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LATE DESMOINESIAN CRINOID FAUNULE FROM OKLAHOMA

by

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FOREWORD

This report is a description of one of the more remarkable fossil discoveries. Crinoids of late Desmoinesian age are rather poorly known. The present faunule consists in large part of excellently preserved material which permits establishment of species and genera upon a firm basis, and which makes crinoids more useful in geologic work.

The deposit is a gravel and cobble lens at the top of the Holdenville formation. The crinoids were eroded from the Holdenville, perhaps before Seminole time, and were redeposited nearby. The possibilities are: (1) that the crinoid bed was eroded and the gravel deposited at the close of the Desmoinesian, and reworked by the Seminole sea; any cementation was removed during recent weathering, or (2) that the crinoid bed was weathered and material eroded and redeposited as Pleistocene terrace material.

Associated with the crinoidal nodular limestone is an iron-bearing slabby, slightly crinoidal limestone from which the following fossils were collected: *Neospirifer dunbari, Juresania nebrascensis, Linoproductus prattenianus, Derbyia* sp., *Aviculopecten* sp., *Wilkingia* sp., *Myalina* sp., an undetermined clam, and a nautiloid. Corals, identified by P. K. Sutherland, are two species of *Stereostylus* and one of *Michelinia.*

M. C. Oakes contributed the following information concerning the crinoid bed:

> Unit IPhd-ls is the only limestone that was mapped in the Holdenville shale of Okmulgee County. It was truncated by pre-Seminole erosion slightly south of the center of sec. 25, T. 15 N., R. 11 E., and was mapped from that point northward to NW¼ sec. 19, T. 15 N., R. 12 E. It was not found farther north and may very well have been removed by pre-Seminole erosion or at least so profoundly leached as to be unrecognizable now. It consists of two beds. The lower one is about 3 feet thick, dense, gray blue at the base and light chocolate brown at the top. The upper one is 3 to 5 inches thick, gray tan and fossiliferous. Both beds weather yellow.
>
> G. L. Luff (1957, M. S. thesis, The University of Oklahoma) found a remarkable deposit of reworked limestone nodules along the small stream which flows westward across NE¼ sec. 24, T. 15 N., R. 11 E., from which a great number of nearly perfect crinoid heads, as well as many other fossils, have been taken. The crinoids include many new genera and species. The nature of the material and its position, only slightly below the outcrop of unit IPhd-ls, as mapped, indicate that it is probably from that limestone. Indeed, in view of the uncertainty as to the exact position of the outcrop in this vicinity, the material may have merely settled slightly, due to leaching in the underlying shale. Pre-Seminole as well as Quaternary and recent weathering may have contributed to its present position and condition.
>
> Of this deposit and the limestone from which it probably came, Luff (in his thesis) said: "The upper zone of this unit proved to be extremely fossiliferous. Its outcrop in the creek in NE¼ of sec. 24, T. 15 N., R. 11 E., yields a variety of fossils. These include corals, Bryozoa, crinoids, brachiopods, pelecypods, and gastropods . . . Of special interest are the unusual number of excellent crinoid specimens collected. . . . From about 65 individual crowns or parts of crowns to date, 11 new species have been identified, which so far have not been named. Some of the specimens were so weathered as to reveal basal plates, calyx structure, and arms. Two showed tegmen structure. The collection was presented to the Oklahoma Geological Survey for classification and study."

— C. C. B.

LATE DESMOINESIAN CRINOID FAUNULE FROM OKLAHOMA

HARRELL L. STRIMPLE

ABSTRACT

A collection of 436 crinoid crowns found in a gravel lens at the top of the Holdenville formation consists entirely of inadunates. Twenty genera, of which 11 are new, 25 species, 21 new, and one new subspecies make up the faunule. The new genus *Zeusocrinus* is from the Pitkin. One new species from the Wann and one from the Wapanucka are described. The specimens are so well preserved that information on regeneration of arms, on anal sacks, on umbrella structures, and on parasites was obtained.

INTRODUCTION

About 420 crinoid crowns or partial crowns in poor or excellent preservation have been recovered and studied from the small creek exposure in the NE¼ section 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma. The exposure was originally discovered by Glen Luff, graduate student at The University of Oklahoma. Specimens were subsequently collected by Malcolm C. Oakes, Dr. Carl Branson, and others in the gravel bars of the stream bed. In 1959, the author was employed by the Oklahoma Geological Survey to locate and develop the source bed of the crinoids. By excavating the gravel bars it was possible to locate the richest area and the crinoids were found in the adjacent clay banks at this point. A small power shovel was brought in and the overburden of dirt was removed from a long, narrow strip parallel to the stream. About 150 crinoids were recovered from this excavation. Later in the early spring of 1960, another excavation was made with a bulldozer, at right angles to the original excavation following the direction the accumulation appeared to extend. Work in this exposure was started back from the stream in order to determine the extent of the accumulation. Crinoids were present but were relatively sparse and poorly preserved. Apparently the

greatest accumulation was to the west of the row of large boulders that made a crescentic line in a northwesterly direction. In July 1960, some amateur collectors trespassed on the excavation and stripped it of fossils. Unfortunately, no scientific use will be made of the material obtained by these individuals.

The crinoid accumulation was no doubt a terrace deposit. There are three zones above a dense limestone having an uneven, strongly weathered surface. The lowermost clay zone contained the best preserved material and was about 1 to 1.5 feet thick in its deepest part. A calcareous zone, that ranged in thickness from 0.25 to 1 inch, contained complete calyces of *Stellarocrinus petalosus* in places. The next clay zone above was about 1 to 1.5 feet thick and most specimens from this zone were badly weathered. There was some clay above this that was entirely devoid of fossils. In the first excavation, the entire crinoid zone pinched out to the north, a short distance from the main accumulation. The accumulation apparently covered an area about 20 feet long by 12 to 15 feet wide. Sandstone and limonitic rubble, from pea size to boulders, was deposited in the same zone with the fossiliferous nodules and small slabs of limestone. The crinoids were mainly preserved as nodules but many were found on the limestone slabs. The zone is about 10 feet below the top of Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian.

One crown of *Paianocrinus aptus* Strimple from the Chesterian is figured to show the terminating spinose roof of the anal sac. A crown of *Stenopecrinus planus* (Strimple) is figured for the same reason. This is a Missourian form. Two magnificent crowns from the Morrowan are figured because of their close relationship with some forms under study. One is described as *Anobasicrinus obscurus* new species, the other as *Stenopecrinus rugosus* new species.

TABULATION OF HOLDENVILLE CRINOIDS BY GENERA

The specimens recovered from the Holdenville crinoid locality represent 21 genera with 25 species (*Plaxocrinus* is represented by five species) and one subspecies (*Graffhamicrinus*).

Genus	*Number of specimens*
Schedexocrinus	38
Metaperimestocrinus	17
Plaxocrinus	91
Pirasocrinus	3
Polygonocrinus	4
Metacromyocrinus	12
Ulocrinus	2
Parethelocrinus	96
Aglaocrinus	3
Ataxiacrinus	7
Texacrinus	32
Haeretocrinus	1
Schistocrinus	1
Polusocrinus	1
Allosocrinus	16
Oklahomacrinus	2
Stellarocrinus	45
Anobasicrinus	17
Graffhamicrinus	38
Corythocrinus	3
Elibatocrinus	3
	436

SYMBOLS FOR CRINOID PARTS

I have for the most part avoided the use of symbols for crinoid parts except for plates of the posterior interradius in the calyces and in designation of brachials of the arms. Where used, the symbols are those proposed by Moore and Laudon (1941, p. 421).

VARIABILITY OF ANAL PLATES IN THE POSTERIOR INTERRADIUS

Strimple (1960) has given a rather comprehensive study of the modification and trends that are exhibited by various inadunate

crinoids of the Carboniferous. In the present paper the terms proposed in that paper are used to save endless repetition.

Surprisingly few specimens exhibit variable tendencies in the number of plates within the posterior interradius and/or their arrangement.

The most variable species is *Ataxiacrinus multiramus* new species, which normally has three anal plates within the calyx proper in normal arrangement (Primitive Type). In this arrangement the X rests solidly on the posterior basal (albeit the junction is at an oblique angle in this genus). It is adjoined to the left by the left posterior radial, to the left above by the left posterior first primibrach, to the right below by RA, and to the right above by RX. There is normally one plate above X, which is X_2, when conditions are favorable for its retention. RA is a quadrangular plate resting obliquely on the posterior basal to the left, and right posterior basal to the right below, adjoining right posterior radial to the right above and X to the left above, and supporting RX directly above. RX is directly above RA and is bordered by X to the left and by the right posterior radial and the first primibrach of the right posterior arm to the right. It supports RX_2 directly above and borders X_2 to the left above in specimens having those upper plates. Only the lower extremity of RX is within the cup limits. In paratype OU 4007, RA has lost contact with the right posterior basal and is in fact 1.8 millimeters above it. RX is missing but the outline shows it to be a small, rudimentary element, almost entirely out of the cup and cut off from the upper section of the posterior interradius by an overlap of the distal tip of the left shoulder of the right posterior first primibrach. It would have a pentagonal outline. Anal X has become large although the proximal edge is narrow owing to the encroachment of the RA. It extends well above the summit of the cup. This specimen most closely approaches Special Type D, except for the existence of the rudimentary RX. Paratype OU 4005 is somewhat like Extreme Type (1), wherein RA has moved to the dominant posterior position, with X and RX above. It differs in two respects: RX extends well above the summit of X, and there is an extra plate between RA and the right posterior basal, which is in the nature of an inferradianal or inferradial. The specimen is decidedly abnormal because another extra or super-

numerary plate is present under the left posterior radial. Further consideration of the specimen will be found in the section dealing with aberrant specimens. Paratype OU 4050 has modifications termed Special Type. This is where X establishes contact with right posterior radial and is thus interposed between RA and RX. RX is pentagonal and still has an appreciable portion of its pointed proximal end within the cup. In these specimens well-developed X_2 and RX_2 are preserved in the distal portion of the posterior interradius, well above the summit of the cup. A small specimen, OU 4019, has the RA in dominant posterior position. It has migrated away from contact with right posterior basal, by 1.4 millimeters, and has a suture in common with the left posterior radial by about the same distance. This specimen is also aberrant in possessing an extra plate. It is further discussed in the section covering aberrant specimens.

In a large paratype of *Schedexocrinus gibberellus* new species, OU 4021, the radianal has established contact with the left posterior radial, with the resultant suture having a length of 3.3 millimeters. In this specimen the RX is pushed entirely out of the cup but has lost none of its size. RA is an exceedingly large plate.

One paratype of *Pirasocrinus depressus* new species, OU 4048, has advanced to Normal Type A, wherein RA has moved from contact with the right posterior basal by about 3.2 millimeters.

Two paratypes of *Metaperimestocrinus spiniferus* new species, OU 4052 and 4064, have advanced to Normal Type A, wherein RA has lost contact with the right posterior basal.

Of 34 specimens of *Plaxocrinus normalis* new species, four specimens have advanced to Normal Type A. These are paratypes OU 4067, 4074, 4076, and 4087.

In *Parethelocrinus ellipticus* new species, there are typically two anal plates, X and RA, with X resting on the distal face of the posterior basal (Special Type C). The small paratype, OU 4141, exhibits the modification wherein RA is in dominant posterior position, separating X from posterior basal (Special Type D-1). However, RA has not lost contact with the right posterior basal, which is a slightly less advanced condition than typical of this type of arrangement.

ABERRANT SPECIMENS

Little attention has been given to abnormalities among Pennsylvanian crinoids. Strimple (1957) described two aberrant specimens, one a *Phanocrinus* from the Chesterian (Mississippian) and the other a *Laudonocrinus* from the Missourian. A camera lucida drawing was given of the specimen of *Laudonocrinus* (1957, figs. 1a-b). Each specimen has two elements not found in the dorsal cups of Late Paleozoic crinoids, a left posterior inferradial (LPiR) and a super anal (sX). The latter may now be referred to as X_2 in conformance with present usage. In addition, the specimen of *Laudonocrinus* has an inferradianal (iRA).

Another abnormal specimen of Morrowan age is known from the literature, *Morrowcrinus fosteri* Moore and Plummer (1938), the genotype and only known species of the genus. This specimen has a large extra plate between and below right posterior and right anterior radials. Moore and Plummer designated the plate as RPB′. Under current usage this would be called an inferradial (RPiR).

