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CONTRIBUTIONS TO THE PALEONTOLOGY OF THE UPPER CRETACEOUS SERIES

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ILLUSTRATIONS.

INTRODUCTORY NOTE.

The specimens described in this paper were collected by the writer at different times while studying the geological formations of Kansas. The Ft. Pierre fossils were collected from the deposits bearing that name in the extreme northwestern part of the State. The Benton fossils were obtained from outcrops of that formation in the central part of the State, in Osborne, Lincoln and Mitchell Counties. The Niobrara species were collected from outcrops on the Smoky Hill river in Ellis County, and from outcrops on the White Rock in Jewell County.

Some of the Benton forms, particularly the gastropods, were taken from calcareous nodules which were so thoroughly indurated that the shell could not be obtained in a form complete enough to warrant specific determinations. Nevertheless, they are figured and the best description possible from the material is given. The remaining specimens are well preserved.

A comparison of some of the species of the same genus led the author to a study of the distribution, ontogeny, and phylogeny of some of the genera. The results of this study are included in the present paper.

The specimens treated of in this paper are now in the paleontological collection of the Field Columbian Museum.

THE GENUS SCAPHITES.

DISTRIBUTION. The genus Scaphites belongs to the family Stephanoceratidæ of the order Ammonoidea. The genus includes about forty known species. Its geological range is confined to the Upper Cretaceous Series, but its distribution is widespread, as it is known to have been an inhabitant of at least four continents. The species were no doubt marine littoral organisms.

The history of the genus forms an interesting record. The earliest known species occurs in the Gault of Europe which seems to form a transition stage from the Lower to the Upper Cretaceous, for it is classed by some authors with the former and by others with the latter series. In this earliest known horizon of the genus there are few species, and individuals are not abundant.

In the formation overlying the Gault, the Cenomian, the primitive species, *Scaphites æqualis* Sowerby, reaches the acme of its abundance. Up to this time, however, few, if any, structural variations have been introduced. But during later Cenomian time dispersion began and the primitive species made its appearance in the Cretaceous seas of France and Switzerland. With the migration came new environments which resulted in a differentiation of organic structure, and the consequent production of new species. All of the new species, however, are closely allied to *S. æqualis*.

It is, of course, questionable whether environment is the sole cause of variability. But it is very highly probable that in this case, at least, the change of environment was one of the prime factors in the production of the new species. For it is not improbable that under new conditions bathmism could more readily assert itself. That it did assert itself rapidly is shown by the production, in a short period, geologically speaking, of nearly fifteen species. From this it must at least be inferred that the change in environment gave an impetus to the growth force. It becomes more obvious in the light of the fact that in the center of dispersion but three or possibly four species are recorded for the entire geological range of the genus. Furthermore it is not certain that two of these species did not migrate to the center of dispersion from the Eastern colonies.

During middle Upper Cretaceous times the genus continued its eastward migration. From India two or three of the primitive types are reported. From the Pacific coast of North America one species which is very closely allied to the early forms has been discovered. During middle Upper Cretaceous times came the introduction of the waters of the great North American epicontinental sea, and with the waters of this sea came in some of the primitive species from the Western or Eastern waters. And here as in the epicontinental sea of Europe conditions favorable to development were found. Bathmism here also found a strong ally in environment, and the result was the production of thirteen or fourteen new species. But differentiation of structure was of a greater degree. The development was more accelerated and the changes more marked. The individual grew to much larger size; nodes were developed where ribs only had existed; the sutures became more complex and the form more globular.

One remarkable fact in connection with the development of the genus Scaphites is that its greatest development in both Europe and America took place in a region lying between parallels 40° and 50° of latitude. This may be only a coincidence, or it may be that when the paleontology of the now unknown regions is thoroughly worked out the present conditions will be found to be only apparent and not the real ones. If neither of these assumptions be correct the explanation may be found to lie in the similarity of environments.

