
**NEW ECHINODERMS FROM THE MAQUO-
KETA BEDS OF FAYETTE
COUNTY, IOWA**

BY

**ARTHUR WARE SLOCOM
AND
AUGUST F. FOERSTE**

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NEW ECHINODERMS FROM THE MAQUOKETA BEDS OF FAYETTE COUNTY, IOWA

The specimens on which this second paper¹ on the paleontology of the Maquoketa Beds of Iowa is based, are taken from four collections, viz.: The Field Museum of Natural History of Chicago; The State University of Iowa, Walker Museum of The University of Chicago and the private collection of Mr. A. G. Becker of Clermont, Iowa, part of whose collection is now on deposit at Walker Museum. Part of the Field Museum specimens and nearly all of the Walker Museum specimens were donated by Mr. Becker. The balance of the Field Museum specimens and all of the University of Iowa specimens were collected by Mr. Slocum.

It was originally intended to have two papers on the Echinoderms, one on the Crinoids by Mr. Slocum followed by one on the Cystoids by Doctor Foerste, but as the work of preparation progressed it was found very desirable to have the benefit of Doctor Foerste's knowledge of certain genera of the crinoids, so at the request of Mr. Slocum, he agreed to take, besides the cystoids, two genera of crinoids. On account of this change, it was thought best to combine the two papers as parts one and two of a paper on "The Echinoderms." An unpublished description of a *Pleurocystites* from this horizon and locality, by Ulrich and Kirk, is included in part two.

¹The first paper is on the Trilobites, Field Mus. N. H., Geol. Series, 1913, vol. 4, pp. 43-83 and republished with slight revision, Iowa Geol. Survey, 1915, vol. XXV, pp. 187-237.

PART ONE

BY ARTHUR WARE SLOCOM

Classification and Terminology

The classification of the Crinoids prepared by Mr. Frank Springer and given in the revised English edition of Zittel's Textbook of Palæontology, 1913, is followed in this paper, and for definitions of the various orders and families, the reader is referred to that work. The terminology may be stated as follows:

Crinoid: A normal crinoid consists of a crown attached by its base to a stem or column, which is fixed to a solid body by a rootlike attachment.

Test or theca: The outer shell, composed of plates united by more or less close sutures.

Stereom: The shell structure or the material of which the test is composed, usually calcium carbonate.

Crown: All of the crinoid above the stem. It includes the calyx and the arms.

Calyx: The body of the crinoid without the free arms or stem. It includes the dorsal cup and ventral disc or tegmen, and within it are enclosed the more important organs of the body.

Dorsal Cup: That part of the calyx below the point of attachment of the free arms. It is usually more or less cup-shaped and is composed of two or more rows of plates having a more or less complete pentamerous symmetry.

Ventral Disc, Tegmen, Dome, etc.: That part of the calyx above the point of attachment of the free arms. It is made up of plates more or less regularly arranged and contains the mouth and usually the anal opening.

Base: That part of the dorsal cup lying between the radial plates and the stem. It consists of a single row of plates, the basals, in a monocyclic base, and of two rows of plates, the basals and infrabasals, in a dicyclic base.

Rays or Brachials: The series of plates which rest upon the basals and extend up to and form the arms. The first plate

is always a part of the dorsal cup, the others may or may not be a part of the cup. There are five of these rays, except in the Zophocrinidae, and they are designated as follows: (Figs. 55 and 56) (1) *right posterior ray*, (2) *right anterior ray*, (3) *anterior ray*, (4) *left anterior ray*, and (5) *left posterior ray*.

Interbrachial areas (iBr^2): The plates in camerate crinoids situated between the rays.

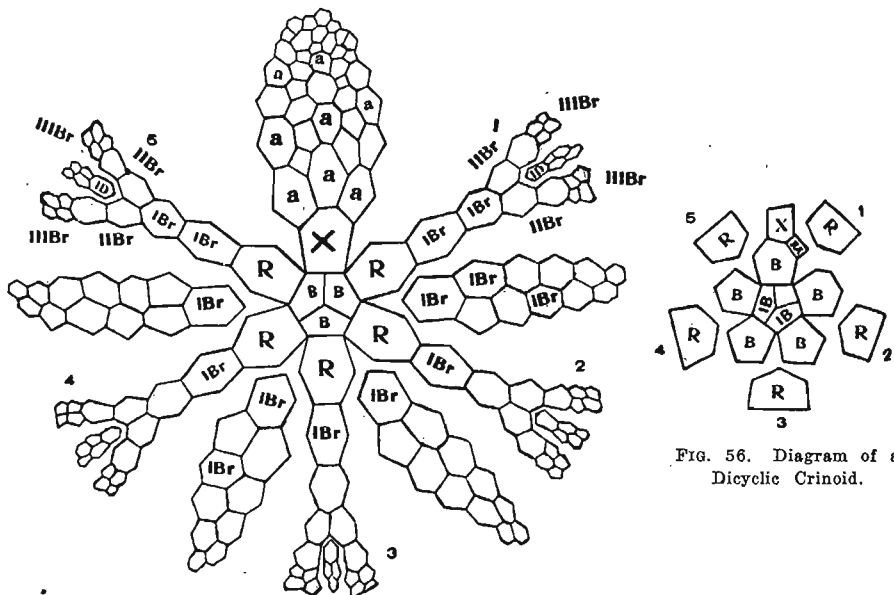


FIG. 55. Diagram of a Monocyclic Camerate Crinoid.

Anal, azygous or posterior interradius Xaa: The area situated between the right and left rays and leading up to the anal opening.

Basals (B): The circle of plates directly below the radials and alternating with them. In a monocyclic base they join the column.

Infrabasals (IB): The first row of plates in a dicyclic base. They separate the basals from the column and are radial in position.

Radials (R): The first plate of each ray, usually resting on the basals. In some families part of the radials are divided horizontally. The parts of these plates are called *superradi-*

²The letters in parentheses refer to those of figures 55 and 56.

als (Rs) and *inferradials* (Ri) respectively. (Fig. 58, p. 337.)

Primibrachs or Costals (IBr): Those plates of each ray extending from the radials, on which they rest, up to the first bifurcation.

Secundibrachs or Distichals (IIBr): All plates of each ray between the first and second bifurcations.

Tertibrachs or Palmers (IIIBr): All plates of each ray between the second and third bifurcations.

Intersecundibrachs (ID): Any plates situated between the secundibrachs.

Anal plate (X): First plate of the anal interradius. It often rests upon the posterior basal and is in line with the radials or nearly so.

Radianal (RA): A plate resting within the angle formed by two basals and below the right posterior radial plate. It joins the anal plate on the left and occupies the position of an inferradial.

Interbrachials (iBr): Any plates of the interbrachial areas.

Pinnules or armllets: Small jointed appendages which are given off alternately from opposite sides of the arms and usually are similar to the arms in appearance.

Stem or Column: The jointed appendages which connect the crown of a crinoid with the *attachment base*. It is composed of *segments* or *columnals* which are pierced by an *axillary canal* through which passes the ligament which holds the stem together. When speaking of the form of a stem, the transverse section is meant.

Brachioles: Food grooves on the ventral surface, leading to the mouth.

Distal: Farthest from the stem.

Proximal: Nearest to the stem.

Lateral: Pertaining to the side.

Archetype: The original form from which a class of related forms in plants or animals may be supposed to have descended.

Genotype: The species upon which a genus is based.

Primary types: All the specimens used by the author of a species for the description or figures.

a) Cotypes: All the specimens described or figured by the author of a species, provided no holotype is selected.

b) *Holotype*: The one of the types chosen and indicated by the author.

c) *Allotype*: A specimen selected by the author and illustrating another part of the organism from the holotype.

d) *Paratypes*: All specimens, other than the holotype or allotype, used in the description.

Supplementary or Hypotypes: Specimens described or figured after the original description to complete or correct it.

a) *Plesiotype*: A specimen from any locality used for a re-description or refiguring of the species.

b) *Metatype*: A specimen from the type locality and horizon and identified by the author.

c) *Plastotype*: An artificial cast or replica of a type.

Authors differ widely in the use of the terms "mold," "cast" and impression," but as used in this paper they may be defined as follows:

Natural mold: A cavity in the rock, or matrix, formed by natural causes, around an organism while the rock was plastic. The external form of the organism is thus preserved.

Natural cast: The rock filling of the internal or visceral cavity of an organism, the shell of the organism having served as a mold. In many cases the shell is afterwards dissolved out, leaving the mold and cast in position. In such cases the space between the two indicates the thickness of the shell.

Impression: An artificial cast, made in a natural mold, which shows the external features of the organism. Many kinds of materials have been used for making impressions; among them may be mentioned plaster, dental wax, printing roller composition and vulcanized rubber. The methods of making impressions from the two latter substances have been previously described by the writer.³

Descriptions of Genera and Species

Family RHODOCRINIDAE Roemer.

When this family was proposed by Roemer the distinguishing characters given were those of *Rhodocrinus*, the only genus then referred to the family. Some of these characters are of generic rather than of family importance and the description has since been somewhat modified.

³Science 1907, N. S. vol. XXV, p. 591.

The last discussion of the family, so far as is known to the writer, was that of Wachsmuth and Springer in 1894, but not published until 1897, at which time only ten Ordovician species, belonging to four genera, were recognized; of these *Rhodocrinus asperatus* Billings (now *Deocrinus asperatus*) had been for nearly forty years the only member of this family reported from an horizon lower than the Trenton. In December, 1894, Miller and Gurley described three species of *Archaeocrinus*, viz: *A. peculiaris*, *A. asperatus* and *A. parvus*, and in the following year, *A. knoxensis*. All these except *A. peculiaris* belong to the genus *Diaboloocrinus* and are here so referred. In 1907 Hudson proposed *Deocrinus* and *Hercocrinus*; the former to receive *Rhodocrinus asperatus* Billings and the latter to receive three new species. In 1916 Weller described *Atactocrinus wilmingttonensis*, gen. et sp. nov., which made, with those described in this paper, a total of twenty-one Ordovician species, divided among seven genera. More than half of these species are of Chazyan age.

The following is a complete bibliography of the Ordovician species and the table gives their vertical distribution.

Archaeocrinus? *delicatulus* Hudson.

A. delicatulus Hudson, Bull. New York State Mus., 107, p. 129, f. 8, 1907. Chazyan

Archaeocrinus desideratus W. R. Billings.

A. desideratus W. R. B., Trans. Ottawa Field Nat. Club, 2, p. 249, 1885; W. and Sp., Mem. Mus. Comp. Zool. Harvard, 20, p. 257, pl. 10, f. 4 a, b, 1897; Bather, Treatise on Zool., pt. 3, p. 200, f. 125, 1900. Trenton.

Archaeocrinus lacunosus (Billings).

Glyptocrinus lacunosus Bill., Geol. Surv. Canada, Rep. Prog. 1853-1856, p. 261, 1857; idem, Decade 4, p. 61, pl. 8, figs. 3a-3e, 1859.

A. lacunosus W. and Sp., Proc. Acad. Nat. Sci. Philadelphia, 1881, p. 364; Mem. Mus. Comp. Zool. Harvard, 20 p. 255, pl. 10, fig. 1, 1897; Springer, Mem. Geol. Surv. Canada, 15P, p. 11, 1911. Trenton.

Archaeocrinus microbasilis (Billings).

Thysanocrinus (*Rhodocrinus*) *microbasilis* Bill., Geol. Surv. Canada, Rep. Prog. for 1853-1856, p. 264, 1857.

Rhodocrinus microbasilis Bill., Geol. Surv. Canada, Decade 4, p. 63, pl. 6, fig. 2, 1859.

A. microbasilis W. and Sp., Proc. Acad. Nat. Sci. Philadelphia, p. 364, 1881, Mem. Mus. Comp. Zool. Harvard,

- 20, p. 256, pl. 10, figs. 2a - c, 1897; Springer, Mem. Geol. Surv. Canada, 15P, p. 11, 1911. Trenton.
- Archaeocrinus obconicus* Slocum. Maquoketa.
- A. *obconicus* sp. nov. This paper. Maquoketa.
- Archaeocrinus peculiaris* Miller and Gurley.
- A. *peculiaris* M. and G., Bull. Illinois St. Mus. Nat. Hist., 5, p. 17, pl. 2, figs. 1-3, 1894; Miller, North American Geol. Pal., 2d. App., p. 734, figs. 1209-1300, 1897. Chazyan.
- Archaeocrinus pyriformis* (Billings).
- Thysanocrinus* (*Rhodocrinus*) *pyriformis* Bill., Geol. Surv. Canada, Rep. Prog. for 1853-1856, p. 262, 1857.
- Rhodocrinus pyriformis* Bill., Geol. Surv. Canada, Decade 4, p. 61, pl. 6, figs. 1a - d, 1859.
- A. *pyriformis* W. and Sp., Proc. Acad. Nat. Sci. Philadelphia, 1881, p. 364; Mem. Mus. Comp. Zool. Harvard, 20, p. 255, pl. 10, figs. 3a-b, 1897; Grabau and Shimer, North American Index Fossils, 2, p. 550, 1910; Springer, Mem. Geol. Surv. Canada, 15P, p. 11, 1911. Trenton.
- Atactocrinus wilmingttonensis* Weller.
- A. *wilmingttonensis* Weller, Contrib. Walker Mus., Univ. of Chicago, vol. 1, No. 10, p. 239, pl. 15, figs. 1-10, 1916. Richmond.
- Deocrinus asperatus* (Billings).
- Rhodocrinus asperatus* Bill., Geol. Surv. Canada, Dec. 4, p. 27, pl. 1, figs. 4a - 4e, 1859.
- Archaeocrinus asperatus* W. and Sp., Proc. Acad. Nat. Sci. Philadelphia, 1886, p. 301.
- Deocrinus asperatus* Hudson, Bull. New York St. Mus. 107, p. 122, fig. 5, pl. 8, 1907. Chazyan.
- Diaboloocrinus asperatus* (Miller and Gurley).
- Archaeocrinus asperatus* M. and G., Bull. Illinois St. Mus. Nat. Hist. 5, p. 19, pl. 2, figs. 7-9, 1894; Miller, 2d. App., North American Geol. Pal., p. 734, fig. 1296, 1297, 1897.
- D. *hieroglyphicus* W. and Sp., Mem. Mus. Comp. Zool. 20, p. 252, pl. 10, figs. 5a-c, 1897. Chazyan.
- Diaboloocrinus knoxensis* (Miller and Gurley).
- Archaeocrinus knoxensis* M. and G., Bull. Illinois St. Mus. Nat. Hist. 6, p. 34, pl. 3, figs. 12-15, 1895.
- Diaboloocrinus parvus* (Miller and Gurley).
- Archaeocrinus parvus* M. and G., Bull. Illinois St. Mus. Nat. Hist. 5, p. 21, pl. 2, figs. 26-28, 1894; Miller, North American Geol. Pal., 2d. App. p. 734, fig. 1298, 1897. Chazyan.

