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ARTICLE 55 (ECHINODERMATA 11)

CRINOIDS OF THE LASALLE LIMESTONE (PENNSYLVANIAN) OF ILLINOIS

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ABSTRACT

A remarkably well-preserved crinoid fauna from the LaSalle Limestone Member, Bond Formation, Missourian, of Livingston County, Illinois, is composed of 33 genera, seven of which are proposed herein, 39 species, 20 of which are first described herein, and one subspecies. One new family Clathrocrinidae, is proposed for some forms with a unique type of ten-armed ramule-bearing crown. Other new taxa from the LaSalle are *Elibatocrinus elegans*, n. sp.; *Contocrinus coupi*, n. sp.; *Exoriocrinus lasallensis*, n. gen., n. comb.; *Microcaracrinus conjugulus*, n. sp.; *Galateacrinus coacervatus*, n. sp.; *Polygonocrinus spiniferus*, n. sp.; *Sciadiocrinus tegillum*, n. sp.; *Anobasicrinus brevis*, n. sp.; *Haeretrocrinus wagneri*, n. sp.; *H. macoupinensis*, n. comb.; *Terpnocrinus ocoyaensis*, n. gen., n. sp.; *Probletoocrinus curtis*, n. gen., n. sp.; *Parulocrinus pontiacensis*, n. sp.; *Chlidonocrinus erectus*, n. sp.; *Halogetocrinus paucus*, n. gen., n. comb.; *Stellarocrinus bilineatus*, n. sp.; *Brabeocrinus christinae*, n. gen., n. sp.; *Clathrocrinus clathratus*, n. gen., n. sp.; *C. clinatus*, n. sp.; *Isoallagecrinus lasallensis*, n. sp.; *Dichocrinus nola*, n. sp.; *Paramphicrinus*, n. gen., and *Euonychocrinus simplex*, n. sp. One new species is described from the Plattsburg Formation, Missourian, of Montgomery County, Kansas, as *Ulocrinus fistulosus*.

INTRODUCTION

The exceptionally fine fossil crinoids described and illustrated in this article come from Upper Pennsylvanian rocks of the north part of the Central Illinois basin. All were collected from a quarry of the Wagner Stone Company in NW $\frac{1}{4}$ of sec. 19, T. 27 N., R. 5 E., Eppards Point Township, near Pontiac in southern Livingston County, 90 miles southwest of Chicago (Fig. 1). The fossil-bearing strata are classed as belonging to the LaSalle Limestone Member of the Bond Formation which comprises the middle one-third of the McLeansboro Group, uppermost division of the Pennsylvanian rocks of Illinois. The Wagner Quarry rocks are Missourian in age, equivalent to Plattsburg-Stanton strata of the Kansas-Missouri-Oklahoma region.

The Bond Formation was introduced and defined by KOSANKE *et al.* (1960) from exposures in Bond County, 40 miles north northeast of St. Louis, Missouri. The formation includes widespread bounding limestones (Shoal Creek at base, Millersville at top) with intervening predominantly shaly strata. The formation, nearly 300 feet thick in the type region, thickens in southeastern Illinois but thins to 75 feet or less in the north.

The crinoids of the LaSalle Limestone in the Wagner Quarry area occur in shaly pockets which are interpreted to represent quiet-water sedimentation in local areas where clayey sediment predominated over calcareous deposits. These were evidently laid down in quiet water without perceptible wave or current actions which would have disturbed the crinoid skeletal remains before or during their burial.

The primary colony described herein was found in a large, circular depression or pool with a diameter of some 20 feet. A diagrammatic sketch of the area involved is

given by Figure 2. The thin (2-3 inch) layer of blue clay covering the entire surface is a fresh water deposit laid down in Pleistocene time when the area was covered by



Fig. 1. Map showing location of crinoid-bearing rocks, LaSalle Limestone Member, Bond Formation (Missourian) of Livingston County, Illinois.

Lake Pontiac. One small slab (Fig. 2A), 4.5 by 4.25 inches, contained eight small, complete crowns, and par-

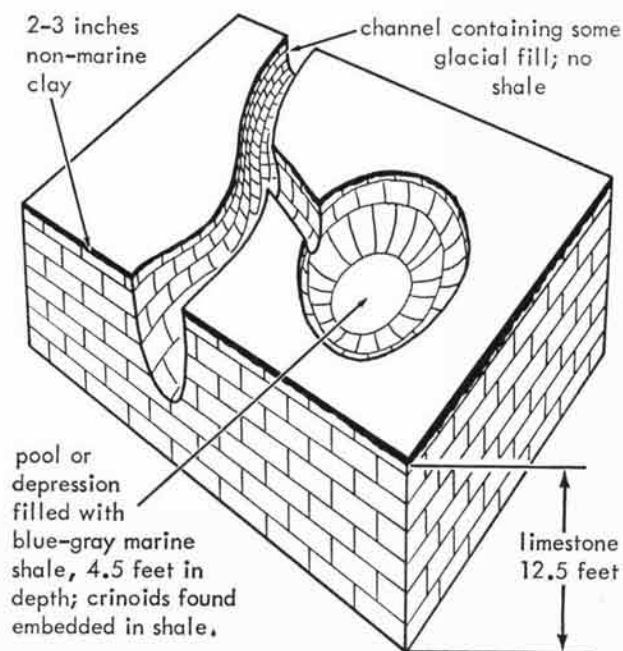


FIG. 2. Diagrammatic sketch showing crinoid pool in upper surface of limestone as found in Wagner Stone Quarry.

tial arms of two others, in one plane. Five of the crowns and the two sets of arms are identified as *Brabeocrinus christinae*, one as *Exocrinus wanni*, one as *Stenopeocrinus planus*, and one as *Clathrocrinus clathratus*. Appreciable portions of the stems are articulated with the crowns and there is no apparent directional evidence of a prevailing current, which leads to the conclusion the specimens probably met their demise as they lived, in close proximity. Numerous other closely associated forms were found but the example given represented the most prolific occurrence noted.

ACKNOWLEDGMENTS

Special gratitude is due Mr. and Mrs. R. E. COUP for their cooperation in allowing exploration in the Wagner Quarry and in preventing careless collectors from destroying the small crinoid-bearing exposures. Perseverance of Mrs. CHRISTINA CLEBURN led to the discovery and recovery of the large colony. We are grateful to the Illinois Geological Survey for financial aid in work on this project. CHARLES G. COLLINSON and LOIS S. KENT of that Survey have been most helpful in many related matters.

REPOSITORIES

All specimens deposited in the Illinois Geological Survey, Urbana, Illinois, are numbered with the prefix IGS42P; those in the Geology Department, The University of Iowa, Iowa City, with the prefix SUI.

SYSTEMATIC PALEONTOLOGY

Subclass INADUNATA Wachsmuth & Springer, 1885

Order CLADIDA Moore & Laudon, 1943

Suborder DENDROCRINOIDEA Bather, 1899

Family SCYTALOCRINIDAE Moore & Laudon, 1943

DIAGNOSIS (after MOORE & LAUDON, 1943).—Dicyclic; crown slender; cup conical to truncate bowl-shaped; infrabasals five, typically visible from side; three anal plates in cup, anal sac tall, slender; radial facets wide, bearing transverse ridge and ligament pits; arms branching isotomously on first primibrach or unbranched, pinnulate; stem pentagonal or round (syn., Scytalecrinidae BATHER, 1899).

GENERA.—*Scytalocrinus* WACHSMUTH & SPRINGER, 1879 (syn., *Dactylocrinus* SLADEN, 1878, not QUENSTEDT, 1876); *Prininocrinus* GOLDRING, 1938; *Aulocrinus* WACHSMUTH & SPRINGER, 1897; *Ophiurocrinus* JAEKEL, 1918; *Corematocrinus* GOLDRING, 1923; *Logocrinus* GOLDRING, 1923; *Gilmocrinus* LAUDON, 1933; *Anemetocrinus* WRIGHT, 1938; *Morrowcrinus* MOORE & PLUMMER, 1938; *Linobrachiocrinus* GOLDRING, 1939 (syn., *Linocrinus* GOLDRING, 1938, not KIRK, 1938); *Histocrinus* KIRK, 1940; *Hypselocrinus* KIRK, 1940; *Pegocrinus* KIRK, 1940; *Phacelocrinus* KIRK, 1940; *Hydriocrinus* TRAUTSCHOLD,

1867; *Melbacrinus* STRIMPLE, 1939; *Elibatocrinus* MOORE, 1940.

DISCUSSION.—In separating *Hypselocrinus* from *Scytalocrinus*, KIRK (1940, p. 327) emphasized the high and prominent infrabasal plates of *Hypselocrinus* as the major criterion for division. The proximal and major portions of the infrabasal plates of *Scytalocrinus* are typically subhorizontal in attitude with only the distal portions upflared. The relative difference in length of the uniserial arms was noted by KIRK (*ibid.*, p. 325) wherein *Hypselocrinus* was reported typically to have arms of great length. In younger species of *Hypselocrinus* two bifurcations of the arms occur commonly and the A ray is atomous in many. The genus is thought to be a specialized member of the family.

The anal tube of *Scytalocrinus* is typically recurved, with the anal opening well down on the anterior side and the distal end accentuated either by a single small spine or several small spines. One related lineage (*Erisocrinidae*) has a short, strongly recurved anal tube with no spines present.

OCCURRENCE.—Devonian to Permian; USA, USSR, Britain.

Genus ELIBATOCRINUS Moore, 1940

TYPE-SPECIES.—*Elibatocrinus leptocalyx* MOORE, 1940 (p. 35).



FIG. 2A. Slab of LaSalle Limestone from Livingston County, Illinois, containing crinoid colony preserved in bedding plane, $\times 1.5$. Identified forms are *Brabeocrinus christinae*, *Exocrinus wanni*, *Stenopocrinus planus*, and *Clathrocrinus clathratus*.

DIAGNOSIS.—*Elibatocrinus* was proposed on the basis of three complete dorsal cups and about a dozen infrabasal circlets. Comparison was made to other inadunate genera having three anal plates in the cup and three infrabasal plates, i.e., *Mollocrinus* WANNER and *Timorocrinus* WANNER from Permian of Timor, *Tribachioocrinus* ETHERIDGE from Permian of Australia, and *Alsopocrinus*

TANSEY from Middle Devonian rocks of Missouri. It was noted that none of these forms are closely related to *Elibatocrinus*. The genus may be related to *Hydrocrinus* TRAUTSCHOLD, from the Moscovian of Russia and the Desmoinesian and Missourian of North America, and to *Melbacrinus* STRIMPLE, from the Missourian of North America. The latter two genera have long, slender dorsal

cups, and three anal plates in the cup, but differ in having five infrabasals. Fusion of infrabasals, reducing five to three, is a process which may be expected in the evolution of late Paleozoic inadunates. The stem of *Hydriocrinus* is pentagonal and the arms branch on the first primibrach in all rays. The stem of *Melbacrinus* is round and typically the arms branch on primibrach 1 in two rays (right and left posterior), with primibrach 2 in two rays (right and left anterior) and is unbranched in the anterior so far as known. The stem of *Elibatocrinus* is round. *E. elegans* STRIMPLE & MOORE, n. sp., has arms that branch on primibrach 2 in all rays. One aberrant paratype has a

nonarm-bearing radial plate (Fig. 3). *E. hoodi*, of Desmoinesian age, has an axillary primibrach 1 in all rays which is also reported for *E. elongatus* WEBSTER & LANE (1966) of Permian age. The Permian species is reported to have another bifurcation in some arms.

The anal sac of *Elibatocrinus elegans* from Illinois is long, slender, and composed of small plates in vertical series of twelve, with an extra series interposed high in the tube, and well-developed pore-slits. A topotype at hand of *Hydriocrinus pusillus* from Russia reflects a smaller tube composed of small, rather irregular polygonal plates in uneven vertical series of about ten and lacking pore-slits.

Elibatocrinus is not a direct derivative of *Hydriocrinus* because the anal series and arm branching usually are more advanced in the latter. This same arrangement of anal plates is found in *Melbacrinus*. The slender elongated cup of *Elibatocrinus* is more like that of typical *Hydriocrinus* than of *Melbacrinus*.

OCCURRENCE.—Missourian and Virgilian, Pennsylvanian; Kansas, Oklahoma, Illinois, Nebraska.

ELIBATOCRINUS ELEGANS Strimple & Moore, n. sp.

Figures 3; 4, 1a, b; Plate 1, figures 3a, b; Plate 2, figure 3

DIAGNOSIS.—Dorsal cup steep-sided cone slightly more than one-third higher than wide, with smooth surface. Infrabasals 3, 2 large, 1 small (C radius); 5 basals are elongated; radials one-third wider than long, articular facet not quite as wide as radial; 3 rather large anal plates in normal (primitive) arrangement. Arms 10, slender, uniserial, branching on primibrach 2; all brachials slightly elongated with constricted midsections; each secundibrach bears a slender pinnule on alternate sides; anal tube dendrocrinid-like, very elongate, composed of small plates in vertical series of 12, having respiratory slits. Proximal columns very short, tapering rather rapidly.

DESCRIPTION.—Size features of *Elibatocrinus elegans* are indicated in following tabulations.

Comparison of *Elibatocrinus leptocalyx* and *E. elegans* showing proportionate differences in cup elements

	<i>E. leptocalyx</i>	<i>E. elegans</i>
Height of cup/length of infrabasal	0.37	0.41
Height of cup/length of basal	0.45	0.58
Height of cup/length of radial	0.33	0.29

Measurements of holotype of *Elibatocrinus elegans* (IGS42P111) in millimeters:

Length of crown (as preserved)	30.3
Length of dorsal cup*	9.5
Width of dorsal cup	6.4
Length of infrabasal	3.4
Length of BC basal	4.7
Width of BC basal	3.0
Length of B radial	2.3
Width of B radial	3.2

* BC radius

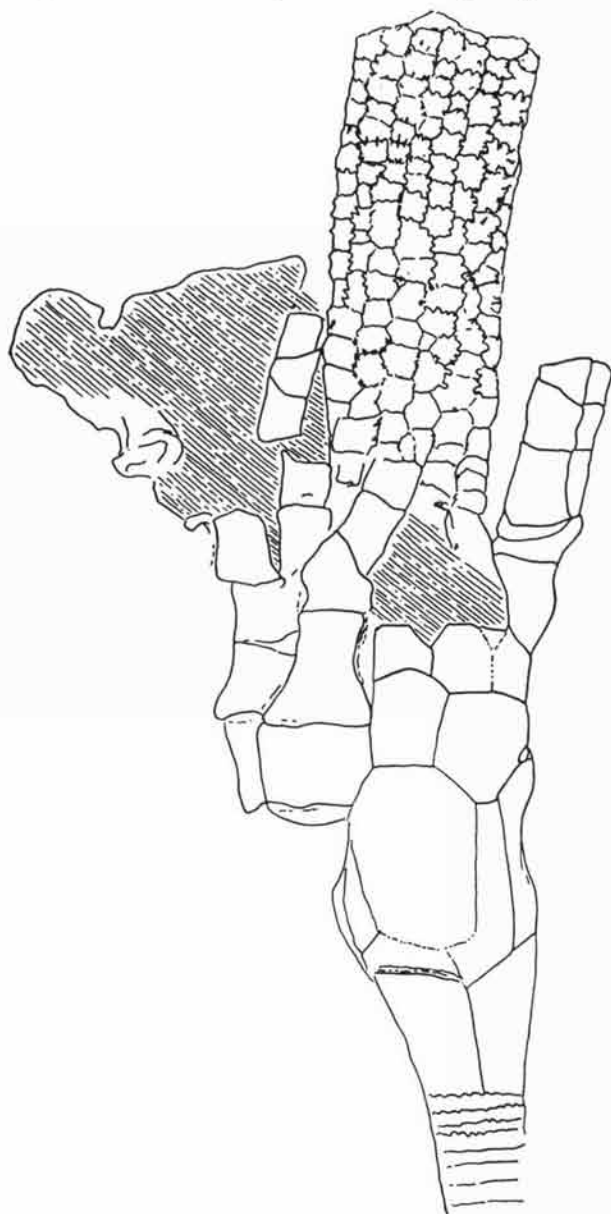


FIG. 3. Camera lucida drawing of *Elibatocrinus elegans* STRIMPLE & MOORE, n. sp., paratype (IGS42P62), posterior view showing elongate anal tube composed of thin polygonal plates with pore-slits and denticulate extensions, $\times 3.8$.

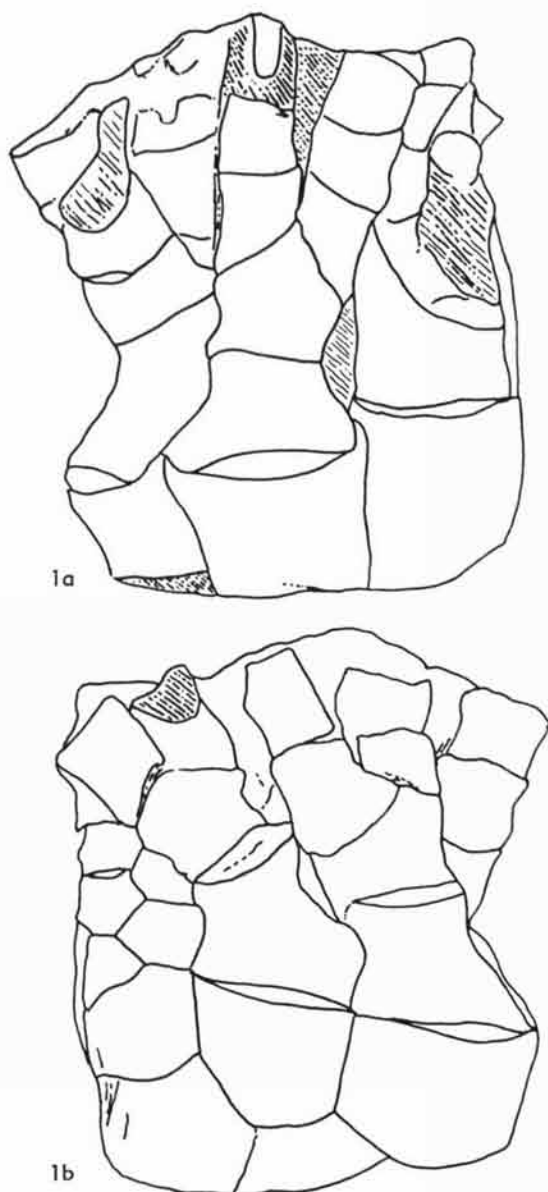


FIG. 4. Camera lucida drawings of *Elibatocrinus elegans* STRIMPLE & MOORE, n. sp., paratype (IGS42P106), partial cup with portions of arms attached, $\times 4.8$.—1a. CD interray to right.—1b. Opposite view.

DISCUSSION.—Specimens from the LaSalle Formation have portions of the arms attached which do not agree in point of branching with either *Elibatocrinus hoodi* STRIMPLE (1961) or *E. elongatus* WEBSTER & LANE (1966). The latter 2 species have axillary primibrachs 1 in all rays but in *E. elegans* branching is on primibrach 2 except for one paratype which does not develop any arms in the B ray. The B radial is projected above others and terminates at a point in the aberrant specimen. Proximal columnals taper rather rapidly for a short distance, then stabilize in width. Short, rapid, proximal tapering is typical of the species.

Types.—Holotype IGS42P111, paratype IGS42P62 collected by CHRISTINA CLEBURN; paratype IGS42P106 collected by H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company quarry, Ocoya, south of Pontiac, Livingston County, Illinois.

Family ERISOCRINIDAE S. A. Miller, 1889

DIAGNOSIS.—Dicyclic; cup truncate cone-shaped or truncate bowl-shaped with subhorizontal infrabasals, base flat to shallowly concave; anal X rudimentary or absent; arms ten, long, medium in width, pinnular, branching on primibrach 1 in all rays; anal tube (*Erisocrinus*) short, slender, recurved; stem round.

GENERA.—*Erisocrinus* MEEK & WORTHEN (1865); ?*Protencrinus* JAEKEL (1918); *Libratocrinus* KNAPP (1969); *Neoprotencrinus* KNAPP (1969); *Sinocrinus* TIEN (1924); *Pontotocrinus* KNAPP (1969); *Exaetocrinus* STRIMPLE & WATKINS (1969); *Parerisocrinus* KNAPP (1969).

DISCUSSION.—This family appears to be in direct lineage leading from the Scytalocrinidae, wherein all anal plates have been essentially eliminated from the dorsal cup, the infrabasals have become subhorizontal and confined to a flattened or mildly concave base and the arms have become biserial (incipient in *Protencrinus moscoviensis* JAEKEL). *P. moscoviensis*, type-species of *Protencrinus*, and other species assigned to the genus by KNAPP (1969, p. 353) have rather pronounced basal concavities, and may belong to a slightly divergent lineage appearing in the Atokan, as proposed by KNAPP (*ibid.*, p. 353), but we do not feel that sufficient data now are available to warrant separation as a discrete family.

Paradelocrinus MOORE & PLUMMER (1938), as represented by the type-species, *P. aequabilis* MOORE & PLUMMER (1938), is a Morrowan form with a very shallow cup and decidedly concave base with downflared infrabasals and is therefore considered to be related to the delocrinids, evolving from *Endelocrinus matheri* (MOORE & PLUMMER, 1938).

Primary evolution within the Erisocrinidae is thought to be from *Pontotocrinus* to *Neoprotencrinus*-*Libratocrinus* to *Erisocrinus*-*Sinocrinus* to *Parerisocrinus* or *Exaetocrinus*. As previously noted, *Protencrinus* is probably an offshoot of the main lineage. *Arkacrinus* KNAPP (1969) and *Atokacrinus* KNAPP (1969) are probably derived directly out of the delocrinids. They both have large, pronounced basal concavities with sharply downflared infrabasals but differ from *Delocrinus* in having eliminated the anal plate from the cup.

OCCURRENCE.—Pennsylvanian to Permian; USA, USSR, Indonesia, China, ?Scotland.

Genus ERISOCRINUS Meek & Worthen, 1865

TYPE-SPECIES.—*Erisocrinus typus* MEEK & WORTHEN, 1865.

DIAGNOSIS.—Dorsal cup truncate cone-shaped, flattened base, with little or no concavity, circular stem impression. Cup outline is pentagonal when viewed from above or below. Five small infrabasals confined to basal area together with proximal portions of five large basal plates. Five radial plates form most of the lateral walls of the dorsal cup. Anal plate is typically a rudimentary piece interposed between upper articular surfaces of two (posterior) radials and not visible when the arms are in place. Arms ten, biserial, branching on short first primibrach in all rays. Brachials have flattened outer surfaces, sharply delineated from sides.

The stem is moderately large and composed of alternately-expanded columnals.

Species Currently Assigned to Erisocrinus

<i>Erisocrinus typus</i> MEEK & WORTHEN (1865)	Missourian; Oklahoma, Kansas, Texas
? <i>E. propinquus</i> WELLER (1909)	Permian; Texas
<i>E. elevatus</i> MOORE & PLUMMER (1940)	Desmoinesian; Texas
<i>E. erectus</i> MOORE & PLUMMER (1940)	Desmoinesian; Texas
<i>E. longwelli</i> LANE & WEBSTER (1966)	Permian; Nevada
<i>E. georgeae</i> STRIMPLE & WATKINS (1969)	Atokan; Texas

DISCUSSION.—*Erisocrinus* has been restricted to crinoids having characteristics of the type-species of the genus, *E. typus*, by STRIMPLE & WATKINS (1969) and KNAPP (1969); these are decidedly pentagonal in outline of the cup when viewed from above or below, flat base with slight basal depression and subhorizontal infrabasals, and ten biserial arms branching on the first primibrach. *Erisocrinus* appears to have developed out of a form like *Neoprotencrinus* KNAPP (1969) through increase in cup height with the first species having a pronounced angulation (pentagonal outline) appearing in Atokan rocks. The primary lineage continues throughout the Pennsylvanian and into the Permian with a divergent group, *Exaetocrinus* STRIMPLE & WATKINS (1969), evolving to a more or less primitive state in development of slightly upflared infrabasals.

The upper Desmoinesian species *Libratocrinus mediator* (STRIMPLE) has a tendency toward shortening of interbasal sutures, which characteristic is strongly developed in *Protencrinus* and less so in some species of *Neoprotencrinus*. *L. mediator* has started to form a pentagonal outline and has a sharp distal edge of the cup which is typical of *Erisocrinus*.

The oldest-known species of *Erisocrinus* is *E. georgeae* STRIMPLE & WATKINS (1969) from the Soldiers Hole Member, Big Saline Formation, Atokan. The dorsal cup of the species has flared sides and a pentagonal outline when viewed from above or below, which characters are typical of *Erisocrinus*.

Sinocrinus TIEN (1924) is a somewhat specialized erisocrinid with broad, subhorizontal base encompassing most of the basal plates and all of the infrabasals. It

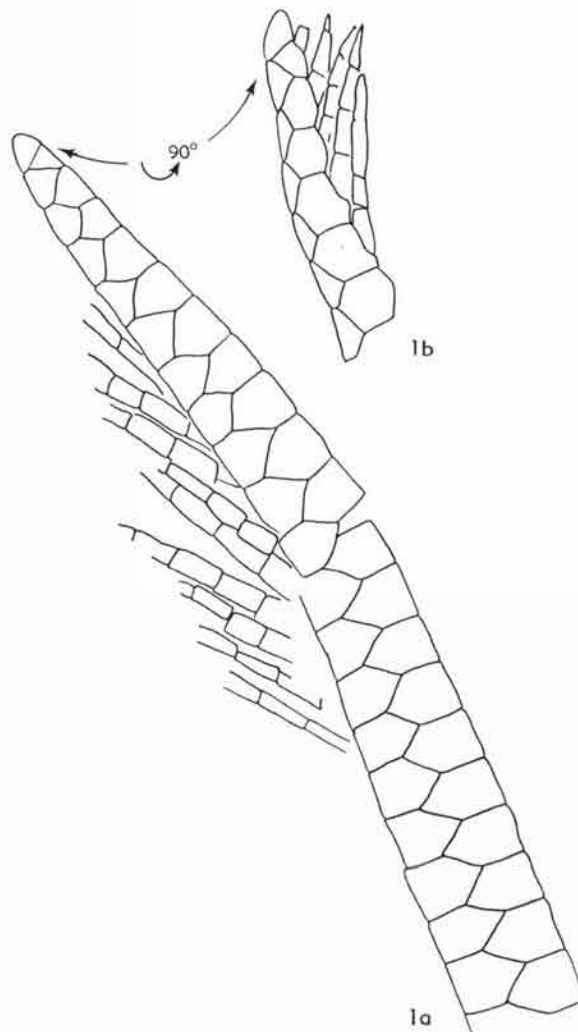


FIG. 5. Camera lucida drawing of arm and pinnules of *Erisocrinus typus* MEEK & WORTHEN, hypotype IGS42P68.—1a. View from exterior, $\times 1.1$.—1b. View of distal tip rotated 90° , $\times 1.1$.

appears to be a derivative of *Pontotocrinus* KNAPP (1969), as represented by the Morrowan species *P. wapanucka* (STRIMPLE, 1961). The arm structure as reported by TIEN (*ibid.*, 1924, pl. 1, fig. 1) is identical to that of *Erisocrinus* and *Neoprotencrinus*.

OCCURRENCE.—Pennsylvanian (Atokan)—Lower Permian; USA.

ERISOCRINUS TYPUS Meek & Worthen, 1865

Figure 5, 1a,b; Plate 1, figure 1; Plate 3, figures 3-5; Plate 4, figure 5; Plate 5, figures 1a,b

DIAGNOSIS.—Cup with decided outward flare in distal portion of essentially horizontal base. All have a pentagonal outline in dorsal and ventral view of the cup. Base rather broad and gently concave to almost flat. Infrabasals may be mildly downflared as reflected by a syntype (Univ. of Illinois X264) and hypotypes figured by MOORE & PLUMMER (1940, text-fig. 25b-c). Basals large, pentagonal, slightly wider than long with angle at

their distal tips measuring 75° to 80° . The ratio of cup height to width is *ca.* 0.41.

DISCUSSION.—Specimens considered herein are similar enough to the species concept to be considered conspecific. Most large ones have a sharply pentagonal outline when the cup is observed from the base or summit and many, but not all, have flared cup sides. Young specimens have a more rounded pentagonal outline. The base of the cup is gently concave and the infrabasals are subhorizontal.

ONTOGENY.—As noted above, the cups of young specimens have a rounded pentagonal outline and have more erect than flared sides. The primibrachs are long, moderately slender and of unequal lengths. Hypotype IGS42P38 has primibrach 1 (?A) 3.2 mm long, (?B) 2.7 mm, (?C) 3.0 mm, (?D) 3.0 mm, (?E) 2.8 mm. With maturity, primibrach 1 increases in width rather than length and becomes equidimensional in all rays. The secundibrachs in young examples are cuneiform but become regularly biserial in young adults. Pinnules are delicate but relatively long in young examples (e.g., a pinnule 2.5 mm long has been observed attached to an arm only 8.6 mm long). In the large figured paratype (Pl. 1, fig. 1) pinnules are only about 10.5 mm long attached to an arm 82.0 mm in length. The arms of a young individual are 5 times the height of the cup but in fully mature individuals they are 8 times the height of the cup.

The round stem is mildly heteromorphic in young adult individuals (e.g., 6 almost equidimensional internodals are interposed between distinguishable nudinodals). In a fully mature specimen (IGS42P68) no differentiation of proximal columnals is noted other than the appearance of a few incipient columnals on the outer side of the column, which is sharply curved. Crenellae are visible from the exterior where the incipient columnals are present but not otherwise. The proximal columnal is visible only on the outer side which brings about a curvature of the stem for a considerable distance. This feature has been noted in all specimens where proximal columnals are preserved. The lumen is round. Almost the entire column is preserved in hypotype IGS42P13, a young mature example, although it is not all illustrated. The length is 46 mm and 3 long cirri are preserved near to the distal portion.

ANAL TUBE.—One anal tube has been observed in hypotype IGS42P115 (Pl. 5, fig. 1a,b). It is small, short, composed of small polygonal plates in series and is sharply recurved.

HYPOTYPES.—IGS42P13, IGS42P24B, IGS42P37, IGS42P38, IGS42P68, and IGS42P115, collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, Livingston County, Illinois.

PHANOCRINIDS AND DERIVATIVES

An assemblage of Late Mississippian small to medium-sized inadunate crinoids which is judged to contain ancestors of several late Paleozoic groups is the Phanocrinidae KNAPP (1969, p. 351). These have a tall, comparatively narrow cylindrical crown with apposed arms. Dorsal cup bowl-shaped medium high or low, base concave or subhorizontal; three anal plates; arms five to ten with branching on primibrach 1, uniserial, with gently convex external surfaces and flattened lateral sides, pinnulate; anal tube slender, shorter than arms; column round.

According to STRIMPLE genera assignable to the Phanocrinidae include *Phanocrinus* KIRK, 1937; *Pentaramicrinus* SUTTON & WINKLER, 1940; *Delocrinus* MILLER & GURLEY, 1890; *Bronaughocrinus* STRIMPLE, 1951; *Endelocrinus* MOORE & PLUMMER, 1940; *Arkacrinus* KNAPP, 1969; *Graffhamicrinus* STRIMPLE, 1961; *Diphuicrinus* MOORE & PLUMMER, 1938; *Paradelocrinus* MOORE & PLUMMER, 1938; *Protencrinus* JAEKEL, 1918; and *Tholia-crinus* STRIMPLE, 1961. In the view of MOORE this is much too broad an interpretation, since, in agreement with KNAPP, he would include only the two first-named genera. In addition, *Diphuicrinidae* STRIMPLE & KNAPP, 1966, has priority over other family-group assemblages.

Phanocrinids are found in the Genevieve Stage represented by *Pentaramicrinus* SUTTON & WINKLER with moderately high, erect cup. One trend evolves to *Phanocrinus* with low, bowl-shaped cups in the Chesteran. The change leading to one anal plate in *CD* interray is demonstrated in the upper Chesteran by *Phanocrinus irregularis* STRIMPLE. *Phanocrinus cooksoni* LAUDON of late Chesteran age demonstrates the change from uniserial to biserial arms; however, all forms do not develop biserial arms. Pennsylvanian representatives of the family have one or no anal plate in the cup and retain a basal concavity.

Phanocrinids have a distinctive feature which serves to distinguish them from erisocrinids. When the dorsal cup of a phanocrinid is viewed from below the distal perimeter is not visible owing to constriction at the summit of radials. This feature is more prominent in some forms than others. In typical erisocrinids the radials do not curve inward at their summit.

Family APOGRAPHIOCRINIDAE Moore & Laudon, 1943

DIAGNOSIS.—Crown cylindrical, medium to elongate, arms closely appressed. Dorsal cup low, bowl-shaped, typically with gently tumid plates separated by impressed sutures, base flattened or shallowly concave; infrabasals downflared or subhorizontal; radials do not reach basal plane; single anal plate; ten uniserial to distally biserial

arms, outer surfaces gently convex, flattened lateral sides, moderately long pinnules on alternate sides; column round.