The following is the distribution of the species of the genus Scaphites. In Europe, *S. æqualis*, *S. obliquus*, *S. texanus*, *S. conradi*, *S. nicolleti*, *S. hippocrepis*, *S. hugardianus*, *S. ivanii*, *S. compressus*, *S. constrictus*, *S. culvieri*, *S. reiformis*, *S. geinitzi*, *S. inlatus*, *S. multinodosus*, *S. nodifer*, *S. ornatus*, *S. quadrispinosus*, *S. tridens*, *S. tuberculatus*, *S. trinodosus*; India, *S. æqualis*, *S. obliquus*, *S. kingianus*; North America, *S. warreni*, *S. conradi* (3 varieties), *S. larvæformis*, *S. vermiformis*, *S. texanus*, *S. nodosus* (3 varieties), *S. mullanus*, *S. subglobosus*, *S. nicolleti*, *S. cheyennensis*, *S. abyssinus*, *S. iris*, *S. mandanensis*, *S. hippocrepis*, *S. culvieri*, *S. quatsinœnsis*, *S. reniformis*, *S. semicostatus*, *S. vermiculus*, *S. verrucosus*, *S. comprimus*.

ONTOGENY, PHYLOGENY AND PALEONTOGENY. No description of the ontogeny or phylogeny of the genus Scaphites has as yet been published. As the adult forms of the majority of the species show evidences of a degenerative character, it was supposed that the genus was an abnormal type, and further that the individual did not per-

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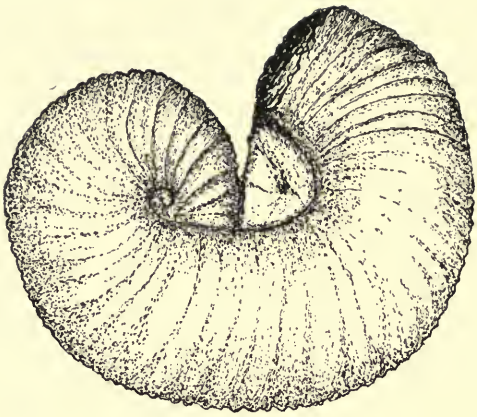

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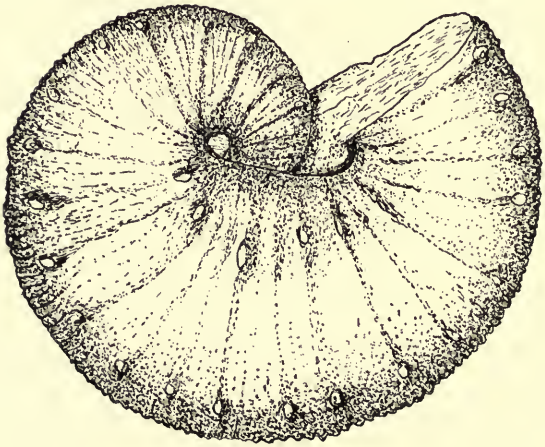
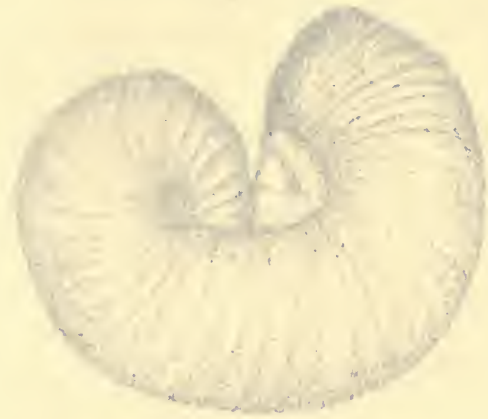


Explanation of Plate XXII.

Scaphites warreni. (Mus. No. P 5940.)
Fig. 1. Side view of specimen.

Scaphites nodosus.
Fig. 2. Side view of specimen.



EXPLANATION OF PLATE XXII.