- Diabolocrinus perplexus** Wachsmuth and Springer.
D. perplexus W. and Sp., Mem. Mus. Comp. Zool. Harvard, 20, p. 250, pl. 11, figs. 1a, b, 1897. Chazyan.
- Diabolocrinus vesperalis** (White).
Rhodocrinus vesperalis White, Proc. U. S. Nat. Mus., 2, p. 259, pl. 1, figs. 11, 12, 1880; 12th Ann. Rpt. U. S. Geol. Surv. Terr., p. 129, pl. 35, figs. 4a-b, 1883.
D. vesperalis W. and Sp., Mem. Mus. Comp. Zool. Harvard, 20, pp. 251, 262, pl. 11, figs. 1c-d, 1897; Wood, Bull. U. S. Nat. Mus., 64, p. 104, 1909.
- Gilbertsocrinus americanus* Troost, Proc. Am. Asso. Adv. Sci. 2, p. 61, 1850 (nom. nud.).
- Lyriocrinus sculptilus* Miller. (not Hall), Jour. Cin. Soc. Nat. Hist. 5, p. 83, pl. 3, figs. 6a, b, p. 117, 1882.
- Archaeocrinus sculptus* W. and Sp., Proc. Acad. Nat. Sci. Philadelphia, 1885, p. 320. Miller, North American Geol. Pal., p. 225, fig. 250, 1889. Chazyan.
- Hercocrinus beecheri** Hudson.
Lyriocrinus beecheri Hudson, Bull. New York St. Mus. 80, p. 277, figs. 4, 5, pl. 3, figs. 1-4, 1905.
H. beecheri Hudson, Bull. New York St. Mus. 107, p. 127, 1907. Chazyan.
- Hercocrinus elegans** Hudson.
H. elegans Hudson, Bull. New York St. Mus. 107, p. 125, pl. 9, text fig. 6, 1907; Grabau and Shimer, North American Index Fossils, 2, p. 549, 1910. Chazyan.
- Hercocrinus ornatus** Hudson.
H. ornatus Hudson, Bull. New York St. Mus. 107, p. 127, pl. 10, text fig. 7, 1907; Grabau and Shimer, North American Index Foss. 2, p. 549, 1910. Chazyan.
- Maquoketocrinus ornatus** Slocum.
M. ornatus sp. nov. This paper. Maquoketa.
- Raphanocrinus gemmeus** Hudson.
R. gemmeus Hudson, Bull. New York St. Mus. 80, p. 280, fig. 6, pl. 2, figs. 1-5, 1905. Chazyan.
- Raphanocrinus sculptus** (Miller).
Glyptocrinus sculptus Miller, Jour. Cincinnati Soc. Nat. Hist. 5, p. 37, pl. 1, fig. 2, 1882; idem, 6, p. 224, 1883; James, idem, 19, p. 116, 1897.
R. sculptus W. and Sp., Mem. Mus. Comp. Zool. Harvard, 20, p. 260, pl. 10, fig. 3, 1897. Richmond.
- Raphanocrinus subnodosus** (Walcott).
Glyptocrinus? subnodosus Walcott, 35th. Rept. New York St. Mus., p. 208, pl. 17, fig. 3, 1883; Miller, Jour. Cincinnati Soc. Nat. Hist. 6, p. 227, 1883.
R. subnodosus W. and Sp., Proc. Acad. Nat. Sci. Philadel.

phia, p. 321, 1885; Mem. Mus. Comp. Zool. Harvard, 20, p. 259, pl. 11, fig. 2, 1897. Trenton.

	CHAZYAN	TRENTON	EDEN AND MAYSVILLE	RICHMOND	TOTAL
Archaeocrinus	2	4		1	7
Atactocrinus				1	1
Deocrinus	1				1
Diaboloocrinus	5				5
Hercocrinus	3				3
Maquoketocrinus				1	1
Raphanoocrinus	1	1		1	3
Total	12	5		4	21

Lack of representation in the Eden or Maysville is significant. Although, of course, no one would care to predict that no species referable to this family will ever be found in these beds, there is reason to believe that in many Richmond forms the line of descent from the Trenton is not through the Maysville. Mrs. McEwan⁴ finds this recurrence of Trenton forms in the Richmond also to be well illustrated in the Platystrophias.

The family may be defined as follows:

Dicyelic crinoids with lower brachials and interbrachials forming an important part of the dorsal cup. Radials separated all around by interbrachials. Infrabasals five; basals five. Anal area slightly and in many cases not at all different from those of the other interrays.

ANALYSIS OF ORDOVICIAN GENERA OF THE RHODOCRINIDAE

I. Anal interradius generally with additional plates.

1. Arms biserial, branching.

A. First interbrachial surrounded by supplementary plates.

a. Interbrachials not continuous onto the tegmen; secundibrachs pinnulate, some of the pinnules incorporated in the dorsal cup.

Tegmen composed of numerous small plates forming a basin, with margins at the arm bases; a central mound contains the anus; first secundibrachs bear a large pinnule which meets its neighbor over the interbrachials; interbrachial areas not uniform; anal

⁴Proc. U. S. Nat. Mus. 56, pp. 383-448.

- area not clearly distinguishable.....
Hercocrinus
 Anus subcentral at the end of a tube;
 anal interradius differing but little
 from the others; intersecundibrachs
 present.....Deocrinus
 b. Interbranchials continuous onto the teg-
 men; anus at the end of a tube; no in-
 tersecundibrachs Diabolocrinus
 B. First interbranchials not surrounded by supple-
 mentary plates; anus without a tube; inter-
 branchials numerous, continuous onto the
 tegmen; intersecundibrachs usually present
 Archaeocrinus
 2. Arms uniserial, not branching.....Raphanocrinus
 II. Anal interradius without additional plates, pentamerous
 symmetry not interrupted.
 a. Secundibrachs not incorporated in the dorsal cup;
 interbranchials continuous onto the tegmen.....
Maquoketocrinus
 b. Basals, radials and first interbranchials about equal;
 right and left anterior interbranchials not in con-
 tact with the basals.....Atactocrinus

Genus **ARCHAEOCRINUS** Wachsmuth and Springer.

ARCHAEOCRINUS OBCONICUS sp. nov., Plate XXIX, figs. 10-13.

Type Specimens Nos. P.17106 and P.11265 Field Museum, Chicago.

The calyx is obconical or subovate, slightly constricted at the arm-bases, greatest width at the height of the second primi-brachs, which is about equal to its length. Base dicyclic with a pentalobate canal. The surface of the plates is covered with rather indistinct, crowded, parallel, raised striae. On the infrabasals the striae are parallel to the lateral edges of the plates; on the basals, radials, interbranchials, etc., they are at right angles to the sutures and divide the surface into more or less regular rhombs whose shorter axes are the lengths of the various edges of the plates and whose longer axes connect the centers of the adjoining plates. Sutures very inconspicuous. Aside from the striae, there are five rather broad, ill-defined ridges which originate at the columnar facet, follow the sutures between the infrabasals and extend across the basal plates, forming an obtusely pentagonal base. The surface of the nat-

ural cast indicates that the inner surface of the plates bore many irregularly placed nodes and that the median line of each ray was marked by a rather wide groove, but no indication of either the nodes or the grooves is visible on the outer surface of the plates.

Infrabasals five, equal, higher than wide. Basals five, heptagonal, truncated above at their meeting with the first interbrachials. The basals are the largest plates in the calyx and with the infrabasals form a cup having a width about twice its height. Radials five, pentagonal, except the left posterio-lateral, which is hexagonal, having one side in contact with the second row of plates in the anal interradius, pointed below. First primibrachs hexagonal, about the size of the radials. Second or axial primibrachs about half the size of the first, heptagonal, bearing on their superior edges the secundibrachs, only the first pair of which are preserved in the type specimen but, as these give no evidence of arm-facets, there probably were others separated by intersecundibrachs. First interbrachials heptagonal, somewhat larger than the radials, in contact with the basals, thus separating the radials from each other, followed by two plates in the second row and three each in the third and fourth rows. The anal area is wider than the other interbrachial areas; the anal plate is followed by three plates in the second row. The upper part of the anal area is missing in this specimen.

Measurements:

Holotype:	Diameter on anterior axis	21.0 mm.
	Diameter on lateral axis	18.0 mm.
	Diameter at top of basals	15.2 mm.
	Height to top of axillary primibrach	21.6 mm.
Allotype:	Height to top of basals	7.1 mm.
	Diameter at top of basals	17.1 mm.
	Height to top of basals	8.6 mm.
Estimated measurements of a complete calyx:		
	Diameter on anterior axis	23.0 mm.
	Height over all	24.0 mm.

This species resembles *A. pyriformis* (Bill.), from the Trenton of Canada, in having the infrabasals visible in a side view of the calyx instead of being situated in a concave base, as in other species. It differs from *A. pyriformis* in having two pairs of secundibrachs in each ray instead of six pairs, in the ornamentation and the relative size of the various plates.

The holotype is a nearly complete natural cast in chert (P. 17106) on which the sutures are well marked; the allotype (P. 11265) has the following plates preserved: the infrabasals, the basals, two radials and an interbrachial. Both specimens are in the collections of the Field Museum of Natural History. The former was donated by Mr. A. G. Becker and the latter was collected by the writer.

Horizon and locality.—Lower Maquoketa beds at Clermont.

Genus **MAQUOKETOCRINUS** gen. nov.

Base dicyclic. Pentamerous symmetry complete; anal area not distinguishable from the other interbrachial areas. Infrabasals five. Basals heptagonal, truncated above where they join the first interbrachials thus separating the radials from each other. Radials pentagonal, pointed below. Primi-brachs two in each ray, the second or axillary plate having arm-facets on its distal edges. Secundibrachs not incorporated in the dorsal cup. Column, judging from the columnar facet, round with a pentagonal canal.

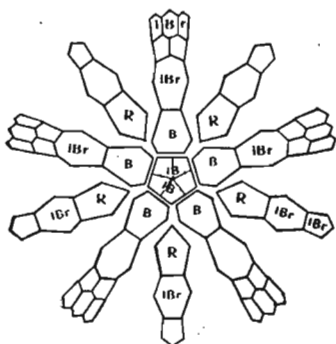


FIG. 57. Diagram of *Maquoketocrinus*

This genus belongs to the group of the Rhodocrinidae having no extra plates in the anal area. The group includes the American genus *Lyriocrinus*, from the Silurian, and the European genera *Anthemocrinus* from the Silurian and *Rhipidocrinus* from the Eifel. This genus is distinguished from the other members of the group by the absence of secundibrachs in the dorsal cup.

MAQUOKETOCRINUS ORNATUS sp. nov., Plate XXX, figs. 12, 13.

Type specimen No. P. 16840 Field Museum, Chicago.

The calyx is cup-shaped, height equal to its diameter at arm-bases, having a flat base with sides expanding at first abruptly and then gently to the arm-bases. Base dicyclic. Pentamerous symmetry complete, anal area not distinguishable from the other interbrachial areas. The plates of the dorsal cup are slightly convex and are ornamented with raised lines usually radiating from a central node and meeting the sutures at right

angles, where they join similar lines from adjoining plates; many of these lines become obsolete before reaching the central nodes. Besides these radiating lines there are ridges composed of two or more parallel, raised lines which originate at a point a little below the center of each basal plate and extend laterally until they meet the ridges from the adjoining basals, thus forming a transverse ridge subparallel to the proximal edges of the basal plates. Two similar ridges extend obliquely from these subcentral points to the centers of the adjoining radials where they unite with ridges from another basal and continue along each ray, becoming more prominent until, at the distal edges of the axillary primibrachs, they form a pronounced protuberance which bears the arm-facets. Sutures indistinct.

Infrabasals five, equal, about half of their length extending beyond the column. Together they form a flat pentagonal disc, with a slight concavity for the reception of the stem. Basals five, equal, a trifle smaller than the radials, heptagonal, with their distal edges truncated where they join the first interbranchials. Radials five, equal, pentagonal, about equal in size to the first interbranchials. Primibrachs two to each ray; the first hexagonal, nearly as large as the radials; the second an axillary plate, pentagonal, higher than wide, bearing on its superior edges oblique facets for the attachment of the free arms. Secundibrachs not incorporated in the dorsal cup. First interbranchials about equal in size to the radials, resting on the basals, thus separating the radials from each other, followed by two smaller plates in the second row and others in the third row, which appear to connect with the plates of the tegmen. Column, judging from the columnar facet on the infrabasals, round with a pentagonal canal.

The above description is based on a single specimen, the holotype, (P. 16840) in the collections of the Field Museum of Natural History, a nearly complete dorsal cup having the arms, tegmen and stem missing.

Horizon and locality.—Lower Maquoketa shale, Clermont. Collected and donated by Mr. A. G. Becker.

Family **CYATHOCRINIDAE**Subfamily **CARABOCRININAE**Genus **POROOCRINUS** Billings

“*Generic Characters*.—Cup composed of three series of plates, with one or more small interradials on one side and with a number of poriferous areas similar to pectinated rhombs of the Cystidea.

“In this genus there are five pelvic plates, five subradials, and five first primary radials alternating with each other, as in *Poteriocrinus*, *Cyathocrinus* and other allied genera. The principal new character upon which the genus is founded consists in the presence of poriferous areas.” (Billings, *Geol. Surv. Canada, Rpt. Prog.*, 1853-56, p. 279, 1857.)

In his discussion of *P. conicus*, Billings refers to the poriferous areas as probably having the same function as pectinated rhombs although differing in form and position on the plate. He says the pores consist of fine elongate parallel slits, which appear to penetrate the plates.

Zittel considered the so-called poriferous areas to be pectinated rhombs and referred the genus to the cystidean family *Cryptocrinidae*. (*Handb. Pal.*, I, p. 420, 1879.)

Bather recognized that the angles of the plates consisted of series of folds and not of openings through the plates. He considered *Porocrinus* to be a dicyclic, Inadunate crinoid and placed it in the family *Palæocrinidae*. (*Treatise on Zoology*, pt. III, p. 172, 1900.)

Springer places *Porocrinus* in the subfamily *Carabocrininae* of his *Inadunata Fistulata*. (*Zittel-Eastman Textb. Pal.*, p. 217, 1913.)

The generic characters, as now understood, may be stated as follows: Calyx obconical to globular; base dicyclic; column composed of thin segments rapidly decreasing in size from the calyx. Infrabasals five; basals five; radials five with narrow, well defined facets; arms uniserial, not branched; axial canal not separate from the ventral groove; anal plate in line with the radials; radianal rhomboidal, not separating the right posterior radial from the right posterior lateral basal. Tegmen composed of five rather thick orals, the posterior one a madreporite, which support the ambulacra on their adjacent

edges and surround the pentagonal peristome; anal opening situated between the anal, posterior oral and the superior lateral edges of the posterior radials, no anal tube. Deep folds lie at the angles of the plates directed towards the angles and not passing at right angles across the sutures nor forming openings through the plates. (See Pl. XXX, fig. 14.)

POROCRINUS FAYETTENSIS sp. nov., Plate XXIX, figs. 14-22; Pl. XXX, fig. 14.

The type material upon which this species is based consists of five complete calyces free from the matrix, one calyx attached to the matrix and having parts of an arm and stem in position, a complete natural cast, two pieces of stem, and a number of separate plates; of these, the holotype (U. C. 24700), is in the collections of Walker Museum, of the University of Chicago; three calyces (P.11262, 16935, 17000), a natural cast (P.16841) and stems (P.11135) are in the collections of the Field Museum of Natural History; two calyces (Nos. 3694, 3695) are in the collections of the State University of Iowa.

The calyx is subglobular, aside from the ornamentation. The plates of the dorsal cup, above the infrabasals, are ornamented with central nodes from which rounded ridges extend to the middle of each edge of the plate and join the ridges from the adjoining plates. On the infrabasals, the ridges cross the plates, forming the edges of the columnar facets, then follow the sutures upward joining the ridges on the basals. The angles of the plates are made up of series of folds; the middle fold bisects the angle of the plate and the others are parallel to it. Sutures not situated in grooves; surface of plates finely granular. Arms five, not branched. Column obtusely pentagonal, diminishing rapidly in size from the calyx; segments thin, crenulated on their superior edges; canal roundly pentalobate (fig. 22). The natural cast is in the form of an elongate spheroid slightly flattened laterally. The impressions of the folded areas at the corners of the plates, the sutures, and the openings through the ventral disc are well preserved.

Infrabasals five, about equal in length and width, forming a

shallow cup. Basals five, the two posterior ones heptagonal, the others hexagonal, about equal in size to the radials. Radials five, the anterior and two antero-laterals hexagonal, the two postero-laterals heptagonal; arm-facets elliptical, occupying not more than one-fourth the width of the radials. Radial quadrangular, resting on the edges of two basals and supporting on its superior edges the right posterior radial and the anal plate. Anal plate pentagonal, resting on the posterior basal and the radial, between the two posterior radials. Anal opening in line with the arm-bases and bordered by the thickened, excavated edges of the two posterior radials, the posterior oral and the anal plate. No anal tube. The tegmen is covered by five thick orals which support the ambulacra and surround the peristome, which appears to be somewhat smaller than the anal opening. The posterior oral is a madreporite, being pierced by a hydropore.

Measurements.—As all the specimens observed have the lateral diameter of the calyx shorter than the anterior, it would seem to be the natural form of the calyx. Most of the specimens are complete and show no evidence of being crushed.