GENERA.—*Apographiocrinus* MOORE & PLUMMER, 1940; *Endelocrinus* MOORE & PLUMMER, 1940; *Contocrinus* KNAPP, 1969.

DISCUSSION.—The Apographiocrinidae are apparently derived from the Phanocrinidae. All Pennsylvanian members of the Phanocrinidae develop biserial arms.

OCCURRENCE.—Pennsylvanian, Permian; USA, Indonesia (Timor).

Genus APOGRAPHIOCRINUS Moore & Plummer, 1940

DIAGNOSIS.—Characters of the family, with gently tumid plates.

DISCUSSION.—The genus is characterized especially by having projections of the outer surfaces of radials adjacent to the sutures into the radial articular areas to the inner edge of the cup and by the anal plate having two upper facets.

OCCURRENCE.—Pennsylvanian (Desmoinesian-Virgilian), Permian; USA, Indonesia (Timor).

APOGRAPHIOCRINUS TYPICALIS Moore & Plummer, 1940

Plate 6, figure 5

DIAGNOSIS.—Crown moderately long and slender. Dorsal cup bowl-shaped, with small but strongly marked basal concavity; distal parts of infrabasals slope steeply downward; basals are tangent to the basal plane for one-third to one-fourth of their length, with distal portions almost reaching mid-height of the cup; radials slope steeply upward and develop prongs between the articular facets; anal X attains its greatest width just above the cup summit and is followed by two equidimensional tube plates. Ten arms are uniserial, pinnulate, branching on primibrach 1 in all rays; lateral sides of arms are flattened, with pinnular sockets notching the inner edges on alternating secundibrachs. Some brachials are slightly cuneiform. Inequality in lengths of primibrach 1 was reported by STRIMPLE (1938, p. 4, as *Graphiocrinus carbonarius*, and 1959, p. 118, as *Apographiocrinus typicalis*) wherein that of the A ray is the longest, C and D rays the next longest and equidimensional, and B and E rays the shortest. Immature specimens have a narrow longitudinal keel extending the full length of the arms. Stem is xenomorphic, proximal columnals being short with rounded exteriors and long, pronounced, interlocked crenellae. The lumen is round. The columnals become elongated distalward and have the appearance of a string of elongated beads, each one a modified lozenge. About 45 mm of the column is attached to the illustrated hypotype (Pl. 6, fig. 5).

DISCUSSION.—This species is one of the more common forms found in the LaSalle Formation of Illinois. The species is widespread geographically, having been reported

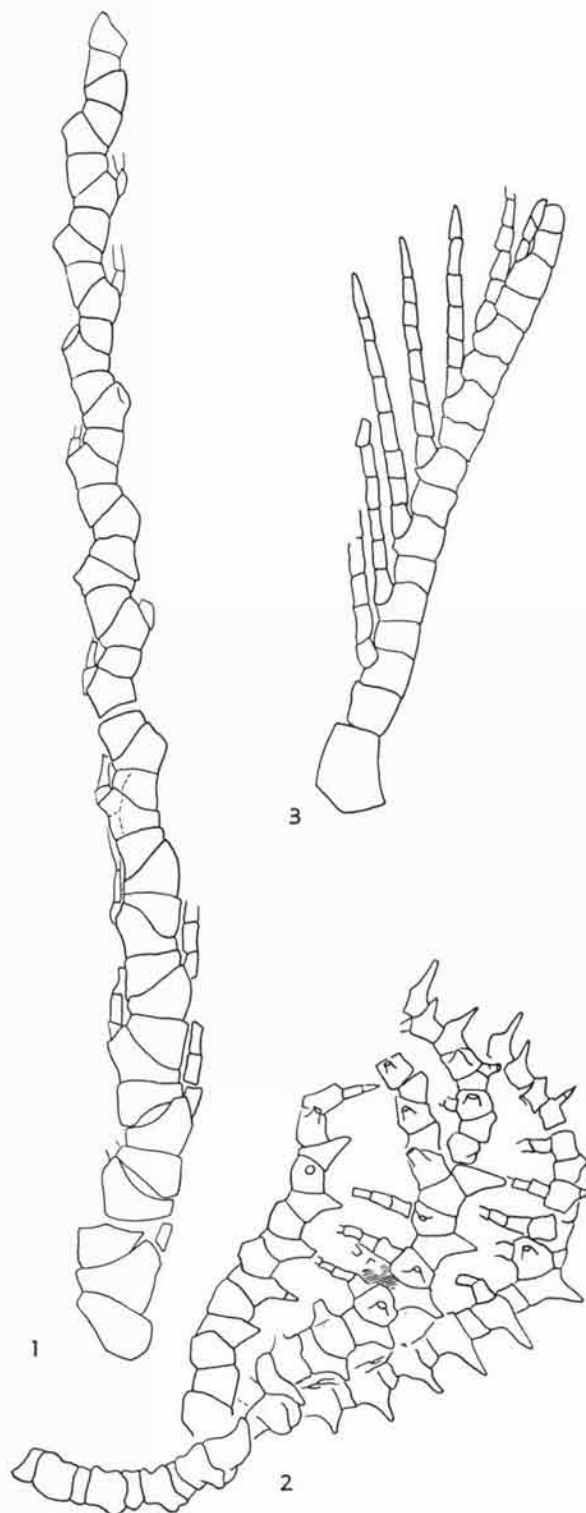


FIG. 6. Camera lucida drawings of arms of *Allosocrinus*, *Brabeocrinus* and *Contocrinus*.—1. *Allosocrinus bronraughi* STRIMPLE, hypotype IGS42P70, arm from exterior showing syzygial pairs. —2. *Brabeocrinus christinae* STRIMPLE & MOORE, n. sp., paratype IGS42P92, single branching arm showing spinose developments and pinnules. —3. *Contocrinus coupi* STRIMPLE & MOORE, n. sp., paratype IGS42P43, side view of arm showing position of pinnules on inner side of arm. All $\times 4.3$.

from Texas, Oklahoma, Kansas, and known to us from Nebraska. It is apparently restricted to upper Missourian strata. Older species of the genus are ornate, which feature is retained in part by juveniles of *Apographocrinus typicalis* having coarsely granular surfaces in the proximal regions of the cup, in the distal portions of the cup, and often on the arms. A common feature in older species is the division of the radial plates wherein a flattened, subvertical, scarlike tract occupies the upper portion, with the lower area sloping evenly downward and essentially smooth. The infrabasal circlets of most older species of *Apographocrinus* are essentially subhorizontal, whereas in *A. typicalis* they are mildly downflared.

HYPOTYPE.—IGS42P172, collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Quarry, Ocoya, Livingston County, Illinois.

Genus CONTOCRINUS Knapp, 1969

DIAGNOSIS.—Characters of the family except for having smoothly confluent plates without impressed sutures.

DISCUSSION.—*Contocrinus* differs from *Apographocrinus* in lacking pronounced projections of the outer surface of the radials into the interbrachial areas, although a few examples of minor, sporadic, spurlike projections have been observed, as noted by KNAPP (1969), and the anal plate has a single distal facet.

OCCURRENCE.—Pennsylvanian (Desmoinesian-Virgilian), Lower Permian; USA.

CONTOCRINUS COUPI Strimple & Moore, n. sp.

Figure 6.3; Plate 3, figure 6; Plate 7, figures 3a-c

DESCRIPTION.—The crown is moderately long, slender, subcylindrical. Dorsal cup is truncate bowl-shaped with a broad flat base; infrabasals form a star-shaped, horizontal disc, typically confluent with the basal plane, but in some specimens there is a shallow basal depression formed by the proximal ends of the basal yet without changing the horizontal attitude of the infrabasals; basals are parallel to the basal plane and curve upward to extend well into the lateral sides of the cup; proximal apex of radials extend to within 1.1 mm of the basal plane in the holotype; anal plate rests on the truncated posterior basal, extends well above the summit of the cup and is faceted for one plate above. There are 10 uniserial arms branching on slightly elongated primibrach 1 in all rays. The sides of the arms are flat, with pinnular notches on alternate sides of the inner edge of the brachials and the exterior is slightly convex. Some brachials are slightly cuneate. The anal tube is unknown. Large, xenomorphic, round stem with small round lumen. Crenellae well-developed, visible in side view of proximal columnals but less distinct in more mature columnals. Proximal columnals noncirriferous, alternately expanded, nodals moderately thick,

internodals thin, consistently considerably larger on one side causing a structural curvature from posterior toward anterior for about 12 mm (see Pl. 3, fig. 6). Thereafter the internodals elongate with equal length on all sides, nodals expand in midsection and a semigirdle is formed; occasional cirri are developed. About 10 cm of the attached stem is preserved in paratype IGS42P41.

MEASUREMENTS OF HOLOTYPE (IGS42P42) IN MILLIMETERS.—Length of crown 37.8, width of dorsal cup 10.1, height of cup 5.0, diameter of infrabasal circlet 3.7, diameter of stem 2.5, length of primibrach 1 (avg.) 2.5.

DISCUSSION.—The crown of *Contocrinus coupi* is very similar to that of *C. stantonensis* (STRIMPLE, 1939, p. 12), from the Missourian, except for the bulbous nature of the cup elements in *C. coupi* and depressed areas at the plate angles between the basal and radial circlets. *C. lineatus* STRIMPLE (1963, p. 191) has more pronounced convexity, both in cup elements and the arms, and has a pronounced basal concavity. The dorsal cup of *C. lineatus* is lower than in either *C. stantonensis* or *C. coupi*. Some specimens of the latter species show a tendency to develop a mildly depressed base but the infrabasals retain a horizontal attitude. *C. delicatulus* MOORE (1939, p. 248), from the Virgilian, has a higher cup and *C. ?kansansensis* (STRIMPLE, 1963, p. 73), from the Lower Permian, has both a high cup and upflared infrabasals. *C. scopulus* (WEBSTER & LANE, 1966, p. 46), from the Wolfcampian, has a narrow anal plate and a basal concavity, and the cup plates are very tumid. *C. bridgeportensis* (STRIMPLE, 1951, p. 201), from the Missourian, does not have the tumidity of plates found in *C. coupi* and has a tendency toward constriction of the cup near its summit. *C. kingi* (MOORE & PLUMMER, 1940, p. 315), from the Missourian, has a somewhat lower cup with some plate tumidity but lacking the depressions at the junction of basal and radial plates. *C. deflectus* STRIMPLE (1962, p. 11), from the Desmoinesian has a lower cup, an irregular linear surface ornamentation as compared to the frosted surfaces of younger species.

The species is named for GARY COUP, of Pontiac, Illinois, who was most helpful in the early stages of development of the two colonies of these crinoids found in the Wagner Stone Company quarry.

TYPES.—Holotype (IGS42P42) and paratypes (IGS42P41, IGS42P43) collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company quarry, Ocoya, Livingston County, Illinois.

Genus ENDELOCINUS Moore & Plummer, 1940

TYPE-SPECIES.—*Eupachycrinus fayettensis* WORTHEN, 1873, p. 565.

DIAGNOSIS (after MOORE & PLUMMER, 1940).—Characters of family with distinction mainly in absence of interrachial "prongs." "Under this name it is proposed to designate delocrinids with dorsal cups characterized by

a strong transverse as well as longitudinal convexity of the basals (BB) and radials (RR) which makes these plates appear distinctly bulbous; or by sharp inflexions of the borders of the basals (BB) and (RR) at angles where they meet; or by both these features. The arms are uniserial, composed of somewhat cuneate segments, in about the lower one-third of their lengths, becoming biserial above. Otherwise, the characters appear to correspond exactly to those observed in *Delocrinus*."

EMENDATION.—STRIMPLE (1961, p. 128) proposed *Corythocrinus*, a homonym of *Corythocrinus* KIRK (1946) with *C. undulatus* STRIMPLE (1961, p. 129) as the type-species, for endelocrinids having a nodose or undulating surface and which usually have strongly bulbous plates.

The name *Tholiocrinus* STRIMPLE (1962, p. 135) was proposed to replace the invalid name *Corythocrinus* STRIMPLE. It is not clear what function various types of surface ornamentation and projection of plates served, but the fact remains that it does exist and remains a reasonably constant feature over a long period of time.

DIAGNOSIS.—Dorsal cup low, truncate bowl-shaped, narrow basal invagination, infrabasals small, extending only slightly below proximal column, radial plates globose, pitlike depressions at corner of plates in basal and radial circlets, single anal plate extending slightly above summit of cup, distally an arcuate area slopes inward to the articular facet of each radial. Ten arms branch on somewhat elongated primibrachs *I*, which are of slightly unequal lengths (*A*-ray elongated, *B* and *E*-rays shortest), very tumid near distal apices but not produced as spines, brachials cuneate for a short distance; upper arms probably become biserial in mature specimens. Proximal columnals round, alternately expanded, nodals tumid and internodals incipiently developed, lumen round.

DISCUSSION.—*Endelocrinus tumidus* is similar to *E. kieri* BURKE, 1966, p. 459, except that the latter has surface nodes or undulations and is here referred to *Tholiocrinus kieri* STRIMPLE & MOORE, n. comb. *E. tumidus* may be related to *T. kieri*, but the progenitor of the latter is probably a form like *T. parinodosarius* or *T. rectus*. The

Species which have been assigned to Endelocrinus and current disposition (by Strimple)

	Stage	State	Assignment
<i>Delocrinus texanus</i> WELLER	Guadalupian	Texas	<i>Endelocrinus</i>
<i>Endelocrinus rotundus</i> STRIMPLE	Admire Group	Kansas	<i>Endelocrinus</i>
<i>Delocrinus allegheniensis</i> BURKE	Missourian	Ohio, West Virginia, Pennsylvania	<i>Endelocrinus</i>
<i>Endelocrinus kieri</i> BURKE	Missourian	Ohio, West Virginia	<i>Tholiocrinus</i>
<i>Eupachyrinus jayettensis</i> WORTHEN	Missourian	Illinois [Type]	<i>Endelocrinus</i>
<i>Endelocrinus grafordensis</i> MOORE & PLUMMER	Missourian	Texas, Oklahoma, Illinois	<i>Endelocrinus</i>
<i>Delocrinus tumidus</i> STRIMPLE	Missourian	Oklahoma, Texas	<i>Endelocrinus</i>
<i>Endelocrinus tumidus spinosus</i> STRIMPLE	Missourian	Oklahoma	<i>Endelocrinus</i>
<i>Endelocrinus parvus</i> MOORE & PLUMMER	Missourian	Texas	= <i>Endelocrinus tumidus</i>
<i>Endelocrinus bifidus</i> MOORE & PLUMMER	Missourian	Texas	<i>Tholiocrinus</i>
<i>Endelocrinus mitis</i> MOORE & PLUMMER	Desmoinesian	Texas	<i>Endelocrinus</i>
<i>Endelocrinus bransoni</i> STRIMPLE	Desmoinesian	Oklahoma	<i>Endelocrinus</i>
<i>Endelocrinus rectus</i> MOORE & PLUMMER	Desmoinesian	Oklahoma, Kansas, Texas	<i>Tholiocrinus</i>
<i>Delocrinus parinodosarius</i> STRIMPLE	Desmoinesian	Oklahoma	<i>Tholiocrinus</i>
<i>Delocrinus matheri</i> MOORE & PLUMMER	Morrowan	Oklahoma, Arkansas	<i>Endelocrinus</i>

DISCUSSION.—KNAPP (1969) suggested division between *Tholiocrinus* and *Endelocrinus* based on the deeper basal concavity and more sharply downflared infrabasals typically exhibited by the former. He considered the normal evolution to be from sharply downflared infrabasals to a subhorizontal attitude so that he should not have been surprised to find one species of *Tholiocrinus*, *T. bifidus*, with the relatively shallow basal concavity typical of *Endelocrinus*. *Tholiocrinus bifidus*, which has a shallow concavity, is the only species referred to *Endelocrinus* by KNAPP, other than the type-species. We believe this one character in itself is not sufficient to remove the species from *Tholiocrinus*.

OCCURRENCE.—Lower Pennsylvanian (Morrowan) to Lower Permian (Guadalupian); USA (Oklahoma, Kansas, Texas, Illinois, Missouri, Pennsylvania, Ohio, West Virginia).

ENDELOCRINUS TUMIDUS Strimple, 1939

Plate 2, figure 2

lectotype of *E. jayettensis* is similar to *E. tumidus* except that the basals are more bulbous in the former.

HYPOTYPE.—IGS42P81, collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, Livingston County, Illinois.

ENDELOCRINUS TUMIDUS SPINOSUS Strimple, 1950

Plate 3, figure 7

DIAGNOSIS.—Dorsal cup low, truncate bowl-shaped, with moderately strong basal concavity, curvature of surface from deep in basal concavity to summit of radials is very uniform; infrabasals downflared, forming about half of the cavity walls, basals large, longer than wide, arrow-shaped, extending well above basal plane, radials nearly twice as wide as long, in longitudinal profile their surface flares outward to a point a short distance below the facets and then curves sharply inward to margin of facets; anal

plate hexagonal, resting on truncated tip of posterior basal or advanced (pentagonal) with posterior (*C* and *D*) radials meeting below the anal, distal portion of anal extending above summit of cup, faceted for one plate above. Surface of cup is smooth, each angle between basal and radial circlet marked by a sharp dimplelike pit, radials mildly tumid, sutures between plates well-defined but not in furrows. Primibrachs 1 axillaries, quadrate in outline, those of *B* and *E* rays distinctly shorter than others, midline flaring upward to blunt spines just below center of upper margins, first 6 or 7 secundibrachs cuneate and higher parts biserial, juvenile specimens have more numerous cuneate brachials, pinnules slender, directed inward. Columnar attachment scar small, round, lumen small and round.

DISCUSSION.—*Endelocrinus tumidus spinosus* is more closely comparable to *E. fayettensis* and *E. grafordensis* than to other forms. A major difference lies in the basal plates which have a decidedly swollen appearance in *E. fayettensis* but essentially smooth contour in *E. grafordensis* and *E. tumidus*. *E. tumidus* has more protuberant primibrachs 1 than *E. grafordensis*. *E. allegheniensis* appears to have more tumid cup plates and the primibrachs 1 are more spinelike than found in *E. tumidus spinosus*.

A complete crown from the LaSalle Limestone has an overall length of 33.7 mm, height of cup 4.5 mm, width of cup 12.3 mm.

HYPOTYPE.—IGS42P50, collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Formation, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, Livingston County, Illinois.

Family PELEOCRINIDAE Kirk, 1941

DIAGNOSIS.—Dorsal cup cone-shaped with truncation at stem impression; infrabasals upflared; radial facets narrow, sloping outward; three anal plates in cup; arms rounded, branching isotomously, more than once, not appressed, pinnulate, primibrachs 1 or 2 in each ray (except anterior, which has several in older forms); sac moderately large, not plicate.

GENERA.—*Pelecocrinus* KIRK, 1941; ?*Tetrabrachiocrinus* YAKOVLEV, 1934; *Exoriocrinus* STRIMPLE & MOORE, n. gen.

OCCURRENCE.—Mississippian (Osagian); Permian; USA, Sicily.

Genus EXORIOCRINUS Strimple & Moore, n. gen.

TYPE-SPECIES.—*Poteriocrinus lasallensis* WORTHEN, 1875.

DIAGNOSIS.—Cup moderately large, medium bowl-shaped, infrabasals visible from side, five large basals; three large anal plates in cup, in normal (primitive) arrangement; five large radials, articular facets do not fill width of plate and are subhorizontal; arms slender, rounded, branching isotomously, not appressed; primi-

brach 1 axillary in each ray, subsequent nonaxillary brachials cuneate; proximal columnal pentagonal but column changes to a circular outline distally, lumen pentalobate.

DISCUSSION.—*Exoriocrinus* differs from *Pelecocrinus* in having subhorizontal, restricted, articulating facets on radials, which are directed outwardly in the latter genus, in having shallow depressions at the corners of the cup plates and in branching on first primibrach in all rays (the *A* ray of *Pelecocrinus* has as many as ten primibrachs). The genera have in common a cone-shaped dorsal cup, with infrabasals subhorizontal or directed upward, a broad *CD*-interray, narrow radial articular facets, three isotomous divisions of the arms and cuneiform brachials.

The name is derived from the Greek *exorios*, meaning strange.

OCCURRENCE.—Pennsylvanian (Desmoinesian-Missourian); USA (Oklahoma-Illinois).

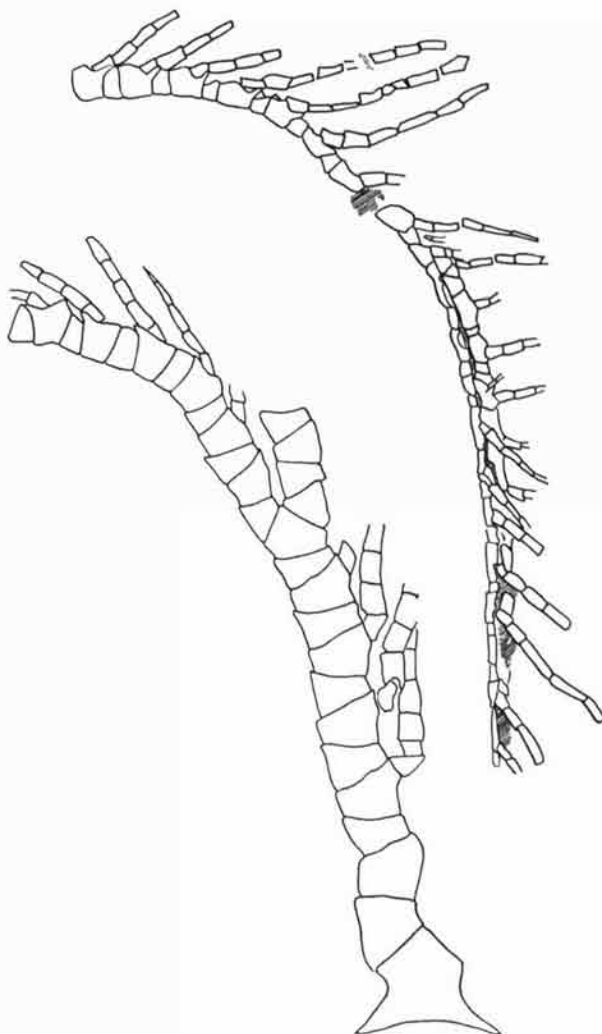


FIG. 7. Camera lucida drawing of complete arm of *Exoriocrinus lasallensis* (Worthen) STRIMPLE & MOORE, n. comb., IGS42P66, $\times 4$.

EXORIOCRINUS LASALLENSIS (Worthen, 1875),

Stimple & Moore, n. comb.

Figure 7; Plate 8, figure 6; Plate 9, figure 2

DIAGNOSIS.—Characters of genus.

DESCRIPTION.—The cup and arms are covered by minute projections or granules. There is a tendency toward depression at the corners of the plates. Sutures between radials and primibrachs are gaped. The long slender arms branch isotomously twice, first on primibrach 1 and then on or about secundibrach 9-11. Brachials are cuneate, moderately elongated, with the midportion constricted. Pinnules alternate on opposite sides. The lateral sides are flattened except for a projected facet for the pinnule. Although the brachials appear from the exterior to be delicate, they are in fact thick and have a narrow ambulacral groove, and provide a substantial structure. Proximal columnals are pentagonal but change to circular a short distance from the cup. The hypotype is slightly flattened, so that measurements are distorted; dorsal cup is 10.8 mm high, 16.0 mm wide; diameter of infrabasal circlet 8.5 mm; length of basals 5.7 mm, width 5.6 mm; length of radials 3.9 mm, width 6.5 mm; overall length of crown 74 mm.

DISCUSSION.—*Exoriocrinus lasalleensis* is closely related to two smooth forms, *Poteriocrinites ramonaensis* (STRIMPLE) (1939, p. 7), from the Avant Formation (Missourian) and *P. magnus* (WRIGHT) (after STRIMPLE, 1939, p. 8) from the Wewoka Formation (Desmoinesian). A species described as *P. pentacolumnus* (STRIMPLE) (1940, p. 6) from the Wewoka Formation is thought to be congeneric and is more ornate than *Exoriocrinus lasalleensis*, with ridges passing to adjoining plates. Assignment is made here as *E. ramonaensis* (STRIMPLE), STRIMPLE & MOORE, n. comb., and *E. pentacolumnus* (Strimple), STRIMPLE & MOORE, n. comb. The smooth form from the Wewoka Formation is only known from an infrabasal circlet, which has a pentagonal proximal columnal attached, and disarticulated radial and basal plates and is referred to here as *Exoriocrinus* sp.

TYPES.—Hypotype IGS42P67 and illustrated hypotype IGS42P66 collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company quarry, Ocoya, Livingston County, Illinois.

Family PACHYLOCRINIDAE Kirk, 1942

DIAGNOSIS.—Cup low, truncate bowl-shaped, base slightly concave, five infrabasals not visible from side; radial facets wide but do not always fill distal surfaces of plate, bear transverse ridge and ligament pits; three anal plates in cup; anal sac slender and long, composed of vertical rows of small plates, commonly reflexed; arms uniserial, branching two or more times, pinnulate.

DISCUSSION.—A complete review of the family is not attempted herein.

OCCURRENCE.—Mississippian-Permian; USA.

Genus PLUMMERICRINUS Moore & Laudon, 1943

TYPE-SPECIES.—*Pachylocrinus mcquirei* MOORE, 1939.

DIAGNOSIS (after MOORE & LAUDON).—Crown slender; cup truncate bowl-shaped, base concave; infrabasals five, not visible from side, mostly concealed by stem; basals five, proximal part sloping downward, distal part upward, reaching mid-height of cup; radials five, projecting outward so as to make interrarial notches, facets equal to full width of radials but somewhat offset outward, with transverse ridges not laterally in contact, bearing transverse ridge and ligament pits; three anal plates in cup, and sac tubular, curved forward, side plates plicated; arms uniserial, branching isotomously in first primibrach and higher, pinnulate.

DISCUSSION.—The dorsal cup of *Plummericrinus* has a distinctive appearance in that the radials project outward so as to make pronounced interrarial notches which prevent the wide articulating facets from being fully in lateral contact. Several small species have been assigned to the genus which lack this distinctive characteristic and are reassigned here to a related genus *Microcaracrinus* STRIMPLE & WATKINS (1969, p. 201): *Plummericrinus bellirugosus* (MOORE, 1939), =*Microcaracrinus bellirugosus* STRIMPLE & MOORE, n. comb.; *Plummericrinus colubrosus* (MOORE, 1939), =*Microcaracrinus colubrosus* STRIMPLE & MOORE, n. comb.; and *Plummericrinus twenhofeli* (MOORE, 1939), =*Microcaracrinus twenhofeli* STRIMPLE & MOORE, n. comb.

The second branching of the arms in most Missourian species is much higher than found in associated *Microcaracrinus*; however, in *Plummericrinus mcquirei*, from the uppermost Virgilian, the branching is erratic and some rays have less numerous secundibrachs.

Galateacrinus MOORE (1940) is thought to be a specialized member of this group, closely related to *Microcaracrinus*.

OCCURRENCE.—Pennsylvanian (Morrowan-Virgilian); USA.

PLUMMERICRINUS ERECTUS Strimple, 1954

Plate 10, figures 1a-c, 2

DESCRIPTION.—Crown long, slender, arms heterotomous. Dorsal cup low, truncate bowl-shaped, broad base occupied by large infrabasals and proximal portions of basals; basals large, extending to midheight of the cup; radials large, slightly wider than high, distal portions mildly extended to form a crescentic ridge well below the outer ligament area. Gaps are formed between radial articular facets at summit of the cup; 3 anal plates, radianal in oblique posterior position with anal X to the left above and right tube plate to the right, the latter extending well above the summit of anal X; arms very long and slender with rounded exteriors, primibrachs 1 of unequal lengths, those of C and D rays slightly elongated, A ray slightly longer and B and E rays short, brachials mildly constricted in midportion. The second

branching takes place on secundibrachs 14-16; some half rays may be unbranched. Nonaxillary brachials are decidedly cuneate and each bears a pinnule on the long side. Anal tube elongate, tubular, composed of thin, usually hexagonal plates with slender pore-slits along margins matching slits in adjacent plates; columnar scar large, circular in outline.

DISCUSSION.—*Plummericrinus erectus* is closely related to *P. striatus* STRIMPLE. Differences are in the more elongate nonaxillary brachials and the striated ornamentation of arms in the latter. *P. mcquirei* (MOORE, 1939) has irregular branching above first bifurcation of the arms. *P. granulosus* STRIMPLE (1954, p. 207) has prominent infrabasals, which are almost upflared, and a granular surface.

MEASUREMENTS OF THE HYPOTYPE (IGS42P56) IN MILLIMETERS.—Length of crown as preserved 76.8, width of dorsal cup (avg.) 17.0, height of cup 19.6, diameter of infrabasal circle 7.8, proximal columnal 3.2, length of anal tube 60.0, diameter of anal tube 8.5.

TYPES.—Hypotypes (IGS42P56, IGS42P14), collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company quarry, Ocoya, Livingston County, Illinois.

Genus MICROCARACRINUS Strimple & Watkins, 1969

TYPE-SPECIES.—*Microcaracrinus delicatus* STRIMPLE & WATKINS, 1969, p. 201.

DIAGNOSIS (after STRIMPLE & WATKINS).—Dicyclic; crown tall, slender; cup low, bowl-shaped with broad basal concavity; infrabasals five, confined to basal concavity; basals five, small, distal tips visible in side view of cup; radials five, tumid, large, pentagonal; anal plates three with radianal in posterior position, anal X and right tube plate above, both with confluent distal facets. Primibrachs occupy the full width of radials; first primibrach axillary, elongated, slender through constriction; brachials slightly elongated with median section mildly constricted, a rimlike ridge marks the top and bottom of each segment, and in series they are more or less sinuous or zigzag appearing; secundibrachs 5-7 axillary, each brachial bears a stout pinnule alternating with the adjacent brachials; column round, columnals alternatingly expanded. Lastly, *Microcaracrinus* has a short, looped anal tube as compared to the delicate long tube of *Plummericrinus*.

Species assigned to *Microcaracrinus* are as follows:

<i>Pachylocrinus bellirugosus</i> MOORE	Wabaunsee Group, Virgilian; Kansas
<i>Pachylocrinus colubrosus</i> MOORE ..	?Fort Riley Limestone, Lower Permian; Kansas
<i>Pachylocrinus twenhofeli</i> MOORE ..	Barneston Limestone, Lower Permian; Kansas

<i>Pachylocrinus pachypinnularis</i>	Kassimovskii Horizon, Lower
YAKOVLEV & IVANOV	Missourian; USSR
<i>Microcaracrinus delicatus</i>	Millsap Lake Formation,
STRIMPLE & WATKINS	Desmoinesian; Texas
<i>Microcaracrinus conjugulus</i>	Bond Formation, Missourian;
STRIMPLE & MOORE, n. sp.	Illinois

DISCUSSION.—All Mississippian genera ascribed to the Pachylocrinidae (i.e., *Pachylocrinus* WACHSMUTH & SPRINGER, 1880; *Abrotocrinus* MILLER & GURLEY, 1890; *Dasciocrinus* KIRK, 1939; *Hylodecrinus* KIRK, 1941; *Rhopocrinus* KIRK, 1942) already have low, truncate dorsal cups with infrabasals confined to the flattened or concave base and they most certainly evolved from forms with cone-shaped dorsal cups, probably the Blothrocrinidae. STRIMPLE & WATKINS (1969), assigned *Microcaracrinus* to the Blothrocrinidae because it was thought to be derived from the basic lineage rather than from the pachylocrinids. It is not possible at this time to prove or disprove the existence of polyphyletic lineages and since *Microcaracrinus* has essentially the characteristics of other pachylocrinids it is placed in the family.

Close relationship with *Plummericrinus* is indicated. Differences between the genera are seen in the projecting radials, typically with distinct interradianal notches, of *Plummericrinus*, which has a truncate cone-shaped cup as compared to the regular bowl-shaped cup and evenly curved radials, and lack of interradianal notches in *Microcaracrinus*. The arms of the latter genus have more pronounced pinnules and typically the brachials have a staggered appearance.

OCCURRENCE.—Pennsylvanian (Desmoinesian)-Lower Permian; USA (Texas, Illinois, Kansas), USSR.

MICROCARACRINUS CONJUGULUS Strimple & Moore, n. sp.

Plate 4, figure 2; Plate 10, figure 3a,b; Plate 11, figure 3

DESCRIPTION.—Crown subpyriform, arms not closely apposed. Dorsal cup small truncate bowl-shaped, height slightly less than greatest width, basal concavity small but distinct. Infrabasals small, extending slightly beyond columnar attachment cicatrix; basals moderately large, with proximal part participating in basal invagination and curving abruptly to form the basal plane and on into cup walls; radials large, length and width about equal; 3 anal plates, with proximal tip of anal X touching or nearly touching C-D basal, radianal small, obliquely placed, distal surfaces of anal X and right tube plate forming a confluent slanted plane. Arms uniserial, nonaxillary; brachials are cuneiform with the long sides protuberant; primibrach 1 axillary, A, C, and D elongated, second branching on secundibrach 4-7; pinnules are stout, occurring on alternate sides of arms, joining the long side of individual brachials; nonaxillary brachials have constrictions in midsection and the long side is projected so as to give a staggered appearance to the arms; anal tube not observed; columnar attachment round.