A paratype, OU 4005, of *Ataxiacrinus multiramus* new species, has two extra plates within the dorsal cup. One of the plates is a well-developed, quadrangular element, obliquely placed in the same plane with the RA. This places the plate in a position below the right posterior radial, so that it could be termed an inferradial (RPiR), or it may be called an inferradianal (iRA). It is unlike iRA of the previously discussed *Laudonocrinus,* in which the plate was below the RA and not in contact with right posterior radial. It is more like the RPiR of *Morrowcrinus fosteri,* but does not extend upward to contact the right anterior radial as in that species. The other plate is a rather large, triangular element, placed below the left posterior radial. The plate does not reach the infrabasal circlet below. It is obviously an inferradial (LPiR). The extra plates do not disturb the surface contour of the cup. A small specimen that has not been taken as a paratype, OU 4019, has an extra plate between the right posterior and right anterior radials, resting on the upper truncated face of the right posterior basal. This plate reaches the summit of the cup but does not extend above the summit. The facet is embedded in hard matrix and it is not known whether it was articulated for a primibrach or not. The plate is

longer than wide and has a quadrangular outline. It is like an anal plate, but the specimen has a normal anal series in posterior position. For reference it might be termed an interradial plate.

Another case of an interradial plate is found in paratype OU 4121 of *Stellarocrinus petalosus* new species. In this case the plate is a fully developed anal plate, almost indistinguishable from the regular anal plate. In the genus *Stellarocrinus,* a single anal plate is in dominant posterior position on the truncated distal end of the posterior basal. There are two plates above of equal size, a condition which is termed Extreme Type (2). The dominant plate is considered to be the radianal (RA). The supernumerary plate is in the left posterior radius. Left posterior basal is slightly elongate but is truncated just as is the posterior basal. The supernumerary is pentagonal with provision for the reception of two plates above. The plate is slightly narrower than the RA and its upper facets have the appearance of anal tube plates. The entire dorsal cup is elliptical with the long axis left posterior to the right anterior-anterior interradius. An allustration appears as plate 15, figure 4.

A specimen of *Plaxocrinus normalis?* new species, OU 4075, of which little is exposed other than the terminating spinose roof of the anal sac, had one spine that is doubly terminated. Since all other spines have single terminations this must be considered as aberrant; however, several interesting factors are involved. The bases of all the spines appear to be thinner and broader than normal for the species, or genus, and would therefore be able to produce more than one spine rather easily. I suspect that doubly terminated plates such as this will usually be found to be wider and thinner than normal. Some of the other plates in the present specimen have raised areas and incipient bulges that could easily have become extra spines. This specimen is illustrated as plate 19, figure 1.

REGENERATION OF CRINOID PARTS

The parts of the exoskeleton that appear to be most often broken are the tips of the spinose plates of the arms and the distal terminating plates of the anal sacs of such forms as *Schedexocrinus, Plaxocrinus,* and comparable forms. Several cases have been observed wherein a new spine has regenerated. The new spine is consistently smaller and shorter than the original spine. Such regeneration has been noted in *Delocrinus* (Hattin, 1958).

The most striking example of regeneration is afforded by a paratype, OU 4060, of *Polygonocrinus multiextensus* new species. In this specimen there is a fully developed second terminating roof or platform of the anal sac. The new platform does not quite cover the older, and the spines are not so large or well developed. The only possible explanation that I am able to advance is that through some accident, or attack, the main axial cords of the sensomotor system serving the area were severed and the regenerative process of the animal reproduced the entire structure.

In paratype OU 4128 of *Metacromyocrinus holdenvillensis* new species, the upper part of the arms of the specimen have been lost and newly regenerated arms are in place. At the time of demise the regenerated portions were about half the width of the older portions. This is illustrated in text-figure 18.

EVIDENCE OF COMPATIBILITY

Several forms appear to have lived in close proximity as evidenced by their preservation. It has been noted in studies of recent crinoids that they are gregarious animals.

The ethelocrinids have been observed in close proximity in several instances, and *Texacrinus* has been found in the same nodules or slabs. *Allosocrinus* appears to have liked the company of its own kind. As many as three specimens have been found on the same slab. They are usually preserved in a zone containing numerous brachiopods. One specimen is on a slab which also contains a crown of *Plaxocrinus*. As many as three *Stellarocrinus* crowns have been found in a single small nodule, and several instances of two specimens in the same nodule have been noted. One specimen of *Elibatocrinus* is on a nodule also containing a crown of *Graffhamicrinus*. It seems likely that the delicate *Elibatocrinus* would seek shelter through close proximity with a more rugged form. A crown of *Plaxocrinus normalis* is on the same slab with a relatively huge *Schedexocrinus gibberellus* crown. The holotype and one paratype of *Pirasocrinus depressus* is on the same slab with a poorly preserved crown of *Stellarocrinus petalosus*. A crown of *Plaxocrinus normalis* is on the same slab as a crown of *Parethelocrinus ellipticus*. One large nodule has two crowns of *Parethelo-*

crinus ellipticus and one crown of *Texacrinus coniformis* lying in parallel position as though affected by a current. A nodule containing three crowns of *Stellarocrinus petalosus* also has a crown of *Parethelocrinus ellipticus*. *Anobasicrinus bulbosus* has been found associated with a crown of *Plaxocrinus normalis* in one nodule and with *Texacrinus coniformis* in another slab. *Graffhamicrinus acutus* has been found in one nodule associated with *Parethelocrinus ellipticus*. The cup and primibrachs of a specimen of *Plaxocrinus normalis*, the terminating roof of another *P. normalis* and the stem and base of *Stellarocrinus petalosus* are exposed in one slab.

No conclusions can be drawn from such evidence because the specimens could have fallen from different heights to repose in the same area after death. I rather expect that each species has a tendency to group even as crinoids do in the ocean today.

ASSOCIATED PARASITIC LIFE

Considering the large amount of material available, there is a surprisingly small amount of evidence of parasitic attachment or attack on the crinoids from the Holdenville formation. In many crinoids of Missourian age, with which I am more familiar, there are borings made by sponges and the distinctive round boring, or pit, such as that figured by Moore and Plummer (1940, p. 290-291, pl. 18, fig. 3) and attributed by them to gastropods. Gastropods are known to be associated with many Paleozoic crinoids, and are often found attached to the anal vent. This is a passive relationship with the gastropod living on the refuse of the crinoid. Two instances have been observed in which the remains of a gastropod are present in association with the upper portion of the crowns. There has been no evidence of sponge attack or of the circular pits on any of the Holdenville specimens observed.

The arms of several specimens of *Schedexocrinus gibberellus* and of one specimen of *Plaxocrinus normalis* (the holotype) have cyst-like swellings. The appearance of these modifications to the arms is so similar to that found in some recent crinoids that one must conclude the same type of parasite is involved. Specific reference is made to the illustration given by Carpenter (1884, pl. 27, figs. 9, 10) of the swellings caused by *Myzostoma pentacrini* von

Graff in the arm of a specimen of *Pentacrinus alternicirrus* Carpenter. It is of interest to note that *Myzostoma* is known only in association with crinoids. Judging strictly from appearances, I would say that the form attached to the holotype of *Plaxocrinus normalis* and to paratype OU 757 of *Schedexocrinus gibberellus* was slightly different from the form attached to most specimens of *Schedexocrinus gibberellus*. In the *Plaxocrinus* specimen, definite slit-like openings are evident, but in *Schedexocrinus* the openings are not so well defined and the swellings are rotund, or knob-like. The specimen figured on plate 19, figure 6, indicates that attachment was made during early stages of development because the arms are considerably reduced in size above the area of attack.

SYSTEMATIC PALEONTOLOGY

Order INADUNATA Wachsmuth and Springer
Suborder DENDROCRINOIDEA Bather

Family PIRASOCRINIDAE Moore and Laudon, 1943

DIAGNOSIS.—(After Moore and Laudon, 1944), dicyclic; crown compact; cup low; base flat or concave; IBB five, not visible from side; R facets wide and moderately long, sloping gently outward, having distinct tranverse ridge, muscle- and ligament-areas; three XX in cup; sac prominent, mushroom-shaped; arms uniserial, branching twice or more isotomously.

RANGE—Mississippian, Pennsylvanian.

GENERA —

	Age	*Remarks*
Adinocrinus Kirk, 1938	Mississippian	Adinocrinidae, new family
Perimestocrinus Moore & Plummer, 1938	Pennsylvanian	Emended
Plaxocrinus Moore & Plummer, 1938	Pennsylvanian	Emended
Sciadiocrinus Moore & Plummer, 1938	Pennsylvanian	
Utharocrinus Moore & Plummer, 1938	Pennsylvanian	Restricted
Aatocrinus Moore & Plummer, 1940	Pennsylvanian	
Athlocrinus Moore & Plummer, 1940	Pennsylvanian	
Galateacrinus Moore, 1940	Pennsylvanian	Questionable assignment
Lasanocrinus Moore & Plummer, 1940	Pennsylvanian	
Laudonocrinus Moore & Plummer, 1940	Pennsylvanian	
Pirasocrinus Moore & Plummer, 1940	Pennsylvanian	
Schistocrinus Moore & Plummer, 1940	Pennsylvanian	Texacrinidae, new family
Metaperimestocrinus, n. gen.	Pennsylvanian	
Zeusocrinus, n. gen.	Mississippian	

Paianocrinus Strimple, 1951	Mississippian
Stenopecrinus, n. gen.	Pennsylvanian
Schedexocrinus, n. gen.	Pennsylvanian
Polygonocrinus, n. gen.	Pennsylvanian

The genus *Utharocrinus* was established on the basis of a unique, irregular, small crinoid cup from the Morrowan of Oklahoma, *Delocrinus pentanodus* Mather. There was only the one specimen, which is the holotype. Moore and Plummer (1938, text-fig. 31) give excellent line drawings of the specimen. It has a broad, flattened basal area, that is above the basal plane formed by the downward directed projections of the basals. Those authors (1938, p. 287, 288) refer to undescribed species from higher Pennsylvanian horizons which reportedly have arrangements of plates comparable to those of the genotype species (i. e., with RA in direct posterior position, supporting X and RX to the right and left above). It is presumed that these are the species described by Moore (1938) as *Utharocrinus oreadensis* Moore from the Oread formation, Shawnee group, Virgilian, at Lecompton, Kansas, and *U. quinquacutus* Moore from the Brownville formation, Wabaunsee group, Virgilian, 5 miles west of Strohm, Osage County, Oklahoma. The latter has a small triangular RA that lies on the posterior basal but the anal X has not migrated upward for any appreciable distance. It is apparent that RA is in the process of being resorbed in this species. *Utharocrinus oreadensis* does have an arrangement of anal plates similar to that of *U. pentanodus* but there are significant differences. The dorsal cup of *U. oreadensis* is higher, the base is not a broad, flattened area, the articular facets are directed strongly outward, and the projections of the BB are not spine-like to the degree found in *U. pentanodus*. The similarity of *U. oreadensis* to *U. pentanodus* is superficial rather than real.

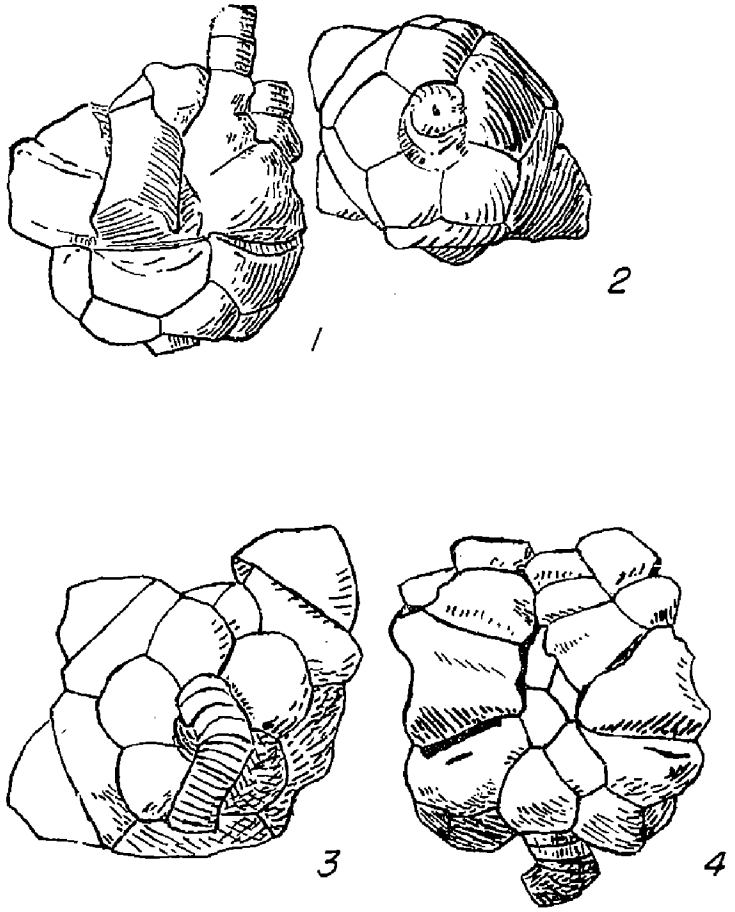
On the basis of Moore and Plummer's interpretation (1938, p. 287, 288) of the potential range and variation in the arrangement of anal plates, I described a species as *U. granulosus* Strimple (1939) from the Wann formation, Ochelata group, Missourian, near Bartlesville, Oklahoma. The arrangement of the anal plates of this species is variable, in most cases being a normal arrangement (Primitive Type), but in some specimens being an advanced arrangement wherein RA has migrated to direct posterior position and supports anal X above. Moore (1939) described one species, *U.*

topekensis, from the Coal Creek member, Topeka formation, Shawnee group, Virgilian, 8 miles north of Iskaloosa, Jefferson County, Kansas, that has a normal arrangement of anal plates (Primitive Type).