	HEIGHT	ANTERIOR DIAMETER	LATERAL DIAMETER
The holotype	9.8 mm.	9.4 mm.	8.4 mm.
The cast	8.5 mm.	7.9 mm.	7.5 mm.

Single plates belonging to this species were found which are nearly twice the size of the corresponding plates on the types.

In form and general appearance this species somewhat resembles *P. pentagonis* W. & M. but the basal plates are smaller in proportion to the radials, the calyx is rounder at the base and the stem is pentagonal instead of round, as in that species. *P. crassus* M. & W., reported from the Maquoketa beds of Illinois, possesses little resemblance to this species; the sutures are situated in grooves, the folded areas are sunken and the calyx is much more robust.

Horizon and locality.—Lower Maquoketa shale, Clermont and Bloomfield.

Family **DENDROCRINIDAE** Bather
Genus **DENDROCRINUS** Hall

Calyx obconical, unsymmetrical. Infrabasals five, equal, extending beyond the column. Basals five, large; four, hexa-

gonal, and equal in size, the posterior one heptagonal, truncated by the anal plate. Radials five; simple in four rays, about equal in size, the right posterior one much smaller, separated from the basals by the radianal. Anal plate large, in line with the radials. Arms long and branching; ambulacral furrows deep; no pinnules. Ventral sac strongly developed, composed of numerous small, hexagonal, alternately interlocking plates of about equal size. Column usually pentagonal.

DENDROCRINUS KAYI sp. nov., Plate XXIX, figs. 1-4.

Calyx irregularly obpyramidal, increasing abruptly in size from the columnar facet to the middle of the basals where it is pentangular in transverse section, while the transverse section at the arm bases is hexangular, the angles being furnished by the five arm bases and the anal ridge. Anal area very wide, the distance between the posterior arms being more than twice that between any other two adjacent arms; this makes the anterior-posterior diameter of the calyx much less than the lateral diameter; height somewhat less than the longer diameter at the arm bases. The calyx is ornamented by several series of ridges, the most prominent of which originate at the columnar facet and follow the direction of the sutures between the infrabasals upward to a point near the middle of the basals where they bifurcate, forming a node, and extend obliquely upward across the radials to the arm bases where they meet ridges from the adjoining basals, except in the right posterior ray where these ridges join on the radianal plate and continue across the radial to the arm base. These ridges are continuations of angles of the column and are most prominent at the base. Another series consists of two or three threadlike parallel ridges which extend transversely between the basal nodes. These with the other series divide the surface of the calyx into a number of more or less concave triangles; three rather indistinct ridges extend inward from the angles and meet at the center of these triangles, which is also the meeting-place of the sutures between the plates. Six parallel ridges connect the arm bases near the tops of the radials but these ridges do not cross the azygous area; on the azygous area a prominent ridge extends upward from the node on the posterior basal across the anal plates up on to the ventral sac. Height of the calyx

at the anterior ray 11.0 mm.; anterior-posterior diameter at arm bases 9.1 mm.; lateral diameter 12.5 mm.

Infrabasals five, equal, pentagonal. Basals five; four hexagonal, about the size of the radials, the posterior basal heptagonal, truncated distally by the anal plate and the largest plate in the calyx. Radials five; three hexagonal, two pentagonal; right posterior radial smaller than the others, being truncated proximally by the radial plate. Together with the left posterior radial it supports the ventral sac. Arm facets prominent, occupying less than half the width of the radials. Arms uniserial, branching, primibrachs three to five in each ray; secundibrachs six to eight pairs; tertibrachs present but number unknown; no pinnules. First anal plate hexagonal, about twice as wide as high, resting on the posterior basal and between the two posterior radials, from whose superior edges rise the plates of the ventral sac. Radial pentangular, resting on the superior edges of the posterior and right posterior basals and supporting the right posterior radial which it separates from the basals. Ventral sac transversely elliptical in section, plates small, hexagonal, width several times their height, grouped in a number of alternately interlocking vertical series; surface ornamented with well defined longitudinal ridges passing along the middle of each series of plates. These ridges are connected by fine threadlike oblique ridges so placed as to give a zigzag appearance. Length of ventral sac unknown, the portion preserved on the holotype extends twenty-seven mm. above the arm bases. Column, judging from the columnar facet, pentangular with a quinquepartite canal. Stems like the one figured are comparatively abundant in the shales in which the holotype was found and as the section of the base of the calyx and that of this column are similar there seems to be little doubt that they belong to the same species. The column is acutely pentagonal in its upper portion and gradually changes to a regular pentagon lower down. The segments of the column are relatively thin and are arranged in pairs consisting of a very thin segment and one about four times as thick with rounded nodes at the angles. The sutures between the segments form wavy lines.

This species somewhat resembles *D. casei* from a similar

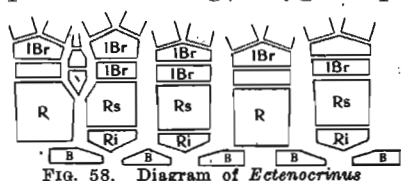
horizon in the Ohio Valley but the ridges are fewer in number and more prominent, the proportions of the height to the width of the calyx are different and the primibrachs and secundibrachs of a much smaller specimen consist of about a half more plates than in this species.

Horizon and locality.—The holotype, the only specimen known, was collected by Mr. A. G. Becker in the Upper Maquoketa shale at Patterson's Springs, near Brainard. The specimen is a part of Mr. Becker's collection but is now on deposit in Walker Museum, The University of Chicago.

Family HETEROCRINIDAE

Genus ECTENOCRINUS S. A. Miller

General form very elongate; calyx small, subcylindrical, moderately expanded; basals five, unequal; radials irregular, four plates in three series before the bifurcation of the free arms, and three in each of the other two series; arms ten, long; pinnules strong; azygous plates three, following each other,



but not in a direct line; vault unknown; column very long, round, tripartite, and attached by an expanded base. Genotype, *E. simplex* (Hall). (Original description, North American Geol. & Pal. p. 242). To this may be added; secundibrachs syzygal, forming pairs of which the distal plate only is pinnulate; anal tube straight and narrow.

ECTENOCRINUS RAYMONDI sp. nov., Plate XXIX, figs. 5-9.

Type specimen number 24701, Walker Museum, The University of Chicago.

The calyx is small, obconical, regularly tapering, height to the top of the radials somewhat less than the width at that place. Surface of the plates smooth, sutures rather inconspicuous, not situated in grooves. Arms ten, subcircular in section, uniserial, composed of plates having their length about half their width and edges nearly parallel near the bifurcation but much shorter and cuneiform farther up. These plates are in pairs of which the distal plate only is pinnulate, the pinnules being on alternate sides of the arm so that there is a pinnule on each side to every four arm-plates. The lateral mar-

gins of the arms are marked with shallow, rounded grooves which are at right angles to the axis of the arms. These grooves are situated on the sutures, and many of them are on alternate sutures but in some cases they are on intervening sutures while in others there are two sutures between grooves. On the first examination these grooves appeared to be sockets for the attachment of the pinnules but upon further study they seem to become obsolete before reaching the ventral margin of the arms where the pinnules are attached and also they are more numerous than the pinnules. (Figs. 8 and 9.) Stem circular, composed of thin segments, gradually diminishing in size from the base of the calyx; canal tripartite.

Basals five, the right posterior lateral regularly pentagonal, the others irregularly so. Radials five, the largest plates in the calyx. The anterior one is hexagonal, the left posterior radial is heptagonal, but neither of these possesses an angle on its proximal edge where it joins the basals. The other three radials are compound, the inferradials are pentagonal, pointed below, width more than twice the height, the superradials are quadrangular except the right posterior which is pentagonal, the extra side on each of the posterior radials is caused by contact with the anal plate. Primibrachs two to each ray, the first rectangular, the second, an axillary plate, pentagonal, both wider than high. Secundibrachs many, either rectangular or cuneiform. The anal series consists of three plates, the first pentangular, resting between the distal edges of the posterior radials, followed by a larger hexangular plate which supports a very small plate which appears to be quadrangular. Other anal plates and the ventral sac are invisible, being covered by the arms.

Measurements.—As the specimen is somewhat crushed laterally, the first measurement is estimated:

Diameter of calyx at top of the radials	6.0 mm.
Diameter of the base of calyx	3.8 mm.
Diameter of stem 10 mm. below the base	2.0 mm.
Height from base to top of radials	4.5 mm.
Height from base to top of axillary primibrachs	7.1 mm.

Of the three known species of the genus, this species approaches *E. grandis* (Meek) from the Eden and Lower Maysville beds of the Ohio Valley. In size, plate formulæ and gen-

eral proportions they are similar but in *E. raymondi* the arm-plates are shorter in proportion to their width and the pinules are more slender. The most conspicuous character is the presence of transverse grooves on the lateral margins of the arms and the fact that the dorsal margins of the arms are arcuate in this species and flattened in *E. grandis*.

The holotype was collected by Dr. P. E. Raymond of Harvard University and the specific name is given in his honor.

Horizon and locality.—Lower Maquoketa limestone at Clermont.

HETEROCRINUS? Plate XXX, figs. 15-17.

A number of attachment bases which seem to belong to the above or a closely related genus are in these collections. All were attached to some object when alive but the larger ones have since been separated. They vary in size from 5 to 28 mm. across their radicular expansions and from 1 to 9 mm. in height. The attachment area for the column is circular, more or less concave in the larger specimens, and marked with well-defined ridges radiating from the center.

The largest specimen observed (fig. 16) is shown natural size. It measured 28 mm. in greatest spread of its radicular expansions and 9 mm. in height; the circular attachment area, which is 9 mm. in diameter and slightly concave, is covered with fine ridges radiating from the axial canal. These ridges increase both by interstitial additions and by bifurcation, some of the ridges bifurcating three times. Near the margin there are eight ridges in a space of 2 mm.

Another specimen (fig. 17), also shown natural size, 13 mm. in spread of its radicular expansions and 3 mm. high, is characterized by its deeply concave attachment area. This area is 5 mm. in diameter, 2 mm. deep and is ornamented with radiating ridges similar to those on the larger specimen.

The shell of an *Orthoceras* bears one attachment base whose radicular expansions have a spread of 10 mm., four bases with a spread of 8 mm., five bases with a spread of 6 mm., one base with spread of 5 mm., and several still smaller elevations which probably represent still younger stages of growth, though their preservation is not such as to permit their identification with certainty. Most of these attachment bases do not exceed 1 mm.

in height but two are from 2 to 2.5 mm. in height. The area for the attachment of the column is, in the case of the larger specimens, from 2 to 2.5 mm. in diameter. Four of these bases are shown in figure 15, magnified three and one-half diameters. The upper one is similar, except in size, to the largest specimen. (Fig. 16.) It measures 8 mm. in width, 2 mm. in height and the diameter of the surface for the attachment of the column is about 2 mm.

Eventually, no doubt, much will be learned regarding these attachment bases of the Heterocrinids, but with our present knowledge, we are unable to connect them with any of the columns or calyces which are associated with them.

Specimens.—Field Museum Nos. P.16882 and 16934.

Horizon and locality.—Lower Maquoketa shales at Clermont.

CRINOID STEMS OR COLUMNS

Associated with the above described crinoids are a quantity of stems. The majority of them are disarticulated columnals but there are also a number of stem fragments in which many columnals are attached. With our present knowledge, there seems to be no way of correlating these columnals with any of the calyces but there are a number of unusual forms among them which seem to be worth describing.

CRINOID COLUMN "A"

This type of stem is characterized by thin, flat columnals, more or less regularly alternating in thickness; serrated suture lines and a profoundly pentalobate axillary canal, each lobe being narrowly obovate in form. The collections contain many fragments of these stems ranging from a single columnal up to thirty or more columnals in length. In general appearance these stems resemble those of genera belonging to the order Flexibilia but several of these specimens have the lower row of plates of the base preserved and in all cases they are five in number and equal. As the base of flexible crinoids consists of three unequal plates, these can hardly be referred to that order. In the specimens of this type of columnals there are three kinds with characters distinct enough to be at least of specific importance.

CRINOID COLUMN "AA", Plate XXX, figs. 1, 2.

This stem is circular, gradually tapering from the top of the row of plates. The surface is smooth except for the serrated suture lines. The columnals are thin and irregularly alternating in thickness. The upper and lower surfaces of the columnals are flat and marked with radiating lines which are deep at the margins, giving crenulated edges to the columnals, and gradually becoming obsolete on approaching the axillary canal. The row of plates, probably infrabasals, are five in number, equal, and together they form a shallow cup with straight sides, somewhat expanding upward. The narrow obovate lobes of the canal are opposite the sutures between these plates, and are somewhat more slender than those in "Ab."

This column is known by four fragments ranging in length from about 7.0 mm. to 20.0 mm. and from 4.7 mm. to 7.6 mm. in diameter. The specimen figured measures: length 11 mm., diameter of upper columnal 7.0 mm., diameter of lower columnal 5.5 mm.

Field Museum P. 16862 and Walker Museum 27042.

Horizon and locality.—Upper Maquoketa shale at Patterson's Springs, near Brainard.

CRINOID COLUMN "AB", Plate XXX, figs. 8-11.

In general appearance this type of column is similar to the preceding; under the magnifier the surface is slightly granular but the most notable difference is in the form of the attached plates (probably infrabasals). These plates are 5.3 mm. wide and 2.3 mm. high along the median line, but only 0.5 mm. to 1 mm. high at the lateral sutures. The surface of these infrabasals curves strongly inward except at their tip where the curvature is distinctly outward. The largest column (fig. 8) has a diameter of 9.0 mm. Though only 5 mm. in length, it consists of ten columnals which show a tendency toward alternation in size. The sutures between the columnals zigzag more or less strongly up and down, about ten crenulations occupying a width of 5 mm. On the surface of the columnals these crenulations appear as lines radiate in direction, but extending inward for a short distance only, beyond which these lines disappear. The central part of the flat face of the columnals is

sparsely and irregularly granulate or smooth. The axial canal is five-rayed, the individual rays being 0.8 mm. long, and very narrowly obovate in form. The rays coincide in position with the suture lines between the infrabasals. The longest column at hand is 21 mm. in length (fig. 11). It widens gradually from a diameter of 4.2 mm. at the base to 6 mm. at the top. Within this length the columnals alternate only slightly in height along the lower third of the column; along the middle third they alternate more distinctly; and along the upper third they alternate strongly.

This column is known by six fragments and thirteen single columnals. Field Museum P. 11265, Walker Museum 24702, and University of Iowa 3681, 3684.

Horizon and locality.—Lower Maquoketa shale at Clermont and Bloomfield.

CRINOID COLUMN "Ac", Plate XXX, figs. 3-7.

This column, while resembling the two preceding forms in having serrated suture lines and the profoundly lobed axial canal, differs from them in having a pustulose surface and in the size and shape of its columnals. In the upper part of the column (fig. 4) the columnals alternate, not only in thickness but the thicker one of the pair is also larger. Farther down in the column this arrangement changes (fig. 7) so that the columnals are in series of fours, consisting of a thick columnal larger than the others and three thin ones of the same size, the middle one of the three being thicker than the other two. The flat surfaces bear shallow rounded radiating furrows, which are visible near the margins only, forming a serrated suture line. The column is circular, the surface is evenly pustulose and the canal is profoundly pentalobate. (Fig. 6.)

The infrabasal plates of this species are intermediate in form between the two preceding species. These plates are five in number, equal, and form a shallow cup whose diameter does not exceed that of the top columnal; the median portion of each plate bends inward but does not curve outward again at the tip as is the case in "Ab."

Thus we find three distinct types of infrabasal plates; both of those from the Lower Maquoketa beds curve inward, although one also curves outward again at the tip of the plate,

while the form from the Upper beds expands upward continuing the expansion of the column. The figures are natural size and the distinguishing characters are well shown.

This column is known by two fragments (figs. 3, 4) having the plates of the base of the calyx attached, one fragment farther down in the column (figs. 5, 7) consisting of eighteen columnals and about fifteen unattached columnals, ranging in diameter from 6 mm. to 13 mm.

