assistance in the laboratory and field; also to the following, for courtesies extended: Mr. T. W. Stanton, of the United States Geological Survey, Washington, D. C.; Mr. W. Madden, Hays City, Kans.; Mr. M. R. Watson, McCracken, Kans.; Prof. H. J. Harnley, McPherson, Kans.; and Mr. Stanley Moore, Pleasanton, Kans.

Outline Showing Distribution of Species in the Upper Cretaceous of Kansas.

Formation. ☞	Fort Benton.				Niobrara.			Fort Pierre.
	Lincoln Marble.	Limestone Group.	Ostrea Beds.	Septaria.	Fort Hays Limestone.	Rudistes Beds.	Hesperornis Beds.	Arickaree Shales.
Avicula gastrodes		—						
Avicula fibrosa								—
Acanthoceras kanabensis				—				
? Anchura sublævis								—
Belemnitella baculus		—						
Baculites ovatus								—
Callista tenuis			—					
Corbula kanabensis	—							
Donax cuneata	—							
Donax oblonga	—							
Exogyra læviuscula	—							
Heliococeras corrugatum				—				
Heteroceras cochleatum								—
Heteroceras angulatum								—
Haploscapha grandis						—		
Haploscapha eccentrica						—		
Haploscapha niobraraensis						—		
Inoceramus brownii					—			
Inoceramus concentricus						—		
Inoceramus truncatus						—		
Inoceramus platinus					—			
Inoceramus fragilis					—			
Inoceramus labiatus		—						
Inoceramus dimidius				—				

Inoceramus pennatus						—		
Inoceramus subtriangulatus						—		
Inoceramus subconvexus		—						
Inoceramus crispii								—
Inoceramus incurvus								—
Inoceramus sagensis								—
Inoceramus altus								—
Inoceramus simpsonii					—			
Inoceramus flaccidus					—			
Inoceramus deformis					—			
Inoceramus gilbertii				—				
Inoceramus undabundus		—						
Inoceramus tenuirostratus				—				
Inoceramus exogyroides		—						
Inoceramus umbonatus		—						
Lucina occidentalis								—
Mortoniceras shoshonense		—						
Modolia multilinigera	—							
Mactra emmonsii	—							
? Mortoniceras vermilionense		—						
Ostrea larva							—	
Ostrea alta	—							
Ostrea congesta			—			—		
Ostrea lugubris	—							
? Prionotropis lœvianus		—						
Prionotropis woolgari		—						
Prionotropis hyattii		—						
Prionocyclus macombi				—				
Prionocyclus wyomingensis				—				
Placenticeras placenta				—				
Pyropsis coloradoensis				—				

Outline Showing Distribution of Species in the Upper Cretaceous of Kansas — *Concluded.*

Formation. ☛	Fort Benton.				Niobrara.			Fort Pierre.
	Lincoln Marble.	Limestone Group.	Ostrea Beds.	Septaria.	Fort Hays Limestone.	Rudistes Beds.	Hesperornis Beds.	Arickaree Shales.
Pharella pealei	—							
Pholadomya papyracea	—							
Parapholas sphenoides	...	...	...	...	—			
Radiolites maximus	...	...	...	...	...	—		
Rostellites willistonii	...	...	...	—				
Scaphites nodosus	...	...	...	...	...	...	...	—
Stramentum haworthii	...	...	...	...	...	—		
Stramentum tabulatum	...	...	...	...	...	—		
Squama spissa	...	...	...	...	...	—		
Squama lata	...	...	...	...	...	—		
Scaphites larvæformis	...	...	...	—				
Scaphites vermiformis	...	...	...	—				
Scaphites warrenii	...	...	...	—				
Scaphites ventricosus	...	...	...	—				
Scaphites mullananus	...	...	...	—				
Serpula intrica	...	...	...	...	...	—		
Serpula tenuicarinata	...	...	...	...	...	—		
Serpula plana	...	...	—					
Teusoteuthis longus	...	...	...	...	...	...	—	
Turritella whitei	—							
Uintacrinus socialis	...	...	...	...	...	—		

General Description of Subkingdoms.

THE animal kingdom is divided into eight subkingdoms. Named in order of their development these subkingdoms are: (1) PROTOZOA. (2) CŒLENTERATA. (3) ECHINODERMATA. (4) VERMES. (5) MOLLUSCOIDEA. (6) MOLLUSCA. (7) ARTHROPODA. (8) VERTEBRATA. The first seven divisions comprise the invertebrate animals, and the eighth or last the vertebrate animals. All of these subkingdoms are represented by fossil forms in the Upper Cretaceous of Kansas except the fifth. In abundance of individuals Protozoa is the best represented, as the large chalk beds of the Niobrara division are largely composed of these forms. Diversity of species is undoubtedly best represented by the Mollusca. In order that the general reader may have a better understanding of the following systematic classification, I have added a short description to the principal subkingdoms. For description of the Protozoa, see Part VII.

Cœlenterata.

Coelenterates are aquatic animals which vary much in form, structure, and size. They are either free and independent, or composite and attached. The body is composed of three modified layers of cells. The lowest cœlenterates belong to a class called Porifera. To this class belong the sponges, hydras, sea-anemones and other forms. The sponges have a skeleton and are attached to some submarine object. The horny or flinty skeleton of sponges possesses an internal and external cellular layer. The internal cells have cilia, the whip-like action of which drives the water through the skeletal canals, allowing the cells to grasp their food and oxygen from the flowing water. The external cells can easily procure their food and oxygen from the water which is in continuous circulation about the sponge. The fresh-water hydra attaches itself mouth downwards to objects in the water. A number of tentacles extend from its mouth. These tentacles possess cells in which jagged, thread-like processes lie coiled up in a narcotic fluid. Objects coming in contact with the tentacle cause the cells to burst and throw the thread like a lasso around the object, which, if it be animate, is poisoned by the fluid. Other marine hydra produce polyps on flinty tubes, from which they project like flowers from the parent, and form a bell-like body with many long, radiating tentacles. In this form the hydra is called a jelly-fish. These jelly-fish produce eggs which in turn produce polyps. The contractile tissues, which are muscle-like in structure, propel the animal through the water.

Echinodermata.

Echinoderms have a well-developed skeleton which is composed of calcareous plates, or of calcareous bodies imbedded in the integument. The subkingdom is represented by rayed animals such as the star-fish, in which the rays spring from a common center; by the sea-lilies, in which they start from a fixed stalk; by the sea-cucumber, which is covered by spicules of calcareous matter; by the sea-urchin, in which the rays are coiled, forming a globular body. The Echinoderms have a digestive tract separate from the body cavity. The sea-water is driven into this cavity, or gastro-vascular space, through canals by cilia. Some of the members of this subkingdom have rudimentary eyes. The star fish has an eye composed of many crystalline lenses at the end of each ray. The test of an Echinoderm is composed of calcareous plates which are arranged in concentric rows. The principal classes of Echinodermata are: Cystidea, Blastoidea, Crinoidea, Asteroidea, Echinoidea, and Holothuroidea.

Vermes.

The representatives of this subkingdom possess a segmented structure. The segmented body of these animals contain a nervous system which consists of a double chain of ganglia passing along the ventral side of the body. Some species are provided with locomotive appendages, while some of the members are provided with a calcareous tube or shell into which the soft parts are drawn. Sometimes these tubes are free, but more often they are attached to some submarine object. The tubes are usually calcareous but sometimes they are composed of sand-grains or pieces of shell cemented together.

Mollusca.

This subkingdom is represented by a great diversity of animal organisms, making a specific definition next to impossible. The members of the mollusca differ physiologically, in that some have none or poorly developed heads and hearts, while others have heads and chambered hearts. Some are naked; some have a gristly covering, while others have either a double or single valve or shell composed of calcareous matter. The individuals range in weight from a few grains to 400 or 500 pounds. A marked difference is found in their manner of growth. Some, like the Radiolites, grow in colonies; others, like the majority of the Ostreæ, grow independently. They possess a soft, non-segmented body, and have the power of secreting matter from the surrounding water for the construction of their own shells. They also possess a thick membrane, called the mantle, which secretes the calcareous matter for the shell, and also determines the shape of the shell. Some of the members of this subkingdom are endo-skeletal, *i. e.*, the horny or calcareous part being on the inside; others are exo-skeletal, with the horny or calcareous part on the outside. Many members of this subkingdom are provided with numerous mouths or suckers for capturing their food. It is said "the *Clio borealis* has no less than 360,000 suckers attached to the wing-like organs which spring from its head." The pearly nautilus, the cuttle fish, the octopus, the sea squirts, the oyster and the clam are all representatives of this subkingdom. The Cretaceous seas of Kansas swarmed with mollusks of all kinds, from the small *Ostrea congesta* to the large *Radiolites maximus*.

Arthropoda.

This division comprises those animals which possess a segmented body and jointed appendages which are variable in number. The body and the appendages are usually protected by an external covering or skeleton. This subkingdom comprises four great classes: (1) Crustacea. (2) Arachnida. (3) Myriapoda. (4) Insecta. Among the representatives of these classes are the crabs, crayfish, lobsters, spiders, centipedes, and insects. The Crustaceans are the only representatives of this subkingdom found in the Kansas Cretaceous beds. This class is represented by two genera and at least twice as many species.

FORT BENTON CRETACEOUS FAUNA.

The most abundant forms among the invertebrate faunas of the Fort Benton Cretaceous are *Inoceramus labiatus* and *Ostrea congesta.* In the lower horizon, including the Lincoln marble and its adjacent shale beds, *Ostrea* and *Inoceramus* predominate. The invertebrate forms in the Lincoln marble are associated with sharks' teeth, the remains of fishes, turtles, and plesiosaurs. *Inoceramus labiatus* is the most abundant form in the Fort Benton limestone. One layer is composed almost wholly of this shell, and resembles a mortar bed into which these forms have been placed. Belemnitellæ are also very abundant in this horizon, but good specimens are difficult to obtain. *Prinonotropis* and *Prionocyclus* are both well represented, but *Ostreæ* are rare in the limestone group. In the shale beds (Ostrea beds) overlying the limestone, *Ostrea congesta* is the most abundant form; it occurs either free or attached to *Inocerami.* Sharks' teeth and pavement plates are also abundant in the Ostrea beds.

In the lower horizon of the Blue Hills shales *Serpulæ* are found attached to large *Inocerami.* The middle zone of these shales seems to be devoid of fossil forms, but the upper horizon in which the septaria nodules are imbedded has furnished many invertebrate forms. Of these the *Scaphites* and *Inocerami* are the most abundant. Nearly all the shells of this horizon have the pearly layer preserved; this does not occur in any other Cretaceous horizon except in the Fort Pierre. Four of the subkingdoms are represented in the Fort Benton, viz.: Cœlenterata, Echinodermata, Vermes, and Mollusca. The first three are each represented by a single form. Mollusca, however, are represented by eighteen genera and forty species. I think it may be truly said that more than one-half of these forty species occur in the Septaria zone.

Outline Classification of Fort Benton Species.

CŒLENTERATA.
- Cnydaria.
  - Anthozoa.
    - Hexacoralla.
      - Madreporaria.
        - Aporosa.
          - Stylophonidæ.

ECHINODERMATA.
- Pelmatozoa.
  - Crinoidea.
    - Articulatæ.
      - Encrinidæ.

VERMES.
- Annelida.
  - Tubicola,
    - Serpulidæ.
      - Serpula.
        - Serpula plana.

MOLLUSCA.
- **Pelecypoda.**
  - Ostreidæ.
    - Ostrea.
      - Ostrea congesta.
      - Ostrea lugubris.
      - Ostrea anceps.
    - Exogyra.
      - Exogyra ponderosa.
      - Exogyra læviuscula.
  - Aviculidæ.
    - Avicula.
      - Avicula gastrodes.
    - Inoceramus.
      - Inoceramus fragilis.
      - Inoceramus labiatus.
      - Inoceramus dimidius.
      - Inoceramus simpsonii.
      - Inoceramus gilbertii.
      - Inoceramus umbonatus.
      - Inoceramus exogyroides.
      - Inoceramus tenuirostratus.
      - Inoceramus undabundus.
      - Inoceramus subconvexus.
  - Mytilidæ.
    - Modiola.
      - Modiola multilinigera.
  - Veneridæ.
    - Callista.
      - Callista tenuis.

Pelecypoda—concluded:
  - Solenidæ.
    - Pharella.
      - Pharella pealei.
  - Mactridæ.
    - Mactra.
      - Mactra emmonsi.
  - Pholadidæ.
    - Parapholas.
      - Parapholas sp.
  - Turritellidæ.
    - Turritella.
      - Turritella whitei.
  - Fusidæ.
    - Pyropsis.
      - Pyropsis coloradensis.
  - Volutidæ.
    - Rostellites.
      - Rostelites ambigua?
      - Rostellites willistonii.

Cephalopoda.
- Ammonoidea.
  - Lytoceratidæ.
    - Helicoceras.
      - Helicoceras corrugatum.
  - Amaltheidæ.
    - Placenticeras.
      - Placenticeras placenta.
    - Prionocyclus.
      - Prionocyclus wyomingensis.
      - Prionocyclus macombi.
    - Prionotropis.
      - Prionotropis woolgari.
      - Prionotropis hyattii.
      - Prionotropis lœvianus.
    - Mortoniceras.
      - Mortoniceras shoshonense.
      - Mortoniceras vermilionense.
  - Stephanoceratidæ.
    - Scaphites.
      - Scaphites larvæformis.
      - Scaphites vermiformis.
      - Scaphites warrenii.
      - Scaphites ventricosus.
      - Scaphites mullananus.
- Decapoda.
  - Belemnitidæ.
    - Belemnitella.
      - Belemnitella baculus.

Description of the Fort Benton Species.

CŒLENTERATA.

A fragment of coral, taken from the Lincoln marble a few miles north of Lincoln Center, in Lincoln county, by Mr. Sahlman, of the latter place, probably belongs to the Stylophonidæ family of the Hexacoralla subclass. The specimen in my possession is not sufficiently well preserved to present generic, much less specific, determinative characteristics. In general appearance the coral resembles the Devonian species *Acervularia davidsonii*, but does not present the same regularity of coralla structure. As no species belonging to this subkingdom have as yet been described from the Fort Benton formation, the finding of such a specimen is important. Further search in this horizon will probably result in the discovery of more perfect specimens.

ECHINODERMATA.

A single fragment of a crinoid stem was discovered among Fort Benton rocks on the Cross ranch, in Mitchell county, by Mr. O. S. Sommers, of Buel, Kan. The crinoid probably belongs to the family Encrinidæ, but generic characteristics are not clear. As a careful search of the locality in which this specimen was discovered failed to disclose further specimens, its occurrence in this horizon may be purely accidental. The substance of the crinoid resembles that of the Lincoln marble, but if crinoids are to be found in this horizon, they are not abundant.

VERMES.

Serpula plana, n. sp. Plate CXIX, fig. 2.

Cylindrical tubes growing in groups on the outer surface of the large Inocerami of the Ostrea shales; irregularly curved, gradually increasing in size, neither regularly coiled nor curved, but grouped irregularly, sometimes lying almost straight. Length of young individual, twenty-four mm.; length of longest fragment of adult, forty mm.; diameter, in excess of two mm. Specimens attached by entire length, upper side showing irregular lines (probably lines of segmentation), as of overlapping concentric plates; surface in some specimens rugose, in others smooth.

This species differs from *Serpula tenuicarinata* in not having a carina, having nearly twice the transverse diameter, being more cylindrical, and (possibly) having more than twice the length.

Specimens of *Serpula plana* are very abundant in the upper horizon of the Ostrea shales of the Fort Benton group. Specimens have been collected by the writer from the above-named beds, on the Smoky Hill river, in Ellis and Trego counties; north of Hays City, on the Saline river; and at the southern point of the Blue Hills, in Mitchell county.

MOLLUSCA.

Ostrea congesta Conrad. Plate xcix, figs. 10, 11, 13.

Ostrea congesta Conrad, 1843, Nicollet's Rep. of Explor. in the Northwest, p. 167; Hall, 1856, Pac. R. R. Reps., vol. iii, p. 100, pl. i, f. 11; Meek, 1876, U. S. Geol. Surv., vol. ix, p. 13, pl. ix, ff. 1a–f; White, 1880, 4th Ann. Rep. U. S. Geol. Surv., vol. ix, p. 294, pl. xxxix, ff. 11, 12, 13; Stanton, 1892, Bull. U. S. Geol. Surv., p. 55, pl. i, ff. 5 and 6.

Meek's description: "Shell elongated; upper valve flat; lower valve ventricose, irregular; umbo truncated by a mark of adhesion.—Conrad.

"This is a small, thin shell, the individuals of which are often crowded together in considerable numbers, so as to assume quite irregular forms. In cases where the individuals had room to grow without interruption, the young shell is usually found to be of an ovate form, and attached by the whole under surface of the lower valve, the beak of which is pointed, provided with a small triangular area, and usually turned a little to the left. In this form they continue to grow to lengths varying from twenty-five hundredths to one inch, when the margins are abruptly deflected upward at right angles to the flat attached base, and produced in this direction often for as much as an inch or more; the greatest extension being on the lateral margins and at the extremity, opposite the beaks. When seen at this stage of their growth, separated from the body to which they were originally attached, and lying partly imbedded in the matrix, with the beak side down, they look like short, cylindrical tubes, with one end abruptly truncated and closed by the flat surface of attachment; so that what was originally the whole under surface of the valve, now appears like the truncated umbo. The other valve is quite flat, or sometimes a little concave, and always retains the form possessed by the attached valve at the time its margin became deflected upward, after which it seems to have increased very little in size. Its umbo is usually a little less pointed than that of the other valve, and provided with a shorter area, on each side of which its margins are sometimes slightly crenulated. The muscular impressions of each valve are obscure, and the face is nearly smooth, or only marked by fine, indistinct lines of growth."

These shells occur abundantly in the Ostrea beds of the Fort Benton area. So abundant are they that the shale thrown from the wells which pierce the Ostrea beds, after a short weathering, is almost white with them. They may be collected from the Ostrea beds exposures along the Smoky Hill, the Saline and the Solomon rivers, and from numerous smaller streams in the Upper Cretaceous area.

Ostrea lugubris Conrad. Plate XCI.

Ostrea lugubris Conrad, 1857, U. S. and Mex. Bound. Rep., vol. I, p. 156, pl. X, ff. 5a, b; Meek, 1876, Macomb's Expl. Exped. from Santa Fe to Junction of Grand and Green Rivers, p. 123, pl. I, ff. 1a–d; White, 1884, 4th Ann. Rep. U. S. Geol. Surv., p. 297, pl. LI, f. 3; Stanton, 1892, Bull. U. S. Geol. Surv., p. 58, pl. IV, ff. 1–10.

Ostrea belliplicata Shumard, 1816, Trans. St. Louis Acad. Sci., vol. I, p. 608; White, 1879, Ann. Rep. U. S. Geol. Surv. Terr. for 1877, p. 276, pl. IV, ff. 3a, b, and pl. VIII, ff. 2a, b; White, 1884, 4th Ann. Rep. U. S. Geol. Surv. Terr., p. 292, pl. LXXVIII, ff. 1, 2, 3.

Ostrea (Alectryonia) blackii White, 1880, Proc. U. S. Nat. Mus., vol. II, p. 293, pl. IV, ff. 1, 2; Ann. Rep. U. S. Geol. Surv. Terr. for 1878, p. 11, pl. XIV, ff. 1a, b, and pl. XVII, f. 4; 4th Ann. Rep. U. S. Geol. Surv., p. 292, pl. XLV, f. 1, and pl. XLVI, f. 2.

Stanton's description: "Shell varying in size from small to medium; outline usually broad subovate, but in small specimens often nearly circular and in large ones occasionally subtriangular; lower valve moderately convex, the greatest convexity being along the median line, which is often subangular in large shells; beak usually small and inconspicuous, but sometimes more prominent and curved laterally, often obscured by the scar of attachment, and by strong concentric lines, and sometimes imbrications of growth. The plications are usually simple, but occasionally they bifurcate. Upper valve nearly flat or sometimes slightly concave, with an outline similar to that of the other valve, except that it is somewhat more narrow along the hinge line. Its surface is smooth for some distance around the beak and the plications toward the margin are not so strongly developed as on the lower valve, which it resembles in other respects. The muscular scars are reniform and subcentral; ligamental area varying greatly in size and form, but never very large. Conrad's type (lower valve) measures seventeen mm. from beak to base, fifteen mm. in breadth, and five mm. in convexity, while the corresponding measurements of *Ostrea blackii*, which is the largest variety of the species, are sixty-eight, sixty-two and thirty-two mm., respectively.''

The above species is found in Lincoln marble, but is not abundant. Good specimens are difficult to obtain on account of the extreme hardness of the matrix in which they are imbedded. They are usually found associated with sharks' teeth. Only the smallest variety of this species has been found in the Kansas rocks, and as it has been found in one horizon only, I am inclined to think that that horizon is correlative with the ''brown calcareous sandstone'' horizon of Colorado in which the form *O. lugubris* is so abundant. See Stanton, l. c.

Ostrea anceps, n. sp. Plate CXVII.

Description: Shell elongate, moderately subovate, dorsal margin straight; ventral margin curved; beak truncated by mark of attachment; surface of truncated portion marked by parallel lines of indentation. Upper valve having an elongate, subovate, internal cavity; lower valve very capacious, hollowed under truncated beak. Internal surface of shell smooth; exterior surface not entirely discernible in type specimen, but appearing rugose at margins; hinge moderately long; ligmental groove deep and containing numerous cartilage pits; test thick, thicker on hinge side. Length of longitudinal axis, seventy mm.; maximum breadth, forty mm.; thickness of test, four to ten mm.

Both valves of this form imbedded in a firm matrix of Lincoln marble were found about fifteen miles southwest of Beloit, on the Buel ranch. In the same stone are the impressions of shells which resemble Modiolæ in form and markings. There are also fragments of other shells which resemble *Ostrea subspatulata*, but which I judge to be *Ostrea congesta*. I have found these shells in the Lincoln marble horizon only, and they are not abundant there.

Exogyra ponderosa Roemer.

Exogyra ponderosa Roemer, 1852, Kreid. von Texas, p. 71, pl. IX, ff. 2a, b; White, 1876, U. S. Geog. and Geol. Surv. West 100th Mer., vol. IV, p. 172, pl. XIV, ff. 1a–c; 1884, 4th Ann. Rep. U. S. Geol. Surv., p. 306, pl. L, ff. 1, 2, 3; Stanton, 1893, Bull. U. S. Geol. Surv., p. 65, pl. VII, ff. 1, 2.

Exogyra costata var. Conr., 1857, U. S. and Mex. Bound. Surv., vol. I, p. 154, pl. VIII, f. 3, pl. IX, f. 1.

Exogyra fimbricata Conr., 1857, id., pl. VII, ff. 2a, b.

"Shell large, capacious; marginal outline irregularly subovate; larger valve very gibbous; umbo distinctly spiral, but the coil is usually obscured by a large scar of attachment; umbonal half obtusely carinate, the sides sloping abruptly from the carina to the margins; basal half not so deeply, but more regularly convex than the other. Test very massive, sometimes having a solid thickness of five or six centimeters, lamellose, so much so that the valve often splits into numerous pieces along the surfaces of layers of growth; inner surface smooth; muscular scar of moderate size, somewhat deep, placed about mid-length the valve, and, as usual, a little nearer to the posterior than the anterior side; surface marked by strong, irregular, imbricating lamellæ of growth, which become laciniate at and near the margins; surface also marked by fine concentric striæ, and by irregular, indistinct, radiating costæ, the latter being usually removed by exfoliation from old shells. Upper valve thick, concentrically laminated; smooth within; umbo horizontal; distinctly spiral; length of an example rather under the average size, from umbo to basal margin, about one cm.; breadth, eight cm.; convexity of larger valve, nearly six cm."

A form found imbedded in a firm matrix of Lincoln marble I think belongs to this species; if so, it is a young individual. Specimen was found associated with *Exogyra læviuscula* in the Lincoln marble outcrops, on Rattlesnake creek, Lincoln county.

Exogyra læviuscula Roemer.

Exogyra læviuscula Roemer, 1852, Kreid. von Texas, p. 70, pl. IX, ff. 3a–c; Conrad, 1857, U. S. and Mex. Bound. Surv., p. 154, pl. VII, ff. 4a, b; White, 1876, U. S. Geog. and Geol. Surv. West 100th Mer., p. 173, pl. XVII, ff. 2a–d; 1884, 4th Ann. Rep. U. S. Geol. Surv., p. 305, pl. LII, ff. 3, 4, 5; Stanton, 1892, Bull. U. S. Geol. Surv. No. 196, p. 64, pl. VIII, ff. 5 and 6.

Ostrea ferdinandi Coquard, 1869, Mon. Gen. Ostrea, Terr. Cret., p. 33.

Exogyra ponderosa Hill, 1889, Check List Cret. Invert. Fossils of Texas, p. 6.

Description: Shell moderately capacious and semiovate in form; test moderately thick; general shape of shell varying in outline from subovate to suborbicular; inferior valve inflated and very much curved and rounded in outline. Superior valve smaller and nearly flat, suborbicular in outline; surface smooth but marked by very faint lines of growth. Umbo small, coiled pirally, forming two volutions which are narrow and closely involuted; hinge line short; scar of attachment small or wanting; umbo in some specimens somewhat free. Diameter from umbo to basal margin, forty-seven mm.; transverse diameter, forty-two mm.; depth of the larger valve, eighteen mm.

Species occurs in the Lincoln marble, but is not abundant. The only specimens found were collected from the outcrops on Rattlesnake creek, in the northern part of Lincoln county.

Avicula gastrodes Meek. Plate LXXXVI, figs. 8, 9.

Avicula (Oxytoma?) gastrodes Meek, 1873, Ann. Rep. U. S. Geol. Surv. fo 1872, p. 491.

Pteria (Oxytoma) gastrodes White, 1879, Ann. Rep. U. S. Geol. Surv. Terr. for 1877, p. 280, pl. x, f. 1a.

Pteria (Oxytoma) erecta White, 1880, Proc. U. S. Nat. Mus., vol. III, p. 157, and vol. IV, ff. 7 and 8 of plate opposite p. 139.

Avicula gastrodes Stanton, 1893, Bull. U. S. Geol. Surv., p. 72, pl. IX, ff. 7–10.

Description: "Shell (as determined from a left valve) attaining a moderately large size, subtrigonal in general outline, rather distinctly convex, and having a very slight backward obliquity; basal outline very profoundly rounded, the deepest or most prominent part being in advance of the middle; posterior margin moderately sinuous below the wing, from the extremity of which it ranges obliquely forward and downward, rounded regularly into the base below; anterior margin strongly and subangularly sinuous under the wing, thence descending with a slight forward obliquity and rounding rather abruptly into the base; hinge margin longer than the height of the valve, the antero-posterior diameter of which (at any point below) it also decidedly exceeds, ranging nearly at straight angles to the vertical axis of the shell; beaks distinctly convex, rising above the hinge margin, strongly incurved, without obliquity, and situated less than one-third the length of the hinge margin from the extremity of the anterior wing, which is subtrigonal in form, somewhat convex, a little rounded at the extremity, and very strongly separated from the abrupt swell of the umbo by a deep rounded concavity extending from the beak obliquely to the marginal sinus below; posterior wing longer and more compressed, narrower, and more angular than the other; both wings, particularly the posterior one, projecting decidedly beyond the margin of the valve below. Surface only showing more or less distinct lines of growth. Height of left valve, one and five-tenths inches; length of same below the wings, about one and three-tenths inches; length of hinge line, one and nine-tenths inches; convexity of left valve alone, four-tenths inch" (Meek). The types of *Pteria* (*Oxytoma*) *erecta* are small individuals that apparently belong to the same species.

Two specimens, collected from a thin layer of sandstone underlying the Lincoln marble horizon on Salt creek, in Mitchell county, so closely resemble this species that I have referred them to it, although the specific character of the wings cannot be determined from the specimens which are not very well preserved, especially in the umbonal region. A closer examination of this stratum will probably reveal more perfect specimens. Should the specimens collected belong to this species they are undoubtedly young individuals, as they are not more than one-half the size of the above-described species.

Inoceramus fragilis M. & H. Plate LXXXVII.

Inoceramus fragilis H. & M., 1856, Mem. Am. Acad. Arts and Sci., n. s., vol. V, p. 388, pl. II, ff. 6a and b; White, 1876, U. S. Geog. and Geol. Surv. West 100th Mer., vol. IV, p. 178, pl. XV, f. 3; Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 42, ff. 1 and 2 in text and pl. V, f. 5; Meek, 1876, Macomb's Expedition from Santa Fe to Junction of the Grand and Green Rivers, Geol. Rep., p. 127, pl. I, f. 6; Whitfield, 1880, Geol. Black Hills of Dak., p. 390, pl. IX, f. 10; Stanton, 1892, Bull. U. S. Geol. Surv. No. 106, p. 76, pl. XI, ff. 1–5.

Inoceramus howelli White, 1876, Geol. Uinta Mts., p. 114; 1879, 11th Ann. Rep. U. S. Geol. Surv. Terr., p. 284, pl. IV., ff. 1a, b, c.

Inoceramus perplexus Whitfield, 1880, Geol. Black Hills of Dakota, p. 392, pl. VIII, f. 3, and pl. X, ff. 4 and 5.

Revised description: "Shell moderately thin, broadly subovate, higher than long, moderately convex; subequivalve; anterior side vertically truncate from the beaks, with slightly concave outline; basal and posterior borders forming a more or less regular, nearly semicircular curve; hinge line rather short, and standing at right angles to the truncate anterior. Beaks pointed, equal, scarcely rising above the hinge, curving inward and slightly forward at the points. Surface marked by fine lines of growth and a few obscure traces of concentric undulations. Height of an average specimen, thirty-five mm.; length, twenty-six mm."

This species occurs in the Fort Benton limestone and also in the Septaria horizon.

Inoceramus labiatus Schlotheim. Plate XCII, fig. 4.

Ostracites labiatus Schloth., 1813, Bronns Jahrb., vol. VII, p. 93.

Mytulites problematicus Schloth., 1820, Petrefactenk. I, p. 302.

Inoceramus mytiloides Mantell, 1822, Geol. of Sussex, p. 215, pl. XXVII, f. 2; Roem., 1852, Kreid. von Texas, p. 66, pl. VII, f. 5.

? *Inoceramus confertim-annulatus* Schiel, 1855, Pac. R. R. Reps., vol. II, pl. II, f. 7.

? *Inoceramus pseudo-mytiloides* Schiel, 1855, ibid., pl. III, f. 5.

Inoceramus mytilopsis Conrad, 1857, U. S. Bound. Surv., vol. I, p. 152, pl. II, ff. 6a and 6b.

Inoceramus problematicus (Schloth.) Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 62, pl. IX, ff. 3a and b.

Inoceramus aviculoides M. & H., 1860, Proc. Acad. Nat. Sci. Phil., p. 181.

Inoceramus problematicus var. *aviculoides* Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 63, pl. IX, f. 4.

Inoceramus labiatus Stanton, 1892, Bull. U. S. Geol. Surv., p. 77, pl. X, f. 4; pl. XIV, f. 2.

Meek's description: "Shell obliquely elongate-oval, subelliptical or ovate, nearly or quite equivalve, rather compressed, thin and fragile; anterior side forming a slightly convex curve from the beaks obliquely downward and backward; postero-basal extremity rather narrowly rounded; postero-dorsal margin very oblique, compressed, nearly straight, or sometimes a little convex in outline below the middle, and slightly concave above; cardinal border short, straight, compressed, and forming an angle of about forty-five degrees with the longest diameter of the shell; beaks terminal, rather small, nearly equal, obtusely pointed, rising little above the hinge, and not much curved. Surface ornamented by more or less regular, concentric undulations, and smaller marks of growth. Greatest length, four inches; breadth at right angles to the longest diameter, about two inches; convexity of the two valves, about eight-tenths inch."

