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 scapulæ 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.

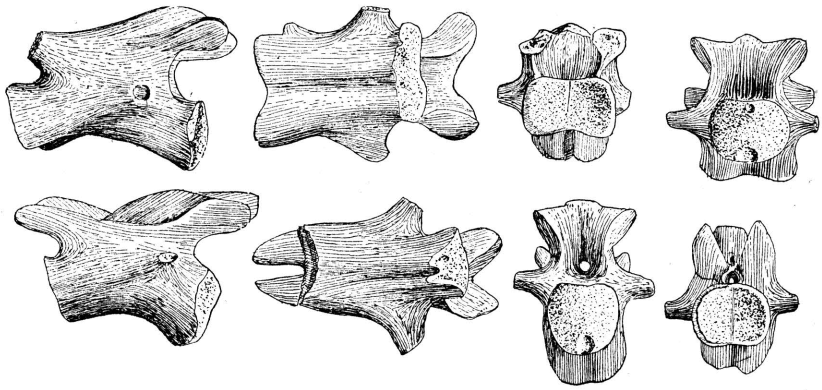

FIG. 6. Caudal vertebræ of *Cynocercus incisus* Cope.

"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]

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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.

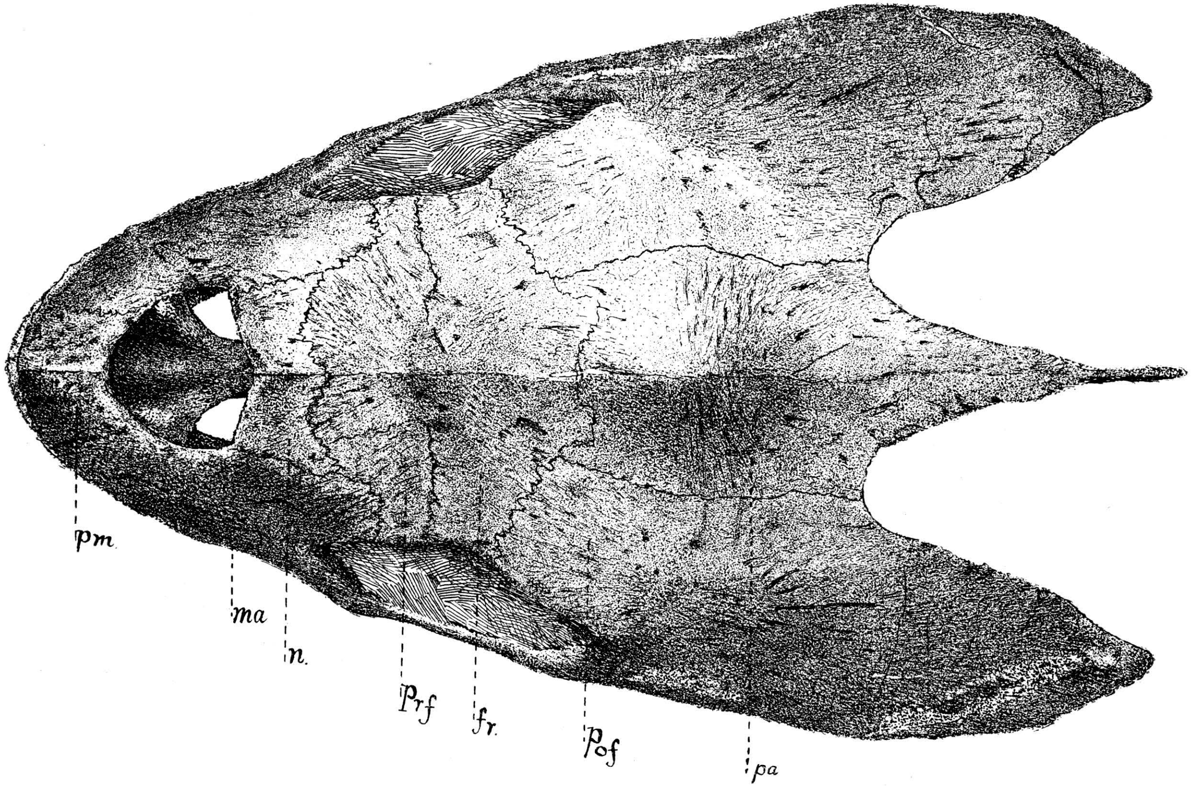
PLATE LXXX.—*Toxochelys.* Fig. 1, scapula, right side; fig. 2, right coracoid; fig. 3, left hyoplastron; fig. 4, left hypoplastron; fig. 5, left xiphiplastron; fig. 6, coracoid of a small specimen; fig. 7, humerus of same; fig. 8, femur of same; fig. 9, ilium of same. Figs. 1, 2, *T. latiremis;* others, *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.