SCAPHITES WARRENI. (Mus. No. P 5040.)
Fig. 1. Side view of specimen.

SCAPHITES NODOSUS.
Fig. 2. Side view of specimen.

petuate racial characteristics. That these suppositions do not accord with the facts is a further confirmation of one of the laws of evolution. It is confirmatory of the law that as characters of development first show themselves in the adult, so also do degenerative characters. In other words degeneration takes place in the inverse order of development. The order of development of the Cephalopods, as shown by Hyatt, has been in regard to form: 1. the straight shell; 2. the arcuate shell; 3. the loosely coiled shell; 4. the closely coiled shell. Along with this development of the form of the shell has gone an increased development in the complexity of the sutures. Scaphites is considered degenerative in form because of the tendency exhibited in the adult to return to an early form by a partial uncoiling of the shell. If this be true degeneration, it has not as yet affected the sutures.

In fact the phylogeny of the genus reveals progression rather than retrogression. As an illustration compare the suture of *Scaphites warreni*. Meek, Fig. 1, Pl. XXII with the suture line of *Scaphites nodosus* Meek, Fig. 2, Pl. XXII.

The first is a Benton species while the second is a Pierre species. The first, therefore, is the primitive form as regards time and suture. Furthermore the ontogeny of *S. nodosus* reveals a stage which corresponds with reference to the suture very closely to the adult suture of *S. warreni*. It seems very probable, then, that the latter is in the line of the direct evolution of the former and represents an earlier stage. The changes in form as revealed by the two species do not point to any marked degree of retrogression. The principal changes have been an increase in the size of the individual; an increase in the complexity of the suture lines; and the development of two rows of nodes, one on the umbilical shoulder and a second on the ventral border. In *S. warreni* the ornamentation consists of strong ridges with a tendency toward nodosity in some individuals. In the young of *S. nodosus* the ridges are well marked while the nodes are entirely absent on the umbilical shoulder and not prominent on the ventral border.

In the excellent work of Branco although Scaphites is mentioned in the list of genera its ontogeny is not exhibited. The omission was no doubt due to a lack of workable material. And, indeed, this was at first a serious obstacle to the success of the present writer. Owing to the highly crystalline character of the calcium carbonate which preserved the form of the shells many specimens were broken up without results. Later, from some young forms furnished by Prof. Weller, of the University of Chicago, the results recorded below

were obtained. Some of the specimens although entirely opaque in the outer whorls were very translucent in the inner whorls so that the suture lines were easily discernible.

Fig. 1, Pl. XXIII, represents a number of sutures as follows: *a.* The first suture is angustisellate and represents the ananepionic stage. *b.* The second suture is a transition from the suture of Anarcestes to that of Tornoceras. *c.* The third suture is Tornoceras. *d.* The fourth suture is a transition from Tornoceras to Glyphioceras, or possibly Prionoceras. *e.* The fifth suture is Glyphioceras. *f.* Is Glyphioceras. *g.* Is a suture on the second whorl which is Gastrioceras but is just approaching Paralegoceras. *h.* Is a suture on the third whorl, diameter 5mm., and is the ammonitic radical, probably nearest Pronorites.

The suture on the first part of the fourth whorl has much the appearance of the suture of *S. warreni*, and toward the end of that whorl reaches the adult form.

In Figs. 2, 3 and 4, Pl. XXIII, views of the protoconch are given which represent the phylembryonic stage of the type *Scaphites nodosus* Meek.

Figs. 7–12, Pl. XXIII, represent six stages of growth between the close of the brephic and the beginning of the ephebic stage.

Fig. 5, Pl. XXIII, shows the suture of the adult form of *S. warreni*, and Fig. 6 that of *S. nodosus*, Museum specimen No. 3653, University of Chicago.

SCAPHITES WARRENI—MEEK.

PROC. ACAD. NAT. SCI. OF PHILA., P. 185. 1860.