To the above description Stanton added: "The name *Inoceramus aviculoides* was applied by Meek and Hayden to a variety with a longer hinge line, greater convexity, and more prominent beak of the left valve, and with the dorsal region more alate than is usual in the species. After studying larger collections Professor Meek found that there were many gradations between this and the typical form, and he therefore treated it as only a variety. Like all species of the genus, it is subject to considerable variation in form, yet it is always easily recognized by its obliquely elongate outline and by the character of the surface markings.

"It is unfortunate that the law of priority compels us to drop the name that has for many years been applied to this species by all American writers who have referred to it, and it is the more unfortunate because the species is so well known under that name as the most abundant characteristic fossil of the Colorado formation. There is no doubt, however, that the American fossil belongs to the species to which European paleontologists now apply the earliest name *Inoceramus labiatus*."

This fossil is extremely abundant in the Fort Benton limestone of Kansas. In one horizon[68] of the limestone group the rock is composed almost entirely of Inocerami. This horizon is

68. The Inoceramus horizon; see Upper Cretaceous of Kansas, Logan, Kans. Univ. Geol. Surv., vol. II, pp. 216, 217.

persistent throughout the Fort Benton area of Kansas. The fossil exists in all of the Fort Benton limestone layers and in the intercalating shale beds. Its abundance is one of the most convenient means of distinguishing the Fort Benton limestone from the Fort Hays of the Niobrara, since it is not abundant, if it occurs at all, in the Niobrara rocks of Kansas. From other states it is reported as being an abundant and characteristic fossil of the Niobrara. Aside from the *Ostrea congesta*, it is the most abundant species of the Colorado formation in Kansas.

Inoceramus dimidius White. Plate XCVIII, figs. 5, 6.

Inoceramus dimidius White, 1874, Expl. and Surv. West 100th Mer., Prelim. Rep. Inv. Foss., p. 25; 1876, U. S. Geol. and Geog. Surv. West of the 100th Mer., vol. IV, p. 181, pl. XVI, ff. 2a, b, c and d; Stanton, 1892, Bull. U. S. Geol. Surv., p. 78, pl. X, ff. 5 and 6.

Description: "Shell very small for one of this genus, inflated, sometimes much so, obliquely subovate in outline; valves subequal, the left one being a very little more capacious than the other; test thin; beaks small, prominent, acute, incurving, and pointing a very little forward; hinge line straight or nearly so, rather short.

"Surface marked by more or less strong and more or less regular concentric folds or undulations. In some cases these undulations continued to be formed only until the shell attained about half its full size, when they ceased, the remainder of the surface being marked only by ordinary concentric lines of growth. This irregularity in the formation of concentric folds is sometimes connected with considerable distortion of the usual symmetry of the shell.

"The long diameter of an average example, from the umbo to the postero-ventral margin, twenty-six mm.; greatest breadth, eighteen mm.; thickness, sixteen mm. This species is especially distinguished by its small size. Its other more conspicuous specific characters are the small but prominent and pointed beaks, and subequal valves.

"From the young of *I. labiatus*, the valves of which are subequal, it differs in the character of the beaks just mentioned, the greater convexity of the valves, and other evidences of mature growth."

This fossil has been found in the Septaria horizon only, and there only in a fragmentary condition. Complete specimens are difficult to obtain, on account of the extreme friable condition of the Septaria nodules in which they occur. The fossil is found associated with *I. tenuirostratus* and *I. fragilis*, in the septaria on the Saline south of Plainville. Fragments have also been found in the septaria of Oak creek, in Smith county.

Inoceramus gilbertii White. Plate XCII, figs. 1, 3.

Inoceramus gilbertii White, 1876, Geol. Uinta Mts., p. 113; 1879, 11th Ann. Rep. U. S. Geol. Surv. Terr., p. 285, pl. III, ff. 3 and 4; Stanton, 1892, Bull. U. S. Geol. Surv. No. 106, p. 79, pl. XIV, ff. 3 and 4.

Description: "Shell irregularly subovate in marginal outline, the transverse diameter being greater than the vertical; front more or less flattened; valves nearly or quite equal, the left one, if either, the larger, both of these gibbous, and sometime quite ventricose; umbones broad and elevated; beaks very near the front, incurved, but not projecting beyond the front margin; front nearly straight vertically, or sometimes more rounded, in the former case forming a nearly right angle with the hinge; front margin rounded below to the basal margin, which is broadly convex for more than half the length of the shell; postero-basal margin extended obliquely upward, with a slight emargination, to the posterior extremity, which is abruptly rounded to meet the downward-sloping postero-dorsal margin; dorsal margin straight, its length equaling more than half the long diameter of the shell. Upon each valve there is an obscure radiating depression or ill-defined furrow extending from the umbonal region to the postero-basal border, and ending there at the emargination before mentioned. Surface marked by the usual lines of growth, and also by numerous, extravagant, irregular folds or wrinkles. Length, seventy-five mm.; height, fifty mm."

Inoceramus gilbertii occurs not only in the Septaria horizon but also in the Fort Benton limestone group.

Inoceramus umbonatus M. & H. Plate LXXXIX.

Inoceramus umbonatus M. & H., 1858, Proc. Acad. Nat. Sci. Phil., p. 50; Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 44, pl. III, ff. 1a, b, c, and pl. IV, ff. 1a, b, and 2a and b; Stanton, 1892, Bull. U. S. Geol. Surv. No. 106, p. 81, pl. XVIII, ff. 1 and 2.

Stanton's revised description: "Shell attaining a rather large size, vertically subovate, extremely inequivalve; height more than one-third greater than the antero-posterior diameter; base regularly rounded; hinge and interior unknown. Left valve very convex; beak greatly elevated, gibbous, strongly and somewhat obliquely involute, so as to form one and a half to two entire turns, the point terminating near the anterior side; surface unknown, that of internal casts sometimes showing faint traces of concentric undulations. Right valve subcircular, or a little oval transversely, much compressed or nearly flat, excepting in the central or umbonal regions, which are moderately convex; beaks rather oblique, projecting little above the hinge, and but slightly incurved; surface of an internal cast ornamented with regular, rather prominent, subangular, concentric undulations, separated by wider rounded depressions. Height of left valve, about 7 inches; antero-posterior diameter, 5.19 inches; convexity, 4.50 inches. Right valve, height, about 5.70 inches; antero-posterior diameter, 5.70 inches; convexity, about 1.60 inches."

This species occurs in the Fort Benton limestone group, but it is not abundant.

Inoceramus exogyroides M. & H. Plate LXXXVIII.

Inoceramus exogyroides M. & H. 1862, Proc. Acad. Nat. Sci. Phil., p. 26; Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 46, pl. V, ff. 3a, b, c; Stanton, 1892, Bull. U. S. Geol. Surv., p. 83, pl. XVII, ff. 1 and 2.

Revised description: "Shell medium size, equivalve or nearly so, valves suborbicular, height of the valves being greater than their lengths from the anterior to the posterior side, very gibbous; anterior and posterior sides rounded, and forming with the base about three-fourths of a circle, the posterior curve being broader than the other; cardinal margin comparatively short, and apparently a little arched; beaks large, elevated, gibbous, distinctly incurved and directed obliquely forward, so as to bring its point near the anterior margin; surface of cast smooth, or marked by obscure concentric undulations. Length from anterior to posterior margin, ten cm.; height, fourteen cm.; convexity, seven cm."

The casts of two valves of this species were obtained from the Fort Benton limestone. The twisted beak precludes the possibility of its belonging to *I. umbonatus*, as suggested by Stanton. (See citation above.)

Inoceramus tenuirostratus M. & H. Plate xcv, figs. 3, 4.

Inoceramus tenuirostratus M. & H., 1862, Proc. Acad. Nat. Sci. Phil., p. 27; Stanton, 1892, Bull. U. S. Geol. Surv. No. 106, p. 83, pl. xvi, ff. 3, 4.
Inoceramus tenuirostris Meek, 1876, U. S. Geol. Surv. Terr., vol. ix, p. 59, f. 5 in text.

Stanton's revised description: "Left valve very gibbous, subquadrate in outline; anterior margin very short or vertically truncated, with a slightly convex outline, immediately in front of the beak, and rounded into the base below; ventral margin nearly semi-elliptical; posterior side rounded, or sometimes subtruncated, with a slightly convex outline above, and a little more prominent and rounded into the base below; hinge of moderate length, with cartilage furrows small, there being about five of them in the space of twenty-hundreths inch; beak very gibbous, prominent, narrowed, strongly incurved, and directed a little forward, its point being directly over the anterior region. Surface of internal cast smooth over the gibbous umbonal region, but showing traces of small, concentric undulations below the middle. Length, 2.10 inches; height from the base to hinge, 1.82 inches; height to tip of umbo, 2.13 inches; convexity of left valve, .90 inch."

A few specimens of this species have been collected from the Septaria horizon of the Fort Benton formation.

Inoceramus undabundus M. & H. Plate xcv, figs. 1, 2.

Inoceramus undabundus M. & H., 1862, Proc. Acad. Nat. Sci. Phil., p. 26; Meek, 1876, U. S. Geol. Surv. Terr., vol. ix, p. 60, pl. iii, ff. 2a, b; Stanton, 1892, Bull. U. S. Geol. Surv. No. 106, p. 84, pl. xvi, ff. 1 and 2.

"Shell obliquely rhombic subovate or subquadrate, gibbous; anterior side very short, and rounding obliquely downward into the base; posterior basal extremity prominently rounded; posterior margin broadly rounded or subtruncated; dorsal and anterior margin diverging from the beaks at an angle of about ninety degrees; hinge short; moderately prominent and nearly terminal, that of the left valve rather strongly incurved and directed obliquely forward, while in the right it is straighter and less elevated; umbonal axis ranging at an angle of about seventy degrees to the hinge line. Surface of both valves (in the condition of casts) ornamented by regular strong, subangular, concentric undulations, separated by wider rounded depressions. Height from the most prominent part of the base to the hinge margin, 2.90 inches; height to top of umbo, 3.36 inches; convexity of left valve, 1.84 inches.''

This species occurs in the Fort Benton limestone, but it is not abundant. Specimens seen were imperfect casts only.

Inoceramus subconvexus, n. sp. Plate CXVIII, fig. 1.

Description: Shell oblong oval, nearly if not entirely equivalve, convex, greatest convexity in anterior region; anterior margin triangular; margin opposite hinge curved; hinge straight, long in comparison with length of shell; posterior margin rounded and extended into a narrow, flat flange. Shell curving abruptly upward from the narrowly pointed beaks, then curving gradually backward and downward; beaks terminal, apparently not rising above the hinge and slightly incurved. Surface marked by moderately prominent undulations and rather closely crowded striations. Length of longitudinal axis, fifty mm.; maximum breadth, thirty mm.; diameter at point of greatest convexity, fifteen mm.

This species seems most nearly related to *Inoceramus labiatus*, to which species I was inclined to ascribe it on first examination, thinking it was a young individual. On comparing the specimen with young individuals of *Inoceramus labiatus*, however, I was able to note specific differences. These differences are greater convexity, pointed beak, and abrupt anterior curve of shell.

A right and left valve of this shell were found by the writer in the Fort Benton limestone on Salt creek, in the southern part of Mitchell county.

The species occurs associated with *I. labiatus*, but it is not at all as abundant as the latter.

Modiola (Brachydontes) multilinigera Meek. Plate LXXXVI, fig. 5.

Modiola (Brachydontes) multilinigera Meek, 1873, Ann. Rep. U. S. Geol. Surv. Terr. for 1872, p. 4922; Stanton, 1892, Bull. U. S. Geol. Surv. No. 106, pp. 86, 87, pl. XIX, f. 3.

Vosella (Brachydontes) multilinigera White, 1880, Cont. to Paleontology, Nos. 2–8, p. 14, pl. XII, ff. 15a, b.; Ann. Rep. U. S. Geol. Surv. Terr. for 1878.

Original description: "Shell rather above medium size, obliquely arcuate subovate; valves strongly convex along the umbonal slopes, thence cuneate posteriorly, and abruptly curved inward below the middle in front; posterior margin forming a broad, regular, convex curve, from the end of the hinge downward to the anterior basal extremity, which is very narrowly and abruptly rounded; anterior margin ranging obliquely backward and downward to the narrow basal extremity, and strongly sinuous along the middle, above which it projects more or less beyond the umbonal ridge, so as to form a moderately prominent, somewhat compressed protuberance; hinged margin nearly or quite straight, running at an angle of fifty to sixty degrees above an imaginary line drawn from the beaks to the most prominent parts of the basal outline, and equaling about half of the greatest oblique length of the valves; beaks nearly terminal, rather compressed, very oblique, and scarcely rising above the hinge margin; umbonal slopes prominent and more or less strongly arcuate. Surface ornamented by fine lines of growth, crossed by regular radiating lines that are very fine and crowded on the anterior part of the valves, but become coarser above and behind the umbonal ridge, the largest being near the dorsal side, where they bifurcate so as to become very fine, and curve more or less upward before reaching the cardinal margin. Greatest length, measuring obliquely from the beaks to the most prominent part of the basal margin of a large specimen, 1.90 inches; greatest breadth at right angles to the same, 1 inch; convexity, 0.76 inch."

This species occurs in a thin stratum of sandstone underlying the Lincoln marble group of the Fort Benton formation.

Callista* (*Aphrodina*) *tenuis H. & M. Plate XCIX, fig. 8, 9.

Cythera tenuis H. & M., 1856, Mem. Am. Acad. Sci., n. s., vol. v, p. 383, pl. I, f. 5.

Meretrix tenuis M. & H., 1860, Proc. Acad. Nat. Sci. Phil., p. 185.

? Dione tenuis Meek, 1864, Smiths. Check-List, Inv. Foss. of N. A., p. 18.

Callista (*Aphrodina?*) *tenuis* Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 188, pl. v, ff. 1a–d; Stanton, 1893, Bull. U. S. Geol. Surv., p. 109, pl. XXIV, ff. 7 and 8.

Description : Shell equivalve, subcircular or subovate, moderately thin ; beaks incurved slightly in specimen and placed in the antero-central region ; anterior side of shell moderately short, rounded below and moderately straight above ; posterior side somewhat subtruncate ; basal margin short, forming a semioval curve. Beaks smooth ; surface marked by fine concentric lines of growth. Length, twenty-four mm. ; height, sixteen mm. ; convexity, ten mm.

Specimen was collected by the writer from the Septaria horizon of the Fort Benton, in the vicinity of Williams butte, in Mitchell county. It consists of the right and the left valve united and firmly held together by an internal cast. For that reason none of the internal characteristics can be noted, and its classification is dependent upon its external features, which are none too well preserved. Species of this and kindred genera are not abundant in the Septaria horizon.

Mactra emmonsii Meek. Plate XCII, fig. 11.

? Mactra emmonsii Meek, 1877, U. S. Geol. Expl. 40th Parallel, vol. IV, pt. I, p. 153, pl. XV, f. 8.

Mactra emmonsii Stanton, 1892, Bull. U. S. Geol. Surv., p. 121, pl. XXVII, ff. 9–13.

Revised description : Shell small, compressed, longer than high, equilateral, anterior side in some specimens longer than the posterior side ; anterior margin narrowly rounded below the middle ; posterior border somewhat broader ; basal margin forming a semielliptical curve ; dorsal margin sloping before and behind the beaks, the anterior slope being greater, with a concave outline ; beaks nearly central, or sometimes placed a little behind the middle, rather depressed and incurved, with very slight obliquity; posterior umbonal slope very obscurely angular from the beaks to the posterior basal extremity; surface marked by lines of growth. Hinge line short, pallial line obscure. Length of large specimen, twenty mm.; height, fifteen mm.; convexity, eight mm.

A cast of a shell which was taken from a thin stratum of sandstone underlying the Lincoln marble in the southern part of Mitchell county undoubtedly belongs to this genus, and probably to this species, although it resembles *M. huerfanensis* in a few points. Fragment of other forms resembling this one were found in the same horizon on the Solomon river near Beloit. On some of the casts the internal features are but poorly portrayed.

***Parapholas*, sp.**

A piece of fossil wood collected by Mr. Sommers, of Buel, from the Lincoln marble horizon of Salt creek, contains casts of forms which resemble *Parapholas sphenoides*, with the exception that they are shorter and more robust. This species may be synonymous with *Parapholas?* sp. Stanton, described from the Pugnellus sandstone of Poison cañon, Colorado. Should such be the case, the circumstance points more clearly to the identity of these two horizons.

***Turritella whitei* Stanton.** Plate XCIX, figs. 1–5.

Turritella urasana White, U. S. Geol. Surv. West 100th Mer., vol. IV, p. 195, pl. XVIII, ff. 11a and b. Not *Turritella urasana* Conrad, 1856, Pac. R. R. Rep., vol. V, p. 321.

Turritella whitei, Stanton, 1892, Bull. U. S. Geol. Surv. No. 196, p. 130, pl. XXVIII, ff. 12–16.

Original description: "Shell of ordinary size, elongate, slender; sides straight; volutions numerous, apparently reaching eighteen or twenty when full grown; the sides of the volutions nearly straight or only slightly convex; suture broad, deeply impressed. Surface marked by numerous revolving raised lines, six or eight of which are moderately large, the smaller ones alternating with them. The larger lines are minutely nodose upon the large volutions, and upon the last one they are even subspinulose. All the specimens of this species in the collection are more or less broken, but judging from their apical angle as indicated by their sides, the largest must have been about five and a half cm. long, and its last whorl about thirteen mm. in diameter."

The claim of this species to recognition as a Kansas form is based upon a very poorly preserved specimen collected from a thin stratum of sandstone underlying the Fort Benton Limestone group.

Pyropsis coloradoensis Stanton. Plate c, figs. 6–8.

Pyropsis coloradoensis Stanton, 1892, Bull. U. S. Geol. Surv. No. 106, p. 154, pl. xxxii, ff. 6–8.

Original description: "Shell of rather large size, pyriform, consisting of four or five rapidly increasing volutions; spire in some specimens much depressed, in others rather prominent; suture distinct, bordered below by a revolving ridge that gives it a channeled appearance; whorls bicarinate around the middle; the upper carina the stronger; obliquely flattened above and rather abruptly contracted below into the canal, which is moderately long and slightly curved. On the whorls of the spire only the upper slope above the greater carina is exposed. In addition to the carinæ that are prominent and more or less nodose on the body whorl, the surface ornamentation consists of numerous strong, granular, revolving lines, usually alternating with finer ones and crossed by distinct lines of growth. Aperture elongate ovate, suddenly narrowed and slightly produced above to form a short posterior canal, and more gradually contracted below into a rather broad anterior canal. Outer lip thin and slightly dentate within; inner lip comparatively thin, forming a broad, thin glaze on the body whorl above, but thickening and narrowing below until it is free from the columella, leaving a distinct and deep umbilicus. There is a single oblique fold on the columella. Length of one of the types, seventy-seven mm.; greatest breath, forty-nine mm."

This species occurs in the Septaria horizon of the Fort Benton formation.

Rostellites ambigua? Stanton. Plate c, figs. 2–5.

Rostellites ambigua Stanton, 1893, Bull. U. S. Geol. Surv. No. 106, p. 156, pl. xxxiii, ff. 8–10.

Original description: "Shell rather large size, spindle-shaped; spire elevated and rather slender, somewhat more than half the length of the aperture; whorls about seven in number, moderately convex, the last one very large; suture distinct, more or less channeled. Below the rounded border of the suture the whorl is slightly constricted or flattened. Surface ornamented by numerous closely arranged revolving lines and by larger curved transverse costæ that are less conspicuous on the body whorl than on the spire, and that have a tendency to form nodes just below the suture. The aperture narrow, prolonged into a rather short canal, and with a short posterior notch. Outer lip thin, obscurely lirate within, and slightly reflexed; inner lip with a very thin callus. The pillar is slightly arched, with two distinct folds, the anterior of which is the stronger, and faint indications of two others behind them. Length of an average specimen, seventy-seven mm.; greatest breadth, twenty-four mm. Other specimens show that the species attained a considerably greater size and sometimes had a more robust form."

The above-described species occurs in the Septaria horizon of the Fort Benton formation, where it is associated with *R. willistonii*.

Rostellites willistonii, n. sp. Plate cxx, fig. 3.

Shell rather large, spindle-shaped; spire passing gradually to a point, equally as long as the aperture; whorls six in number, the body whorl being much larger than the first in the spire. Whorls slightly constricted both above and below the suture, which has a slightly raised border, which is somewhat rounded. Suture not especially distinct. Surface marked by parallel revolving lines and by curved, prominent costæ, forming oblong nodes or ridges on each whorl, but more prominent ones on the body whorl than on the spire. Nodes decreasing in prominence as the apex is approached. Aperture inversely conical, prolonged into a moderately long canal.

Length of a medium-sized specimen, fifty mm.; greatest breadth, fifteen mm. Pillar arched but apparently without folds. There seems to be no well-marked irregularity in the costæ, and parallel ridges or oblong nodes are formed on each whorl.

This species corresponds more nearly to *R. ambigua* Stanton than to any other form, and may be a variety of that species. The chief differences are found in the nodes and sutures and an absence of folds in the pillar. The specimens of this species were collected by Professor Williston during the past summer from the Septaria of the Blue Hills shales at Williams' Butte, in Mitchell county. Its discovery is interesting from the fact that it is the first gastropod described from this horizon in Kansas. A poorly preserved specimen belonging to this class, but to a different genus, was found imbedded in the same mass of iron pyrites in which the species *R. willistonii* occurred.

? Helicoceras corrugatum Stanton. Plate c, fig. 3.

? Helicoceras corrugatum Stanton, 1892, Bull. U. S. Geol. Surv., p. 165, pl. xxxv, fig. 5.

Original description: "Shell dextral, forming a very low, broad, open spiral; whorls with an ovate cross-section, increasing rapidly in size, apparently not in contact. Surface marked by small, regular, rather closely arranged costæ that pass obliquely entirely around the whorl. The costæ are narrowly rounded, not quite as broad as the interspaces, and without nodes or spines. Full form of the shell and septa not known. The type specimen, which is about half of one volution, measures 105 mm. in length, with sections 10 by 12 mm. at the smaller end, and 18 by 23 mm. at the larger end."

From Stanton's figure, I am led to believe that a fragment of a shell collected from the Septaria horizon of the Fort Benton belongs to this species.

Placenticeras placenta Dekay.

Ammonites placenta Dekay, 1828, Ann. N. Y. Lyc. Nat. Hist., vol. II, p. 278, pl. V, f. 2, and of various authors.

Ammonites (Placenticeras) placenta Meek, 1870, U. S. Geol. Surv. Terr., p. 297, and 1870, Proc. Amer. Phil. Soc., vol. XI, p. 429.

Placenticeras placenta Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 465; Stanton, 1892, Bull. U. S. Geol. Surv., p. 169, pl. XXXIX, ff. 1-3.

Meek's description: "Shell lenticular in form, attaining a large size; umbilicus small; volutions deeply embracing, compressed laterally, with sides converging from near the umbilicus to near the periphery, which is very narrowly truncated and flattened or a little concave, with its smooth margins becoming more obtuse with age; aperture narrowly sagittate; surface generally smooth or only showing very obscure traces of curved, transversely elongated prominences on each side, with sometimes a row of very small indistinct nodes around the umbilicus; in young exfoliated shells also usually showing small, faintly defined, divaricating corrugations, directed backward around the outer half of each side. Large examples attain two feet or more in their greatest diameter. Young specimens, three and seventy-hundredths inches in breadth, show a thickness of about ninty-hundredths of an inch, while large individuals are proportionally thicker, and on the periphery become more obtuse. Septa with twelve lateral lobes, and as many sinuses on each side, in large examples crowded and very complex."

I obtained a large fragment of this species from the Blue Hills shales in the vicinity of Williams' Butte, in Mitchell county. It is the only specimen known to have been collected from the Fort Benton of this state.

Prionocyclus wyomingensis Meek. Plate CVI.

Ammonites serratocarinatus Meek, 1871, Proc. Am. Phil. Soc., vol. XI, p. 429.

Ammonites (Pleuroceras?) serratocarinatus Meek, 1871, Ann. Rep. U. S. Geol. Surv. Terr. for 1870, p. 298.

Prionocyclus wyomingensis Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 452; White, 1880, Ann. Rep. U. S. Geol. Surv. Terr. for 1878, p. 35. pl. XV, ff. 1a-e; Whitfield, 1880, Geol. Black Hills Dak., p. 440, pl. XIV, ff. 1-3; Stanton, 1893, Bull. U. S. Geol. Surv. No. 106, p. 171, pl. XL, ff. 1-4.

Original description: "Shell attaining a rather large size; discoid, with periphery provided with a very narrow, prominent, serrated, mesial keel, including the siphuncle. Volutions increased rather gradually in size, somewhat compressed laterally, and a little excavated without being distinctly channeled on each side of the ventral keel; inner ones but slightly embraced by each succeeding turn, and consequently well exposed in the wide umbilicus. Surface ornamented with numerous unequal costæ, some of the larger of which bear a small, somewhat elongated node near the umbilicus, and two closely approximated, small nodes around the ventro-lateral margins, where they all curve strongly forward as they pass upon the periphery; spaces between each two of the large nodose costæ occupied by from one to about three smaller ones. Septa unknown."

Stanton adds: "The costæ are very irregular and vary considerably in strength on different individuals, but they retain the same characters throughout all the stages of growth, excepting that the smaller intermediate ones almost disappear from the last whorl of very large specimens. Frequently two costæ spring from the same node near the umbilicus and sometimes are again united in the node near the periphery, but in other cases they continue separate until they disappear near the keel. Very few specimens show more than one row of nodes near the periphery, and these are never developed into spines. The serrations of the keel are small and somewhat more numerous than the costæ. The breadth of the whorl is about two-thirds of the height in young specimens; in larger ones it is proportionately somewhat greater. The species sometimes reached a size of not less than twenty-five cm. in diameter. The outer whorl of a specimen that is 125 mm. in diameter measures thirty-eight mm. in width by forty-eight in height."

Specimens from Septaria horizon, near Williams' Butte.

Prionocyclus macombi Meek. Plate CI.

Prionocyclus macombi Meek, 1876, Macomb's Expl. Exp., Geol. Rep , p. 132, pl. II, ff. 3a–d.

Prionocyclus macombi Stanton, 1893, Bull. U. S. Geol. Surv. No. 106, p. 172, pl. XLI, ff. 1–5.

Original description "Shell discoidal; umbilicus shallow; somewhat less than the diameter of the last whorl from the ventral to the peripheral side, and showing all the inner turns; volutions increasing greatly in size, very slightly embracing, so as to be nearly flat on the sides, but rounding into the umbilicus; periphery rather narrow, nearly flat, and provided with a small mesial carina, which is very slightly waved in outline; lateral margins of the periphery each having a row of small, compressed nodes, arranged at the termination of each of the costæ, with their long diameters nearly parallel to the peripheral keel; sides of each turn ornamented by from thirty-six to forty rather obscure, slightly flexuous costæ, only every second, third or fourth one of which extends across the umbilical margin, where they are usually a little swollen. The septa are generally a little crowded in adult shells, and divided into two very unequal principal lobes on each side. Siphonal lobe rather longer than wide, ornamented by three branches on each side, the two terminal of which are a little larger and much less spreading than the lateral pair, and each ornamented by some five or six sharp digitations along the margin and at the extremity, where the first pair of principal lateral branches above the terminal ones are of nearly the same form as the latter, but more spreading, and the third pair are smaller, and merely provided with a few digitations; first lateral sinus (dorsal saddle of old nomenclature) as long as the siphonal lobe, but much wider, and deeply divided into two unequal parts, of which the one on the siphonal side is larger than the other, each of these principal divisions being ornamented by some four or five short, irregular branchlets, with obtusely digitate margins; first lateral lobe slightly wider than the siphonal, and provided with some seven or eight short, rather unequal, merely digitate, and palmately spreading terminal and lateral branchlets; second lateral sinus narrower, but as long as the first on the outer or siphonal side, and much shorter on the umbilical, having two short, unequal, digitate branches at the end, and some three or four short, irregular divisions along the oblique margins of the umbilical side; second lateral lobe small, or scarcely more than twice as large as the auxiliary lobe of the siphonal sinus, and somewhat irregularly bifid, the divisions being short, and, like the lateral margins, more or less digitate. Greatest diameter of the specimen, retaining only a small portion of the non-septate outer whorl, four and four-tenths inches; greatest convexity of the same, ninety-five hundredths of an inch; breadth of umbilicus, one and thirty-five hundredths inches; breadth of the last whorl from the siphonal to the umbilical side, one and eight-tenths inches."

Additional description by Stanton: "In the young stages of this species the costæ are simple, linear, closely arranged, and strongly curved forward. The keel is then minutely crenate, with one crenation to each costa. After the third volution, some of the costæ are more strongly developed and bear nodes or small spines at their outer ends, while the intermediate ones become obsolete. The crenations of the keel still continue numerous and small. . . . It can be easily distinguished [from *P. wyomingensis*] by its more compressed form, by the greater regularity of the costæ, and by the much greater difference between its young and adult stages."

A single specimen from Williams' Butte, Mitchell county, in the Septaria horizon.

Prionotropis woolgari Mantell. Plate CII, figs. 1–4.

Ammonites woolgari Mantell, 1822, Geol. of Sussex, p. 197, pl. XXII, ff. 6, 7; Sowerby, 1829, Min. Conch., vol. VI, p. 25, pl. DLXXXVII, f. 1; Sharpe, 1853, Fossil Remains Moll. Chalk of England, p. 27, pl. II, ff. 1, 2; Meek and Hayden, 1861, Proc. Acad. Nat. Sci. Phil., p. 421.

Prionocyclus (*Prionotropis*) *woolgari* Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 455, pl. VII, ff. 1a–h, and pl. VI, f. 2.

Ammonites percarinatus H. & M., 1856, Mem. Am. Acad. Arts and Sci., 2d ser., vol. V, p. 396, pl. IV, f. 2.

Prionotropis woolgari Stanton, 1892, Bull. U. S. Geol. Surv. No. 106, p. 174, pl. XLII, ff. 1–4.

Meek's description: "Shell attaining a medium size, more or less compressed-discoidal, the outer turn being proportionally more convex (including nodes) than those within; umbilicus about equaling the greater dorso-ventral diameter of the last turn; each volution embracing about one-fifth of the next within, and having its umbilical margin slightly indented by the uncovered nodes forming the inner of the two outer rows on the succeeding volution within.

"Young examples, half an inch to one inch in diameter, with costæ linear, closely arranged, of nearly uniform size, and manifesting scarcely any tendency to develop nodes, but already showing the forward curve of their outer ends well defined, while the peripheral keel is low, narrow, and simple, and the furrow on each side shallow. At a somewhat larger size, costæ usually more or less unequal in size, the larger ones now beginning to develop the two nodes at their outer curved ends, and to become a little more prominent and compressed at their inner extremities, while the rather more prominent keel begins to develop its crenate outline, and the nodes nearest it to assume their compressed form and parallel arrangement. On attaining to two and one-half to three inches in diameter, costæ, nodes, and keel becoming more prominent, the latter being strongly compressed and deeply and largely scalloped, with divisions rounded in outline; while, at this stage of growth, the periphery as seen in profile would seem to be very deeply sulcated on each side of the keel, but this is due to the prominence of the row of nodes on either side of the same. Costæ, when the shell has attained a diameter of four inches, much depressed in the middle, with the nodes at their inner ends thicker and more obtuse, and those nearest the keel more depressed or nearly obsolete, while those of the third series, near by, become much enlarged and produced obliquely outward as short, thick, spine-like projections. Soon the outer compressed nodes disappear, and the keel is only represented by distinctly separated, low, elongated nodes; and when the shell has attained a diameter of seven inches, the costæ are more distant, greatly elevated, compressed, and almost wing-like, but still retain a large, prominent, subtrigonal node or projection at their outer ends, and again become, as it were, pinched up at their inner extremities, which do not quite reach the umbilical margin.