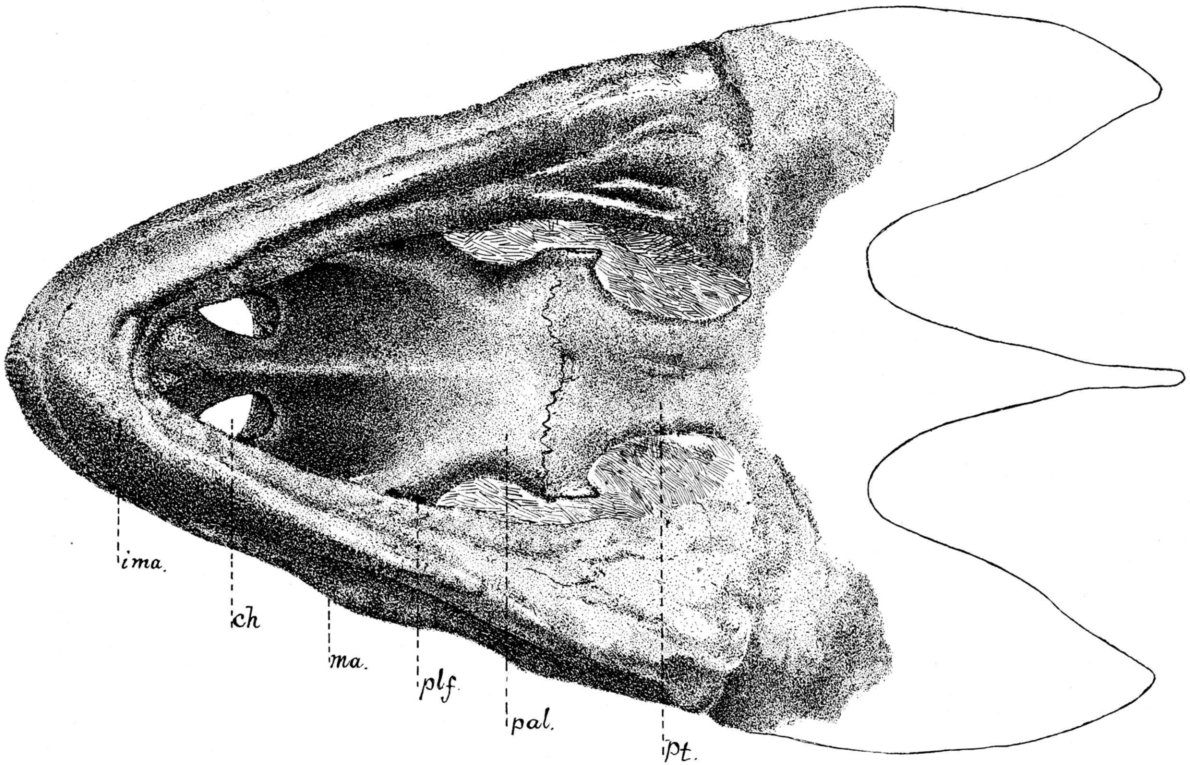
PLATE LXXXII.—Fig. 1, fourth or fifth finger of *Toxochelys latiremis;* fig. 2, first finger of same; fig. 3, nuchal plate of same; fig. 4, under view of anterior part of skull of *Toxochelys serrifer* Cope; fig. 5, the same, upper view; fig. 6, ischium of *Toxochelys latiremis.*

PLATE LXXXIII.—Fig. 1, posterior portion of carapace of *Toxochelys serrifer;* figs. 2, 3, 4, cervical vertebræ of *T. latiremis.*

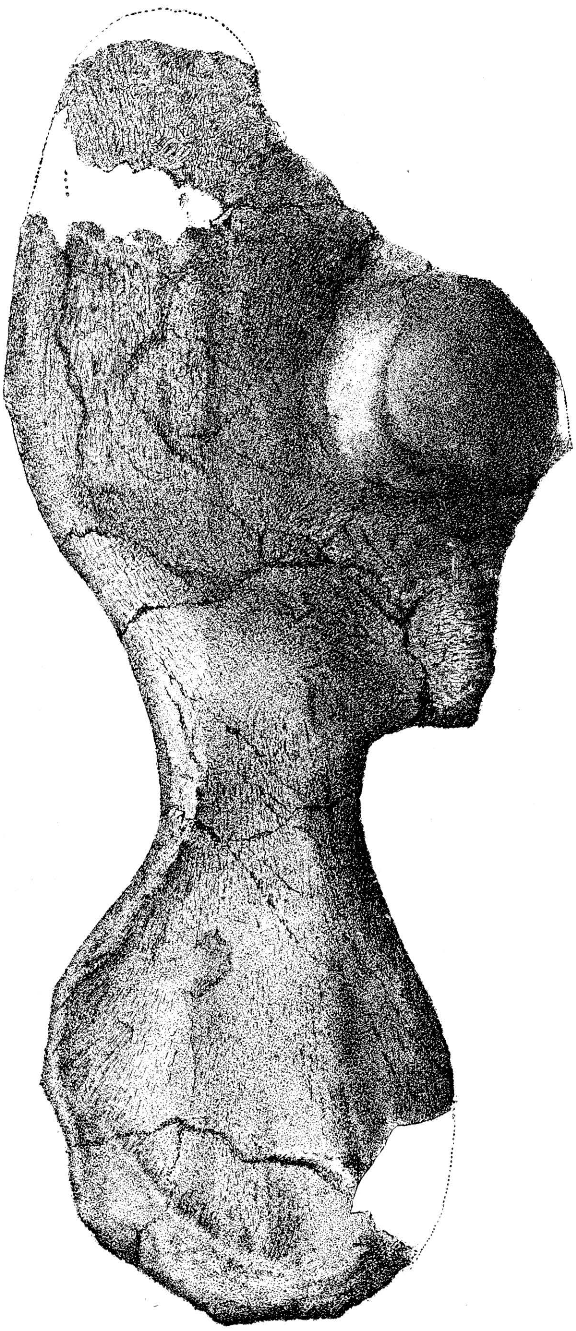
PLATE LXXXIV.—Fig. 1, upper view of skull of *Toxochelys brachyrhinus* Case, reduced; fig. 2, the same, restored, natural size.