In "Index Fossils of North America" (Shimer and Shrock, 1944, p 137-209) Moore and Laudon list both *U. pentanodus* and *U. quinquacutus* under *Utharocrinus,* although in the meanwhile a genus *Triceracrinus* Bramlette (1943) was proposed and is most certainly closely related to those species. According to Bramlette (1943, p 552), Moore gave advice and criticism relative to the description of the genus. In the introduction by Bramlette (1943, p. 550), the occurrence of primibrachial and radial plates assignable to *Triceracrinus* extends to the Brownville limestone of northern Oklahoma and southern Kansas. The genotype species, *T. moorei* Bramlette (1943) is from the upper Cisco group, Wolfcampian, Lower Permian. The species has a normal arrangement of anal plates (Primitive Type). The primibrachs are somewhat lower than those of *Utharocrinus granulosus* but are of the same general structure.

In 1950, I referred *Triceracrinus* into synonomy with *Utharocrinus.* At that time, I expressed dissatisfaction with the status of *Utharocrinus* but considered that, if such forms as *U. quinquacutus, U. topekensis,* and *U. oreadensis* are bona fide representatives of the genus, then *Triceracrinus* must also belong.

It is now apparent that we are dealing with a group that could not have evolved from *Utharocrinus pentanodus,* which species is more advanced than any of the younger species. Regressive evolution in the shape of the dorsal cup is known in several phyletic lines, but not in the arrangement of the anal plates. An applicable genus has already been established, although its relationship has escaped my attention for many years and will require considerable change in some generic determinations. Sketches of *Perimestocrinus noduliferus* (the genotype) and of *Triceracrinus moorei* are given here (text-figs. 1-4) for ready observation and comparison. Although *T. moorei* is a highly nodose form in the calyx as well as in the arms, the similarity of $PBrBr_1$ and general contours of the calyces are readily apparent. It is also noted that both forms develop nodes on the non-axillary as well as the axillary brachials.



TEXT-FIGURES 1-4. The genotypes of *Perimestocrinus* and *Triceracrinus*.

(1, 2), *Perimestocrinus noduliferus* (Miller & Gurley); drawings of the holotype after Moore & Plummer (1938); 1, anterior view of the crown; 2, basal view.

(3, 4), *Perimestocrinus (Triceracrinus) moorei* (Bramlette); drawings of the holotype; 3, basal view of the crown; 4, posterior view.

It is proposed that *Utharocrinus* be restricted to characteristics of *Delocrinus pentanodus* Mather, the genotype. At this time the only described species known is the genotype species. It is further proposed that *Perimestocrinus* be restricted to characteristics of *Hydreionocrinus noduliferus* Miller and Gurley, the genotype, and that species younger than Morrowan, previously referred to *Utharocrinus* or *Triceracrinus,* be assigned to *Perimestocrinus.* Forms that have been assigned to *Perimestocrinus* will remain under the genus unless they are known to have spinose protrusions of the axillary brachials. This restriction will require the removal from the genus of all species for which the arms are known. *Stenopecrinus* Strimple, new

genus, is proposed for the reception of those species, with *Perimestocrinus planus* Strimple as the genotype.

The shallow nature of the dorsal cup of the Mississippian genus *Adinocrinus,* and the advanced arrangement of the cup plates (BB very small and separated by the proximal portions of RR) are characters more advanced than those of most of the Pennsylvanian genera. The genus is assigned to ADINOCRINIDAE Strimple, new family. For potential ancestral genera, I have included *Paianocrinus* and *Zeusocrinus* Strimple, new genus, under the PIRASOCRINIDAE.

Most species previously referred to *Schistocrinus* are assigned herein to *Sciadiocrinus* and the species *Malaiocrinus azygous* Strimple is assigned to *Schistocrinus.* On the basis of characters of *S. azygous,* the genus *Schistocrinus* is placed under the TEXACRINIDAE, new family.

Genus *Zeusocrinus* Strimple, new genus

GENOTYPE.—*Tholocrinus foveatus* Strimple, 1951.

The dorsal cup is low, bowl-shaped with narrow basal concavity. IBB obscured by proximal columnals, entirely within basal concavity. Five BB curve sharply out of basal concavity and are readily visible in side view of cup. Five RR wide, pentagonal, proximal edges do not enter basal concavity. Three anal plates (X, RA, and RX) in normal arrangement (Primitive Type). The arms are uniserial, axillary BrBr are spinose, first bifurcation is with PBr_1 and again with about SBr_7 (isotomous) and one other bifurcation is known is some rays. Anal sac is mushroom-like. The terminating platform has a circlet of horizontally directed, flat, spinose plates surrounding smaller plates. Column round with alternatingly expanded columnals.

RANGE.—Pitkin formation, Chesterian, Mississippian; Oklahoma.

REMARKS.—This genus is proposed to provide a clear phyletic line leading out of the Mississippian to Pennsylvanian genera like *Stenopecrinus. Tholocrinus* has biserial arms and accepted concepts will not allow for evolution to progress from biserial to uniserial arms, even in regressive trends.

The only species known at this time is *Zeusocrinus foveatus* (Strimple), new combination.

Genus *Paianocrinus* Strimple, 1951

GENOTYPE.—*Paianocrinus durus* Strimple, 1951.

RANGE.—Chesterian; Oklahoma.

Paianocrinus aptus Strimple, 1951

Plate 3, figures 4, 5; text-figure 6

A beautifully preserved metatype, collected by Mr. Allen Graffham of Ardmore, Oklahoma, affords considerable additional information concerning the species. The arms are complete to their terminations in several rays and the spinose termination of the umbrella-like anal sac is preserved. The species is included in this study because of its close relationship to various Pennsylvanian genera, such as *Stenopecrinus* and *Metaperimestocrinus*.

The umbrella or platform at the distal termination of the anal sac is composed of 6 spine-like plates that are directed outwardly. The bases of the plates are primarily oval although the upper sides are flattened, and when viewed from above the lateral sides reflect no curvature. A triangular area in the center is weathered away but a restoration is possible and is illustrated as text-figure 6. The largest, and primary, spine is located in the right posterior-anterior interray. It is in contact with all of the other spines. The spine in posterior position and the one in the right anterior are shorter in the basal portions and do not reach the central apex of the platform.

The arms are uniserial, endotomous and have well-rounded exteriors. The upper mid-portion of the axillary first primibrach is protruded as a blunt, node-like spine, as was found in the original type specimens. The second branching takes place with the sixth SBr in all rays except the right arm of the left posterior, which has bifurcation with SBr_8. The inner rays remain unbranched above this point. The third bifurcation takes place with TBr_8 to TBr_{10} in outer rays only. There are as many as seven QBrBr to the terminations of the arms. The pinnules are strong, and in the uppermost portions of the arms are almost as large as the brachials.

The crown is almost 21 millimeters long and 14.5 millimeters wide. The dorsal cup is 13.5 millimeters wide by 3.5 millimeters high.

METATYPE.—Deposited in the paleontological collections of The University of Oklahoma, number OU 4168.

OCCURRENCE.—Pitkin limestone formation, Chesterian, Mississippian; SE¼ sec. 27, T. 13 N., R. 20 E., Muskogee County, Oklahoma.

Genus *Perimestocrinus* Moore and Plummer, 1938

SYNONYMY. — *Peremistocrinus* Strimple, 1948, *Triceracrinus* Bramlette, 1943.

GENOTYPE.—*Hydreionocrinus noduliferus* Miller and Gurley, 1894.

As outlined under the discussion of the family PIRASOCRINIDAE, the genus *Perimestocrinus* is restricted to characters of the genotype species. This eliminates all previously described species for which the arms are known, other than the genotype. Forms which have previously been referred to *Utharocrinus* (other than the genotype) or to *Triceracrinus* are referred to *Perimestocrinus*. It is quite likely that subsequent studies will provide for a separate group covering most of the forms previously ascribed to *Utharocrinus,* and in that event *Triceracrinus* may well be reactivated for the group. Many forms previously assigned to *Perimestocrinus* will be found to belong under *Stenopecrinus* if, and when, specimens with the arms attached are found.

The genus is well described by Moore and Plummer (1938) and a review is not considered necessary. Those authors have never accepted a species under *Perimestocrinus* where spinose BrBr are known.

Species assigned to *Perimestocrinus*:

	Occurrence	*Remarks*
Hydreionocrinus noduliferus Miller & Gurley	Missourian; Mo.	Genotype, *Perimestocrinus*
Hydreionocrinus nodulifer Moore & Plummer	Missourian; Mo.	Syn. *H. noduliferus*
Hydreionocrinus granuliferus Miller & Gurley	Missourian; Mo.	*Perimestocrinus*
Hydreionocrinus granulifer Moore & Plummer	Missourian; Mo.	Syn. *H. granuliferus*
Eupachycrinus parvus Miller & Gurley	Missourian; Mo.	*Perimestocrinus*
Perimestocrinus pumilis Moore & Plummer	Morrowan; Okla.	*Perimestocrinus*
P. teneris Moore & Plummer	Morrowan; Ark. & Okla.	*Perimestocrinus*
P. subtilis Moore	Virgilian; Okla.	*Perimestocrinus*
Plaxocrinus politus Moore	Missourian; Okla.	*Stenopecrinus*
Perimestocrinus calyculus Moore & Plummer	Desmoinesian; Texas	*Perimestocrinus*

Delocrinus excavatus Weller	Wolfcampian; Texas	*Perimestocrinus*
Perimestocrinus formosus Moore & Plummer	Missourian; Texas & Okla	*Perimestocrinus*
P. impressus Moore & Plummer	Missourian; Texas & Okla	*Perimestocrinus*
P. moseleyi Strimple	Missourian; Texas	*Stenopecrinus*
P. hexagonus Strimple	Missourian; Okla.	*Stenopecrinus*
P. planus Strimple	Missourian; Okla.	*Stenopecrinus* (genotype)
Utharocrinus oreadensis Moore	Virgilian; Kans.	*Perimestocrinus*
U. quinquacutus Moore	Virgilian; Okla.	*Perimestocrinus*
U. topekensis Moore	Virgilian; Kans.	*Perimestocrinus*
U. granulosus Strimple	Missourian; Okla.	*Perimestocrinus*
U. facilis Strimple	Virgilian; Kans.	*Perimestocrinus*
U. habitus Strimple	Missourian; Okla.	*Perimestocrinus*
U. fabulosus Strimple	Missourian; Kans.	*Perimestocrinus*
U. spinosus Strimple	Missourian; Okla.	*Perimestocrinus*
Triceracrinus moorei Bramlette	Wolfcampian; Tex.	*Perimestocrinus*

KNOWN RANGE.—Morrowan (Pennsylvanian) to Lower Permian; North America.

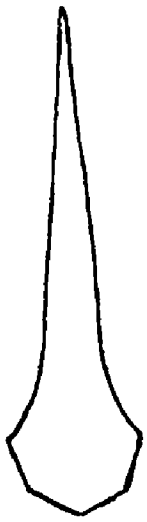
TEXT-FIGURES 5-8. Drawings of plates and spinose terminations of various crinoid species that possess a mushroom-like anal sac. Enlargements are x2 unless specified otherwise.

(5), *Stenopecrinus planus* (Strimple): a, large, spinose terminating plate of the distal roof of the sac viewed from above; b, a lower sac plate showing the double grooves in the lateral sides, x11.

(6), *Paianocrinus aptus* Strimple: restoration of the terminating roof of the mushroom-like anal sac.

(7), *Stenopecrinus rugosus*, n. sp.: a, one of the terminating spines of the anal sac viewed from below; b, side view of a lower sac plate showing the single grooves in each side, x11.

(8), *Plaxocrinus octarius*, n. sp.: the spinose termination roof of the anal sac.