"Septa moderately close together; siphonal lobe longer than wide, with three or four short branches on either side, the two terminal of which are largest, more or less parallel, and merely serrated; first lateral sinus broader than the siphonal lobe, more or less deeply divided into two subequal branches with short, irregular branchlets and digitations ; first lateral lobe somewhat longer than the siphonal and bipartite, with short irregular branchlets and digitations occasionally in small specimens, with the middle terminal branch proportionally broad, and so deeply sinuous at the end as to impart more nearly the appearance of a bipartite arrangement of the whole ; second lateral sinus nearly resembling one of the divisions of the first, and in the adult with merely a number of marginal digitations ; second lateral lobe a little more than one-third as long, and from one-third to one-half as wide as the first, generally tripartite at the end, but sometimes in large specimens bipartite on one side of the shell, the divisions being very short and simple, or serrated ; third lateral sinus very small and merely bilobate, or in large specimens digitate along the margins ; third lateral lobe hardly half as long as the second, and in small specimens merely tridentate at the end.

"Largest specimen seen, seven inches in its greatest diameter ; convexity, measuring between the costæ at the larger, broken end of the last turn, one and sixty-hundredths inches ; convexity of the same, measuring so as to include the greatly expanded costæ, three and twenty-five-hundredths inches."

Impressions of these shells occur abundantly in the Fort Benton limestone. They have been found in that horizon in Ellsworth, Lincoln and Mitchell counties.

Prionotropis hyattii Stanton. Plate CII, figs. 5–8.

Prionotropis hyattii Stanton, 1892, Bull. U. S. Geol. Surv., p. 106, pl. XLII, ff. 5–8.

Stanton's description : "Shell of rather small size, compressed discoidal, consisting of five or six whorls ; volutions gradually increasing in size, embracing the earlier ones but very slightly, so that the umbilicus is broad, though different specimens vary somewhat in this respect. In very young examples the height of the whorls is greater than the breadth, the keel is small, and more or less crenate, and the costæ are simple, lineate, and strongly curved forward at the outer ends, without any nodes at first. Usually every third or fourth costa is stronger than the others. Some specimens three-fourths of an inch in diameter are scarcely distinguishable from the young of *Prionotropis woolgari*, excepting that usually the costæ are slightly more unequal. As the shell continues to grow the costæ become more marked and each of the larger ones develops two nodes near the outer end, where it curves forward, and on some of them there is also an elongated node near the umbilicus. At first the two outer nodes are equal, one being just on the angle between the side and the abdomen and the other about half way between it and the keel, but at a later stage the nodes nearest the keel become obsolete, while the others rapidly increase in size, and some of them are developed into prominent sharp spines that are directed obliquely outward and backward. On the outer whorl of the large example the costæ become distant, apparently by the suppression of the intermediate smaller ones. While these changes in the surface ornamentation are developing, the form of the volution is also considerably altered. The abdomen becomes flattened on each side of the narrow, prominent keel, the sides become less convex, and the breadth of the whorl is finally almost equal to the height, so that its cross-section is subquadrate. The keel in all the larger specimens is usually more or less serrate, the serration equaling the costæ, though sometimes it is only slightly sinuous, and it is never completely divided into nodes as it is in *Prionotropis woolgari*. Septa very much like those of *Prionotropis woolgari*, as is shown by the figures. None of the specimens shows the complete living chamber, but the well-developed spines and other features of the surface ornamentation seem to be adult characteristics, and it is therefore probable the species never attained a very large size. The largest one before me measures forty-seven mm. in diameter; the outer whorl is sixteen mm. in height, exclusive of the keel, and fifteen mm. in breadth. Some of the spines on specimens of this kind are six mm. or seven mm. long. Some fragments apparently of this species belong to larger individuals."

Numerous impressions of forms which are undoubtedly of this species occur in the Fort Benton limestone in the Salt creek and Rattlesnake creek outcrops.

Prionotropis lœvianus White. Plate CIII, figs. 3, 4.

Prionotropis lœvianus White, 1876, U. S. Geol. and Geog. Surv. West 100th Mer., vol. IV, p. 201, pl. XIX, ff. 1a, b; Stanton, 1892, Bull. U. S. Geol. Surv. No. 106, p. 178, pl. XLIII, ff. 3, 4.

Original description: "Shell moderately large, robust; volutions four or more, increasing rapidly in size, especially the outer one, so that the umbilicus is rather deep, but yet showing all the volutions, each volution embracing between one-quarter and one-third of the width of each preceding one; transverse section of outer volution, between the nodes, oval-subquadrate; surface, upon each side, marked by a row of moderately elevated, transversely elongate nodes, situated about one-third of the distance from the umbilicus to the dorsum; and also by a row of very prominent nodes on each side of the dorsum. Each of these rows consists of the same number of nodes. The dorsal nodes diverge strongly, but are wholly embraced by each succeeding volution, and do not therefore appear in the umbilicus. Between these two rows of dorsal nodes, the dorsum is slightly convex, and the outer surface of the shell appears to have been marked by a small median carina. Between these nodes and the umbilicus the sides of the volution are broadly convex. A greater transverse elongation of the lateral nodes than existed in our example would make each continuous with its corresponding dorsal node, which would give to each lateral pair of nodes the character of a rib. It is not improbable that this modification may be found to exist in some examples of the species. Septa complex; dorsal lobe and part of dorsal saddle unknown; superior lateral lobe moderately large, but not bifid; accessory lobes and saddles more or less deeply lobed or notched. Diameter, 140 mm."

Imperfect specimens of a form which I believe to belong to this species were obtained from the Septaria horizon of the Blue Hills shales on the Saline river north of Hays City. Specimen was imbedded in a hard matrix of one of the Septaria nodules; therefore its determination was difficult.

Mortoniceras shoshonense Meek. Plate CIII, figs. 1, 2.

Mortoniceras shoshonense Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 449, pl. VI, ff. 3a, c, 6b; Stanton, 1892, Bull. U. S. Geol. Surv., p. 179, pl. XLIII, ff. 1, 2.

"Shell compressed-discoidal, with umbilicus apparently nearly or quite twice as wide as the outer whorl; volutions very narrow, with dorso-ventral and transverse diameters equal, and section subquadrangular, those within scarcely one-sixth embraced by the succeeding turn; costæ each mainly represented by two nodes, the inner of which is low, compressed, and elongated so as to extend from near the umbilical margin about half way across the sides, while the outer near the peripheral margin are more prominent, rounded, and directed laterally; keel less prominent than the row of compressed nodes on each side about half way between it and the rounded nodes along the margins of the periphery; compressed nodes on the periphery of each inner turn covered by the succeeding volution, the inner margin of which is indented by the rounded lateral nodes of that next within. Septa moderately approximate; siphonal lobe oblong, about once and a half as long as wide, with small, short, nearly parallel, serrated terminal branches, and three or four very short, digitate and simple branchlets and points on each side; first lateral sinus wider than the siphonal lobe, which it equals in length, unequally bipartite at the anterior end, both divisions being digitate, and the larger one on the siphonal side deeply bifid; first lateral lobe somewhat longer but narrower than the siphonal, and having its terminal division deeply bifid, and its lateral margins bearing a few very simple branchlets; second lateral sinus scarcely more than half as wide as the first, and much shorter on the umbilical side, unequally bifid or trifid at the end, with more or less sinuous margins; second lateral lobe only about half as long and wide as the first, and trilobate, with the small middle division emarginate at the end; third lateral sinus a little shorter and narrower, and irregularly tridentate at the end; antisiphonal lobe about as long as the first lateral, but narrower, with a few short, nearly simple, lateral divisions, and a tridentate posterior extremity."

This fossil occurs in the Septaria horizon of the Fort Benton formation, but so far only fragments or impressions have been found. These were collected from the vicinity of William's Butte, in Mitchell county.

Mortoniceras vermilionense M. & H. Plate CIV, fig. 1.

Ammonites vermilionensis M. & H., 1860, Proc. Acad. Nat. Sci. Phil., p. 77.
Mortoniceras vermilionense Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 450, pl. 7, ff. 2a, b; Stanton, 1892, Bull. U. S. Geol. Surv. No. 106, p. 180, pl. XLIV, f. 1.

"Shell compressed-discoid, with its shallow umbilicus about one-fifth wider than the last turn; volutions increasing gradually in size, with convexity about three-fourths the dorso-ventral diameter, each turn less than one-fifth embraced by the succeeding outer one; costæ simple and closely arranged in the very young shell, but gradually becoming larger, more distant, and a little thickened at their inner and outer extremities, which latter are slightly curved forward, in examples an inch or so in diameter; peripheral keel moderately prominent, with the depression on each side shallow. Septa not crowded; siphonal lobe oblong, about one-fourth longer than wide, with two short, narrow or subequal or equal, nearly simple, lateral branches, the two terminal of which are diverging and moderately distant; first lateral sinus as long and nearly twice as wide as the siphonal lobe, and deeply divided into two nearly or quite equal parts, with merely sinuous and obtuse digitate margins; first lateral lobe slightly longer than the siphonal, and of the same breadth, with some five or six spreading unequal digitations at the posterior end, the middle two of which sometimes become more prominent, so as to give a slightly bifid appearance to the extremity; second lateral sinus short, or scarcely more than half as long on the inner side as the first, subquadrate in form with shallow marginal sinuosities; the mesial very shallow indentations, causing a faint tendency to bilobate outline at the anterior extremity; second lobe very small, or even less than the auxiliary lobe of the first lateral sinus, about twice as long as wide, narrower, and truncated at its posterior end, with a very few shallow sinuosities along its lateral margins; third lateral sinus hardly half as long or wide as the second, and merely faintly bilobate at the end; third lateral lobe a little oblique, simple and smaller than one of the principal terminal digitations of the first lateral lobe. Greatest diameter, 1.10 inches; convexity, about .26 inch."

This form occurs in both the Fort Benton limestone and the Septaria horizons. In the former it occurs as impressions in the rock; in the latter, as casts in the calcareous nodules which are in the Blue Hills shales.

Scaphites larvæformis M. & H. Plate CIV, fig. 2.

Scaphites larvæformis M. & H., 1856, Proc. Acad. Nat. Sci. Phil., p. 58; Meek, 1876, U. S. Geol. Surv. Terr., vol IX, p. 418, pl. VI, ff. 6a, b, c; Stanton, 1892, Bull. U. S. Geol. Surv. No. 106, p. 182, pl. XLIV, f. 2.

Revised description: "Shell small, transversely subovate, compressed, evenly rounded on the periphery; volutions slender, nearly round, the inner or coiled ones forming only a very small part of the entire shell, and so closely involuted as to leave only a very small umbilical pit; extended body portion rather long, slender and straight to the recurvature, thence continued backward until it comes nearly in contact with coiled inner volutions; aperture apparently circular; surface ornamented by small costæ, which pass from the inner side of the volutions to about half way across their lateral surfaces, where they swell into small obscure, transversely elongated nodes, and then branch each into two or three small linear ribs, all of which pass straight over the periphery. Septa moderately simple, having two main lateral lobes on each side, all of which are only moderately divided. The siphonal lobe is longer than wide, and has two very small, short, nearly parallel, obscurely bifid terminal divisions, with a more oblique, somewhat similar branch on each side above. The first lateral sinus is wider than the siphonal lobe, and nearly as long, with its extremity deeply divided by a slender, obscurely trifid, auxiliary lobe, into very unequal, more or less sinuous, and obtusely digitate branches. First lateral lobe about half as wide as the siphonal, but somewhat shorter, and bearing two very small terminal divisions similar to those of the siphonal lobe.

Second lateral lobe very small and obscurely trifid at the end forming the ventral lobe. Second lateral sinus but little if any larger than the first, and merely obscurely divided into very short, simple, obtusely rounded terminal subdivisions."

Specimens of this species are abundant in the Septaria horizon of the Fort Benton formation. They have been collected from the Blue Hills shales on the Smoky Hill river, and from similar outcrops on the Saline river.

Scaphites vermiformis M. & H. Plate CIV, fig. 3.

Scaphites vermiformis M. & H., 1862, Proc. Acad. Nat. Sci., Phil., p. 22; Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 423, pl. VI, ff. 4a, b; Stanton, 1893, Bull. U. S. Geol. Surv. No. 106, p. 183, pl. XLIV, f. 3.

Revised description: " Shell somewhat less than medium size, ovate subdiscoidal in form; umbilicus moderately small in comparison with the size of the shell; inner volutions closely involute, regularly coiled, deeply embracing and composing a rather large portion of the entire shell; deflected part very short, so as only to be slightly disconnected from the inner turns at the aperture, which is a little contracted and quadrato-subcircular in outline, with a slightly sinuous inner margin; surface ornamented by numerous straight costæ, which are rather small and nearly regular on the inner volutions, but become more distant and larger as well as more prominent, on the inner half of each side of the body portion, where they each support a prominent node at the outer end, so arranged that those on the opposite sides generally alternate; costæ all passing nearly straight across the periphery, on which they are nearly uniform in size, with the exception of their regular enlargement with the whorls. The nodes mentioned above are directed out at right angles to the sides of the shell, and, like the costæ, become again smaller toward the aperture. Most of the large costæ bifurcate at the nodes of the body part of the shell, but their number is also increased by the intercalation of others between. Where they thus branch at the nodes on one side, the two divisions crossing over the periphery from the point of bifurcation never both connect at a node on the opposite side, but in some cases one, and sometimes each division, terminates between two of the nodes on the other side. Siphonal lobe somewhat longer than wide, with a moderately narrow body, provided with three branches on each side, the upper pair of which are small and nearly simple, while the next pair are longer and each bifid, and the terminal pair, which are larger than the second, are each ornamented by three small, pointed branchlets or digitations, or sharp, nearly or quite simple branchlets. The first lateral sinus scarcely equaling in width the siphonal lobe, but longer and divided at the extremity into two nearly equal branches. The first lateral lobe is irregularly tripartite; the lateral divisions being bifid and sharply digitate, while the terminal, which is not quite central, is longer than the others and has about five pointed digitations or short, simple branchlets. Second lateral lobe (ventral?) moderately small and obscurely bifid. Second lateral sinus small, nearly as long as wide, and regularly tripartite. Length, sixty mm.; height, forty-eight mm.; greatest convexity, measuring from the extremities of the nodes on either side, thirty-six mm."

This species occurs in the Septaria horizon of the Blue Hills shales. It occurs not only free in the shale, but also in the calcareous nodules.

Scaphites warrenii M. & H. Plate CIV, figs. 5–7.

Scaphites warrenii M. & H., 1860, Proc. Acad. Nat. Sci., Phil., p. 185; White, 1876, U. S. Geog. and Geol. Surv. West 100th Mer., vol. IV, p. 299, pl. XIX, f. 3a; Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 420, pl. VI, f. 5; Whitefield, 1880, Geol. Black Hills of Dakota, p. 144, pl. XIII, f. 141; Stanton, 1892, Bull. U. S. Geol. Surv. No. 106, p. 185, pl. XLIV, ff. 4–7.

Description: "Shell medium sized, subovate, compressed; inner volutions nearly circular, closely involute, and composing a comparatively rather large part of the bulk; deflected body portion short and rather more compressed proportionally than the inner turns; surface costate and without proper nodes; costæ small on the inner volutions, where they do not differ materially in size, but on the body part about every fourth or fifth one becomes more prominent than the others, and extends entirely across from the inner side to and over the periphery, in passing upon which they bifurcate, or give off lateral branches, so that the whole, with some intercalated ones, assume there a uniform size." Septa, as shown in an imperfect specimen, obscure, simple, and provided with at least two lateral lobes which are but obscurely divided. Siphonal lobe not prominent, and has two short terminal divisions. Other details are entirely wanting. Length, thirty-eight mm.; height, thirty mm.; convexity, fourteen mm.

This species occurs moderately abundant in the Septaria horizon of the Fort Benton group in the outcrops on the White Rock in Jewell county, and in similar ones on the Saline river.

Scaphites ventricosus M. & H. Pl. CIV, figs. 8–10.

Scaphites ventricosus M. & H., 1862, Proc. Acad. Nat. Sci. Phil., p. 22; Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 435, pl. VI, ff. 7a, b, and 8a, b; Stanton, 1892, Bull. U. S. Geol. Surv. No. 106, p. 186, pl. XLIV, ff. 8–10; pl. XLV, f. 1.

Revised description: "Shell medium size, ventricose, oval, broadly rounded over the periphery; inner turns closely involute; deeply embracing, and composing a large portion of the entire body; deflected portion very short; umbilicus very small and deep; aperture transversely sublunate or reniform, but deeply sinuous, and but slightly disconnected from the inner turns on the inner side; surface ornamented with costæ that pass nearly straight over the periphery, where they are of uniform size, excepting their gradual enlargement with the volutions, while on the sides of the last or outer volution, about every fifth or sixth one is larger and more prominent than the intermediate ones, which latter do not extend inward to the umbilical margin. The septa are provided with deeply divided lobes or sinuses. Siphonal lobe longer than wide, and bearing on each side of its very slender body three branches, the two terminal of which are slightly larger than the succeeding lateral ones, and each unequally bifid and digitate; first lateral sinus as large as the siphonal lobe, very narrow at its base, and profoundly divided at its extremity into two unequal branches, of which the one on the siphonal side is larger than the other, and, like the latter, deeply bifid, with sinuous and deeply digitate margins; first lateral lobe as wide as the siphonal lobe, but somewhat shorter, and provided with two nearly equal, bifurcating and digitate terminal branches; second lateral sinus not more than half as long and little more than half as wide as the first, and somewhat similarly divided and subdivided; second lateral lobe about half as long and wide as the first, but tripartite at the extremity, the divisions being nearly equal and digitate; third lateral sinus small and merely provided with two nearly equal terminal branches, with more or less sinuous margins; third lateral lobe hardly more than half as large as the second, and bearing two very short terminal divisions. Between the last-mentioned lobe and the umbilicus there is a minute, trigitate lobe, very similar to the auxiliary lobe of the third lateral sinus, but smaller. Length, eighty mm.; height, sixty-nine mm.; convexity, forty-eight mm."

Specimens belonging to this species occur somewhat abundantly in the shales of the Septaria division of the Fort Benton Cretaceous. They have been found in the upper Blue Hills shales in the vicinity of Williams' Butte and in similar outcrops on the Smoky Hill river.

Scaphites mullananus M. & H. Plate CV, figs. 2-4.

Ammonites mullananus M. & H., 1862, Proc. Acad. Nat. Sci. Phil., p. 63.
? *Ammonites mullananus* Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 607, pl. VIII, ff. 1a-c.
Scaphites mullananus Stanton, 1892, Bull. U. S. Geol. Surv. No. 106, p. 187, pl. XLV, ff. 2-4.

Description: "Shell compressed subglobose; rounded on the border; umbilicus small, deep, and acutely conical, between one-third and one-half as wide as the breadth of the outer whorl from the dorsal to the ventral side, showing about one-third of each inner volution. Whorls increasing rather rapidly in size, particularly in convexity, sloping on each side from near the umbilicus toward the periphery, and rounding abruptly into the umbilicus on the inner side, each of those within deeply embraced by the succeeding turn. Aperture transversely reniform or sublunate. Surface ornamented by rather small, regular, rounded costæ, which pass nearly straight across the sides of the whorls, and arch slightly forward in crossing over the periphery on which from thirty-six to forty of them may be counted to every turn; each of those commencing at the umbilicus, usually there a little enlarged, especially on the larger whorls, so as to form a small subnodose prominence. Beyond these they all bifurcate regularly once, near the middle of each side, and on the larger turns others are also intercalated between so as to make the number on the peripheral side five or six times as great as at the umbilicus. The septa are rather crowded, and provided with branched and deeply sinuous lobes and branches. The siphonal lobe is about one-fourth longer than wide, nearly obovate in form, and ornamented with three principal branches on each side, the two terminal of which are larger than the others, and each provided on the outer side with two or three more or less digitate terminal branchlets, while the inner parallel margins are merely sharply serrated. The first lateral sinus is of about the same size as the siphonal lobe, a little oblique, nearly oblong in form, and divided at the extremity into two tripartite and obtusely digitate branches, of which the one on the outer side is larger than the other; behind these it is provided on each side with two alternating lateral branches with sinuous margins. The first lateral lobe is narrower and shorter than the siphonal lobe, and provided with two principal branches on each side, the two terminal of which are much larger than the others and of unequal size, the one on the right or peripheral side being the larger. Both of these terminal branches are distinctly bipartite, the subdivisions being ornamented with several branchlets and digitations. The second lateral sinus is about half as wide and nearly two-thirds as long as the first, more or less oblique, and rather deeply divided at the extremity into two subequal, bifurcating and obtusely digitate terminal branches. The second lateral lobe is as long as the second lateral sinus, but a little narrower, and ornamented with three variously digitate terminal branches, the middle one of which is longer than the others, a little oblique, and not exactly central. The third lateral lobe is small, being less than half as long and scarcely two-thirds as wide as the second lateral, and provided with three nearly equal spreading digitate terminal branches. Between the third lateral lobe and the umbilical margin there are two other small, very unequal, lateral lobes, the first of which has two or three digitations on each side, while the second is nearly simple or but slightly sinuous on the margins."

This form occurs associated with *Scaphites warrenii* in the Blue Hills shales of the Fort Benton formation. It is found in the outcrops in the vicinity of the White Rock river, in Jewell county, northeast of Mankato.

***Belemnitella baculus*, n. sp.** Plate cx, fig. 2.

Description: Guard cylindrical, expanding gradually toward the pro-ostracum, and coming to a point at the inferior or guard end. Vascular markings moderately well defined; shell substance thin and marked by parallel lines of growth, curving spirally toward the pro-ostacum. Phragmocone tapering, with a gradually widening superior flange. Length of specimen, 140 mm.; greatest breadth of alveolar cavity, 15 mm.

Specimen was found imbedded in the Fort Benton limestone, and so crystallized as to make its description and determination difficult. Specimen appears to be closely allied to *Belemnitella bulbosa* M. & H., but is much larger, and more conical in form than their type. Species is very abundant in the lower strata of the Fort Benton limestone.

THE NIOBRARA FAUNA.

The Niobrara species are numerous and varied. They represent forms ranging in size from the microscopic rhizopod to the large bivalve mollusk, the Radiolites. Species belonging to six of the invertebrate subkingdoms are found. These are represented by about twelve genera and more than thirty species.

In the lower horizon, that of the Fort Hays limestone, fossils are not abundant, especially in the lowermost beds. Those forms found are Ostreæ and Inocerami, and these occur for the most part in the upper portion of the formation. The lower Ornithostoma beds, and possibly the upper Fort Hays, contain the large Radiolites, which are usually found in colonies. There are also the immense Haploscaphæ, with their adhering forms of *Ostrea congesta*, and the broad, flat Inocerami, measuring three or four feet in height. Numerous other species of Inocerami, much smaller, are also abundant, while the Uintacrinidæ, with their ball-like bodies and long-tentacled arms, occur more rarely.

In the Hesperornis beds Ostreæ occur, but are not particularly abundant. Crustaceans are represented to the extent of at least two genera and twice as many species. These belong to the small cirriped type, and are not abundant. Inocerami representing still smaller species than those in the lower beds are the most abundant types of this horizon. The chalk of which these beds are formed is chiefly composed of protozoa and coccoliths.

It is more than probable that in time a much larger list of invertebrate forms will be found in the Niobrara beds of Kansas, since, as yet, but little systematic collecting has been done. But since, as yet, the Colorado formation has not been separated into faunal divisions corresponding to its stratigraphical divisions by the American invetebrate paleontologists, but has had its faunas grouped as a whole, it is impossible to say what part of the already described species belongs to the Niobrara division, or what ones are likely to be found in our Kansas fields.

Outline Classification of Niobrara Species.

PROTOZOA.
- Rhizopoda.
  - Foraminifera.
    - Vitro-calcarea.
      - Globigerinidæ.
      - Textularidæ.

CŒLENTERATA.
- Porifera.
  - Spongiæ.
    - Silicispongiæ.

ECHINODERMATA.
- Crinoidea.
  - Uintacrinidæ.
    - Uintacrinus.
      - Uintacrinus socialis.

VERMES.
- Serpulidæ.
  - Serpula.
    - Serpula intrica.
    - Serpula tenuicarinata.

MOLLUSCA.
- Pelecypoda.
  - Ostreidæ.
    - Ostrea.
      - Ostrea congesta.
      - Ostrea larva.
  - Aviculidæ.
    - Inoceramus.
      - Inoceramus flaccidus.
      - Inoceramus deformis.
      - Inoceramus simpsonii.
      - Inoceramus pennatus.
      - Inoceramus subtriangulatus.
      - Inoceramus brownii.
      - Inoceramus concentricus.
      - Inoceramus platinus.
      - Inoceramus fragilis.
    - Haploscapha.
      - Haploscapha grandis.
      - Haploscapha eccentrica.
      - Haploscapha niobrarensis.
  - Rudistæ.
    - Radiolites.
      - Radiolites maximus.
  - Pholadidæ.
    - Parapholas.
      - Parapholas sphenoideus.
- Cephalopoda.
  - Decapoda.
    - Teuthidæ.
      - Tusoteuthis.
        - Tusoteuthis longus.

ARTHROPODA.
- Crustacea.
  - Cirripidæ.
    - Stramentum.
      - Stramentum haworthii.
      - Stramentum tabulatum.
    - Squama.
      - Squama spissa.
      - Squama lata.

Description of Species in the Niobrara Formation.

PROTOZOA.

For descriptions and figures of the Protozoa, see Part VII.

CŒLENTERATA.

Sponge spicules occur in the chalk of the Ornithostoma beds, showing the presence of members of this class in the Niobrara seas of Kansas. See Part VII.

ECHINODERMATA.

Uintacrinus socialis Grinnell. Plates LXXI, CXII, CXIII.

Uintacrinus socialis Grinnell, 1876, Am. Jour. Sci., vol. XII, p. 81; Meek, 1876, Bull. U. S. Geol. Surv. Terr., vol. II, p. 375; Clark, 1893, Bull. U. S. Geol. No. 97, p. 21, pl. I, ff. 1a–c, and pl. II, ff. 1a–e; Williston and Hill, 1894, Kans. Univ. Quart., III, 19; Bather, 1895, Proc. Zoöl. Soc. Lond., pp. 974–1004, pls. LIV–LVI.

Revised description: "Body subglobose, with ten long radiating arms; basal plate small pentagonal, surrounded by five subradial, quadrangular plates. The six plates (one basal and five subradial) present a stellate appearance, and form an area not much greater in extent than the first radial plate. There are three radial plates, varying in size and shape, either pentagonal, hexagonal, or heptagonal. Of these three radial plates the third or superior seems always the largest and most regular in outline. It is heptagonal in form, with its two longest sides sloping downward from the superior angle. The second radial is about equal in size to the first. All are wider than high. The third radial bears on its superior sloping sides in immediate succession five secondary radials, irregularly pentagonal, or hexagonal in shape, and all wider than high. The fifth of these approaches in shape the proximal armpiece, to which it gives immediate support.

"The arm pieces are thin and horizontally compressed from without inward, their shape being subelliptical. The arms give support to delicate pinnulæ or tentacles throughout their entire length. The articulate surfaces of the arm pieces present a radiate structure. There is also on the inner side of each arm piece a depression, the radial furrow, which gives to the plates a subcrescentoid shape. The arm pieces decrease in size toward the end of the arm. The interradial arms are irregular in shape, somewhat contracted near the middle, becoming wider above and below. They consist of about sixteen plates, large, irregular, and varying widely in size, and of many smaller ones, which gradually diminish in size to the apex, forming a short arm. The arrangement of the interradial plates varies, but in some specimens the order is as follows: Commencing below, opposite the first radial, is a single plate; next above, in line with the second radial, are two; and three opposite the third. Succeeding these, and lying between the first of the second radials, is a single, wide, octagonal plate, and above this eight others, somewhat irregular, extending up in pairs between the fifth secondary radials. Immediately above these eight follow the smaller plates, diminishing rapidly in size until the apex of the short interradial arm is reached. A very small quadrangular plate is inserted between the first and second radials, and the interradial plates, which are opposite these. This arrangement is not constant.

"The interaxillary plates vary also with regard to shape and arrangement. In the axillary area of one specimen three pentagonal plates are succeeded above by three pairs of smaller plates of various shapes; these followed, each, by two branches composed of still smaller plates. In another axillary area of the same specimen one pentagonal plate is succeeded above by two heptagonal ones, which are in turn succeeded by three pairs of smaller plates of variable shapes; these each being followed by two branches of smaller plates."

Two large slabs of crinoidal limestone in the University collection are almost wholly covered with *Uintacrinus socialis*. The adhering forms on one of these slabs are evidently of adult size; on the other slab are a few individuals approaching adult size, all the others being but one-fourth that size. It was thought that two species are represented in these two slabs, but a careful examination failed to reveal any specific differences except in the matter of size. It is remarkable that there should be such a uniformity of size among all the individuals of one slab.

The limestone to which these two forms adhere is composed almost entirely of the plates of this crinoid, the plates being cemented together by a calcareous matrix. Nearly all of the larger individuals present the lateral surface. This condition is probably due to the stronger arms of the adult causing the crinoid as it lay on the sea floor to be crushed laterally instead of vertically. The fragile condition of the arms of the young individual allowed it to be crushed vertically as it lay on its ventral side. Specimens of *Uintacrinus socialis* are rare in the Kansas fields. The specimens in the University collection were collected from the lower part of the Hesperornis beds.

VERMES.

? *Serpula tenuicarinata* M. & H. Plate LXXXVI, fig. 4.

? *Serpula tenuicarinatus* M. & H., 1857, Proc. Acad. Nat. Sci. Phil., p. 134; Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 507, pl. VI, f. 1.

? *Serpula tenuicarinata* Stanton, 1893, Bull. U. S. Geol. Surv. No. 106, p. 53, pl. I, f. 2.

Revised description: "Tubes growing in groups, or rarely single, nearly cylindrical, increasing very gradually in size, irregularly curved, but apparently never spirally coiled, attached by the under side throughout most of the entire length, upper side having a distinct, rather sharply elevated, flexuous, longitudinal carina; surface smooth; carina sometimes wavy.

"Length of species unknown; length of longest fragment, fifteen mm.; average transverse diameter, less than two mm.

"As entire specimens of this species have not been seen it is somewhat doubtfully referred to this genus."

The University specimens consist of a fragmentary mass of these forms attached to a portion of a shell of a large *Inoceramus* collected by the writer from the Ornithostoma beds in the Niobrara area of Jewell county.

Serpula intrica White. Plate C, fig. 1.

Serpula intrica White, 1876, U. S. Geol. and Geog. Surv. Terr. West 100th Mer., vol. IV, p. 205, pl. XV, f. 5a; Stanton, 1893, Bull. U. S. Geol. Surv., p. 53, pl. I, f. 1.

Original description: "Tubes small, slender, cylindrical, smooth, very long and very tortuous, not perceptibly increasing in size, so far as our examples show, but neither the distal nor proximal extremity of the tube has been found unbroken. Diameter of the tube a little more than one mm. This species is remarkable for the great length and uniform size of the tubes and for the intricacy of their contortion."

A single coiled specimen attached to the flat surface of a portion of a large *Inoceramus*, and surrounded by small, broken fragments of tubes, is doubtfully referred to this species. In general appearance this specimen resembles *S. tenuicarinata*, and may belong to that species. The absence of a carina and its coiled condition may be accidental. The specimen was collected from the Ornithostoma beds on the Smoky Hill river, south of Gove City.

MOLLUSCA.

Ostrea (Alectronia) larva Lamarck.

Ostrea falcata Morton, Syn. Org. Rem. Cret. Group, p. 51, pls. III, IX; White, 1884, 4th Ann. Rep. U. S. Geol. Surv., p. 294, pl. XXXIX, ff. 11, 12, 13.
Ostrea mesenterica Morton, ibid.; White, ibid.
Ostrea nasuta Morton, ibid.; White, ibid.
Ostrea larva Lamarck, A. S. V., vol. VI, p. 216; White, ibid.