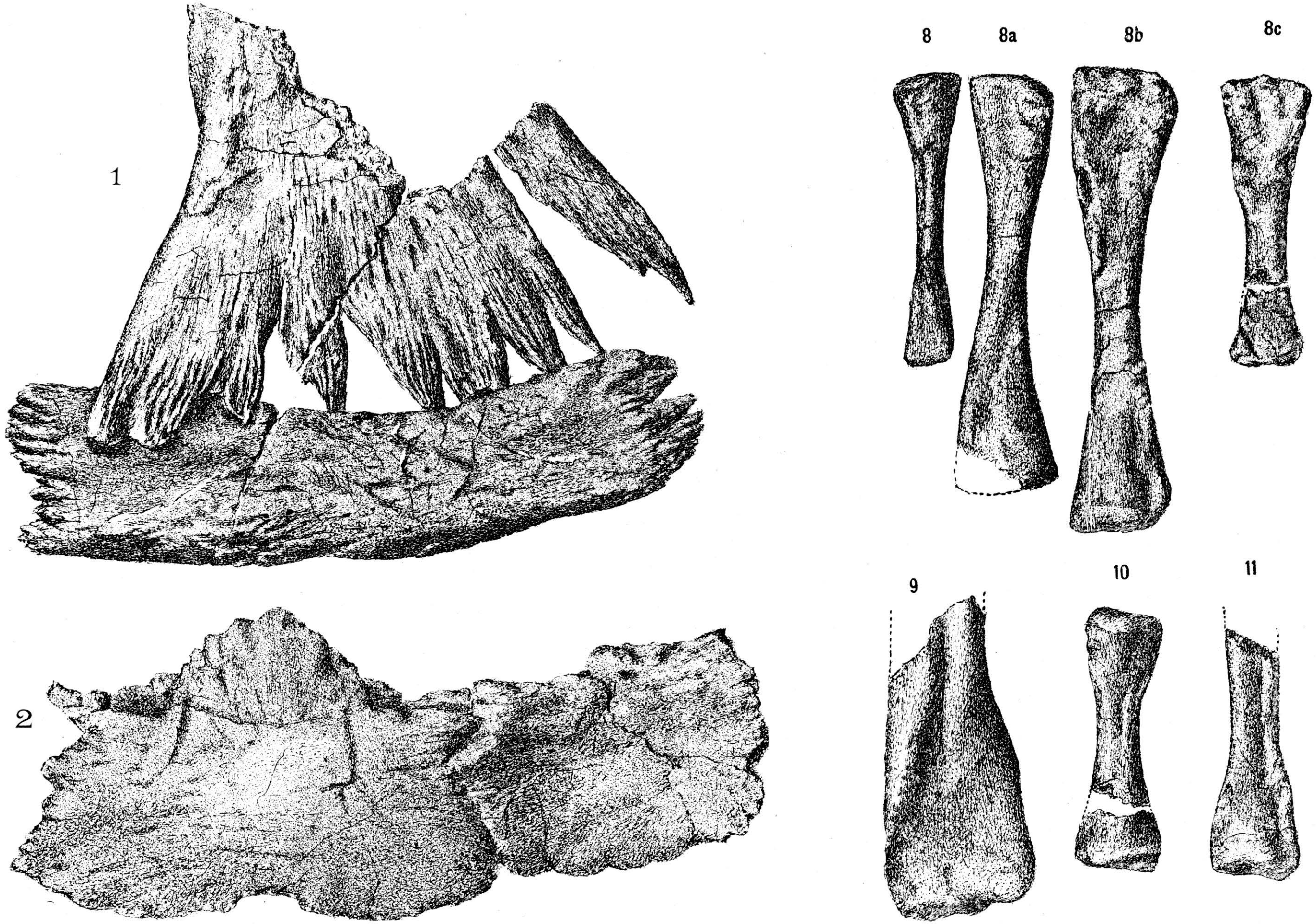
DESMATOCHELYS LOWII (from above), × two-thirds.



DESMATOCHELYS LOWII (from below), × two-thirds.



DESMATOCHELYS LOWII, × two-thirds.