(Pl. XXII, Fig. 1 and Pl. XXIII, Fig. 5. Mus. No. P 5940.)

REVISED AND ENLARGED DESCRIPTION. "Shell medium size, transversely subovate, moderately compressed, inner volutions nearly circular, closely involute, and composing a little more than one-half the bulk; deflected body portion longer than the diameter of the involute portion and rather more proportionally than the inner turns; surface costate and without proper nodes; costæ small on the inner whorls, where they do not differ materially in size, but on the body part some, usually every third or fourth one, become more prominent than the others, and extend entirely across from the inner side to and over the periphery, in passing upon which they bifurcate, or give off branches and assume, with these, a uniform size. The aperture

EXPLANATION OF PLATE XXIII.

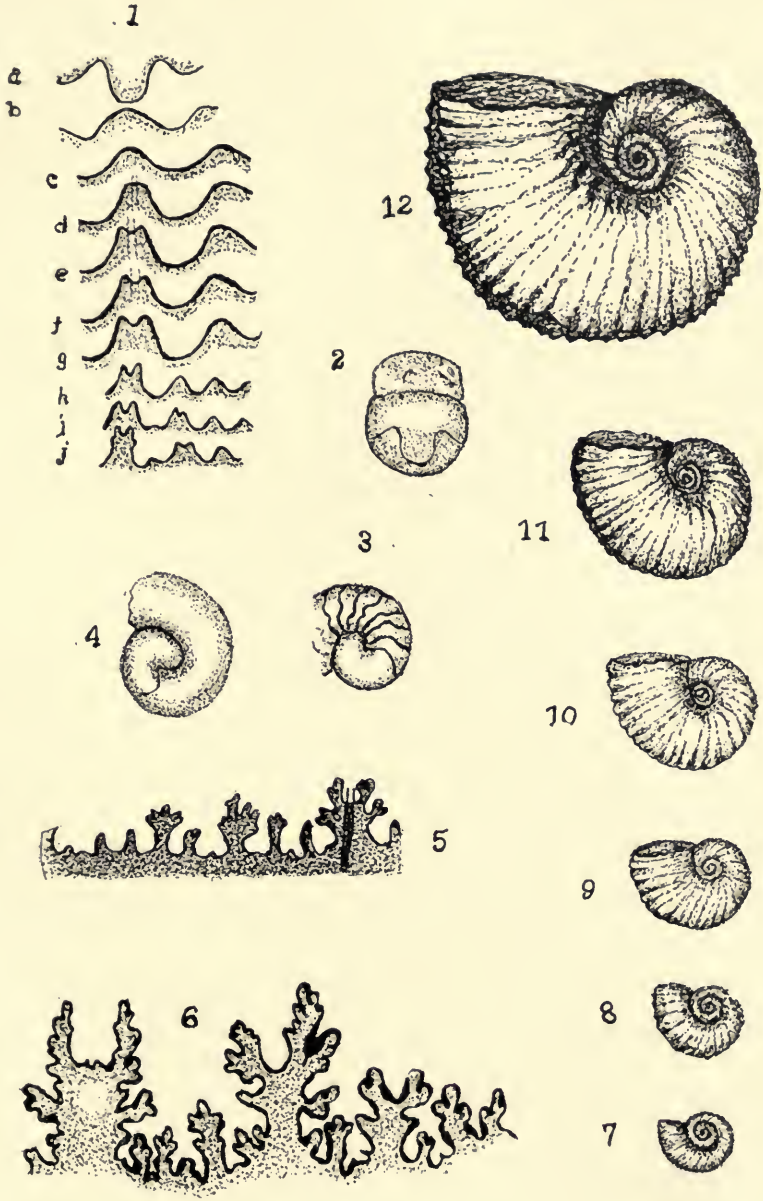
SCAPHITES NODOSUS Owen.

Fig. 1. Views of sutures.
Figs. 2, 3 and 4. Views of protoconch.
Fig. 5. Suture of *S. warreni*.
Fig. 6. Suture of adult *S. nodosus*.
Figs. 7–12. Young individuals.