Description: Shell small, narrow, subelliptical in general shape, diminishing in size posteriorly; posterior dorsal margin deeply crenate or toothed; anterior ventral margin slightly toothed; exterior of shell in some specimens showing lines of growth, in others smooth; interior smooth; beak obliquely rounded; umbonal slope abrupt; hinge line short, almost straight, placed tangentially to the rounded beak.

Length, following central line of curvature, thirty mm.; breadth in antero-central region, ten mm.; height of longest tooth, five mm.

The margins of the two shells when they are fitted together form a zigzag line. This line diminishes in the length of its excursions from a central line as each end of the shell is approached. The distance between the lines of the excursions remains nearly constant. All of the varieties represented by Doctor White's figures in the Fourth Annual Report of the United States Geological Survey are represented in the University collection. These forms represent Morton's three varieties —*falcata*, *mesenterica*, and *nasuta*.

Ostrea larva occurs in both the Hesperornis and the Rudistes beds of the Niobrara Cretaceous, but specimens are not abundant.

Inoceramus flaccidus White. Plate XC.

Inoceramus flaccidus White, 1876, U. S. Geog. and Geol. Surv. West of the 100th Mer., vol. IV, p. 187, pl. XVI, ff. 1a, b; Stanton, 1893, Bull. U. S. Geol. Surv. No. 106, p. 80, pl. XIII, f. 1.

Original description: "Shell large, irregularly subovate in marginal outline, exclusive of the ears; valves subequal, not much inflated; wing moderately large, well defined at its inner side by an auricular furrow; hinge line not very long, nearly at right angles with the front of the shell, and only a little oblique with the axis; a more or less distinct, but somewhat irregular furrow extending the entire length of the shell from the posterior side of the umbo to the postero-basal margin, giving each valve an obscurely bilobed appearance; crenulated face of the hinge narrow, crenulations small; umbonal region narrow; beaks prominent, curved forward and inward; test comparatively thin throughout the whole shell; surface having the ordinary concentric lines of growth, and the test is also thrown into numerous, rude and irregular concentric undulations. Length of the largest example in the collection, about twenty-two cm.; greatest breadth, about fifteen cm."

This species occurs in the lowermost Ornithostoma beds of the Niobrara Cretaceous.

Inoceramus deformis Meek. Plate XCII, fig. 2.

Inoceramus deformis Meek, 1871, Ann. Rep. U. S. Geol. Surv. Terr. for 1870, p. 296; White, 1876, U. S. Geol. and Geog. Surv. West 100th Mer., vol. IV, p. 179, pl. XV, ff. 1a, b; Meek, 1877, U. S. Geol. Surv. Expl. 40th Par., vol. IV, pt. I, p. 146, pl. XIV, ff. 4, 4a; Stanton, 1893, Bull. U. S. Geol. Surv. No. 106, p. 85, pl. XIV, f. 1, pl. XV. ff. 1, 2.

Haploscapha capax Conrad, 1874, Ann. Rep. U. S. Geol. Surv. Terr. for 1873, p. 456.

? *Haploscapha deformis* White, 1876, U. S. Geol. and Geog. Surv. Terr., vol. II, pp. 23, 24, pls. LXVI, LXVII.

Inoceramus ——— ? Hall, 1845, Fremont's Rep. Expl. Rocky Mts., p. 310, pl. IV. f. 2.

Meek's description: "Shell attaining rather large size, obliquely ovate, and rather compressed in young examples, but more rounded, gibbous, and irregular, as well as much less oblique, in adult specimens; more or less inequivalve, but never very decidedly so; posterior and basal margins rounded; the latter curving up more gradually and obliquely to the short anterior margin; hinge short and usually not very oblique; beaks moderately prominent, and placed between the middle and anterior margin; neither greatly more elevated than the other. Surface ornamented with large, strong concentric undulations, which are sometimes moderately regular but often very irregular, and generally becoming rather abruptly smaller on the umbones, where their curves indicate the greater obliquity of the young shell. Height of a medium-sized specimen, about four and fifty-hundredths inches; length of same, four and thirty-hundredths inches; convexity of right valve, about two and fifty-hundredths inches."

This species is found somewhat abundant in the uppermost Fort Hays limestone of the Niobrara Cretaceous. Should *Haploscapha* be made a subgenus of *Inoceramus*, as I have suggested, the thickness of its test and the depths of its undulations would place this species under that subgenus.

Inoceramus simpsonii Meek. Plate XCVII.

Inoceramus simpsonii Meek, 1860, Proc. Acad. Nat. Sci. Phil., p. 312; 1876, Simpson's Exp. across Great Basin of Utah, p. 360, pl. IV; 1877, U. S. Geol. Expl. 40th Par., vol. IV, pt. 1, p. 142, pl. XIII, f. 4; Whitfield, 1880, Geol. Black Hills of Dakota, p. 395, pl. VIII, f. 1; Stanton, 1893, Bull. U. S. Geol. Surv. No. 106, p. 79, pl. XII, f. 1.

Meek's description: "Shell (right valve) attaining a rather large size, transversely oval suboblong, gibbous, the greater convexity being in the antero-central region, cuneate posteriorly; length nearly twice the height; anterior end very short and rounded from the beaks; base forming a long, semielliptic curve, most prominent near the middle and somewhat straightened, or even sinuous, posteriorly; hinge long, straight, and ranging parallel to the longer axis of the shell; posterior margin subtruncated, with a slight backward slope above, and forming an oblique curve into the posterior basal margin; beaks depressed so as to extend a little above the hinge line, incurved, and placed nearly over the anterior margin. Surface ornamented with moderately distinct regular, concentric undulations and lines of growth. Length, eight and ten-hundredths inches; height, about four and thirty-hundredths inches; convexity of right valve, nearly two inches."

This form is found in the Fort Hays limestone of the Niobrara formation. The species is not abundant in the Kansas area.

Inoceramus pennatus, n. sp. Plate CXVIII, fig. 2; CXX, 2.

Description: Shell (right and left valves) oblong ovate, moderately thin, slightly convex, greatest convexity in central region; hinge long (sixty mm.), thicker than shell body; marked with transverse grooves two mm. in breadth, upper border of grooves bent inward; grooves marked with striations running parallel and transverse to the groove; hinge raised and curved inward. Interior of shell smooth, showing no marks or undulations; exterior covered with adhering forms of *Ostrea congesta.*

Length of longer diameter, 150 mm.; height, 75 mm.; greatest convexity not more than 10 mm. Type specimen is imbedded in a matrix of chalk, having valves spread out and open, somewhat resembling wings. Both valves taken together somewhat resembling a leaf in general outline, the hinge corresponding to the midrib and stem.

In general form, *Inoceramus pennatus* does not resemble any of the other species belonging to this genus. In thickness of test it resembles *Inoceramus deformis*, but differs from that species materially in other respects, as will be seen by a comparison of their descriptions.

This is common in the upper horizon of the Pteranodon beds, fragments being found in many places, but on account of the fragile nature of the shell whole specimens are difficult to obtain.

Inoceramus subtriangulatus, n. sp. Plate CXX, fig. 1.

Shell (left valve) large, subtriangular, slightly convex, fibrous, greatest convexity in the antero-central region; hinge long, straight, composed of columnar fibers and crossed transversely by costæ; length of hinge in type specimen, eighty mm. Interior of shell smooth, ornamented with scarcely visible concentric lines or striæ. Length of longitudinal axis, 200 mm.; height of shell, 120 mm. Anterior lateral margin forming an angle with the longer axis of the shell equal to the hinge angle. Posterior margin curved, oval in outline. A single left valve (the type specimen) is imbedded in a matrix of chalk, from which, owing to the fragile condition of the shell, it cannot be removed without endangering the specimen. For this reason I have not been able to determine the general character of the exterior of the shell. From the smooth condition of the interior, it seems there are no ridges or undulations such as mark a majority of the species of this genus. Aside from the condition of the hinge and this apparent lack of ridges and the almost total want of convexity, it most closely resembles *Inoceramus deformis*, but has not the thickness of test of that species.

The above specimen was collected from the upper chalk beds (Hesperornis beds) of Gove county. Fragments of the shell, especially of the hinge, are abundant in these beds, but whole specimens are rare.

Inoceramus brownii Cragin.

Inoceramus brownii Cragin, Cont. to the Paleontology of the Plains, Bull. Washb. Coll. Lab. Nat. Hist., 1889.

Original description: "Shell large, fibrous, equivalve, inequilateral, short, broad, elevated, and concentrically ribbed and striate; valves boat-shaped, or unevenly pear-shaped in exterior view, posteriorly shouldered, depressed on the summit of the umbonal region; beaks obtuse, incurved, closely approximated, their cavity capacious, hinge line more or less angulated between the beaks, provided with numerous transverse cartilage grooves; interior of shell bearing, on the distal part of the umbonal cavity (in the right valve at least), several large, compressed teeth; ribs of the shell six or eight on each valve, prominent rounded, broadening from their origins toward the convexities of the valves, more or less folded, grooved, and striated in the direction of their course.

"Dimensions: Height, eight and one-half inches; breadth (distance between greatest exterior convexities of valve), eight inches; approximate length (greatest anterio-posterior diameter measured parallel to hinge line), six inches; thickness, mostly thirteen-hundredths to twenty-five hundredths of an inch. The exterior of the type specimen is more or less studded with the inferior valves of *Ostrea congesta*, but much less thickly than is usual with the common, large Inocerami of the Niobrara.

A considerable fragment of a younger specimen is free from them. Believing that 'he is a thoroughly good naturalist who knows his own parish,' and in recognition of the valuable aid rendered me in my studies of the geology of Kansas by his careful work in the stratigraphy of his district, I have named this shell in honor of its collector, Benjamin Brown, Esq., late of Knebworth, England, who discovered it in the Fort Hays limestone, at some ten to twenty feet above the base of the latter, at a locality known as Devil's Gap, near the post-office of Topley, in Osborne county, Kansas.

"The woodcut of *Inoceramus culverii* given in Mantell's "Medals of Creation" (p. 408) strongly recalls the present shell, but descriptions of the former seem to forbid reference of the latter to it."

It is a fact much to be regretted that no illustrations of this specimen accompanied the above description. Especially as, to my knowledge, none other of the Kansas collections contain specimens of this species; consequently it is not within the power of the writer to figure it. On account of its large size, fibrous structure, and the fact that it occurs in comparatively durable limestone, there is little probability of many good specimens of this species being obtained by collectors.

***Inoceramus concentricus*, n. sp. Plate CXVI, fig. 1.**

Description: Shell semicircular, medium sized, almost flat, slightly convex in anterior region; hinge not prominent, curved, umbonal region showing moderate depression; beaks rounded obtusely; interior of valve smooth, not marked; exterior surface ornamented with concentric, prominent ridges, terminating near beaks; ridges of surface rounded, smooth, marginal border of last one marked by parallel lines of growth. Shell body moderately thick, increasing slightly in thickness from central region toward border.

Length of longitudinal axis, 160 mm.; height, 80 mm.; thickness, 4 mm. at margin, much thinner at greatest convexity. Shell found with *Ostrea congesta* attached to it by their lower valves.

This description is made from two incomplete specimens collected from the Niobrara outcrops north of Ellis, in Ellis county. It occurs in the lowermost horizon of the Pteranodon beds, where it occurs associated with *I. platinus* and *I. truncatus*.

There exists a striking similarity between this species and the description of *Inoceramus brownii* described by Professor Cragin, and it may be that the form just described is a synonym of the latter. But there are certain points of difference, such as the absence of transverse grooves on the hinge line, and compressed teeth on the distal portion of the umbonal cavity in the former. As no figure accompanied Professor Cragin's description of *I. brownii*, I am unable to decide definitely as to whether they are synonyms or not. The two forms occur in different horizons, *Inoceramus concentricus* occurring in the Pteranodon horizon, and *I. brownii* occurring in the Fort Hays limestone horizon.

Inoceramus platinus, n. sp. Plate CXVI.

Description: Shell large, thin, flat, oblong oval; hinge margin long, straight, smooth, marked by shallow pits or undulations, not concentric, and not regular as in *Inoceramus concentricus*. Body of the shell is thin, and increases but slightly in thickness toward the hinge. Shell substance fibrous and the surface somewhat striated, striations giving a banded appearance to the shell in some specimens. Umbonal region slightly depressed; cavity broad, shallow. Length of longer diameter of adult specimen, from three to four feet; height, from one and one-half to two feet.

Fragments of this shell are numerous throughout the Ornithostoma beds, but on account of the extreme fragility of the shell whole specimens are difficult to obtain. I have described the species as seen in the field and from fragments collected for the University collection. I have often found adult specimens of this shell exposed by the weathering of the chalk, but, upon attempting to remove them with the means at hand, they would be broken up into so many fragments as to make restoration next to impossible. Two large fragments of this shell in the University collection measure more than eighteen inches in longest diameter. The shell is sometimes free from adhering form, but usually has *Ostrea congesta* attached.

These forms are abundant in all the exposures of the Ornithostoma beds which I have visited in the state. Next to *Ostrea congesta*, they are the most abundant forms in the Niobrara Cretaceous of Kansas.

Inoceramus truncatus, n. sp. Plate CXIV.

Description: Shell large, somewhat cordate in outline, thick, moderately convex, convexity in antero-central region; hinge long, straight, formed by reflex fold of shell, not marked, smooth, anterior lateral margin forming a lobe. Shell smooth, marked by small pits on the exterior surface, probably made by some burrowing animal; interior of shell smooth, marked by a prominent groove near the margin; exterior surface marked by broad undulations running parallel with the longitudinal axis; posterior margin truncated, but having a rounded lobe in the central portion of the truncated region. Thickness of shell in central region from eight to twelve mm., gradually decreasing in thickness as the margin is reached. Length of longer axis in adult, three feet; height, from one to one and one-half feet.

The adult specimens of this species are difficult to obtain, but young specimens are obtained more easily. In describing this species, I have used adult specimens as seen in the field and a young individual collected from the Niobrara outcrops on the Saline river, north of Ellis. This form, like *Inoceramus platinus*, which it most nearly resembles, is very abundant in the Ornithostoma area of Kansas, in Jewell, Phillips, Gove, Trego and Ellis counties. This species is comparatively free from adhering forms, but *Serpula tenuicarinata* is often found attached to it.

Haploscapha grandis Conrad. Plate XCIV.

Haploscapha grandis Conrad, 1875, U. S. Geol. Surv. Terr., vol. II, p. 23, pl. LXVI.

Original description: "Shell subovate or subtriangular, hinge long and straight, edentulous, oblique; curved, prominent ridges occupy the upper portion of the interior, the ridges beginning and ending at a distance from the margins of the shell; a singular twisted callus composes the hinge, the back of which is transversely ribbed.

"Length greater than height; hinge line very long; ridges concentric, about twelve in number, extending into the cavity under the hinge, submargin thick; test composed of columnar transverse fibers. No muscular impression can be traced unless the ridges indicate their station. The posterior side of the shell is slightly elongated. The exterior of the shell, and in many specimens the interior, covered with *Ostrea congesta*."

Stanton[69] has made *H. grandis*, *H. capax* and *H. eccentricca* synonymous with *Inoceramus deformis*. The test of *I. deformis* is much thinner than that of *H. grandis*; the shell is more convex; the ridges more acute; the marginal border narrower; the side more triangular. So, after a careful examination of many specimens, including both adult and young, I decided to return to Conrad's classification. I am inclined to think, however, that *Haploscapha* is better as a subgenus under *Inoceramus*. Should such a classification as I have suggested be made, then *I. deformis* would properly belong to that subgenus, as it corresponds more nearly to the form of *Haploscapha* in general characteristics.

I. deformis occurs near the upper surface of the Fort Hays limestone, but I have never found it in a higher horizon. The different forms of *Haploscapha* occur in the lowermost Ornithostoma beds, and are abundant in this horizon throughout the Niobrara area. They are especially abundant a few miles south of Castle Rock, in Trego county; on the Saline river a few miles north of Ellis, in Ellis county, and near Marvin, in Phillips county.

***Haploscapha niobrarensis*, n. sp.** Plate CXVI, fig. 2.

Description: Shell large, subtriangular, hinge line short; test thick in both young and adult specimens, convex — convexity greater than in any of the other species. Ridges broadly rounded, passing into a smooth margin gradually. Smaller

69. Stanton, T. W., U. S. Geol. Surv. Bull. 106, 1893.

than *H. grandis* or *H. eccentrica;* margin narrower than in the latter. The internal undulations or ridges are more prominent in the young individuals.

The young of this species seem to have nearly twice the thickness of test as the young of the same size belonging to the other species. This form occurs like the other species of this genus in the lowermost Ornithostoma beds of Trego, Gove and Logan counties.

Haploscapha eccentrica Conrad. Plate XCIII.

Haploscapha eccentrica Conrad, 1875, U. S. Geol. Surv. Terr., vol. II, p. 24, pl. LXVII.

Revised description: "Shell subovate, dorsal side straight, hinge line thick, and shorter than in *H. grandis*. Concentric ridges not as well marked, and less numerous. Outer smooth margin showing a well-marked sinus. Cavity more profound. Ridges passing more gradually into the margin, not ending so abruptly as in *H. grandis*. Hood, two and one-half inches in length; length of shell, nine inches; height of valve, ten inches." *H. eccentrica* was placed under the subgenus Cucullifera by Conrad, but I doubt if it has sufficient generic distinctions to warrant such a classification. There is little doubt, however, that it is a species distinct from *H. grandis*, with which it is associated in the Ornithostoma beds.

Radiolites maximus, n. sp. Plate CXV; also, CXIX, fig. 1.

Shell inversely conical; lower valve three to four feet in height; outer surface marked by parallel longitudinal ridges composed of overlapping plates. Inner surface smooth, showing striations formed by intersection of plates and prisms. Valve composed of circular plates placed one upon the other; plates composed of prisms filled with calcareous matter. Upper extremety of lower valve resembling a flange bent upward and outward.

Diameter of lower valve at top, 250 mm.; thickness of outer layer of shell, 75 mm. Prismatic layers of shell ornamented with branching ridges upon the upper surface, with a corresponding depression on the under surface.

Although sometimes found singly, they are more often found in groups. Adults often found with young attached to them by their lower valves. Type specimens are adult forms united by their entire lengths; one of the specimens having three young ones attached to it near its upper extremity by their lower valves.

Specimens of this mollusk were first observed by Doctor Williston in 1874 on the Saline river; however, nothing but small fragments were secured for the University collection until the past summer, when a few specimens of a large lower valve were obtained from Mr. M. R. Watson, of McCracken. A fragment of another specimen was collected by Doctor Williston from Niobrara outcrops on the Saline river in Ellis county. Other forms belonging to the same species have been collected by Mr. Allen, of Hays City. One of the specimens collected by Mr. Watson has *Ostrea congesta* adhering to the inner surface of the valve. All other forms which I have seen were free from adhering forms.

Radiolites are not abundant in the Kansas fields. They occur at the base of the Ornithostoma beds just above the Fort Hays limestone, and possibly in the upper surface of that formation. None have been reported except from the south-central portion of the Niobrara area in Trego, Gove and Ellis counties. Collectors in looking for these shells will find it to their advantage to follow the line of contact of the Fort Hays limestone with the Ornithostoma beds.

Parapholas sphenoideus White. Plate xcix, fig. 12.

Turnus sphenoideus White, 1876, Geol. Uinta Mts., p. 117.
Parapholas sphenoideus White, 1879, Ann. Rep. U. S. Geol. Surv. for 1877, p. 300, pl. v, ff. 1a–d; Stanton, 1893, Bull. U. S. Geol. Surv. No. 106, p. 125, pl. xxvii, ff. 1, 2.

Revised description: "Shell elongate, cuneate, inflated in front, narrowed and laterally compressed behind; beaks anterior, incurved, adjacent; dorsal margins of the valves straight and sloping from the beaks to the posterior end, capped or connected by a slender, styliform, plain accessory plate; posterior extremity small, truncated, or narrowly rounded; basal margins nearly straight, connected by a ventral accessory plate similar to the dorsal one, except that it is shorter, broadest behind, but coming to a slender point in front about midlength the shell, longitudinally divided by a linear groove; front regularly rounded both vertically and laterally; anterior gape consisting of a narrow vertical slit, which occupies the middle of a somewhat prominent projection at the antero-basal portion of the shell, which projection has the shape of a Norman shield, as seen by front view when both valves are in their natural position, and which seems to have been occupied by a much wider gape in the younger than in the adult condition of the shell; both umbonal grooves distinct, both upon the outer surface and upon that of the stony cast; anterior grooves broader and deeper than the other, but both are slender; besides the two umbonal grooves there is another somewhat broader groove or furrow, extending with a broad downward curve from the posterior side of the beak to the posterior end of the shell. This groove, like the others, is distinctly traceable upon the outer surface, but is more distinctly seen upon the stony cast. A broad, subcircular, cake-like umbonal accessory valve covers the beaks and the space between them, the valve being divided by a suture into two nearly semicircular pieces so neatly that it is hardly perceptible until the valves are slightly displaced. The margins of the principal valves between the beaks and the Norman-shield-shaped projection are narrowly but abruptly averted, which, with the beaks above and the borders of the projection below, bound a distinctly hollow space each side and below each beak. Besides the grooves before mentioned, the surface is marked by fine concentric, distinctly raised lines on each side of the shell, but they are less distinct upon the surface of the Norman-shield-shaped projection than elsewhere. Between the posterior grooves or furrow before mentioned as ending at the posterior margin of the shell and the dorsal margin, the surface is occupied by strong, irregular scales and laminæ that were successively increased as the shell increased in size. Length, thirteen mm.; greatest height, seven mm.; breadth at front, six mm."

A piece of fossil wood collected from the Niobrara beds near Hays City contains the casts of forms very similar in general character to the above-described species. The fossils occur either in the uppermost horizon of the Fort Hays limestone or in the lowermost horizon of Ornithostoma beds.

***Tusoteuthis*, gen. nov.**

Gladius moderately convex, lanceolate, corneous in texture, having greatest breadth centrally; inferior point obtuse, rounded, partly covered with a calcareous layer. Striation on the surface of the gladius running parallel with the border. Midrib at base broad and rounded. Shaft cylindrical, inclosing a hollow cone; striations in midrib run parallel with edges.

The genus seems nearest related to *Teuthopsis* (Zittel), but differs from that genus in having a lanceolate instead of a spatulate gladius, and a thicker, shorter shaft. It differs from *Phylloteuthis* Meek and Hayden, in general shape and in not being angular posteriorly as in this genus.

***Tusoteuthis longus*, n. sp. Plate cx, fig. 1.**

Endoskeletal corneous portion composed of blade and shaft; blade moderately convex, with a midrib which is broad and rounded at the base; inferior point obtuse, rounded, and partly covered with a calcareous layer; striated, with striations running parallel with the border; marginal border rounded.

Shaft cylindrical, inclosing a hollow cone; length of shaft, 120 mm.; length of form, 520 mm.; maximum breadth, 160 mm.; diameter of shaft, 25 mm.

The above genus and species are founded upon a single specimen from the Hesperornis beds of the Niobrara Cretaceous on the Smoky Hill river, collected by Mr. Martin. Its discovery was referred to by Professor Williston in his report on the Niobrara of Kansas in vol. II of the University Geological Survey. The form was found imbedded in a matrix of chalk, and had on the under side the contents of the ink sac. A part only of the shaft was obtained, and a portion of the upper part of the gladius near the central region is wanting.

Fragments of the shafts of *Tusoteuthis longus* or allied forms are abundant in the Ornithostoma beds, but complete specimens are extremely rare.

ARTHROPODA.

Stramentum.

Stramentum Logan, 1897, Kans. Univ. Quart., vi, p. 198.

Capitulum composed of eight or nine plates; plates of the peduncle narrow, with the ends turned down, presenting a thatched appearance; plates each with a groove running longitudinally. The two known species of this genus are evidently from a higher horizon than those of *Squama*, coming from the yellow chalk, the same beds which contain the toothed birds.

Stramentum haworthii Williston. Plate cxi.

Pollicipes haworthii Williston, 1896, Univ. Geol. Surv., vol. ii, p. 243, pl. xxxvi.

Stramentum haworthii Logan, 1897, Kans. Univ. Quart., vol. vi, No. 4, Oct., series A, p. 188.

Description: Capitulum small, composed of nine plates, viz.: Carina, scuta (2), terga (2), lateralia (4); height, five mm.; breadth, eight mm. Terga triangular, with the apex pointing toward the base of the capitulum; surface marked by striations, moderately indented in the type specimen; height, ten mm.; greatest breadth, four mm. Superior laterals triangular, with apex rounded; convex, overlapping scuta in the single specimen; height, nine mm.; breadth at base, thirteen mm. Scuta shorter than the superior laterals, their edges slightly rounded; moderately convex; triangular, with the apex truncated by a line parallel with the base, which is inclined at an angle of thirty degrees toward the base of the capitulum; height, ten mm.; breadth at base, two mm. Carina long, narrow, rounded; height, ten mm.; breadth at base, two mm. Peduncle composed of nine rows of plates; plates narrow, one mm. in breadth and four mm. in length, with about thirty plates in each row; plates turned downward at the end, grooved along central line. Height of specimen, twenty-seven mm.; height of capitulum, ten mm.; height of peduncle, seventeen mm. The type specimen is attached to an *Ostrea congesta* by the extremity of its peduncle. It was discovered by Professor Haworth, and placed provisionally in the genus *Pollicipes* by Professor Williston in the work cited. Its horizon is the yellow chalk from the vicinity of Gove City, in Gove county.

Stramentum tabulatum Logan.

Stramentum tabulatum Logan, 1897, Kans. Univ. Quart., vol. vi, No. 4, Oct., series A, p. 189.

Description: Capitulum composed of eight plates, viz.: Terga (2), scuta (2), lateralia (4); height, five mm.; breadth, seven mm. The plates are flat and marked by lines, and the whole capitulum is short and pointed. Terga triangular, the longest side of the triangle adjoining the carino-lateral, the shortest side adjacent the superior lateral; breadth at base, two mm.; height, five mm. Scuta small, but one-half the size of the terga; triangular, almost equilateral. Carino-lateral long, moderately narrow, triangular, the most acute angle at the apex; height and breadth about the same as those of the terga. Superior laterals small, in the form of an isosceles triangle, and of about the same size of the scuta. Peduncle short, rounded, composed of six, or possibly seven, rows of plates, with about sixteen plates in each row; plates less than one mm. in width, their length more than two mm.; turned downward at the ends and overlapping in rows.

Type specimen was collected by Mr. H. T. Martin from the Upper Niobrara chalk of the Smoky Hill river.

Squama.

Squama Logan, 1897, Kans. Univ. Quart., vi, 187.

Description: Capitulum composed of from nine to twelve plates of medium size and subtriangular; peduncle short, composed of seven rows of plates, tapering gradually to near the extremity, and ending in a rapidly, almost abruptly, diminishing reflex area of smaller plates; form adhering to *Inoceramus* by its entire length.

Squama spissa **Logan. Plate cx, fig. 3.**

Squama spissa Logan, 1897, Kans. Univ. Quart., vol. vi, No. 4, Oct., series A, p. 187.

Description: Capitulum composed of twelve plates, viz.: Carina, terga (2), scuta (2), rostrum, subrostrum, subcarina, superior laterals (2), and carino-laterals (2). Height of capitulum from base to tip, nineteen mm.; width (lateral) from carina to subrostrum, seventeem mm. Carina long, narrow, somewhat shield-shaped, and slightly convex; length, five mm.; maximum breadth, two mm., overlapping lateral in specimen. Terga triangular, with apex pointing toward base of capitulum, and base somewhat rounded; very slightly convex, smooth; length, ten mm.; breadth (maximum), fifteen mm., joined closely with laterals in one specimen. Scuta large, convex, in general shape triangular; superior border almost straight; rostral border convex, base smooth, slightly concave; length, ten mm.; maximum breadth, seven mm., adhering closely to superior lateral and overlapped by rostrum. Rostrum club-shaped, slightly convex; length, six mm.; breadth, two mm. Subrostrum with the same characteristics as rostrum, except that it is smaller. Carino-laterals long, triangular, with apex distal, smooth; length, ten mm.; maximum breadth, four mm. Superior laterals shorter, three mm.; otherwise much the same as carino-laterals. Peduncle short, composed of seven rows of plates; plates oblong, narrow, overlapping, short; maximum breadth, six mm.

The type specimen was collected from the base of the Ornithostoma beds by the writer, in the northern part of Jewell county. A group of these forms were found adhering to a fragment of a shell of *Inoceramus*.

Squama lata **Logan. Plate cx, fig. 4.**

Squama lata Logan, 1897, Kans. Univ. Quart., vol. vi, No. 4, Oct., series A, p. 188.

Description: Capitulum composed of ten plates, viz.: Carina, terga (2), scuta (2), subcarina, superior laterals (2), carino-laterals (2); height, eight mm.; width, sixteen mm. Carina long, narrow, rounded, slightly convex, the surface marked by parallel striæ; height, four mm.; breadth, two mm. Terga triangular, with the base rounded; slightly convex, the surface smooth; length, eight mm.; maximum breadth, four mm. Scuta large, convex, quadrangular, its superior lateral border somewhat rounded; rostral border straight, surface marked; length, eight mm.; maximum breadth, five mm. Carino-laterals long, triangular in outline, the surface marked by transverse lines; length, eight mm.; breadth, three mm. Superior laterals shorter, resembling the carino-laterals in general shape. Peduncle short; its maximum breadth, six mm.; composed of seven rows of plates; plates quadrangular, with the upper border curved; six or seven larger plates in the upper part of a row, succeeded below by about ten very much smaller ones. Type specimen adhering to the shell of an *Inoceramus* by its entire length.

The type specimen was presented by Mr. M. R. Watson, of Trego county, and had evidently come from the lowermost beds of the Upper Niobrara, probably from the Hesperornis beds.

THE FORT PIERRE FAUNA.

The Fort Pierre area of Kansas has not been productive of a very great number or diversity of invertebrate forms. Fossils were collected in an early day from a Fort Pierre outcrop on Butte creek, by Prof. B. F. Mudge, and, later on, some specimens were collected from the same locality by Prof. S. W. Williston. Fort Pierre fossils were collected also by Judge West, Professor Williston and Mr. Cooper from the Fort Pierre shales on the North Fork of the Smoky Hill river, near McAllaster, in Wallace county. But no very extensive outcrops of the Fort Pierre formation occur in Kansas except in Cheyenne county, and these outcrops were thought to be barren until recently. In the summer of 1895 I collected a few fossils from the Cherry creek and Arickaree outcrops, in the northern part of Cheyenne county. These fossils were determined through the kindness of Mr. T. W. Stanton, of the United States Geological Survey. In the summer following, in company with Prof. H. J. Harnley, of McPherson, I again visited the Arickaree outcrops, and an outcrop in Rawlins county, a few miles north of Atwood, and secured additional forms.

The form which occurs most abundantly in the Fort Pierre of Kansas is *Baculites ovatus;* but it is not the most characteristic one, as it is also found in the Fox Hills formation. *Lucina occidentalis,* one of its characteristic forms, is abundant in one Arickaree horizon. Both of these fossils occur free in the shales, as do a few other forms, but many of the Fort Pierre fossils are imbedded in argillaceous nodules, which are scattered throughout the shale beds.