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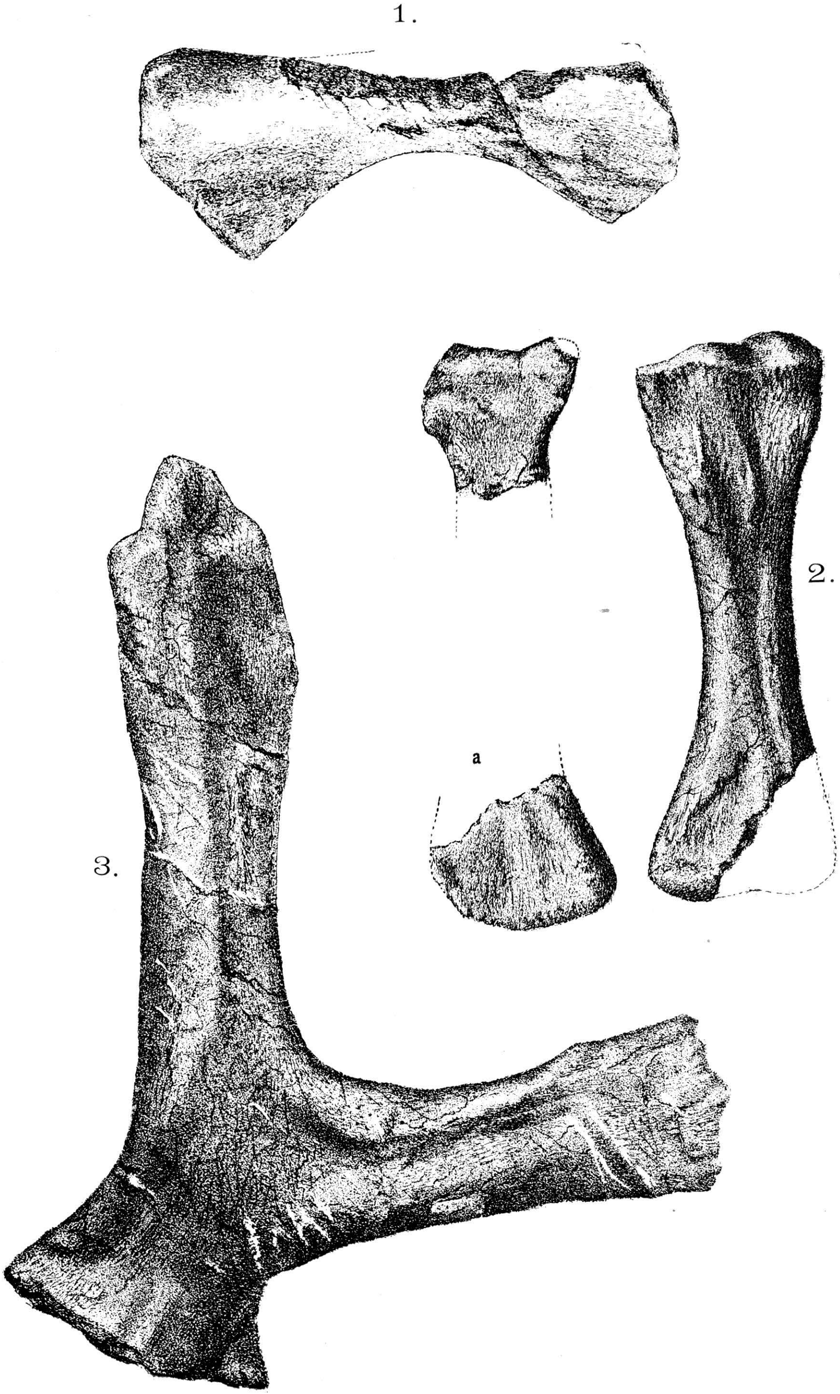
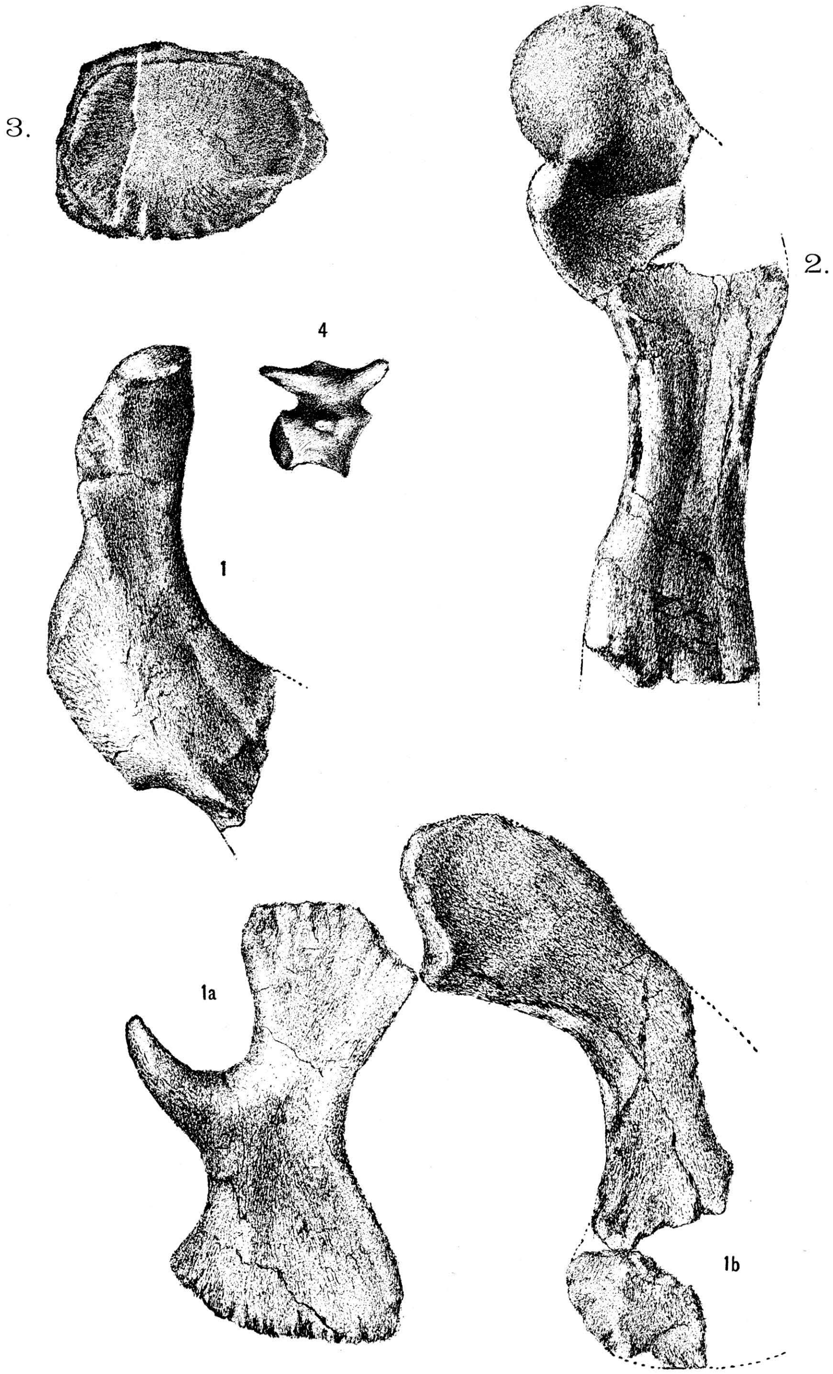
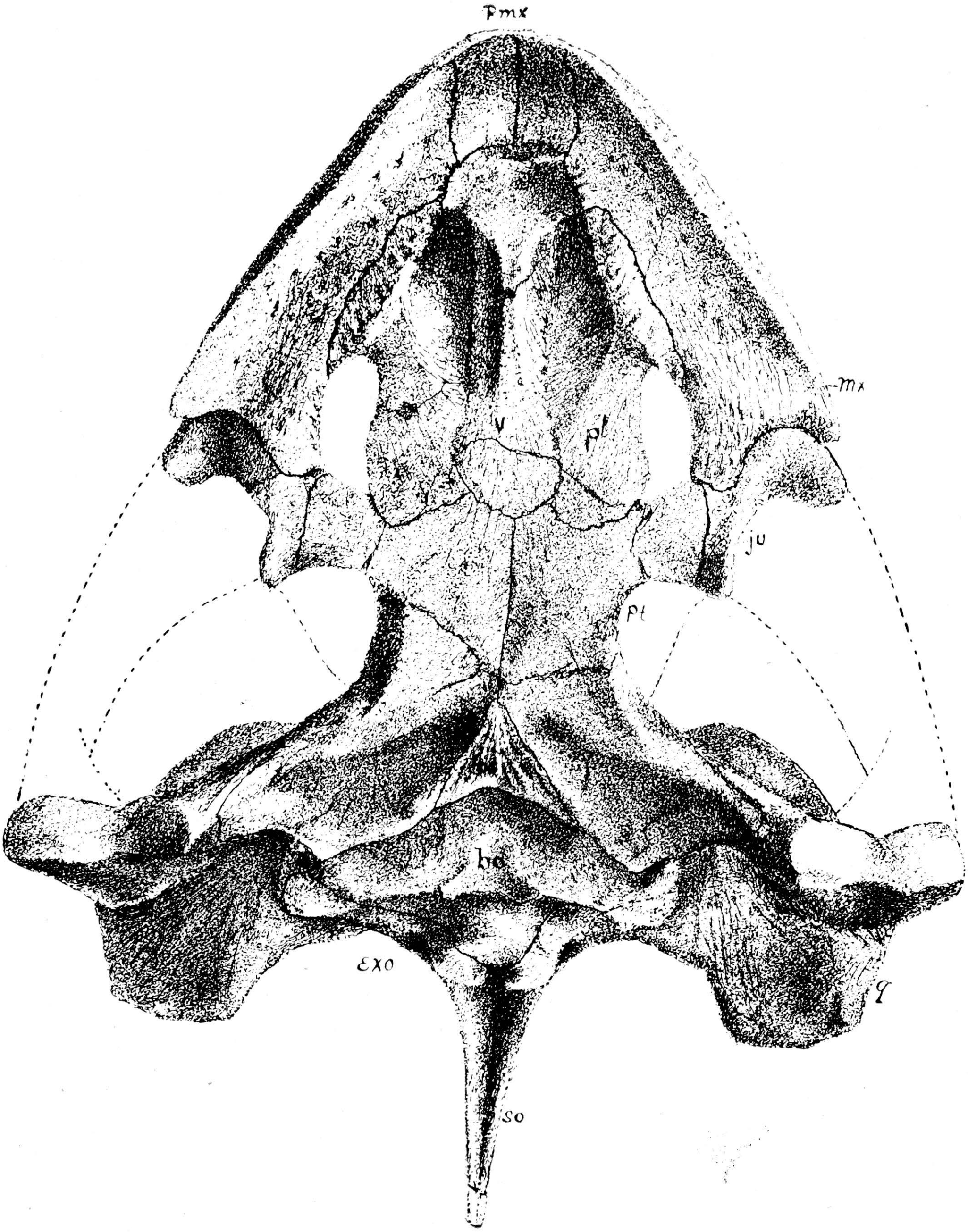