MEASUREMENTS OF HOLOTYPE IN MILLIMETERS.—Length of crown 13.5, width of dorsal cup 4.1, height 2.0, diameter of proximal columnal 0.9, infrabasals essentially covered by columnals.

DISCUSSION.—*Microcaracrinus conjugulus* is comparable to *M. colubrosus* (MOORE, 1939, p. 220) in cup shape and nature of the arms. *Exocrinus wanni* STRIMPLE is associated with *M. conjugulus* and has exotomous arms and similar primibrachs but differs in having hyperpinulation, and the cup is truncate cone-shaped rather than truncate bowl-shaped. *Exocrinus* could very well have evolved from a form like *M. conjugulus* by migration of radial to full posterior position and fusion of some brachials.

The associated *Plummericrinus ocoyaensis* is a much larger form in which the second branching of the arms is much higher; the base of the cup is flat with infrabasals extending well beyond the columnar attachment cicatrix and the radials protruded in their distal portions. *Microcaracrinus conjugulus* has a basal concavity with infrabasals covered by the stem and there is no protrusion of the radials.

The name *conjugulus* has reference to the unusual uniting of the brachials.

TYPES.—Holotype IGS42P12A, paratypes IGS42P55 and IGS42P12B collected by CHRISTINA CLEBURN.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, south of Pontiac, Livingston County, Illinois.

Genus GALATEACRINUS Moore, 1940

TYPE-SPECIES.—*Galateacrinus stevensi* MOORE, 1940.

DESCRIPTION (after MOORE).—Dorsal cup discoid, the circlet of radials projecting laterally very prominently and rather sharply separated from the basals; base gently concave. Infrabasals five, relatively small, flaring gently downward, not visible in side view of the cup. Basals five, subequal, medium-sized, somewhat bulbous, clearly visible in side view of the cup, tangent to basal plane of cup at about their midlength. Radials five, with outer part near facets extremely convex in longitudinal profile, their proximal and distal areas nearly horizontal, with intervening area produced laterally as a flange; articular facets subhorizontal, short, distinctly narrower than greatest width of these plates but with ends of neighboring transverse ridges almost touching. Three anal plates in the cup; anal sac unknown. First primibrachs axillary in at least three of the rays. Arms uniserial, endotomous, bifurcating on first primibrachs and three or more times in each half ray, brachials strongly cuneate in outline and pinnulate. Stem circular, heteromorphic, with sides of smooth columnals well-rounded longitudinally, non-cirriforous.

DISCUSSION.—Discovery of essentially complete arms in crowns identified as belonging to *Galateacrinus* (e.g., *G. coacervatus* from the LaSalle Limestone of the Liv-

ingston area in Illinois) has made possible a description of the arm structure. These crowns are reliably identified by features of the dorsal cups. The endotomous nature of the arm branching and nature of the cuneate brachials are closely similar to those of *Texacrinus*. The arms, structure of the cup, and nature of the radial articular facets are different from those of *Texacrinus* and therefore *Galateacrinus* has been removed from the Texacrinidae. Close affinity of *Galateacrinus* with *Microcaracrinus* is indicated by the arm structure.

OCCURRENCE.—Pennsylvanian (Desmoinesian-Virgilian); USA (Kansas, Oklahoma, Texas, Illinois).

GALATEACRINUS COACERVATUS Strimple & Moore, n. sp.

Plate 8, figure 1; Plate 12, figures 3a,b

DIAGNOSIS.—Shape of dorsal cup typical of the genus, but more evenly bowl-like than in *Galateacrinus stevensi*. The round heteromorphic column is composed of series of 2 nodals with large priminternodal midway between and 2 secundinternodals. Crenulae are sparse and gross, lumen round.

MEASUREMENTS OF HOLOTYPE (IGS42P11B) IN MILLIMETERS.—Height of crown 21.0, height of dorsal cup 2.1, width of cup 6.0, diameter of proximal columnals approximately 1.1 mm.

DISCUSSION.—Portions of the arms are preserved (30 indicated) in the holotype of *Galateacrinus coacervatus* (IGS42P11B), disclosing their endotomous structure. Brachials are cuneiform, with the long, pinnule-bearing sides projected as short spines; axillary brachials in distal portions extended sideward as blunt, thin, spatula-like projections. In viewing the cup of *Galateacrinus coacervatus* from the base, the radials are less prominent than in other species of the genus. Ornamentation of *G. coacervatus* consists of a few elongated ridges that trend parallel to the longitudinal axis of the radials, reminiscent of the numerous ridges on the radials of the older *G. stevensi*.

The name *coacervatus* means heaped together, referring to the strongly clustered grouping of the basals.

TYPES.—Holotype IGS42P11B, paratypes IGS42P12 and IGS42P12D collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya south of Pontiac, Livingston County, Illinois.

Family PIRASOCRINIDAE Moore & Laudon, 1943

DIAGNOSIS (after MOORE & LAUDON, 1944).—Dicyclic; crown compact; cup low; base flat or concave; infrabasals five, not visible from side, radial facets wide and moderately long, sloping gently outward, having distinct transverse ridge, muscle, and ligament areas; three anals in cup; sac prominent, mushroom-shaped; arms uniserial, branching twice or more isotomously.

GENERA.—*Zeusocrinus* STRIMPLE, 1961; *Stenopeocrinus* STRIMPLE, 1961; *Aatocrinus* MOORE & PLUMMER, 1940;

Polygonocrinus STRIMPLE, 1961; *Plaxocrinus* MOORE & PLUMMER, 1939; *Pirasocrinus* MOORE & PLUMMER, 1940; *Anchicrinus* STRIMPLE & WATKINS, 1969; *Perimestocrinus* MOORE & PLUMMER, 1938; *Paianocrinus* STRIMPLE, 1951; *Triceracrinus* BRAMLETTE, 1943; *Utharocrinus* MOORE & PLUMMER, 1938; *Metaperimestocrinus* STRIMPLE, 1961; *Schedexocrinus* STRIMPLE, 1961; *Laudonocrinus* MOORE & PLUMMER, 1940; *Bathronocrinus* STRIMPLE, 1962; *Hypemorphocrinus* ARENDT, 1968; *Eimocrinus* STRIMPLE & WATKINS, 1969.

DISCUSSION.—KNAPP (1969, p. 369) stated: "Presumably, the ancestry of the pirasocrinids is in a phanocrinid-like dorsal cup, and by multiplication of the arms, lowering of the dorsal cup, and by decreasing the downflaring of the infrabasal plates, the Pirasocrinidae were established." The phanocrinid lineage is remarkably stable and, as demonstrated by KNAPP, continued with ten-armed derivatives into the Permian. It is not involved in the pirasocrinid lineage. We find no valid reason for questioning *Zeusocrinus* STRIMPLE as the probable progenitor of the pirasocrinids, as propounded by STRIMPLE (1961, p. 21). *Zeusocrinus* has a low cup with multiple arms and a terminating umbrellalike platform on the anal tube.

OCCURRENCE.—Mississippian (Chesteran)—Lower Permian; USA, USSR.

Genus POLYGONOCRINUS Strimple, 1961

TYPE-SPECIES.—*Polygonocrinus multiextensus* STRIMPLE, 1961.

DIAGNOSIS.—Crown wide and squat; arms branch three or more times and are partially biserial; dorsal cup is little more than a platform with a broad impressed base formed by infrabasals, concave basals, and proximal portions of radials; termination of anal tube a large platform surrounded by at least 14 outwardly directed spines.

OCCURRENCE.—Pennsylvanian (Desmoinesian-Missourian); USA (Texas, Oklahoma, Illinois).

POLYGONOCRINUS SPINIFERUS Strimple & Moore, n. sp.

Plate 5, figures 2a,b

DESCRIPTION.—Crown low and broad, with arms branching twice isotomously; cup extremely low; terminal platform of the anal tube at the crown summit large. The height of the cup is provided by the distal portions of the radials, which have finely granular outer surfaces; outline of radials hexagonal when viewed from below; proximal portions of radials, basals and infrabasals restricted to basal invagination; 5 infrabasals form subhorizontal disc almost covered by large proximal columnals; 5 basals are mildly concave in midsection; 5 large radials form the basal plane and flex sharply to produce the short lateral cup walls; a flattened, arcuate area may be formed just below the outer ligament area but is indistinct in the holotype; posterior interradius (C-D) impressed; 3 elongated anal plates are in normal arrangement. Arms are

uniserial, broad in proximal portions but reduce sharply after second bifurcation; axillaries are large, primibrach 1 protruded but not as a spine, other axillaries produced as long spines; nonaxillary brachials short, with rounded exteriors and inner portions of each brachial slightly expanded and pinnule-bearing on one side, alternating brachials shortened and nonpinnule-bearing on same side; 4 to 6 secundibrachs present followed by a third bifurcation of some arms. Termination of anal sac is a large platform composed of polygonal plates surrounded by 14 large, outwardly directed spines with large, spadelike proximal sections. Column round, heteromorphic, in series of one large columnal (nodal) followed by a smaller internodal; crenellae readily visible in side view; lumen round.

The crown has a height of about 39.0 mm, dorsal cup 2.6 mm high, 25 mm wide.

DISCUSSION.—This species is closer in general structure of the short crown to typical *Polygonocrinus* than to the closely related *Eimocrinus* STRIMPLE & WATKINS (1969, p. 204) which has very long arms. Only one interlocking brachial (a secundibrach) has been observed in *P. spiniferus*, whereas biserial or incipiently biserial, structure is found in all sections of the arms in other species assigned to the genus and is found in the lower arms (secundibrachs) of *E. grossus*. The primibrachs of all known species of *Polygonocrinus*, including *P. spiniferus*, are protuberant but not produced as pronounced spines, unlike *E. grossus*, which has primibrachs protruded as long spines.

It appears that the Upper Pennsylvanian species *Polygonocrinus spiniferus* either represents a separate lineage within the genus, which has not advanced to biserial arm structure reflected by Lower Pennsylvanian species of the genus, or that the tendency to become biserial is variable.

The structure of the dorsal cup is characteristic of the genus, that is, the infrabasals, basals, and distal portions of the radials are not visible in side view of the cup; the basals are concave in midportions. The cup has a sharply angular outline when viewed from the summit or from below, and the posterior interradius (C-D) is impressed. The dorsal cup of typical *Pirasocrinus* has bulbous radials and a deeper, more restricted basal invagination; it also differs in having a taller crown with smaller terminating anal platform having less numerous perimeter spines. Other genera of the pirasocrinids have more prominent, convex basals.

TYPES.—Holotype IGS42P109 collected by AMEL PRIEST, paratype IGS42P110 collected by D. L. GOOD.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; north end of Wagner Stone Company Quarry, Ocoya, south of Pontiac, Livingston County, Illinois.

Genus LAUDONOCRINUS Moore & Plummer, 1940

TYPE-SPECIES.—*Hydreionocrinus subsinuatus* MILLER & GURLEY, 1894.

DIAGNOSIS.—The type of the type-species is a low, modified bowl-shaped dorsal cup without any arms preserved. The infrabasals are subhorizontal but with their distal tips appearing in side view of the cup; basals curve very gently outward and then upward to join the radials in forming the sides of the cup; *CD* interray and adjoining areas are confluent and form a gentle concavity. Three anal plates are in normal (primitive) arrangement within the cup.

Hypotype specimens of the type-species of this genus from the LaSalle Limestone afford information relative to the arms and anal tube. Uniserial, pinnulate arms branch on primibrach *1* in all rays and again isotomously on secundibrach *6*. Primibrach *1* has a thin spinelike projection near its distal end; axillary secundibrachs are gently tumid and do not produce spines. The brachials are slightly cuneate, with long sides bearing elongate slender pinnules. The anal tube is stout, composed of an interlocked series of hexagonal plates having margins penetrated by slits; the sac terminates in a platform of spinose plates just above distal terminations of the arms.

The summit platform of the anal sac is composed of a small central disc, which is not preserved in the Illinois material studied; it is surrounded by seven large, spade-like plates which extend laterally as long spines. Proximal columnals are round, thin, and strongly crenulated, with a small, round lumen.

DISCUSSION.—Apparently a close relationship associates *Laudonocrinus*, *Stenopeocrinus* STRIMPLE (1961, p. 39) and *Plaxocrinus* MOORE & PLUMMER (1940, p. 187), as reflected by the nature of the summit platform of the anal sac, which is composed of a small central disc surrounded by six or seven large plates produced as long spines, and by the almost identical arm structures of these genera. *Bathronocrinus* STRIMPLE (1962, p. 37) has a shallow cup with flared sides and no basal concavity.

Laudonocrinus and *Plaxocrinus* have spinose primibrachs *1* but subsequent axillary brachials are not produced as spines. *Stenopeocrinus* has spinose primibrachs *1* and subsequent axillary brachials are spinose. Differentiation of the genera is based mostly on structure of the dorsal cup which in *Laudonocrinus* has a modified bowl shape with the infrabasal plates visible in side view of the cup—albeit in two species of Desmoinesian age (*L. cucullus* MOORE & PLUMMER, 1940, p. 176, and *L. catillus* MOORE & PLUMMER, 1940, p. 178) the base of the cup is essentially flat, with the infrabasals not visible in side view. The cited species probably belong to another genus. *Plaxocrinus* and *Stenopeocrinus* have a basal concavity, but in *Plaxocrinus* it is broad and shallow and in *Stenopeocrinus* it is narrow and deep. The basal plates of *Plaxocrinus* do not extend appreciably onto sides of the cup, but in *Stenopeocrinus* they are more prominent elements. Both genera tend to develop long arms in larger specimens. *Anchicrinus* STRIMPLE & WATKINS (1969, p. 206) is probably related to this lineage. All axillary brachials

are spinose, the terminating platform of the anal tube bears eight spines and the base of the cup is shallowly depressed. *Metaperimestocrinus* STRIMPLE (1961, p. 36), which has no basal concavity at all but carries an expanded terminating anal platform with numerous surrounding spines, might be an evolutionary derivative of *Anchicrinus*. *Pirasocrinus* MOORE & PLUMMER (1940, p. 235) has a very tall crown; the dorsal cup is shallow, with a pronounced basal concavity containing the subhorizontal infrabasal circlet and basal plates within the depression; its radial plates are bulbous and ten spinose plates surround a small anal summit platform.

Polygonocrinus STRIMPLE (1961, p. 63), *Eirmocrinus* STRIMPLE & WATKINS (1969, p. 204), and *Sciadiocrinus* MOORE & PLUMMER (1940, p. 238) are highly specialized forms with broad crowns, shallow cups having broadly depressed basal areas and a large number of spines around the broad platform at top of the anal sac.

OCCURRENCE.—Pennsylvanian (?Desmoinesian-Missourian); USA (Missouri-Illinois, Oklahoma-Texas).

LAUDONOCRINUS SUBSINUATUS (Miller & Gurley), 1894

Plate 9, figures 1a,b; 3

DISCUSSION.—The arms and tegmens of the 2 young specimens from the LaSalle Limestone are discussed under the generic discussion. The dorsal cups are essentially like that of the holotype except in one specimen (IGS42P61A) which exhibits more tumidity of the cup plates than the other hypotype (IGS42P92) or the holotype. The crowns are equidimensional, having an overall height of about 19 mm.

The horizon from which the holotype was procured at Kansas City, Missouri, is unknown other than being in the Missourian Stage.

TYPES.—Hypotypes IGS42P61A and IGS42P92 collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, Livingston County, Illinois.

Genus SCIADIOCRINUS Moore & Plummer, 1938

TYPE-SPECIES.—*Zeacrinus* (*Hydreionocrinus*) *acanthophorus* MEEK & WORTHEN, 1879.

DESCRIPTION (after STRIMPLE & WATKINS, 1969, p. 211).—The genus is distinguished by having a relatively short, broad crown; radials have a tendency to touch infrabasals, and commonly make contact with them; the basal circlet is substellate in outline (except for its posterior part); the base of the cup is shallowly concave; arms are essentially isotomous, with first three bifurcations on axillary primibrach *1*, on secundibrach *2*, and tertibrach *3* to *5*; none of the axillaries develop spines and subsequent bifurcations usually are restricted to outermost branches of the two half rays; brachials are decidedly uniserial; umbrellalike extremity of the anal tube composed of numerous small polygonal plates surrounded by 12 to

15 outwardly directed spinelike plates (some of the peripheral spines short and blunt).

Species assigned to *Sciadiocrinus* are tabulated as follows:

Species of Sciadiocrinus

	Occurrence	Present Assignment
<i>Zeacrinus (Hydreionocrinus) acanthophorus</i> MEEK & WORTHEN, 1870	Desmoinesian; Illinois, Missouri	<i>Sciadiocrinus</i> Type-species
<i>Sciadiocrinus? crassacanthus</i> MOORE & PLUMMER, 1940	Morrowan; Oklahoma, Arkansas	Spinelike plates
<i>Sciadiocrinus disculus</i> MOORE & PLUMMER, 1940	Missourian; Texas	<i>Sciadiocrinus</i>
<i>Sciadiocrinus harrisae</i> MOORE & PLUMMER, 1940	Desmoinesian; Oklahoma, Texas	<i>Sciadiocrinus</i>
<i>Eupachycrinus platybasis</i> WHITE, 1883	Lower Aubrey Group; Utah	<i>Sciadiocrinus</i>
<i>Schistocrinus confertus</i> MOORE & PLUMMER, 1940	Desmoinesian; Texas	<i>Sciadiocrinus</i>
<i>Schistocrinus planulatus</i> MOORE & PLUMMER, 1940	Desmoinesian; Texas	<i>Sciadiocrinus</i>
<i>Plaxocrinus obesus</i> MOORE & PLUMMER, 1940	Desmoinesian; Texas	<i>Sciadiocrinus</i>
<i>Schistocrinus parvus</i> MOORE & PLUMMER, 1940	Desmoinesian; Texas	<i>Syn., Sciadiocrinus confertus</i>
<i>Sciadiocrinus llanoensis</i> STRIMPLE & WATKINS, 1969	Atokan; Texas	<i>Sciadiocrinus</i>
<i>Pirasocrinus invaginated</i> STRIMPLE, 1951	Missourian; Texas	<i>Sciadiocrinus</i>
<i>Athlocrinus clarus</i> STRIMPLE, 1962	Desmoinesian; Oklahoma	<i>Sciadiocrinus</i>
<i>Athlocrinus clypeiformis</i> MOORE & PLUMMER, 1940	Missourian; Texas	<i>Sciadiocrinus</i>
<i>Sciadiocrinus humilis</i> STRIMPLE, 1951	Missourian; Kansas	<i>Sciadiocrinus</i>

OCCURRENCE.—Lower Pennsylvanian (Morrowan)-Upper Pennsylvanian (Missourian); USA (Arkansas, Oklahoma, Missouri, Illinois, Texas, Utah).

SCIADIOCRINUS TEGILLUM Strimple & Moore, n. sp.

Plate 2, figures 1a,b

DESCRIPTION.—Crown short, arms narrow, composed of equidimensional brachials with well-rounded exteriors. Dorsal cup very shallow, bowl-shaped, base gently concave except in midportion, which is sharply invaginated; sides of cup curve gently upward to subvertical at summit; CD interradius rather broad, gently convex; sutures mildly impressed; contour of cup smooth; 5 infrabasals mostly covered by stem and confined to sharply impressed median portion of base, distal tips in shallow basal concavity and not visible in side view of cup; 5 basals small,

interbasal sutures very short or reduced to points, plates subhorizontal except for distal tips which may be barely visible in side view in some interrays; 5 large radials with proximal tips extending to basal plane, facets slightly less than maximum width of plates producing shallow notch at interrarial sutures in summit plane; 3 anal plates in normal (primitive) arrangement. Column round, relatively large. Arms pinnulate, bifurcating isotomously on tumid axillary primibrach 1, on nontumid secundibrach 2 and again on tertibrach 4. Summit platform of anal sac subhorizontal, its central portion composed of numerous small, polygonal plates and border surrounded by 12 to 16 large outwardly directed spinose plates, bases of which are long and flattened, expanding gradually to near mid-length and distally tapering to thin rounded apex.

Holotype is about 26 mm tall, maximum width 21 mm; dorsal cup 3.2 mm tall, 19.5 mm wide.

DISCUSSION.—*Sciadiocrinus tegillum* is closely related to *S. acanthophorus* but has a less pronounced basal concavity and lacks the tumidity of radial plates found in the latter species. General contour of the cup is close to that of *S. clarus* (STRIMPLE) and *S. clypeiformis* (MOORE & PLUMMER). Major differences lie in the smaller basals and shorter (or lack of) interbasal sutures in *S. tegillum*.

NAME.—Species name from Latin *tegillum*, diminutive roof.

TYPES.—Holotype IGS42P47, paratype IGS42P171, collected by CHRISTINA CLEBURN.

OCCURRENCE.—LaSalle Limestone, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, Livingston County south of Pontiac, Illinois.

Genus STENOPECRINUS Strimple, 1961

TYPE-SPECIES.—*Perimestocrinus planus* STRIMPLE, 1952.

DESCRIPTION.—This genus exhibits general characters of the Pirasocrinidae but is distinguished by its deep and restricted basal concavity in which the proximal parts of basal plates overhang the bottom of the concavity; notches between radial facets are narrow, giving the cup a circular outline; plates are tumid and sutures impressed; the arms are uniserial, endotomous.

OCCURRENCE.—Lower Pennsylvanian (Morrowan)-Upper Pennsylvanian (Missourian). USA (Oklahoma-Texas-Illinois).

STENOPECRINUS sp. cf. S. PLANUS (Strimple), 1952

Figure 2A; Plate 12, figure 1a,b

DESCRIPTION.—Dorsal cup low bowl-shaped, with rather deep and narrow basal concavity; infrabasals restricted to basal area of concavity; basals forming steep sides of the concavity, curving sharply out of it so as to be visible in side view of the cup; radials large, with distal portions upright, articular facets sloping mildly outward and not filling distal width of plates, notches present at the summit of the interrarial sutures but not pronounced; 3 anal plates are usually in normal (prim-

Species of *Stenopeocrinus*

	Occurrence	Present Assignment
<i>Perimestocrinus planus</i> STRIMPLE, 1952	Missourian; Oklahoma, Illinois	<i>Stenopeocrinus</i>
<i>Perimestocrinus papillatus</i> STRIMPLE, 1962	Desmoinesian; Oklahoma	<i>Stenopeocrinus</i>
<i>Perimestocrinus impressus</i> MOORE & PLUMMER, 1940	Desmoinesian- Missourian; Texas, Oklahoma	<i>Stenopeocrinus</i>
<i>Perimestocrinus moseleyi</i> STRIMPLE, 1951	Missourian; Texas	<i>Stenopeocrinus</i>
<i>Stenopeocrinus rugosus</i> STRIMPLE, 1961	Wapanucka; Oklahoma	<i>Stenopeocrinus</i>

itive) arrangement but the radianal may move to posterior position as in many specimens studied by STRIMPLE (1952). Arms uniserial, first branching on primibrach 1, second branching on or about secundibrach 6, and a third branching high in outer rays only, all axillaries produced in distal portions as long slender spines. The platform at the summit of anal tube reported by STRIMPLE (1961, p. 41) was composed of 6 small, polygonal plates surrounded by 7 elongate, spinelike plates. The present holotype has a platform composed of at least 7 small polygonal plates surrounded by 8 elongated spinelike plates. Column is round.

Crown of hypotype (IGS42P59) is 25.6 mm high, dorsal cup 3.0 mm high, 7.6 mm wide.

HYPOTYPE.—IGS42P59, collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone; Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, south of Pontiac, Livingston County, Illinois.

STENOPECRINUS sp.

Plate 8, figures 4a-c

A juvenile crown is presented to demonstrate characters which differ from older forms. Without an ontogenetic sequence it is not possible to assign the single specimen to a species.

DESCRIPTION.—The outer surfaces of dorsal cup and arms are covered by minute, granulelike projections. Slender axillary primibrachs 1 are unequally elongated, that of the A ray having greatest length. The base of a small spine is seen near the apex of each primibrach 1. Secundibrachs are slender and elongate with secundibrach 4-7 axillary and spinose. Arms lack more than 3 observed tertibrachs. Terminating platform of anal tube is small, with perimeter composed of 7 broad-based short spines surrounding a subhorizontal disc of small, polygonal plates. Several relatively large, preserved columnals have a circular outline.

MEASUREMENTS OF FIGURED SPECIMEN IN MILLI-

METERS.—Crown 14.0 long; cup 1.8 high, 4.2 wide; terminating platform 2.2 diameter; column 1.0 diameter.

FIGURED SPECIMEN.—IGS42P58 collected by CHRISTINA CLEBURN.

OCCURRENCE.—LaSalle Limestone, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, south of Pontiac, Livingston County, Illinois.

Family ANOBASICRINIDAE Strimple, 1961

DIAGNOSIS.—Dicyclic; expanded crown. Cone-shaped or truncate cone-shaped dorsal cup. Infrabasals five, unflared or subhorizontal; basals five; radials five with articular facets almost or entirely filling summit of plate; anal plates three, primitive to advanced. Arms long, uniserial, pinnulate, with rounded exterior, branching endotomous, heterotomous or exotomous, primibrach 1 axillary in all rays. Large recurved anal sac which may become bulbous or balloon-shaped.

GENERA.—*Anobasicrinus* STRIMPLE, 1961; *Tundracrinus* YAKOVLEV, 1928; *Synphocrinus* TRAUTSCHOLD, 1867; *Schistocrinus* MOORE & PLUMMER, 1940; *Haeretocrinus* MOORE & PLUMMER, 1940; *Terpnocrinus* STRIMPLE & MOORE, n. gen.

DISCUSSION.—This lineage is apparently derived from the Aphelecrinidae STRIMPLE, 1967, and more specifically from forms with heterotomous branching, such as *Cosmetocrinus indianensis* (MEEK & WORTHEN, 1865, p. 155) from the Borden Formation. An undescribed species from the Menard Formation (Chesteran) has even more divergence.

STRIMPLE (1961, p. 114) referred *Plummericrinus* MOORE & LAUDON (1943, p. 56) and *Glaukosocrinus* STRIMPLE (1951, p. 191) to the family. LANE & WEBSTER (1966, p. 41) suggested that *Plummericrinus* should remain in the Pachylocrinidae. *Glaukosocrinus* is herewith referred to the family Decadocrinidae.

OCCURRENCE.—Lower Pennsylvanian (Morrowan) to Lower Permian; USA (Oklahoma, Missouri, Nebraska), USSR.

Genus ANOBASICRINUS Strimple, 1961

TYPE-SPECIES.—*Anobasicrinus bulbosus* STRIMPLE, 1961, p. 115.

DESCRIPTION.—Widely expanded with low, truncate cone-shaped dorsal cup. Infrabasals small, subhorizontal, or rising evenly from the columnar attachment area. The cup has five short basal plates, five radial plates, and three anal plates. The articular facets do not fill the entire width of radials. Arms are slender, uniserial, with isotomous or biendotomous branching. All arms branch on first primibrach and evenly again on a second or third secundibrach, with further bifurcation in some half arms. The anal sac is recurved, strongly expanded into a balloonlike structure which does not extend above the arms. The column is round.

OCCURRENCE.—Pennsylvanian (Morrowan-Virgilian); USA (Oklahoma, Texas, Illinois).

ANOBASICRINUS BREVIS Strimple & Moore, n. sp.

Plate 4, figures 3a-c

DISCUSSION.—The dorsal cup is shorter and with more flared sides than is typical for the genus. Basals and interbasal sutures are shortened so that proximal ends of the radials almost reach the slightly upflared infrabasal circlet. Anal plates 3, in modified normal (primitive) arrangement wherein distal edges of anal X and right tube plate form a common plane. A small but pronounced notch is present between arm articulating surfaces of the radials.

Lowering of the cup and shortening of the interbasal sutures demonstrates an evolutionary trend in this species leading to *Schistocrinus*, in which the radials actually separate the basals. STRIMPLE (1961) referred *Schistocrinus* to the Anobasicrinidae.

MEASUREMENTS OF HOLOTYPE IN MILLIMETERS.—Height of cup 8.5, width (average) 28.8; diameter of infrabasal circlet 18.8, proximal columnal 5.0; length of basal 4.9, width 6.9; length of radial 5.2, width 9.7.

TYPE.—Holotype IGS42P49 collected by CHRISTINA CLEBURN.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry south of Pontiac, Illinois.

Genus HAERETOCRINUS Moore & Plummer, 1940

TYPE-SPECIES.—*Haeretocrinus missouriensis* MOORE & PLUMMER, 1940, p. 110.

DIAGNOSIS.—Dorsal cup conical, truncate at point of stem attachment. Five infrabasals rise evenly, readily visible in side view; interrational sutures located in furrows, articular facets slope gently outward; three anal plates commonly Primitive Type B or Extreme Type (1) arrangement (see Strimple, 1969, p. 250, 251). Arms uniserial, first bifurcation on primibrach 1 in all rays; thereafter they may branch exotomously two or more times. Anal sac large, long, recurved, with large anus about midway down on anterior side (e.g., *H. wagneri*, n. sp.). Stem round.

OCCURRENCE.—Pennsylvanian (Desmoinesian-Virgilian); USA (Illinois, Missouri, Oklahoma, Kansas, Texas).

HAERETOCRINUS WAGNERI Strimple & Moore, n. sp.

Plate 1, figures 2a,b; Plate 13, figures 1a-c

DISCUSSION.—The crown is tall with expanded arms; dorsal cup is moderately high and evenly cone-shaped. Three anal plates are in normal (primitive) arrangement. The 30 arms are so constructed as never to become apposed; the brachials are short, causing the pinnules to be closely packed. Anal sac is large, recurved.

Haeretocrinus depressus STRIMPLE (1962, p. 44) has a more globular cup with depressions at angles of the cup plates. *H. missouriensis* MOORE & PLUMMER (1940, p. 110) has an advanced arrangement of anal plates with the radial reaching the D radial and anal X and right tube plates above. *H. turbinatus* STRIMPLE (1952, p. 245) has

a confluent upper surface of the anal X and right tube plates. *H. wagneri* has a normal (primitive) arrangement for all three anal plates.

MEASUREMENT OF HOLOTYPE (IGS42P64) IN MILLIMETERS.—Height of crown (incomplete) 95.0, height of dorsal cup 17.6, height of large anal sac 51.5, width of dorsal cup 22.8.

NAME.—The species is named for Mr. WAGNER, owner of the quarry from which the material was recovered.

TYPES.—Holotype, IGS42P64, collected by CHRISTINA CLEBURN and H. L. STRIMPLE; paratype IGS42P112 collected by CHRISTINA CLEBURN.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, south of Pontiac, Livingston County, Illinois.

HAERETOCRINUS MACOUPINENSIS (Worthen, 1873),
Strimple & Moore, n. comb.

Plate 4, figure 4

DISCUSSION.—This species, based on a single dorsal cup from rocks of Missourian age in Macoupin County, Illinois, is conspecific with a dorsal cup from an upper crystalline limestone of the LaSalle Limestone Member exposed along the west wall of the Wagner Limestone Company Quarry. The dorsal cup is cone-shaped, with 5 upflared infrabasals, 5 basals, 5 radials, and 2 anals including the radial in direct posterior position.

MEASUREMENTS OF HYPOTYPE IN MILLIMETERS.—Height of cup 19.8, width of cup 22.0; height of infrabasals circlet 6.0.

HYPOTYPE.—IGS42P65 collected by D. W. BURDICK.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, south of Pontiac, Livingston County, Illinois.

Genus TERPNOCRINUS Strimple & Moore, n. gen.

TYPE-SPECIES.—*Terpnocrinus ocoyaensis* STRIMPLE & MOORE, n. sp.

DESCRIPTION.—Crown medium large, somewhat taller than wide, with robust arms at least four times greater in height than cup. Dorsal cup moderately deep bowl-shaped, with well-rounded sides and base, plates mildly tumid, with somewhat impressed sutures; five infrabasals are distally upflared but with sharply impressed proximal portions; five basals large, five radials large, slightly wider than long; three anal plates in normal (primitive) arrangement. Arms stout, more than 20, uniserial, with well-rounded exteriors; two isotomous branchings, first on primibrach 1, again on secundibrach 6 to 8, third branching not preserved in most rays; nonaxillary brachials wider than high and bear pinnules on alternating sides. Anal sac recurved, slightly expanded at termination and composed along outer perimeter of a series of moderately thick plates with sharp elongated keels, but in the interior the plates are thin and smaller. Column round, lumen round.

DISCUSSION.—The cup of *Terpnocrinus* is like that of *Goleocrinus* STRIMPLE & WATKINS except for the infrabasals, which in the former are shallowly impressed in midportion of the circlet with distal portions readily visible in side view but decidedly downflared in proximal portions; the distal tips are subhorizontal in the latter. The recurved anal sac has a structure similar to that of *Haeretocrinus*, but the cup of the latter is cone-shaped rather than bowl-shaped or subglobose.