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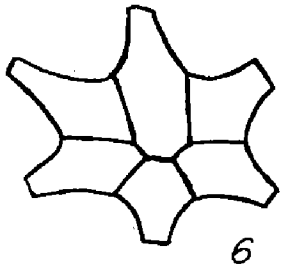

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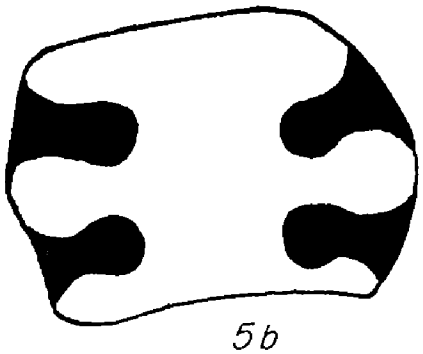

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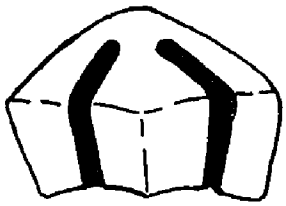

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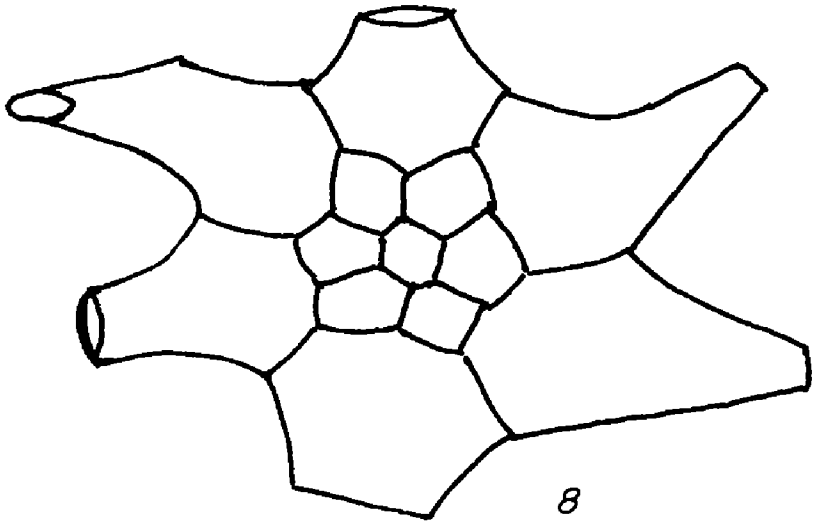

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Genus *Sciadiocrinus* Moore and Plummer, 1938

GENOTYPE.—*Hydreionocrinus acanthophorus* Meek and Worthen, 1879.

This genus is distinctive and is based on a well-preserved crown with the terminating roof-like extension of the anal sac in place.

Three species were described by Moore and Plummer (1940) as *Schistocrinus* that are referred to *Sciadiocrinus*. *Schistocrinus confertus, S. parvus,* and *S. planulatus* all have arms that branch with low PBr_1ax and again with PBr_2ax with other BrBr quadrangular, rather elongated elements. *S. confertus* has a roof-like termination at the distal end of the anal sac composed of 15 flat, spine-like plates surrounding a large central area composed of smaller polygonal plates. *S. parvus* is reported to have similar spine-like tegmenal plates. These are all characteristics of *Sciadiocrinus acanthophorus*. The dorsal cup of *Sciadiocrinus parvus* is too distorted by lateral compression and the cup of *S. planulatus* is distorted by horizontal compression to determine whether or not there was a basal concavity, although the illustrations indicate a shallow depression. The holotype of *Schistocrinus confertus,* as illustrated, shows a broad basal concavity. All three species are reported to have short sutures between the BB, but this is also typical of *Sciadiocrinus,* as reflected by the holotype.

Species assigned to *Sciadiocrinus:*

	Occurrence	*Remarks*
Hydreionocrinus acanthophorus Meek & Worthen	Desmoinesian; Ill., Mo.	*Sciadiocrinus* genotype
Sciadiocrinus ? crassacanthus Moore & Plummer	Morrowan; Okla., Ark.	Tegmen spines
S. disculus Moore & Plummer	Missourian; Tex.	*Sciadiocrinus*
S. harrisae Moore & Plummer	Desmoinesian; Okla., Tex.	*Sciadiocrinus*
Eupachycrinus platybasis White	Lower Aubrey group; Utah	*Sciadiocrinus*
Schistocrinus confertus Moore & Plummer	Desmoinesian; Tex.	*Sciadiocrinus*
S. parvus Moore & Plummer	Desmoinesian; Tex.	*Sciadiocrinus*
S. planulatus Moore & Plummer	Desmoinesian; Tex.	*Sciadiocrinus*

RANGE.—Morrowan ? to Missourian: Midcontinent region, North America.

Genus *Schedexocrinus* Strimple, new genus

GENOTYPE—*Schedexocrinus gibberellus* Strimple, new species.

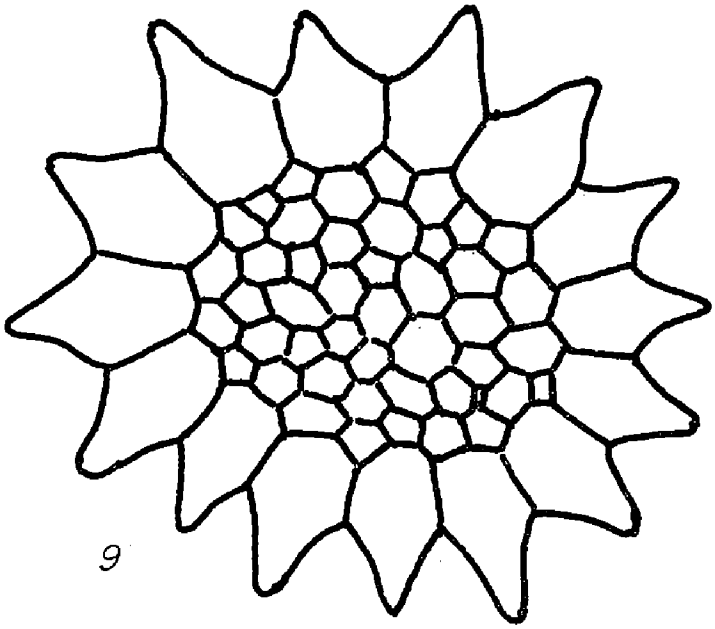
Dorsal cup low, truncate, bowl-shaped, wide basal concavity; five IBB confined to base of basal concavity; five BB form sides of basal concavity, may or may not curve upward far enough to be visible in side view of the cup; five RR, wide, with distal portions erect, facets do not fill distal width of plates; three anal plates (X, RA, RX) are normally partially or entirely within the cup in Primitive Type arrangement but may be in advanced arrangement, X_2 and RX_2 are present in many cases, well above the summit of the cup.

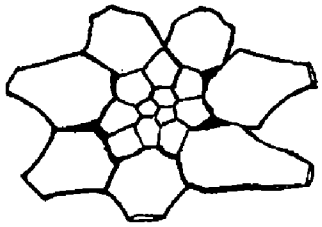
The arms are normally 40 or more, endotomous, uniserial or partially biserial. PBr_1ax are large tumid plates but are not produced as long spines. Axillary BrBr above primibrachs are normally produced as long spines.

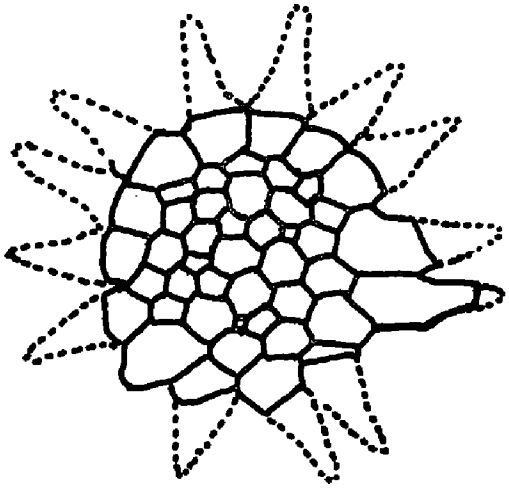
Mushroom-like anal sac, extending above the termination of the arms. The roof-like termination is typically composed of 15 long, flat spines directed outward and surrounding a platform of about 32 smaller polygonal plates.

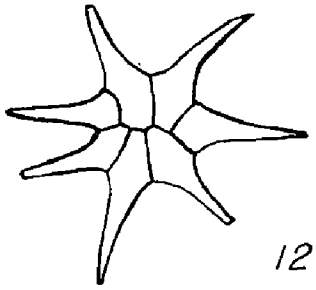
DISCUSSION.—The structure of the anal sac and the general arm structure indicate close relationship with *Sciadiocrinus*. However, the structure of the dorsal cup is much closer to *Plaxocrinus*. In *Sciadiocrinus* the BB as well as the IBB are entirely confined to the basal concavity and, of more importance, the RR approach contact with the IBB. Also the second bifurcation of the arms is uniformly with $SBrBr_2ax$ but is normally with $SBrBr_4ax$ in *Schedexocrinus*. *Plaxocrinus perundatus* Moore and Plummer represents a stage between the two genera and has been assigned to *Schedexocrinus* because of the low, wide brachial plates. *Sciadiocrinus* has uniform, rather long quadrangular, uniserial brachials. *Plaxocrinus* has decidedly spinose primibrachs and the termination of the anal sac is composed of a much smaller number of plates (usually seven large spine-like segments surrounding about 7 small polygonal plates). *Pirasocrinus* also appears to be closely related. The dorsal cup of that genus would be assigned to *Sciadiocrinus* without knowledge of the rest of the crown. The large, tumid $PBrBr_1ax$ are almost identical with those of *Schedexocrinus,* as well as the spinose axillary BrBr of the upper arms; however, the arms of *Pirasocrinus* are longer and

have uniformly isotomous branching. The terminating spinose roof of the anal sac is reportedly composed of four large plates without any small plates involved. *Stenopecrinus* has a more erect, compact









TEXT-FIGURES 9-12. Drawings of the spinose, roof-like terminations of the anal sacs of various species of crinoids.

(9), *Sciadiocrinus confertus* (Moore and Plummer) after the restoration of Moore and Plummer.

(10), *Sciadiocrinus acanthophorus* (Meek and Worthen) restoration after Moore and Plummer, 1938.

(11), *Plaxocrinus normalis*, n. sp., the holotype.

(12), *Tholocrinus weatherbyi* (Wachsmuth and Springer) after Springer, 1926.

dorsal cup, narrower basal concavity, spinose PBr_1ax and a smaller terminating platform-like roof of the anal sac than *Schedexocrinus*. *Metaverimestocrinus* has a relatively higher, more compact dorsal cup, more spine-like PBr_1ax and the nature of the terminating platform-like roof of the anal sac is slightly different. The flat spines, surrounding the perimeter of the platform, are narrower than those of other genera and slope midly downward. In *Schedexocrinus* the platform is subhorizontal. *Perimestocrinus* (as emended herein) is known to have a spinose termination to the anal sac, but the spines are directed upward and do not form a platform.

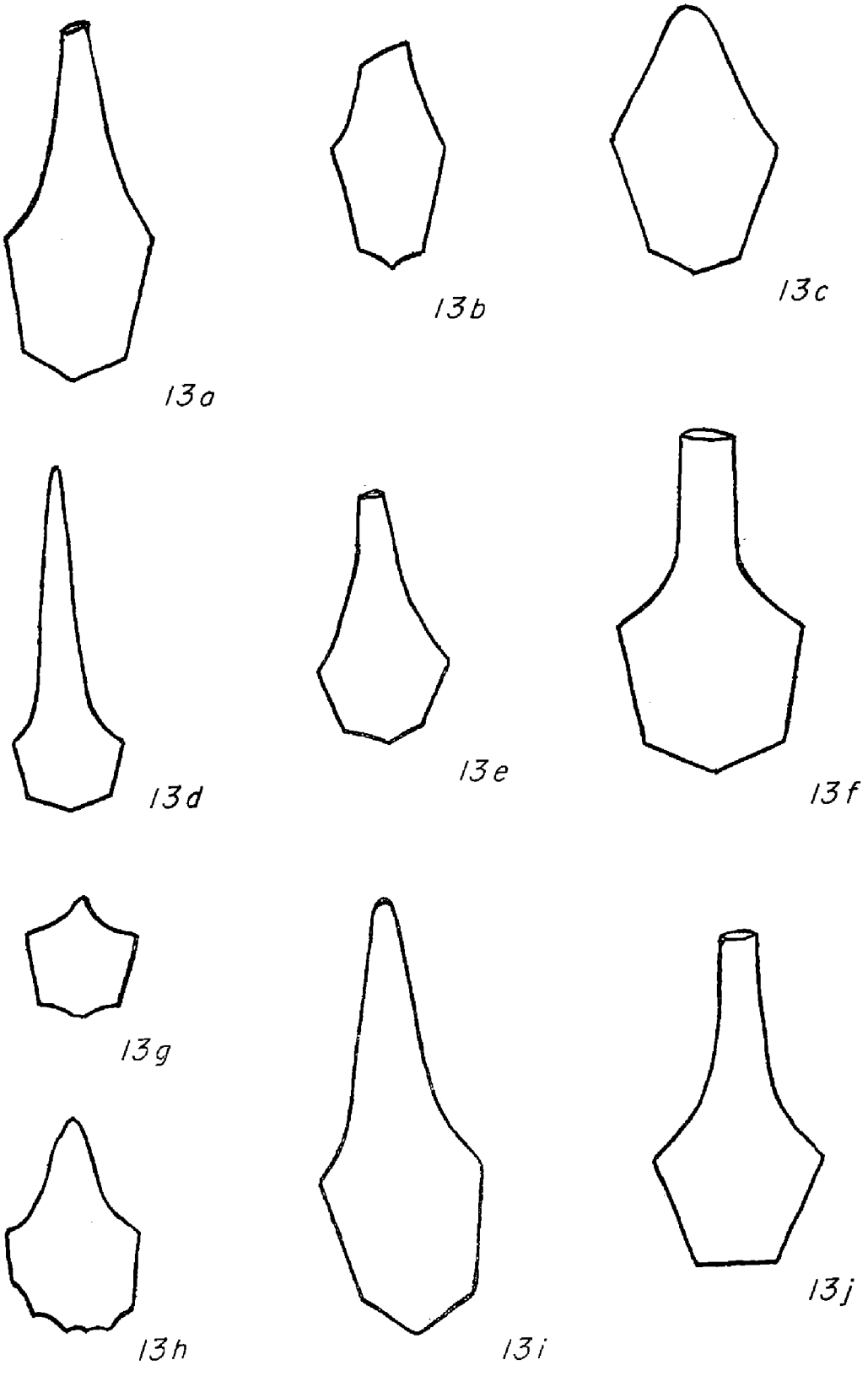
OCCURRENCE.—Desmoinesian, Pennsylvanian; Midcontinent region, North America.