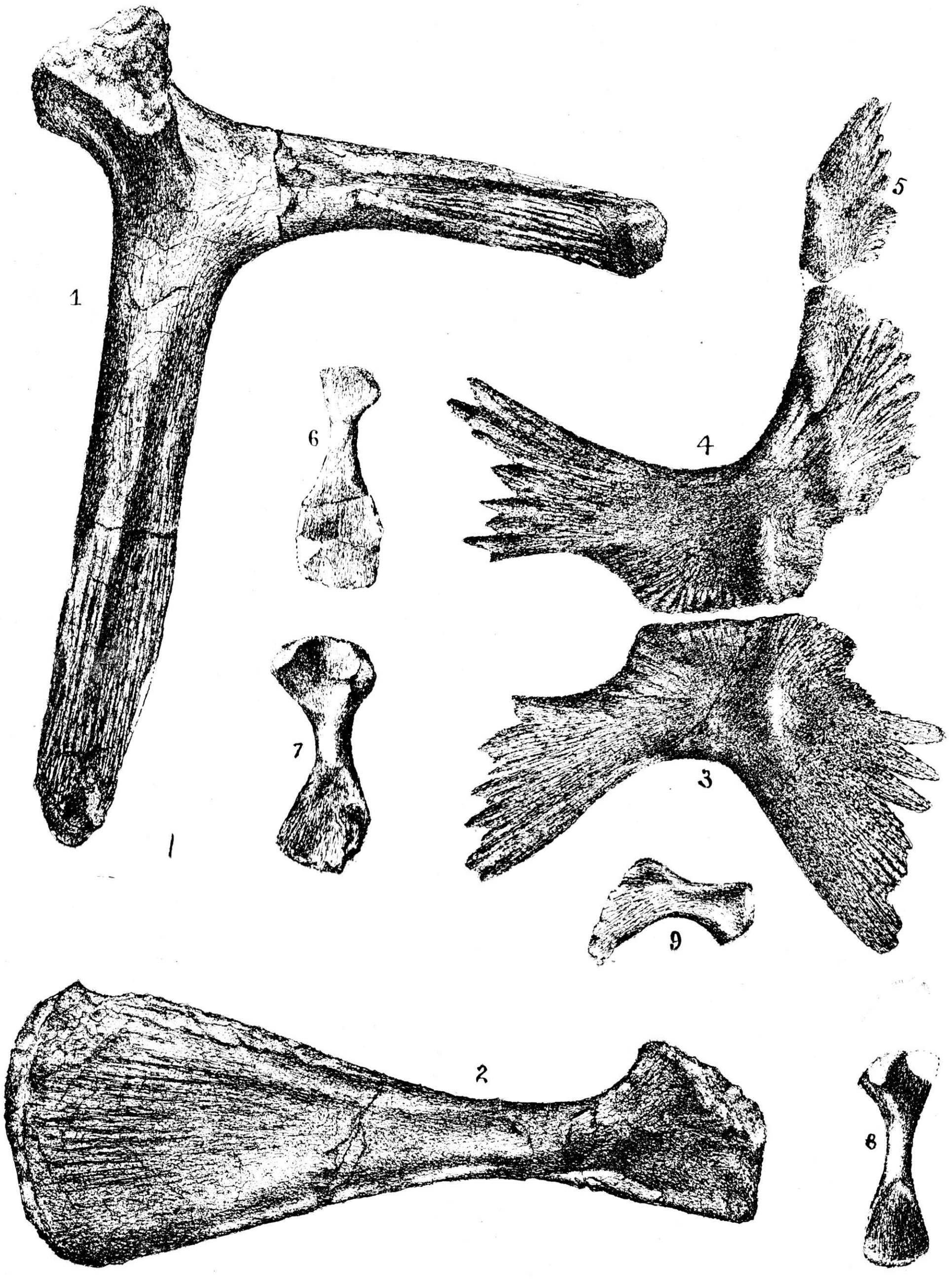
DESMATOCHELYS LOWII, × two-thirds.