Field Museum P.11264, University of Iowa 3677, Walker Museum 24703.

Horizon and locality.—Lower Maquoketa shales at Clermont.

ATACTOCRINUS ? COLUMNALS, Plate XXX, figs. 20-31.

The most abundant forms of crinoid remains in these beds are the variously shaped, beadlike columnals which are illustrated. They appear to be congeneric with those described by Weller⁵ from a similar horizon at Wilmington, Illinois, and doubtfully referred to the above genus. The surface ranges from granular to smooth in various parts of the columnal. The axillary canal is circular or nearly so.

These columnals may be divided into two kinds: (1) Those having flat upper and lower surfaces; these may be lozenge-shaped, such as the group in figure 31 or may have its height equal to its diameter, as the upper columnal in figure 20, which was attached to the base of the calyx, and whose upper surface shows the impression of the lower row of plates. (2) Those of the more beadlike forms which have a deep, almost hemispherical concavity on their upper and lower surfaces. These forms vary from very oblate spheroids to spheroids, spheres, cylinders with rounded corners, ellipsoids or spindle-shapes, etc. As the surface ornamentation of both these kinds is granular near the middle and smooth above and below, there seems to be little doubt that they all belong to the same genus; besides several columnals have been found in which the upper surface is nearly flat and the lower surface is concave, thus joining both kinds in the same column (see second columnal from the top of figure 20). Columnals as unlike as these are known to exist in the same column, as Springer⁶ illustrates

⁵Contr. to Walker Museum Vol. 1, No. 10, p. 239, 1916.

⁶Crinoidea Flexibilia, Pl. V.

Mespilocrinus in which the columnals are lozenge-shaped in the upper part of the column and spindle-shaped farther down. The figured specimens are Walker Museum 24704, others are Field Museum P.18525, and University of Iowa 3679.

Horizon and locality.—Lower Maquoketa shale at Clermont and Bloomfield.

Acknowledgements

The writer is under obligations to Dr. O. C. Farrington, Curator of Geology, Field Museum of Natural History of Chicago, for the loan of specimens from the collections of that institution, also to Mr. A. G. Becker of Clermont, Iowa, for the loan of specimens from his private collection and for assistance in collecting in the field.

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WALKER MUSEUM,
THE UNIVERSITY OF CHICAGO.

PART TWO

BY AUGUST F. FOERSTE

CARABOCRINUS Billings

Dorsal cup consisting of eighteen plates, including five infrabasals, five basals, five radials, and three plates belonging to the anal series. Of the latter, the chief plate *X* is similar in shape and size to the radials, and is intercalated in the same row as the latter. The other two plates are intercalated in the same row as the basals; conjointly they exceed moderately in height any one of the basals, but they equal the latter in width. The upper one of the two plates, the radianal *RA*, is slightly shorter than the lower one, the supplementary plate *S*. (See also Plate XXXI, fig. 11.)

The radianal and supplementary plates are inserted between the posterior and right posterior basals, causing both of the latter to be moderately asymmetric in form. Along that part of the outline of these basals which is in contact with the supplementary plate, the curvature is slightly concave, usually more distinctly concave in case of the posterior basal than of the right posterior one. The other three basals are alike in form, all being symmetrical, hexagonal, and elongate. Four of the infrabasals are alike in form, but the fifth or left posterior infrabasal has an obliquely truncated tip, where it comes in contact with the lower left margin of the posterior basal. The left end of the truncated part of the left posterior basal always is more elevated than the right end.

The character of the ornamentation varies considerably in different species, and even in specimens belonging to the same species. In general, however, if any conspicuous ornamentation is present, this is likely to include more or less distinct ridges, most of which cross the sutures more or less at right angles, therefore at points distant from the corners. Each of the infrabasals has two ridges, one along each of the lateral margins. The left posterior infrabasal has in addition a third ridge, extending from the base toward the truncated tip; some-

times that ridge which extends along the right margin of this plate is much weaker than the neighboring ridge, on the right posterior infrabasal. That ridge of the posterior basal which extends toward the truncated tip of the left posterior infrabasal is single. All of the other basals, and also the supplementary plate in the same row, have two moderately diverging ridges extending downward, matching the lateral ridges of the infrabasal series. In the radials, only the two ridges extending downward are likely to be conspicuous. Similar ridges occur not infrequently on the anal plate X. The preceding description of the ornamenting ridges has been drawn chiefly from a species resembling *Carabocrinus vancortlandti* Billings, occurring on Goat Island, northeast of Little Current on Manitoulin Island, in strata corresponding to the Curdsville limestone in age. (Plate XXXI, fig. 11.) It will be found useful in identifying the isolated plates of the species of *Carabocrinus* occurring in the Lower Maquoketa of Iowa.

In the species of *Carabocrinus* occurring on Goat Island, the anal plate X is surmounted by three small plates, and a fourth small plate occurs over the left margin of the right posterior radial. All of these small plates increase in size successively from left to right; possibly a fifth small plate occurred over the left margin of the anal plate X itself, but this part of the specimen has been injured. This series of small plates supports the exterior side of that elevated part of the tegmen at the top of which the anus is located. (Plate XXXI, fig. 11.)

The facet on the radials, for the support of the arms, is long and narrow, with a relatively deep ambulacral sinus. (Text-figure 59 and Plate XXXI, fig. 11.) The ambulacral groove of the arms is correspondingly deep and narrow. On each side of the facet, the outer surface of the radials in many cases is channelled at right angles to its upper margin, the lower ends of these channels converging toward the median line of the plate. Each channel is bordered on each side by a narrow striation or elevation. The striations between each pair of grooves usually are connected by a sharp curve along their upper ends, but those bordering on the same groove either may be connected at their lower ends or may

leave an open gap at this point. Bather states that these radio-oral folds probably are vestigial hydrospires as in *Hybocrinus*. (Echinoderma, p. 172, 1900.) These grooves and stereom folds appear to differ greatly in number and size in different individuals of the same species. Usually they are very few in number on the anal X plate, and may be absent altogether. Judging from some of the Goat Island specimens, that part of the radials which is grooved was covered by a thin membrane bearing numerous small granules. It is assumed that this membrane extended to the adjacent parts of the orals and connected up with the covering protecting the ambulacral grooves between the latter, and also with the ambulacral grooves traversing the arms lengthwise.

One of the Goat Island specimens exposes the ambulacral side of two of the dichotomously dividing arms. There are two series of quadrangular plates, one on each side of the median line of the ambulacral face of each arm or armlet (fig. 13, Pl. XXXI). Five of these quadrangular plates occupy a length of 2 mm., at a point where three of these quadrangular plates occupy the length of one arm plate. The quadrangular plates are slightly wider than long. Between the two median series of quadrangular plates and the lateral margins of the ambulacral side of the arms there are numerous smaller plates, more or less irregularly arranged; about two or three of these smaller plates occur in the width intervening between the ambulacral plates and the nearest part of the lateral margin of the arm plates. There is a tendency toward elongation of the smaller plates where they are adjacent to the median quadrangular plates, and a tendency toward a more circular outline where they are more distant from the latter; the circular plates usually are much smaller than the more elongate ones. Along the sutures between successive arm plates (fig. 14, Pl. XXXI) a depression is developed, extending from the ambulacral side of the arms along its lateral sides for fully or slightly more than half the dorso-ventral diameter of the arm along its lateral face. Along the lateral outline of the ambulacral face of the arms, these depressions along the sutures between the arm

plates meet, but dorsally they become narrower, terminating with a strongly rounded outline. These depressions along the sutures are covered by minute plates, which probably studded the surface of some covering membrane. It is assumed that these lateral grooves with their covering of minute plates correspond to the recumbent arms or armlets of cystids. Since *Carabocrinus* is a crinoid, this structure might be called a recurrent or recumbent pinnule.

A closely similar structure is figured by Frank Springer in the case of a left anterior ray of *Cupulocrinus jewetti* (Billings), from the lower Trenton, at Kirkfield, Ontario. (Memoir Geol. Surv. Canada, No. 15P, pl. III, fig. 5b, 1911.) Here the minute plates covering the recurrent pinnules are drawn as regularly arranged, about five plates occupying a transverse section of the pinnules along the lateral margin of the ambulacral face of the ray, while eleven or twelve minute plates occur along the median line of the pinnule.

Mr. Springer describes the Kirkfield specimen as follows: "Here the left anterior ray is pulled out of position, so that we see the lateral face which is usually concealed by contact with the adjoining ray; it exposes a very peculiar surface marking—as of very small plates or the imprint of them—above the interbrachial plates, extending outward between transverse keels on the brachials, and obliterating the sutures."

Cupulocrinus is the most primitive genus among the Dendrocrinidae, in fact it is the most primitive genus of the entire order of Inadunata among the Crinoidea, as shown by Mr. Springer. There are good reasons for considering *Cupulocrinus* as close to the ancestral type of the two orders: Inadunata and Flexibilia. In his recent monograph on the Flexibilia Mr. Springer states that *Cupulocrinus* shows clearly an intermingling of the characters of the two orders, and that it is evident that it is a transition form.

Carabocrinus is another of the primitive Inadunata, belonging to the Cyathocrinidae. Similar recurrent pinnules may occur in other primitive crinoids among the Inadunata.

The arms of *Carabocrinus* branch dichotomously three or

four times, the two inner arms after the second branching in some cases remaining undivided.

The column was relatively narrow, tapering distally, equaling 1.5 mm. in diameter at a distance of 20 mm. from the base of the calyx in the Goat Island specimens. In the latter the calyx has a height of 33 mm. and a width of 25 mm. The columnals alternate moderately in size and thickness.

For the Goat Island specimens (fig. 11, Pl. XXXI), here mentioned frequently in describing the general generic features of *Carabocrinus*, the name *Carabocrinus huronensis* is proposed. It differs from *Carabocrinus vancortlandti* Billings in its obconical rather than obovate outline, the basal part being distinctly more acute, the middle less inflated, and the top of the calyx less contracted than in that species. Moreover, the radiating ridges are much stronger, those of *Carabocrinus vancortlandti* being even smaller and more distant from each other than those of *Carabocrinus radiatus*.

Carabocrinus is chiefly a North American genus. The earliest known species, *Carabocrinus geometricus* Hudson, occurs in the Valcour limestone in the middle Chazyan of the Lake Champlain area of New York. *Carabocrinus dicyclicus* Sarde-son occurs in the Decorah beds of Minnesota and Wisconsin. *Carabocrinus radiatus* Billings and *Carabocrinus vancortlandti* Billings are from the lower Trenton of Ontario. *Carabocrinus ovalis* Miller and Gurley is from the Curdsville member of the Trenton in Kentucky. *Carabocrinus* (?) *tuberculatus* Billings was described from the Vaurial (formerly Charleton) member of the Richmond formation on Anticosti Island. Ulrich cites an undescribed species of *Carabocrinus* from the Decorah beds, and two undescribed species from the Maquoketa (Richmond) of Minnesota (Geol. Minnesota, vol. III, pt. 2, p. cxxiii, 1897).

Recently a crinoid was described from the Wassalem limestone near Reval, in Esthonia, one of the Baltic States of Europe, under the name *Carabocrinus esthonus* Jaekel (Palaeontologische Zeitschrift, 3, pt. 1, 1918, p. 50, fig. 38). As far as may be determined from the figure it is remarkably similar in form, outline of plates, and ornamentation to *Carabocrinus ra-*

diatus, the genotype. The Wassalem limestone is regarded by Professor Raymond as of later age than those Trenton beds of Ontario which contain *Carabocrinus radiatus* and *Carabocrinus vancortlandti*. The presence of *Carabocrinus esthonus* in the Baltic area of Europe suggests the origin of this genus in northern North America and its migration into northern Europe. This agrees with the belief that the Decorah beds and the Curdsville member of the Trenton represent northern invasions, connecting with circumpolar areas.

CARABOCCRINUS SLOCOMI sp. nov., Plate XXXI, figs. 1-10; Plate XXXII, figs. 1, 7-9, 12-14, 26-29, 19?, 20?.

Two fragments of calyces are at hand; in one fragment (figs. 1-3) the length of the radials is 5 mm., and that of the basals is 7.5 mm.; in the other fragment (figs. 4, 5) the length of the radials is 6 mm., that of the basals is 9.5 mm., and that of the infrabasals is 7 mm. The complete calyx of the second specimen is estimated to have had a height of 19 mm., with a width at the top of 12 or 13 mm. The general form of the dorsal cup is obovate, or almost inversely conical, with the radials more nearly erect.

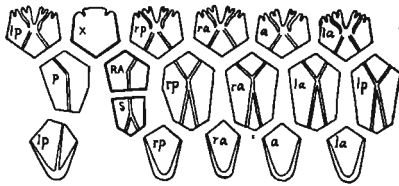


FIG. 59. Diagram of *Carabocrinus slocomi*.

One fragment (figs. 1-3) shows all of the plates belonging to the two upper circles of the dorsal cup, including the radials and basals. Of one of the radials only the upper half is visible. Of the anal plate X the right margin is concealed. The lower left margin of the posterior basal and the upper left part of the supplementary plate also are concealed. Each of the anterior and posterior pairs of basal plates is marked by four radiating ridges, of which two pass diagonally upward toward the middle of the sutures, and the other two pass downward with only a moderate amount of divergence. The lateral ridges are obsolete. That part of the posterior basal which is exposed does not show any distinct ridge in this specimen, but in the second fragment here described (figs. 4, 5) this posterior basal is marked by one ridge passing toward the suture separating it from the truncated infrabasal, and another ridge passing diagonally upward and toward the left to the middle of the

suture separating this posterior basal from the left posterior radial. Each radial is marked by two ridges passing from the arm-facet diagonally downward toward the middle of the sutures beneath. The supplementary plate is marked by a median ridge which continues to the middle of the radianal and then turns toward the right, crossing the middle of the suture separating the radianal from the right posterior radial. The anal plate X shows a faint median elevation, but the radiating ridges are practically obsolete. The upper margin of the radials, on each side of the arm-facet, is marked by one or two, rarely three grooves. The left side of the upper margin of the anal plate X bears a single groove, the right side of this margin being concealed. In a free anal plate X, (fig. 7, Plate XXXII) from another specimen, the right side of this margin bears one groove, and the left side bears two. All of the ridges on the radial and basal plates rise but slightly above the elevation which they would have if the intercepted parts of the plates were flat, but met each other along straight lines at widely spreading angles, like facets of a crystal.

In the second fragment of a dorsal cup, here figured (figs 4, 5), the left side and lower part of the right posterior basal and all of the right anterior basal is preserved. The supplementary plate and the posterior basal are partly exposed. A considerable part of the left posterior basal is present, but no recognizable trace of the left anterior basal is exposed. Two of the radial plates are present, but neither is complete. Of the infrabasals, all except the left anterior one are present, well preserved, and fairly well exposed. The radiating ridges bordering the lateral margins of these infrabasals are replaced chiefly by broadly rounded marginal elevations which may become obsolete before reaching the upper margins of these plates or which may terminate there as narrow ridges, similar to those traversing the basals. The median line of the left posterior plate is traversed by a third ridge directed toward the upper truncating suture. One side of one of the radials bears only a single groove along its upper margin; and one side of a second radial bears two well defined grooves and one indistinct groove.

Numerous isolated plates are present. One infrabasal, 18

mm. long, suggests that the dorsal cup of this species may have attained a height of 50 mm. One right posterior basal, 21.5 mm. long, suggests that the dorsal cup to which it belonged was 43 mm. in height. An isolated radial, 15 mm. in height, but possibly belonging to another species, suggests that the dorsal cup to which it belonged was about 48 mm. in height.