Schedexocrinus gibberellus Strimple, new species
Plate 2, figures 1-3; plate 9, figures 3-5; plate 11, figures 3, 4; plate 17, figures 4-6; plate 19, figure 6; text-figures 13i, j; 14a, b; 15

This species is by far the most spectacular of the crinoids found and several crowns are excellently preserved. The crown may reach an unprecedented size of 11 centimeters high by 11 centimeters wide, with the dorsal cup 5.4 centimeters wide. Several specimens have a more "normal" size of about 7 to 8 centimeters in height, 6 to 7 centimeters in width, with the dorsal cup about 4 centimeters wide. The distal portion of the anal sac is in the form of a large round platform, with elongate, flat spines surrounding the perimeter and directed outwardly in a horizontal plane. For simplicity in reference, I usually term this development "umbrella-like" or "mushroom-like," although the connotation of such terms is a downflared condition. The umbrella is as wide, or slightly wider, than the greatest width of the crown.

The dorsal cup is low, truncate bowl-shaped, with a more or less flat-bottomed basal concavity. The sutures are impressed. Viewed from below, the cup has a hexagonal outline with pronounced notches at the junctures of radials. One facet of the outline is made by the strongly depressed posterior interradius. Five infrabasals form a mildly down-flared disk at the bottom of the basal concavity. The five large tumid basals form the sides of the concavity and curve outward and upward rather gently, with distal

portions plainly visible in side view of the cup. Five large tumid radials are wide, pentagonal elements. The proximal tips reach the basal plane in some specimens, but do not enter the concavity proper.



The facets are less than the greatest width of the plates and a distinct notch occurs at the summit of the interradial sutures.

The outer ligament area is bounded by a curving ridge that is marked by denticles at the lateral sides and has a nearly vertical plane. The outer ligament pit is deep, wide and unusually long, being about half as wide as the plate. The transverse ridge is not continuous because of the fact that the area where it should adjoin the ligament pit is depressed. The depression behind the ligament pit is shallow and in the form of a triangle with a rather wide apex that is confluent with the short intermuscular furrow. The lateral extensions of the transverse ridge are low and well marked by denticles. A relatively wide and long intermuscular notch separates the shallowly depressed, large muscle areas. Low, ill-defined oblique ridges extend from the base of the intermuscular notch to the lateral ends of the transverse ridge. The lateral furrows are shallow and narrow. Lateral ridges are low and curved so that they are not exactly parallel with the ridge that bounds the muscle area. The adsutural slopes are wide and shallow. The interarticular sutures of the radials are not in a straight line but are composed of interlocking ridges and depressions. The lateral lobe of one facet forms a confluent, subhorizontal plane with the lobe of the adjacent facet. Observed from above, a confluent ligament pit is seen to occupy the main width of this facet.

The posterior interradius is occupied by four tumid plates, three of which are entirely below, or partly below, the summit of the cup. One larger paratype has an advanced arrangement wherein RA has

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TEXT-FIGURES 13a-j. Drawings of individual spine plates from the spinose terminations of the anal sacs of various Pennsylvanian crinoid species, x2.

(a, b), *Metaperimestocrinus spiniferus*, n. sp., large plate in the anterior-right anterior interradius and normal sized plate in the posterior radius of a large paratype.

(c), *Schedexocrinus gibberellus*, n. sp., short plate in the right posterior radius of the holotype.

(d), *Plaxocrinus* aff. *P. obesus* Moore and Plummer: normal plate in the left posterior radius of a plesiotype.

(e), *Plaxocrinus normalis*, n. sp.: a normal plate in the right posterior radius of a paratype.

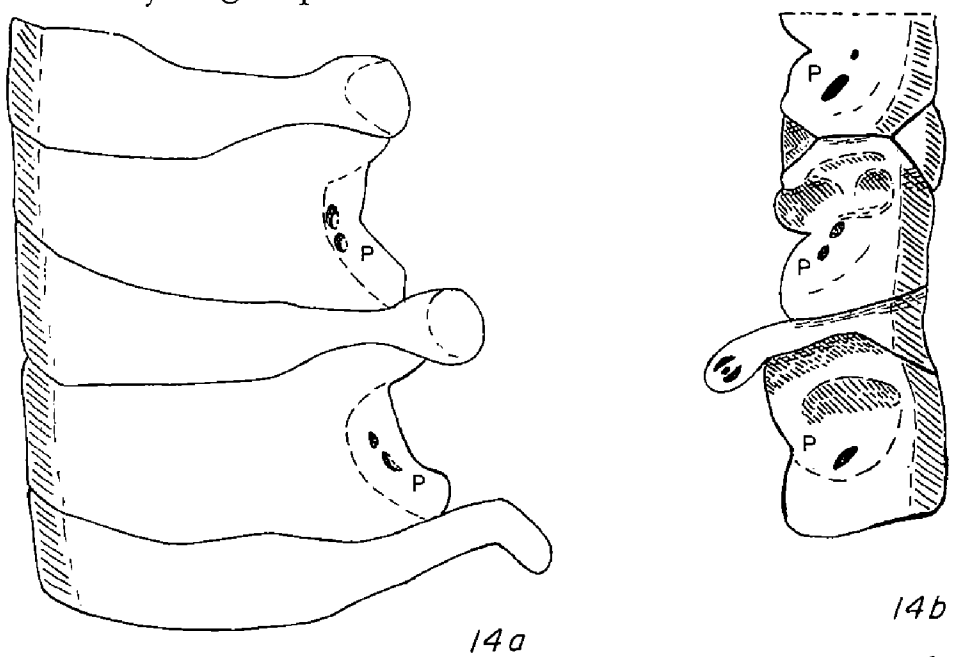
(f), *Schedexocrinus gibberellus*, n. sp.: the largest plate, which is in the right posterior-right anterior interray of a paratype.

(g, h), *Plaxocrinus beggsi*, n. sp.: a short spine in the anterior radius and a large spine in the left anterior radius of the holotype.

(i, j), *Schedexocrinus gibberellus*, n. sp.: a normal plate in the posterior radius and a normal-sized plate with only one facet for contact with the center plates from a paratype.

become large, has established contact with left posterior radial, and has practically pushed RX entirely out of the cup. Almost all other specimens have a normal arrangement (Primitive Type), other than a tendency for RA to push RX out of the cup. X_2 is a well-developed plate resting evenly upon X and to right below upon RX. In the holotype, and several paratypes, it is readily apparent that lower arms of the left and right posterior are curved to the right and left respectively so as to completely close-in the posterior interradius from the exterior. This is well shown by the specimen figured as plate 9, figure 3.

To the left, X is indented to receive the protruded first secundibrach. X_2 has a pronounced bulge, or ridge, to contact a similar bulge of the first tertibrach. To the right, RX has a tumid protrusion that meets a similar development on the third secundibrach, and a curvature to follow the irregular lateral sides of the left ray of the right posterior arm. The arrangement is not so pronounced in some of the younger specimens.

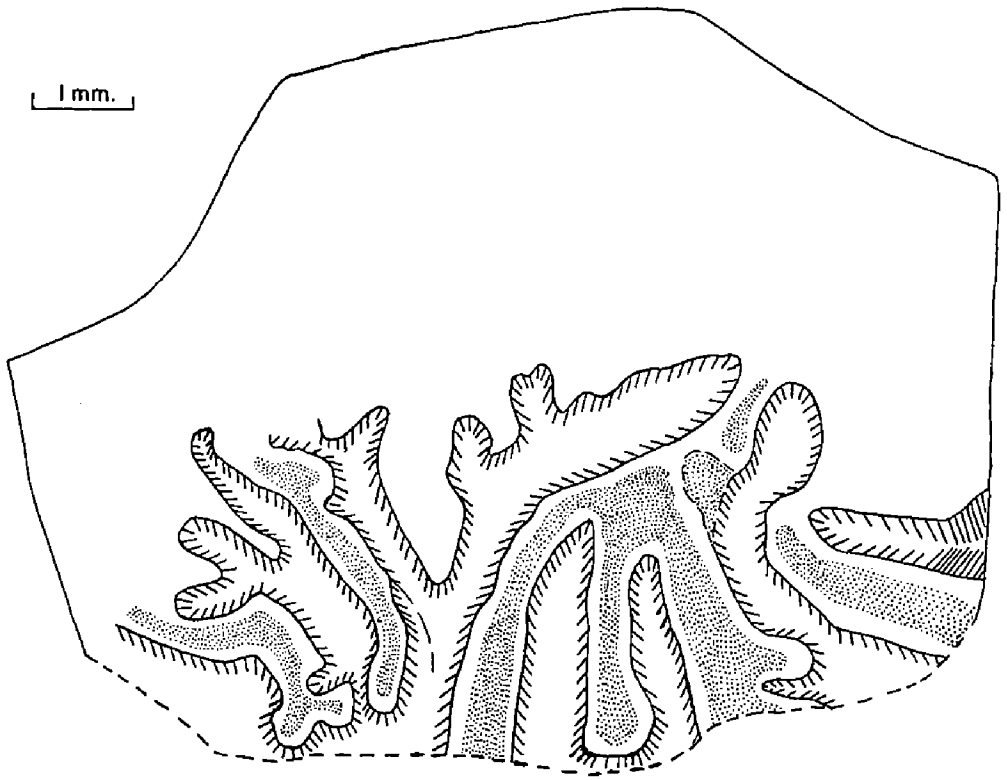


TEXT-FIGURE 14. Drawings of segments of the arms of a paratype of *Schedexocrinus gibberellus*, n. sp., made with the aid of a camera lucida, enlarged approximately x5. Facets for reception of pinnules are designated by the letter P.

(a), Side view of arm showing the peculiar inward extensions of the brachials and the points of attachment for the pinnules. All brachials do not reflect this condition. In fact there are instances in which they interlock along the lateral sides (see upper right of figure b).

(b), Internal view of upper arms restricted to the pinnular articulation facets of half the arm. Facets are indicated by the letter P.

The arms have well-rounded exteriors, are endotomous, and are broad. It appears there are normally more than 40 arms. The first primibrachs are axillary, large, tumid, and pentagonal. They are produced as blunt spines, as in *Pirasocrinus*. The first secundibrachs are large, quadrangular plates. The second secundibrach is low and wide. The third secundibrach is low and wide, and does not fill the entire width of the arm, thereby creating a biserial condition. The fourth secundibrach is axillary, low, and is produced as a spine. Inner arms above this bifurcation are unbranched and are composed of mildly wedge-shaped elements (uniserial to slightly cuneate). In the outer ray, another bifurcation usually takes place with about the sixth tertibrach and again with about the sixth quartibrach. The brachials are low, wedge-shaped, but not biserial except at the brachial below the axillary plate. The brachial below each axillary is in most specimens, but not in all, narrower than the full width of the arm. All axillary plates are usually produced as spines, except for the



TEXT-FIGURE 15. Terminating canal systems on the under side of a large spine from the umbrella-like platform of a paratype of *Schedexocrinus gibberellus*, n. sp. Primary canals are outlined with diagonal lines, secondary depressions (canals?) are stippled. The primary canal to the upper right is very deep at the suture line and is met by a confluent canal on the adjoining spine plate. It probably represents a canal passing to the exterior above.

primibrachs. All brachials are pinnule bearing. No evidence of syzygial suture (fusion of brachials) has been observed, other than in some exceptional circumstances where parasites have bored into the arms and the crinoid has secreted an undue amount of stereome. Extensions along the sides of brachials in the region of the posterior interradius have been discussed, but such extensions also occur sporadically between arms of different rays. Extension of the first, third, and fifth quartibrachs have been noted, with similar developments on the adjacent arms. This is well shown by the specimen figured as plate 9, figure 5.