OCCURRENCE.—Pennsylvanian (Missourian); USA (Illinois).

TERPNOCRINUS OCOYAENSIS Strimple & Moore, n. sp.

Figure 8; Plate 14, figures 1a-d

DIAGNOSIS.—Characters of the genus.

DISCUSSION.—The cup of *Terpnocrinus ocoyaensis* has the general appearance of *Goleocrinus* but differs in having tumid infrabasals readily visible in side view of the cup.

MEASUREMENTS OF HOLOTYPE IN MILLIMETERS.—Height of crown (incomplete) 26.0, height of cup 6.8, width of infrabasal circlet 1.1 mm, diameter of columnar scar 3.7.

HOLOTYPE.—IGS42P108 collected by CHRISTINA CLEBURN.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, south of Pontiac, Livingston County, Illinois.

Family CROMYOCRINIDAE Jaekel, 1918

DIAGNOSIS.—Cup medium globular to high globose, or bowl- to cone-shaped, greatest width below summit of the cup; infrabasals downflared or subhorizontal in older forms but generally upflared; two or three anal plates in posterior interradius; arms long, uniserial in older forms to biserial in younger ones, ten in most, branching on primibrach 1, but arms reduced to five in *Cromyocrinus* and *Ureocrinus*; column round.

GENERA.—*Cromyocrinus* TRAUTSCHOLD, 1867; *Dicromyocrinus* JAEKEL, 1918; *Mooreocrinus* WRIGHT & STRIMPLE, 1945; *Parulocrinus* MOORE & PLUMMER, 1940; *Parethelocrinus* STRIMPLE, 1966; *Aglaocrinus* STRIMPLE, 1961; *Paracromyocrinus* STRIMPLE, 1966; *Metacromyocrinus* STRIMPLE, 1961; *Synarmocrinus* LANE, 1964; *Ulocrinus* MILLER & GURLEY, 1890; *Ureocrinus* WRIGHT & STRIMPLE, 1945; *Mantikosocrinus* STRIMPLE, 1951; *Probletocrinus* STRIMPLE & MOORE, n. gen.; *Ethelocrinus* KIRK, 1937.

DISCUSSION.—The arms are known for all genera currently assigned to the cromyocrinids. Discovery of 16 arms in *Parulocrinus pontiacensis*, n. sp., has caused reassessment of the genus *Parulocrinus*.

OCCURRENCE.—Mississippian (Tournaisian-Chesterian) through Pennsylvanian (Morrowan-Virgilian); USA, USSR, Scotland.

Genus ULOCINUS Miller & Gurley, 1890

TYPE-SPECIES.—*Ulocrinus buttsi* MILLER & GURLEY, 1890, p. 7.

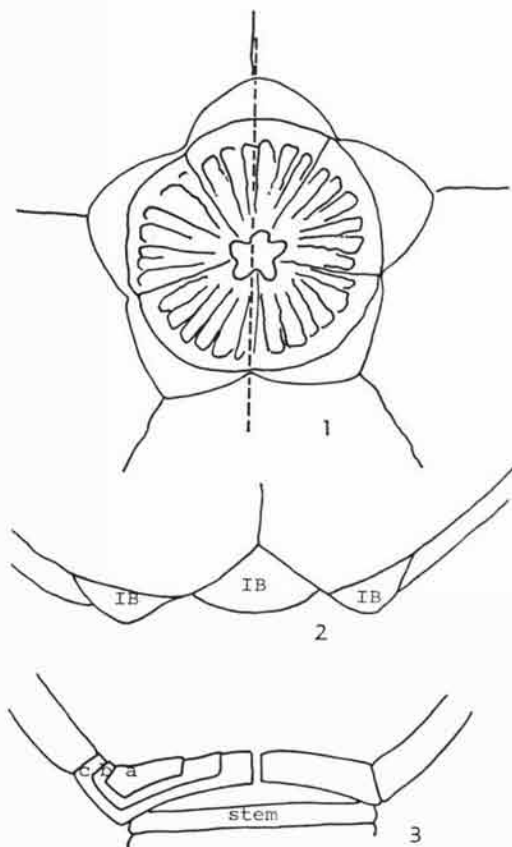


FIG. 8. Camera lucida drawings of *Terpnocrinus ocoyaensis* STRIMPLE & MOORE, n. gen., n. sp., from LaSalle Limestone, base of dorsal cup, holotype (IGS42P108), $\times 8$.—1. Exterior of infrabasal circlet showing large concave stem-facet area.—2. Side view showing upflared distal parts of infrabasal plates.—3. Section of infrabasal circlet showing inferred growth increments (a-c).

DISCUSSION.—The oldest known species referred to the genus is *Ulocrinus percutus* KNAPP, 1969, from the Burgner Formation of Missouri, which has a high cup with vertical sides and upflared infrabasals. The associated *Metacromyocrinus decoratus* KNAPP, 1969, has a lower cup which is constricted near the summit. The attitude of the infrabasals (subhorizontal) and the surface ornamentation is very similar in two forms. Both genera have ten large biserial arms branching on primibrach 1. It appears that they share a common ancestor, probably a form like *Mantikosocrinus* STRIMPLE, 1961, from the Upper Mississippian Fayetteville Formation. Both *Ulocrinus* and *Metacromyocrinus* range well up into the Pennsylvanian and at least *Ulocrinus* appears to continue into the Permian.

OCCURRENCE.—Pennsylvanian (Atokan, Desmoinesian, Missourian), Lower Permian; USA (Oklahoma, Missouri, Illinois, Kansas, Texas), USSR, ?Indonesia (Timor), ?India.

ULOCINUS FISTULOSUS Strimple & Moore, n. sp.

Plate 15, figures 2a-d; Plate 16, figures 1a-c, 2a-c

DESCRIPTION.—Dorsal cup slightly constricted at sum-

mit appearing somewhat elongate partly owing to slight protrusion in the radial area, but height and width actually are about equal; cup plates tumid; pronounced ridges crossing deeply impressed suture areas produce appearance of a series of pits. Infrabasal circlet bowl-shaped, with sharply impressed stem attachment area; 5 large basals sharply differentiated from infrabasal circlet; 5 radials moderately large, slightly wider than long, with pronounced subhorizontal area below outer ligament furrow, horizontal articular facets broad; 2 anal plates; radial quadrangular; anal X long, extending well above summit of cup and followed above by two small tube plates.

MEASUREMENTS OF HOLOTYPE IN MILLIMETERS:

Height of cup (anterior side)	30.2
(right posterior side)	31.9
Width of cup (C ray to AE basal)	34.0
(B ray to DE interray)	33.0
Height of infrabasal circlet	10.2
Width of infrabasal circlet	19.3
Diameter of stem attachment area	7.0
Length of AB basal	17.8
Width of AB basal	16.8
Length of B radial	16.2
Width of B radial	11.8

DISCUSSION.—The infrabasal circlet of *Ulocrinus fistulosus* is cup-shaped, whereas in *U. convexus* the infrabasals are more evenly upflared and are confluent with the overall cup shape. Cup plates of *U. convexus* are much thinner and the sutures are not so impressed. *Goleocrinus confossus* STRIMPLE & WATKINS (1969, p. 168) has tumid plates and well-defined holes in the impressed suture areas, but the cup is low truncate bowl-shaped. Probably *G. confossus* and *U. fistulosus* are related. *U. zeschii* STRIMPLE & WATKINS (1969, p. 167) has a cup shape and lack of tumidity more like that of *U. convexus*, and traces of ridges cross the impressed suture areas.

The species name is from Latin *fistulosus*, full of holes.

TYPES.—Holotype SUI 34176, collected by J. M. COCKE, paratypes SUI 34177, 34545, collected by H. L. STRIMPLE, deposited in the Geology Department, The University of Iowa, Iowa City.

OCCURRENCE.—Upper Plattsburg (Mound Rock), Missourian Stage, Pennsylvanian; SE ¼ SW ¼ sec. 24, T. 31 S., R. 15 E., Montgomery County, about three-fourths mile west of Sycamore, Kansas; Wann Formation, Ochelata Group, Missourian, Pennsylvanian; the "Mound" just west of Bartlesville, Washington County, Oklahoma. An excellent crown has been found also in the LaSalle Limestone at the Wagner Quarry, Ocoya, Illinois.

ULOCRINUS SANGAMONENSIS (Meek & Worthen), 1861

Plate 15, figures 1a-d

DESCRIPTION.—A modern description of the species follows. Dorsal cup subglobose, plates mildly tumid, with slightly impressed sutures. Five infrabasals form moder-

ately broad low circlet with columnar attachment area slightly impressed at perimeter and sloping inward to pentastellate lumen with radially disposed points; 5 basals large, equidimensional; 5 radials, slightly wider than long with slight subhorizontal area at summit of radial below outer ligament area, articulating facets horizontal and large, leaving a relatively limited opening to the body cavity; detailed features are obscure but a thin, low transverse ridge is present and an outer ligament furrow; 2 anal plates comprise elongated radial quadrangular in outline and large anal X plate with short contact on CD basal and hardly extending above cup summit. This description applies just as well to the holotype as to the hypotype from Iowa. The latter shows faint ridges crossing the slightly impressed suture areas so as to give the appearance of indistinct pits along suture lines other than the intrabasal sutures.

MEASUREMENTS IN MILLIMETERS:

	Holotype	Hypotype
Height of cup	22.0	12.8
Width of cup (anteroposterior)	29.5	19.1
(B to DE radius)	32.5	20.5
Height of infrabasal circlet	4.1	2.6
Width of infrabasal circlet	16.0	10.0
Length of AB basal	15.5	8.7
Width of AB basal	15.7	9.6
Length of A radial	10.7	6.0
Width of A radial	17.3	11.0
Length of radial	11.3	5.5
Width of radial	8.7	3.6
Length of anal X plate	7.8	4.9
Width of anal X plate	7.3	3.3
Diameter of stem attachment area	5.7	4.3

DISCUSSION.—The low cup of *Ulocrinus sangamonensis* is distinctive. The entire posterior side appears to be somewhat projected and the anterior side almost vertical. The holotype, and only known specimen, was reportedly found in the "Coal Measures, Sugar Creek, Sangamon County, Illinois." MOORE & PLUMMER (1940, p. 48) considered the species to be Missourian in age. A specimen found in the Wyandotte Limestone, Kansas City Group, Missourian, in a quarry at Stenzel, Madison County, Iowa, is smaller than the holotype but has all characteristics of the species.

HYPOTYPE.—Collected by NAN COCKE, deposited in the Geology Department, The University of Iowa, Iowa City, cat. SUI 34175.

OCCURRENCE.—Argentine Limestone Member, Wyandotte Limestone, Kansas City Group, Missourian, Pennsylvanian; Schildberg Construction Co. quarry north of Hwy. 92, Madison County, Iowa (Center E. line SE ¼ SW ¼ sec. 5, T. 25 N., R. 29 W.).

ULOCRINUS CONVEXUS (Strimple), 1939

Plate 16, figures 3a-c; Plate 17, figures 3a,b

SYNONYMS.—*Ethelocrinus convexus* STRIMPLE, 1939, p. 13; *Ulocrinus buttsi* WRIGHT & STRIMPLE, 1945, p. 222;

Ulocrinus convexus STRIMPLE, 1961, p. 74; *Ulocrinus convexus* STRIMPLE & WATKINS, 1969, p. 166.

DISCUSSION.—An excellent uncrushed crown belonging to this species with a portion of the stem attached is considered herein. The species is now known from well-preserved specimens in the Wann Formation of Oklahoma, the Graford Formation of Texas, and the Bond Formation of Illinois, which formations all belong to the upper part of the Missourian Stage. Characters of the cup and arms have been adequately described by STRIMPLE & WATKINS (1969), but details relative to the column and pinnular structures have not been reported previously. The arms are large, with well-rounded exteriors and long lateral sides. Brachials become biserial with secundibrach 4, each bearing a moderately long slender pinnule on its inner side. Pinnules are about 23.5 mm long at midlength of the arms. Five cm of the large, round stem which is preserved show proximal columnals 8.2 mm in diameter and 1.7 mm high. Nodals bear 1 to 4 cirri in series. One internodal between each pair of nodals is differentiated by its slightly smaller height. The lumen is pentastellate. Height of dorsal cup 40.5 mm, maximum width 45.0 mm, maximum diameter of infrabasal circlet 24.7 mm, length of arms 10.1 cm (incomplete).

HYPOTYPES.—IGS42P91 collected by H. L. STRIMPLE and CHRISTINA CLEBURN, SUI 34546 (infrabasal circlet) collected by H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, Livingston County, Illinois, south of Pontiac; Wann Formation, Ochelata Group, Missourian, Pennsylvanian; the Mound just west of Bartlesville, Washington County, Oklahoma.

Genus PROBLETOCRINUS Strimple & Moore, n. gen.

TYPE-SPECIES.—*Probletocrinus curtus* STRIMPLE & MOORE, n. sp.

DESCRIPTION.—Crown tall, subcylindrical, with at least 14 biserial arms. Dorsal cup subglobular, somewhat pear-shaped with distal neck removed but protruded in the area about the radianal; infrabasals moderately large, readily visible in side view but almost subhorizontal in attitude; basals quite large, decidedly curved longitudinally; radials large, five-sided; two large anals, with radianal in oblique position and anal X plate in broad contact with posterior (CD) basal; two arms preserved in A ray, four arms (with second branching on secundibrach 1) in B and E rays, other arms missing or unattached, but almost certainly the C and D rays were identical, having no less than two arms each, arm exteriors mildly convex, pinnules imperfectly preserved; anal tube not observed; columnar cicatrix round, crenulated, lumen subpentagonal.

DISCUSSION.—*Cromyocrinus grandis* MATHER (1915, p. 102) of the Morrowan has a cup shape very close to that of *Probletocrinus curtus*, but arms of the former are unknown and three anal plates occur in the posterior in-

terradius. *Cromyocrinus simplex* TRAUTSCHOLD (1867, p. 19) of the Moscovian (lower Desmoinesian) has five uniserial arms, which is considered to be primitive, and three anal plates in the cup. *Metacromyocrinus*, with range from Morrowan to Desmoinesian, also has a comparable cup shape, two or three anal plates, ten biserial arms, and is probably more closely related to *Probletocrinus* than is *Cromyocrinus*. *Ulocrinus* MILLER & GURLEY typically has a relatively longer cup, two or three anal plates, and ten biserial arms. The progenitor of these forms is probably a form like *Ureocrinus* WRIGHT & STRIMPLE (1945, p. 225) from the Visean of Scotland which has a globose cup and five uniserial arms, or *Anartiacrinus* KIRK from the Chesteran, which has ten uniserial arms.

The name is from the Greek *probletos* for projected, with reference to the protruded area about the radianal.

OCCURRENCE.—Pennsylvanian (Missourian); USA (Illinois).

PROBLETOCRINUS CURTUS Strimple & Moore, n. sp.

Plate 7, figure 2; Plate 14, 2a-c

DIAGNOSIS.—Characters of the genus.

DISCUSSION.—Discussion of general relationships is given in the generic section. Two arms are host to parasites (*Myzostoma*?) which have bored in and caused the crinoid to secrete excessive stereom about them (see Pl. 7, fig. 2). The name is from Latin *curtus* for short, with reference to the squat cup.

MEASUREMENTS OF HOLOTYPE IN MILLIMETERS.—Length of crown (as preserved) 117.0, width of cup (average) 37.0, height of cup 31.5, diameter of infrabasal circlet 19.0, height of infrabasal circlet 4.8.

HOLOTYPE.—IGS42P107, collected by CHRISTINA CLEBURN.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; north end of Wagner Stone Company Quarry, Ocoya, south of Pontiac, Livingston County, Illinois.

Genus PARULOCRINUS Moore & Plummer, 1940

TYPE-SPECIES.—*Ulocrinus blairi* MILLER & GURLEY, 1894.

DIAGNOSIS.—Crown moderately tall, having more than ten biserial arms branching on primibrach 1 in all rays and primibrach 2 in some rays. Dorsal cup medium-sized, deep bowl-shaped to globose, no appreciable constriction at cup summit, typically no basal concavity although there may be an almost imperceptible concavity or mild convexity; infrabasals subhorizontal; typically with two anal plates in cup but proximal tip of right tube plate may enter cup.

SPECIES.—*Ulocrinus blairi* MILLER & GURLEY, 1894; *Phialocrinus americanus* WELLER, 1909; *Parulocrinus beedei* MOORE & PLUMMER, 1940; *Ulocrinus cavana* STRIMPLE, 1949; *Parulocrinus pontiacensis* STRIMPLE & MOORE, n. sp.

DISCUSSION.—The only known species of this genus

with arms preserved is *Parulocrinus pontiacensis*, which has at least 14 biserial arms preserved and probably has a total of 16 arms. The flattened base distinguishes it from other cymenocrinids.

OCCURRENCE.—Pennsylvanian (Missourian-Virgilian) to Permian (Wolfcampian); USA (Oklahoma, Kansas, Illinois, Texas).

PARULOCRINUS PONTIACENSIS Strimple & Moore, n. sp.

Plate 2, figures 4a,b; Plate 5, figure 3; Plate 17, figures 4a-c

DESCRIPTION.—Crown cylindrical, moderately tall, with biserial arms closely apposed when closed. Dorsal cup asymmetric due to protrusion of right posterior area, about twice as wide as tall, no appreciable constriction at cup summit, sutures mildly impressed, surface delicately granulose, base flat, lateral sides vertical; 5 infrabasals form a pentagonal-shaped disc, plates mildly convex, columnar impression slightly wider than proximal columnals; 2 large anal plates, anal X in wide contact with posterior basal and C radial, radianal quadrangular, proximal tip of right tube plate barely notching articular surface of the cup. Arms narrow, outer surfaces delicately granular; primibrach 1 axillary in all rays, low, wide and mildly convex; secundibrach 2 axillary in A and D rays, probably so in C ray; subsequent brachials have almost flat exteriors and sharply delineated lateral sides, each bearing a delicate pinnule. Anal sac unknown. Column round; alternately expanded columnals with coarse crenulae visible in short portion preserved; lumen round.

MEASUREMENTS OF HOLOTYPE IN MILLIMETERS.—Height of crown (incomplete) 41.5; maximum width of cup (anteroposterior radius) 15.0, height 7.0; width of infrabasal circlet 5.0; diameter of column 2.9.

DISCUSSION.—*Parulocrinus blairi* (MILLER & GURLEY) has a proportionately wider infrabasal circlet than *P. pontiacensis* and the latter has impressed sutures. *P. beedei* MOORE & PLUMMER has almost identical proportions of the infrabasal circlet to cup width (when maximum width of cup is used as one factor) as well as in ratio of cup height or width. In *P. blairi* the sutures are not impressed and the surface is smooth, whereas in *P. pontiacensis* the sutures are impressed and the surface is finely granular. The anal plate of *P. beedei* has a peculiar slant from left to right which may not be a specific character.

TYPES.—Holotype IGS42P45, paratype IGS42P113 collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, south of Pontiac, Livingston County, Illinois.

Family CYMBIOCRINIDAE Strimple & Watkins, 1969

DIAGNOSIS.—Cup dicyclic, infrabasals subhorizontal, confined to basal concavity, one anal plate, articular facets of radials short; arms normally ten, branching on primibrach 2 or not at all, brachials cuneiform, pinnule-bearing on alternate sides except for syzygial pairs; moderate-

sized anal tube, recurved in older genera with opening on anterior side, very long, stout, and straight in younger genera; column subpentagonal or pentagonal; prolific cirri.

GENERA.—*Cymbiocrinus* KIRK, 1944; *Aesiocrinus* MILLER & GURLEY, 1890 (syn., *Pentadelocrinus* STRIMPLE, 1939); *Phialocrinus* TRAUTSCHOLD, 1879 (non EICHWALD, 1856); *Oklahomacrinus* MOORE, 1939; *Lecobasicrinus* STRIMPLE & WATKINS, 1969; *Allosocrinus* STRIMPLE, 1949.

DISCUSSION.—The cymbiocrinids differ from ampelocrinids chiefly in having a basal invagination.

OCCURRENCE.—Mississippian-Permian; USA, USSR.

Genus ALLOSOCRINUS Strimple, 1949

DIAGNOSIS.—Dorsal cup medium, bowl-shaped, base shallowly concave; five infrabasals subhorizontal, confined to concavity; radial articular facets short; one anal plate (radianal) with single distal facet; five uniserial arms, brachials short with some syzygial pairs, pinnular; column pentagonal or subpentagonal.

OCCURRENCE.—Pennsylvanian (Desmoinesian-Missourian); USA (Oklahoma, Illinois).

ALLOSOCRINUS BRONAUHI Strimple, 1949

Figure 6, 1; Plate 8, figure 5

DIAGNOSIS.—Crown elongate, slender. Dorsal cup broad, bowl-shaped; infrabasals confined to shallow basal concavity, forming a broad, subhorizontal disc; basals large, participating strongly in lateral cup walls, posterior basal truncated for contact with single large radianal plate which is longer than wide, truncated for single tube plate; radials wider than high; all calyx plates are thick, ornamented with many coarse granules, and have crenulated joint surfaces. Arms are unbranched, narrowing rapidly for a short distance, then retaining their width for a considerable distance, composed of thin, slightly cuneate brachials with strongly convex exteriors, syzygially paired, fine striations from front to back on joint surfaces; pinnules small, short, with very convex outer surfaces. Column pentagonal, heteromorphous, nodals cirriferous, as many as 5 smooth internodals between nodals.

DISCUSSION.—*Allosocrinus bronauhi* STRIMPLE (1949, p. 18) is the type-species of *Allosocrinus*. Only 2 other species are known, *A. porus* STRIMPLE (1951, p. 19), which lacks protuberant surface ornamentation and has bulbous basals, and *A. libratus* STRIMPLE (1940, p. 105), which has a shallower cup with a deep basal concavity. Proximal columns have a rounded appearance but the stem is pentagonal.

MEASUREMENTS OF HYPOTYPE (IGS42P70) IN MILLIMETERS.—Length of crown (as preserved) 84.0; height of cup 10.2; width of cup 19.1; diameter of infrabasal circlet 7.3; diameter of proximal columnals 2.0; width of primibrach 1 9.7; height of primibrach 1 1.7.

HYPOTYPE.—IGS42P70, collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, Livingston County, Illinois.

Family AMPELOCRINIDAE Kirk, 1942

DIAGNOSIS.—Dicyclic, infrabasals visible in side view of cup, one anal plate, arm articular facets short; arms usually branch on primibrach 2, pinnule-bearing on alternate sides except for syzygial pairs; anal tube moderate, recurved in older forms, straight in younger genera; stem subpentagonal, round or pentalobate.

DISCUSSION.—This family is distinguished from cymbiocrinids in having mildly or decidedly upflared infrabasals.

SUBFAMILIES.—Ampelocrininae KIRK, 1942, Paragassizocrininae STRIMPLE & WATKINS, 1969.

OCCURRENCE.—Mississippian to Permian; USA, USSR, Scotland.

Subfamily AMPELOCRININAE Kirk, 1942

DIAGNOSIS.—The Ampelocrininae are distinguished from the Paragassizocrininae in having five discrete infrabasals and an attached column.

GENERA.—*Ampelocrinus* KIRK, 1942; *Polusocrinus* STRIMPLE, 1951; *Moundocrinus* STRIMPLE, 1939; *Chlidonocrinus* STRIMPLE & WATKINS, 1969; *Halogetocrinus* STRIMPLE & MOORE, n. gen.

DISCUSSION.—The stem in the Paragassizocrininae is desiccated in ontogeny, although a remnant may persist, encircled in the fusion and expansion of the infrabasals which form a solid cone.

Chlidonocrinus was ascribed to the Cymbiocrinidae by STRIMPLE & WATKINS (1969), because they thought there was a concave base. It is now known that the base is subhorizontal with distal tips of the infrabasals upflared.

OCCURRENCE.—Mississippian to Permian; USSR, Scotland, North America.

Genus MOUNDOCRINUS Strimple, 1939

TYPE-SPECIES.—*Moundocrinus osagensis* STRIMPLE, 1939.

DIAGNOSIS.—Dorsal cup medium, bowl-shaped, broadly truncate flattened or mildly concave base, sutures unimpressed, cup plates smooth. Five infrabasals confined to basal area, not visible in side view; radial articular facets short, not extended beyond normal thickness of plate; anal plate moderately large, does not extend appreciably above cup summit, followed in series by a single tube plate. Ten uniserial arms, branching on primibrach 2 or fused. Proximal columnals pentagonal.

DISCUSSION.—*Moundocrinus* is apparently more closely related to *Aesiocrinus*, *Polusocrinus*, or *Halogetocrinus* than to other forms, based on morphologic features of the cup. *Aesiocrinus* differs in having longer radial articular facets, tumid cup plates, and the anal plate is followed by

two tube plates. *Polusocrinus* has a taller, more rotund cup, infrabasals are larger, more prominent and the anal plate is followed by two tube plates. *Halogetocrinus* has a shorter cup, short interbasal sutures, a very large anal plate resting diagonally on posterior basal and with a straight distal face which is partitioned for reception of two tube plates.

OCCURRENCE.—Pennsylvanian (Missourian-Virgilian); USA (Oklahoma, Kansas, Illinois).

MOUNDOCRINUS sp. cf. M. OSAGENSIS Strimple, 1939

Plate 6, figures 3a-c; Plate 7, figures 1a-d

DESCRIPTION.—Calyx low with moderately flared sides and no basal concavity; 5 infrabasals subhorizontal, extend well beyond proximal columnal; 5 basals moderately large; 5 radials large, terminating with a relatively sharp distal edge; narrow anal plate rests evenly on posterior basal, widens slightly distalward, does not extend appreciably above cup summit and is faceted for reception of one quadrangular tube plate; 10 long arms, uniserial, narrow, pinnular, branching on primibrach 2; however, primibrachs 1 and 2 show only a faint common suture.

MEASUREMENTS OF HYPOTYPE (IGS42P114) IN MILLIMETERS.—Height of cup 8.5, width 21.6, width of infrabasal circlet 9.2, diameter proximal columnal 2.8, length of basal 6.9, width 8.2, length of radial 6.4, width 13.0, length of anal 5.6, width 5.4.

DISCUSSION.—Figured hypotype (see Plate 6, figs. 3a-c) has been distorted in preservation by horizontal compression so that it appears to have a slight basal concavity and mild tumidity of basals. The specimen has an appearance very close to the specimen of *Phialocrinus patens* figured by YAKOVLEV, 1956, which also may be slightly distorted in preservation. Without more knowledge of the Russian species it is not possible to make any further observations. Figured specimen (Plate 7, fig. 1a-d) is undistorted and favorably comparable to the holotype of *Moundocrinus osagensis*.

TYPES.—Hypotypes IGS42P74, IGS42P114 collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, south of Pontiac, Livingston County, Illinois. Type occurrence is the Wann Formation, Ochelata Group, Missourian; the hill locally termed the Mound just west of Bartlesville in Osage County, Oklahoma.

Genus POLUSOCRINUS Strimple, 1951

TYPE-SPECIES.—*Polusocrinus avanti* STRIMPLE, 1951.

DIAGNOSIS.—Dorsal cup high, truncate bowl-shaped, with subhorizontal to mildly upflared large infrabasals; large single anal plate evenly placed on posterior basal followed by two equidimensional tube plates; radial articular facets short. Arms typically ten, slender, uniserial, with even sutures, elongated, well-rounded exteriors, pinnular, branching on primibrach 2. Anal tube long, com-

posed of series of thin plates with pore slits along margins. Column pentagonal, with alternatingly expanded columnals, cirri present.

OCCURRENCE.—Pennsylvanian (Atokan-Missourian); USA (Oklahoma, Texas, Kansas).

POLUSOCRINUS AVANTI Strimple, 1951

Plate 6, figure 2

DIAGNOSIS.—Characters of genus.

DISCUSSION.—The hypotype from the LaSalle Limestone is closely comparable to the holotype from the Avant Limestone. These forms display little change except for *Polusocrinus ochelataensis* which has a second bifurcation of the arms. Typically arms branch only once on primibrach 2. In considering specimens from the older Holdenville Formation (Desmoinesian), STRIMPLE (1961, p. 102) concluded that they were indistinguishable from *P. avanti*. A section of the pentagonal stem is preserved, and is composed of alternatingly expanded columnals in series of 5.

MEASUREMENTS OF FIGURED HYPOTYPE IN MILLIMETERS.—Height of cup 17.2, width 26.0, width of infrabasal circlet 12.3, proximal columnal 4.5, height of basal 10.5, width 11.6, height of radial 8.0, width 12.3, height of anal 7.1, width 7.8.

HYPOTYPES.—IGS42P72, IGS42P80, collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, south of Pontiac, Livingston County, Illinois.

Genus CHLIDONOCRINUS Strimple & Watkins, 1969

DIAGNOSIS.—Dorsal cup low, wide, truncate cone-shaped with truncation beyond columnar attachment area; five infrabasals subhorizontal with distal tips visible in side view; brood plications passing from plate to plate; articular facets narrower than full width of plate; single anal plate (radial); arms uniserial, narrow, very elongate, branching several times, first bifurcation with primibrach 2; column pentagonal, cirriferous.

OCCURRENCE.—Mississippian (Chesteran), Pennsylvanian (Atokan-Missourian); USA (Texas, Oklahoma, Illinois).

CHLIDONOCRINUS ERECTUS Strimple & Moore, n. sp.

Plate 6, figures 1a-c

DIAGNOSIS.—Dorsal cup truncate cone-shaped; small subhorizontal basal area with distal tips of infrabasals flexed sharply upward to be visible in side view; proximal parts of basals forming small subhorizontal circlet surrounding infrabasals then bent upward to join large radials on sides of cups; all corners of plates, including distal ends of infrabasals, located in pronounced depressions, with broad low ridges passing from each plate to that adjoining; articular facets narrower than full width of radials; single anal plate, almost as large as radials, not extended appreciably above cup summit, is followed by 2

equidimensional plates above; primibrachs 1 low, imperceptibly tapered, primibrachs 2 short, axillary; column moderately large, pentalobate, lumen pentagonal.

DESCRIPTION.—*Chlidonocrinus erectus* has a more erect, deeper cup than either *C. echinatus* STRIMPLE & WATKINS, 1969, p. 189, from the Marble Falls Formation, Atokan, or *C. trinodus* STRIMPLE & WATKINS, 1969, p. 190, from the Fayetteville Formation, Chesteran. The genus has been removed from Cymbiocrinidae because it is now known that distal tips of the infrabasals are visible in side view of the cup.

MEASUREMENTS OF HOLOTYPE IN MILLIMETERS.—Height of cup 6.4, width (average) 9.4, width of infrabasal circlet 4.1, diameter of proximal columnal 2.5.

HOLOTYPE.—IGS42P54, collected by CHRISTINA CLEBURN.

OCCURRENCE.—LaSalle Limestone, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, Livingston County, Illinois.

Genus HALOGETOCRINUS Strimple & Moore, n. gen.

TYPE-SPECIES.—*Aesiocrinus paucus* STRIMPLE, 1951, p. 22.

DIAGNOSIS.—Dicyclic; cup low, saucer shaped; five infrabasals not visible from side but subhorizontal in attitude; five basals usually small: five radials large, width and length about equal, with articular facets filling their upper face; one large anal (radial) in line with radials, in oblique contact with posterior basal, followed evenly above by two plates; brachials cuneiform above first branching, may be syzygial; armlets nonpinnulate, composed of rectilinear brachials, first branching on primibrach 3; stem round or subpentagonal, very cirriferous.

SPECIES.—*Aesiocrinus paucus* STRIMPLE, 1951, p. 22, *Aesiocrinus prudentia* STRIMPLE, 1963, p. 72, *Lecobasiocrinus subidus* STRIMPLE & WATKINS, 1969, p. 192.

DISCUSSION.—*Halogetocrinus* may be a derivative of *Corythocrinus*, retaining the characteristics of three primibrachs and the articular facet occupying the full width of radials. The cup height has been lowered drastically by widening of the base, and by positioning the infrabasals and much of the basals in a subhorizontal attitude. *Araeocrinus* STRIMPLE & WATKINS (1969, p. 196), has a high conical cup somewhat like *Corythocrinus* and more than three primibrachs. *Halogetocrinus* is distinctive in having nonpinnulate armlets.

OCCURRENCE.—Pennsylvanian (Atokan-Virgilian); USA (Texas, Oklahoma, Kansas, Illinois).

HALOGETOCRINUS PAUCUS (Strimple),
Strimple & Moore, n. comb.

Figure 9, 1a-c; Plate 1, figure 4; Plate 4, figure 1; Plate 8, figure 3

DIAGNOSIS.—All diagnostic features of the genus.