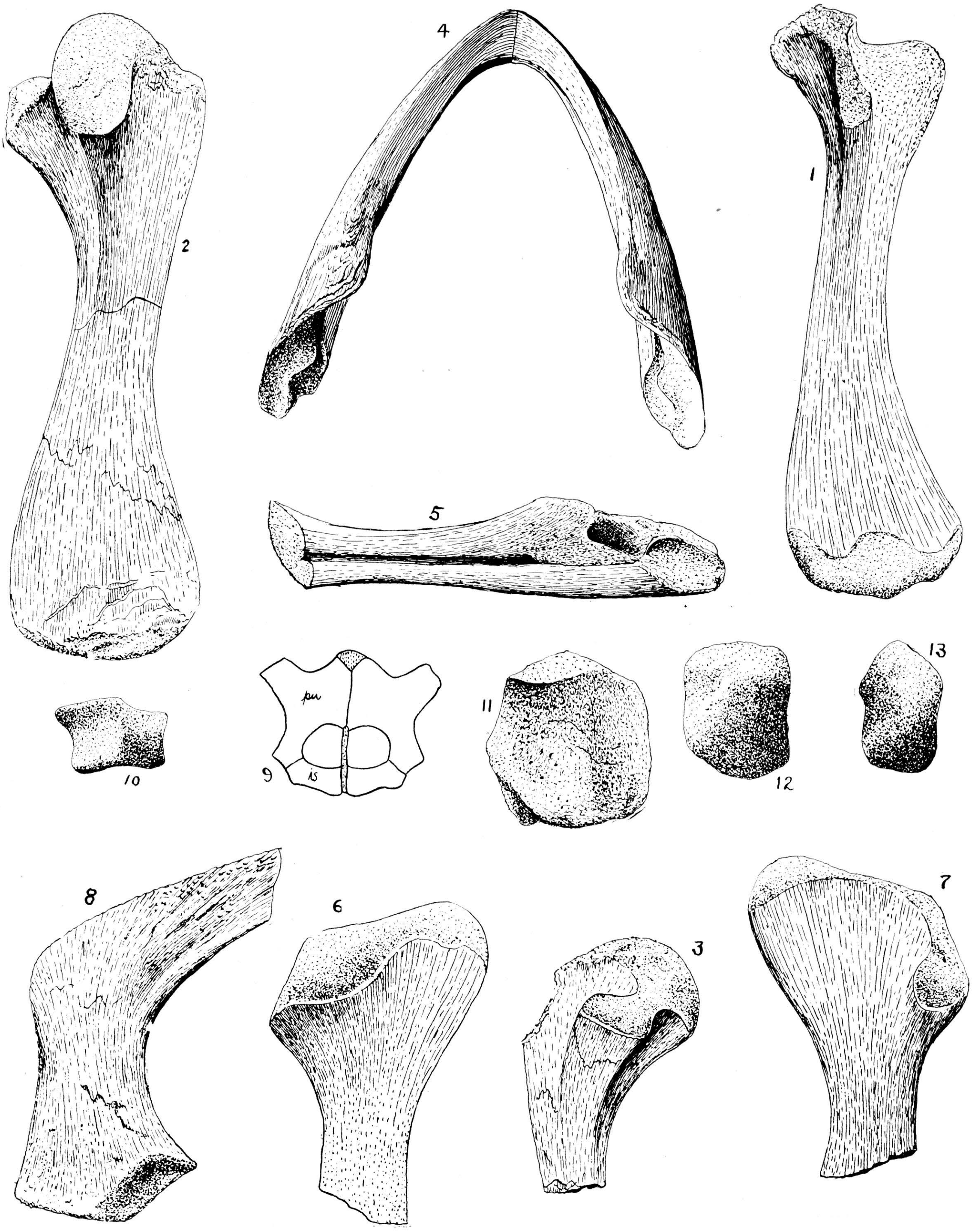
DESMATOCHELYS LOWII, × two-thirds.



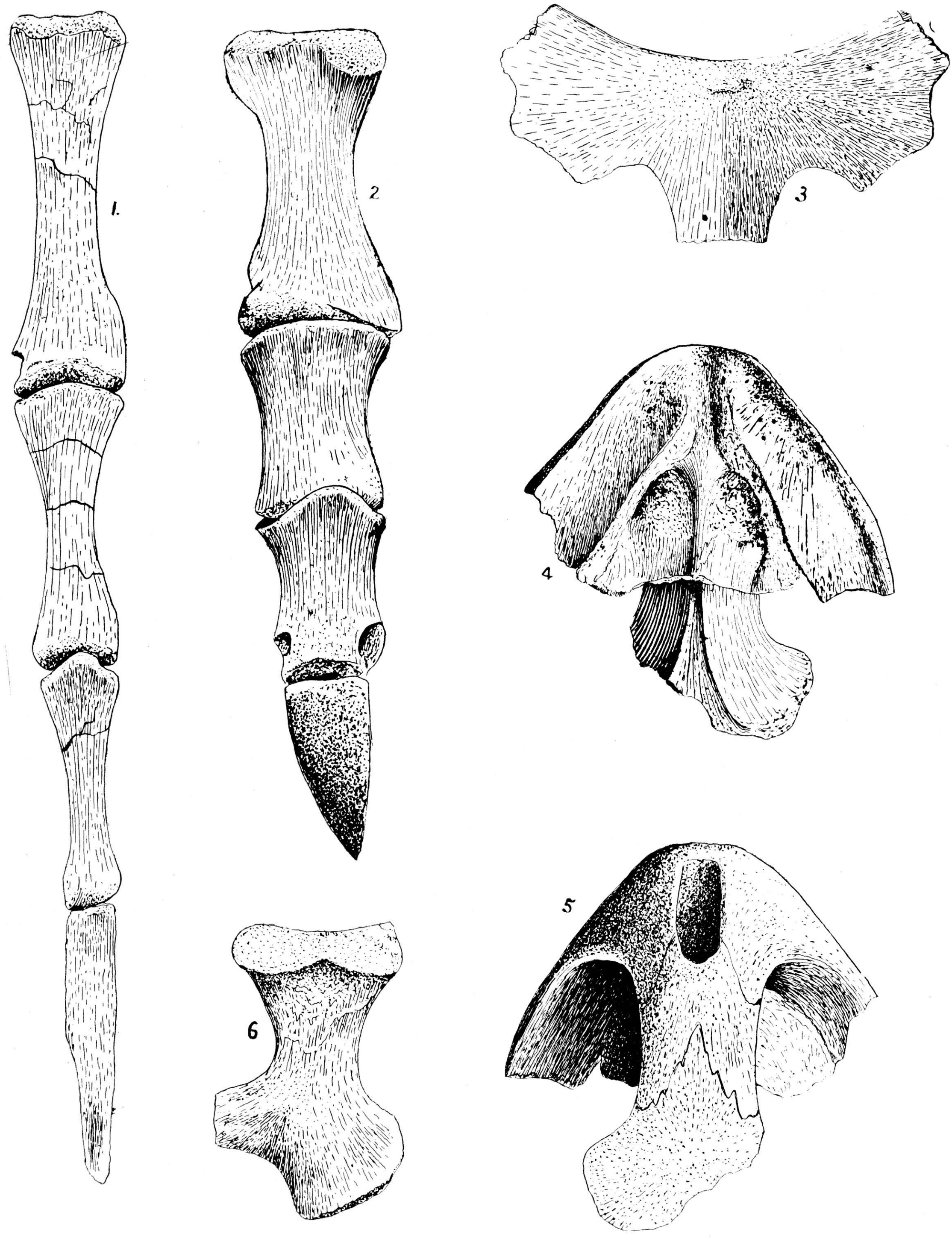
TOXOCHELYS LATIREMIS, natural size.