Explanation of Plate XXIII.

Scaphites nodosus—Meek.

Fig. 1. Views of sutures.
Figs. 2, 3 and 4. Views of protoconch.
Fig. 5. Suture of *S. warreni.*
Fig. 6. Suture of adult *S. nodosus.*
Figs. 7–12. Young individuals.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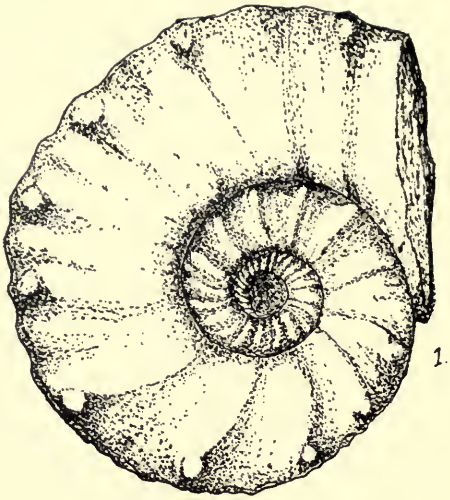
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Explanation of Plate XXIV.

Prionotropis woolgari—Meek. (Mus. No. P 5931.)

Fig 1. Side view of specimen.
Fig. 2. View of suture.
Fig. 3. Side view of young specimen.
Figs. 4 and 5. Cross section of young specimen.
Fig. 6. Dorsal view of specimen.

EXPLANATION OF PLATE XXIV.

PRIONOTROPIS WOODWARDI—Meek. (Mus. No. P 5 3.)

Fig. 1. Side view of specimen.
Fig. 2. View of suture.
Fig. 3. Side view of young specimen.
Figs. 4 and 5. Cross section of young specimen.
Fig. 6. Dorsal view of specimen.

is oval in form with a smooth periphery; it is turned inward toward the coil of the shell.

"Septa are provided with moderately broad lobes and sinuses. The siphonal lobe is longer than wide, and bears two rather prominent lateral branches, each of which is unequally bifid, and digitate. The first lateral sinus is about the size of the siphonal lobe and has approximately the same width at the base; it is divided at its extremity into two unequal lobes both of which are bifid, the one nearest the siphonal lobe having its lobes again subdivided; first lateral lobe, about the size of the siphonal lobe, divided at its extremity into two tripartite lobes each of which is digitate; second lateral sinus shallow, divided into two rounded lobes each of which is slightly indented; second lateral lobe tripartite, central division not divided, other two bifid; third lateral sinus small bifid; remaining portion of septa not visible."

Suturally our type is very closely allied to *S. ventricosus* Meek, and it is quite probable if they do not belong to the same species that they are varieties of the same species. The specimen here described is much larger than Meek's type of *S. warreni*, but it has the same general form. It resembles the former species in aperture and suture, and the latter in body shape and costæ. It is the belief of the writer that *S. warreni*, *S. wyomingensis* and *S. ventricosus* are varieties of the same species.

PRIONOTROPIS WOOLGARI—MEEK.

U. S. GEOL. SURVEY OF THE TERRITORIES, VOL. IX, P. 455. 1867.

(Pl. XXIV, Figs. 1 to 6. Mus. No. P 5931.)

Further collecting and study of this form may reveal a new species. A comparison of the suture of *P. woolgari* with the suture of the form here figured and placed provisionally in the above species reveals many differences. However, these differences may be only such as exist between the young and the adult individuals of the same species. As the sutural differences seem to be the only well marked ones the original description will be given here and the reader asked to make the comparison of the figures.