All told, the Fort Pierre formation in Kansas has furnished fifteen species, none of which are new to science. It is more than probable that a careful examination of the outcrops in the localities above mentioned will reveal many of the hundred or more species which have been described from this formation in other states. The following species have already been described from the Fort Pierre:

Hemiaster humphreysiana,
Ostrea patina,
O. inornata,
Gryphea vesicularis,
Inoceramus sublævis,
I. proximus,
I. cripsii,
I. incurvus,
I. convexus,
I. sagensis,
I. altus,
I. balchii,
Pholadomya hodgei,
Trigonarca exigua,
Volsella meekii,
Yoldia ventricosa,
Nemodon sulcatinus,
Nuculana bisulcata,
N. equilateralis,
N. obsoletiatriata,
Nucula planimarginata,
N. subplana,
Nuculata subnasuta,
Pteria fibrosa,
P. linguiformis,
P. haydenii,
P. nebrascensis,
Anomia subtrigonalis,
Syncyclonema rigida,
Chlamys nebrascensis,
Gervillia subtortuosa,
Protocardia rara,
Lucina subundata,
Veniella subturnida,
Crassitella evansii,
Thetis circularis,
Eriphyla gregaria,
Callista pellucida,
Neaera moreauensis,
Corbulamella gregaria,
Corbula crassimarginata,
Callista deweyi,
Tellina cheyennensis,
Mactra gracilis,
Teredo selliformis,
Acma parva,
A. occidentalis,
Anisomyon alveolus,
A. patelliformis,
A. subovatus,
A. shumardii,
A. sexsulcatus,
A. borealis,
Haninea subcylindrica,
H. occidentalis,
Dentalium gracile,
Entalis paupercula,
Odontobasis ventricosa,
Fasciolaria cheyennensis,
F. flexicostata,
Anchura sublævis,
A. para,
A. nebrascensis,
Aporrhais biangulata,
Trachytriton vinculum,
Margarita nebrascensis,
Closteriscus tenuilineatus,
Margaritella flexisticata,
Vanikoro ambigua,
Pyrifusus intertextus,
Amauropsis puludiniformis,
Actæon attenuata,
Baculites ovatus,
B. compressus,
Ptychoceras mortonii,
Ancycloceras uncum,
Heteroceras cheyennense,
H. angulatum,
H. cochleatum,
H. mortonii,
H. tortum,
H. umbilicatum,
Placenticeras placenta,
Ammonites complexus,
Phylloceras hallii,
Scaphites nodosus, var. brevis,
S., var. quadangulatus,
S. nodosus, var. plenus,
Nautilus dekayii,
N. dekayi, var. montanensis.

Outline Classification of Fort Pierre Species.

MOLLUSCA.
- Pelecypoda.
  - Aviculidæ.
    - Avicula.
      - Avicula fibrosa.
    - Inoceramus.
      - Inoceramus cripsii.
      - Inoceramus incurvus.
      - Inoceramus sagensis.
      - Inoceramus altus.
  - Lucinidæ.
    - Lucina.
      - Lucina occidentalis.
- Gastropoda.
  - Aporrhaidæ.
    - Anchura.
      - ? Anchura sublævis.
- Cephalopoda.
  - Lytoceratidæ.
    - Baculites.
      - Baculites ovatus.
  - Stephanoceratidæ.
    - Scaphites.
      - Scaphites nodosus.
  - Turrilitidæ.
    - Heteroceras.
      - ? Heteroceras cochleatum.
      - ? Heteroceras angulatum.

Inoceramus cripsii, var. *barabina*, Morton. Plate CIX, fig. 2.

Inoceramus barabina Morton, 1854, Stn. Org. Rem. 62, pl. XVII, f. 3.
Inoceramus gibbus Tuomey, 1854, Proc. Acad. Nat. Sci. Phil., VII, 170.
Inoceramus cuneatus M. & H., 1860, ibid. 181.
Inoceramus cripsii, var. *barabina*, Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, pp. 49, 50, pl. XIII, ff. 1a, b, c; and pl. XII, f. 3.

Meek's description: "Shell transversely ovate, moderately gibbous in the anterior and umbonal region and cuneate posteriorly, very nearly or quite equivalve, rather thin; anterior margin descending from the beaks, at first almost at right angles to the hinge, after which it gradually curves obliquely backward and downward, so as to pass by a graceful sweep into the base; posterior side long, compressed and rather regularly rounded; hinge long and straight, ventral margin forming a broad semiovate curve; beaks nearly terminal or located directly over the anterior margin, rather prominent, but rising little above the hinge, equal, oblique, somewhat incurved, and nearly contiguous. Surface ornamented with moderately distinct, more or less regular concentric undulations. Length of a large, rather long specimen, three and ninety-hundredths inches; height, two and seventy-five hundredths inches; convexity of both valves, two inches."

In the summer of 1896, I collected some casts of young individuals of this species from shale thrown from a well a few miles north of Atwood, in Rawlins county. There are also some adult forms in the University collection, which were collected by West and labeled *Inoceramus cuneatus*, following Meek and Hayden's classification. (See reference above.) The specimens collected by West were from the Fort Pierre shales near Wallace, on the Nork Fork of the Smoky Hill river.

Inoceramus incurvus M. & H.

Inoceramus incurvus M. & H., 1876, U. S. Geol. Surv. Terr., vol. IX, p. 61, pl. XII, ff. 4a, b.

Meek's description: "Shell subglobose, oval or ovate cardiform, very gibbous, nearly or quite equivalve; beaks oblique, placed a little back of the anterior side, strongly incurved; umbonal elevated above the hinge and points of the beaks and very ventricose in both valves. Surface ornamented by concentric undulations, which become sharply elevated over the most prominent portions of the umbones, but are less distinct or nearly obsolete toward the base and extremities of the shell.

"Judging from the curve of the undulations near the beaks, young individuals of this species must have been nearly ovate in form, the posterior side being broader than the other. At this stage of its growth, the shell seems to have been much less convex, and the beaks more nearly terminal; but as it advanced in age it became rapidly more ventricose and extended somewhat in front of the beaks. The surface was probably marked by lines of growth, but, owing to the exfoliation of the external fibrous layer, they are not preserved on our specimens, none of which are in a condition to give a very clear idea of its general form. The peculiar and equally incurved character of the beaks, together with the ventricose, elevated umbonal region and sharply prominent undulations, when taken together, will serve to distinguish it from any other species known from these rocks."

A rather incomplete cast of what is evidently a young individual occurring associated with *I. cripsii*, I somewhat doubtfully refer to this species. The specimen was collected from Fort Pierre shales, a few miles northwest of Atwood, in Rawlins county. Fragments of nodules containing similar casts were found in the shale thrown from a well a few miles west of this locality.

***Inoceramus sagensis*, var. *nebrascensis* Owen.** Plate CIX, fig. 2.

Inoceramus nebrascensis Owen, 1852, Rep. Minn., Iowa, and Wis., 582, pl. VIII, f. 1.

Inoceramus sagensis Owen, 1852, ibid., pl. VII, f. 3.

Inoceramus sagensis, var. *nebrascensis*, Meek, 1876, U. S. Geol. Surv. Terr., pl. XIII, ff. 2a, b.

Description: "Shell large, obliquely broad ovate or subcircular, moderately gibbous, about as high as long; anterior side short, making a very broad oblique curve from the beaks to the base; ventral and postero-ventral margins nearly regularly rounded; hinge rather short, forming an angle of about fifty degrees with the axis of the umbones; beaks moderately convex, rising little above the hinge, oblique, scarcely incurved, located about one-fifth the horizontal diameter (length) of the shell behind the anterior border. Surface ornamented by regular, distinct, concentric undulations. Length, about five and seventy-hundredths inches; height, five and sixty-hundredths inches. These measurements are taken from a medium-sized specimen."

After a comparison of specimens Meek concludes that *Inoceramus nebrascensis* Owen is but a variety of *Inoceramus sagensis* Owen. The specimen in the University collection was collected by Prof. B. F. Mudge, from the Butte creek Fort Pierre shales, and is a smaller specimen than that described by Meek.

***Inoceramus altus* Meek.** Plate CVII, fig. 1.

Inoceramus altus Meek, 1878, Hayden's Rep. Geol. Surv. Terr., 302; 1876, U. S. Geol. Surv. Terr., vol. IX, pl. XIV, ff. 1a, b.

Meek's description: "Shell attaining a medium size, vertically or a little obliquely subovate, being in the adult higher than long, and widening from the hinge downward, moderately convex, equivalve, very inequilateral; hinge very short and ranging nearly at right angles to the longer axis in the adult, but a little more oblique in young shells; anterior side straight, long, and truncated vertically, or nearly at right angles to the hinge, immediately in front of the beaks; base regularly rounded; posterior outline forming a broad, somewhat oblique, gentle curve from the posterior end of the hinge into the base;

beaks nearly or quite equal, rising little above the hinge line, pointed, obliquely incurved, and placed immediately over the anterior margin. Surface of cast showing more or less regular, rather obscure, concentric undulations, and faint tracing of radiating markings; the latter probably not being defined on the exterior. Height, about six and fifty-hundredths inches; length, about four and ninety-hundredths inches; convexity, two and seventy-hundredths inches; length of hinge, about two and forty-hundredths inches."

A specimen of this species was collected from the Fort Pierre shales, a few miles from Atwood, in Rawlins county. The species is not abundant in the Kansas area.

Lucina occidentalis Morton. Plate cvii, fig. 3.

Tellina occidentalis Morton, 1842, Journ. Acad. Nat. Sci. Phil., viii, p. 210, pl. xi, f. 3.

Mould of lucina Owen, 1852, Rep. Geol. Surv. Wis., Iowa, and Minn., tab. vii, f. 8.

Lucina occidentalis ? M. & H., 1856, Proc. Acad. Nat. Sci. Phil., viii, 272.

Lucina occidentalis Meek, 1876, U. S. Geol. Surv. Terr., vol. ix, pl. xvii, ff. 4a, b, c, d.

Meek's description: "Shell transversely broad oval, rather thick, moderately convex; anterior side broadly rounded; basal border semiovate in outline, the most prominent part being toward the front; posterior side narrower, and subtruncated at the extremity, usually having a nearly obsolete flattening, extending from the beaks above the umbonal slopes obliquely backward and downward to the posterior extremity; dorsal border nearly straight, or faintly sinuous, and declining very slightly in front of the beaks, convex, and more obliquely sloping behind; beaks depressed, small, and nearly central; lunule lanceolate, small, and shallow, or somewhat excavated. Surface ornamented by very distinct, rather regular, concentric lines; exfoliated specimens also showing obscure, radiating marks on the inner laminæ.

"Length of a large specimen, one and eighty-five hundredths inches; height, one and fifty-eight hundredths inches; convexity, ninety-three hundredths inch. The hinge of this species shows the two cardinal teeth to be rather small in the right valve, the posterior one being a little larger than the other, and faintly emarginate at the extremity. Between these two teeth there is a little larger pit, and further back a smaller one for the reception of the two cardinal teeth under the beak of the left valve. Each valve has one small, obtuse, anterior lateral tooth, situated some distance in advance of the beaks, with apparently very faint traces of a remote posterior lateral in one or both valves. The posterior muscular impression is shallow, subquadrate in form, and usually bounded in front by a faint linear ridge, extending obliquely up toward the beaks. The upper part of the anterior muscular impression has the same form, while its prolonged portion below is slender, a little arcuate, rather long, and directed obliquely downward toward the middle of the basal margin. Just above this impression of the anterior adductor, the small, oval scar of the pedal muscle is seen quite detached from it.''

In the summer of 1896 I collected a large number of this species from an outcrop of Fort Pierre shales in Cherry creek cañon, in Cheyenne county, a few miles west of Jackson's ranch. Aviculæ and Ostreæ were found associated with them. The horizon in which they occur is probably near the upper horizon of the Fort Pierre formation. They have not been found in the lower beds of the North Fork of the Smoky Hill river or on Butte creek.

? *Anchura sublævis* M. & H.

Aporrhais sublævis M. & H., 1860, Proc. Acad. Nat. Sci. Phil., XII, 178.
Aporrhais sublevata (misprint) M. & H., 1860, ibid., 428.
? *Anchura sublævis* Meek, 1864, Smiths. Check-List, N. Am. Cret. Foss., 19; Meek and Hayden, 1876, U. S. Geol. Surv. Terr., vol. IX, pl. XIX, ff. 3a, b.

Description: "Shell unequally fusiform; spire elevated; volutions seven or more, convex, and separated by a rather distinct, though not deep suture, last one convex above and abruptly contracted below, with a single, small, revolving angle, which passes, around to the suture, but is not visible on the succeeding turns of the spire; surface polished, and marked by moderately distinct arcuate lines of growth, which are crossed by rather obscure revolving lines, nearly equaling the spaces between on the spire, but more distant, with sometimes a few indistinct, irregular, very fine, parallel striæ between on the body whorl; aperture and lip unknown.

"Length, about fifty-four hundredths inch; breadth of body whorl, twenty-six hundredths inch; apical angle, slightly convex; divergence, thirty-seven degrees."

In Meek's type specimen the lip and apex are wanting; in those collected by the writer the spire is entire but the lip is wanting. The spire is much as he restored it, but consists of two more whorls than is represented in his specimen. I collected a few imperfect specimens of this species a few miles west of Jackson's ranch, in Cherry Creek cañon, in Cheyenne county. They were found associated with *Lucina occidentalis*, and probably occur near the upper limit of the Fort Pierre.

Baculites ovatus Say. Plate CIX, fig. 3.

Baculites ovatus Say, 1821, Silliman's Am. Journ. Sci., Phil., VI, 196, pl. V, ff. 5, 6; and 1830, Am. Journ. Sci. and Arts, XVIII, 248, pl. I, ff. 6, 7, 8; also 1834, Syn. Org. Rem. Cret. Group U. S., 42, pl. V, ff. 5, 6, Hall and Meek, 1854, Mem. Am. Acad. Arts and Sci., V (n. s.), 399, pl. V, ff. 1a, b, pl. VI, ff. 1–7; Meek, 1876, Geol. Surv. Terr., pl. XX, ff. 1a, b, and 2a, b, d.

Baculites baculus M. & H., 1861, Proc. Acad. Nat. Sci. Phil., XXII, 442.

Meek's description: "Shell attaining a large size, elongated, and rather gradually tapering; section ovate, the antisiphonal side being more broadly rounded than the opposite; aperture of the same form as the transverse section; extension of the lip on the siphonal side long, tapering, and narrowly rounded at the end; lateral sinuses of the same depth and about half to one-third the greater diameter of the shell; antisiphonal margin of the lip prominently rounded in outline; surface of young and medium-sized specimen generally nearly smooth, while the non-septate part of the adult shell is provided with broad, undefined, obliquely transverse ridges or undulations that are parallel to the obscure lines of growth, and become nearly or quite obsolete as they approach the siphonal side, on which they are rarely represented by very small irregular ridges, scarcely distinct from the marks of growth.

"Septa moderately closely arranged, or sometimes a little crowded; siphonal lobe nearly twice as wide as long, and provided with two large terminals widely separating more or less spreading branches, each of which has sometimes three and sometimes two nearly equal, digitate branchlets at the end, and two or three similar ones on the other side ; first lateral sinus about as wide as long, but narrower than the siphonal lobe and divided at the free end into two short, nearly equal free branches, each of which is again less deeply subdivided into about two or three or four sinuous, spreading and digitate branchlets ; first lateral lobe oblong ovate, being longer and narrower than the siphonal lobe, and deeply divided at its end into two very nearly equal branches, with each from four to five spreading and digitate subdivisions, in part so arranged as to give the main branches a tripartite appearance at their extremities ; second lateral sinus of nearly the same size as the first, and, excepting in unimportant details, similarly branched and subdivided ; second lateral lobe broader and shorter than the first, and bearing two large, equal, tripartite, sinuous and digitate terminal branches, and small digitate and simple lateral branches ; third lateral sinus much smaller than either of the others, with two unequal, short, dentate terminal divisions, and a few irregular, short, smaller spurs ; dorsal or anti-siphonal lobe (ventral lobe of d'Orbigny and others) scarcely as large as three or four small lateral branches, and normally a trifid free extremity."

No complete specimens of *Baculites ovatus* have been collected from the Kansas Fort Pierre area. In the summer of 1896 I collected several large fragments of the shell from Devil's Cañon of the South Fork of the Republican, in Cheyenne county. The longest of these fragments measured fifteen inches in length. It is the most common form in the Arickaree shales, where it occurs free. Other specimens of this species now in the University collection were obtained by Williston from the Fort Pierre formation on the North Fork of the Smoky Hill river, near McAllaster. The interior of many of these specimens is filled with beautiful crystals of barite. These latter specimens were from the large mass discovered many years previously by Prof. B. F. Mudge, and to which the letter from Meek refers, as quoted on page 20 of this volume.

Scaphites nodosus, var. *brevis* Meek. Plate CVIII, fig. 3.

Scaphites (*Ammonites?*) *nodosus* Owen, 1852, Rep. Geol. Surv. Iowa, Wis., and Minn., 580, tab. VIII, f. 4; Meek and Hayden, 1860, Proc. Acad. Nat. Sci. Phil., XII, 420; Gabb, 1861, Syn. Cret. Fauna, 32; Meek, 1864, Smiths. Check-List N. Am. Cret. Foss., 28.

Scaphites nodosus, var. *brevis* Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, pp. 426, 427, pl. XXV, ff. 1a, b, c.

Description: "Shell longitudinally oval, moderately convex; volutions generally higher than convex, inner ones forming a considerable portion of the entire bulk; deflected or body portions high, moderately; but short and only becoming a little free at the aperture, periphery rounded throughout; umbilicus small; aperture oval subquadrate, being higher than wide, and more or less sinuous on the inner side; surface ornamented by small, bifurcating costæ, that are somewhat flexuous on the sides, but becoming even and nearly straight on the periphery; each side of body portion also bearing near the periphery a row of rather prominent, subquadrangular nodes, and a few smaller ones about one-third the height from the umbilicus.

"Septa divided into rather deep lobes, and sinuous; siphonal lobe longer than wide, nearly oblong in form, and provided on each side with two principal slender branches, the two terminal of which are parallel, longer than the others, and each subdivided into two unequal, variously sinuous and subdivided branchlets; first lateral lobe narrower and shorter than the siphonal lobe, and provided with two nearly equal bifid and sharply digitate terminal branches, and on each side with one smaller, nearly simple, lateral division; second lateral lobe not more than half as long and wide as the first, but very similarly branched; third lateral sinus much smaller than the second, and divided at the end into two equal, slightly sinuate terminal branches, with some small, obtuse, lateral projections; third lateral lobe not longer than one of the terminal branches of the second, and trifid at the end, the division being very small and nearly or quite simple. Farther in there is a minute simple projection, that probably represents the minute fourth lobe in some of the other varieties."

A fragment of a specimen belonging to this species was collected from the upper Fort Pierre shales of Devil's Cañon, in Cheyenne county. It was found associated with *Baculites ovatus*, which occur free in the shales.

? *Heteroceras cochleatum* M. & H. Plate CVII, fig. 2.

Turrilites (*Helicoceras*) *cochleatus* M. & H., 1858, Proc. Acad. Nat. Sci. Phil., x, 55.

Helicoceras cochleatum Meek, 1864, Smiths. Check-List, N. Am. Cret. Foss., 25.

? *Heteroceras cochleatum* Meek, 1876, U. S. Geol. Surv., vol. IX, pp. 477, 478, 479, pl. XXII, ff. 2a, b.

Description: "Shell sinistral, very thin, and composed of rounded nearly or quite contiguous whorls, which gradually increase in size from the smaller to the larger extremity; umbilicus slightly wider than the largest whorl: surface ornamented by numerous rather regular bifurcating annular costæ, which first pass obliquely backward and outward from the umbilicus above, then curve so as to cross the ventral or outer side obliquely downward and forward; but on reaching the under side, they curve backward as they reach the umbilicus. There are also two rows of irregular obscure, flattened, or depressed oval nodes, one of which rows passes around nearly over the siphuncle, which is located near the middle of the outer side of the whorls, while the other is placed less than one-fifth the circumference of the whorl lower.

"The septa are distant, and divided into complex lobes and sinuses, which are a little unsymmetrical in their subordinate details, but of about the same size and general form on opposite sides of the siphuncle. The siphonal lobe is comparatively small, and ornamented at the extremity by four small branches, the two terminal of which are a little larger than the others, slightly dissimilar, and each provided with five or six unequal, sharp digitations; the other two branches are not exactly opposite, differ slightly in form, and are each armed with from three to five or six unequal, sharp digitations; the other two branches are not exactly opposite, differ slightly in form, and are each armed with from three to five or six unequal serrations; in advance of these principal terminal divisions, there are, along the sides of the lobe, a few very small, alternating, subordinate, lateral branchlets and sinuosities. The first lateral sinus is small, very oblique, much contracted at base, and divided at the extremity into two unequal, variously subdivided, sinuous branches. The first lateral lobe is much larger than the first siphonal one, and very deeply divided into two great, spreading subequal branches, the larger of which is on the ventral side, and unequally subdivided into three bifurcating branchlets, the two terminal of which are much larger than the others, and more or less digitate, while the other main branch has two bifurcating branchlets, with many smaller digitations and sinuosities. The second lateral sinus is not so oblique, but in other respects very similar to the first; while the second lateral lobe is smaller than the first, and very much like it in its mode of branching.

"The largest and best specimen of this species that has been found consists of a little more than half of one volution, the greatest transverse breadth of which is two and thirty-four hundredths inches; diameter at larger end (which is a little oval), seventy-three hundredths by sixty-four hundredths inch; breadth of umbilical space, eighty-five hundredths inch. In form and other external characters, even fragments of this shell will be at once distinguished from *H. mortonii* by its shorter curve and proportionally thicker whorls, which also differ in being nearly or quite in contact. Its costæ are also smaller in proportion to the diameter of the whorls, and more regular."

The determination of this species as belonging to the Fort Pierre fauna of Kansas is based upon a single fragment imbedded in a hard, nodular mass of stone. The specimen was collected from the lower Fort Pierre shales of Butte creek, and is associated with *I. altus*.

? *Heteroceras angulatum* M. & H. Plate CVIII, fig. 2.

Helicoceras angulatum M. & H., 1860, Proc. Acad. Nat. Sci. Phil., XII, p. 176.
? *Heteroceras angulatum* Meek, 1876, U. S. Geol. Surv. Terr., vol. IX, p. 485, pl. XXI, ff. 3a, b, c; 1864, Smiths. Check List N. Am. Cret. Foss., 25.

Description: "Of this shell we have a single non-septate fragment, two and seventy-eight hundredths inches in length, with a diameter of one and fifty-hundredths inches at the large end, and one and thirty-seven hundredths inches at the smaller extremity. It is rounded or subcylindrical, and makes a broad (dextral?) curved spiral, in such a manner that, if continued around, the volutions would be disconnected and encircle an umbilical cavity apparently more than three times their own breadth. The surface is ornamented by distinct angular costæ, which pass around the whorls obliquely, where they sometimes bifurcate. I have not yet seen the septa of this species, but its large size and very broad curve will distinguish it from any other known species of this type in these rocks, excepting the last (*H. cochleatum*), from which it differs in having angular instead of rounded costæ and in being coiled in the opposite direction. Its angular costæ will equally distinguish it from any of the others, even should they be found attaining as large a size, and in such short fragments as not to show the exact nature of the curve. Like the last, it is only referred provisionally to this genus upon the supposition that it belongs to the deflected part of the body of the shell."

The specimen in the University collection is a small, non-septate fragment, having a length of about fifty mm., its circumference, at the larger end, being thirty-three mm. and at the smaller end, twenty-six mm. The specimen was collected by Mr. George Cooper from Wallace county, probably from the Fort Pierre shales on the North Fork of the Smoky Hill river, near McAllaster.

EXPLANATION OF PLATES.

(Pages 519 to 583.)

PLATE LXXXVI.—*Placenticeras placenta* Dekay ?. Fig. 1, septum of inner volution, magnified; figs. 2, 3, two views of small specimen.

Serpula tenuicarinata M. & H. Fig. 4, copy of White's figure.

Modiola (*Brachydontes*) *multilinigera* Meek. Fig. 5, left valve (after White).

Avicula gastrodes Meek. Figs. 8, 9, two left valves (after Stanton).

PLATE LXXXVII.—*Inoceramus fragilis* H. & M. Fig. 1, right valve of one of Whitfield's types of *I. perplexus;* fig. 2, a large right valve (after Meek); figs. 3, 4, two views of *I. howellii* (after White); fig. 5, a large example (after Stanton).

PLATE LXXXVIII.—*Inoceramus exogyroides* M. & H. Figs. 1, 2, two views of left valve, cast (after Meek).

PLATE LXXXIX.—*Inoceramus umbonatus* M. & H. Fig. 1, dorsal view of cast of left valve (after Meek); fig. 2, anterior view (after Meek).

PLATE XC.—*Inoceramus flaccidus* White. Fig. 1, left valve (after White).

PLATE XCI.—*Ostrea lugubris* Conrad. Fig. 1, small lower valve (after Conrad); figs. 2 to 10, other views (after Stanton).

PLATE XCII.—*Inoceramus deformis* Meek. Fig. 2, anterior view of small specimen (after Stanton).

Inoceramus gilberti White. Figs. 1, 3, two views of left valve (after White).

Inoceramus labiatus Schloth. Fig. 4, small right valve (after Stanton).

Mactra emmonsi Meek. Fig. 11, cast of left valve (after Stanton).

PLATE XCIII.—*Haploscapha eccentrica* Conrad. Fig. 1, interior view of valve; fig. 2, exterior view of same (after Meek).

PLATE XCIV.—*Haploscapha grandis* Conrad. Figs. 1, 4, interior views of valve (after Meek); figs. 2, 3, views of hinge.

PLATE XCV.—*Inoceramus undabundus* M. & H. Figs. 1, 2, two views of left valve (after Meek).

Inoceramus tenuirostratus M. & H. Figs. 3, 4, two views of type specimen (after Meek).

PLATE XCVI.—*Inoceramus deformis* Meek. Fig. 1, view of small specimen (after Stanton); fig. 2, a large right valve (after Meek).

Mactra emmonsi Meek. Figs. 3, 4, two views of a large left valve.

PLATE XCVII.—*Inoceramus simpsonii* Meek. Fig. 1, right valve of type specimen.

PLATE XCVIII.—*Donax cuneata* Stanton. Fig. 1, cast of right valve.

Donax oblonga Stanton. Fig. 2, cast of a large left valve.

Exogyra columbella Meek. Figs. 3, 7, views of lower valve; fig. 8, view of both valves united (after White).

Inoceramus labiatus Schloth. Fig. 4, right valve (after Meek).

Inoceramus dimidius White. Figs. 5, 6, views of both valves.

Pholadomya papyracea M. & H. Fig. 11, left valve of type specimen (after Meek).

Pholadomya coloradoensis Stanton. Fig. 12, left valve of type specimen.

Parapholas sphenoideus White. Fig. 10, view of type specimen.

PLATE XCIX.—*Turritella whitei* Stanton. Figs. 1, 2, 3, 4, 5, views of type specimen.

? Pharella pealei Meek. Figs. 6, 7, two views of type specimen (after White).

Callista (*Aphrodina?*) *tenuis* M. & H. Figs. 8, 9, two views of type (after Meek).

Ostrea congesta Conrad. Figs. 10, 11, 13, views of upper and lower valves (after Meek).

Parapholas sphenoideus White. Fig. 12, another view.

PLATE C.—*Serpula intrica* White. Fig 1, type specimen.

Rostellites ambigua Stanton. Figs. 2, 4, 5, views of type specimen.

Pyropsis coloradoensis Stanton. Figs. 6, 7, 8, views of type.

? Helicoceras corrugatum Stanton. Fig., basal view of type.

PLATE CI.—*? Prionocylus macombi* Meek. Figs. 1, 2, side view of small specimen (after Stanton); fig. 3, septum, magnified; figs. 4, 5, two views of type (after Meek).

PLATE CII.—*Prionotropis woolgari* Mantell. Figs. 1, 2, two views of small specimen (after Meek); fig. 3, view of fragment of large specimen (after Meek); fig. 4, septum, magnified.

Prionotropis hyattii Stanton. Figs. 5, 6, two views of type; fig. 7, side view; fig. 8, septum of small specimen, magnified.

PLATE CIII.—*Mortoniceras shoshonense* Meek. Figs. 1, 2, two views of type specimen.

Prionotropis lævianus White. Fig. 3, portion of septum of type (after Stanton); fig. 4, side view of type.

PLATE CIV.—*Mortoniceras vermilionense* M. & H. Fig. 1, side view of type (after Meek).

Scaphites larvæformis M. & H. Fig. 2, side view of type (after Meek).

Scaphites vermiformis M. & H. Fig. 3, side view of type (after Meek).

Scaphites warrenii M. & H. Fig. 4, side view of type (after Meek); fig. 5, side view of specimen referred to *S. wyomingensis* (after Whitfield); fig. 6, side view of another specimen (after Whitfield); fig. 7, septum of a large specimen (after Whitfield).

Scaphites ventricosus M. & H. Fig. 8, septum, magnified (after Meek); fig. 9, side view of inner volutions (after Meek); fig. 10, side view of another specimen (after Stanton).

PLATE CV.—*Scaphites ventricosus* M. & H. Fig. 1, view of large specimen (after Meek).

Scaphites mullananus M. & H. Fig. 2, septum, magnified (after Meek); figs. 3, 4, two views of type (after Meek).

PLATE CVI.—*Prionocyclus wyomingensis* Meek. Fig. 1, septum of type (after Stanton); figs. 2, 3, 4, views of type specimen.

PLATE CVII.—*Inoceramus altus* Meek. Fig. 1, view of type.

? *Heteroceras cochleatum* M. & H. Fig. 2, view of type (after Meek).

Lucina occidentalis Morton. Fig. 3, view of specimen (after Meek).

? *Acanthoceras kanabense* Stanton. Fig. 4, side view of specimen, enlarged; fig. 5, septum, enlarged; fig. 6, view of large specimen.

Avicula gastrodes Meek. Fig. 7, large left valve (after Stanton).

PLATE CVIII.—Fig. 1, *Scaphites conradii*, side view (after Meek); fig. 2, *Heteroceras angulatum*, view of type (after Meek); fig. 3, *Scaphites nodosus*, var. *brevis*, side view (after Meek).

PLATE CIX.—Fig. 1, *Inoceramus sagensis*, var. *nebrascensis*, side view of type (after Meek); fig. 2, *Inoceramus cripsii*, var. *barabina*, side view of type (after Meek); fig. 3, *Baculites ovatus*, transverse section of shell (after Meek).

PLATE CX.—*Tusoteuthis longus*, n. sp. Fig. 1, view of type specimen.

Belemnitella baculus, n. sp. Fig. 2, view of type.

Squama spissa Logan. Fig. 3, view of type; fig. 5, view of plates.

Squama lata Logan. Fig. 4, view of type.

PLATE CXI.—*Stramentum haworthii* Williston, figure of type specimen, enlarged.

PLATE CXII.—*Uintacrinus socialis* Grinnell, portion of large slab in the University museum.

PLATE CXIII.—*Uintacrinus socialis* Grinnell.

PLATE CXIV.—*Inoceramus truncatus*, n. sp., type specimen.

PLATE CXV.—*Radiolites maximus*, n. sp., interior view of three young specimens.

PLATE CXVI—Fig. 1, *Inoceramus concentricus*, n. sp., fragments of large valve.

Fig. 2: Large figure, *Haploscapha niobrarensis*, n. sp.; left-hand lower figure, *Inoceramus platinus;* middle figure, *Serpula plana;* right figure, *Inoceramus subconvexus.*

PLATE CXVII.—*Ostrea anceps*, n. sp., interior view of type.