Of the column, only the relatively thin proximal columnals are known. They are in series of five segments. The first and last of the series are the largest and are girdled by a keel-like ridge. The next columnal is narrow and very thin, and not readily visible in most specimens. The outer edge is scalloped in appearance, with ridges and depressions extending out from the crenellae of the articular surfaces. The next columnal (middle of the series) is thicker and wider, but is not so fully developed as the largest segments. There are 62 crenellae on a columnal 4.5 millimeters wide. The column has a circular outline and is pierced by a pentalobate lumen.

Several paratypes are preserved in such a way as to show the nature of the anal tube, and in addition a few isolated tubes have been found. The anal tube appears to be composed of circlets of about 6 plates in the proximal portion but as the tube approaches its summit it expands, probably recurving. Plates of the expanded sac adjoin the undersides of the flat, spine-like plates that mark the perimeter of the umbrella. The sac plates have thin, grooved, horizontally directed, fan-like projections. The grooves are without doubt channels for the movement of fluid. The large, flat platform (umbrella) is composed of about 34 polygonal plates, in typical specimens, surrounded by 14 flat, horizontally directed spine-like plates. The spines have wide bases, taper rather rapidly to a narrow width and attain a considerable length. Each spine is adjoined by two of the smaller center plates except in the left anterior posterior where one spine is adjoined by three plates. The smaller plates are mostly in the posterior indicating that new plates are added in that region and move toward the anterior.

Measurements of the holotype in millimeters:

Length of crown	96.0
Width of crown	68.5
Width of dorsal cup (maximum)	41.8
Height of dorsal cup (to outer ligament area)	7.8
Height of dorsal cup (to distal edge of lateral side of radial)	9.2
Width of basal concavity	19.5
Length of basal (right anterior)	12.5
Width of basal (right anterior)	11.8
Length of radial (to outer ligament ridge)	12.7
Width of R (right anterior)	24.2
Length of RA	10.3
Width of RA	8.0
Length of X	11.0
Width of X	7.0
Diameter of proximal columnals	6.5

The smallest observed specimen is slightly distorted and has a cup width of about 25.5 millimeters, height about 6.0 millimeters.

REMARKS.—This species exhibits various characteristics that may be compared to those of almost any form assigned to the family PIRASOCRINIDAE. Comparison is made on a broad basis to avoid repetition of factors that are more of a generic than of a specific stature. The umbrella-like anal sac has an arrangement and appearance almost identical with the spinose termination of the sac in *Sciadiocrinus confertus* (Moore & Plummer, 1940). The arms of that species (and of the genus) are slightly different from those of *Schedexocrinus gibberellus*. *Pirasocrinus* has arms that are comparable in many respects to those of *Schedexocrinus gibberellus,* but they are isotomous and the nature of the cup is different as well as is that of the small terminating umbrella of the anal sac. *Plaxocrinus, Stenopecrinus,* and *Metaperimestocrinus* have smaller tegminal terminations (umbrellas). *Aatocrinus* has a slightly different type of basal concavity, wherein the basals enter the basal concavity, and one species of the genus is reported to have spine-like primibrachs. *Laudonocrinus* and *Athlocrinus* have no pronounced basal concavity. *Lasanocrinus* has downflared projections of the radial plates and *Utharocrinus* (as restricted) has downflared spines on the basals. *Perimestocrinus* has a more compact cup, normally with rather high, steep sides.

TYPES.—Holotype (OU 4020) and paratypes are deposited in the paleontological collections of The University of Oklahoma, numbers OU 757, 783, 888, 4021-4029, 4132-4134, 4197, 4198.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Oklahoma.

Genus *Metaperimestocrinus* Strimple, new genus

GENOTYPE.—*Metaperimestocrinus spiniferus* Strimple, new species.

The dorsal cup is low, truncate bowl-shaped with a mildly depressed basal area. Five IBB form a pentagonal, subhorizontal disk just above the basal plane. The proximal edges of the five BB form the lateral sides of the depression. Their lower portions form the basal plane and curve upward to become readily visible in side view of the cup. Five RR are wider than long. Proximal portions do not extend into the basal area. There are usually three anal plates within the cup limits (X, RA, and RX) in normal arrangement (Primitive Type). There are depressions at the angles of the cup plates.

First primibrachs are protruded as short, stout, blunt spines and are axillary. Subsequent brachials are quadrangular, with rounded exteriors in lower arms but rather flattened in upper portions. A second bifurcation takes place with SBr_4 to SBr_6 which plate may be node-like or as a short spine. Another bifurcation takes place with about TBr_7 to TBr_{10} in the outer rays only. This indicates a minimum of 40 arms with endotomous branching.

The anal sac is umbrella-shaped, with a wide distal termination. The large flattened spines surrounding the elliptical central area are much narrower and longer at the base than those known for related forms, and they are more numerous. It is interesting that Moore, in his study of fragmentary crinoid remains, recognized this type of spine as being distinctive (1938, p. 241, pl. IV, figs. 5a, b). The specimen he figured was called *Gisacanthostega angusta.* The specimen has a long groove in midsection that is more pronounced than that found in the present species. A large paratype of *Metaperimestocrinus spiniferus* has 20 spines, but the holotype and a well-preserved paratype have only 15 spines. The plates of the large central area are in disarray in every specimen but are obviously numerous polygonal

elements. The mid-portion of the platform is slightly elevated, with all outer areas sloped downward.

Columnar attachment is weak but the stem cicatrix on the IBB disk is circular in outline and is crenellated.

DISCUSSION.—On the basis of the dorsal cup, the genus is comparable to several genera, but the shallowly impressed base with lateral sides consisting of the proximal edges of BB is different from other described forms. *Stenopecrinus* is the only genus closely comparable and it has a deeper and narrower basal concavity. It also differs in having spinose PBr_1ax and a much smaller terminating roof to the anal sac. The arms of normal specimens of *Metaperimestocrinus* are like those of *Stenopecrinus* and some species of *Plaxocrinus* except that the spinose $PBrBr_1$ do not attain the length found in those genera. Large specimens of *Metaperimestocrinus* have arms that are comparable to those of *Schedexocrinus* except that the latter genus does not develop spines on PBr_1ax and does develop spines on subsequent axillary BrBr.

One paratype of *Metaperimestocrinus spiniferus* is so close in appearance to *Paianocrinus* Strimple, from the Chesterian, that I believe they must at least represent the same phyletic line.

RANGE.—The genus is known to have a considerable geographic as well as stratigraphic range on the basis of undescribed material. It is presently considered to be Desmoinesian, Pennsylvanian; Midcontinent region, North America.

Metaperimestocrinus spiniferus Strimple, new species
Plate 4, figures 3-7; plate 18, figure 5; text-figure 13a, b

The species has those characters ascribed to the genus. A few additional notations are given below.

Five of the crowns, or partial crowns, including the holotype, are of approximately equal size. When undistorted, the infrabasals of many specimens are visible in side view of the cup because of the deep impressions between basals. Two crowns are almost twice as large as the holotype, and one specimen is more than twice as large. None of the specimens has shown any appreciable deviation in the arrangement of the anal plates. Larger specimens show a pyramid of six anal plates of the posterior interradius, which area is mildly

impressed but the plates themselves are somewhat tumid and give the area a more or less full, rounded appearance. The only plates that are partially or entirely within the cup are X, RA, and RX and they are in normal arrangement (Primitive Type). X_2 and RX_2 are well developed but are slightly smaller than the lower plates. X_2 rests solidly on X with RX_2 resting on its upper right shoulder and on RX. X_3 rests directly on X_2 and the upper left shoulder of RX_2. Two paratypes, OU 4052 and 4064, have an advanced anal arrangement wherein RA has lost contact with the right posterior basal (Normal Type A).

One of the larger paratypes has three proximal columnals preserved in place. Unfortunately the last one is partly weathered away and the articular surface is smooth. The segments are moderately thick, the sutures are impressed, and the exteriors are rough as though ornamented. The articular crenellae continue to the exterior and mark the sutures with their depressions and ridges. There are about 45 crenellae on the columnar cicatrix of the holotype.

The smallest paratype, OU 4064, has a crown 20.8 millimeters high by 15.5 millimeters maximum width. The dorsal cup is 3.2 millimeters high by 11.5 millimeters wide. The tegminal platform at the termination of the anal sac is not perfectly preserved, but the shape of the spines is consistent with that of more mature forms. The primibrachs are slightly elongate but have the same blunt termination found in older specimens. The basal concavity is more pronounced than is typical for the species.

Measurements of the holotype in millimeters:

Maximum width of roof of the anal sac	29.5
Height of crown	32.5
Height of dorsal cup	3.9
Width of dorsal cup	16.1
Width of IBB circlet	4.6
Diameter of columnar scar	3.3
Length of basal (right anterior)	6.0*
Width of basal (right anterior)	5.1*
Lenght of radial (right anterior)**	4.0*
Width of radial (right anterior)	8.2*
Length of RA	5.9*
Width of RA	3.0*
Length of X	3.7*
Width of X	3.2*

*Measurements taken along surface of curvature.
**To outer ligament area.

TYPES.—Holotype (OU 4015) and 15 paratypes are deposited in the paleontological collections, The University of Oklahoma, numbers OU 772, 777, 4010-4015, 4051-4058, 4064.

OCCURRENCE.—Holdenville formation, Marmaton group, Des. moinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Oklahoma.

Genus *Stenopecrinus* Strimple, new genus

GENOTYPE—*Perimestocrinus planus* Strimple, 1952.

The dorsal cup is low, bowl-shaped with rather deep, narrow basal concavity. Five IBB are restricted to the basal area of the concavity. Proximal portions of five BB form the steep sides of the concavity and curve sharply out of the concavity and are visible in the side view of the cup. Five RR are large, pentagonal elements with distal portions upright. The proximal portions do not enter the basal concavity. Facets slope mildly outward and do not completely fill the distal widths of the plates. Notches are present at the summit of the interradial sutures but are not pronounced. The three anal plates normally present may be in stage of modification from Primitive Type to Special Type B to Normal Type A to Special Type D. In other words the anal X may be in normal position on the posterior basal with RA to the right below and RX to the right above (Primitive Type); or RA may move to the dominant posterior position, pushing X upward; or RX may be the element being pushed out of the calyx. There are also instances where RA is in the process of being resorbed. The column is rounded and crenulated.

The arms are uniserial, endotomous, with curved exterior surfaces in the lower portions and curved or flattened surfaces in distal portions. The first primibrachs are axillary and a spine is developed in the distal portion. In the closely related genus, *Plaxocrinus,* the first PBrBr are also axillary and protrude as spines, but the proximal portions of the plates participate in the spinose development. In *Stenopecrinus* subsequent axillary brachials are normally produced as spines. The only known exception to this characteristic is *S. politus* (Moore), which species is assigned to *Stenopecrinus* on the basis of the typical PBr_1ax, the structure of

the non-axillary BrBr, and the contour of the dorsal cup. In *Stenopecrinus* the second bifurcation is normally with SBr_4 to SBr_6 and third branching with about TBr_8. Some variations are to be expected.

The anal sac is known to have a small platform-like roof at the distal termination, with large flattened, spine-like plates directed outwardly. The genotype species is known to have 7 spine-like plates surrounding 6 small polygonal plates.

Species assigned to *Stenopecrinus:*

	Occurrence	*Remarks*
Perimestocrinus planus Strimple	Missourian; Okla.	*Stenopecrinus* genotype
P. moseleyi Strimple	Missourian; Tex.	*Stenopecrinus*
P. hexagonus Strimple	Missourian; Okla.	,,
Plaxocrinus politus Moore	Missourian; Okla.	,,
Stenopecrinus rugosus, n. sp.	Morrowan; Okla.	,,

REMARKS.—The basis for establishment of this genus is given in the discussion of the family PIRASOCRINIDAE. *Perimestocrinus* has nodose $PBrBr_1ax$ and subsequent BrBr. *Plaxocrinus* has a shallower dorsal cup with wide, shallow basal invagination and the PBr_1ax is more completely involved in producing a spine. *Metaperimestocrinus* has a closely comparable cup shape but the base does not have a concavity sensu stricto. It also has a much larger roof to the anal sac.