"Shell attaining a medium size, more or less compressed discoidal, the outer turn being proportionally more convex (including nodes) than those within; each volution embracing about one-fifth of the next within, and having its umbilical margin slightly indented by

the uncovered nodes forming the inner of the two outer rows on the succeeding volution within; umbilicus about equaling the greatest dorso-ventral diameter of the last turn. Young examples, half an inch to one inch in diameter, with costæ linear, closely arranged, of nearly uniform size, and manifesting scarcely any tendency to develop nodes but already showing the forward curve of their outer ends well defined, while the peripheral keel is low, narrow and simple, and the furrow on each side shallow. At a somewhat larger size, costæ usually more or less unequal in size, the larger ones now beginning to develop the two nodes at their outer curved ends, and to become a little more prominent and compressed at their inner extremities, while the rather more prominent keel begins to develop its crenate outline, and the nodes nearest to assume their compressed form and parallel arrangement. On attaining to two and one-half to three inches in diameter, costæ, nodes and keel become more prominent, the latter being strongly compressed and deeply and largely scalloped, with divisions rounded in outline; while at this stage of growth the periphery, as seen in profile, would seem to be very deeply sulcated on each side of the keel, but this is due to the prominence of the row of nodes on either side of the same. Costæ, when the shell has attained a diameter of four inches much depressed in the middle, with the nodes at their inner ends thicker and more obtuse, and those nearest the keel more depressed or nearly obsolete, while those of the third series, near by, become much enlarged and produced obliquely outward as short, thick, spine-like projections. Soon the outer compressed nodes disappear, and the keel is only represented by separated, low, elongated nodes; and when the shell has attained a diameter of seven inches, the costæ are more distant, greatly elevated, compressed, and almost wing-like, but still retain a large, prominent, subtrigonal node or projection at their outer ends, and again become, as it were, pinched up at their inner extremities, which do not quite reach the umbilical margin.

"Septa moderately close together; siphonal lobe longer than wide with three or four short branches on each side, the two terminal of which are largest, more or less nearly parallel, and merely serrated; first lateral sinus broader than the siphonal lobe, more or less deeply divided into two subequal branches with short, irregular branchlets and digitations; first lateral lobe somewhat longer than the siphonal, and tripartite, with short, irregular branchlets and digitations occasionally in small specimens, with the middle terminal branch proportionately broad and so deeply sinuous at the end as to impart more nearly the appearance of a bipartite arrangement of the whole; sec-

ond lateral sinus nearly resembling one of the divisions of the first, and in the adult with merely a number of marginal digitations; second lateral lobe little more than one-third as long, and from one-third to one-half as wide as the first, generally tripartite at the end, but sometimes in large specimens, bipartite on one side of the shell, the divisions being very simple and short, or serrated; third lateral sinus very small and merely bilobate, or in large specimens digitate along the margins; third lateral lobe hardly half as long as the second, and in small specimens merely tridentate at the end."

The suture, shown in Fig. 2, Pl. XXIV, is from a specimen evidently much larger than any seen by Meek. The diameter of the septate portion is more than two inches and although the non-septate part is not known it is probably at least three inches in diameter. The specimens here figured were collected from the Blue Hill shales of the Benton, in Osborne County, Kansas.

THE GENUS OSTREA.

The genus Ostrea has many representatives in the strata of the Cretaceous System, although the entire system comprises a part only of its geological range. Its distribution was as wide as the distribution of the genus to-day plus its distribution in the epicontinental seas. A few species are common to Asia, Europe, Africa and North America. Five species are common to Africa, Europe and North America. Fifteen species found in Africa are also found in Europe. One species not found in Europe is common to Africa and North America. The Lower Cretaceous seas furnished the greatest abundance of species and individuals.

During middle Upper Cretaceous times the waters of the American epicontinental seas were too clear or lacked some characteristic conducive to the life of Ostreæ, for few species or individuals are present in the strata except a very small form which was probably able to adjust itself to the environments. This species, *Ostrea congesta*, is one of the best known and most widely distributed of the genus. It is remarkable also for its abundance.