The surface of the plates of the dorsal cup is covered by a shagreen of minute, microscopic granules, arranged more or less in lines, which may anastomose in a more or less reticular manner, but which tend to be more or less continuous, crossing the sutures approximately at a right angle. About twelve lines occupy a width of 1 mm. Within these narrow limits the lines curve irregularly and at minute distances from right to left and back again, but on a few plates they are remarkably straight. As in other crinoids, the individual plates tend to be divided into cuneate fields radiating from more or less central points, the theoretical lines of separation between these fields extending from these central points to the various angles on the margin of the plates. Most of the infrabasals have only two conspicuous fields, with the minute lines directed toward the two upper sutures; in case of the left posterior infrabasal there is a third field with minute lines directed toward the truncating suture. On the basals there are six fields. On the radials there are four fields. The minute ornamenting lines appear to be most irregular and most anastomosing on the infrabasals; on the basals they appear to be straighter and parallel to one another; on the radials they are in some cases distinctly straight and fairly conspicuous under a lens, appearing like sharp parallel lines, which, however, number twelve in a width of 1 mm., as in the case of the less regular lines on the basals. Apparently it is impossible to distinguish two species among the specimens at hand on the basis of differences shown by the more microscopic features presented by the surface of the plates of the dorsal cup. Distinctions based upon differences in the prominence of the radiating ridges or ribs will be discussed later.

Locality and horizon.—Clermont, Iowa; in the lower part of the Maquoketa beds.

Figured specimens: Holotype, No. 3686, in Museum of University of Iowa; Allotype, in collection of A. G. Becker. Isolated plates from Museum of University of Iowa, the collection of A. G. Becker, and the Field Columbian Museum at Chicago.

CARABOCRINUS SLOCOMI COSTATUS var. nov., Plate XXXII, figs. 15-18, 21-25, 30, 2-6?, 10?.

Carabocrinus slocomi is based chiefly on two fragments of dorsal cups, described in the preceding pages. Associated with these two fragments are numerous loose plates of dorsal cups, some of which closely agree with corresponding plates of the two fragments in the inconspicuous character of the radiate ribbing, while others are much more coarsely ribbed. A considerable number of coarsely ribbed infrabasals, including also truncated infrabasals, are present. There is also a fair number of coarsely ribbed radials. In these coarsely ribbed radials the number of grooves along their upper margins, on each side of the arm facet, tends to be greater, sometimes conspicuously so. Possibly these more coarsely ribbed plates are merely from older specimens, and do not even represent a distinct variety. Unfortunately no basal plates with equally conspicuous ribbing as the infrabasals and radials here discussed are known. Provisionally, the more coarsely ribbed forms are separated from the others as a variety.

LICHENOCRINUS MINUTUS sp. nov., Plate XXX, figs. 19 and 19.

Six specimens are at hand. The holotype (figure 19) is attached to the brachial valve of an entire specimen of *Strophomena fluctuosa occidentalis* Foerste. Three specimens are attached to the interior surface of a brachial valve of *Leptaena uncostata* Meek and Worthen. One specimen is attached to the exterior of a small fragment of a brachial valve of some Orthid.

The first of these specimens has a diameter of 2.2 mm. and is about one-third of a millimeter in height. The specimen may be described as consisting essentially of two circlets of plates, the individual plates differing in size, all plates more or less irregularly arranged, there being a tendency toward a

third circlet of plates. The central part is depressed. At the center of the depression there is a minute attachment area, about one-fourth of a millimeter in diameter, to which the column supporting the calyx was attached. The specimen itself is the attachment disk of some crinoid, probably a Heterocrinid.

Of the three specimens on the brachial valve of *Leptaena uniconcostata*, the two larger ones have diameters of 3.3 mm., and the smallest of 2 mm. The plates are not very clearly defined, but here again the arrangement of plates is irregular and varies between two and three concentric rows in different parts of the attachment disc, the different rows not being differentiated.

The specimen on the exterior of the brachial valve of an orthoid shell has a maximum diameter of 4 mm., and a height of 1 mm. Here the tendency toward three concentric rows is very pronounced, but the plates still differ in size and are irregularly arranged. The surface of the disc itself is very irregular in its elevation; its center is deeply depressed.

A specimen from Walker Museum, attached to an infrabasal plate of *Carabocrinus*, is similar to the holotype in form and arrangement of plates. It is 2.3 mm. in diameter. In figure 18, this specimen is shown enlarged $3\frac{1}{2}$ diameters, associated with *Corynotrypa elegantula*.

Type specimens.—The holotype is No. P. 16885; four paratypes are No. P. 18533, all in the Field Museum of Natural History; the other paratype is No. 27043 in Walker Museum.

Locality and horizon.—From Clermont, Iowa. In the Lower Maquoketa.

Remarks.—Dr. E. O. Ulrich cites *Lichenocrinus* from nearly all the divisions of the Platteville and Decorah and from the Prosser member of the Trenton. At the northern end of Goat Island, northeast of Little Current, Ontario, where the railroad crosses to Cloche Island, *Lichenocrinus* occurs eleven feet above the horizon containing *Carabocrinus vancortlandti* Billings, in the lower or Curdsville part of the Trenton formation. Schuchert cites *Lichenocrinus affinis*, a Richmond species, from among Mohawkian strata at the head of Frobisher Bay in the southern part of Baffin Land, in Arctic America.

Among described species of *Lichenocrinus*, all are from the Ohio-Indiana-Kentucky area, where they range from the Cyn-

thiana formation to the top of the Richmond. It is probable that the geographical range of *Lichenocrinus* is much greater than here indicated, but that the difficulty of discriminating species from specimens usually consisting of the attachment bases alone is too great to invite their citation in faunal lists.

The occurrence of *Lichenocrinus* in the lower part of the Maquoketa suggests their eventual discovery in other faunas of northern origin.

Still farther north, at Swift Current, at the northern end of Cloche Island, *Lichenocrinus* occurs at the base of the Cloche Island member of the Black River, immediately above the very fine-grained white limestone forming the top of the Swift Current member. If the Cloche Island member be referred to the Decorah, and the Swift Current member to the upper Platteville of the Mississippi Valley, then the occurrence at Swift Current is of later date than the occurrences cited by Ulrich from the Platteville of Minnesota.

PLEUROCYSTITES Billings

The genus *Pleurocystites* belongs to the superfamily Glyptocystoidea, within which there is a systematic arrangement of the thecal plates. This arrangement varies more or less in different genera, but it is possible to imagine all the various arrangements as based on the same original scheme, variations from this scheme being due to gradual displacement of one or more of the plates. In the supposed archetype of this superfamily five transverse rows of plates are imagined to have been present, each row consisting of five plates. However, in all species known there are only four plates in the first or lower row, though one of these (No. 3) always has a truncated top and may be regarded as resulting from the fusion of two plates, which may be supposed to have been actually distinct in the archetype. The second plate on the left of the truncated plate (No. 1) always is connected across the suture with the plate resting on its upper left margin (No. 5) by trans-sutural folds of the stereom, occupying rhomboidal areas known as *pectinirhombs*. In the case of all *pectinirhombs*, half of one rhomb rests on one plate and the other half on the adjoining plate. In addition to the *pectinirhomb* on plates 1 and

5 there are other pectinirhombs variable in position in different genera. In the genus *Pleurocystites* there are two additional pectinirhombs, one connecting plates 14 and 10, and another connecting plates 11 and 12.

In the archetype of the Glyptocystoidea the anal opening is supposed to have been located between plates 7 and 8 of the second row and plate 13 of the third row. In the genus *Pleurocystites* the anal area has enlarged so enormously that it occupies almost all except the marginal part of one side of the theca. Plate 13 apparently has disappeared, whether by consolidation with some other plate or by actual disappearance is unknown, but the result of this disappearance is to bring plates 12 and 14 into direct contact with the anal area. Moreover, plates 7, 8, 12 and 14 have moved apart sufficiently to permit one corner of plates 6 and 9 almost to reach the anal area, while the upper margins of plates 2 and 3 form almost all of the lower border of this area. Other minor changes in the arrangement of plates have taken place. Plates 7 and 8 have moved below the level of plates 5, 6, and 9, which belong to the same transverse series. Plate 23, which belongs to the fifth transverse series, has lengthened basally, so that its lower part separates plates 17 and 18. The brachioles are supported, not on the upper margins of the fourth row of plates, but on plates 20, 22 and 17 of the fifth row, the number of brachioles being not five, but two. The anal area is covered by forty or more plates in addition to the smaller ones forming the anal protuberance which overlaps the lower right margin of the theca when viewed from the anal side.

Possibly plate 13 united with plate 14, but no proof for such a combination has been adduced. Since the brachials properly should be supported by the plates of the fourth transverse series, it would be interesting to learn which of the five arms of the archetype are retained in the genus *Pleurocystites*.

Pleurocystites belongs to the family Cheirocrinidae, in which the pectinirhombs on plates 14-15, and on plates 12-18, so characteristic of other families among the superfamily Glyptocystoidea, have been suppressed, and in which plate 13 has disappeared.

Pleurocystites differs from other genera belonging to the

same family, namely *Cheirocrinus*, *Homocystis*, and *Glyptocystis*, in the restriction of the number of pectinirhombs, in the locations mentioned in the preceding lines.

The genus *Pleurocystites* appears to have originated in North America, from which it spread to Great Britain. In North America six species and two varieties have been described. Three of these species and one of the varieties occur in the Trenton formation at Ottawa, presumably in strata approximately at about the same horizon as those at Curdsville, in Kentucky, where another species is found. The Ottawa forms include *Pleurocystites squamosus* and its variety *robustus*, also *P. filitextus*, and *P. elegans*, all described by Billings. *Pleurocystites squamosus matutinus* Ruedemann occurs in the lower or Glen Falls division of the Trenton in New York. *Pleurocystites exornatus* Billings was described from the Trenton near Montreal, in Quebec. *Pleurocystites mercerensis* Miller and Gurley was described from the Curdsville limestone in central Kentucky. *Pleurocystites anticostiensis* Billings was described from the Vaurial (formerly Charleton) member of the Richmond on Anticosti Island. Of these species the genotype *P. squamosus*, its variety *robustus*, and *P. mercerensis* have anal areas covered by several hundred small plates, while those of *P. filitextus* and *P. exornatus* are covered by forty to fifty plates. Nothing is known of the anal areas of *P. elegans* or *P. anticostiensis*. Ulrich cites *P. squamosus* and two undescribed species from the Prosser member of the Trenton in Minnesota. (Geol. Minnesota, vol. 3, Pal., pt. 2, p. cxxiii, 1897.)

In Great Britain six species are known. *Pleurocystites rugeri* Salter is from the Caradoc of South Wales. *Pleurocystites anglicus* Jaekel is from the lower Ashgillian formation, a little younger than *P. rugeri* and a little older than the four species occurring in the lower Ashgillian of the Girvan area of Scotland, namely *Pleurocystites procerus* Bather, *P. quadratus* Bather, *P. gibbus* Bather, and *P. foriohus* Bather. Bather regards these British species as of later age than the Trenton species described from various parts of North America. The anal area of all British species except that of *P. procerus* is known; in all cases this area is covered by hundreds of small plates.

Recently Jaekel has proposed the new generic term *Dipleurocystis* for *Pleurocystites rugeri* and *P. anglicus*, on the basis of their having a larger anal area, with smaller plates, the pectinirhombos being narrowly elongated in a direction parallel to the rhomb-ridges or folds. In view of the numerous plates on the anal area of *P. squamosus*, the genotype, it appears difficult to draw the line between typical *Dipleurocystis* and typical *Pleurocystites*, while, if *P. filitextus* had been the genotype this division could more readily have been maintained. It is evident that Jaekel must have followed Haeckel in regarding *P. filitextus* as the genotype of *Pleurocystites*.

The direction of migration of *Pleurocystites* from the Ottawa area into the British Isles is unknown. At present none of the peculiar cystids or crinoids of the Ottawa area are known north of the head of Frobisher Bay, on Baffin Land. Here *Porocrinus shawi* Schuchert occurs in Mohawkian strata. *Porocrinus conicus* Billings is from the lower Trenton of the Ottawa area. *Porocrinus smithi* Grant is from the Trenton of Belleville, Ontario. *Porocrinus kentuckiensis* Miller and Gurlley is from the Curdsville member of the Trenton in central Kentucky. *Porocrinus pentagonius* Meek and Worthen is of still older age, from the Platteville beds of Illinois. Ulrich cites *Porocrinus* from the Decorah of Minnesota. (Geol. Minnesota, vol. 3, Pl., Pt. 2, p. cxxiii, 1897.)

Recently Jaekel has referred the species formerly known as *Porocrinus radiatus* Beyrich, from the Ordovician of the St. Petersburg area, to a new genus *Perittocrinus*, with *Perittocrinus transitor* from the same area and horizon as a new species. Both species are from the Vaginatenkalk or Kunda formation, regarded as distinctly older than any part of the Mohawkian. From this genus *Perittocrinus* Jaekel regards *Porocrinus* as a possible derivative.

The general distribution of *Pleurocystites*, *Porocrinus*, *Perittocrinus*, and *Carabocrinus* suggests that they belong to a northern, circumpolar fauna, known in North America during early Trenton times, especially during Curdsville times, and the recurrence of these genera in the Lower Maquoketa of Iowa suggests that here also we have a northern invasion.

In the description of species of *Pleurocystites* it has been

found convenient to use certain terms not in common use. The *shoulders* are the angulate parts of the outline of the theca formed by plates 12 and 14 at the terminations of pectini-rhombs. The *shoulder-angle* is the apical angle of the theca, formed by an extension of the upper lateral outlines of this theca, above the shoulders. The *lobes* are the lateral extensions of the theca below the level of the area of attachment of the theca to the column. The *thecal ratio* is found by dividing the greatest width of the theca by the height of that part of the theca which extends from the area of attachment to the column to the oral pole; in this measurement of the height, the vertical height of the lobes is not included. A similar ratio of width to height is worked out for plate 5 as the most valuable ratio furnished by any single plate, since this is the plate most frequently found well preserved in specimens otherwise injured.

The shape, prominence, and other features of the pectini-rhombs often are characteristic. On the other hand, the surface ornamentation has been found extremely variable, even in specimens belonging to the same species, and is regarded as of least diagnostic value, unless supported by other differences.

The various species here described from the Lower Maquoketa of Iowa differ chiefly in their surface ornamentation, but other differences apparently also may be noted. The discrimination of these species would be regarded as more satisfactory if more specimens were at hand, but, for the present at least, the recognition of several species among the material at hand appears warranted.

1. PLEUROCYSTITES BECKERI sp. nov., Plate XXXIII, figs. 1, 6; Plate XXXIV, figs. 1A-D; Plate XXXI, fig. 12.

Type specimen.—Plate XXXIII, fig. 1; Plate XXXIV, figs. 1A, B, C, D); Plate XXXI, fig. 12.

Outline subquadrate, with a relatively obtuse apical or shoulder angle, equalling 95 degrees. Total height of theca above attachment area 34 mm., height up to shoulders 24 mm. The ratio of width of theca to height is 0.80, the width at plates 8 and 7 being 27 mm.; at plates 9 and 6 it is 26 mm.; and at plates 14 and 12 it is 25 mm. The lateral margins between

plates 7 and 12 and between plates 8 and 14 are distinctly concave, though interrupted by angulations at plates 6 and 9. The lobes at the base of the theca descend about 2 mm. below the attachment area. The lobe formed by plates 2 and 7 is truncated at an angle of 50° with the vertical line. The lobe formed by plates 3 and 8 protrudes slightly beyond a rectangular outline. The angles at the shoulders and lobes are rounded, rather than abrupt. Plate 5 has a height of 11.7 mm. and a width of 11.9 mm. The pectinirhomb 1-5 is elliptical in outline, and is elongated in a direction parallel to the rhomb-folds. Pore-field only moderately smaller than the entire pectinirhomb, and also of elliptical form; containing fourteen folds. Pectinirhomb 14-10 is kite-shaped in outline, 11.5 mm. in length parallel to the rhomb-folds, 7 mm. in width at right angles to the folds, the corresponding measurements for the pore-field being 6 and 4.2 mm. The greater part of both the pectinirhomb and of the pore-field rests on plate 14. The distal margin of the pore-field on plate 14 is more broadly rounded than that on plate 10. There are twenty-one folds. The pectinirhomb on plates 11-12 also is kite-shaped, but with the narrow end pointing in the opposite direction. Its length and width are approximately 10 and 5 mm., the corresponding dimensions of the pore-field being 5.6 mm. and 2 mm. The greater part of the pore-field rests on plate 12. There are thirteen folds.