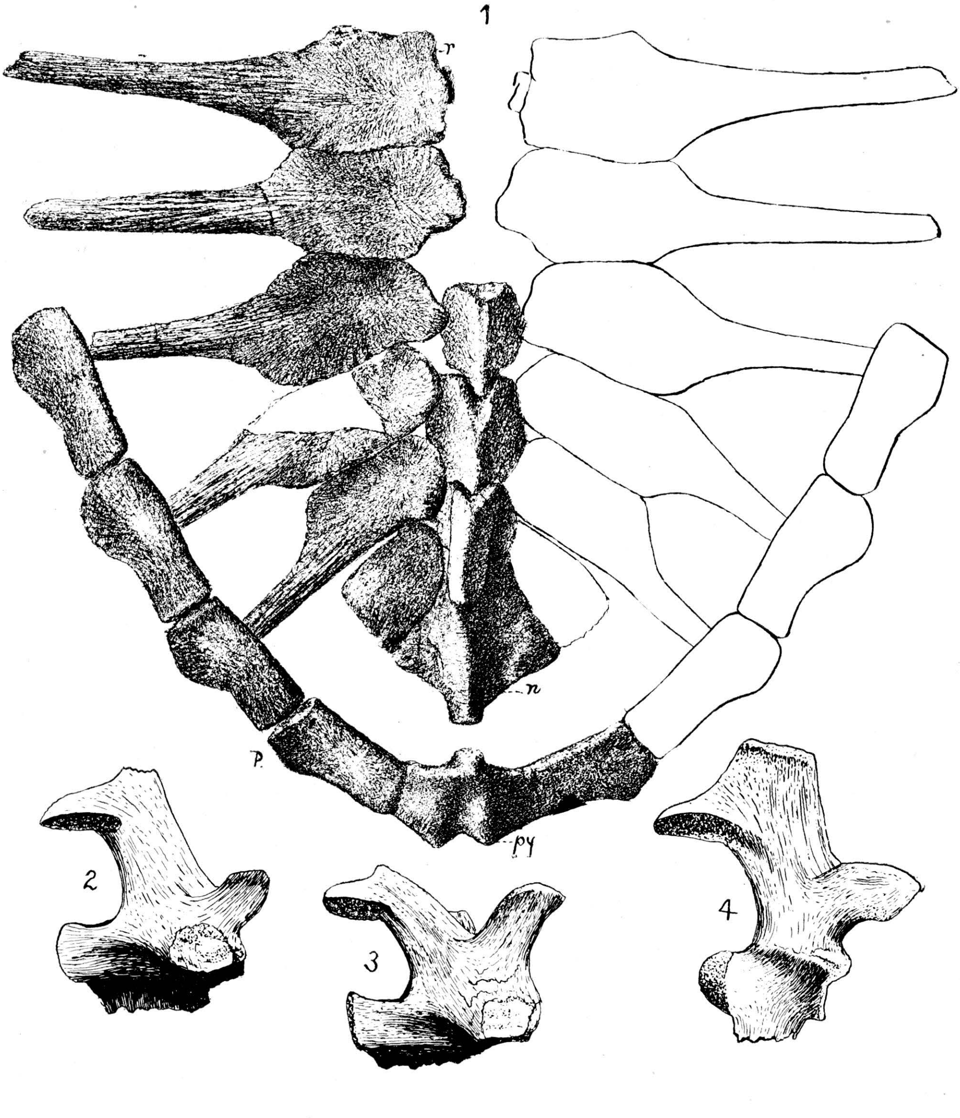
TOXOCHELYS.



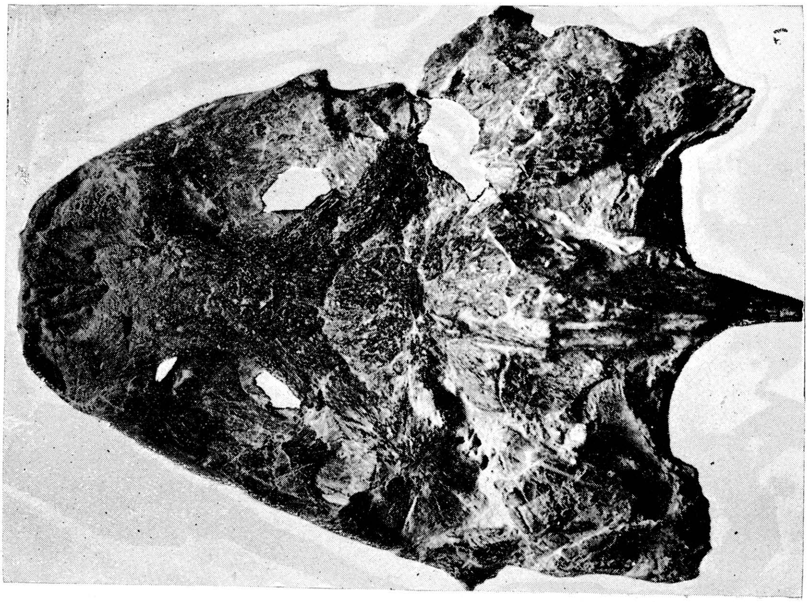
TOXOCHELYS, × two-thirds.



TOXOCHELYS, natural size.



TOXOCHELYS, × two-thirds.