Probably the greatest beds of fossil Ostrea in existence are in the Lower Cretaceous strata of Texas. There beds of almost pure

shells several feet in thickness, having a meagre arenaceous matrix, are traceable for miles. Farther north in Kansas they still form the most abundant types.

OSTREA BELOITI, *n. sp.*

(Pl. XXV, Figs. 7 and 8. Mus. No. P 5944.)

Shell thin, oblong, moderately capacious, and possessing more than ordinary symmetry. Beaks are long and sharply pointed; fitting closely. Lower valve deep; area broad, triangular, with rounded borders, possessing a slight depression in the posterior-central portion; posterior border, rounded; anterior border, pointed; dorsal border, slightly concave, nearly straight; ventral border, convex.

Upper valve, flat or slightly convex transversely; in general outline it is very similar to the lower valve; area much the same, perhaps a little shorter. Muscular impression in both valves, sub-central and indistinct. Surface not rough or but little imbricated.

Dimensions—Length, 45mm.; width, 25mm.; height, 8mm.

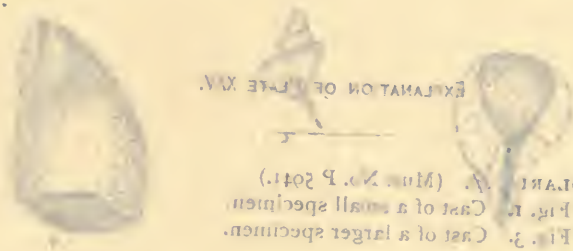
The species occurs in the Lincoln Marble horizon of the Benton. It is not abundant and has been collected from two localities only. The specimen here described was collected from an outcrop on the Solomon river in the Kansas area.

FASCIOLARIA *sp.*

(Pl. XXV, Figs. 1 and 3. Mus. No. P 5941.)

Shell a little more than moderate size, stout fusiform; spire consisting of three rather convex volutions. The body whorl large and possessing in the central region a flat area; whorl merging into a rather short canal which is slightly curved; last whorl (body) and canal more than equalling the length of the spire. Surface ornamentation not distinct in specimen, hence the difficulty of determining the species.

Several fragmentary specimens which probably belong to the genus Fasciolaria were collected by the writer from the septaria of the Blue Hill shales (Benton). The material is in such a condition as not to warrant specific determination. They are figured and mentioned only for the purpose of making our literature as complete as possible and with the hope that in the future better material may be obtained through the suggestion of the presence of such forms.



Explanation of Plate XXV.

Fasciolaria, *sp.* (Mus. No. P 5941.)
- Fig. 1. Cast of a small specimen.
- Fig. 3. Cast of a larger specimen.

Fusus, *sp.* (Mus. No. P 5942.)
- Fig. 2. Cast of small specimen.
- Fig. 5. Cast of type specimen.
- Figs. 4 and 6. Views of an indeterminable Gastropod.

Ostrea beloiti, *n. sp.* (Mus. No. P 5944.)
- Fig. 7. Interior view of left valve.
- Fig. 8. Interior view of right valve.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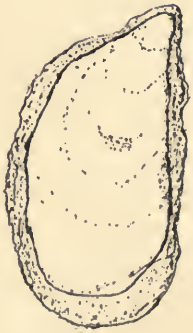
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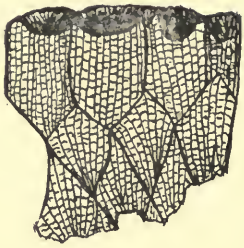

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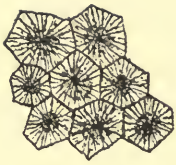

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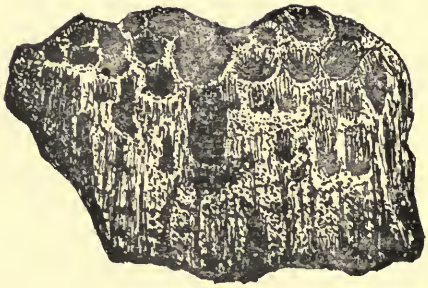

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Explanation of Plate XXVI.