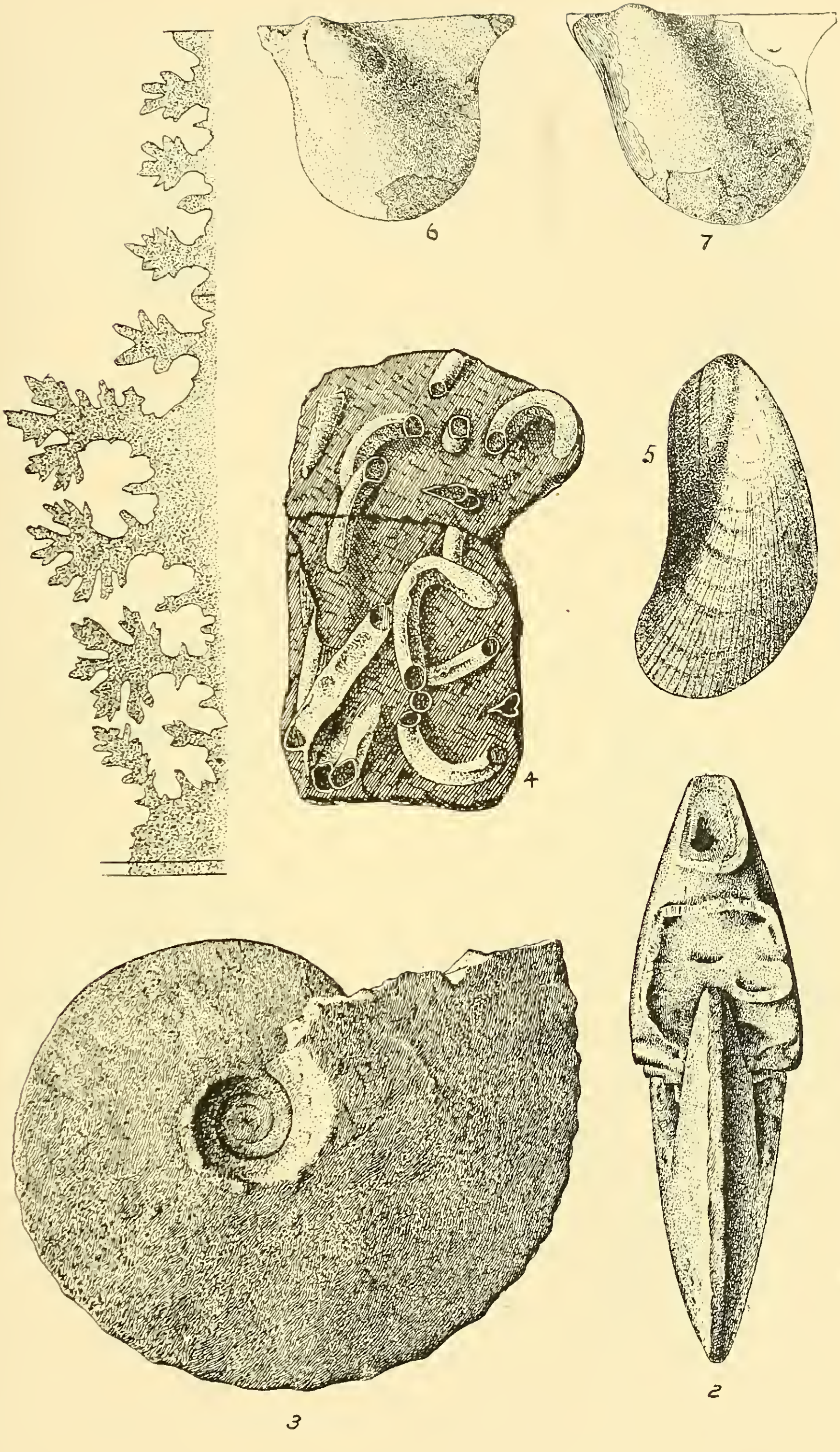
PLATE CXVIII.—Fig. 1, *Inoceramus subconvexus*, n. sp., exterior view of both valves.

Fig. 2, *Inoceramus pennatus*, n. sp., interior view of one valve.

PLATE CXIX.—Fig. 1, *Radiolites maximus*, n. sp., fragment of large specimen.

Fig. 2. *Serpula plana.*

PLATE CXX.—Fig. 1, *Inoceramus triangulatus;* fig. 2, *Inoceramus pennatus*, n. sp.; fig. 3, *Rostellites willistonii*, enlarged.



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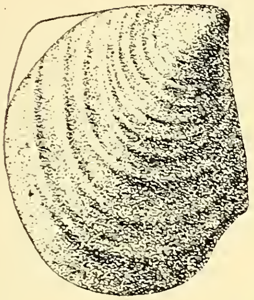

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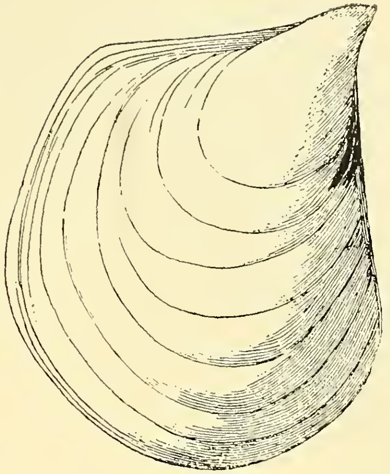

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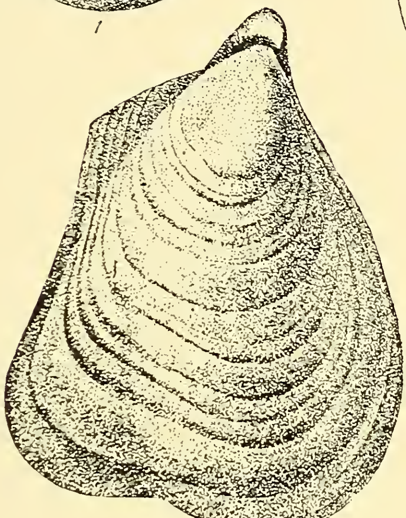

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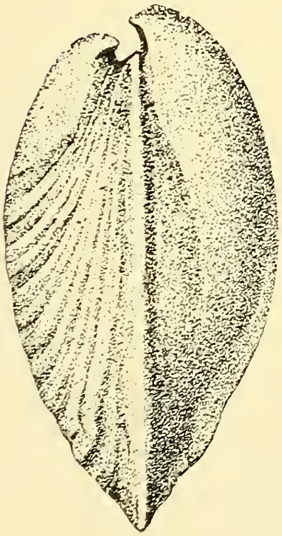

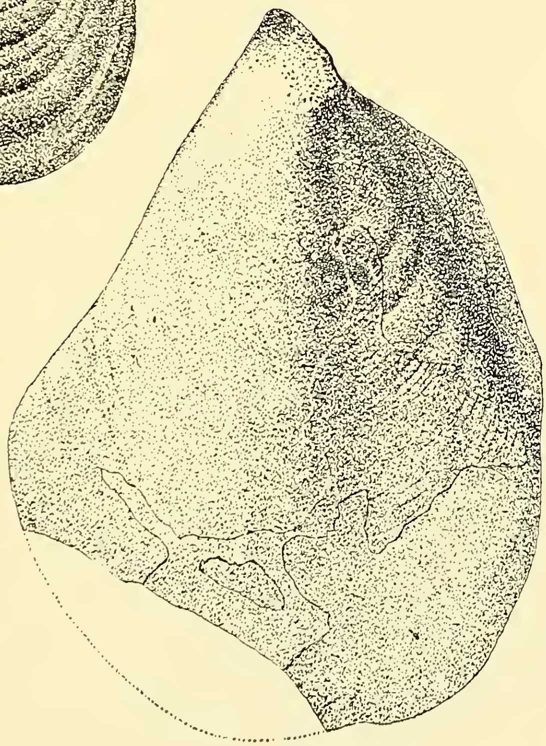

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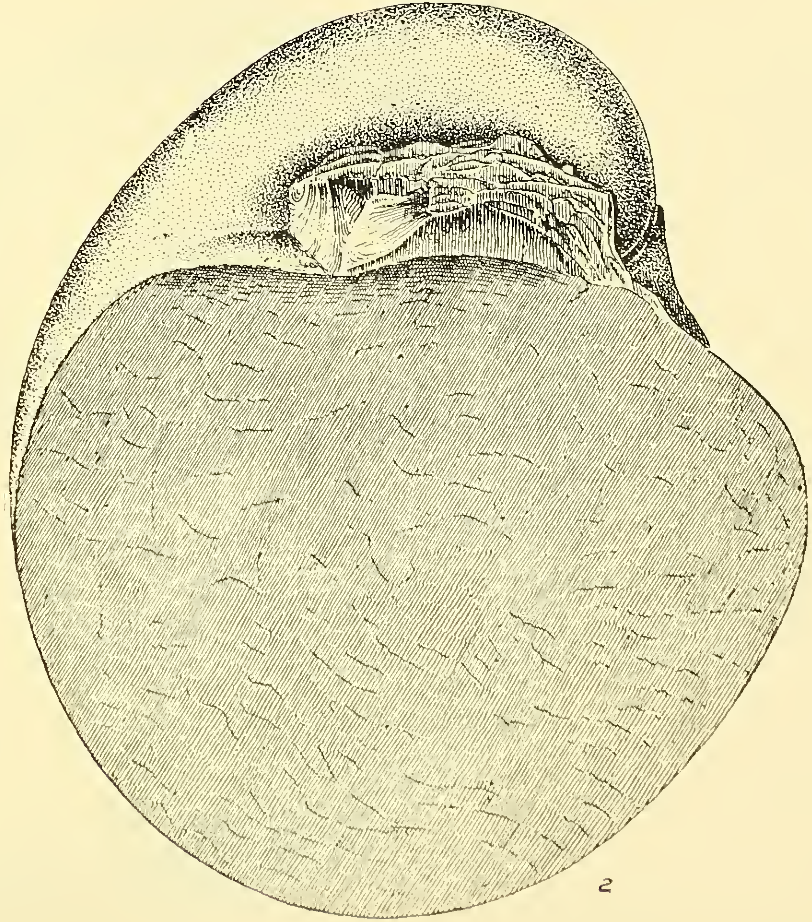

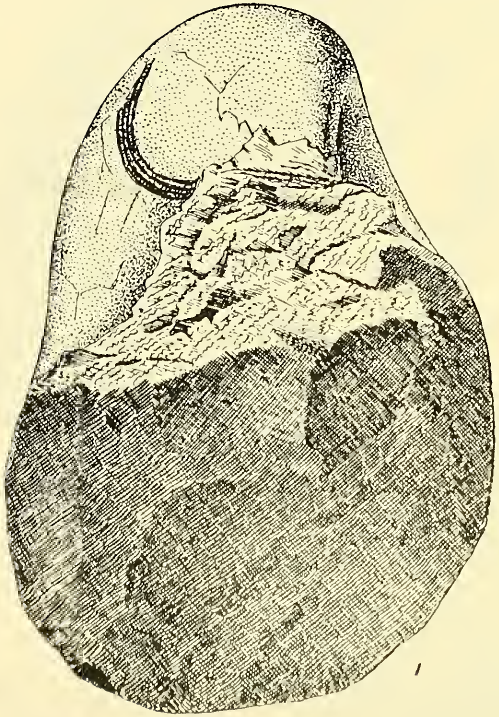

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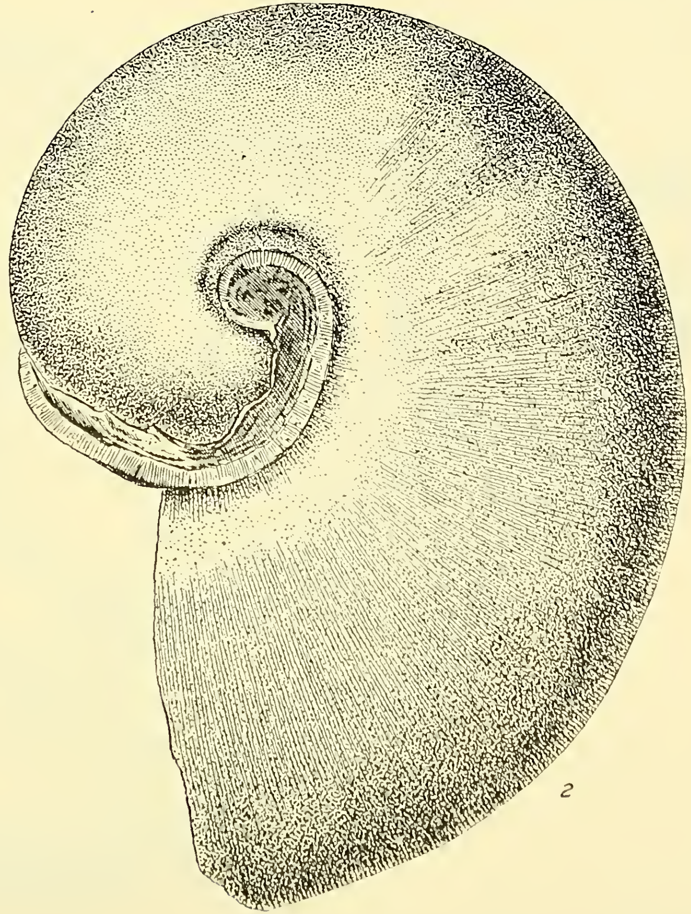

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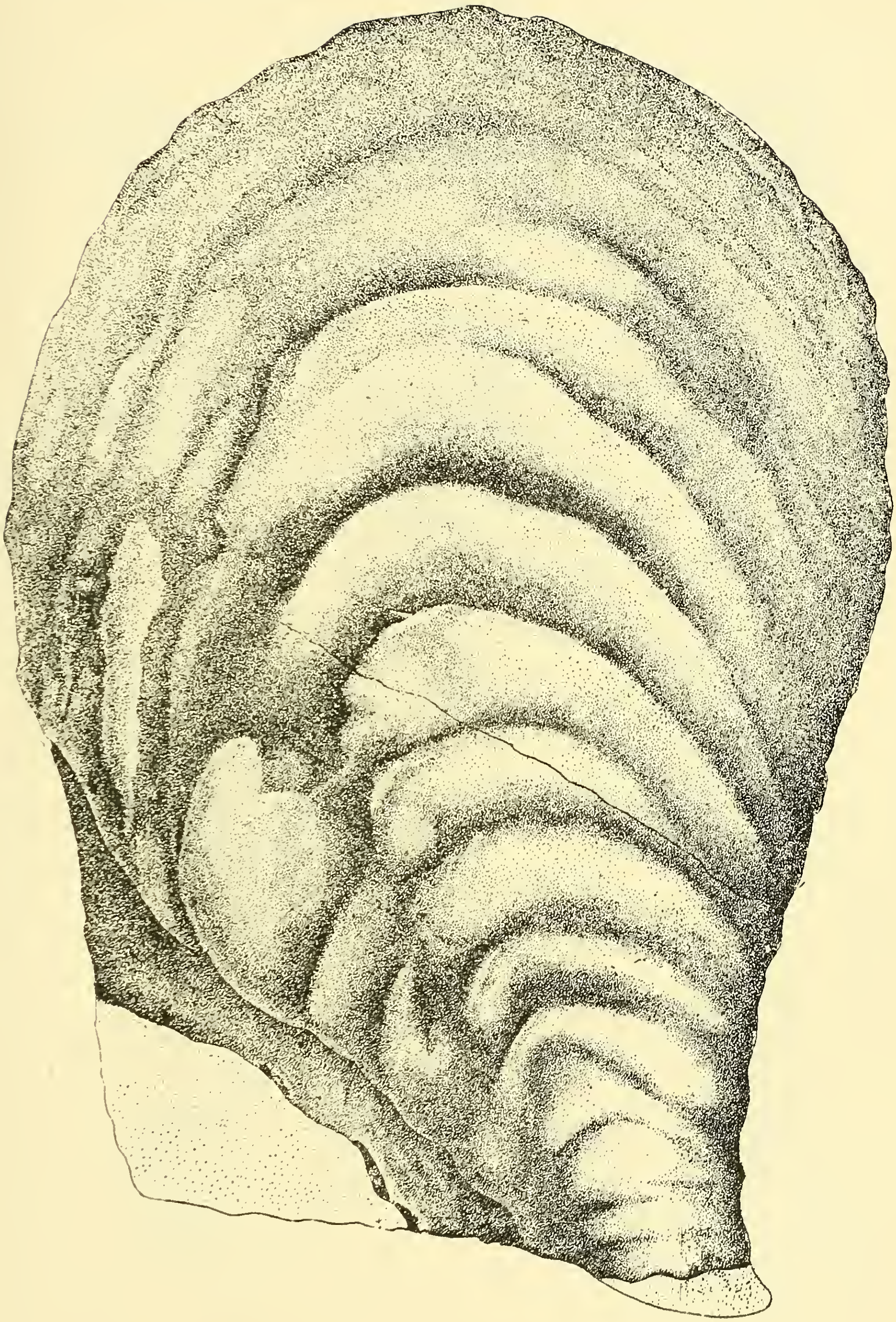

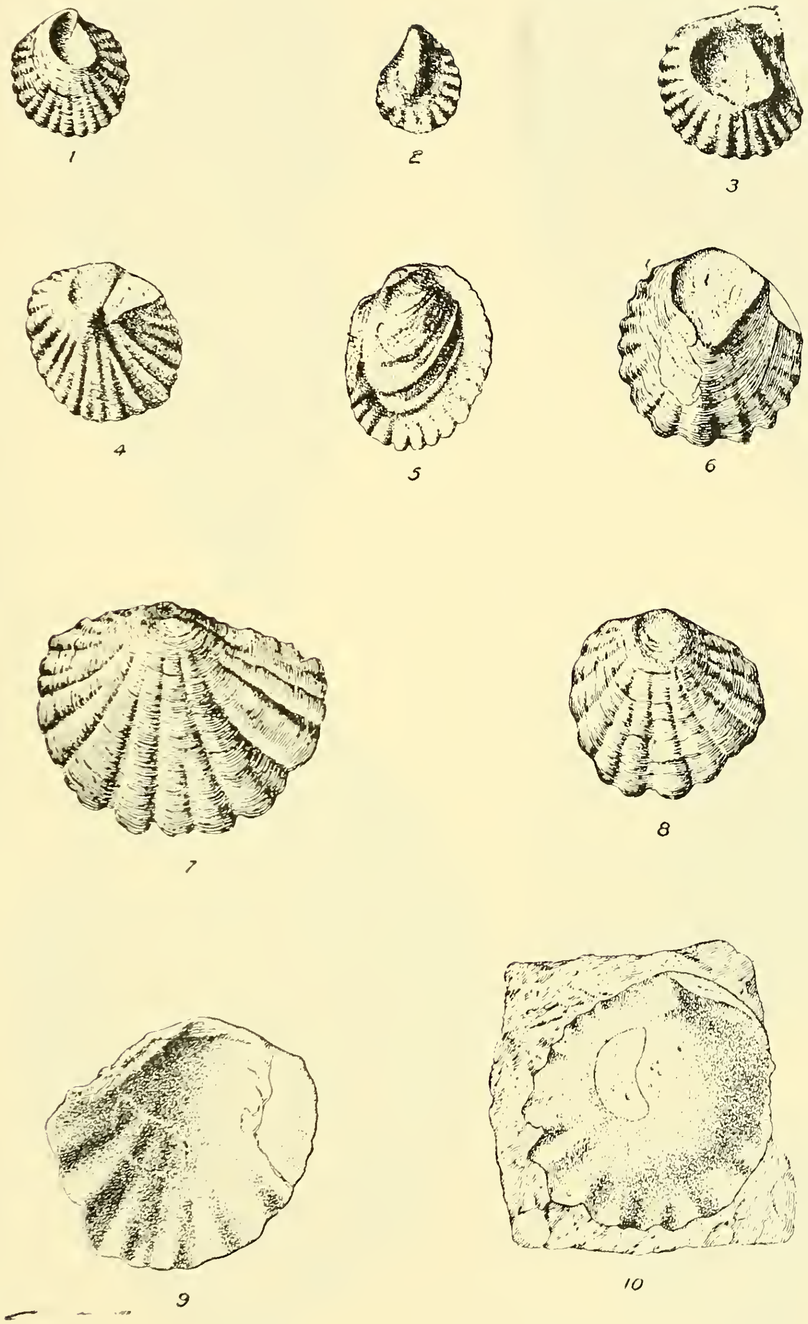
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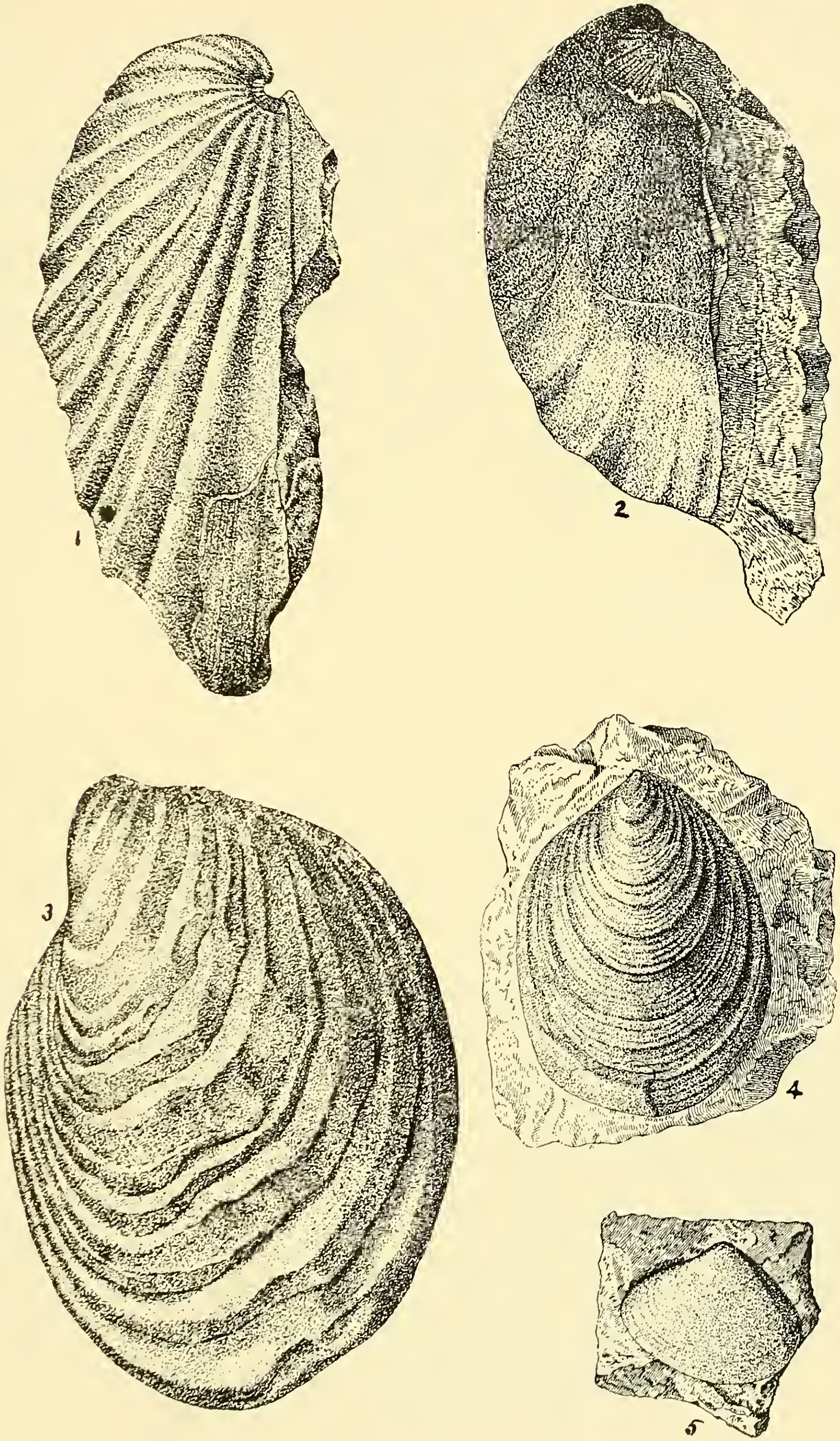
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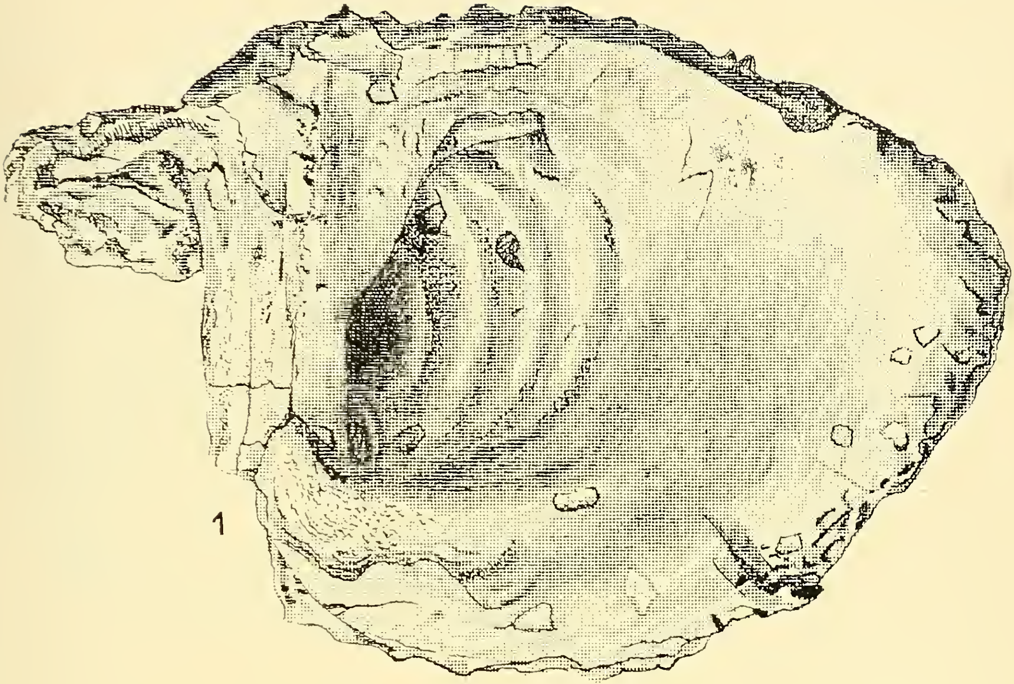
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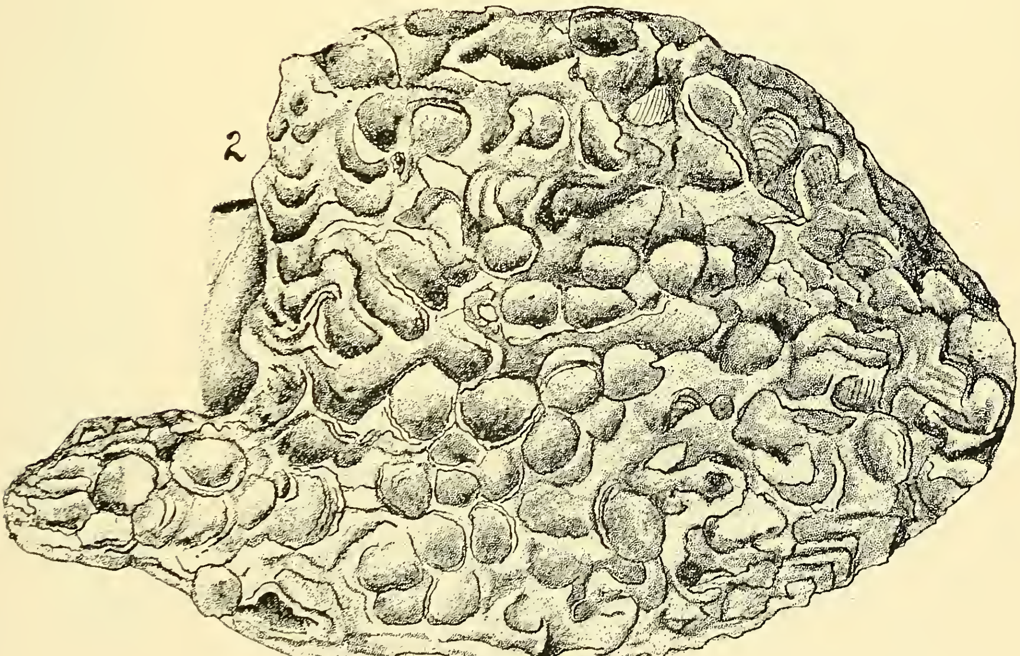
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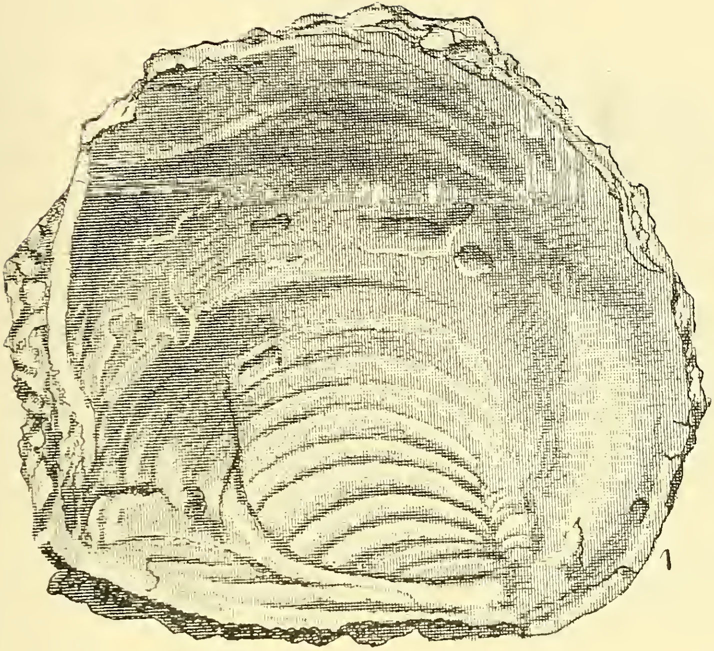

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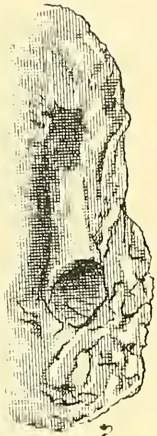

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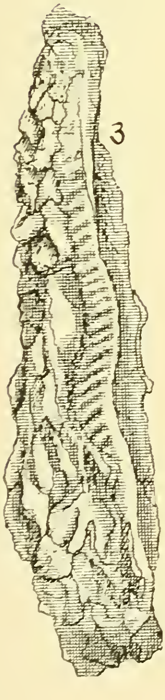

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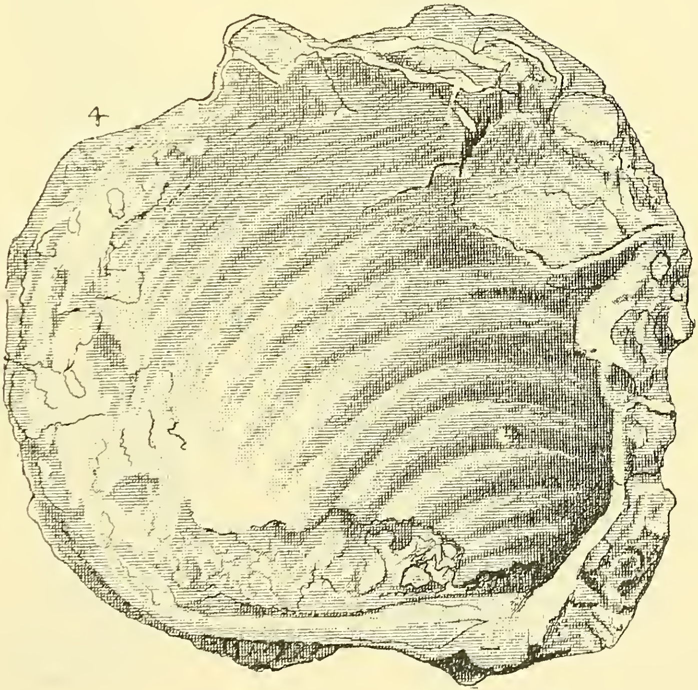