DESCRIPTION.—Crown expanded, with relatively small cup and moderately long arms. Cup shallow, truncate cone-shaped; infrabasal circlet rather large; basals with short lateral sides, posterior basal sharply sloped on upper

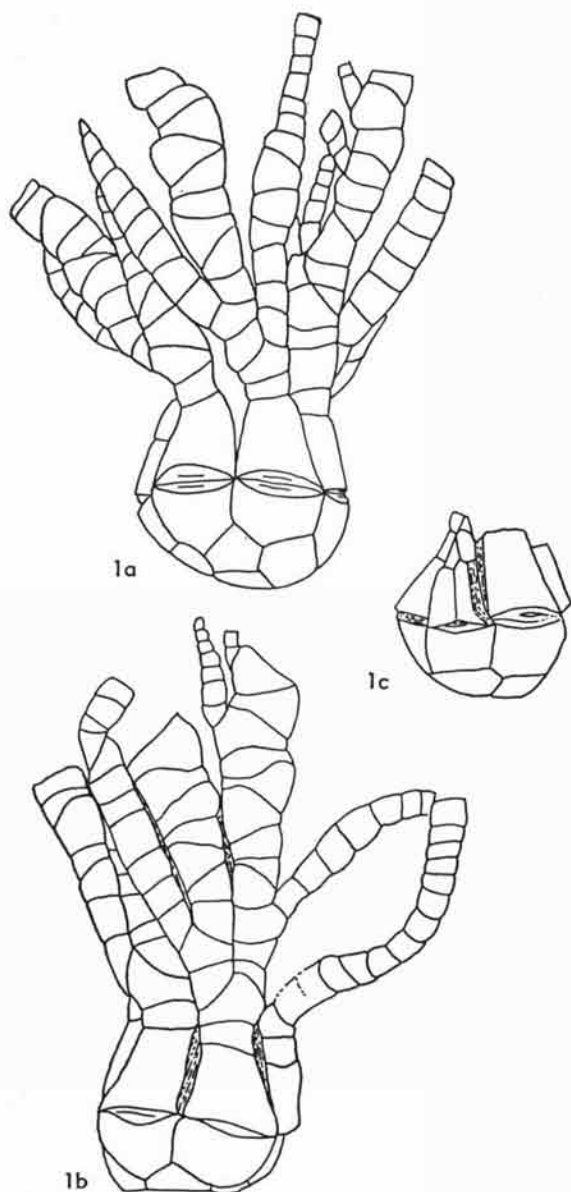


FIG. 9. Camera lucida drawings of *Halogetocrinus paucus* (Strimple) STRIMPLE & MOORE, n. comb., IGS42P25, $\times 4$.—1a. View of crown from BC interray showing combination of pinnular arms with cuneiform brachials and armllets with equidimensional brachials.—1b. Opposite view.—1c. Posterior view showing wide, radial-like anal plate followed by two tube plates.

surface; radials large, almost touching infrabasals, lower left side of posterior radial short. Arms 10 uniserial, first branching on primibrach 3, elongated primibrach 1 tapering rapidly, followed by a short and narrow primibrach 2, then a slightly elongated and expanded axillary primibrach 3. Subsequent brachials may be syzygially paired and expanded; they are decided cuneate and bear pinules or armllets with rectilinear articulations between brachials. The outer ray branches do not reach full height of the crown and resemble ramules. Column is very

cirriferous, round, composed of alternatingly expanded columnals, and has a pentalobate lumen.

MEASUREMENTS OF HOLOTYPE IN MILLIMETERS.—Dorsal cup 6.5 wide, 2.1 high; length of arms (as preserved) 33.2.

DISCUSSION.—*Halogetocrinus subidus* (STRIMPLE & WATKINS), does not have as pronounced a distal reduction in width or of elongation of primibrach 1 as found in *H. paucus*. The tendency for radials to touch infrabasals (shortening of interbasal sutures) is limited to *H. paucus*. *Halogetocrinus prudentia* (STRIMPLE), of the upper Virgilian, has characteristics of the Atokan *H. subidus* except for the slope of the distal face of posterior basal, which is more pronounced in the latter.

FIGURED HYPOTYPES.—IGS42P24A, IGS42P25, collected by CHRISTINA CLEBURN and H. L. STRIMPLE, reposit at Illinois Geological Survey, Urbana, Illinois.

OCCURRENCE.—LaSalle Limestone, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, Livingston County, Illinois.

Family STELLAROCRINIDAE Strimple, 1961

TYPE-GENUS.—*Stellarocrinus* STRIMPLE, 1940, p. 1.

DIAGNOSIS.—Crown widely expanded to midheight, thereafter contracted, arms not apposed; cup low, truncate bowl-shaped, with broadly concave basal area; five infrabasals confined to small area about the column, subhorizontal; five basals forming sides of basal concavity and flexing sharply to form portion of lateral walls of cup; five radials consisting of wide low elements with arm articular facets narrower than width of plate; three anal plates (*Heliosocrinus*) or only single one of them remaining (*Stellarocrinus* and others) within cup; anal tube stout, usually extending above arms, with termination a rosette composed of small plates covering the anal opening and six perimeter spinose plates directed horizontally; arms may be uniserial (with cuneiform brachials) or biserial, branching once on primibrach 1 in all rays and usually having another isotomous division in all rays, with further branching in some species; column pentagonal in older forms, round in younger forms, composed of alternatingly expanded columnals.

GENERA.—*Stellarocrinus* STRIMPLE, 1940, p. 1; *Brychiocrinus* MOORE & PLUMMER, 1940, p. 146; *Heliosocrinus* STRIMPLE, 1951, p. 675; *Brabeocrinus* STRIMPLE & MOORE, n. gen.; *Celonocrinus* LANE & WEBSTER, 1966, p. 47.

DISCUSSION.—The most distinctive feature of crinoids belonging to this family is the horizontally wide-spraddled pattern of isotomous arm bifurcations, with adjacent branches invariably well separated from each other. Crowns thus have a very distinctive appearance which readily separates them from all others. In addition, the low dorsal cup with its ridged plates is distinctive in shape.

OCCURRENCE.—Mississippian (Chesteran), Pennsylvanian (Morrowan-Virgilian), Permian (Wolfcampian); USA (Oklahoma, Texas, Nevada, Kansas, Missouri, Illinois, Nebraska).

Genus **STELLAROCRINUS** Strimple, 1940

TYPE-SPECIES.—*Cyathocrinus stillativus* WHITE, 1879, p. 258.

DESCRIPTION.—Cup and crown with general characters of the family and restricted to forms having biserial arms, notches between radial articular facets and advanced arrangement of anals consisting of single plate (radial) on truncated tip of posterior basal, with two higher ones poorly developed or missing.

Species assigned to *Stellarocrinus*

	Occurrence	Remarks
<i>Cyathocrinus stillativus</i> WHITE, 1879	Virgilian; Kansas; Missourian; Oklahoma	<i>Stellarocrinus</i> type-species
<i>Whiteocrinus exculptus</i> STRIMPLE, 1939	Missourian, Oklahoma	<i>Stellarocrinus</i>
<i>Stellarocrinus distinctus</i> STRIMPLE, 1940	Missourian, Oklahoma	<i>Brabeocrinus</i>
<i>Stellarocrinus texani</i> STRIMPLE, 1951	Missourian, Texas	<i>Stellarocrinus</i>
<i>Stellarocrinus virgilensis</i> STRIMPLE, 1951	Missourian, Oklahoma	<i>Stellarocrinus</i>
<i>Stellarocrinus petalopus</i> STRIMPLE, 1961	Desmoinesian, Oklahoma	<i>Stellarocrinus</i>
<i>Apollocrinus florealis</i> MOORE & PLUMMER, 1940	Desmoinesian, Texas	<i>Stellarocrinus</i>
<i>Apollocrinus geometricus</i> MOORE & PLUMMER, 1940	Missourian, Kansas	<i>Stellarocrinus</i>
<i>Aesiocrinus angulatus</i> MILLER & GURLEY, 1894	Missourian, Missouri	<i>Celonocrinus</i>
<i>Brychiocrinus texanus</i> MOORE & PLUMMER, 1940	Desmoinesian, Texas	<i>Brychiocrinus</i>
<i>Stellarocrinus comptus</i> WEBSTER & LANE, 1968	Wolfcampian, Nevada	<i>Brabeocrinus</i>
<i>Stellarocrinus cuneatus</i> LANE & WEBSTER, 1966	Wolfcampian, Nevada	* <i>Brabeocrinus</i>
<i>Stellarocrinus bulbosus</i> STRIMPLE & WATKINS, 1969	Desmoinesian, Texas	<i>Stellarocrinus</i> narrow arms
<i>Stellarocrinus bilineatus</i> STRIMPLE & MOORE, n. sp.	Missourian, Illinois; Oklahoma	<i>Stellarocrinus</i>

* Arms incipiently biserial.

OCCURRENCE.—Lower Pennsylvanian (Morrowan), Upper Pennsylvanian (Virgilian), Permian (Wolfcampian); USA (Kansas, Oklahoma, Texas, Illinois, Nebraska, Missouri).

STELLAROCRINUS BILINEATUS Strimple & Moore, n. sp.

Plate 18, figure 1

DESCRIPTION.—Dorsal cup moderately high, strongly ornate; broad base with multiple ridges and depressions of basal plates forming perimeter of the concavity; 5 infrabasals form a subhorizontal disc at base of the concavity; 5 basals form sides of basal concavity and flex sharply so that their distal ends participate in lateral sides of cup, with raised multiple ridges passing to adjacent radials; 5 radials with multiple radiating ridges passing to

basals below and to adjacent radials, articular facets not filling distal face. Posterior interradius is broad, anals 3, moderately large radial followed above by 2. Anal tube stout, many tube plates extended as spines. Arms 30, biserial, with gently convex exteriors; primibrach 1 axillary, short and broad, with short lateral sides; second axillary small, triangular element resting on about the sixth or seventh secundibrach and completely surrounded by brachials; third branching in inner rays only, with axillary a small triangular brachial resting on about tertibrach 18 or 19, surrounded by other brachials. None of the brachials are produced as spines. Column large, heteromorphic round, with alternately expanded columnals, about 9 in a series, crenellae visible in side view; lumen round.

MEASUREMENTS OF HOLOTYPE (IGS42P52) IN MILLIMETERS.—Dorsal cup 19.0 mm wide, 9.2 mm high; arms (as preserved) 41 mm long.

DISCUSSION.—*Stellarocrinus bilineatus* has a more ornate cup than other species of the genus, yet there is no development of spines on the brachials.

Name *bilineatus* has reference to the double rows of ridges passing from basals to radials.

HOLOTYPE.—IGS42P52, collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, Livingston County, Illinois.

STELLAROCRINUS sp. cf. *S. VIRGILENSIS* Strimple, 1951

Plate 11, figures 1,2,4-6; Plate 18, figures 3-4

DESCRIPTION.—Dorsal cup broad, shallow, with lateral sides sloped at a low angle; shallow basal concavity accentuated by a sharp ridge on basal plates surrounding the concavity and forming a star with points in the mid-section of each basal. Five infrabasals form a subhorizontal pentagonal disc; 5 basals slope gently in the concavity and then flex sharply to participate in sides of the cup; 5 radials wide, with 2 low ridges passing from each radial to the adjacent basals, articular facets not filling distal face of radial; an anal plate in posterior position is followed above by 2 equidimensional other plates. Arms 30, biserial; primibrach 1 axillary, low with short lateral sides; axillary triangular secundibrach extended into a long spine, resting on about secundibrach 9 or 10, thereafter with another branching in inner rays only. In addition to the upper axillaries being spinose a random brachial develops into a long spine. Anal tube composed of biserially disposed plates in longitudinal rows capped by 5 spinose plates enclosing very diminutive plates grouped around the tiny anal vent. Column large, round, composed of alternately expanded columnals.

DISCUSSION.—*Stellarocrinus virgilensis* is distinguished by its very low dorsal cup, shallow basal concavity, simple, low ridges on cup plates, and pronounced development of spines on upper axillary brachials, as well as by sporadic spines on other brachials.

HYPOTYPES.—IGS42P53, IGS42P7, collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, Livingston County, Illinois.

Genus CELONOCRINUS Lane & Webster, 1966

TYPE-SPECIES.—*Celonocrinus expansus* LANE & WEBSTER, 1966, p. 48.

DIAGNOSIS.—Crown spreading, cup large, low, moderately invaginated at base, with one anal plate; arms biserial, nonpinnulate, branching isotomously on primibrach 1, and secundibrach 3, with a single additional branch on the inner side of each half ray; stout, elongate anal tube terminating with spinose plates.

DISCUSSION.—*Celonocrinus* is a stellarocrinid, and thus member of a crinoid group characterized by having the pinnular attachment facets on inner edges of the arms in such manner that if the pinnules are closed in vertical attitude they could be invisible from outside, as apparently they were in the material examined by LANE & WEBSTER. Mature, well-preserved crowns of *Stellarocrinus* may have exotomous arms, the same as found in *Celonocrinus*. Both genera have a stout anal tube terminating with a spinose, unexpanded platform. The Permian species *Celonocrinus expansus* has a widened radial articular facet in the D ray, which is a possible evolutionary advancement but has not been demonstrated as such with other known materials.

The characteristics of *Celonocrinus* which appear to be of generic significance are its lack of radiating ridges on the cup plates and the low, bowl-shaped form of the cup. Lineage within the Stellarocrinidae demonstrates these characters though it may be difficult to differentiate when transitional forms are involved.

Species assigned to *Celonocrinus*

	Occurrence	Present Assignment
<i>Celonocrinus expansus</i>	Wolfcampian;	<i>Celonocrinus</i>
LANE & WEBSTER, 1966	Nevada	type-species
<i>Aciocrinus angulatus</i>	Missourian;	<i>Celonocrinus</i>
MILLER & GURLEY, 1892	Kansas	
<i>Stellarocrinus</i> sp. cf. <i>S.</i>	Missourian;	<i>Celonocrinus</i>
<i>angulatus</i> STRIMPLE &	Texas	
WATKINS, 1969		

OCCURRENCE.—Pennsylvanian (Missourian)-Permian (Wolfcampian); USA (Kansas, Texas, Nevada).

Genus BRABEOCRINUS Strimple & Moore, n. gen.

TYPE-SPECIES.—*Brabeocrinus christinae* STRIMPLE & MOORE, n. sp.

DIAGNOSIS.—Crowns with general characters of the family but restricted to those having box-shaped dorsal cup, uniserial (cuneiform brachials) arms, notches be-

tween radial articular facets, and advanced arrangement of three anal plates in CD interray.

SPECIES.—*Brabeocrinus christinae* STRIMPLE & MOORE, n. sp.; *Stellarocrinus distinctus* STRIMPLE, 1940; *Stellarocrinus cuneatus* LANE & WEBSTER, 1966; *Stellarocrinus comptus* WEBSTER & LANE, 1968.

DISCUSSION.—*Brabeocrinus* has cuneate brachials and narrow arms which are more primitive than the typically biserial, broad arms of *Stellarocrinus*. *S. bulbosus* is intermediate to *Brabeocrinus* in that its arms are narrow but its interlocking brachials lack a fully biserial arrangement. The dorsal cup of *S. bulbosus* is low and has a shape much like that of typical species of *Stellarocrinus*. *Brychiocrinus* has a more or less box-shaped cup and narrow arms with interlocking brachials which, together with the widened articular surfaces of the radials, serves to distinguish it readily from *Brabeocrinus*. From present information it appears that species of *Brabeocrinus* do not attain the magnitude of most fully mature species of *Stellarocrinus*.

OCCURRENCE.—Pennsylvanian (Atokan, Desmoinesian, Missourian, Virgilian)-Permian (Wolfcampian); USA (Oklahoma, Nevada, Illinois, Kansas).

BRABEOCRINUS CHRISTINAE Strimple & Moore, n. sp.

Figures 2A; 6,2; Plate 18, figure 5; Plate 19, figures 1-5

DIAGNOSIS.—Characters of genus.

MEASUREMENTS OF HOLOTYPE IN MILLIMETERS.—Height of crown (to summit of anal tube) 35, width of cup 11.0, height of cup 6.0, diameter of proximal columnals 2.3.

DISCUSSION.—The anal tube is composed of decidedly spinose plates in series of 6 which terminate above the arms with a rosette of small plates covering the anus and surrounded by outwardly directed spinose plates. Each tube plate has a ridge subhorizontal in midsection which is produced into a pronounced spine. Although the tube plates are staggered, the ridges are placed in such a manner as to be confluent with those on adjacent plates. The column is heteromorphic, columnals low, with narrow sharp keel and crenellae visible in side view. In a series of 9 are 2 large nudinodals, 1 priminternodal, 2 secundinternodals and 4 tertinternodals. The species is named for CHRISTINA CLEBURN.

TYPES.—Holotype IGS42P5A, paratypes IGS42P6, IGS42P8, IGS42P10, IGS42P51, IGS42P92B, collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, south of Pontiac, Livingston County, Illinois.

Family EXOCRINIDAE Strimple & Watkins, 1969

DIAGNOSIS (after STRIMPLE & WATKINS).—This family is comprised of small forms with multiple arms. The cup is shallow, cone-shaped with infrabasals mildly upflared in the older genus and subhorizontal to downflared in the younger genus. Five basals are small with five radials

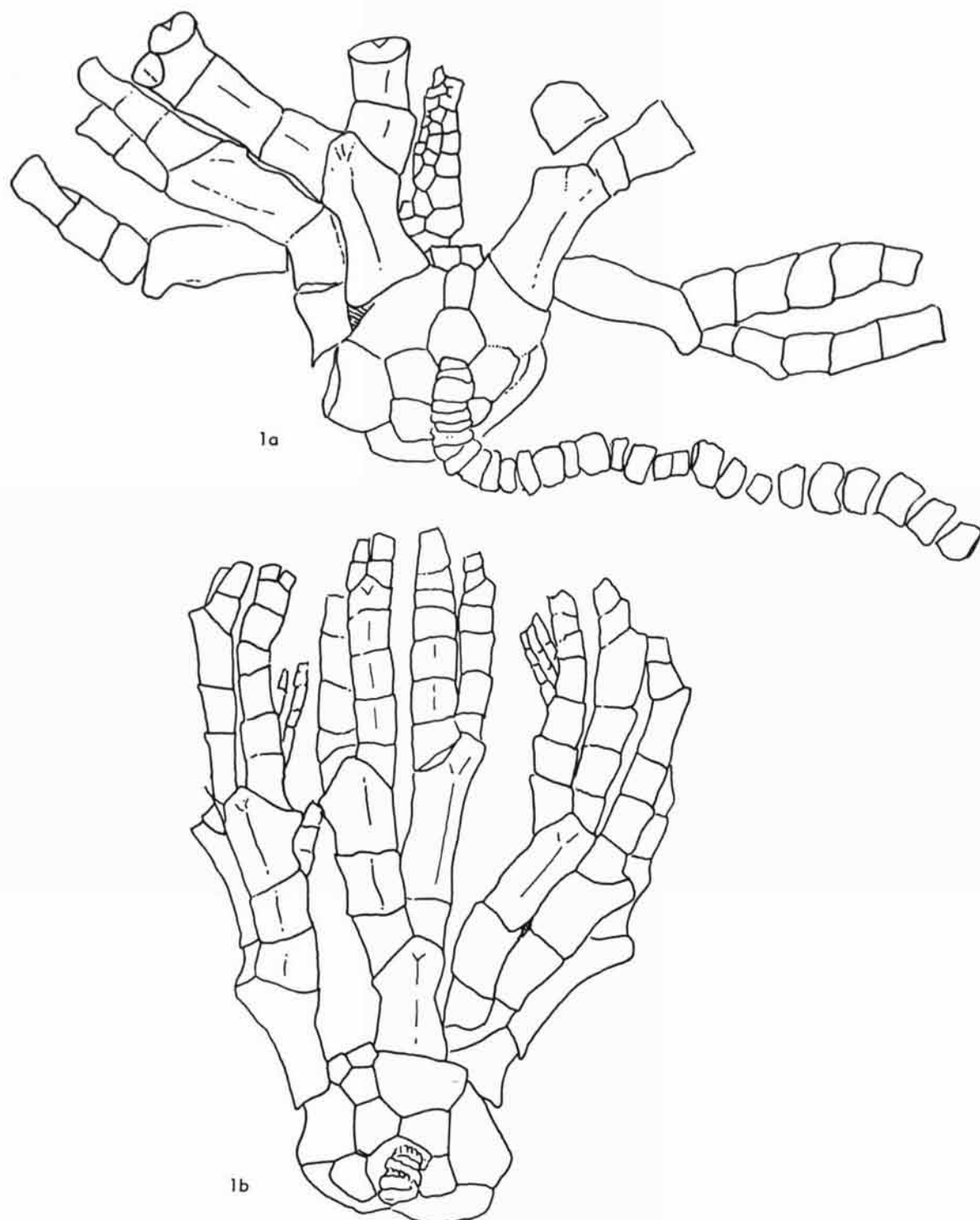


FIG. 10. Camera lucida drawings of *Exocrinus wanni* STRIMPLE from the LaSalle Limestone, $\times 6$.—1a. Hypotype (IGS42P120) with portion of anal tube and considerable portion of column.—1b. Hypotype (IGS42P121), nearly complete crown from posterior.

being the dominant cup plates. In the older *Oxynocrinus* there are three anal plates in more or less primitive arrangement (i.e., anal *X* is in contact with the posterior

basal), but the radialial is more vertical than diagonal in position. In *Exocrinus* the radialial has moved to posterior position and supports two anal plates above. Fusion of

brachials is a common feature in *Exocrinus* but has not commenced in *Oxynocrinus*.

GENERA.—*Exocrinus* STRIMPLE, *Oxynocrinus* STRIMPLE & WATKINS.

DISCUSSION.—It should be noted that the arms are uniserial, pinnulate, with primibrach 1 axillary in all rays.

OCCURRENCE.—Pennsylvanian (Morrowan-Virgilian)-Lower Permian; USA (Oklahoma, Kansas, Texas, Nebraska, Illinois, Nevada).

Genus EXOCRINUS Strimple, 1949

TYPE-SPECIES.—*Exocrinus multirami* STRIMPLE, 1949.

DIAGNOSIS.—Characters of family.

DISCUSSION.—*Exocrinus* is distinguished by the tendency toward fusion of brachials, particularly axillaries, which leads to hyperpinnulation. The advanced arrangement of anal plates (i.e., radianal to posterior position with anal X to left above and right anal to right above with the latter two plates forming a confluent surface above) has been termed "Extreme Type (2)" by STRIMPLE (1960, p. 252). The stem is round, relatively large.

OCCURRENCE.—Pennsylvanian (Desmoinesian-Virgilian)-Lower Permian; USA (Kansas, Oklahoma, Texas, Illinois, Nevada, Nebraska).

EXOCRINUS WANNI Strimple, 1949 (p. 12)

Figures 2A; 10, 1a, b; 11; Plate 6, figures 4, 6; Plate 8, figure 2

DESCRIPTION.—Crown expanded, moderately tall. Dorsal cup truncate cone-shaped, expanding evenly, basal area slightly invaginated, with 5 downflared infrabasals; basals fairly large, forming an appreciable portion of sides of the cup; radials large, slightly wider than long, with straight and wide articular facets typical of the genus; 3 anal plates normally within the cup, large radianal resting obliquely on truncated posterior basal and 2 equidimensional small plates above extending well above cup summit and forming a confluent distal surface; arms uniserial, keeled, branching on primibrach 1 in all rays and again on secundibrach 3 or 4, thereafter branching once or twice exotomously; some brachials, other than primibrachs (which are of unequal lengths), are elongated and appear to be 2 or 3 fused brachials, commonly supporting 3 short, narrow and keeled pinnules; when first formed, pinnules are almost as large as brachials observed at distal tips of the arms; anal sac small, tubular and appearing to extend about two-thirds length of the arms, terminating in a blunt point, with tube plates of the posterior side in adjacent series having the distal edge of each plate slightly higher than next one, other tube plates hexagonal and interlocking with neighbors; stem round, xenomorphic, proximal columnals composed of noncirriferous nodals alternating with thin internodals but in full development differentiation not so distinct, crenellae pronounced but few, with interlocking visible in side view of stem, lumen round.

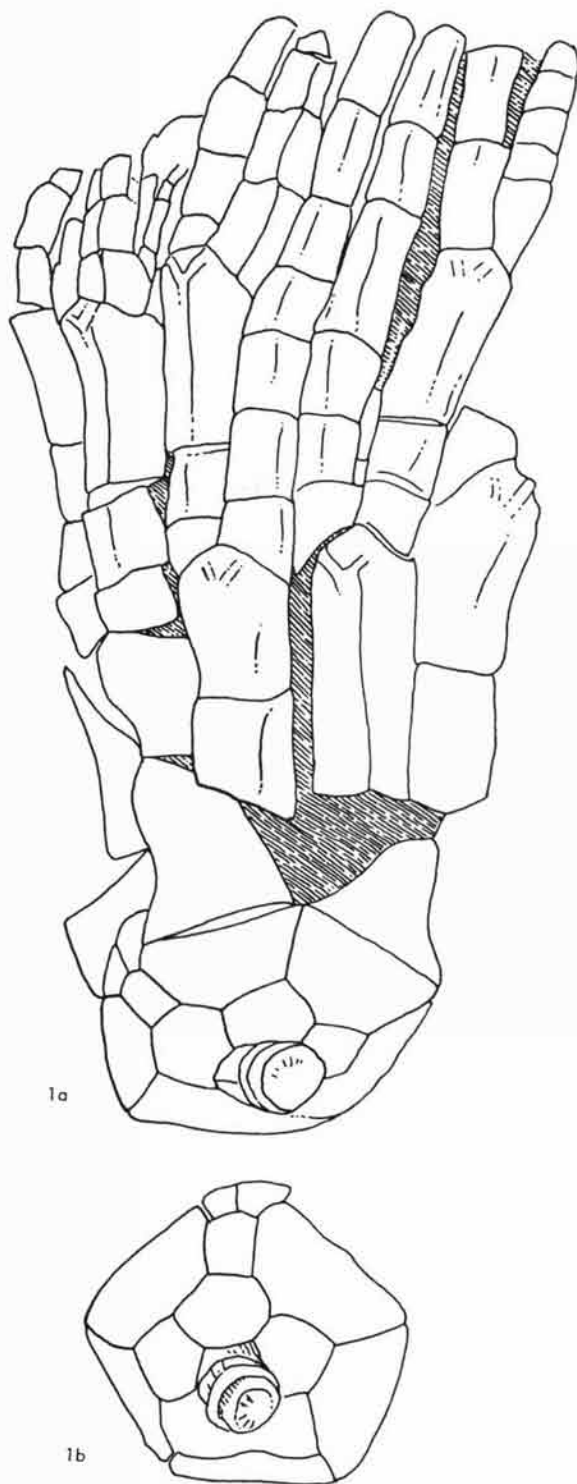


FIG. 11. Camera lucida drawings of large hypotype (SUI 34564) of *Exocrinus wanni* STRIMPLE from Wann Formation near Ochelata, Washington County, Okla., $\times 5.4$.—1a. BC interray of well-preserved crown.—1b. Basal view with CD interray at top.

MEASUREMENTS OF HYPOTYPE (IGS42P35) IN MILLIMETERS.—Height of crown 20.3, length of arms 17.4, approximate width of dorsal cup 7.0, diameter of proximal columnals 1.1, width of radial plate 2.6, length of radial plate 1.8.

DISCUSSION.—*Exocrinus wanni* is distinguishable from the closely related *E. multirami* STRIMPLE (1949, p. 10) by more erect sides of the cup and the oblique suture between the radianal and posterior basal in *E. wanni*. *E. pallium* STRIMPLE (1949, p. 14) has a shallow cup and tumid basals. *E. desmoinesensis* STRIMPLE (1949, p. 12) has a shallow cup, an elongated posterior basal, and the radianal is small. *E. virgilensis* STRIMPLE (1949, p. 13) has an elongated radianal extending well above the summit of the cup and faceted for a single tube plate. *E. moorei* (LANE & WEBSTER, 1966, p. 34) has shorter primibrachs and the number of secundibrachs is reduced to 2 (normally 3 or 4 in *E. wanni*). Some variability is shown by various specimens in structure and exact placement of the anal plates of the CD interray and general appearance of the crown. The radianal may be narrower and more elongated than in typical specimens which affects the position of the 2 anal plates above. A few specimens have a more rugged appearance, i.e., slightly stouter arms and more compact appearing cup (Pl. 6, fig. 4).

The unequal lengths of axillary primibrach 1 are typical of the genus; the longest is the A ray, those of C and D rays are a mirrored pair considerably longer than the B and E first primibrachs, which are approximately equal in length.

TYPES.—Hypotypes IGS42P51, IGS42P35, IGS42P92D, IGS42P57, IGS42P120, collected by CHRISTINA CLEBURN and H. L. STRIMPLE; topotype SUI 34564 collected by H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, Livingston County, Illinois; Wann Formation, Ochelata Group, Missourian, Pennsylvanian; roadcut northwest of Ochelata, Washington County, Oklahoma.

Family CLATHROCRINIDAE Strimple & Moore, n. fam.

TYPE-GENUS.—*Clathrocrinus* STRIMPLE & MOORE, n. gen.

DIAGNOSIS.—Characters of genus.

DISCUSSION.—Especially unique features of arm structure observed in *Clathrocrinus* make it unassignable to any presently recognized crinoid family. Therefore, it is placed apart in a family of its own.

OCCURRENCE.—Upper Pennsylvanian (Missourian), USA.

Genus CLATHROCRINUS Strimple & Moore, n. gen.

TYPE-SPECIES.—*Clathrocrinus clathratus* STRIMPLE & MOORE, n. sp.

DIAGNOSIS.—Dorsal cup shallow bowl-shaped with evenly rounded sides, shallow concavity at base containing

subhorizontal infrabasals well visible beyond stem impression; five moderately large basals curving upward to form part of sides of cup succeeded by five wide relatively short radials, characterized by slightly out-facing articular facets narrower than greatest width of radials, with small gaps separating them from first primibrachs; anal plates three in normal arrangement with large radianal obliquely below C radial and resting against posterior basal, anal X with or without contact on latter and bordered by right tube plate which moderately indents cup summit; slender, moderately tall anal sac composed of quadrangular to hexagonal plates in vertical series surmounted by one to four spines directed vertically or obliquely upward.

DESCRIPTION.—Moderately small crinoids with crown typically taller than wide. Dorsal cup low, bowl-shaped, with flat or shallowly concave base and gently sloping sides; cup plates smooth with sutures not indented or slightly tumid with indented sutures; infrabasal circlet evenly pentagonal in outline, small, flat or gently concave, with distal parts of plates well-exposed beyond stem impression, not visible in side view of cup; basals mostly pentagonal, sloping gently upward, CD basal unevenly hexagonal; radials wider than high, sloping evenly upward to articular facet which occupies less than full width of plate; anal plates three, with radianal, anal X and right tube plate entering dorsal cup; anal sac slender, moderately tall (four or five times height of dorsal cup but reaching only part way to arm tips), capped by one to three or four elongate spines directed straight upward or obliquely upward and outward, sides of sac composed of small plates in vertical series, commonly with small round pores along sutures but some lacking these pores and thus fitted tightly together. Arms ten, composed of elongate slender brachials which are transversely semicylindrical on outer (dorsal) side, without pinnules, but on inner (ventral) side carrying biserially arranged ambulacra which are not normal cover plates because they bear a circular pore at mid-distance between margin and midline of brachials, with 10 to 20 or more such plates on each side of midline of brachial; pattern of arm branching highly distinctive in that each primaxil is followed by two secundaxils directed laterally straight outward or obliquely outward and upward, each axillary plate above primaxil bearing single free armlet and another axillary plate, free armlets being given off in regular alternation from opposite sides of arms, whole presenting a grill- or lattice-like pattern, which suggests the name of the crinoid (*clathrum*, grill, lattice, or trellis). Stem circular, slender, lacking cirri, distinctly heteromorphic, tending to diminish in diameter distally and with slightly taller columnals in this region; with keeled or nearly smooth columnals; articular facets with coarse to medium fine crenulae; axial canal diminutive, circular in section.

OCCURRENCE.—Upper Pennsylvanian (Missourian), USA (Illinois).

CLATHROCRINUS CLATHRATUS Strimple & Moore, n. sp.