OCCURRENCE. — Missourian, Pennsylvanian; Midcontinent region, North America.

Stenopecrinus planus (Strimple, 1952), new combination

Plate 1, figures 4, 5; text-figures 5a, b

The discovery of a nearly perfect crown of this species by Mr. Allen Graffham, Ardmore, Oklahoma, has afforded information relative to the distal extremities of the arms and the nature of the spinose termination of the anal sac.

In several rays of the metatype, a fourth bifurcation takes place in the outer arms with about the QBr_9. Quite a number of

brachials, in outer and inner rays, develop spines, especially as the distal terminations are approached. More or less sporadic development of spines was noted for the holotype and it is probable that the species has 40 arms.

Sporadic ornamentation in the form of widely spaced, minute rounded nodes is noted on the cup plates, the primibrachs, and the first secundibrachs. They are not visible without slight magnification. The original types were entirely devoid of surface markings.

The anal sac is apparently composed of circlets of six plates that are low and hexagonal. Two pores are present on each lateral side of a plate, with the canal extending onto the outer surface. The plates have a mild transverse curvature, and are perfectly smooth except for the depressed grooves with light grooves marking their outlines. The platform at the summit of the sac is composed of 7 elongate, spine-like plates surrounding 6 small, polygonal plates. Each spine is adjoined by 2 center plates except for that of the posterior which is adjoined by a single plate. The center is slightly elliptical with the long axis from right to left as oriented with the calyx.

Measurements of metatype in millimeters:

Height of crown	41.0
Width of crown	21.0
Estimated width of umbrella	28.5
Height of cup	4.0
Width of cup	17.0
Width of IBB circlet	4.7
Height of basal concavity	1.9
Width of basal concavity	6.2
Length of basal (right anterior)	4.5*
Width of basal (right anterior)	4.0*
Length of radial (raght anterior)	6.0*
Width of radial (right anterior)	9.9*
Width of columnar scar	2.8

* Measurement taken along surface curvature.

METATYPE.—Deposited in the paleontological collections of The University of Oklahoma, number OU 4165

OCCURRENCE.—Abandoned tank dike in hill located in NW¼ section 10, T. 28 N., R. 13 E. about 2½ miles NE of Copan, Washington County, Oklahoma; unnamed shale about 30 feet above the Torpedo sandstone formation, Ochelata group, Missourian, Pennsylvanian.

Stenopecrinus rugosus Strimple, new species

Plate 2, figures 4, 5; plate 14, figure 7; text-figures 7a, b

The dorsal cup is low, truncate bowl-shaped with a shallow but pronounced basal concavity. The basal concavity is filled by the proximal columnals but I have been able to remove them and have found that only the tips of some of the infrabasals are visible beyond the columnar scar. There are probably five plates in the form of a disk at the bottom of the concavity. The proximal edges of the five basals form the erect sides of the concavity, curve sharply into a horizontal position to form the basal plane, thence curve gently upward to become visible in side view of the cup. The five radials are tumid, wide pentagonal plates, with a small flattened area in vertical position just below the outer ligament area. There are distinct notches at the summits of the interradial areas. The three anal plates (X, RA, and RX) are unusually long elements in normal placement (Primitive Type). The posterior interradius is rather narrow and distinctly depressed. Two upper plates are present in the anal pyramid (X_2 and RX_2). RA is unusally large and is encroaching strongly on the X, which plate is still in narrow contact with the posterior basal. RX is a cup element only by virtue of the lower one-fifth of the plate being below the summit of the right posterior radial. All cup elements except the infrabasals are marked by a series of low, indistinct ridges and depressions that cross the strongly impressed sutural areas. There are two ridges between each radial and the adjoining basal and one ridge, near the summit of the cup, between radials. There are in addition decidedly depressed areas at the angles of the plates in the basal and radial circlets. The pattern is complicated in the posterior interradius. Two ridges join RA and RPR, two pass between RA and PB, and only one ridge to RPB, X, and RX. There is no ridge on the narrow facet between X and PB, but two pass from X to RX and one from X to X_2. A faint ridge passes from RX to RA, another to RPR, one to X_2, and one to RX_2. The lateral sides of the anal pyramid, above the summit of the cup, are undulating so that depressions are formed for the reception of bulbous projections of adjacent arm segments. In the right posterior radius, the first and third SBrBr are protruded and in the left posterior radius, it is also the

first and third SBrBr, however, the projection of the third SBr is above the pyramid and fills a depressed area in the left arm of the posterior ray.

The arms are preserved in their lower half in several rays. The primibrachs are rather elongate, axillary with the distal extremities projected as long, thin spines. They do not fill the distal facets of the radials. Bulbous lateral projections of various secundibrachs in the posterior area have been discussed above. Almost all brachials extend either to the right or left in alternating fashion so as to meet depressed areas in the adjacent arms. Second bifurcation takes place with a spinose SBr_6. A third branching occurs in the outer rays only with spinose TBr_7 or TBr_8. A minimum of 30 arms is thus indicated. The exteriors of the arms are well rounded and the brachials are quadrangular (uniserial). Branching is endotomous although the first two bifurcations are, strictly speaking, isotomous.

The column tapers slowly and is composed of alternately expanded segments. About 21 columnals are preserved. The nodals are rather thick with strong longitudinal curvature. The crenellae are extended to the exterior and are visible at the suture line where they are seen to interlock with the sharply defined ridges and depressions of the thinner and narrower internodals. The internodals have an ornate scalloped appearance. The lumen is fairly large and is pentalobate.

A few sac plates at the distal end of the crown show the simple grooves that originate on the exterior of the plate and pass to the interior. There is one groove to each lateral facet and the plates are extended in mid-portion, though not in the nature of a spine. The plates are normally hexagonal. The existence of a spinose termination of the anal sac is known from two long spines that were found in the proper position in the shale-clay matrix of the crown. None of the plates in the upper portion of the crown is in exact placement and it has not been possible to determine the exact nature of the umbrella-like termination. The long spines have an elliptical base that is more like that of *Paianocrinus aptus* than the flattened bases of younger species of *Stenopecrinus*. A normal sac plate and one of the spines are illustrated as text-figures 6a, b.

Measurements of the holotype in millimeters:

Height of crown	38.0
Width of crown	20.0
Height of cup	3.0
Width of cup (maximum)	11.4
Width of cup (posterior to anterior)	10.0
Height of basal concavity	0.9
Width of basal concavity (approximate)	3.0
Width of IBB circlet	2.3
Width of columnar scar	2.1
Length of basal (right anterior)	3.9*
Width of basal (right anterior)	3.8*
Length of radial (right anterior)	4.3*
Width of radial (right anterior)	5.7*
Width of posterior interradius	2.8

* Measurement taken along the surface of curvature.

REMARKS.—This species has some characteristics of both *Stenopecrinus* and *Metaperimestocrinus.* The shallow nature of the basal concavity is close to that of *Metaperimestocrinus;* however, the overhang of the basals as they approach the infrabasals is typical of many species of *Stenopecrinus.* The depressions at the angles of the plates of the basal and radial circlets are typical of *Metaperimestocrinus.* The thin spines at the distal end of each primibrach is one of the more distinguishing characteristics of *Stenopecrinus.* It is obvious that close relationships exist among these forms and it is quite possible that *Stenopecrinus rugosus* should be considered as a separate genetic entity, perhaps ancestral to both *Stenopecrinus* and *Metaperimestocrinus.* As a specific entity, is is readily distinguished by the presence of low ridges passing from plate to plate and the shallow nature of the cup.

HOLOTYPE.—Deposited in the paleontological collections of The University of Oklahoma, number OU 4166.

OCCURRENCE.—Blue-gray shale and limestone lentils at the base of the Wapanucka formation, Morrowan, Pennslyvanian; bank of Canyon Creek near C Sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma.

GENUS *Plaxocrinus* Moore and Plummer, 1938

GENOTYPE.—*Hydreionocrinus crassidiscus* Miller & Gurley, 1894.

The genus *Plaxocrinus* was proposed by Moore and Plummer (1938) with *Hydreionocrinus crassidiscus* Miller and Gurley as the genotype species. This species was and is known only from a dorsal cup, which is the holotype. In 1939, Moore modified the generic concept primarily on the basis of the crown of *Plaxocrinus politus* Moore (now referred to *Stenopecrinus*) but reportedly including some undescribed species. This modification incorporates the arm structure into the generic concept, wherein the arms branch isotomously on the axillary first primibrach and each secondary branch divides equally on the fourth or fifth secundibrach. It was noted that the axillary PBr_1 is spine-bearing in each case and, by omission, it is assumed the following axillary brachials were not spinose. At least that is true of *S. politus*. The existence of an umbrella-type anal sac was also noted by Moore.

In 1940, Moore and Plummer modified the generic concept again to include forms having non-spinose primibrachs. Since the only species of this nature was *Plaxocrinus perundatus* Moore and Plummer (1940), it is assumed the modification was for the purpose of including that species under the genus. The species is herein referred to the genus *Schedexocrinus*.

In 1951, I described a magnificent crown of the genus from the Graford formation, Missourian, of Texas as *Plaxocrinus oeconomicus*. No remarks were made at that time relative to the genus. In 1952, in my study of the arm structure of *Perimestocrinus,* a brief discussion of the close relationship between *Plaxocrinus* and *Perimestocrinus* was given. At that time I referred both *Plaxocrinus politus* and *P. praevalens* to *Perimestocrinus* because of the contour of the dorsal cups; i. e., the narrow, relatively deep basal concavity. Under present concepts *Plaxocrinus politus* is referred to *Stenopecrinus,* and *Plaxocrinus praevalens* is properly designated.

It is obvious that a large group of crinoids existed in Pennsylvanian time having characteristics ascribed to *Plaxocrinus* as reflected by the dorsal cups. It is also obvious that many forms are intermediate between *Plaxocrinus* and closely related forms such as *Stenopecrinus, Schedexocrinus,* etc.

Under discussions of the PIRASOCRINIDAE I have restricted *Perimestocrinus* to characteristics of the genotype species, which provides for the PBr_1ax to be non-spinose. A new genus, *Stenopecrinus* has been proposed to cover forms previously referred to *Perimestocrinus* but having the PBr_1ax produced as a spine; however, the spine is restricted to the distal portion of the element.

At this time, there are only two species of *Plaxocrinus* for which the arms are known. These are *P. gloukosensis* Strimple and *P. oeconomicus* Strimple. The arms of those species are like those of *P. normalis* Strimple, new species, described herein from the Holdenville formation, Desmoinesian. In all three of these species the PBr_1ax is large, low, with a long spine-like protrusion. All but the proximal edge of the primibrach participates in the formation of the spine. None of the upper BrBrax develop spines. The PBr_1ax ascribed to the species *P. dornickensis* Strimple and the single PBr_1ax attached to *P. praevalens* Moore are typical of the genus.

The anal sac of *P. gloukosensis* is known to be of the mushroom type. The terminating roof of the anal sac is displaced but there appear to have been 9 large spines surrounding a relatively small number of polygonal plates. In *P. normalis,* there are normally 7 large, flat, spine-like plates surrounding about 7 smaller polygonal plates. One species, *P. octarius,* has only six large spines. *P. obesus* has 8 large spines; however, the species is not a normal representative of the genus.

Species referred to *Plaxocrinus:*

	Occurrence	*Remarks*
Hydreionocrinus crassidiscus Miller & Gurley	Missourian; Mo.	*Plaxocrinus* genotype
Hydreionocrinus kansasensis Weller	Virgilian; Kans.	*Plaxocrinus*
Zeacrinus discus Meek & Worthen	Missourian; Ill.	*Plaxocrinus*
Zeacrinus mooresi Whitfield	Desmoinesian; Ill.	"
Eupachycrinus? sancti-ludovici Worthen	Mississippian; Mo.	*? Plaxocrinus*
Plaxocrinus perundatus Moore & Plummer	Desmoinesian; Tex.	*Schedexocrinus*
Plaxocrinus politus Moore	Missourian; Okla.	*Stenopecrinus*

P. aplatus Moore & Plummer	Desmoinesian; Tex.	*Plaxocrinus*
P. lobatus Moore & Plummer	Missourian; Tex.	”
P. modestus Moore	Virgilian; Okla.	”
P. obesus Moore & Plummer	Missourian; Tex.	”
P. omphaloides Moore & Plummer	Missourian; Tex.	”
P. orthodoxus Moore	Virgilian; Okla.	”
P. parilis Moore & Plummer	Missourian; Tex., Kans.	”
P. praevalens Moore	Virgilian; Okla.	”
P. strigosus Moore & Plummer	Morrowan; Okla., Ark.	”
P. virginarius Moore	Virgilian; Okla.	”
P. gloukosensis Strimple	Virgilian; Kans.	”
P. laxus Strimple	Missourian; Tex.	”
P. oeconomicus Strimple	Missourian; Tex.	”
P. dornickensis Strimple	Desmoinesian; Okla.	”
P. tumulosus Strimple	Desmoinesian; Okla.	”
P. normalis, n. sp.	Desmoinesian; Okla.	”
P. octarius, n. sp.	Desmoinesian; Okla.	”
Hydreionocrinus uddeni Weller	Lower Permian; Tex.	”

RANGE.—?Mississippian, Pennsylvanian; North America.