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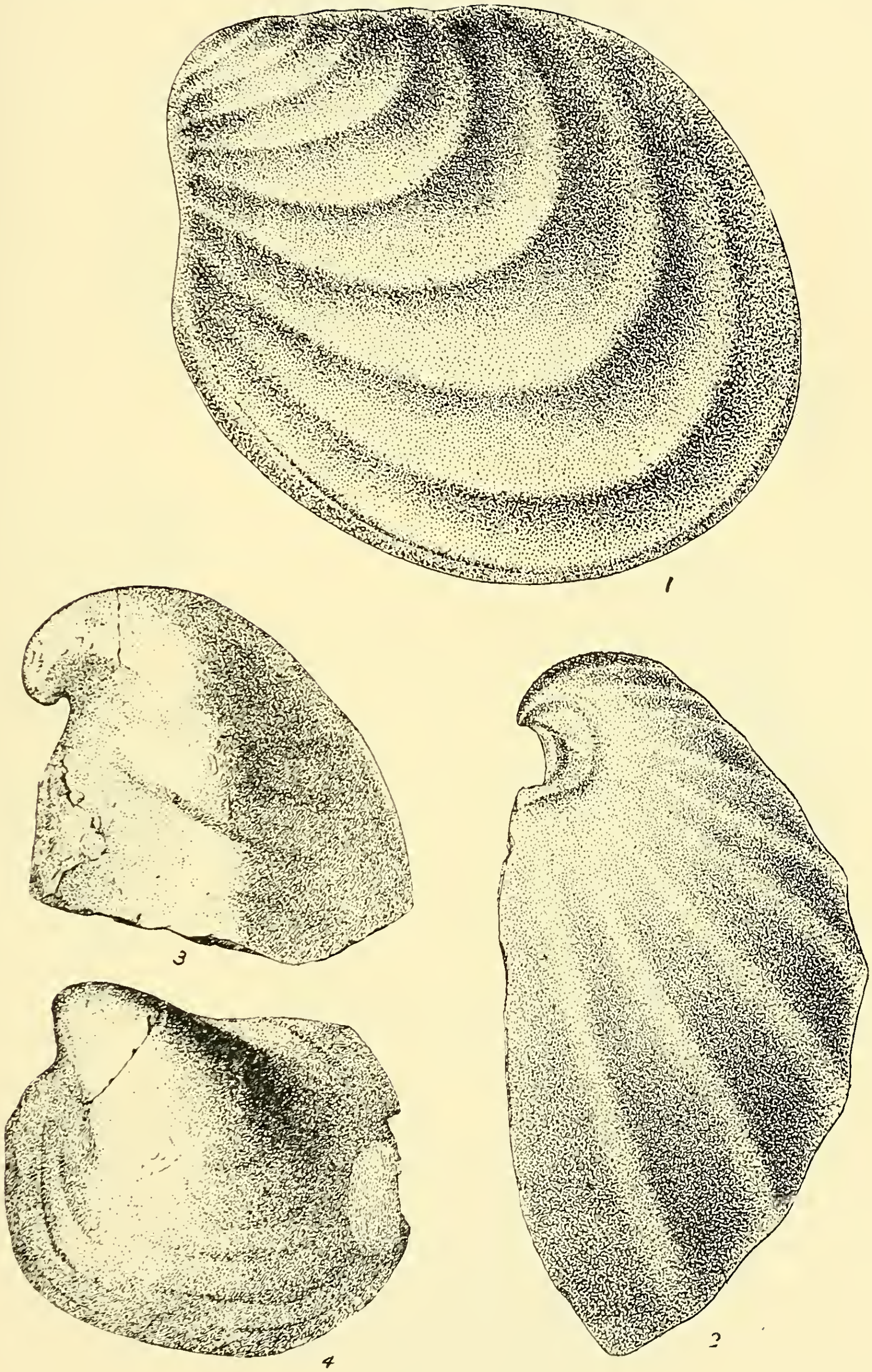
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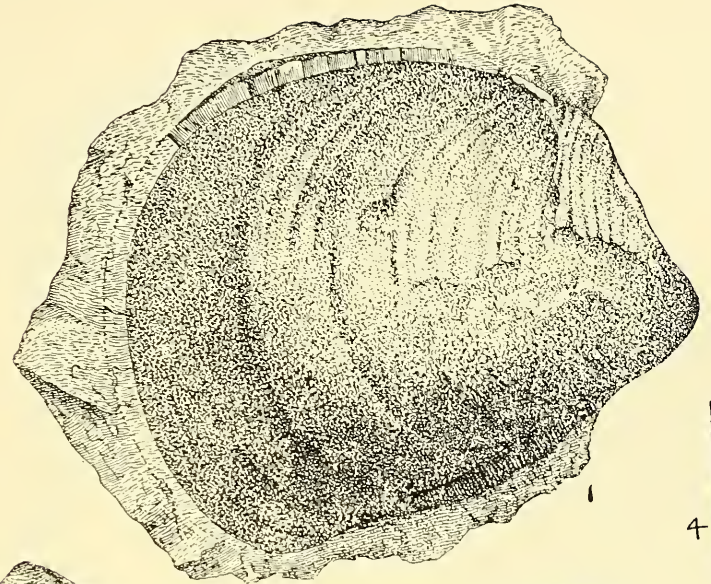

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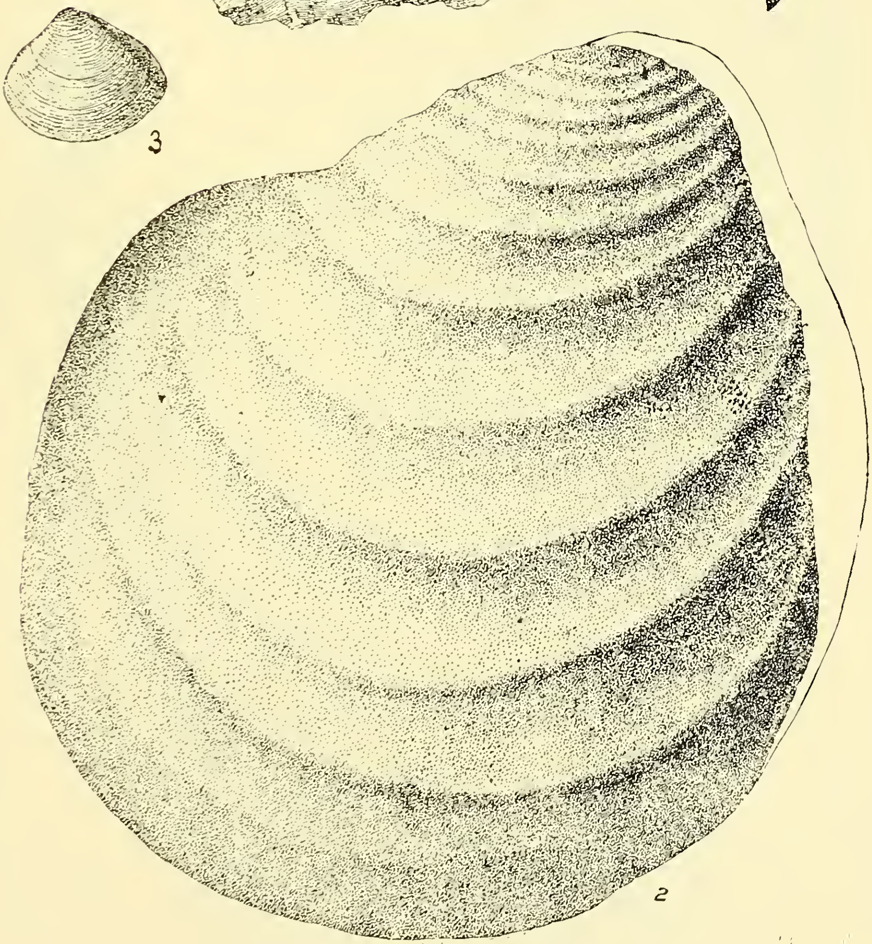

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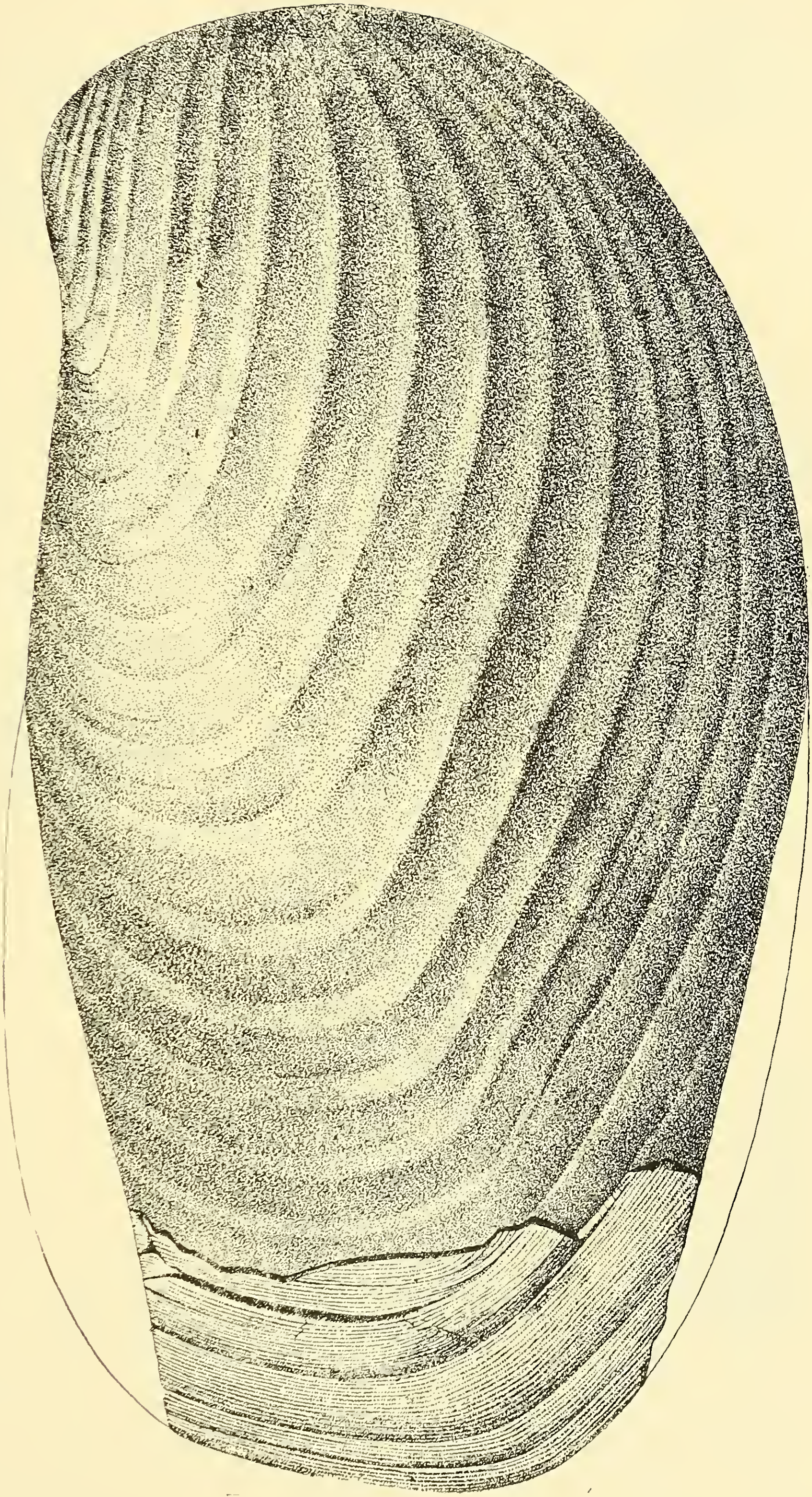

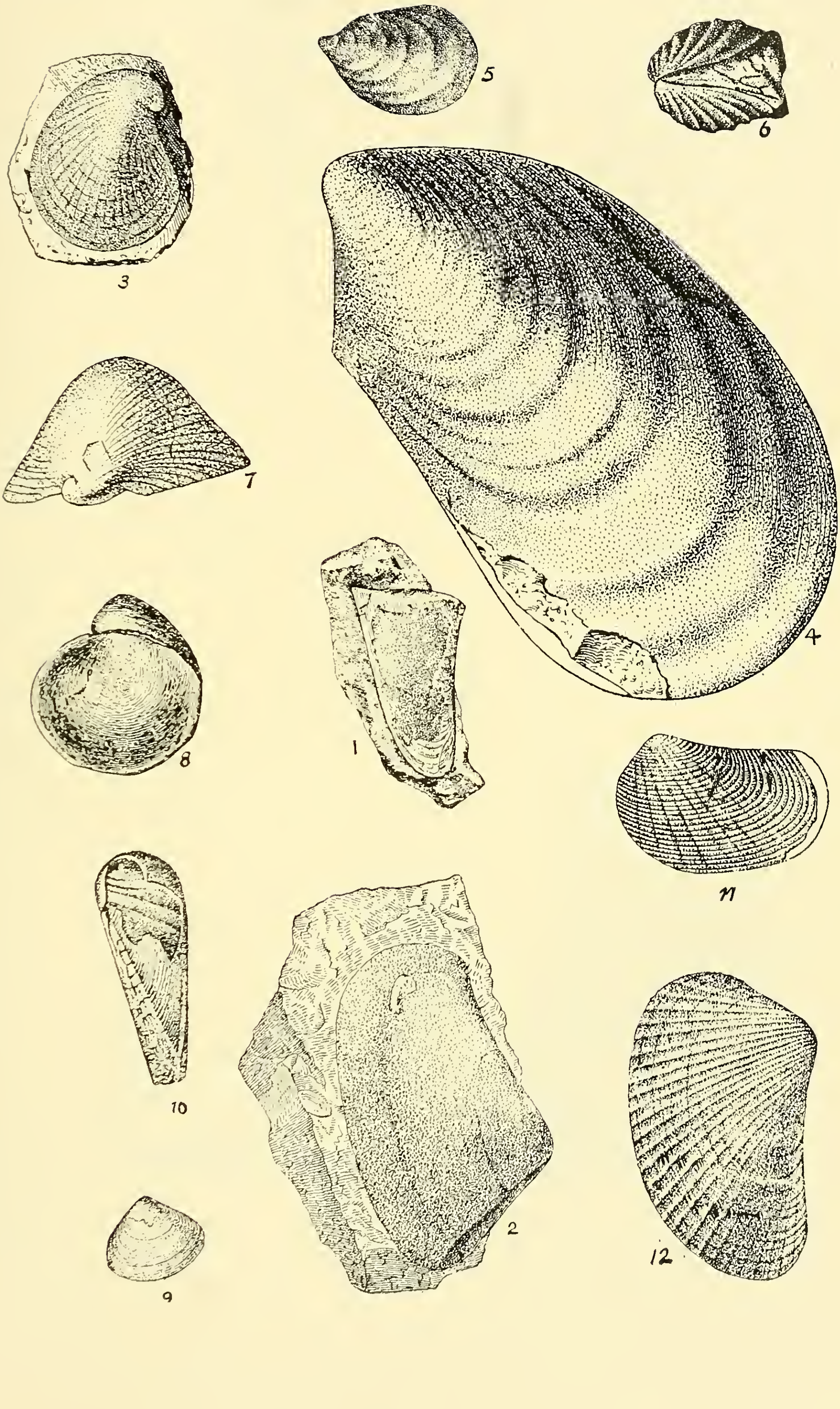
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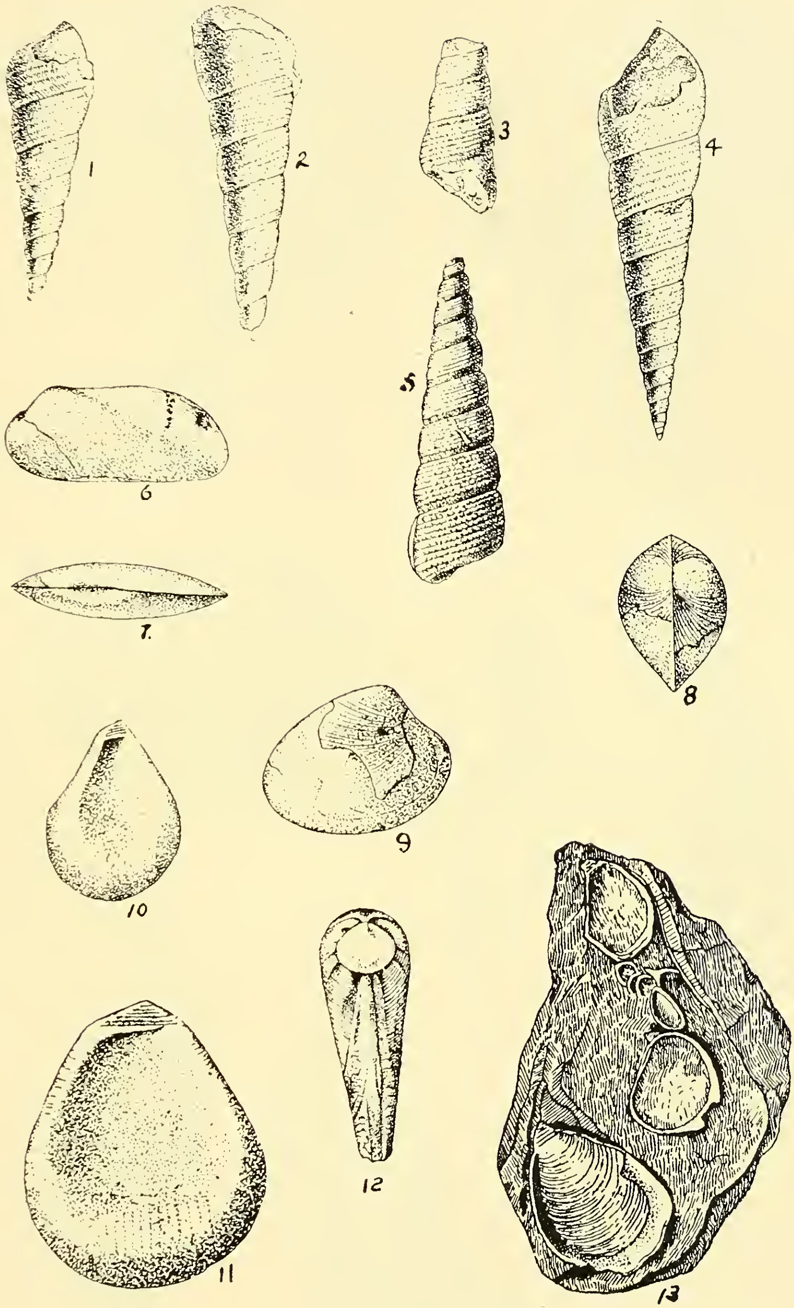
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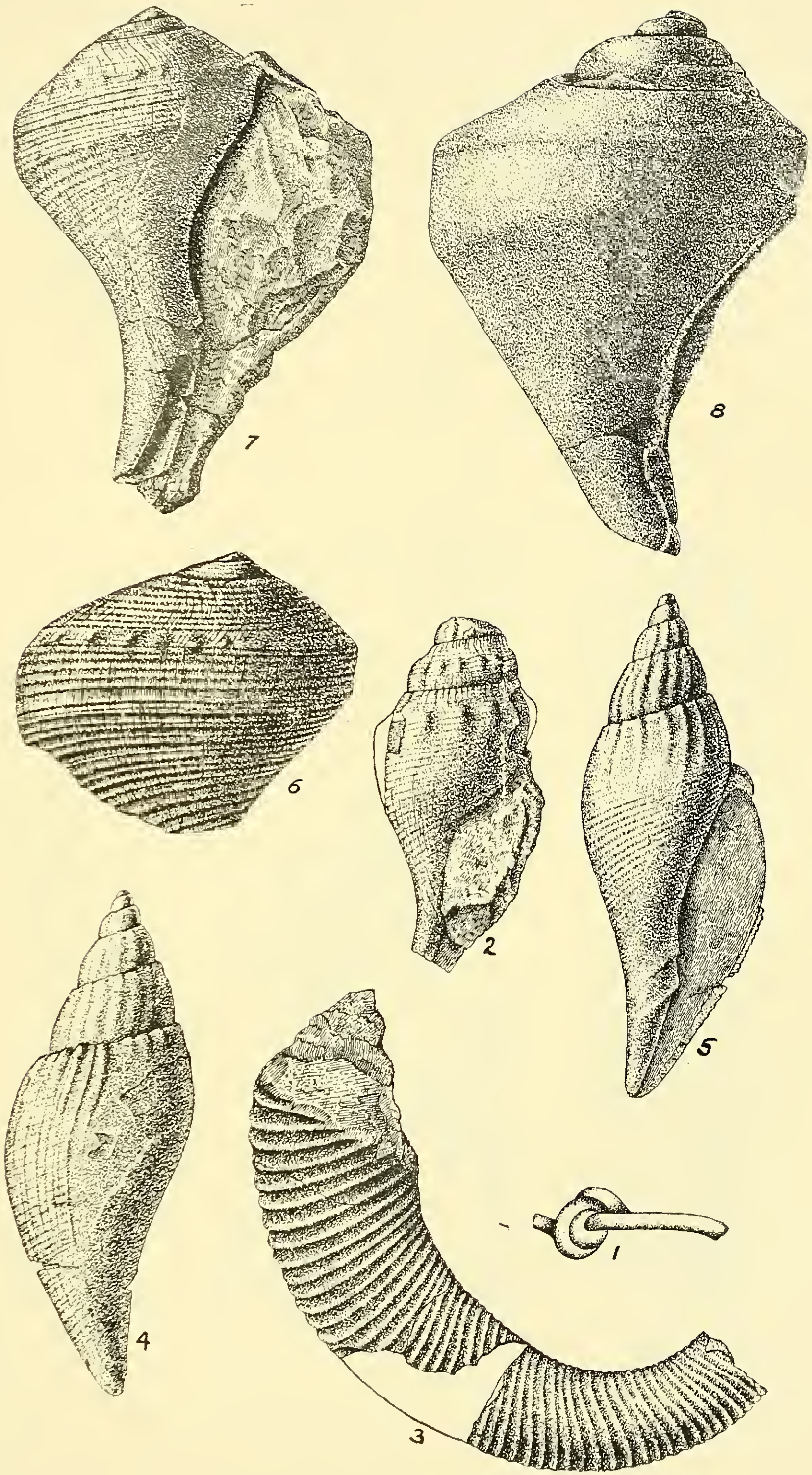
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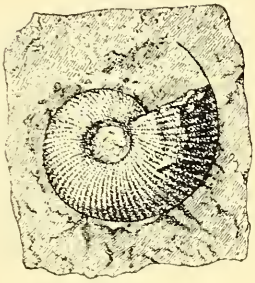

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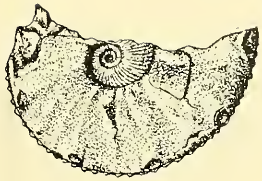

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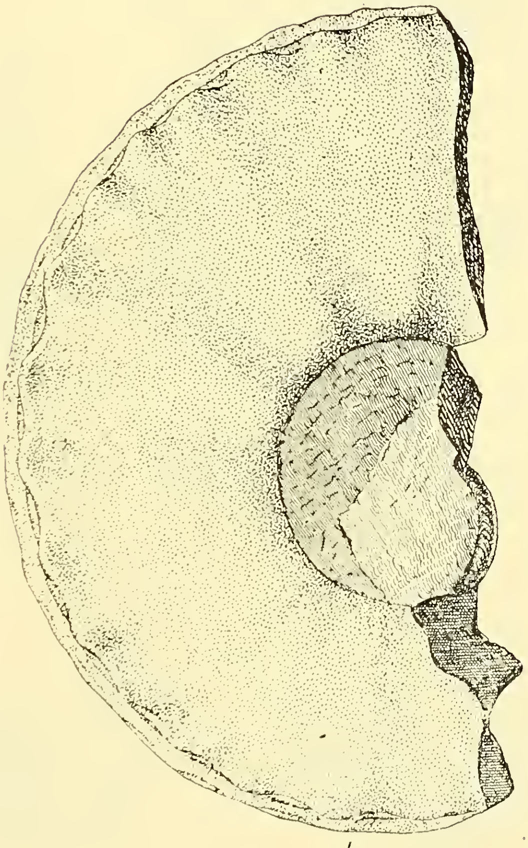

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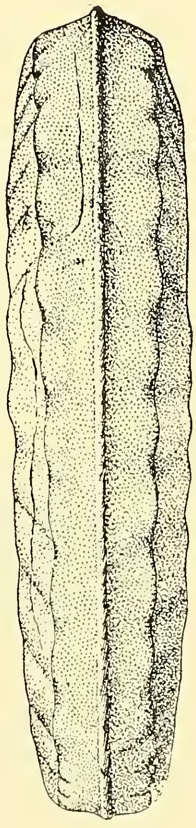

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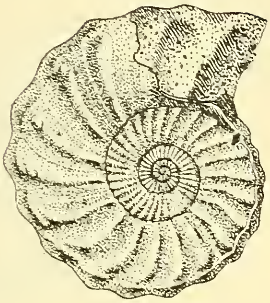

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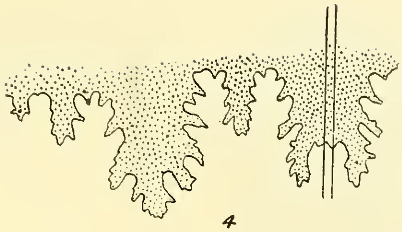

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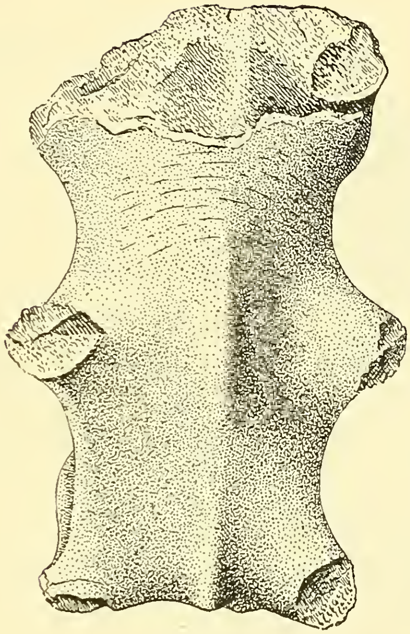

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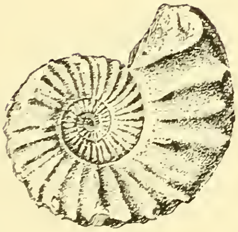

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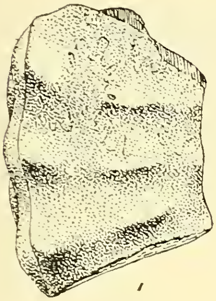

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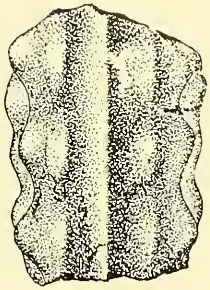

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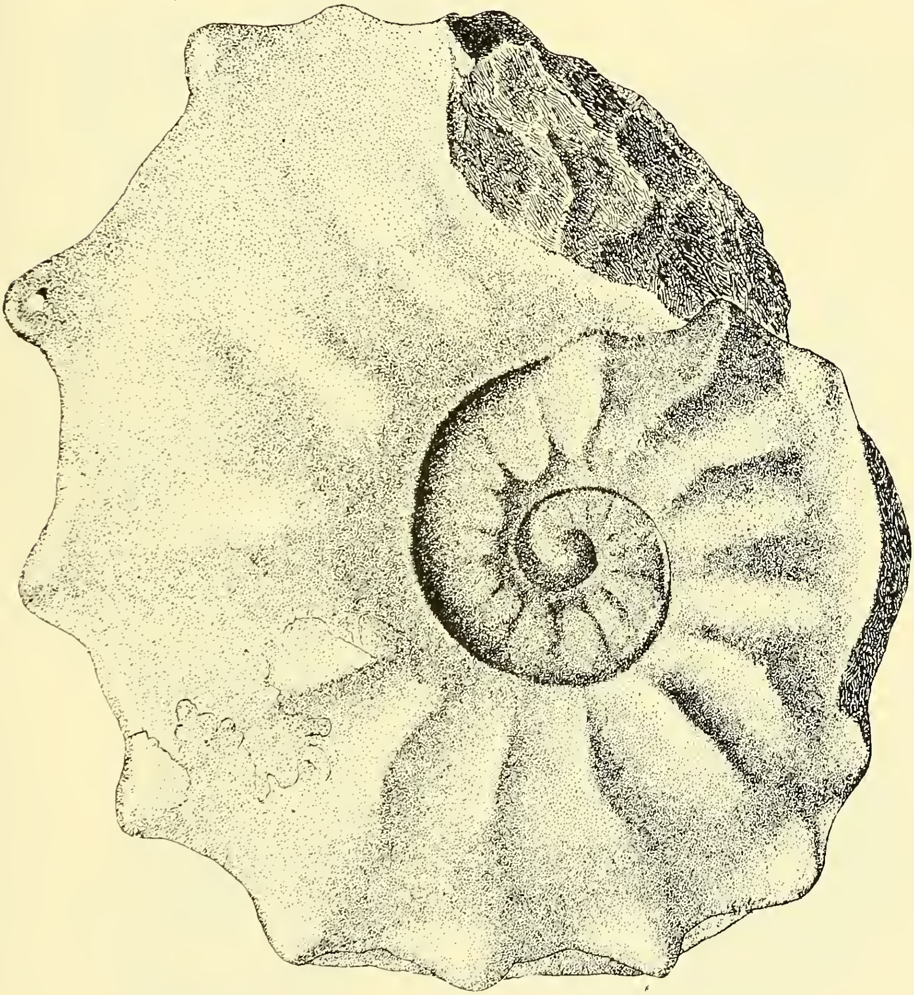

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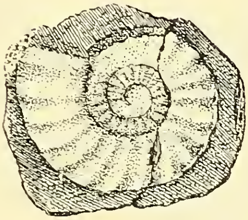

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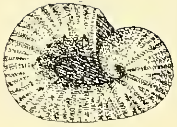

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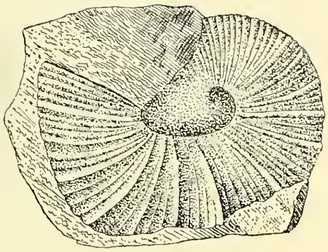

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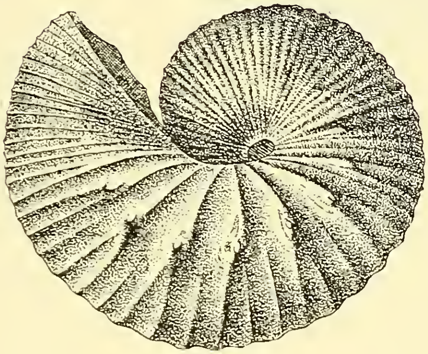

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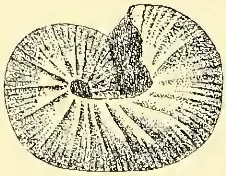

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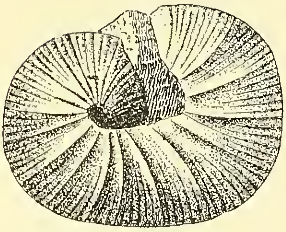

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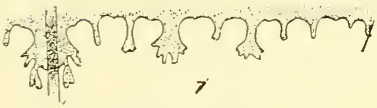

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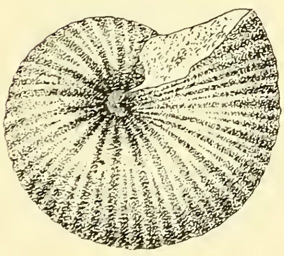

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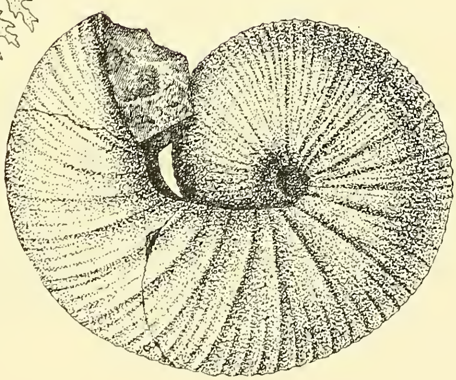