Figures 2A; 12, 1a; 13, 1a,b; Plate 20, figures 4,8; Plate 21, figures 1, 2, 4-6

DESCRIPTION.—Dorsal cup with small shallow basal concavity in which infrabasal circlet is mostly concealed by stem; all other plates distinctly tumid, with sutures well-impressed, radials with slight shoulder beneath articular facet which occupies less than full distal width of plate. Primaxils of arms elongate, slender, erect, narrowing abruptly above radial facet and terminating distally in narrow smooth tip flanked by steeply inclined facets for articulation with secundaxils which extend laterally straight outward or with only moderately upward tilt; free arms and other axillary plates arranged in nearly rectangular zigzag pattern; free arms short except in the upper part of crown where their length may be 3 or 4 times greater than that of axillary plate bearing them. Anal sac slender and moderately tall, reaching approximately half height of crown, sides composed of small plates arranged in vertical series with pores along sutures; tip of sac bearing 3 or 4 elongate spines extending radially upward and outward. Slender circular stem faintly to very distinctly heteromorphic, with keeled columnals, arranged in noditaxes of 4 columnals in which priminter-

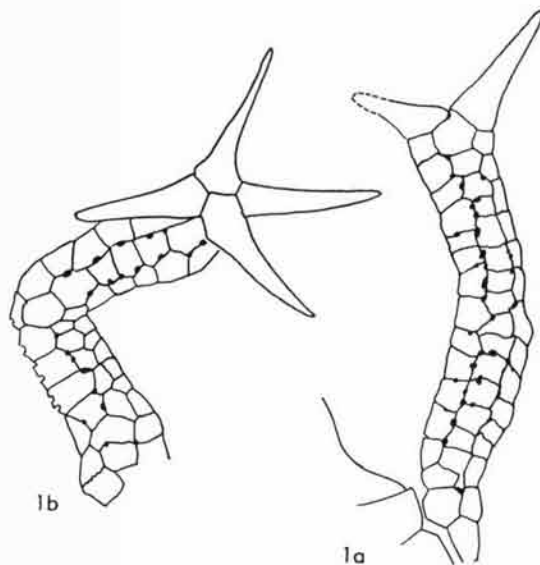


FIG. 13. Camera lucida drawings of anal tubes of *Clathrocrinus clathratus* STRIMPLE & MOORE, n. sp.—1a-b. Paratypes IGS42P16 and IGS42P22, $\times 4.5$ and $\times 4$.

nodal is only slightly smaller than nodals but secundinternodals lower and narrower than other columnals; articular with medium-sized crenulae.

DISCUSSION.—This species is chiefly characterized by its tumid thecal plates and the rectangular or subrectangular trellis pattern of the arms. Also noteworthy is the faint to very distinct heteromorphic nature of stem.

TYPES.—Holotype IGS42P92E; paratypes IGS42P11A, IGS42P12C, IGS42P14B, IGS42P15, IGS42P16, IGS42P16A, IGS42P22, collected by CHRISTINA CLEBURN.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, Livingston County, Illinois.

CLATHROCRINUS CLINATUS Strimple & Moore, n. sp.

Figures 12, 1b,c; 14, 1a-d; 15, 1a,b; 16, 1a,b; Plate 12, figure 2; Plate 20, figures 1-3, 5-7, 9; Plate 21, figure 3

DESCRIPTION.—Dorsal cup evenly bowl-shaped, with smooth plates and sutures not indented; infrabasal circlet evenly pentagonal in outline, with approximately half of each plate occupied by part of stem impression; radials sloping with moderate steepness, with or without faint shoulder beneath radial facet, which is distinctly narrower than width of plate. Anal sac slender, sides composed of small plates with round pores along sutures, disposed in more or less regular vertical series and capped by one or more spines. Arms similar to those of *Clathrocrinus clathratus* except that branching is distinctly more oblique. Stem slender, with heteromorphic nature clearly determined in some specimens with keeled columnals, indistinct in others; articular surfaces with coarse crenulae.

DISCUSSION.—Paratype IGS42P23 differs from other specimens in somewhat larger size of the anal sac, which

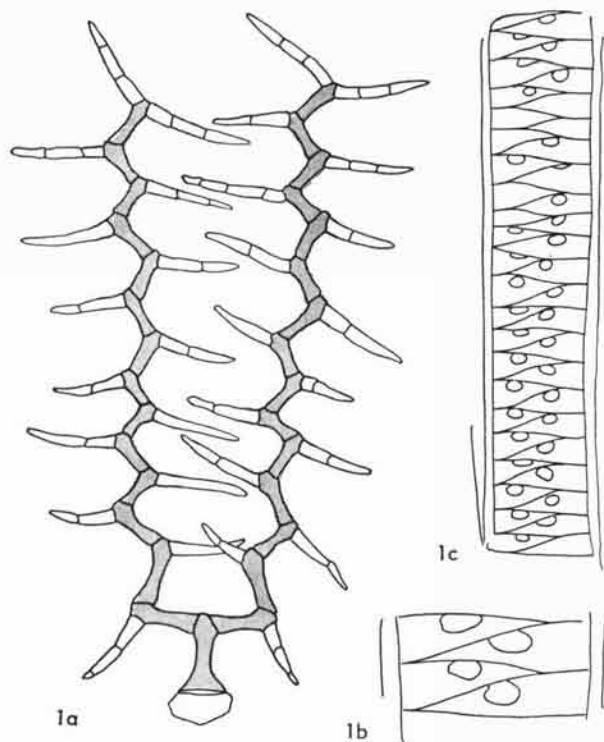


FIG. 12.—1a. Diagram showing dorsal view of arm structure of *E* ray of *Clathrocrinus clathratus* STRIMPLE & MOORE, n. sp. (IGS42P14B), main rays darkened, $\times 2.5$.—1b-c. *C. clinatus* STRIMPLE & MOORE, n. sp. Drawings of ventral side of *C*-ray brachials showing covering plates, (IGS42P21), $\times 8.4$ and $\times 4$.

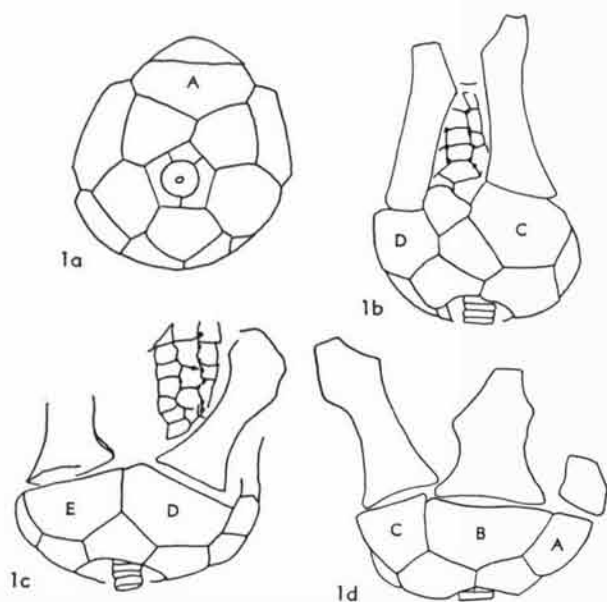


FIG. 14. Camera lucida drawings of *Clathrocrinus clinatus* STRIMPLE & MOORE, n. sp. (IGS42P17A), $\times 4$.—1a. Base (CD interray down).—1b. CD interray, showing lower part of anal tube.—1c. DE interray.—1d. B ray.

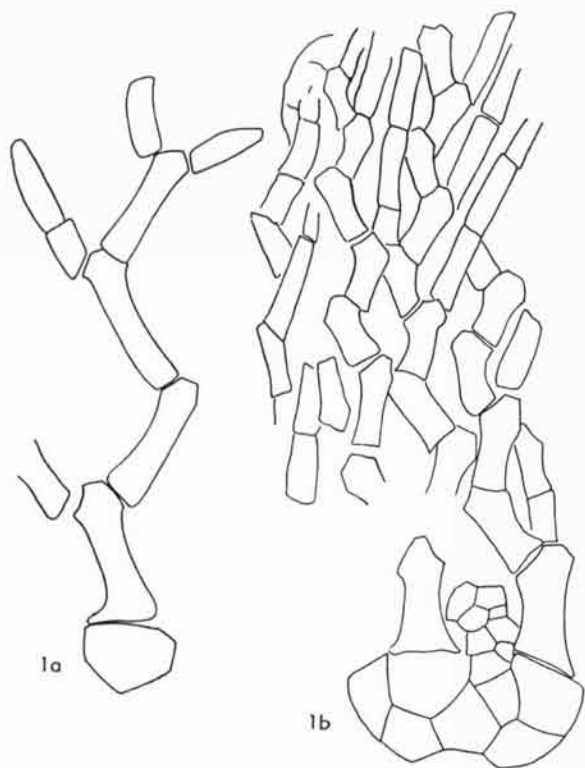


FIG. 15. Camera lucida drawings of *Clathrocrinus clinatus* STRIMPLE & MOORE, n. sp., $\times 4$.—1a. B ray starting with radial (IGS42P15).—1b. Crown from posterior (IGS42P17).

has side plates larger than average and summit seemingly rounded smoothly owing to absence of terminal spines, possibly lost in fossilization. Also, this specimen is exceptional in having elongate free arms in the lower part of the rays. The anal sacs of paratypes IGS42P19 and IGS42P20 bear a single spine at tip directed straight upward, whereas paratype IGS42P21 has more than a single terminal spine.

Types.—Holotype IGS42P17, paratypes IGS42P15A, IGS42P17A, IGS42P18, IGS42P19, IGS42P20, IGS42P21, IGS42P23, collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

Occurrence.—LaSalle Limestone, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, south of Pontiac, Livingston County, Illinois.

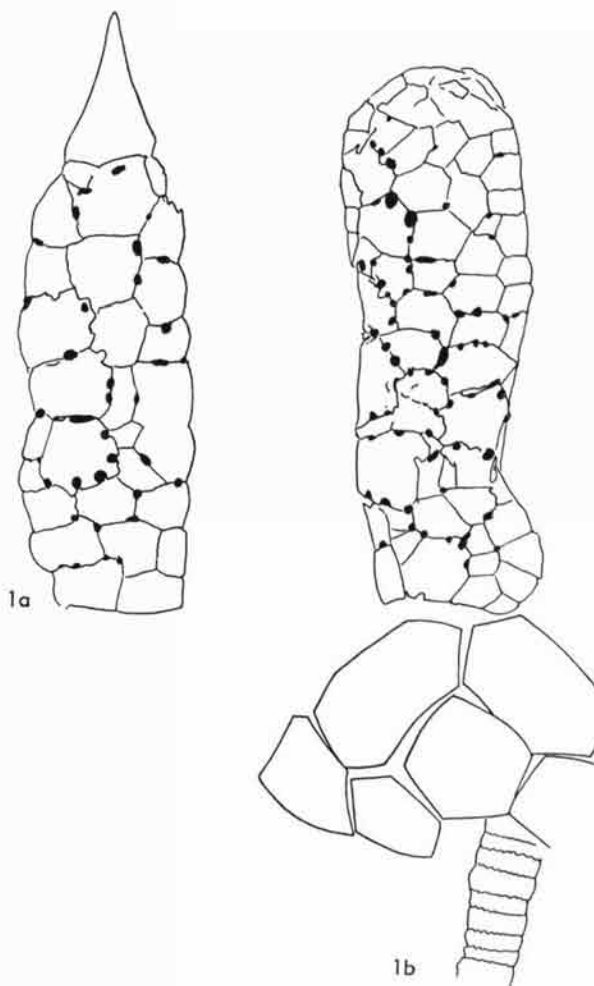


FIG. 16. Camera lucida drawings of anal tubes of *Clathrocrinus clinatus* STRIMPLE & MOORE, n. sp., showing pore slits and one distal spine, $\times 4.4$.—1a. Paratype (IGS42P19), individual anal tube.—1b. Paratype (IGS42P23), partial dorsal cup with column attached and anal tube.

Order DISPARIDA Moore & Laudon, 1946

Family ALLAGECRINIDAE Carpenter & Etheridge, 1881

DIAGNOSIS (after MOORE, 1940, p. 112).—Small, monocyclic crinoids, mostly asymmetrical, having distally thickened radials that each bear facets for attachment of one or many arms; facets generally marked by a transverse ridge, by a dorsal canal opening, and on the inner side by a groove that is bounded by longitudinal ridges. Arms, slender, unbranched, nonpinnulate, ranging in number from five to an observed maximum of 58. Dorsal cup low, truncate bowl- or cone-shaped to stelliform, the base mostly covered by large proximal stem segments. Orals present in immature stages and in very diminutive adult forms. Anal plate and series strongly developed in some genera but absent in others. Stem round to somewhat elliptical, typically tapering distally.

SUBFAMILIES.—Catillocrininae MOORE, 1940; Allagecrininae MOORE, 1940.

OCCURRENCE.—Devonian to Permian; Europe, North America, East Indies.

Subfamily ALLAGECRININAE Moore, 1940

DIAGNOSIS (after MOORE, 1940, p. 113).—Dorsal cup truncate bowl- or cone-shaped to stelliform symmetrical in some microscopic forms but mostly having strong asymmetry. Basals three or fused together. Radials five, equal to very unequal, three plates of this circlet (left posterior radial, anterior radial, right anterior radial) typically larger than the others and multiple-armed, but included forms range from cups having a single facet on each radial to those having all radials multifaceted. Anal series present or absent. Stem round, expanding toward cup, the proximal segment covering most of the basals.

GENERA.—*Allagecrinus* CARPENTER & ETHERIDGE, 1881; *Kallimorphocrinus* J. M. WELLER, 1930; *Trophocrinus* KIRK, 1930; *Wrightocrinus* MOORE, 1940; *Allocatillocrinus* WANNER, 1937; *Neocatillocrinus* WANNER, 1937; *Xenocatillocrinus* WANNER, 1937; *Isocatillocrinus* WANNER, 1937; *Desmacriocrinus* STRIMPLE, 1966; *Isoallagecrinus* STRIMPLE, 1966; *Metallagecrinus* STRIMPLE, 1966.

DISCUSSION.—The above diagnosis must be emended to include forms having five basals (e.g., *Desmacriocrinus* STRIMPLE).

OCCURRENCE.—Devonian to Permian; Europe, North America, East Indies.

Genus ISOALLAGECRINUS Strimple, 1966

TYPE-SPECIES.—*Allagecrinus bassleri* STRIMPLE, 1938.

DIAGNOSIS.—Dorsal cup low, broad, with sharp delineation between basal and radial circlets and marked by tumidity of radial plates; three basals with sutures usually visible, form low disc; five radials of unequal size in maturity, articular facet marked by transverse ridge; orals

none or five; arms none to 13, one on right posterior and left anterior radials, maximum number on left posterior radial; notch for anal plate pronounced. The open lattice-like, or trabecular, composition of the plates is readily visible under low magnification.

DISCUSSION.—It has been suggested by STRIMPLE (1966, p. 101) that *Isoallagecrinus* evolved through the young stages of *Allocatillocrinus*, Morrowan.

Isoallagecrinus is known from the Atokan Stage and on into the Permian age. The tendency to develop a great number of arms is retained throughout the lineage into the Permian, e.g., *I. bassleri* (STRIMPLE), of Missourian age, and *I. eageli* STRIMPLE, of Early Permian age, although a number equal to that found in *Allocatillocrinus* is never quite attained. Conversely, a trend toward a relative reduction in the number of smaller arms also prevails and is perhaps climaxed in *I. copani* (STRIMPLE), of Missourian age, which has a larger dorsal cup than found in *I. bassleri*, therefore presumably could produce just as many arms, yet falls far short of that accomplishment. Occurring with *I. copani* is a much smaller form than either *I. bassleri* or *I. copani*, described here as *I. lasallensis*, n. sp.

OCCURRENCE.—Lower Pennsylvanian (Atokan)-Lower Permian; USA (Oklahoma, Kansas, Missouri, Illinois, Texas), USSR (Urals).

ISOALLAGECRINUS LASALLENSIS Strimple & Moore, n. sp.

Plate 3, figures 1a-c, 2a-c

DIAGNOSIS.—Cup erect, radials moderately bulbous, *A*, *B* and *D* radials bear 2 arms (*A* radial is the last to develop two), *C* and *E* rays bear single, slightly robust arm.

DESCRIPTION.—Young specimens have a longitudinal keel in midportion of each radial giving the cup an angular appearance. The radials become bulbous with age and the cup width increases appreciably. Primibrach *I* is moderately large in all rays and followed by elongated brachials in series in all except *C* and *E* rays where primibrach *2* is equal in length to about 10 brachials in *A*, *B* or *D* rays. The stem is round and wide in proximal portion and no crenulations appear at the attachment with the cup. The lumen is round. All elements of the crown have a meshlike appearance, due to penetration of the surface by minute pits, which is more pronounced on the robust arms than elsewhere. For the holotype, the crown is 10.9 mm long (incomplete); cup height 1.6 mm, width 2.8 mm.

DISCUSSION.—*Isoallagecrinus lasallensis* STRIMPLE & MOORE has a more erect and less bulbous cup than that of *I. bassleri* (STRIMPLE) but more bulbous than found in *I. copani* (STRIMPLE). Large mature specimens of *I. copani* have no more arms than young specimens of *I. lasallensis*. *I. graffhami* (STRIMPLE) has the same cup shape as in *I. lasallensis* but the outline when viewed from below is more stellate. In *I. bassleri*, *A* ray usually has a smaller

number of arms than the *D* ray (and in some specimens fewer than *B* ray), but in *I. lasallensis* all 3 have the same number. In *I. bassleri*, the 2 large arms have a longitudinal raised median section, whereas in *I. lasallensis* the exterior is evenly rounded, as in *I. copani*. All of the following species have strongly bulbous or projecting radials, and are thus readily separable: *Isoallagecrinus strimplei* KIRK, *I. kyleensis* (STRIMPLE), *I. status* (STRIMPLE), *I. eaglei* STRIMPLE, *I. constellatus* (MOORE), *I. dignatus* (MOORE). *I. pecki* (MOORE) has projections in immaturity and the lower portion of the cup is broad, due to expanded basals in maturity.

TYPES.—Holotype (IGS42P83) and paratype (IGS42P83A). Reposited Illinois Geological Survey, Urbana, Illinois, collected by CHRISTINA CELBURN.

OCCURRENCE.—LaSalle Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, Livingston County, Illinois.

Subclass CAMERATA Wachsmuth & Springer, 1885

Order MONOBATHRIDA Moore & Laudon, 1943

Family DICHOCRINIDAE S. A. Miller, 1889

DIAGNOSIS (modified after MOORE & LAUDON, 1943).—Monocyclic; two basals, equal, running from center of base of anal *X* to center of *A* radial; radials in contact except at anal side; primibrachs excluded from cup, occurring only as free brachials; a single anal plate in cup.

GENERA.—*Dichocrinus* MÜNSTER, 1837; *Paradichocrinus* SPRINGER, 1926; *Campocrinus* WACHSMUTH & SPRINGER, 1897; *Talarocrinus* WACHSMUTH & SPRINGER, 1881; *Pterotocrinus* LYON & CASSEDAY, 1859; *Neodichocrinus* WANNER, 1937; *Stomiocrinus* WANNER, 1937.

OCCURRENCE.—Mississippian to Permian; North America, Europe, East Indies.

Genus DICHOCRINUS Münster, 1837

TYPE-SPECIES.—*Dichocrinus radiatus* MÜNSTER, 1829, p. 2.

DIAGNOSIS.—Dorsal cup steeply conical; anal *X* large, almost equal in size to radials; arms uniserial or biserial; tegmen low, consisting of small plates; anus opens directly through tegmen or through small tubelike extension.

OCCURRENCE.—Mississippian to Pennsylvanian; North America, Europe.

DICHOCRINUS NOLA Strimple & Moore, n. sp.

Plate 17, figures 1a,b, 2a,b

DESCRIPTION.—The species is represented by 2 calyces, one (holotype) with the anal tube and some primibrachs *I* preserved; the other (paratype) is smaller and has a platyceratid gastropod attached. Two equidimensional basal plates form a rapidly expanded cone and are fol-

lowed above by 5 long radial plates together with a radial-like primanal which together form almost vertical lateral sides of the calyx. Articular facets are narrowly crescent-shaped and hold short, nonaxillary primibrachs *I* in the holotype. The primanal supports several tube plates followed by a series of additional small polygonal plates which form a short anal tube with the anus at its distal end. Tube and tegmen are slightly collapsed into the body cavity, but the tube appears to have a diameter about one-third the size of the body cavity. The proximal columnals are relatively large, short, equidimensional, and have a circular outline. Lumen is small and round. Height of calyx (holotype) is 3.8 mm, width 3.3 mm, height of basal circlet 1.0 mm.

DISCUSSION.—Only one other *Dichocrinus* is known from the Pennsylvanian—*D. dilatus* STRIMPLE & WATKINS, 1969, p. 222, from the Lemons Bluff Limestone (Atokan) of Texas. *D. dilatus* has a more expanded cup with proportionately shorter radial plates than the new species from Illinois. The anal tube is much like that of *Caucacrococrinus* MOORE & STRIMPLE, 1969, p. 28. Close affinity between some acrocrinids and dichocrinids appears obvious as more material become available. The name is derived from the Latin word *nola* for little bell.

TYPES.—Holotype IGS42P48, paratype IGS42P36 collected by CHRISTINA CELBURN.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry, Ocoya, south of Pontiac, Livingston County, Illinois.

Subclass FLEXIBILIA Zittel, 1879

Order SAGENOCRINOIDEA Springer, 1913

Family DACTYLOCRINIDAE Bather, 1899

DIAGNOSIS.—Crown ovoid, moderately elevated, with virtually no distinction between fixed brachials forming upper part of calyx and dorsal cup composed of radials and lower plate circlets; radianal normally lacking but anal *X* commonly distinct and relatively large, followed by other anal plates. Proximal columnal concealing infra-basal circlet in most genera, as well as much or all of basal plates and even portions of radials. Branching of arms strongly heterotomous or istomous with bifurcations at similar or different levels in various arm branches; interbrachials few or may be absent.

GENERA.—*Dactylocrinus* QUENSTEDT, 1876; *Axiotrophocrinus* STRIMPLE & WATKINS, 1969; *Caldenocrinus* WRIGHT, 1946; *Calpiocrinus* ANGELIN, 1878; *Lithocrinus* WACHSMUTH & SPRINGER, 1879 (1880); *Paramphicrinus* STRIMPLE & MOORE, n. gen.; *Wachsmuthicrinus* SPRINGER, 1902; *Euryocrinus* PHILLIPS, 1837; *Ainacrinus* WRIGHT, 1939; *Amphicrinus* SPRINGER, 1906; *Artichthyocrinus* WRIGHT, 1923; *Dieuryocrinus* WRIGHT, 1954; *Nevadacrinus* LANE & WEBSTER, 1966; *Rumphicrinus* WANNER, 1924; *Temnocrinus* SPRINGER, 1902.

OCCURRENCE.—Upper Silurian to Upper Permian; North America, Europe, East Indies.

Genus **PARAMPHICRINUS** Strimple & Moore, n. gen.

TYPE-SPECIES.—*Paramphicrinus oklahomensis* (STRIMPLE), 1939.

DESCRIPTION.—Crown rotund, medium-sized, with stoutly built bowl-shaped calyx forming lower half of crown and closely adjoined parallel free arms upper half, curving inward at summit so that arm tips nearly meet; infrabasal circlet and all except posterior plate of basal circlet covered by stem, subhorizontal in attitude; only distal edges of radials exposed, those of *C* and *D* rays slightly smaller than others and visible parts asymmetrical; no radianal but moderately large anal *X* on truncate extremity of posterior basal, followed by 16 to 20 higher anals in double series, interlocking sideward with fixed brachials from primibrach to tertibrach series. Arms broad in proximal portion, branching isotomously on primibrachs 2 and secundibrachs 3 in each ray, thereafter displaying well-marked heterotomy of bi-endotomous type, distal parts of all arms narrowing upward, with 80 to 100 arm tips at crown summit, each complete half-ray with 20 arms; interbrachial sutures mostly sinuous; interradial polygonal plates 16 to 20 beginning between first primibrachs with large plate, much smaller distal ones suturedly joined to tertibrachs; interbrachials beginning between proximal secundibrachs and extending upward nearly to distal tertibrachs; two small areas of three to five intertertibrachs in each ray. Stem large, composed of very low crenulate columnals with quinquelobate axial canal, proximal part tapering gradually and strongly curved toward *DE* interray or *A* ray.

OCCURRENCE.—Upper Pennsylvanian (Missourian), USA (Oklahoma, Illinois).

PARAMPHICRINUS OKLAHOMAENSIS (Strimple), 1939

Figures 17; 18; Plate 22, figures 2a-d; Plate 23, figures 3a,b

DIAGNOSIS.—Stoutly built, relatively small-plated form showing all diagnostic features of genus.

DESCRIPTION.—Species characterized by very compact, rotund crown with exceptional development of closely abutting, mostly slender free arms in upper two-fifths of crown, strongly incurved arm tips numbering at least 80 and possibly up to 100 in well-preserved complete specimens. Arms bifurcating isotomously on primibrachs 1 and with not quite perfect isotomy on secundibrachs 3, thereafter branching in well-defined heterotomous manner in two endotomous groups; axillary tertibrachs (numbered in each ray from left to right for outer-inner-inner-outer main branches) in *A* ray 5-5-0-7, in *B* ray 4-5-6-5, in *C* ray 5-6-6-5, in *D* ray 5-5-5-5, and in *E* ray 5-6-5-5. Bowl-shaped calyx built of interlocking well-sutured plates, in addition to entirely concealed subhorizontal infrabasal, basal, and proximal part of radial circlets, comprising fixed primibrachs, secundibrachs, and tertibrachs, combined with intervening interprimibrachs (interradials), intersecundibrachs, and intertertibrachs, all but

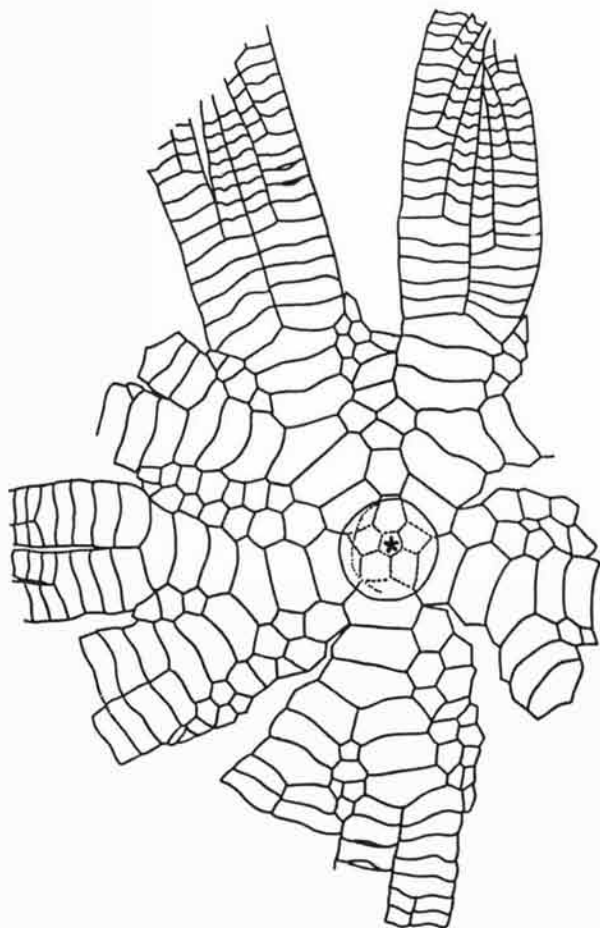


FIG. 17. Camera lucida drawing of holotype (USNMS4031) of *Paramphicrinus oklahomensis* (STRIMPLE), $\times 1.5$.

last-mentioned in longitudinal double series; anal *X* followed by about 20 additional anals, mostly in double series as in other interrays which have 16 to 20 plates with proximal one distinctly largest, single area of intersecundibrachs in each ray with 10 or 11 plates, each ray containing 2 small intertertibrach areas with 3 to 5 plates in each ray; sutures between radials and first primibrachs and between primibrachs gently curved, all others distinctly flexuous owing to development of patelloid processes and sockets at outer edges of facets.

Small proximal part of column attached to holotype specimen shows strong curvature from *B* ray toward *DE* interray along with taper in diameter from 10.5 mm at calyx attachment to 7 mm measured at distance of 7 mm along outer curvature; slightly flexuous columnals extremely low, with height of 0.4 mm on convexly curved part of stem and approximately half as much on concave part; quinquelobate axial canal with narrowly lobate extensions oriented radially, 1.5 mm in greatest width across star-shaped outline and 0.4 mm at inner points of rays; peripheral part of columnal facets finely crenulate with

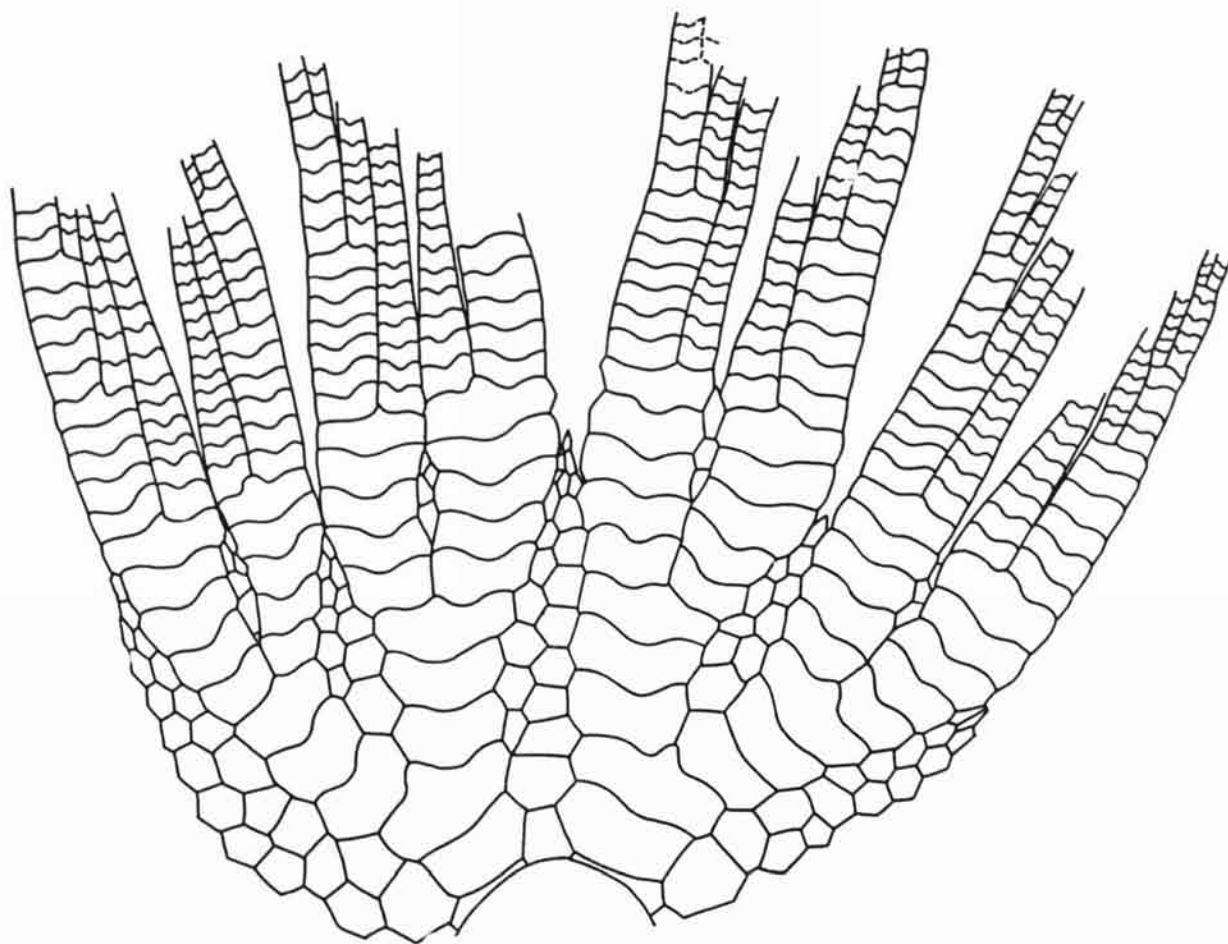


FIG. 18. Camera lucida drawing showing posterior interray and adjacent rays of hypotype (IGS42P61) of *Paramphicrinus oklahomaensis* (STRIMPLE).

narrow culmina and crenellae extending about one-fifth of distance from margin to axial canal.

DIMENSIONS.—The obliquely somewhat flattened holotype specimen has width of crown amounting to approximately 50 mm and height of 40 mm; in an undistorted crown these measurements are estimated to be 40 and 35 mm, respectively. Exposed parts of radials have width ranging from 5.4 to 8.0 mm and height of 0.3 to 1.5 mm; *C* and *D* radials are distinctly narrower than others. Other dimensions of plates of the crown can be scaled readily from accurate camera lucida drawing (Fig. 17) made by viewing all parts normal to their exposed surface so as to avoid distortion in shape and size which would be inescapable in oblique views.

DISCUSSION.—An interesting feature of the so-called isotomous bifurcations next above the axillary primibrach in each ray is observation that the distal articular facets differ slightly in width on their outer and inner sides. The outer parts of these axillaries are 3.9 mm in average width, whereas the inner ones are 3.4 mm. Thus, the

facets of inner sides are 15 percent shorter than the outer ones. This slight disparity is observed to be consistent in all rays.

In the strongly built nature of its calyx, with double series of interradyal plates in all interrays and wide, smooth fixed brachials of the main arm branches, *Paramphicrinus oklahomaensis* resembles *Dieuryocrinus duplex* WRIGHT (1954), from upper Lower Carboniferous (Viséan) rocks of northern England. The latter, which is type-species of the genus, has a basally truncate calyx and evenly out-flaring sides, dissimilar proximal anals (interpreted as small anal *X* and relatively large radianal displaced upward). Also its arm branches to the height of quarti-brachs 3 in some rays display only even isotomous bifurcations. The Pennsylvanian species from Illinois cannot be assigned to *Dieuryocrinus* and seems entirely unrelated to *D. duplex*.