Astrocœnia conica, *n. sp.* (Mus. No. P 5946.)

Fig. 1. A longitudinal section of type.
Fig. 2. A transverse section of type.
Fig. 3. A fragment of corallum—type.

Pseudo-perna wilsoni, *n. sp.* (Mus. No. P 5945.)

Fig. 4. Exterior view of left valve.
Fig. 5. Interior view of left valve.

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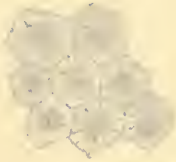

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EXPLANATION OF PLATE XXVI.

ASTROCENIA [illegible], n. sp. (Mus. No. P 5916.)

Fig. 1. A longitudinal section of type.

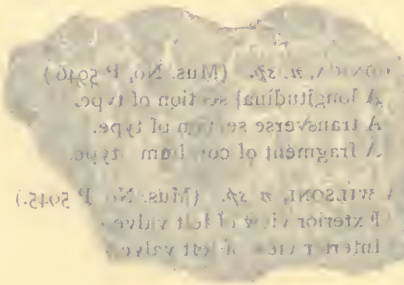
Fig. 2. A transverse section of type.

Fig. 3. A fragment of [illegible] type.

PSEUDO-PER[illegible] WILSONI, n. sp. (Mus. No. P 5915.)

Fig. [illegible] Exterior view of left valve.

Fig. [illegible] Interior view of left valve.



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FUSUS *sp.*

(Pl. XXV, Figs. 2 and 5. Mus. No. P 5942.)

The shells of these specimens are entirely absent and a specific determination is not warranted upon evidences such as are presented by casts alone. The reader is asked to compare the figures of these specimens with the figures of *Fusus staminea*, Conrad. The forms represented here were found associated with *Rostellites*, and the above described species.

ASTROCŒNIA CONICA, *n. sp.*

(Pl. XXVI, Figs. 1, 2 and 3. Mus. No. P 5946.)

Corrallum tuber-like, about the size of a medium-sized orange; corallets inversely conical, not greater than 8mm. in diameter, calices of the corallets of moderate depth, six sided but not always distinctly so, with moderately thin interstices but bordering each other; columella distinct but not prominent; intersection of dissepiments and septæ forming prominent carinæ; vertical septæ extending more than half the distance to the columella, the secondary ones only about half the length. Specimen somewhat weathered so that generic characters are doubtful.

This specimen is interesting as being the only species of coral as yet described from the Benton of the Interior Cretaceous. It was collected by the writer from the Lincoln Marble horizon on Rattlesnake creek in Mitchell County, Kansas.

PSEUDO-PERNA WILSONI, *n. sp.*

(Pl. XXVI, Figs. 4 and 5. Mus. No. P 5945.)

Shell thin, capacious, triangular in general outline with short beaks turned slightly toward ventral border, and fitting closely. Lower valve thick on the margins, thin centrally; not as capacious as upper valve and nearly flat on the adhering surface; fluted on margin in some specimens, and lacking the symmetry of outline noted in upper valve; ventral border possessing a triangular excursion near the central portion; dorsal border, concave; posterior border, convex.

Upper valve, flat or nearly so on postero-ventral wing, convex in general; ventral margin in region of beak crossed by slight ridges of

muscular attachment; area small and depressed; muscular impression prominent and possessing fine striæ concentrically arranged; dorsal border convex; ventral border nearly straight, somewhat wavy; posterior border concave; shell becoming very thin at the margins; exterior surface, marked by fine wavy concentric lines of growth which are cut transversely by slight depressions or partings of the shell; interior smooth, corneous.

Dimensions—Length, 38mm.; width, 42mm.; height, 10mm.

This species occurs in the Hesperonis beds of the Niobrara. It was collected from the outcrops on the Smoky Hill river in the Kansas area.