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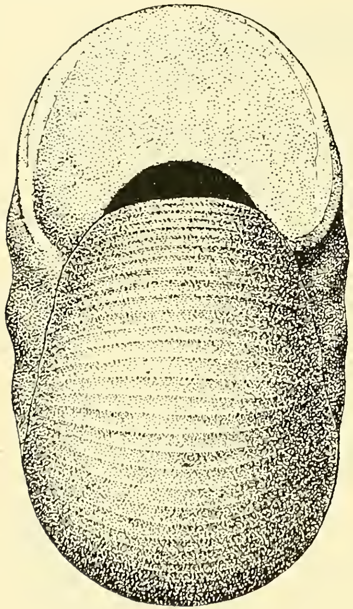

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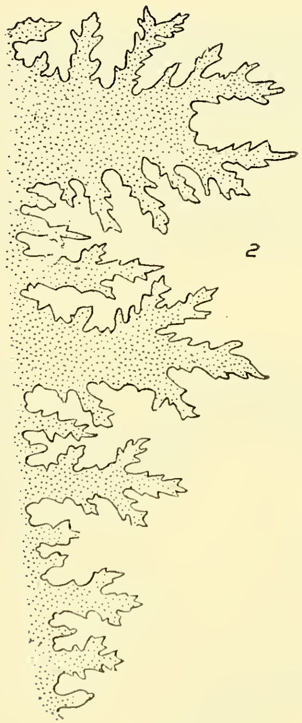

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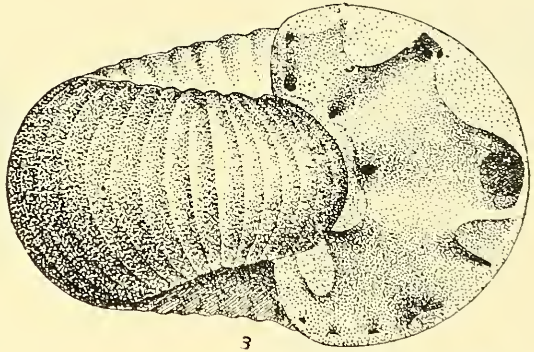

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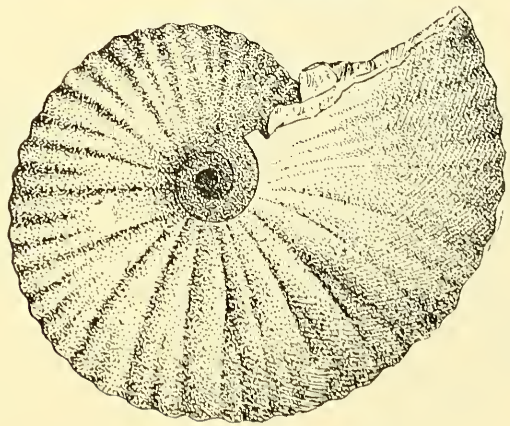

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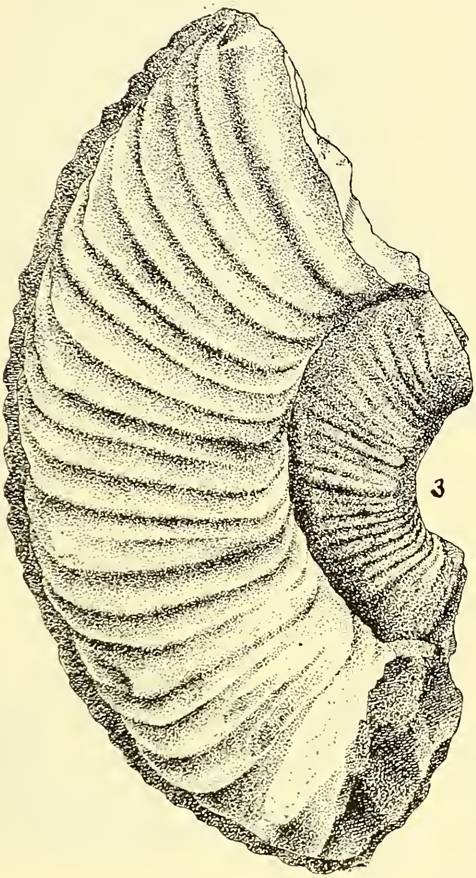

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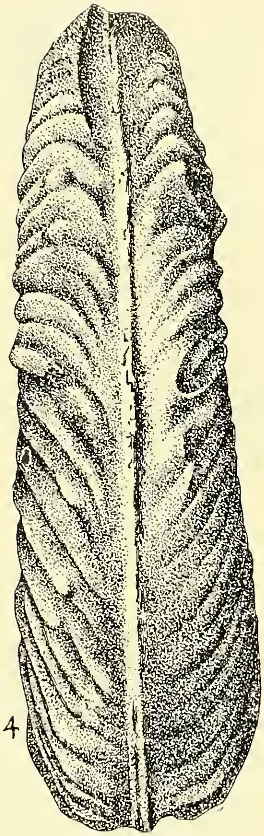

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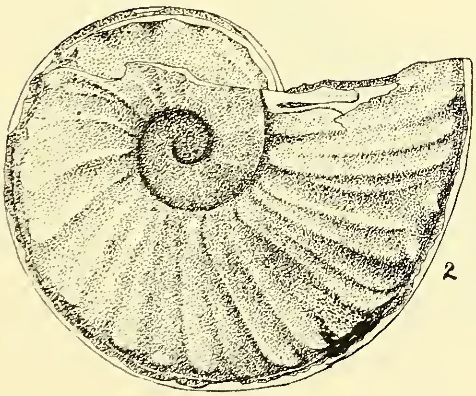

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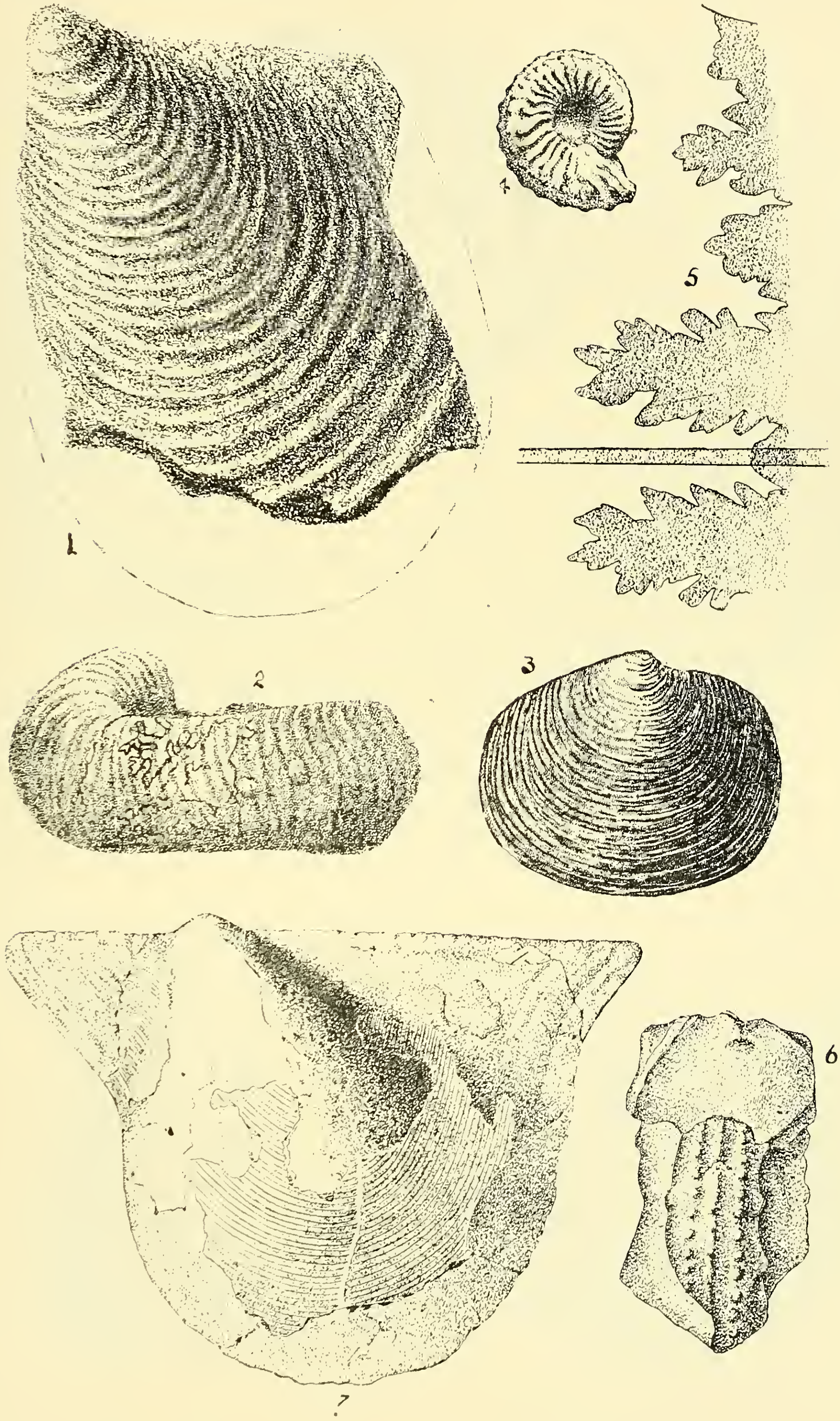
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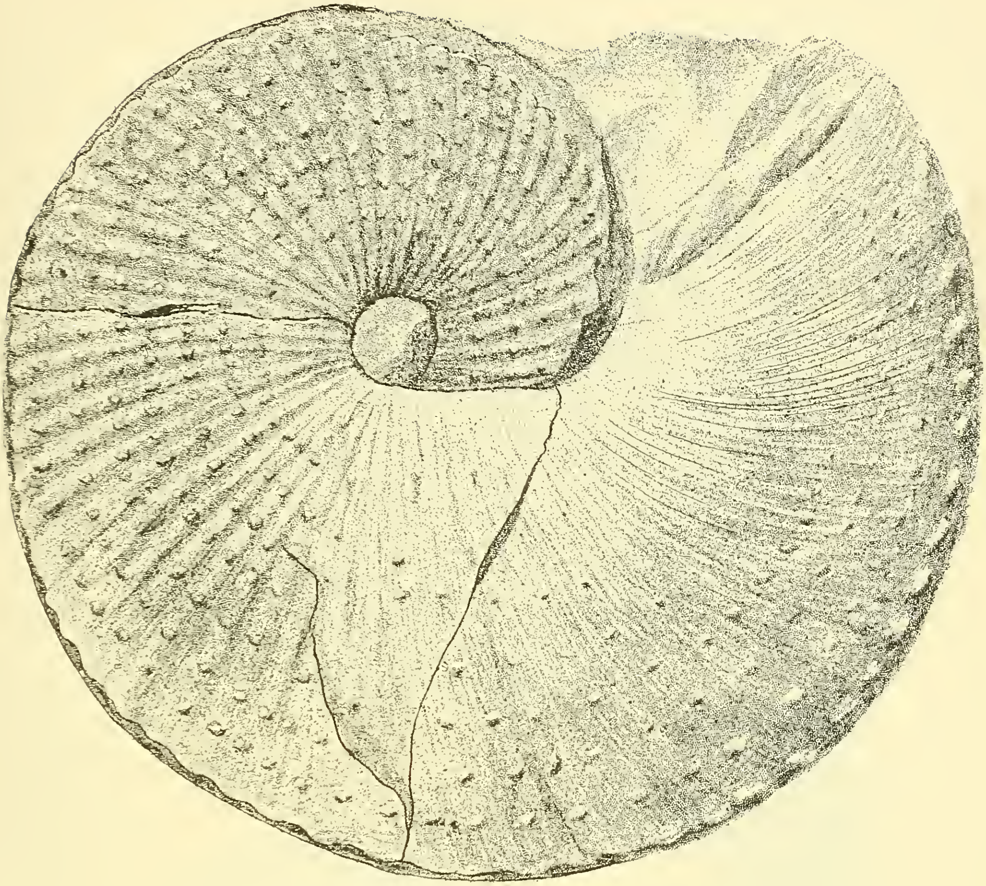

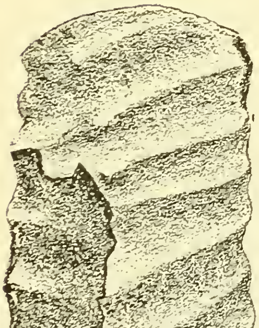

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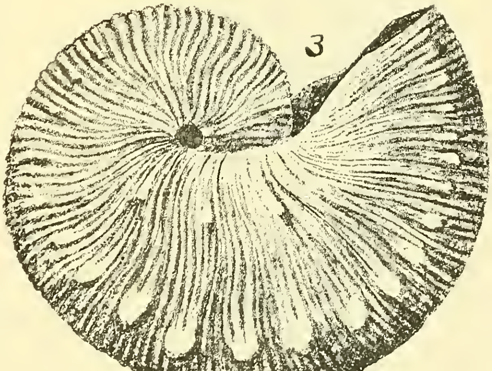

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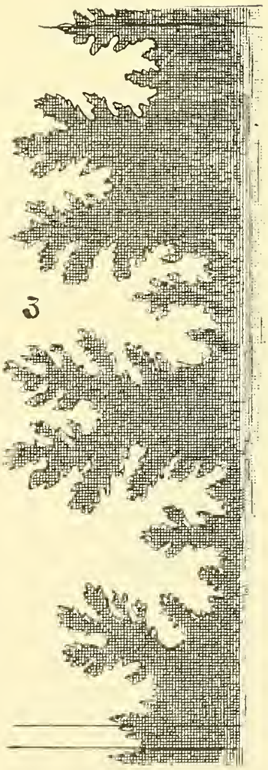

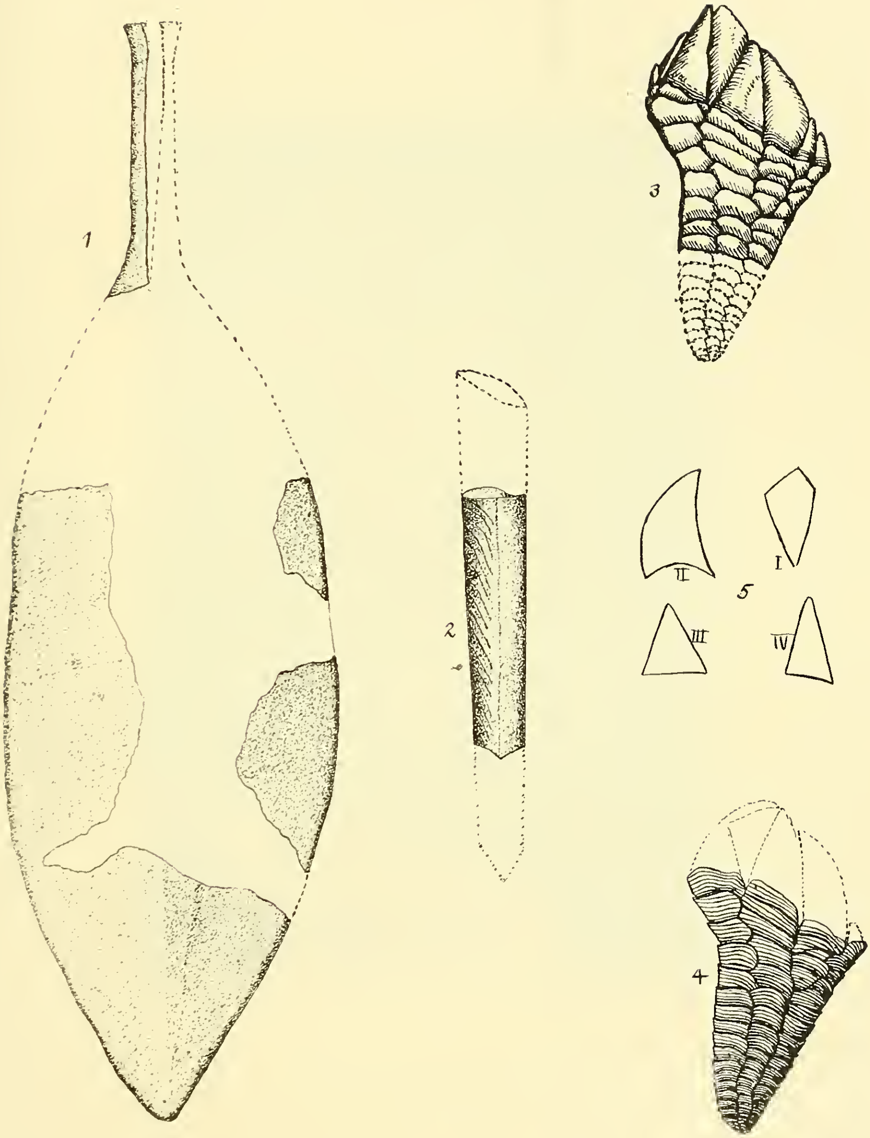
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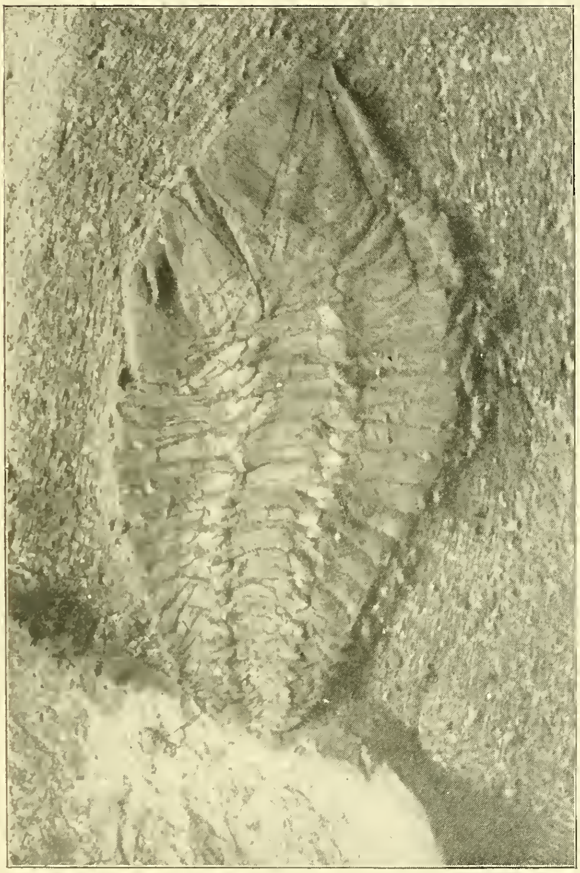

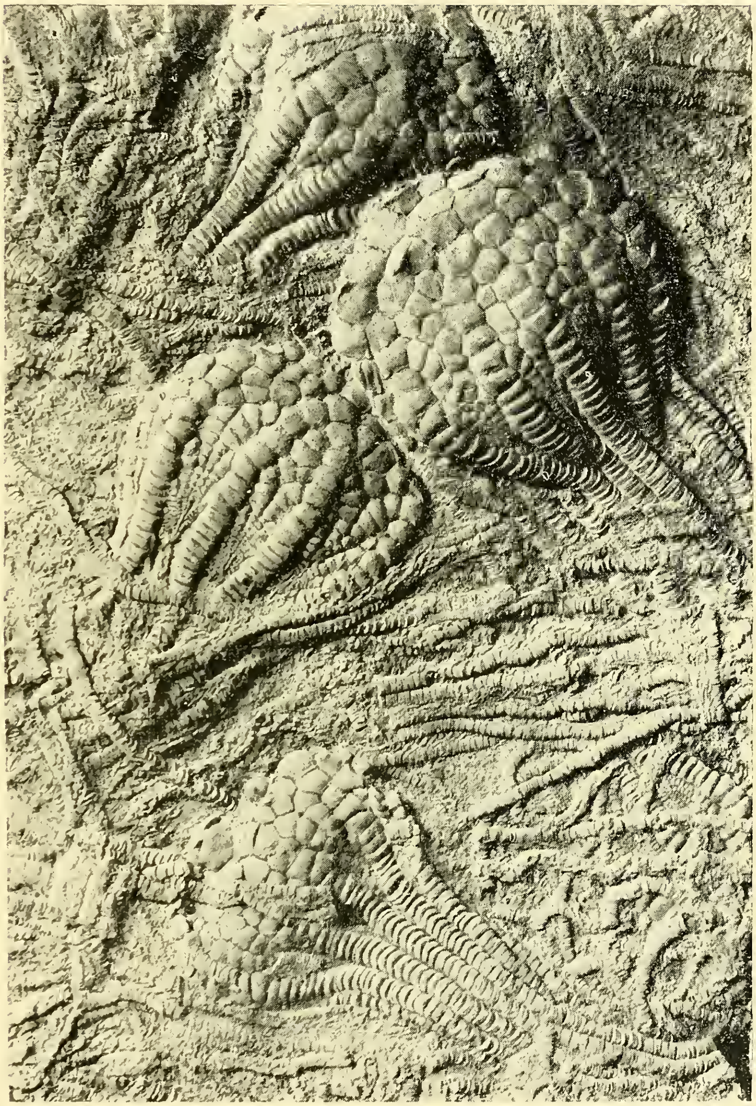

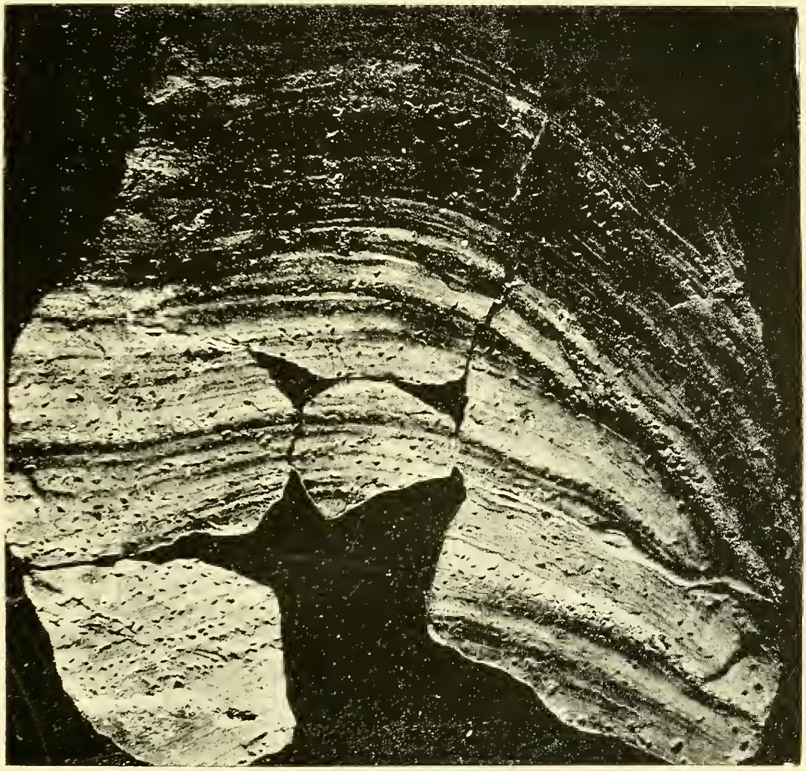

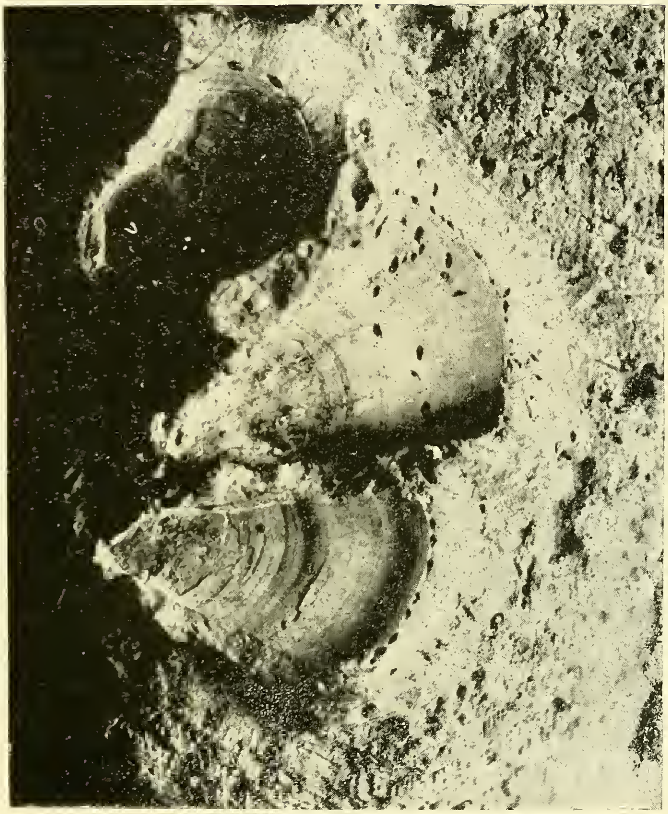

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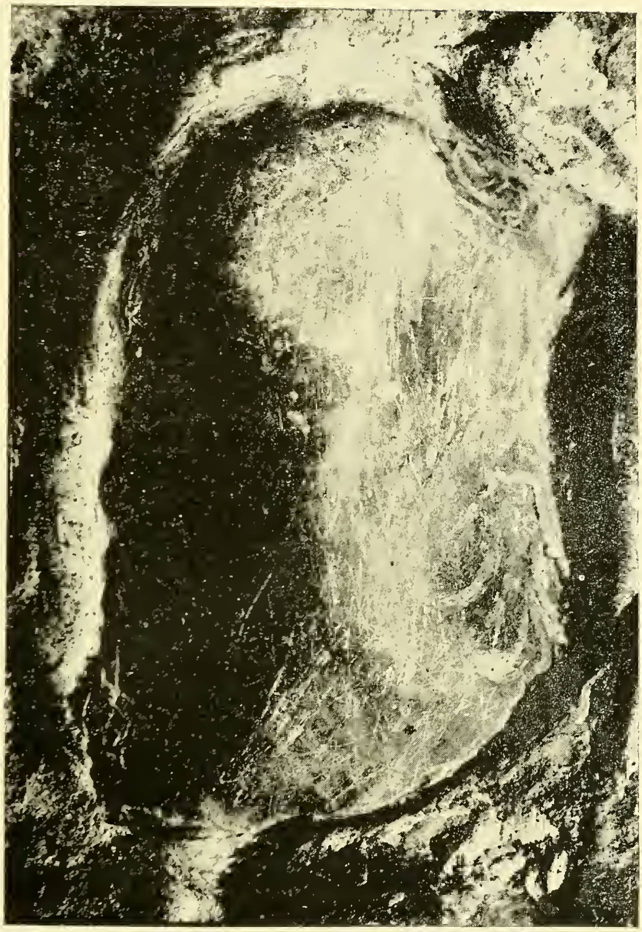

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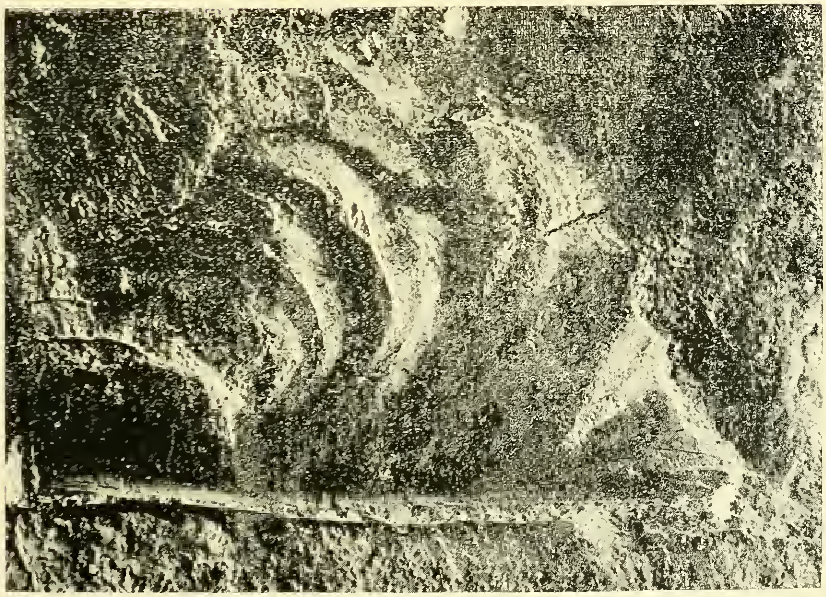

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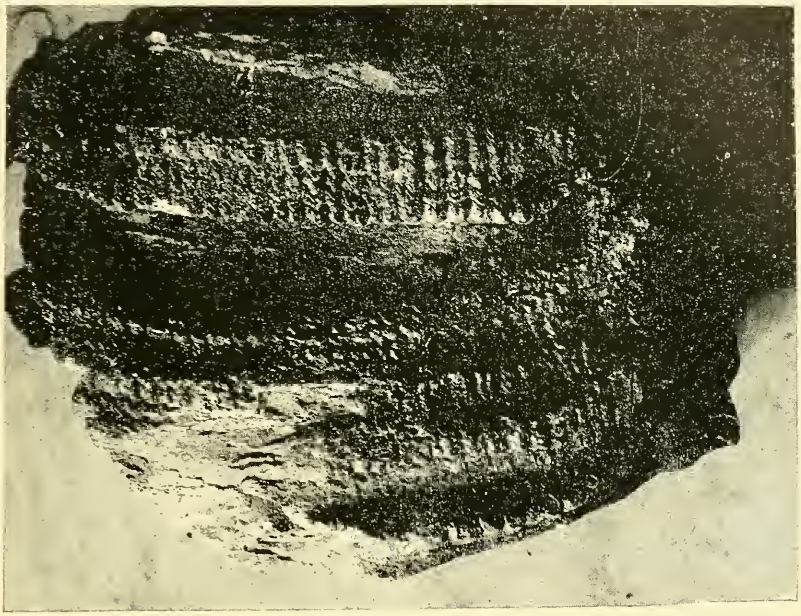

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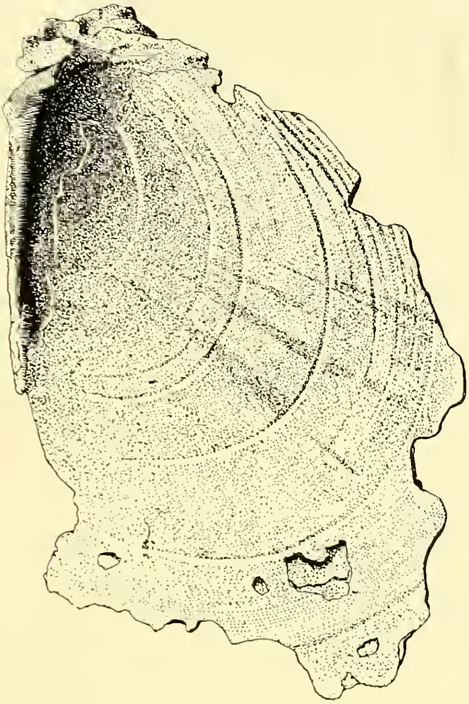

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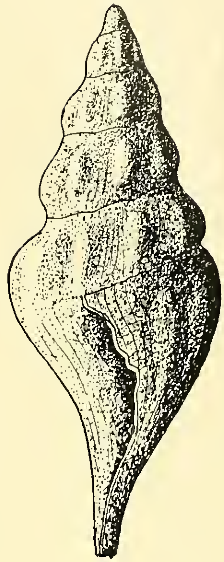

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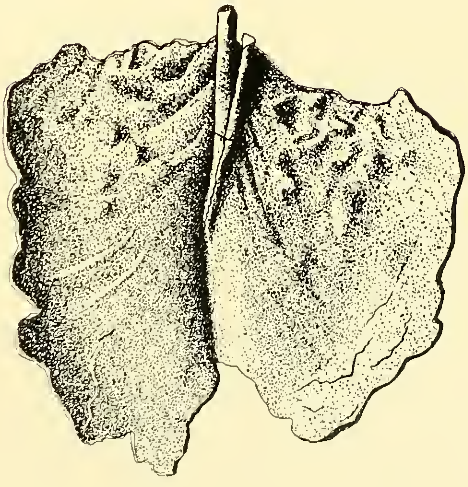

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