TYPES.—The holotype USNM S4031, is from the Wann Formation of Oklahoma; hypotype IGS42P61 is the only specimen found in Illinois and was collected by H. L. STRIMPLE and CHRISTINA CLEBURN.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Pennsylvanian; Wagner Stone Company Quarry at Ocoya, approximately 5 miles south of Pontiac, Livingston County, Illinois.

Order TAXOCRINOIDEA Springer, 1913

Family TAXOCRINIDAE Angelin, 1878

DIAGNOSIS.—Crown usually elongate, with rays above radials partly or wholly separated all around; posterior interray invariably differentiated by presence of anal plates in tubelike series not incorporated in calyx; branching of arms isotomous or heterotomous.

SUBFAMILIES.—*Taxocrininae* ANGELIN, 1878; *Synerocrininae* JAEKEL, 1918.

OCCURRENCE.—Middle Ordovician (Trenton) to Upper Pennsylvanian (Virgilian); North America, Europe.

Subfamily SYNEROCRININAE Jaekel, 1918

DIAGNOSIS.—Taxocrinids distinguished by distinctly heterotomous branching of arms.

GENERA.—*Synerocrinus* JAEKEL, 1897; *Enasocrinus* STRIMPLE & WATKINS, 1969; *Euonychocrinus* STRIMPLE, 1940; *Onychocrinus* LYON & CASSEDAY, 1860.

OCCURRENCE.—Lower Mississippian (Osagean) to Upper Pennsylvanian (Virgilian), Lower Carboniferous (Viséan) to Upper Carboniferous (Moscowian); North America, Europe.

Genus EUONYCHOCRINUS Strimple, 1940

TYPE-SPECIES.—*Euonychocrinus dubius* STRIMPLE, 1940, p. 103.

DESCRIPTION.—Crown elongate ovoid with 20 well-separated, transversely rounded arms rising in forked manner from axillary secundibrachs, arm branching isotomous to this level, above which arm pairs give off short rounded unbranched ramules on sides facing each other, thus producing a very simple sort of bi-endotomous heterotomy, each ramule-bearing tertibrach commonly separated by one without ramule; like *Synerocrinus* in having two primibrachs and three secundibrachs in each arm branch above axillary primibrach; each interray with small number (four to six) moderately large interradians; only tips of basals appearing beyond stem impression, posterior one longer than others and supporting anal X, followed by transversely rounded anal tube not laterally united to brachials.

OCCURRENCE.—Middle Pennsylvanian (Desmoinesian)-Upper Pennsylvanian (Missourian); USA (Oklahoma, Kansas, Texas, Illinois).

EUONYCHOCRINUS SIMPLEX Strimple & Moore, n. sp.

Figure 19; Plate 23, figures 1a-c, 2a-d

DIAGNOSIS.—Characters of genus.

DESCRIPTION.—Originally studied specimen is almost perfectly preserved complete crown, automatically design-

nated as holotype; it is evenly compressed very slightly normal to plane intersecting anteroposterior axis but without dislocation or other disturbance of plates and without appreciably affecting arms. Except for topmost columnal attached to base of calyx, no portion of stem is preserved.

Calyx composed of well-sutured radials with circlets enclosed by them, succeeded upward by fixed brachials, consisting in each ray of 2 primibrachs and 2 sets of three secundibrachs, these plates associated with medium-sized interprimibrachs (interradians) in each interray except CD and 1 to 4 small polygonal intersecundibrachs in each ray, calyx thus having scalloped upper limit produced by projections of topmost fixed brachials above interray and intersecundibrach areas. Anitaxis in form of transversely well-rounded tube which begins with proximal plate (anal X) resting on obliquely hollowed right extremity of posterior basal, impinging very slightly on C radial but not suturally joined to it, other plates of anal tube likewise separated from adjacent fixed primibrachs and secundibrachs by extremely diminutive platelets of perisome.

Free arms forming slightly more than half height of crown, well separated from each other all around; brachials with height mostly slightly smaller than width, hemispherical to subtrapezoidal in transverse section, typically with well-rounded surface on side facing outward from arms; small but well-developed ramules produced from 2 sets of arm pairs in each ray and directed toward median axes of half-rays; 9 or possibly up to 11 ramules borne by each arm, consequently indicating a total of approximately 200 ramules in entire crown. All arms taper very gradually and curve rather evenly inward toward their extremities, but owing to their downbending at crown summit no arm tip actually seen.

Stellate lumen of proximal columnal with rays directed interradianally.

Lower part of calyx basally truncate bowl-shaped, with evenly rounded sides produced by radials and primibrachs.

DISCUSSION.—The anal tube of *Euonychocrinus simplex* and general features of its crown readily establish it as belonging to the Taxocrinoidea and to its single included family, the Taxocrinidae. This Upper Pennsylvanian crinoid most closely resembles *Synerocrinus incurvus* (TRAUTSCHOLD) which occurs in beds of nearly equivalent age in the Moscow Basin of the Soviet Union, but unknown elsewhere. The new crinoid species from Illinois, despite its similarities to *S. incurvus* in essential structures, differs most markedly in the strong separation of its free arms from the calyx and especially in their spread-out pattern, with bi-endotomously arranged small ramules much more sharply set off from the arms. Also the ramules are directed straight away from the brachials to which they are attached, rather than extending subparallel to the arms as in *S. incurvus*.

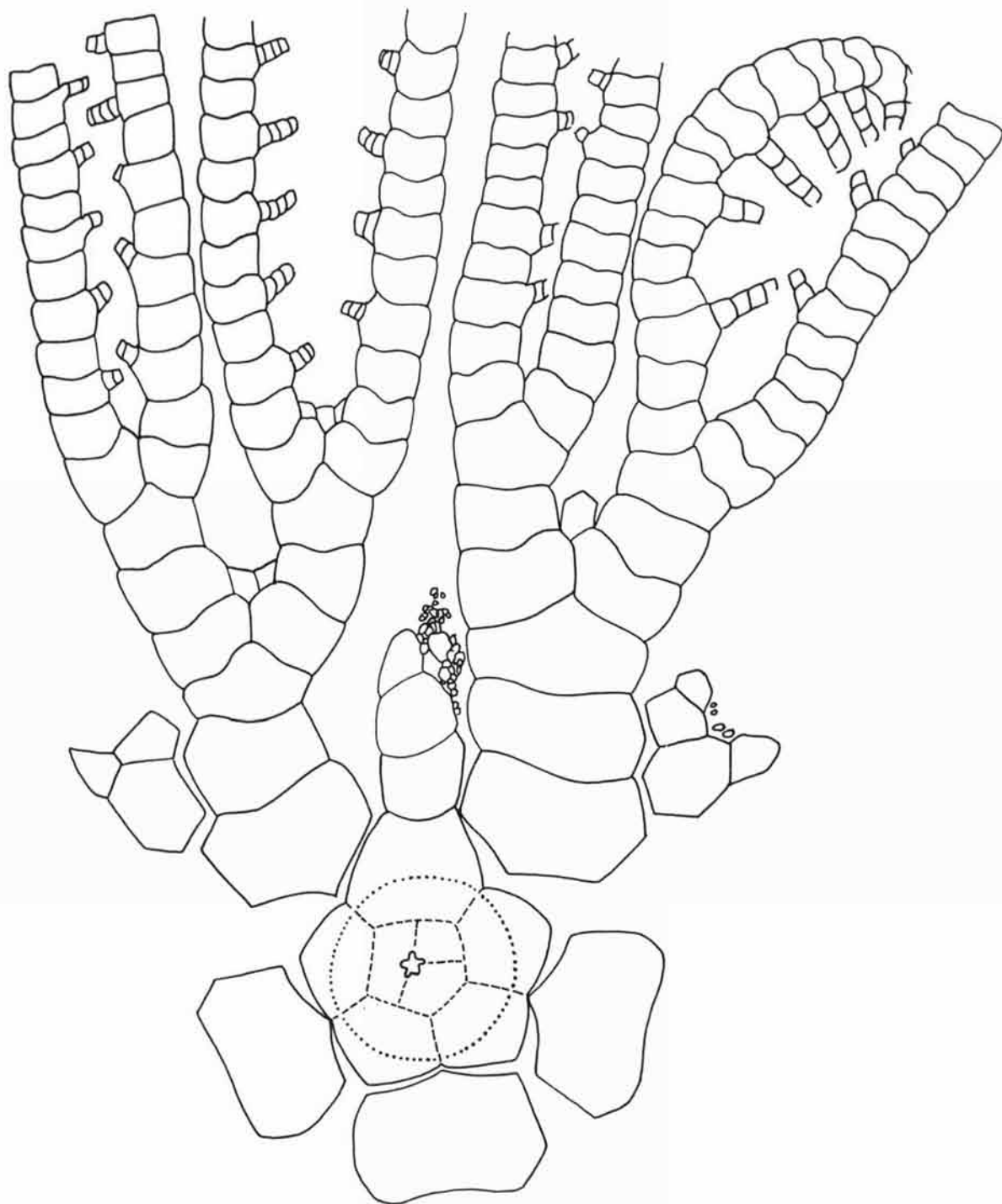


FIG. 19. Camera lucida drawing of holotype (IGS42P69) of *Euonychocrinus simplex* STRIMPLE & MOORE, n. sp., showing dorsal cup, posterior interray and adjacent rays.

DIMENSIONS.—Greatest width of the crown, at about two-thirds of its height, is 41 mm in the anteroposterior axis and 20 mm transverse to this owing to the lateral compression of the holotype specimen previously men-

tioned; in undeformed condition the crown should measure approximately 30 mm in width. Height of the crown, not affected by compression, is 35 mm. Height of the calyx at mid-rays is 10 to 12 mm and in interray

positions, 8 or 9 mm. Thus, free arms represent more than two-thirds of the total crown height. Width of basal circle 7.5 to 8 mm except anteroposteriorly, which is 10 mm. Diameter of stem impression is 6.8 mm. Dimensions of the calyx and arm plates are most readily determined by scaling from camera lucida drawings (Fig. 19).

TYPES.—Holotype IGS42P69, paratypes IGS42P81, IGS42P90, collected by CHRISTINA CLEBURN and H. L. STRIMPLE.

OCCURRENCE.—LaSalle Limestone Member, Bond Formation, Missourian, Upper Pennsylvanian, at Wagner Stone Company Quarry at Ocoya, approximately 5 miles south of Pontiac, Livingston County, Illinois.

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EXPLANATION OF PLATES

PLATE 1

Crinoids from LaSalle Limestone, Upper Pennsylvanian, from vicinity of Pontiac, Livingston County, Illinois (Fig. 1-4).

FIGURE

1. *Erisocrinus typus* MEEK & WORTHEN, nearly complete crown (IGS42P68), of adult showing pairs of arms borne by axillary primibrachs of three unidentified rays and well-marked biserial succession of brachials, $\times 0.9$.
2. *Haeretocrinus wagneri* STRIMPLE & MOORE, n. sp., holotype (IGS42P64), crown viewed from opposite sides.—2a. A-ray view showing round-topped anal sac.—2b. C-ray view showing uniserially arranged brachials with pinnules of biextomous arms; both $\times 0.9$.
3. *Elibatocrinus elegans* STRIMPLE & MOORE, n. sp., paratype (IGS42P62), incomplete crown with tall subcylindrical anal sac and short attached part of stem.—3a-b. CD-interray and A-ray views, $\times 1.5$.
4. *Halogetocrinus paucus* (STRIMPLE), hypotype (IGS42P24A), incomplete crown and long attached part of highly cirriferous stem, arm structure and slender anal sac well shown, $\times 1.9$.

PLATE 2

Crinoids from LaSalle Limestone, Upper Pennsylvanian, from vicinity of Pontiac, Livingston County, Illinois (Fig. 1-4).

FIGURE

1. *Sciadiocrinus tegillum* STRIMPLE & MOORE, n. sp.—1a-b. Anterior and posterior views of holotype crown (IGS42P47), subhorizontally directed umbrella spines surrounding polygonal plates of anal sac well shown in 1b, $\times 2.1$.
2. *Endelocrinus tumidus* STRIMPLE, hypotype crown (IGS42P81) with portion of stem attached from E-ray, $\times 2.2$.
3. *Elibatocrinus elegans* STRIMPLE & MOORE, n. sp., holotype crown (IGS42P111) from D-ray, $\times 2.2$.
4. *Parulocrinus pontiacensis* STRIMPLE & MOORE, n. sp.—4a-b. Basal (CD interrays directed upward) and anterior views of paratype (IGS42P113), $\times 1.1$.

PLATE 3

LaSalle crinoids—*Isoallagecrinus* (Fig. 1-2), *Erisocrinus* (Fig. 3-5), *Contocrinus* (Fig. 6), and *Endelocrinus* (Fig. 7).

FIGURE

- 1-2. *Isoallagecrinus lasallensis* STRIMPLE & MOORE, n. sp., from vicinity of Pontiac, Livingston County, Ill.—1a-c. Holotype (IGS42P83), basal, A-ray, and CD-interray views, $\times 8.25$.—2a-c. Paratype (IGS42P83A), basal, AB- and CD-interray views, $\times 8.25$.
- 3-5. *Erisocrinus typus* MEEK & WORTHEN.—3-4. Side views of juvenile crowns, rays unidentified (IGS42P38 and IGS42P37),

- ×1.—5. Incomplete adult crown, rays unidentified (IGS42P24), ×2.25.
6. *Contocrinus coupi* STRIMPLE & MOORE, n. sp., side view of paratype, crown with attached part of xenomorphic stem, rays unidentified (IGS42P41), ×1.1.
7. *Endelocrinus tumidus spinosus* STRIMPLE, hypotype (IGS42P50), crown viewed obliquely from below, DE-interray located medially, ×2.25.

PLATE 4

Crinoids from LaSalle Limestone, Upper Pennsylvanian, from vicinity of Pontiac, Livingston County, Illinois (Fig. 1-5).

FIGURE

1. *Haloetocrinus paucus* (STRIMPLE), hypotype (IGS42P25), BC-interray view of crown with proximal part of stem, one long pinnule-bearing arm and short exotomously placed nonpinnulate armlets distinguished by rectilinear articulations between brachials, ×2.5.
2. *Microcaracrinus conjugulus* STRIMPLE & MOORE, n. sp., holotype (IGS42P12A) crown viewed from D-ray and CD-interray side, showing fine granulose surface of plates and uniserial arrangement of cuneate brachials, ×4.5.
3. *Anobasicrinus brevis* STRIMPLE & MOORE, n. sp., holotype (IGS42P49) incomplete crown with large rounded anal sac.—3a. Basal view, CD interrays directed upward.—3b-c. CD- and AB-interray views showing especially well pore-indented sutures of polygonal sac plates with accompanying dendritic extensions on exterior surface of plates; all ×2.
4. *Haeretocrinus macoupinensis* (Worthen) STRIMPLE & MOORE, n. comb.; hypotype (IGS42P65), D-ray view of calyx, radianal and anal X plates at upper right, ×0.8.
5. *Erisocrinus typus* MEEK & WORTHEN, well-preserved crown (IGS42P13) with attached part of stem, rays unidentified, ×3.

PLATE 5

Crinoids from LaSalle Limestone, Upper Pennsylvanian, from vicinity of Pontiac, Livingston County, Illinois (Fig. 1-3).

FIGURE

1. *Erisocrinus typus* MEEK & WORTHEN.—1a-b. Side view of crown and opposite side showing small anal tube, hypotype IGS42P115, ×1.7.
2. *Polygonocrinus spiniferus* STRIMPLE & MOORE, n. sp.—2a-b. Oblique (posterior to right) and summit (showing spinose umbrella-like platform at summit of anal tube and spinose perimeter plates) views of holotype (IGS42P109), crown, ×1.1.
3. *Parulocrinus pontiacensis* STRIMPLE & MOORE, n. sp.; posterior view of large paratype (IGS42P113), crown, ×1.1.

PLATE 6

Crinoids from LaSalle Limestone, Upper Pennsylvanian, from vicinity of Pontiac, Livingston County, Illinois (Fig. 1-6).

FIGURE

1. *Chlidonocrinus erectus* STRIMPLE & MOORE, n. sp.—1a-c. BC-interray, dorsal, and A-ray views of holotype (IGS42P54), ×2.1.
2. *Polusocrinus avanti* STRIMPLE. Posterior view of hypotype (IGS42P72), ×1.5.
3. *Moundocrinus* sp. cf. *M. osagensis* STRIMPLE.—3a-b. Dorsal and ventral sides of hypotype dorsal cup (IGS42P74), ×1.5.—3c. Three arms of same specimen, ×1.5.

4. *Exocrinus wanni* STRIMPLE; C-ray view of hypotype crown (IGS42P57), ×2.6.
5. *Apographocrinus typicalis* MOORE & PLUMMER; side view of hypotype crown (IGS42P172) with attached part of xenomorphic stem, ×1.5.
6. *Exocrinus wanni* STRIMPLE, D-ray view of hypotype crown (IGS42P35), ×2.1.

PLATE 7

Crinoids from LaSalle Limestone, Upper Pennsylvanian, from vicinity of Pontiac, Livingston County, Illinois (Fig. 1-3).

FIGURE

1. *Moundocrinus* sp. cf. *M. osagensis* STRIMPLE.—1a-d. Basal (CD-ray directed upward), anterior, summit, and posterior views of hypotype (IGS42P114), ×2.1.
2. *Probletocrinus curtus* STRIMPLE & MOORE, n. gen., n. sp., side view (B ray) of holotype crown (IGS42P107), ×1.1.
3. *Contocrinus coupi* STRIMPLE & MOORE, n. sp.—3a-c. Posterior (CD interrays), basal (CD interrays directed upward), and side (E ray) views of holotype (IGS42P42) crown, ×2.1.

PLATE 8

Crinoids from LaSalle Limestone, Upper Pennsylvanian, from vicinity of Pontiac, Livingston County, Illinois (Fig. 1-6).

FIGURE

1. *Galateacrinus coacervatus* STRIMPLE & MOORE, n. sp.; posterior view of holotype crown (IGS42P11B) with short part of attached stem, ×3.
2. *Exocrinus wanni* STRIMPLE; posterior view of holotype (IGS42P92D) with attached part of xenomorphic stem, ×2.1.
3. *Haloetocrinus paucus* (STRIMPLE); C-ray view of hypotype crown (IGS42P24A) with small part of attached stem, ×3. [See Plate 1, fig. 4.]
4. *Stenopocrinus* sp.—4a-c. CD-interray, A-ray, and summit views of hypotype crown (IGS42P58), rosette of seven umbrella plates directed slightly upward at tip of slender anal sac shown in 4b-c, ×3.5.
5. *Allosocrinus bronraughii* STRIMPLE; oblique dorsal view of hypotype crown (IGS42P70) with attached proximal part of stem, C ray directed upward, ×1.5.
6. *Exoriocrinus lasallensis* (Worthen) STRIMPLE & MOORE, n. comb., DE-interray view of hypotype crown (IGS42P67), ×1.5.

PLATE 9

Crinoid from LaSalle Limestone, Upper Pennsylvanian, from vicinity of Pontiac, Livingston County, Illinois (Fig. 1-3).

FIGURE

1. *Laudonocrinus subsinuatus* (MILLER & GURLEY).—1a-b. B- and D-ray views of hypotype crown (IGS42P61A), ×2.8.
2. *Exoriocrinus lasallensis* (Worthen) STRIMPLE & MOORE, n. comb.; AB-interray view of hypotype crown (IGS42P66), ×1.5.
3. *Laudonocrinus subsinuatus* (MILLER & GURLEY); B-ray view of hypotype crown (IGS42P92), ×2.

PLATE 10

Crinoids from the LaSalle Limestone, Upper Pennsylvanian, from vicinity of Pontiac, Livingston County, Illinois (Fig. 1-3).

FIGURE

- 1-2. *Plummerocrinus erectus* STRIMPLE.—1a-c. Hypotype

(IGS42P56) crown viewed from C-ray, CD-interray, and A-ray sides, showing very finely granulose surface of plates, $\times 2.2$.—2. Hypotype (IGS42P14) viewed from EA-interray side, with one nearly complete arm of A-ray, structure of tall anal sac with small smooth-surfaced polygonal plates of posterior side and larger, deeply indented plates of anterior side in strong contrast, $\times 1.5$.

3. *Microcaracrinus conjugulus* STRIMPLE & MOORE, n. sp., paratype (IGS42P55).—3a-b. Views from DE-interray and B-ray sides, showing longitudinally fine-keeled primibrachs and some succeeding brachials, arms pushed inward by cross-cutting bryozoan (*Cystodictya* sp.) in 3a, both $\times 4.7$.

PLATE 11

Crinoids from LaSalle Limestone, Upper Pennsylvanian, in vicinity of Pontiac, Livingston County, Illinois (Fig. 1-6).

FIGURE

- 1-2,4-6. *Stellarocrinus* sp. cf. *S. virgilensis* STRIMPLE.—1. Juvenile specimen (IGS42P7) showing short anal sac with radially divergent large terminal spines, $\times 2.1$ (opposite side of specimen illustrated in Plate 18, fig. 3).—2a-b. Individual (IGS42P5A) more mature than crinoid shown in fig. 1 with taller anal sac having biserially disposed plates in longitudinal rows, CD-interray directed upward in 2a, opposite side of specimen in 2b, $\times 2.1$.—4. Specimen (IGS42P75) viewed from above showing incurved arms surrounding summit of anal sac, five spinose plates enclosing very diminutive plates grouped around tiny anal vent, $\times 2$.—5. Exceptionally well-preserved crown (IGS42P9) viewed from below, $\times 1.5$.—6. Juvenile crown (IGS42P10) viewed from below, $\times 3$.
3. *Microcaracrinus conjugulus* STRIMPLE & MOORE, n. sp., paratype, extremely juvenile individual (IGS42P12B) viewed obliquely from below, $\times 7.3$.

PLATE 12

Crinoids from LaSalle Limestone, Upper Pennsylvanian, from vicinity of Pontiac, Livingston County, Illinois (Fig. 1-3).

FIGURE

1. *Stenopocrinus* sp. cf. *S. planus* (STRIMPLE).—1a-b. Posterior and anterior sides of hypotype crown (IGS42P59) with part of attached stem, $\times 2.6$.
2. *Clathrocrinus clinatus* STRIMPLE & MOORE, n. gen., n. sp.; dorsal view of paratype (IGS42P17A), DE interrady directed upward, $\times 7.5$.
3. *Galateacrinus coacervatus* STRIMPLE & MOORE, n. sp.—3a-b. Dorsal views of paratypes (IGS42P12 and IGS42P12D), with D ray and BC interrady directed upward, respectively, both $\times 7.5$.

PLATE 13

Crinoids from LaSalle Limestone, Upper Pennsylvanian, from vicinity of Pontiac, Livingston County, Illinois.

FIGURE

1. *Haeretocrinus wagneri* STRIMPLE & MOORE, n. sp.—1a-c. Basal (CD interrady directed downward to right) and side views of paratype (IGS42P112), AB interrady and D ray (showing large recurved anal tube), respectively, $\times 1.2$.

PLATE 14

Crinoids from LaSalle Limestone, Upper Pennsylvanian, from vicinity of Pontiac, Livingston County, Illinois (Fig. 1-2).

FIGURE

1. *Terpnocrinus ocoyaensis* STRIMPLE & MOORE, n. gen., n. sp.—1a-d. Side (AE interrady), oblique (view of recurved anal tube), oblique (CD interrady), and summit (rugose recurved anal tube) views of holotype (IGS42P108) crown, $\times 2.1$.
2. *Probletoocrinus curtus* STRIMPLE & MOORE, n. gen., n. sp.—2a-c. Basal (anterior directed upward), posterior, and DE interrady views of holotype (IGS42P107) crown, $\times 1.1$. (See also Plate 7, fig. 2.)

PLATE 15

Ulocrinus from Kansas and Iowa (Fig. 1-2).

FIGURE

1. *Ulocrinus sangamonensis* MEEK & WORTHEN.—1a-d. Base, posterior, summit, and anterior view of hypotype (SUI34175), dorsal cup from Adair County, Iowa, $\times 2.25$.
2. *Ulocrinus fistulosus* STRIMPLE & MOORE, n. sp.—2a-d. Base, summit, posterior, and anterior views of holotype (SUI34176), dorsal cup from Montgomery County, Kans., $\times 1.7$.

PLATE 16

Infrabasal circlets of *Ulocrinus* from Wann Formation near Bartlesville, in Osage County, Oklahoma (Fig. 1-3).

FIGURE

- 1-2. *Ulocrinus fistulosus* STRIMPLE & MOORE, n. sp.—1a-c. Base (showing impressed columnar attachment area), summit, and side views of paratype (SUI34177) infrabasal circlet showing undulating surfaces at distal edges.—2a. Base (with proximal columnar in place).—2b. Summit (showing portions of irregular rim about the lumen).—2c. Side views of paratype (SUI34545), infrabasal circlet, $\times 2.25$.
3. *Ulocrinus convexus* (STRIMPLE).—3a-c. Base, summit, and side views of hypotype (SUI34546), infrabasal circlet, $\times 2.25$.

PLATE 17

LaSalle crinoids—*Dichocrinus* (Fig. 1-2), *Ulocrinus* (Fig. 3) and *Parulocrinus* (Fig. 4).

FIGURE

- 1-2. *Dichocrinus nola* STRIMPLE & MOORE, n. sp., specimens from vicinity of Pontiac, Livingston County, Ill.—1a-b. Paratype (IGS42P36), B-ray and CD-interrady views, $\times 2$.—2a-b. Holotype (IGS42P48), B-ray and summit views of calyx, latter showing anal pyramid in CD interrady near lower margin of view, $\times 7.4$.
3. *Ulocrinus convexus* (STRIMPLE), hypotype (IGS42P91) from vicinity of Pontiac, Livingston County, Ill.—3a-b. D- and B-ray views of incomplete crown with attached proximal part of stem, some of the arms showing well-preserved pinnules, $\times 0.8$.
4. *Parulocrinus pontiacensis* STRIMPLE & MOORE, n. sp., holotype (IGS42P45) from vicinity of Pontiac, Livingston County, Ill.—4a. CD-interrady view.—4b-c. A-ray views (4b obliquely from below). All $\times 1.6$.

PLATE 18

Crinoids from LaSalle Limestone, Upper Pennsylvanian, in vicinity of Pontiac, Livingston County, Illinois (Fig. 1-5).

FIGURE

1. *Stellarocrinus bilineatus* STRIMPLE & MOORE, n. sp., holotype (IGS42P52), nearly complete crown with attached part of stem viewed from posterior side, anal X and pitted higher sac

plates separating *C* and *D* radials and their primibrachs beneath two most complete sets of branching arms, $\times 1.8$.

2. *Stellarocrinus* sp., extremely juvenile specimen (IGS42P15A) with nearly featureless cup plates and primibrachs much taller than wide, $\times 2.1$.
- 3-4. *Stellarocrinus* sp. cf. *S. virgilensis* STRIMPLE.—3. Small immature specimen (IGS42P7) with only partially developed sculpture of dorsal cup plates and only incipient biserial arrangement of brachials in arms, $\times 2.8$.—4. Large, fully adult specimen (IGS42P53) with part of stem belonging not far beneath few attached columnals; almost random distribution of spine-bearing brachials clearly evident, $\times 1.8$.
5. *Brabeocrinus christinae* STRIMPLE & MOORE, n. gen., n. sp., part of anal sac (IGS42P8) with attached platyceratid at left (tip of conical shell directed downward), showing horizontally ridged sac plates beneath large terminal spines, $\times 3$. [This is same specimen as illustrated in Plate 19, fig. 4.]

PLATE 19

Crinoids from LaSalle Limestone, Upper Pennsylvanian, from vicinity of Pontiac, Livingston County, Illinois (Fig. 1-5).

FIGURE

- 1-5. *Brabeocrinus christinae* STRIMPLE & MOORE, n. gen., n. sp.—1a-b. Holotype (IGS42P5A), *D*-ray and *AB*-interray views of crown and part of attached stem, both showing distinctive arm structure and nature of spine-tipped anal sac, $\times 2.1$.—2. Paratype (IGS42P6), oblique view of crown from below, *C* ray located medially, $\times 2.1$.—3. Paratype (IGS42P92B), *CD*-interray view, $\times 2.1$.—4. Paratype (IGS42P8), part of anal sac with attached platyceratid gastropod (opposite side of specimen illustrated in Plate 18, fig. 5).—5. Paratype (IGS42P51), crown in side view, $\times 2.3$.

PLATE 20

LaSalle crinoids—*Clathrocrinus* (Fig. 1-9).

FIGURE

1. *Clathrocrinus clinatus* STRIMPLE & MOORE, n. sp. Paratype (IGS42P18), *D*-ray view, showing stout, relatively short axillary primibrach bearing obliquely disposed secundibrachs, $\times 2.6$.
2. *C. clinatus* STRIMPLE & MOORE, n. sp. Paratype (IGS42P21), *BC*-interray view, anal sac visible at extreme left, dorsal cup very shallow, $\times 3$.
3. *C. clinatus* STRIMPLE & MOORE, n. sp. Holotype (IGS42P17), *CD*-interray view, anal *X* plate touching posterior basal, $\times 3$.
4. *C. clathratus* STRIMPLE & MOORE, n. sp. Paratype (IGS42P16A), side view of unidentified ray and single arm, $\times 2.25$.
5. *C. clinatus* STRIMPLE & MOORE, n. sp. Paratype (IGS42P20), incomplete crown with partially displaced plates viewed obliquely from below, *E* ray central, anal sac with terminal erect spine at right, $\times 2$.
6. *C. clinatus* STRIMPLE & MOORE, n. sp. Paratype (IGS42P17A), posterior view of well-preserved dorsal cup, anal *X* plate separated from posterior basal, surface of plates finely granulose, $\times 5.25$.
7. *C. clinatus* STRIMPLE & MOORE, n. sp. Paratype (IGS42P19), *A*-ray view with anal sac in background, $\times 2.25$.
8. *C. clathratus* STRIMPLE & MOORE, n. sp. Paratype (IGS42P16), posterior view with *D* radial slightly left of midline, anal sac relatively tall and slender, $\times 2.25$.

9. *C. clinatus* STRIMPLE & MOORE, n. sp. Paratype (IGS42P15A), *BC*-interray view of crown and slender stem, $\times 2.25$.

PLATE 21

LaSalle crinoids—*Clathrocrinus* (Fig. 1-6).

FIGURE

1. *Clathrocrinus clathratus* STRIMPLE & MOORE, n. sp. Paratype (IGS42P22), *E*-ray view of crown which well shows the nearly right-angled branching of arms with very elongate, slender brachials all axillary along two main arms of each ray, plates of dorsal cup somewhat tumid, with sutures between them impressed, $\times 3$.
2. *C. clathratus* STRIMPLE & MOORE, n. sp. Paratype (IGS42P11A), posterior view showing exceptionally tall primibrachs of *C* and *D* rays and slender anal sac topped by obliquely divergent long spines, $\times 3.7$.
3. *C. clinatus* STRIMPLE & MOORE, n. sp. Paratype (IGS42P23), *E*-ray view of incomplete crown, unbranched arms given off by some brachials unusually long, with rectilinear articulations of successive brachials, $\times 1.5$.
4. *C. clathratus* STRIMPLE & MOORE, n. sp. Holotype (IGS42P92E), *EA*-interray view of somewhat compressed crown with well-preserved arms and part of stem, anal sac at lower right, $\times 2.25$.
5. *C. clathratus* STRIMPLE & MOORE, n. sp. Paratype (IGS42P12C), oblique view of dorsal cup from below, *CD* interrady at lower left, tumid nature of plates and deeply impressed sutures well shown, $\times 7.5$.
6. *C. clathratus* STRIMPLE & MOORE, n. sp. Paratype (IGS42P14B), *E*-ray view of crown and proximal part of attached stem, arms with brachials insufficiently disturbed to obliterate distinctive pattern of branching, $\times 2.25$.

PLATE 22

Wayside (Kansas) and Ocoya (Illinois) crinoids—*Amphicrinus* (Fig. 1) and *Paramphicrinus* (Fig. 2).

FIGURE

1. *Amphicrinus poudi* STRIMPLE, from Stanton Formation, Upper Pennsylvanian (Missourian), near Wayside, Montgomery County, southeastern Kans.—1a. Exterior and interior views of lower part of calyx (holotype, USNM S4302).—1b. *CD* interrady directed upward, $\times 5$.
2. *Paramphicrinus oklahomaensis* (STRIMPLE), exceptionally well-preserved complete crown (IGS42P61) from LaSalle Limestone near Pontiac, Livingston County, Ill.—2a. Slightly oblique basal view, *CD* interrady near midline directed upward.—2b. Basal view, *B* ray directed upward.—2c. *B*-ray side view.—2d. Oblique view of upper part of crown showing incurved arm tips, left half of biendotomous arms of *D* ray at midline. All $\times 1.5$.