The ornamentation of the antanal side of the theca consists of rhombic fields of parallel ridges bisected by sutures passing between opposite angles of the rhombs, at right angles to the parallel ridges. Those halves of the fields which belong to the same plate form cuneate areas with their apices heading toward the same center, and with their bases formed by the various sides bounding the plate. The ornamenting parallel ridges cross the sutures approximately at right angles. On plate 5 about twelve or thirteen of these ridges occur in a width of 5 mm. On the anal side of plates 12, 7, 2, 3, 8, and 14 the surface ornamentation is granular, but there is a tendency on the part of these granules to be arranged in parallel lines.

The anal area, in conformity with the general outline of the theca, is large and quadrangular, with relatively straight lateral and basal sides but with a convex upper outline. The

anal opening protrudes across the lower right angle of the theca, viewed from the anal side. Plates 2 and 3 appear to be represented by single plates, meeting along the median line of the theca along a suture 1.7 mm in height. Plates 12 and 14, on the contrary, meet along the median line at a suture only 0.5 mm. in height. From the anal side, the plates surrounding the anal area form a border ranging chiefly between 3 and 4 mm. in width. The field of the anal area is occupied by numerous small plates, chiefly hexagonal in outline and averaging about 0.8 mm. in diameter. It is estimated that about 800 of these small plates were present within this area. Only a few patches of these plates remain, but within these patches the individual plates are clearly defined.

The pectinirhombs rise with a convex curvature above the general surface of the theca. The pore-field on plates 14-10 rises only 0.5 to 0.7 mm. above this surface. The rim of the pore-field rises but slightly above this field, along some parts of the margin less than 0.1 mm.

Second specimen (Plate XXXIII, Fig. 6).—This second specimen resembles the type very closely, although certain differences can be observed. The chief of these consists in its outline. This outline, instead of being subquadratic, is more nearly ovate in form, the theca narrowing distinctly, from 20 mm. between plates 8 and 7 to 15 mm. between the tips of the pectinirhombs on plates 14 and 12; moreover, the apical or shoulder angle is distinctly more acute, equalling 80 degrees. Consequently, that part of the theca which is above the shoulders forms a greater part of the total height of the theca. The elevation of the pectinirhombs is relatively more abrupt and higher, equalling 1 mm. The pectinirhomb on plates 1-5 has ten folds, that on plates 14-10 has seventeen folds, and that on plates 11-12 has twelve folds. One of the brachioles is present, but it is slightly separated from the top of the theca so that its original point of attachment is uncertain. The surface ornamentation is as in the type. On the anal side the rim of plates bordering on the anal area also is broad, as in the type.

Locality and Horizon.—From Clermont, Iowa, in the lower part of the Maquoketa formation.

Type specimen.—In the collection of A. G. Becker.

Second specimen.—Specimen No. 16884, Field Museum of Natural History, Chicago, Illinois. Collected October, 1912, by A. W. Slocum.

Third specimen.—An isolated plate 5, numbered 17001 in the Field Museum of Natural History in Chicago, Illinois, is labelled as coming from Bloomfield, Iowa, in the lower part of the Maquoketa formation. Collected in October, 1912, by A. W. Slocum.

2. PLEUROCYSTITES SLOCOMI sp. nov., Plate XXXIII, fig. 5; Plate XXXIV, figs. 5A-D.

Outline of theca trapezoid ovate. The lower left margin of the theca slopes upward forming an angle of 25° with the horizontal, and the lower right margin slopes upward forming an angle of 35° with the horizontal. The sides of the theca are nearly straight but converge in an upward direction, from a width of 22.5 mm. between plates 8 and 7, to a width of 18 mm. between plates 14 and 12. The apical or shoulder angle is 85° . The shoulder and lobe angles are relatively abrupt. Total height of theca above attachment area about 31 mm.; height up to shoulders 21 or 22 mm. Ratio of broadest width of theca to height 0.72; the corresponding ratio for plate 5 is 0.95, the width being 10 mm., and the length 10.5 mm. The column apparently has been displaced slightly, having moved downward and toward the left. On the left side of the theca, viewed from the antanal side, the proximal part of plate 3 forms a lobe descending about the height of one columnal. Pectinirhombs as in the preceding species, but all are shorter in a direction parallel to the rhomb-folds, and all are more abruptly elevated above the general surface of the theca. Pectinirhomb 1-5 is 5 mm. long and 2.5 mm. wide; its pore-field being 2.5 mm. long and 1.7 mm. wide; the number of folds being eight. Pectinirhomb 14-10 is 8.5 mm. long, parallel to the rhomb-folds, and 7 mm. wide; its pore-field is 4 mm. long and almost 5 mm. wide; the number of folds being twenty-one. Pectinirhomb 11-12 is 8 mm. long and 4.5 mm. wide; its pore-field being 3 mm. long and almost 3 mm. wide; the number of folds being twelve. While the sides of the pectinirhombs rise more abruptly than in the pre-

ceding species, the border surrounding the pore-field is equally low in elevation .

The lower left part of the antanal side is margined by a thick, prominent border, a corresponding border margining the left side of the theca as far up as the basal part of plate 19. The lower right side of the theca appears to have a flat margin, and the border along the right margin is much less conspicuous than that on the left. The rhomb-ridges are more prominent, fewer in number, and more widely spaced. In the rhomb-field connecting the two upper pectinirhombs, the number of rhomb-ridges is nine in a width of 5 mm., a corresponding number occurring along the upper left margin of plate 5. In some rhomb-fields the rhomb-ridges are more widely spaced. The rhomb-fields are separated by conspicuous radiate ridges, passing from the umbos to the angles of the plates. The radiate ridges are regarded as diagnostic features, distinguishing this species from the preceding.

Of the column six segments or columnals remain. These narrow from a width of 6.8 mm. at the top of the column to 3.8 mm. at its base, the distance being 8.5 mm. Within this distance the columnals all are of short height. The columnals probably were tuberculated, but their surface ornamentation is not well preserved.

Locality and horizon.—From Clermont, Iowa, in the lower part of the Maquoketa formation.

Type.—Specimen No. 16858, in the Field Museum of Natural History, Chicago, Illinois; collected October, 1912, by A. W. Slocum.

3. *PLEUROCYSTITES CLERMONTENSIS* sp. nov., Plate XXXIII, fig. 7; Plate XXXIV, figs. 7A-D.

Outline ovate. The right margin of the specimen is missing, being cut away by the cleaning tools; apparently this part was not well preserved in the matrix. As far as may be judged from the specimen in its present state it was widest between plates 8 and 7, apparently 18 mm., narrowing toward plates 14 to 12, apparently to 15.5 mm.; the apical or shoulder angle apparently is somewhere near 75 degrees. On the left side of the theca, viewed from the antanal side, the proximal part

of the lobe at the base of the theca descends the height of two of the prominent columnals below the attachment area. The corresponding part on the right is not preserved. The height of the theca from the attachment area to the oral pole is 22 mm.; the height to the left shoulder is about 15 mm. Apparently the ratio of width to height is about 0.82. The height of plate 5 is 7 mm. and its width is estimated at 6.5 mm., giving a corresponding ratio of 0.93. The lower left margin of the theca along plates 3 and 8 rises at an angle of about 45° above the horizontal, the angle at the middle of plate 8 being 95° . The angle at plate 14 appears rather broadly rounded. The pectinirhombs, as far as known, are similar to those of the two preceding species. They are fully as prominent as those of the second species here described, but the pore-fields are narrower and more elongate. Pectinirhomb 1-5 is 4 mm. long and 2.7 mm. wide; its pore-field is 2 mm. long and scarcely 1 mm. wide; the number of folds is four. Pectinirhomb 14-10 is 7 mm. long and 4 mm. wide; the number of folds is nine or ten. Pectinirhomb 11-12 is missing along with the remainder of the right margin of the theca.

In some respects the ornamentation of the antanal surface of this species resembles that of the preceding form. For instance, in the heavy border along the lower margin of plates 3 and 8; in the fairly heavy border along the left margin of the theca, and in the coarseness of the rhomb-ridges. In fact, the rhomb-ridges are even coarser, considering the size of the theca. Along the upper left margin of plate 5 there are six rhomb-ridges in a width of 2.5 mm., or at the same rate as eleven in a width of 5 mm., but toward the left of the rhomb-field intervening between the umbos of plates 1, 5 and 10 the rhomb-ridges are much more distant from each other. The most characteristic feature of this species, contrasted with the preceding one, is the absence of the radiate ridges which separate the rhomb-fields. Sufficient of the marginal border of the anal area is exposed to indicate that the exterior edge of this border is smooth, but that the remainder is closely tuberculated. The border is relatively broad.

Of the column a length of 15 mm. is preserved. In a length of 10 mm. this column narrows from a diameter of 4 mm. at

the attachment area to 2.5 mm. at the seventh one of the more prominent columnals beneath this attachment area. Between these more prominent columnals, in alternate order, are six less prominent columnals whose upper and lower margins are covered or telescoped by the adjacent margins of the more prominent ones, so that in case of the upper columnals but little of the intermediate less conspicuous columnals is visible. Below the 10 mm. length of column there is an additional length of 5.5 mm., consisting of eight columnals, only slightly alternating in size, of which the lowest one has a diameter of 2 mm. Apparently the column diminishes abruptly in size near the theca, but gently at a greater distance, and the telescoping takes place only along the proximal part of the column. The columnals are tuberculated. The uppermost columnal has only a single transverse row of tubercles, but the broader columnals have additional tubercles above and below the more prominently elevated middle row.

Locality and horizon.—From Clermont, Iowa, in the lower part of the Maquoketa formation.

Type specimen.—No. 16858B, Field Museum of Natural History, collected by A. W. Slocum, in October, 1912.

4. *PLEUROCYSTITES* sp., Plate XXXIII, fig. 4.

Outline ovate triangular. Only the anal side of the theca is exposed. That part of the lower margin which is formed by plates 3 and 8 curves downward until it reaches the level of the second prominent columnal below the attachment area of the theca, and thence it curves upward as far as the corner formed by the middle of the margin of plate 8. This corner is nearly rectangular. From the corner formed by plate 8 to the shoulder which is located a little above the distal end of the pectinirhomb on plate 14, the lateral outline of the theca is straight. On the opposite side of the theca the outline is more curved. The lower margin of the theca here curves only slightly below the level of the uppermost prominent columnal, and thence curves upward along plates 2 and 7, the angulation on plate 7 being rounded. From this angulation to the shoulder on plate 12 the outline is straight, but the angulation at the shoulder is rounded so that the general appearance along

the side of the specimen formed by plates 2, 7, 6, and 12 is that of convexity, while the outline along plates 8, 9, and 14 is straight, with an angular base. The outline of the theca above the shoulders is rounded to such an extent that it is difficult to state what the apical or shoulder angle is, but it is estimated at 85°. The height of the theca above its attachment area is 14.6 mm.; its height up to the shoulders is 11 mm. The width between plates 8 and 7 is 12 mm.; between the shoulders at plates 14 and 12 it is 7.5 mm.

At the apical part of the anal side, plates 12 and 14 at present are separated a distance of 1.5 mm., and appear never to have met. Plate 18 is very much reduced in size, while plate 19 is broad.

The interior faces of the plates forming the antanal side of the theca are marked by hexagonal outlines about 0.5 to 0.7 mm. in diameter, as though a trace of the plates covering the anal area remained here. If that is the case then the antanal area was covered by about 250 plates, possibly more.

Of the column a length of 15 mm. remains. In the upper 4.5 mm. of this length the column narrows abruptly from 2.6 mm. at the top to 1.8 mm. at the base of this length. This part includes six prominent columnals between which intermediate columnals occur whose lower and upper edges are more or less telescoped by the adjacent edges of the more prominent columnals. Below this level the character of the column changes abruptly. The next two columnals are each 0.3 mm. in length and 1.5 mm. in width. This is followed in a distal direction by columnals 0.7, 0.8, 1.2, 1.3, 1.5, 1.7, and 2 mm. in length, of which the last is scarcely 1 mm. in diameter; all of these longer columnals probably are produced by the coalescence of two or more columnals, as far as may be learned by the presence of a slight transverse annulation at or a little above mid-length.

Locality and horizon.—From Dover township in Fayette county, the next township west of Clermont township, in which Clermont, Iowa, is located. In the Middle Maquoketa.

Figured specimen.—Collected by A. G. Becker.

5. PLEUROCYSTITES MULTISTRIATUS sp. nov., Plate XXXIII, figs. 2, 3; Plate XXXIV, figs. 2A-C. (*Description by E. O. Ulrich and Edwin Kirk.*)

This is stratigraphically one of the latest known species of *Pleurocystites*, the possible exception being *P. anticostiensis*, the exact stratigraphic position of which is uncertain, to say the least. The species is well marked and is represented by a fairly well preserved individual. The upper two ranges of plates, and the marginal plates on the left side are missing for the most part, but the nature of the theca is such that a very exact reproduction of the missing plates is possible.

As restored, the theca has a length of 36.8 mm. and a breadth of 27.2 mm. The greatest breadth lies in the plane passing through the angles formed by plates 7 and 8. The base of the theca on either side of the stem is flat for a short distance. The sides then turn abruptly upward, at a comparatively high angle, the change in direction taking place within plates 2 and 3. The restoration of the specimen may err in that the lower left-hand part of the theca is given as approximately symmetrical with respect to the opposite side. It is quite possible that the asymmetry developed on this side as the result of the presence of the anal structure is quite marked, and that this part of the theca should be considerably produced. This direction is maintained until the upper portions of plates 7 and 8 are reached. Here the sides make another abrupt angle. The sides now converge very slightly to the middle of plates 12 and 14, where the rate of convergence is abruptly accelerated. As is suggested by the lateral depressions and the intermediate flattened area, in the extreme distal portion of the theca, it seems probable that the theca ended in a blunt, rather square nose, as is indicated in the figure. The theca is more elevated and has greater relief than any other species of *Pleurocystites* known. The center of the theca is highly elevated while within the elevated area itself, and lying between the three rhombs, is a somewhat depressed area. The slope to the margin from this elevated area is quite abrupt on all sides except toward the anterior and posterior ends. Just anterior to the angles formed by plates 12 and 14, and just posterior to the angles formed by plates 7 and 8 are sharply defined lateral depressions. A lateral view of the theca, Plate XXXIII, figure 3, shows a remarkable flexure in the marginal plates.

The ornamentation of this species consists of a complicated

series of parallel striae. From each face, and perpendicular to it, numerous striae run back toward the center of the plate. The sets of lines from adjoining faces intercept one another along lines running from each angle to a common center. This common center, in no case where it was observed, coincides with the center of the plate. On plates bearing rhombs, the point is at the apex of the rhomb. On other plates, so far as observed, the point, as mentioned above, is excentric, and is located in the portion of the plate nearest the margin of the theca.

Plates 1 and 4 are of moderate size. They have a common suture 3.8 mm. in height, and plate 1 has a maximum length of 10.4 mm. Plates 2 and 3 are of average size but are relatively inconspicuous, owing to the fact that they form the bottom of the posterior, lateral depressions that have been noted above. Plate 7 enters to a considerable extent into the composition of the dorsal side. On the ventral surface, plate 7 meets plate 11 at about the level of the top of plate 5. Plate 5 is broader than long, the measurements being 13.4 mm. by 12.6 mm. The lateral faces of this plate are convex, and the upper pair of faces are slightly concave. The lower faces are straight. Plate 6 is notable chiefly as making the crest of the flexure that is such a characteristic feature of the margin of this species. As is usual among the species of *Pleurocystites*, plate 11 is appreciably smaller than plate 10. The higher ranges of plates are not preserved. A notable feature about the plates as a whole, is their unusual thickness and solidity. The plates of the ventral surface are unknown, except for a few isolated patches along the margins. These patches are made up of very small plates.