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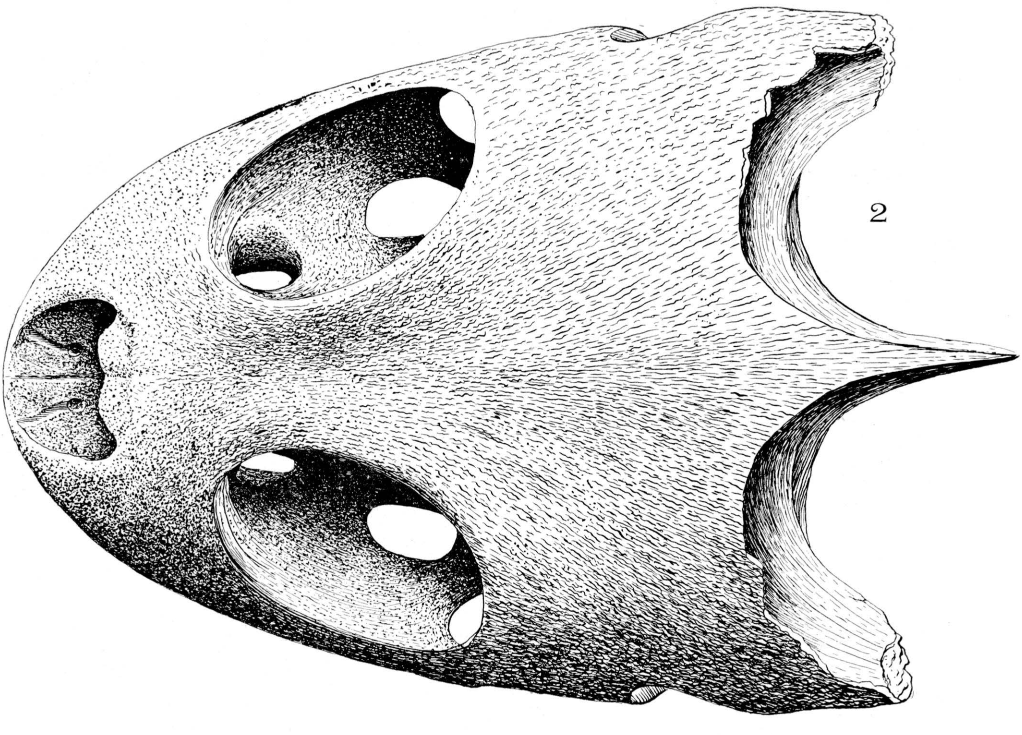


2

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.

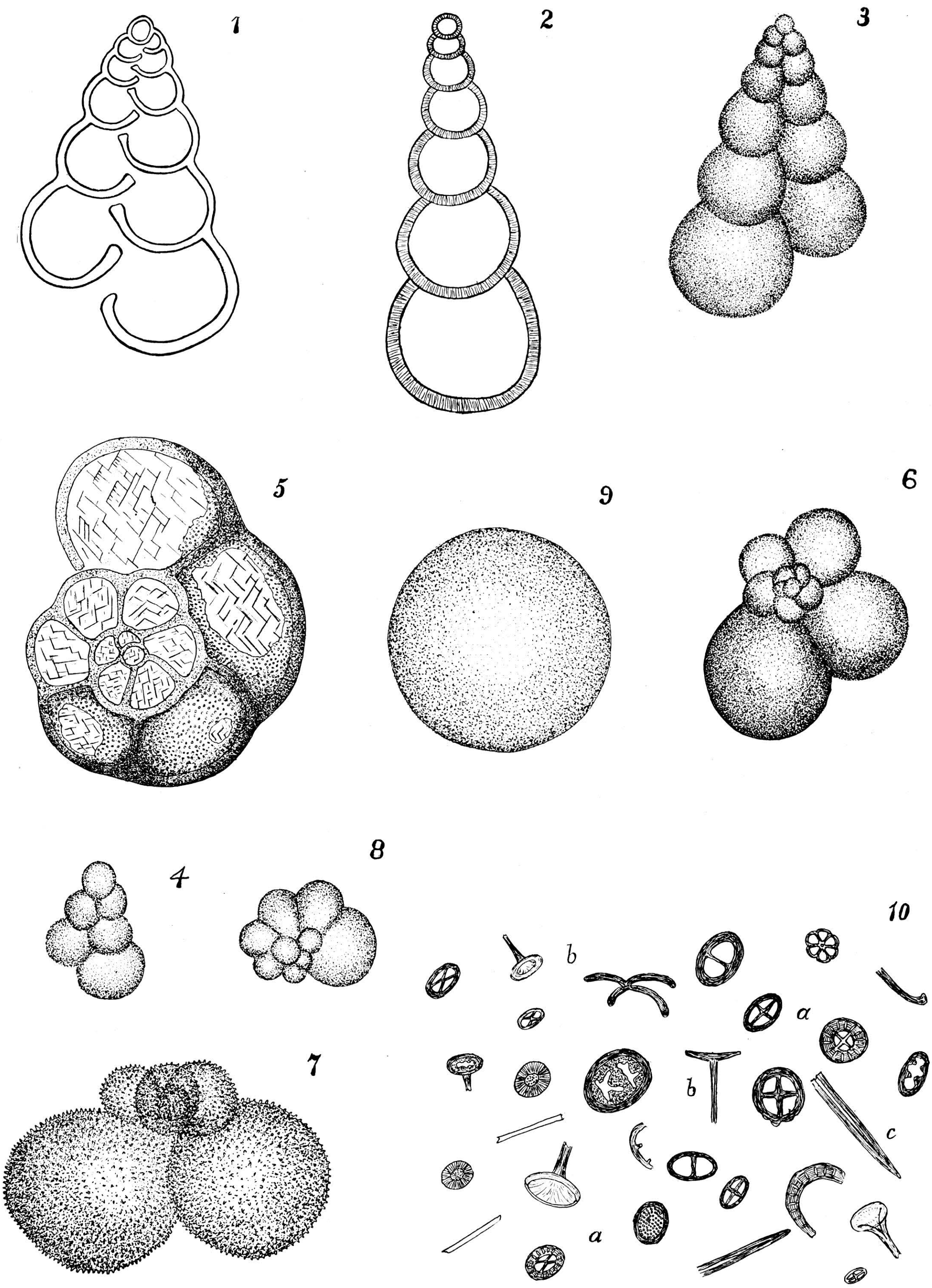
FIG. 6. Surface view of *Globigerina bulloides*, exhibiting the arrangement of chambers and their shape. × 150.

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.