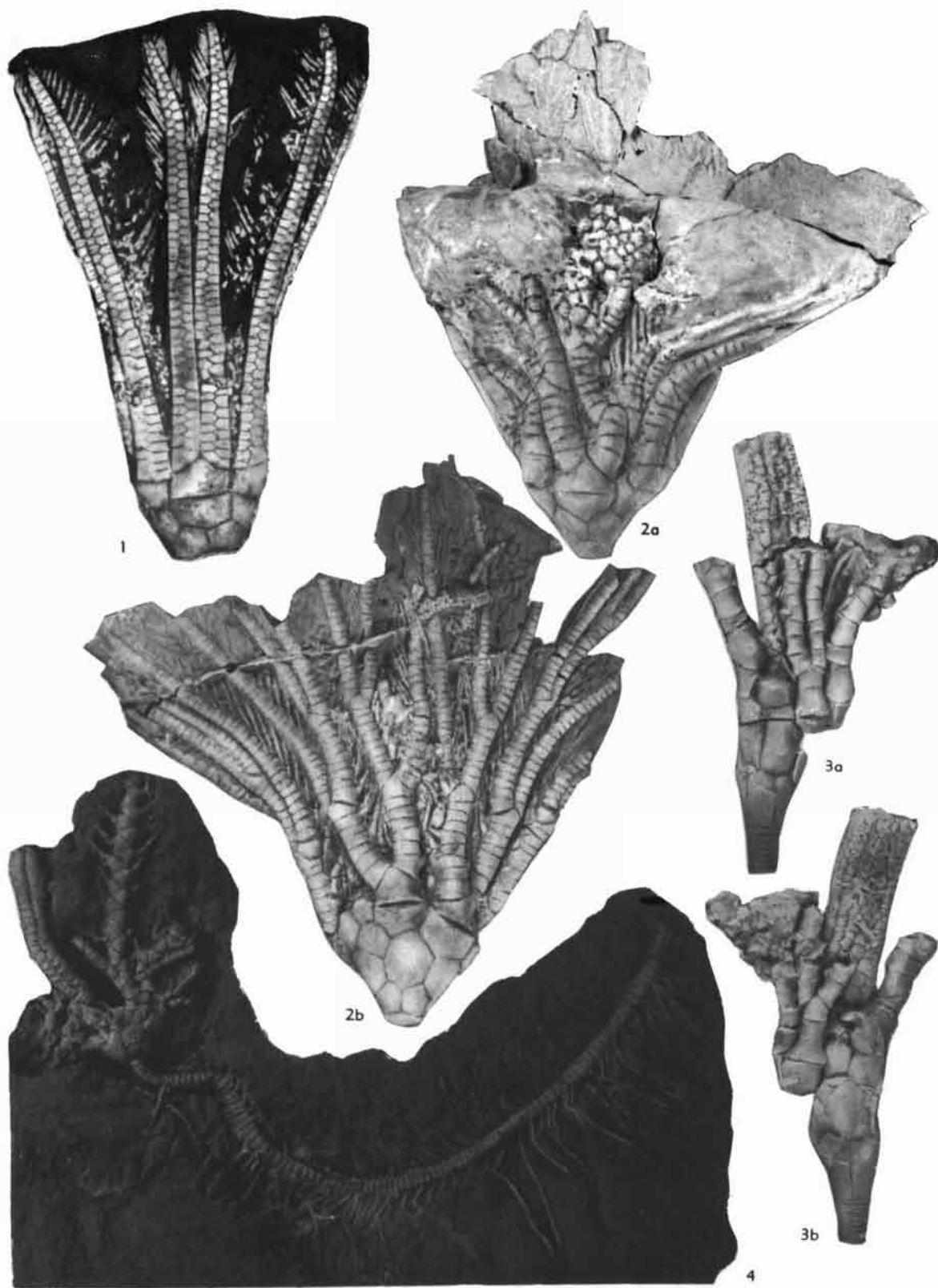
PLATE 23

Wann (Oklahoma) and LaSalle (Illinois) crinoids—*Euonychocrinus* (Fig. 1-2) and *Paramphicrinus* (Fig. 3).

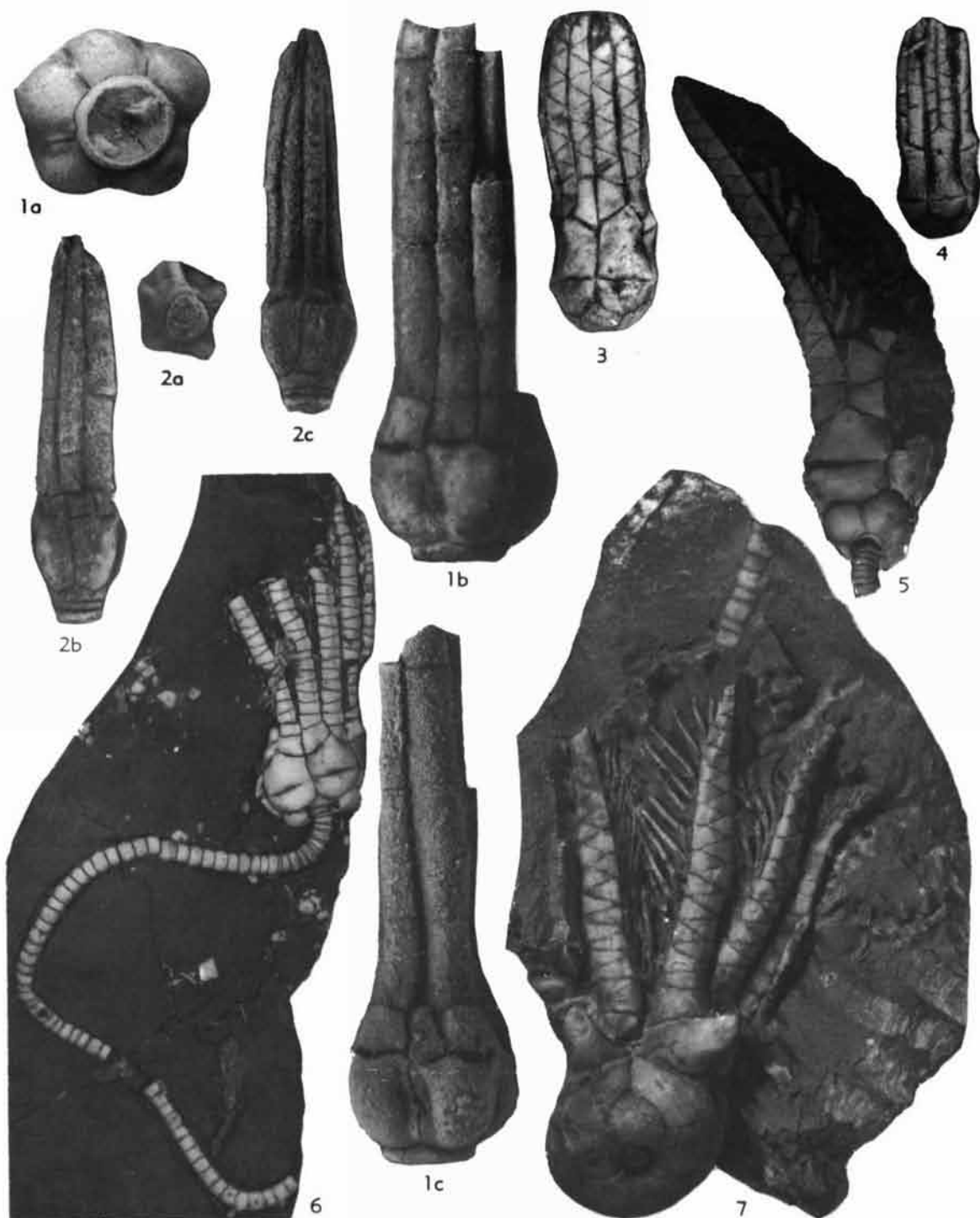
FIGURE

1. *Euonychocrinus simplex* STRIMPLE & MOORE, n. sp., paratype (IGS42P81) from LaSalle Limestone near Pontiac, Livingston County, Ill.—1a-c. *BC*-interrady, *CD*-interrady, and *A*-ray views of incomplete crown with attached part of tapering curved stem, $\times 1.4$.

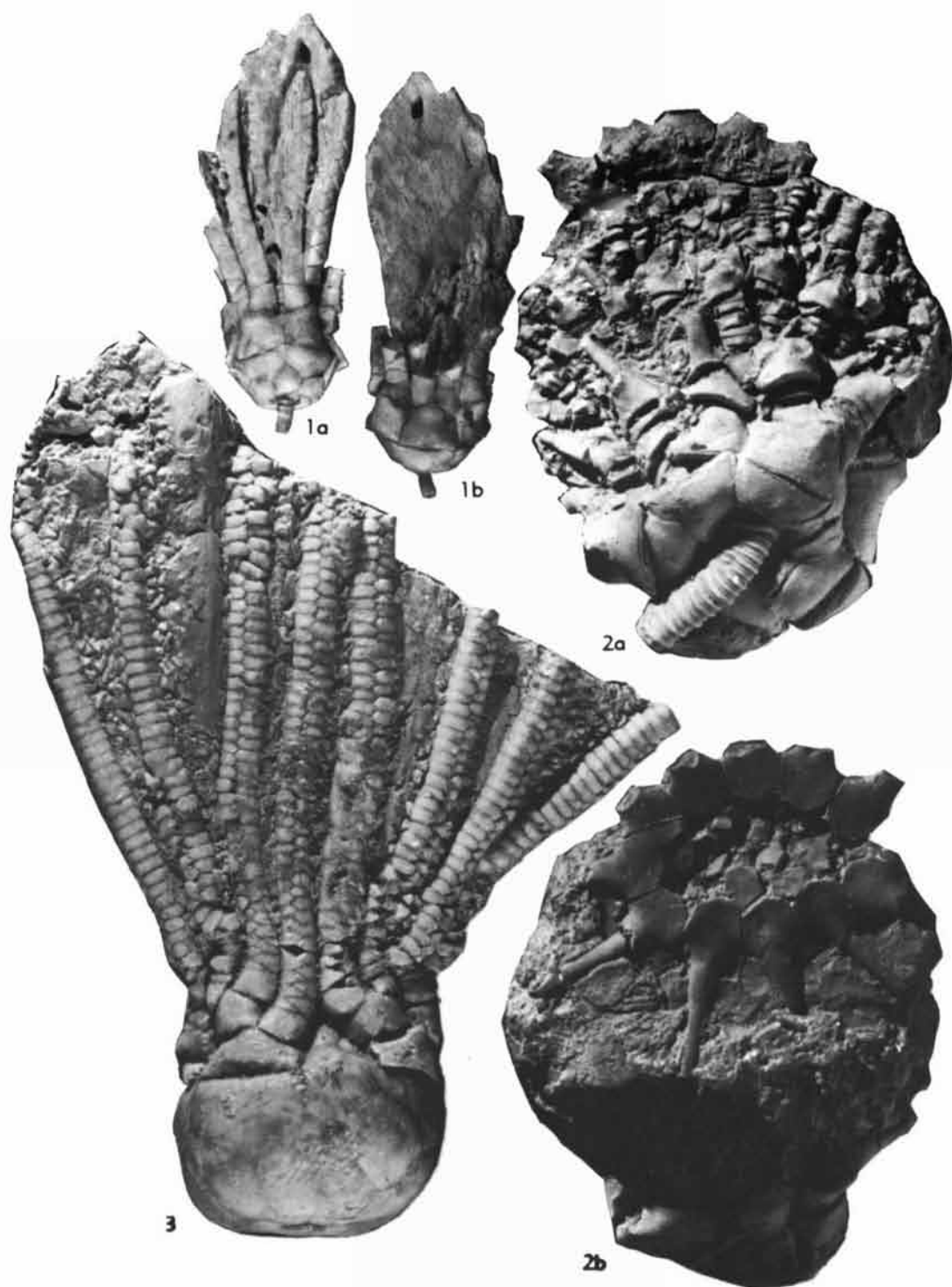
2. *Euonychocrinus simplex* STRIMPLE & MOORE, n. sp. holotype (IGS42P69), from LaSalle Limestone near Pontiac, Livingston County, Ill.—2a-c. *E*-ray, *BC*-interray, and *CD*-interray side views.—2d. Basal view, *CD*-interray directed upward; all $\times 1.4$.
3. *Paramphicrinus oklahomaensis* (STRIMPLE), holotype (USNMS4031) from Wann Formation, Upper Pennsylvanian (Missourian), near Bartlesville, Washington County, Okla.—3a. Basal view of crown, *A*-ray directed upward, $\times 2.7$.—3b. Summit view of crown, *CD* interrays in upper part of view at midline, $\times 2.9$.

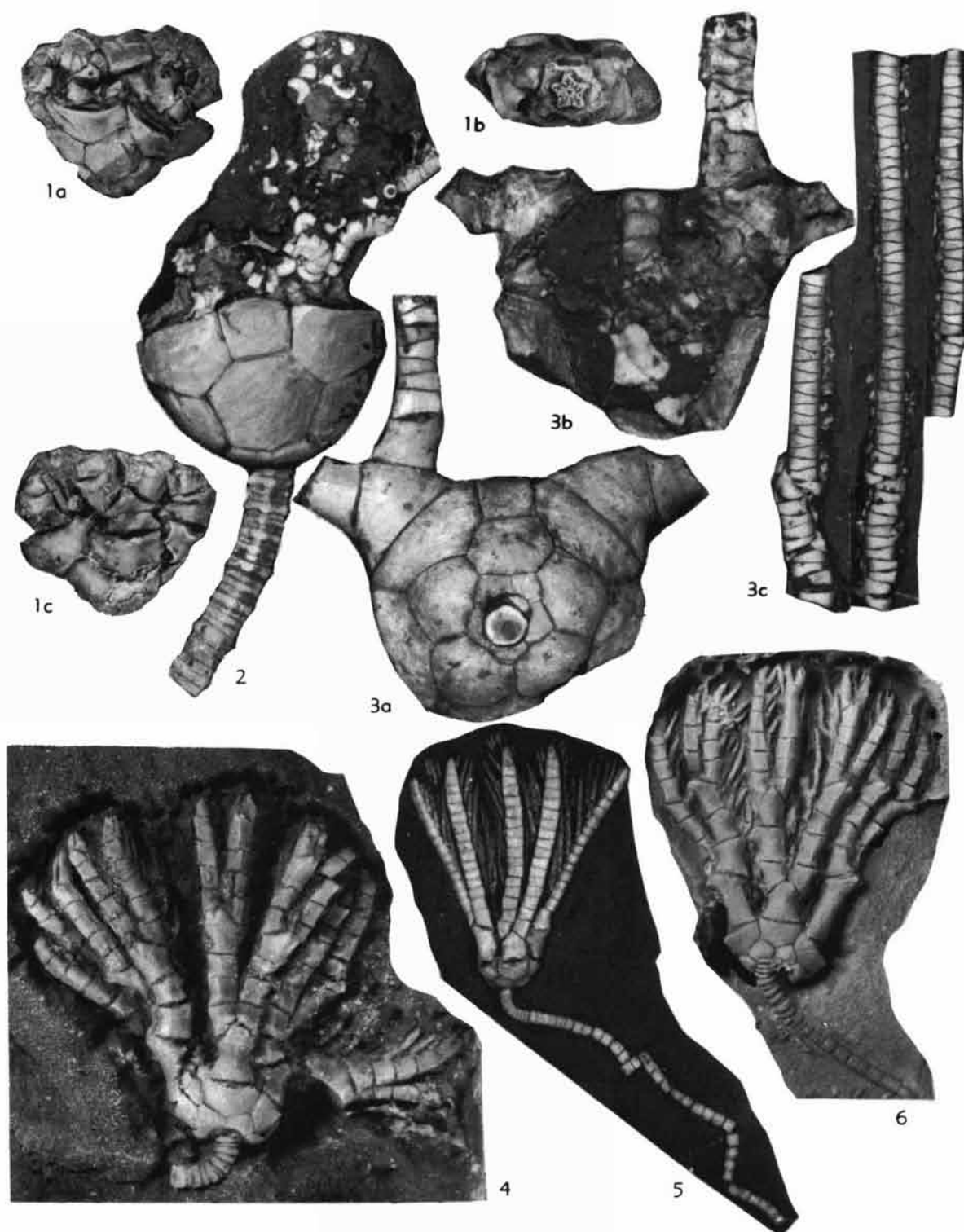


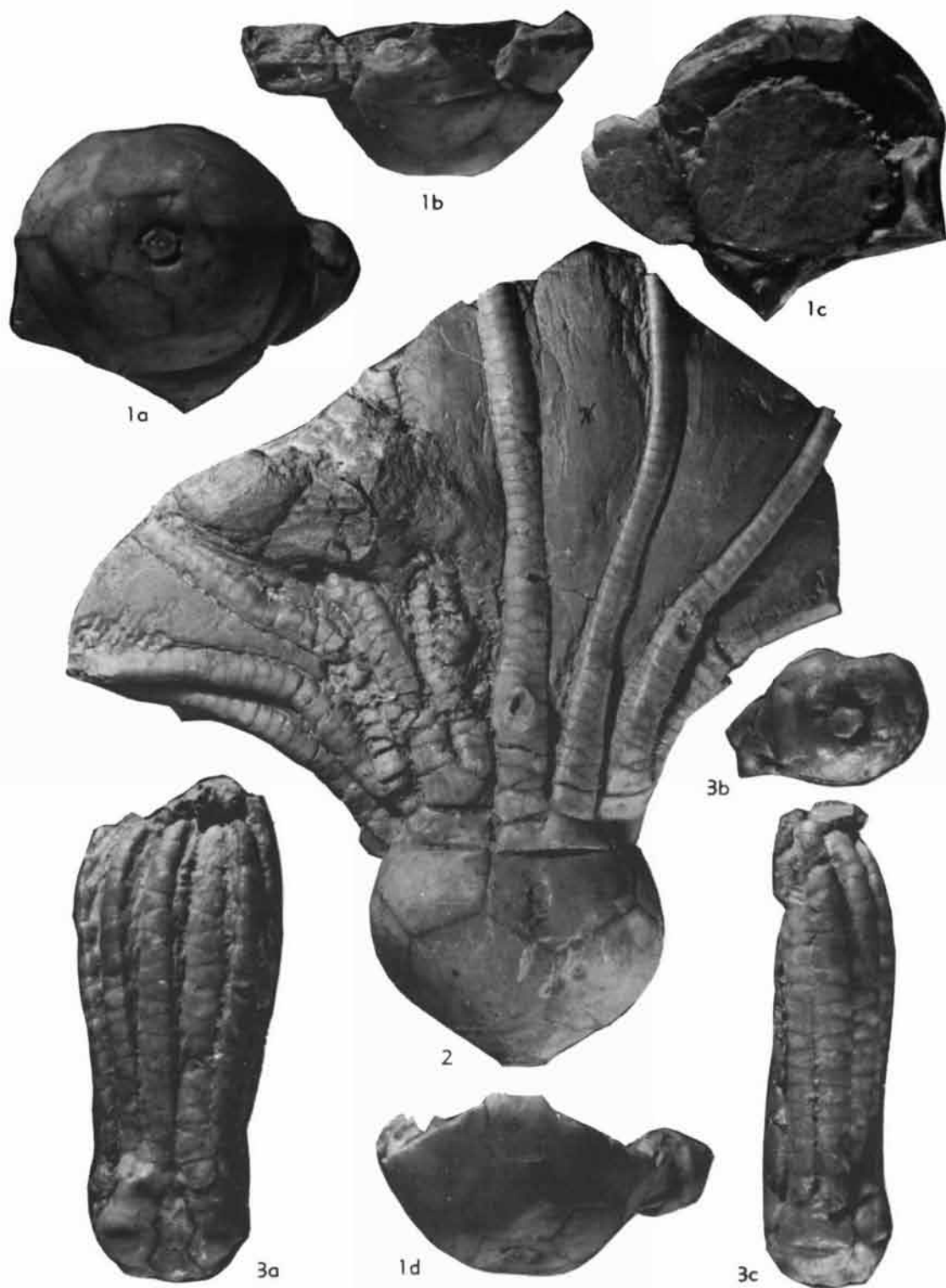




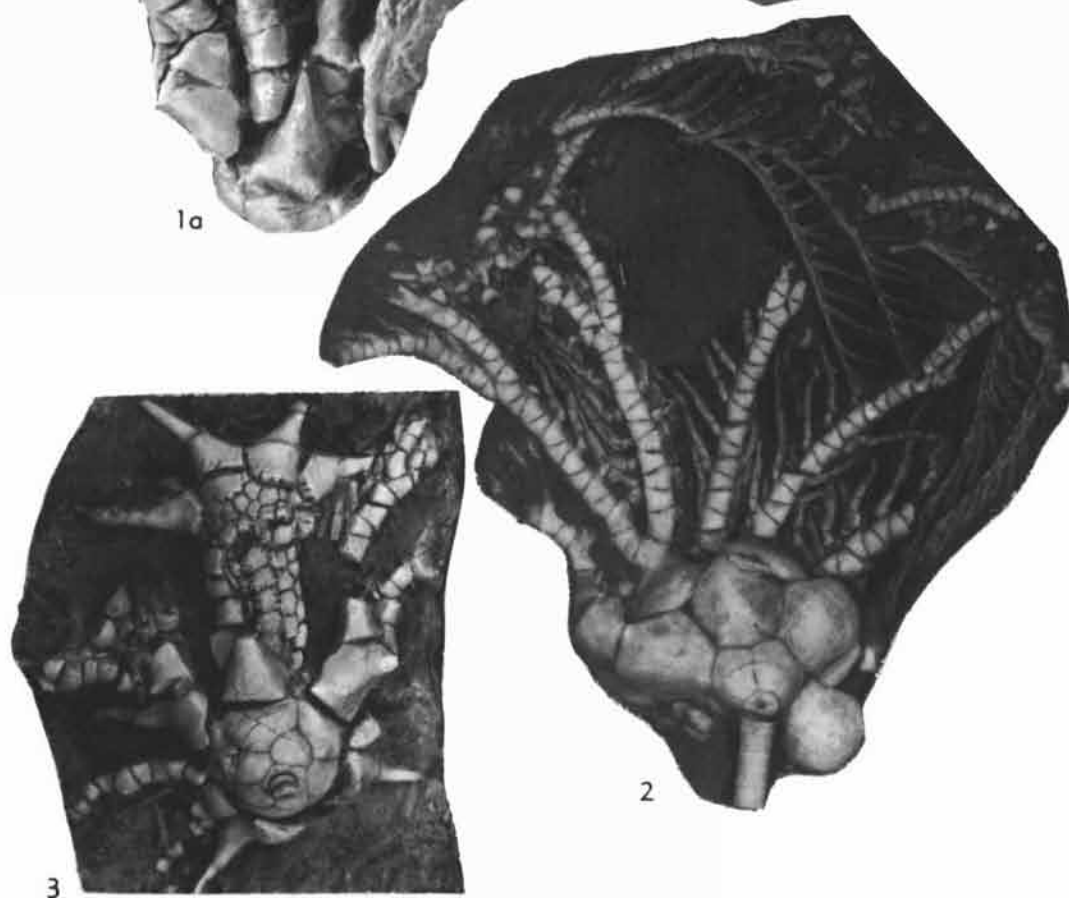
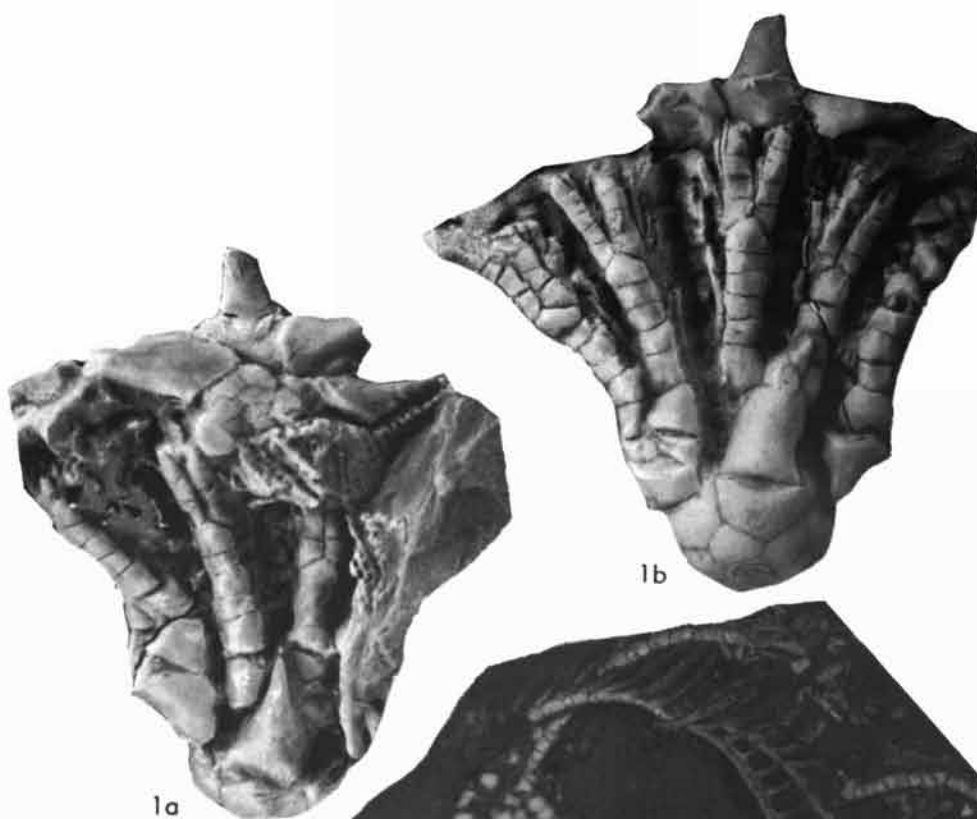




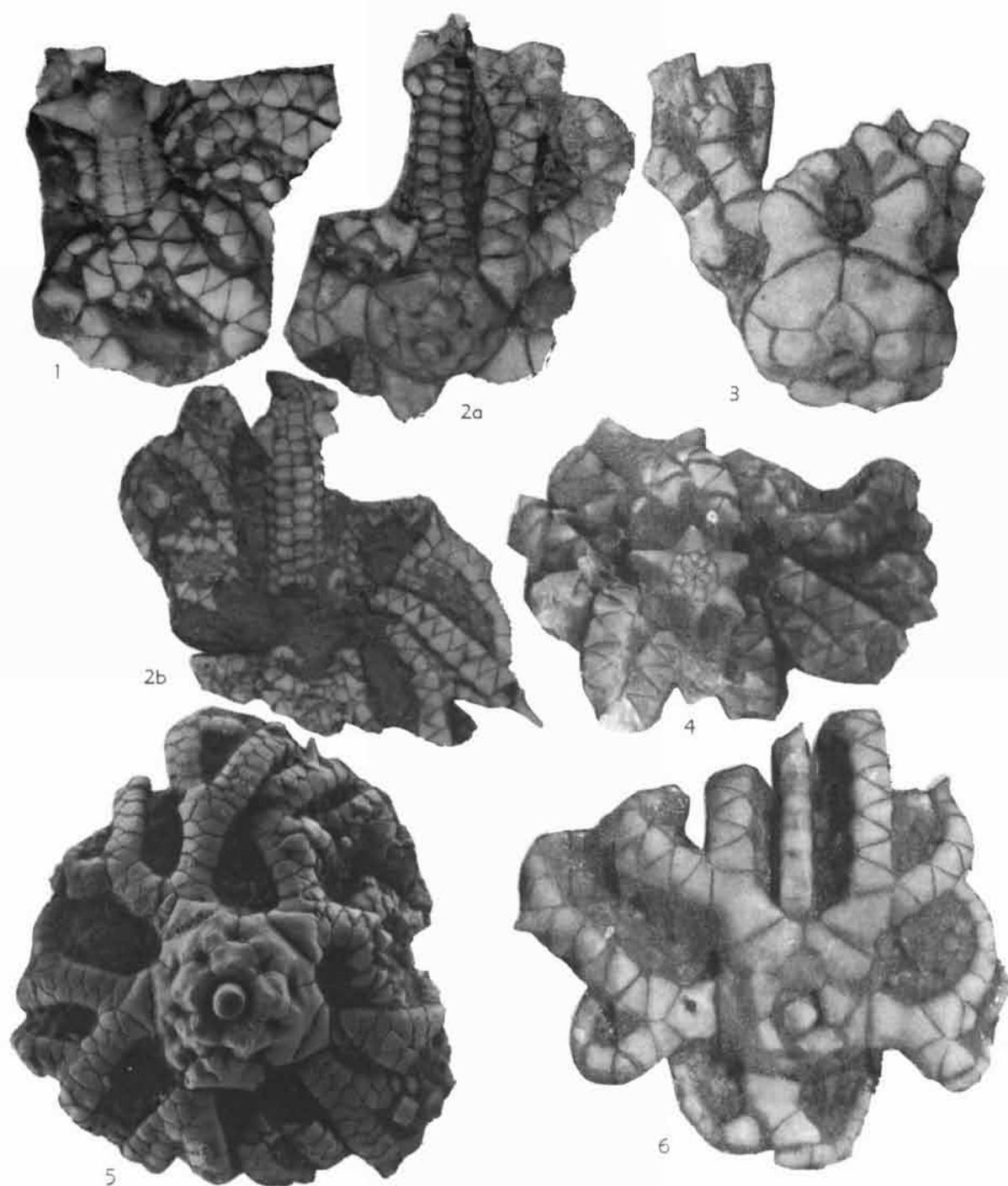










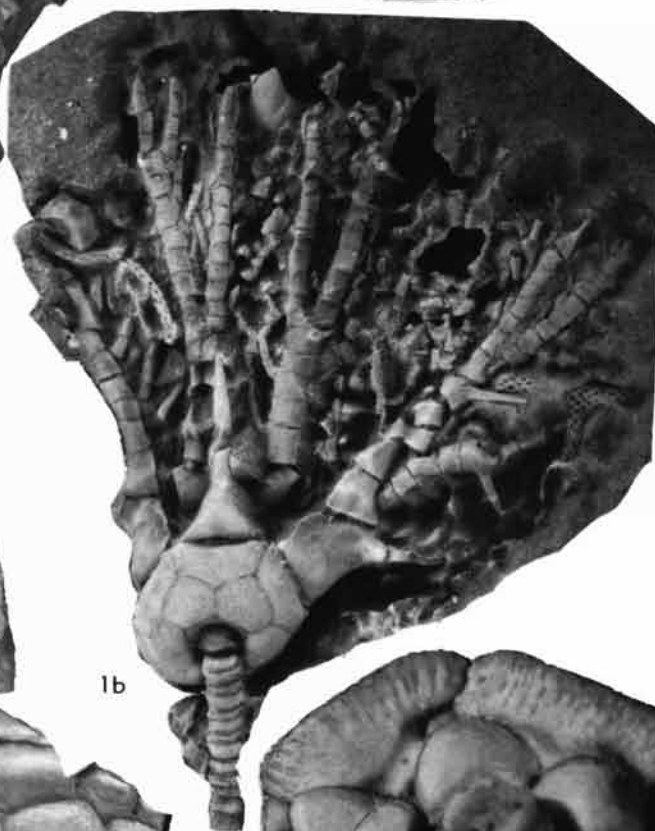




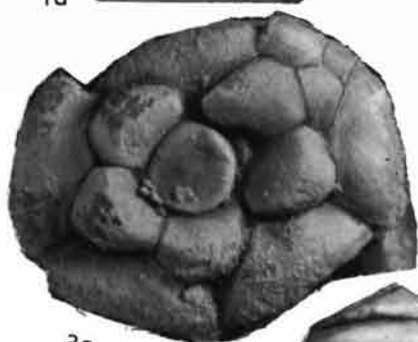
1a



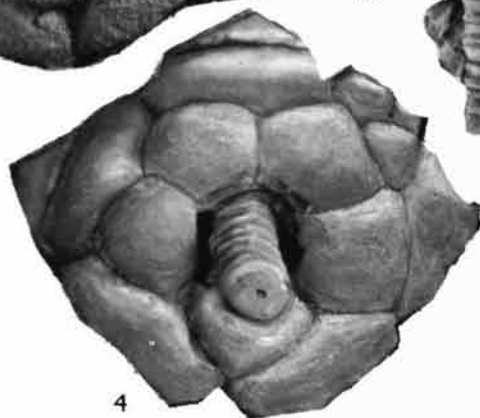
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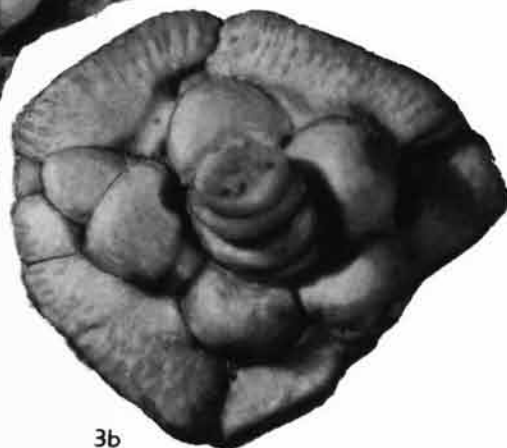
1b



3a



4



3b