Rhomb 1-5 is elongate oval, the long axis, which lies perpendicular to the suture, measuring 5.6 mm. in length, while the short axis gives a measurement of 2.5 mm. There are fifteen slits in this rhomb. The raised area about the rhomb is diamond-shaped, with the long axis coinciding with that of the rhomb itself. As in other species, the portion of the rhomb lying on plate 1 is greater than that on plate 5. By measurement, the portion on plate 5 has a length of 2.3 mm. and on plate 1 of 3.3 mm. Rhomb 11-12 is irregular egg-

shaped in outline, having a measurement of 5.7 mm. at right angles to the suture by 3.6 mm. along the suture. The rhomb has eighteen slits. In the long axis of this rhomb 3.9 mm. lie within plate 12 and 1.8 mm. within plate 11. The raised border surrounding the rhomb is irregular in outline, and variable in thickness, the general outline, however, being elongate kite-shaped. Of rhomb 10-14 we have preserved only that part lying on plate 10. This gives a length of 5.4 mm. along the suture and a measurement of 3 mm. perpendicular to the suture for that portion preserved. There are twenty-six slits in the rhomb. The raised rim surrounding the rhomb is of moderate thickness, and seems to have been fairly regular in outline. It is probable that the rhombiferous area was nearly square, resembling the corresponding area of *P. angularis*.

None of the openings is known, owing to the poor preservation of the ventral surface.

The stem, from a measurement made from the proximal nodal, has a diameter of 6.6 mm. The nodals are marked by low, broad, smoothly-rounded and closely-set transverse ridges. Each of these ridges seems to have been formed by the confluence of two marginal tubercles. The ornamentation of the column is essentially similar to that of *P. anticostiensis*. The column so far as observed is composed of alternating narrow and wide ossicles.

This species is not closely comparable with any other described *Pleurocystites*. From *P. anticostiensis*, the only species having approximately the same stratigraphic position, it differs in possessing a marked linear ornamentation, and in the character of the rhombs. It is unquestionably the most strongly ornamented species of the genus yet described.

Horizon and locality.—Lower Maquoketa, two miles northwest of Clermont, Iowa.

Type.—The type and only known specimen is in the United States National Museum.

Pleurocystites multistriatus Ulrich and Kirk

- Plate XXXIII, fig. 2. Dorsal view of type specimen $\times 3/2$.
Plate XXXIII, fig. 3. Lateral view of type specimen $\times 3/2$.
Plate XXXIV, fig. 2A. Lower half of rhomb 10-14, $\times 3$.
Plate XXXIV, fig. 2B. Rhomb 11-12, $\times 3$.
Plate XXXIV, fig. 2C. Rhomb 1-5, $\times 3$.

Explanation of Plate XXIX.

Dendrocrinus kayi Slocum, page 335.

Figs. 1-3. Anterior, posterior and lateral views of the holotype. x 3/2.

Fig. 4. A column probably of this species. x 3/2. Coll. of A. G. Becker.

Ectenocrinus raymondi Slocum, page 337.

Figs. 5-7. Right lateral, posterior and left lateral views of the holotype. x 5/4. Walker Museum 24701.

Figs. 8, 9. Dorsal and lateral views of a portion of the arms, showing transverse grooves, pinnules and form of the arm plates. Greatly enlarged.

Archaeocrinus obconicus Slocum, page 328

Figs. 10, 11. Lateral and posterior view of the holotype. Natural size. Field Museum P.17106.

Fig. 12. Basal view of the allotype. Natural size.

Fig. 13. Lateral view of the allotype showing ornamentation of the plates. Enlarged 3 1/2 diameters. Field Museum P.11263.

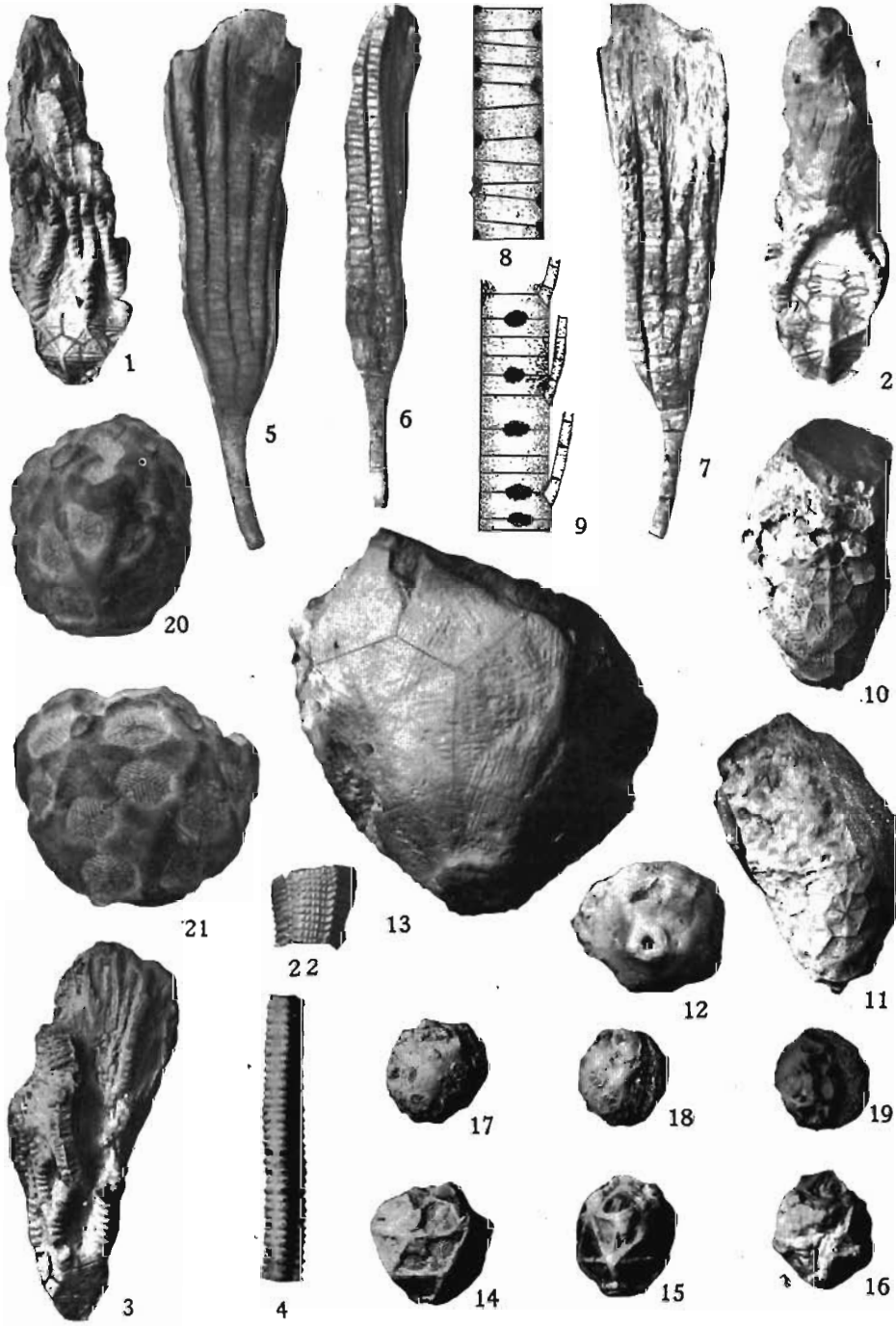
Porocrinus fayettensis Slocum, page 333.

Figs. 14-16. Lateral, posterior and ventral views of the holotype. x 3/2. Walker Museum 24700.

Figs. 17-19. Lateral, posterior and ventral views of the allotype. x 3/2. Field Museum P. 16841.

Figs. 20, 21. Lateral and posterior views of one of the paratypes. x 4. Field Museum P.11262.

Fig. 22. Fragment of a very large column. x 3/2. Field Museum P.11135.



Explanation of Plate XXX.

Crinoid Column "AA", page 341.

Figs. 1, 2. Lateral and end views x 3/2. Walker Museum 27042.

Crinoid Column "Ac", page 342.

Fig. 3. Interior of basal cup.

Fig. 4. Side view of the upper part of the column showing the alternating columnals and the basal plates, three of which are attached. University of Iowa 3677.

Fig. 5. View of section of column showing form of columnals lower down on the column.

Fig. 6. End view showing radiating lines and shape of axial canal.

Fig. 7. View of the opposite side of fig. 5 showing the transition from fig. 4 to fig. 5. Field Museum 11264. Figures 3 to 7 natural size.

Crinoid Column "AB", page 341.

Fig. 8. Side view of the largest specimen with infrabasal plates. Fig. 11 side view of longest specimen. x 3/2. Field Museum P. 11265.

Fig. 9. Interior of basal cup. x 3/2. University of Iowa 3684.

Fig. 10. End view showing axial canal, radiating lines and granules. x 3/2. Walker Museum 24702.

Maquoketocrinus ornatus Slocum, page 330.

Figs. 12, 13. Basal and lateral views of the holotype. Field Museum P. 16840. Enlarged 3 1-2 diameters.

Porocrinus fayettensis Slocum, page 333.

Fig. 14. Edge of a plate enlarged 16 diameters, showing the folding at the angles. University of Iowa 3676. Photo by Dr. H. E. Wilson.

Heterocrinus?, page 339.

Fig. 15. Attachment bases on *Orthoceras*. Field Museum P. 16934. Enlarged 3 1/2 diameters.

Figs. 16, 17. Large bases. Natural size. Field Museum P. 16882.

Lichenocrinus minutus Foerste, page 353.

Fig. 18. One of the paratypes attached to a plate of *Cara-*

bocrinus, with *Corynotrypa elegantula*. Enlarged 3 1/2 diameters. Walker Museum No. 27043.

Fig. 19. The Holotype, attached to a *Strophomena fluctuosa* Foerste. Enlarged 2 diameters. Field Museum P. 16885.

Atactocrinus? columnals, page 343.

Fig. 20. A line of eight columnals of average size, showing variation in form.

Fig. 21. End view of the upper columnal in fig. 20.

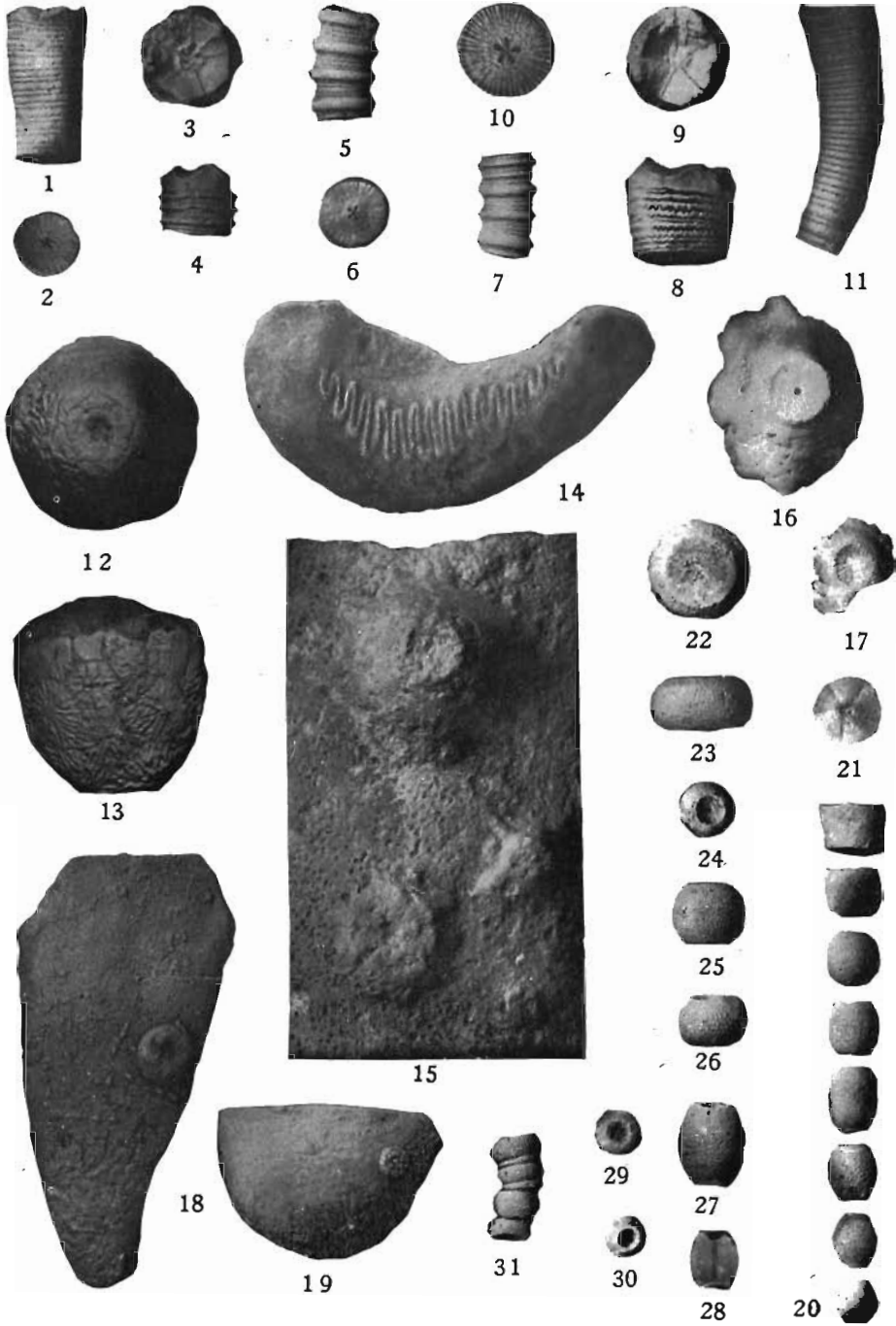
Figs. 22, 23. End and side views of the most oblate columnal observed.

Figs. 24-27. End and side views of some of the larger columnals.

Fig. 28. Longitudinal section of a columnal.

Figs. 29,30. End views of average columnals.

Fig. 31. Fragment of a column, consisting of 6 lozenge-shaped columnals, attached. All Walker Museum 24704. Enlarged 1 1/2 diameters.



Explanation of Plate XXXI.

Carabocrinus slocomi Foerste, page 350.

Figs. 1-3. Three views of a fragment retaining the basals and radials. From Clermont, Iowa; in Lower Maquoketa. Holotype; Museum of University of Iowa. No. 3686. Magnified 3 diameters.

Figs. 6-8. Diagrams of the same figures, designating the plates.

Figs. 4-5. Two views of a fragment retaining the infrabasals, and also parts of the basal and radial series of plates. From Clermont, Iowa; in Lower Maquoketa. Allotype; in collection of A. G. Becker.

Figs. 9-10. Diagrams of the same figures, designating the plates.

Carabocrinus huronensis Foerste, page 345.

Fig. 11. Diagram of plates of the type specimen. From the northern edge of Goat Island, directly east of the railroad bridge; in the lower part of the Trenton formation. In collection of A. F. Foerste.

Pleurocystites beckeri Foerste, page 359.

Fig. 12. Anal side, showing traces of the minute plates covering the anal area. Type specimen. Anal side of fig. 1 on Plate XXXIII.

Carabocrinus huronensis Foerste, pages 347, 349.

Fig. 13. Ambulacral side of one of the arms.

Fig. 14. Lateral side of another arm of the same specimen. Both figures magnified 6 diameters. From the northern edge of Goat Island, directly east of the railroad bridge; in the lower part of the Trenton formation. In collection of A. F. Foerste.

In the diagrams of *Carabocrinus*, the following abbreviations are used; a, anterior; p, posterior; r, right; l, left; X, anal X plate; RA, radianal plate; S, supplementary plate; R, radial series of plates; B, basal series of plates; IB, infra-basal series of plates; the broken lines indicate the location and direction of the radiating ribs.



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2



3



14



13



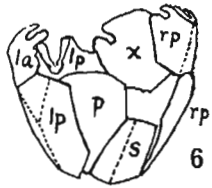
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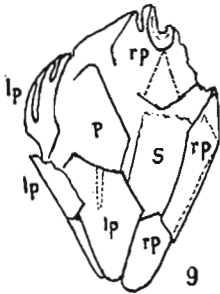
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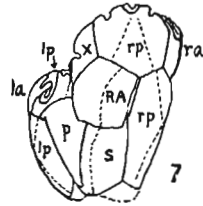
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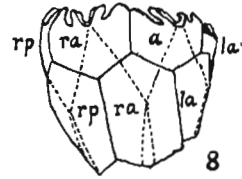
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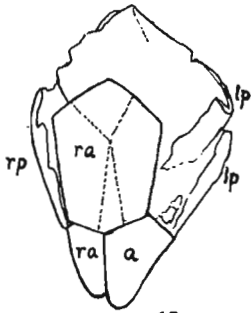
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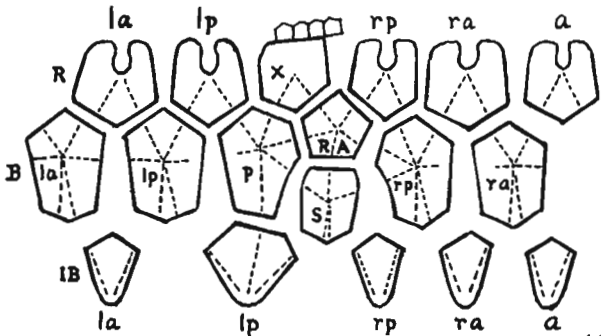
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10



11

Explanation of Plate XXXII.

Carabocrinus slocomi Foerste, page 350.

Figs. 1, 7, 8, 9, 11, 12, 13, 14. *Carabocrinus slocomi* Foerste. Possibly figures 19, 20, also belong here.

Carabocrinus slocomi costatus Foerste, page 353.

Figs. 15-18, 21-25. *Carabocrinus slocomi costatus* Foerste. The figures cited above are those of the types of the variety. Possibly figures 2-6, 10, also belong here.

Figs. 1-5. Radials, showing facets for articulation with brachials, and the bordered grooves along their upper margins. Plates 2, 3 and 4 are imperfect along their lateral and lower margins.

Fig. 6. Another plate from the same row as the radial series, but without a deep ambulacral notch; possibly an anal X plate. Basal part broken off.

Fig. 7. An anal X plate.

Fig. 8. A radianal.

Fig. 9. A basal; either right or left anterior, or left posterior.

Fig. 10. A right posterior basal, broken at the top.

Figs. 11-19. Infrabasals; either one of the three anterior basals, or the right posterior one.

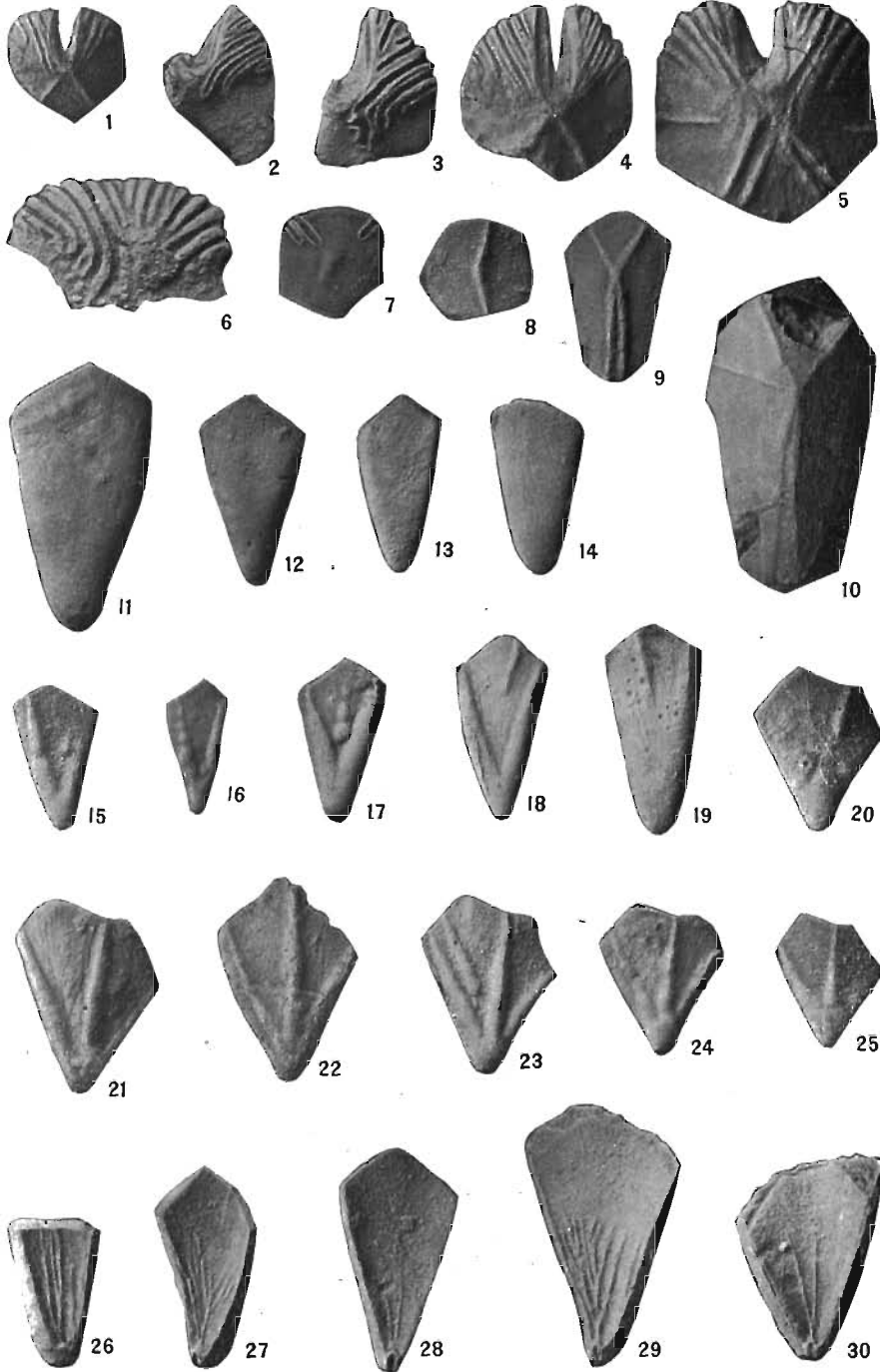
Figs. 20-25. Left posterior infrabasals. 22 is broken at the top.

Figs. 26-30. Vascular markings on the inner surface of the infrabasals. 26, 30 are broken at the top.

All of these plates were found near Clermont, Iowa, in the Lower Maquoketa. All figures magnified 3 diameters. 7, 8, 9, 10 belong to the Field Columbian Museum at Chicago, Illinois, and are numbered 7-9=P.18531; 10=P.18532.

2, 3, 6, 15, 16, 20, 23, 24, 25, 26, 30, belong to the Museum of the University of Iowa and are numbered 3687, 3688 and 3689.

1, 4, 5, 11, 12, 13, 14, 17, 18, 19, 21, 22, 27, 28, 29 belong to the collection of A. G. Becker.



Explanation of Plate XXXIII.

Fig. 1. *Pleurocystites beckeri* Foerste, page 359.

Lower left margin broken; outline restored there. Magnified 2 diameters. From Clermont, Iowa; in the Lower Maquoketa. From the collection of A. G. Becker. Holotype. The anal side of this specimen is figured on plate XXXI (fig. 12). The plate diagram of the theca and the pectinirhombs are figured on plate XXXIV (figs. 1 A-D).

Figs. 2, 3. *Pleurocystites multistriatus* Ulrich and Kirk, page 366.

The upper two ranges of plates and the left side of the theca are missing for the most part. Holotype. 2, antanal view, magnified $3/2$ diameters; 3, lateral view, magnified $3/2$ diameters. The pectinirhombs are figured on plate XXXIV (figs. 2A-C). From two miles northwest of Clermont, Iowa, in the Lower Maquoketa. From the U. S. National Museum.

Fig. 4. *Pleurocystites* sp., page 365.

Anal side of a specimen, not showing any of the plates covering the anal area. Magnified 2 diameters. From Dover township in Fayette county, Iowa; in the Middle Maquoketa. From the collection of A. G. Becker.

Fig. 5. *Pleurocystites slocomi* Foerste, page 362.

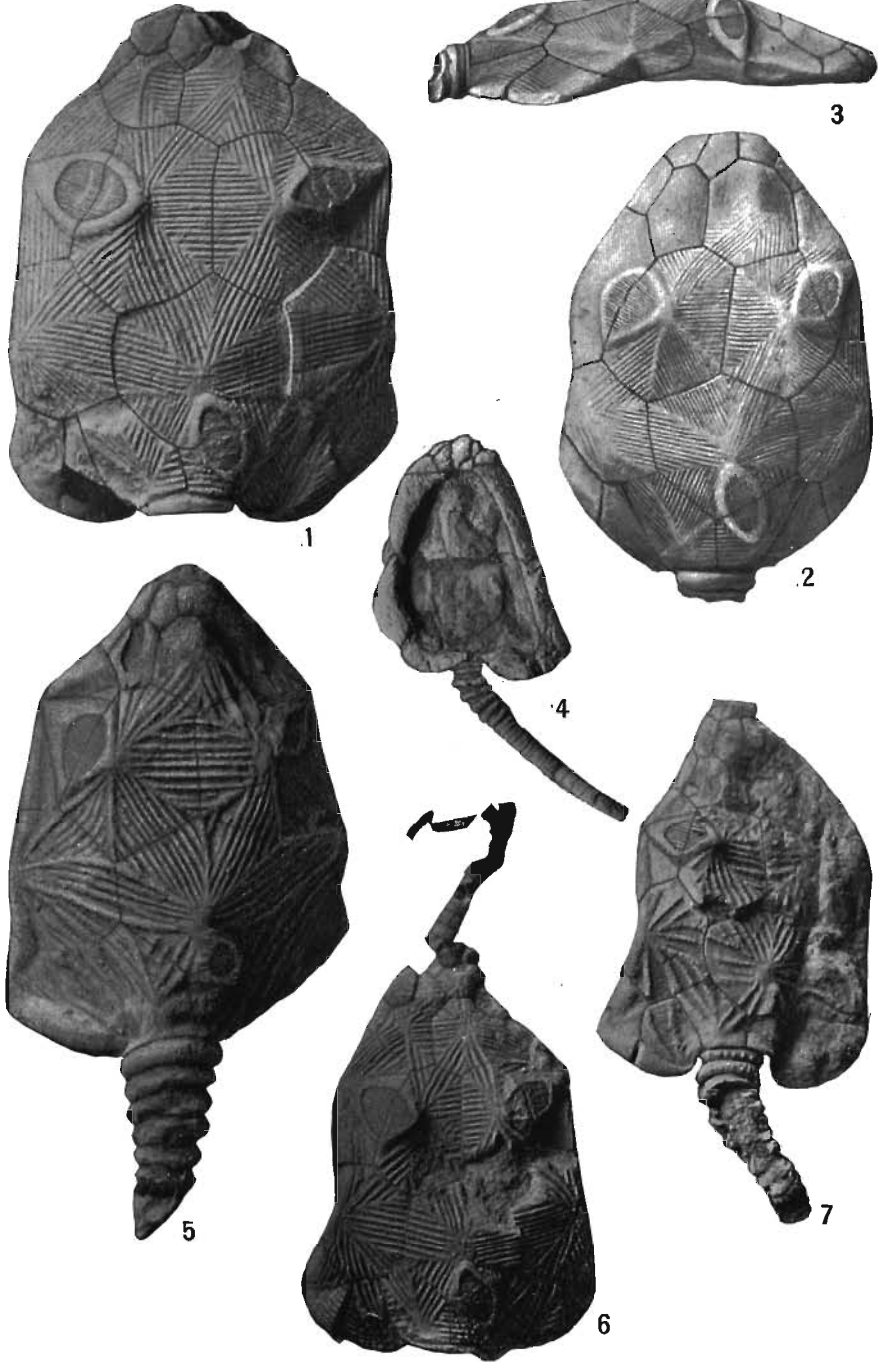
Antanal side of theca, with part of one of the brachioles. Well preserved only along the central parts of the specimen. Magnified 2 diameters. From Clermont, Iowa; in the Lower Maquoketa. From Field Museum of Natural History; No. P.18529. The plate diagram of the theca and the pectinirhombs are figured on plate XXXIV (figs. 5A-D).

Fig. 6. *Pleurocystites beckeri* Foerste, page 359.

Antanal side of theca, with part of one of the brachioles. Magnified 2 diameters. From Clermont, Iowa, in the Lower Maquoketa. From Field Museum of Natural History; No. 16884.

Fig. 7. *Pleurocystites clermontensis* Foerste, page 363.

Antanal side of theca, with all of the right margin indistinctly preserved. Magnified 2 diameters. From Clermont, Iowa, in the Lower Maquoketa. From Field Museum of Natural History; No. 16858. The plate diagram of the theca and two of the pectinirhombs are figured on plate XXXIV (figs. 7A, C, D).



Explanation of Plate XXXIV.

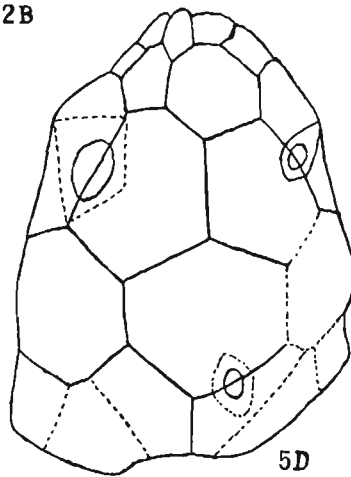
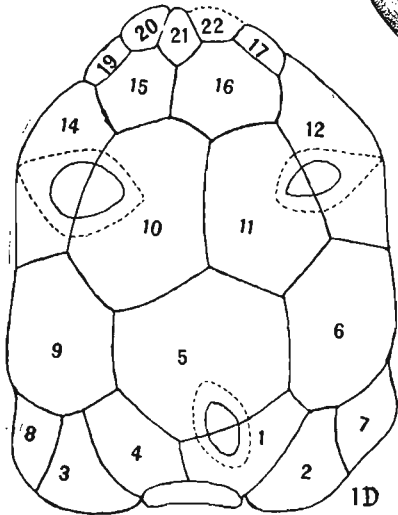
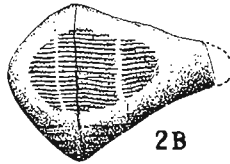
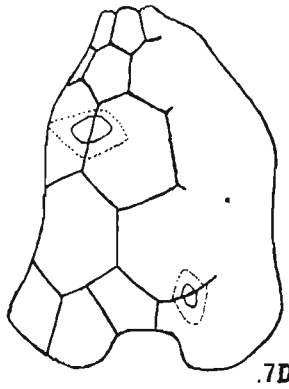
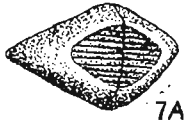
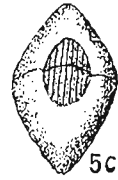
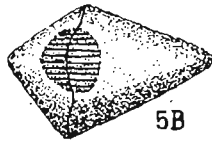
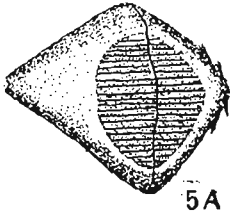
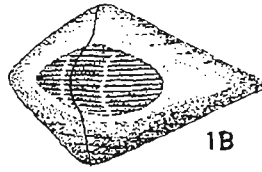
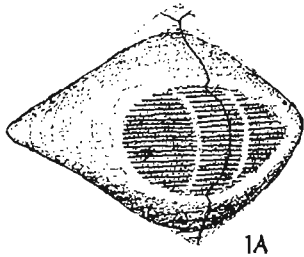
Fig. 1. *Pleurocystites beckeri* Foerste, page 359.

Fig. 2. *Pleurocystites multistriatus* Ulrich and Kirk, page 366.

Fig. 5. *Pleurocystites slocomi* Foerste, page 362.

Fig. 7. *Pleurocystites clermontensis* Foerste, page 363.

The numbers of the figures on this plate correspond to those used on plate XXXIII. The pectinirhombs are magnified about 3.7 diameters. In all figures A represents pectinirhomb 14-10; B represents pectinirhomb 11-12, and C represents pectinirhomb 1-5. In figure 1D the plates of the antanal side are numbered in accordance with the system used by Dr. F. A. Bather of the British Museum of Natural History.



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