Plaxocrinus aff. *P. obesus* Moore and Plummer, 1940
Plate 16, figure 3; plate 19, figure 4; text-figure 13d

This species is represented by one crown in rather indifferent preservation in a nodule associated with the large accumulation of crinoids at the Beggs, Oklahoma, location. The species is well defined by the characters of the basal cup, and it is not a normal representative of the genus, as was pointed out by Moore and

Plummer, because the tips of the tumid radials participate in the basal cavity. In the present specimen, the distal tips of the basals are visible in side view of the cup only by virtue of the strongly depressed areas between the radials. The radials are not quite as bulbous as in the figured holotype and paratype of the species. The anal plates are in normal arrangement (Primitive Type).

In the arms, the first primibrachs are axillary in all rays and are protruded as stout, long spines. First secundibrach is quadrangular and rather large. Second and third secundibrachs are rather low, wide elements. The fourth secundibrach is axillary, tumid and fairly large. The inner rays remain unbranched above this point and the regular brachials develop flattened exteriors. They are slightly wedge-shaped, but do not become interlocking, and they are pinnule bearing.

The umbrella-like termination of the anal sac is preserved. There are about 11 small polygonal plates surrounded by 8 spine-like, flattened plates that are directed outwardly. The spines are of medium width, about 5.6 millimeters, at their base, taper rapidly to a narrow width and are extended for a considerable distance (length about 18 millimeters). It is estimated a diameter of 53 millimeters was attained by the extended spines. The central portion has a width of 11.0 millimeters. The width of the cup is 17.5 millimeters.

PLESIOTYPE.—Deposited in the paleontological collections of The University of Oklahoma, number OU 4137.

OCCURRENCE—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Plaxocrinus normalis Strimple, new species
Plate 11, figures 5-7; plate 15, figure 5; plate 18, figures 3, 4; plate 19, figures 1, 3; text-figure 13e

Dorsal cup is low, truncate bowl-shaped with rather broad basal concavity. The five infrabasals extend well beyond the proximal columnal, forming a subhorizontal disk at the base of the concavity, and have a mildly down-flared attitude. The lateral sides of the concavity have a rather gentle curvature and are composed mainly of the proximal portions of the basals. The five basals are mildly

tumid with distal portions curved upward slightly and visible in side view of the cup. Five radials are mildly tumid and form the main part of the cup height. The proximal tips reach the basal plane but do not participate in the cavity. Sutures between radials are in the depressed area that continues into the inter-articular area. These depressed areas break the continuity of the cup outline when viewed from below, as does also the relatively broad, depressed posterior interradius. Morphologic features of the radial articular facets are afforded by paratype OU 4086. The facets slope outwardly. Outer marginal ridge is present but ill-defined, and the outer ligament furrow is shallow. The outer ligament furrow is faint but the ligament pit is well defined. The transverse ridge is low and is marked by denticles. It is restricted to the lateral sides by a V-shaped depression that acts as the central pit in being connected with the intermuscular furrow. Just to the fore of the two sections of the transverse ridge there is a long, thin, well-defined slit that is above the ligament pit furrow. The lateral furrows are well defined but the oblique ridges are low and rounded into the shallow muscle areas. The intermuscular notch is a well-defined, V-shaped element and lateral lobes are well developed. There is an elevated lateral ridge but no adsutural slope, strictly speaking, because there is a sharp drop to the flattened adsutural areas. A slightly dislocated plate discloses the existence of a series of interlocking projections and depressions along the sutural edges. Three anal plates are usually in normal placement (Prmitive Type). They are X, RA, and RX. Variants are given above in the section on variability of anal plates.

The arms are fundamentally uniserial, although a few segments may interlock in biserial fashion. Bifurcation is endotomous above the first branching, which is with the first primibrach in all rays. First primibrach is projected as an elongate spine. These plates are generally broken but in paratype OU 4063 two spines are 21.5 millimeters long. Subsequent branching is with the fourth to sixth secundibrach, which axillary plates are swollen, or tumid, but are not spinose. Thereafter the inner ray remains unbranched as in subsequent divisions (endotomous). The outer arm may divide with the eighth to tenth tertibrach and again with about the tenth quatribrach. Normal brachials are mildly wedge-shaped, not

interlocking, and have flattened exteriors above the second bifurcation. They have flattened lateral sides for close union with adjacent arms, but the sutures between arms are very erratic. The brachial of one arm will be laterally projected on one side to occupy an indentation in the adjacent arm, and recessed on the opposite side to provide space for a projected area of that adjacent arm. The arms in this manner become more or less interlocked when in repose. There may be as many as 35 arms.

A peculiar protrusion is present in the upper arms of the holotype. The brachials are enlarged and surround a mouth-like aperture that one must presume housed some type of parasite. The occurrence is discussed under a prior section on associated parasitic life.

There are about 11 center plates surrounded by 7 large, spine-like plates at the distal termination of the anal sac. In the holotype, two plates adjoin the broad base of each spine except for that of the right posterior which is adjoined by three plates. The presence of 7 spine plates appears to be a constant feature of the species.

Proximal columnals are annulated, alternatingly expanded and rather thin. The interlocking ridges and depressions marking the sutural areas are extensions of the crenellae of the articular surfaces. The lumen is small, mildly pentalobate.

One specimen, OU 4149, has one primibrach in the anterior ray that closely approaches the appearance of typical primibrachs of *Stenopecrinus*. That is, the projected spine is high on the outer face of the primibrach. Other primibrachs in the specimen are normal for the species. An illustration of the specimen showing the anterior primibrach in profile is given on plate 18, figure 3.

Measurement of holotype in millimeters:

Height of crown	54.0
Width of crown	42.0
Height of dorsal cup	5.5
Width of dorsal cup (maximum)	22.8
Width of cup (posterior to anterior)	18.2
Width of basal concavity	10.0
Width of infrabasal circlet	5.6
Length of basal (right anterior)	6.0*
Width of basal (right anterior)	6.0*
Length of radial (right anterior)	7.2*
Width of radial (right anterior)	11.8*
Diameter of proximal columnals	3.1

*Measurement along surface curvature.

REMARKS.—The dorsal cup of *Plaxocrinus dornickensis* is somewhat like that of *P. normalis;* however, in the former the cup plates are not so tumid, the basal concavity is more pronounced and the sutures are not so impressed. *P. lobatus* is closer than other described species except for the slightly convex posterior interradius that does not interrupt the rounded contour of the cup when viewed from above or below. The posterior interradius of *P. normalis* is depressed. *P. omphaloides* has a depressed posterior interradius but does not have distinct notches in interradial positions and has a smooth surface curvature to the cup.

TYPES.—Holotype (OU 4066) and paratypes are deposited in the paleontological collections of The University of Oklahoma, numbers OU 758, 781, 4009, 4063, 4066-4092, 4149, 4184, 4196, 4199.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Plaxocrinus aff. *P. dornickensis* Strimple, 1949
Plate 14, figures 5, 6

One dorsal cup of this species was found in the stream bed at the Beggs, Oklahoma, locality of the Holdenville formation, but well below the crinoid accumulation. The darkened appearance of the replacement material shows that it is from a horizon other than that containing the majority of the crinoids.

Measurements in millimeters:

	Holotype	*Beggs specimen*
Maximum width of dorsal cup	21.2	26.9
Height of cup to transverse ridge	5.5	6.6
Width of posterior interradius	5.8	5.9
Width of columnar impression	3.9	
Width of proximal columnals		3.3

The facets of the present specimen do not slope outward quite as strongly as those of the holotype and the basal concavity is not quite as deep. Exact comparison of the columnar cicatrix is not possible because of the presence of proximal columnals in the Beggs specimen; however, the columnals have a diameter just slightly less than the diameter of the cicatrix of the holotype. The ratio of height to width of the dorsal cup is almost identical for the two

specimens, as well as the width of the posterior interradius. Considering all factors, the present specimen is taken to be closely related to *P. dornickensis* but not conspecific.

Five proximal columnals are preserved with the Beggs specimen. They have a circular outline, are relatively thin and have smooth exteriors with slight impression of the sutures. The sutures are marked by the outward manifestation of the ridges and depressions of the crenellae. The lumen is apparently pentalobate. This structure is not like that found in *Plaxocrinus normalis* wherein the columnals are alternatingly expanded with the larger segments having a keel-like, undulating girdle.

TYPE.—The specimen is deposited in the paleontological collections of The University of Oklahoma, number OU 4016.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Oklahoma.

Plaxocrinus beggsi Strimple, new species
Plate 12, figures 1-3; text-fig. 13g, h

This species is represented by one weathered crown and one crown that is rather firmly embedded in a nodule. The terminating roof of the distal extremity of the anal sac is different from all others that have been observed. Nine flat spines are broad at the base and the spinose portions are relatively short and blunt in most plates. Considerable variation exists in the number of plates adjoining each of the larger plates. As few as 2 center plates adjoin a spine, and there may be as many as 5 in other instances. The center plates are polygonal and are small and more numerous than in other species of the genus. Relatively broad, short spines are regularly placed about the perimeter of the roof of *Sciadiocrinus confertus* (Moore and Plummer) and there are numerous polygonal plates in the central disk. But in that species the arms branch isotomously and the basals are confined to the basal concavity. Also the second bifurcation is with the second secundibrachs in all rays (a generic character), whereas in the present form the second bifurcation is with the fourth secundibrach.

The dorsal cup is low, truncate bowl-shaped, with a shallowly invaginated base. Five infrabasals form a mildly down-flared disk

that is just slightly above the basal plane. Proximal portions of the five basals form the short lateral sides of the basal concavity. Distal portions of basals curve upward to be readily visible in side view of the cup. Five radials are more than twice as wide as long, are pentagonal with proximal edges reaching the basal plane but longitudinally curved to become erect just below the outer ligament area. Facets are not as wide as the greatest width of the plates, but the notches at the summit of the interradial sutures are not pronounced. Three anal plates (X, RA, and RX) are in normal arrangement (Primitive Type). First primibrachs are axillary, rather large and appear to have developed short, stout spines. These elements have been weathered rather strongly but they appear to be normal for the genus. Subsequent axillary brachials are not produced as spines. From the arms preserved, there appear to be three low, wide, transversely curved secundibrachs with a large fourth axillary secundibrach. Subsequent brachials are quadrangular, of medium length, and have flattened exteriors. They are pinnule bearing. Another bifurcation takes place with about the eighth to tenth tertibrach in outer rays only. This would produce a minimum of 30 uniserial arms, branching endotomously.

The column is composed of alternatingly thick and thin segments. The thin segments are not quite as wide as the columnals on each side and are not readily visible without low powered magnification. The larger columnals have an undulating surface and the crenellae of the articular facets extend to the outer surface so that a maze of ridges and depressions is formed. Distal segments are not perfectly preserved but it is estimated that 36 or more crenellae are present. The lumen is pentalobate.

Measurements of holotype in millimeters:

Height of crown	42.3
Width of crown (estimated)	37.0
Width of the roof of the anal sac	28.2
Maximum width of central portion of the roof	14.6
Height of dorsal cup (to transverse ridge)	4.7
Width of dorsal cup (maximum)	17.0
Length of basal (right anterior)	5.6*
Width of basal (right anterior)	5.6*
Length of radial (right anterior)	4.7*
Width of radial (right anterior)	11.0*
Width of posterior interradius	5.1
Width of infrabasal disk	6.0
Width of proximal columnals	2.2

* Measurement taken along surface curvature.

REMARKS.—The distinctive features of this species were outlined in the opening remarks of the description. It is of some interterest to note that one spine of the roof of the anal sac is close to the shape of a spine figured by Moore and Plummer (1938, text-fig. 22g) from the Brentwood limestone member of the Bloyd formation, Morrowan of northeastern Oklahoma, as probably representative of *Sciadiocrinus*.

TYPES.—Holotype and paratype are deposited in the paleontological collections of The University of Oklahoma, numbers OU 4004, 4065.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Plaxocrinus octarius Strimple, new species
Plate 4, figures 1, 2; text-figure 8

This species is represented in the collections by two crowns. The arms are poorly preserved but the dorsal cups and terminating, spinose platform of the anal sacs are excellently preserved. The dorsal cup is low, truncate bowl-shaped. There is a mild basal concavity with the infrabasals slightly flared downward. The basals have their proximal tips curved into, and forming the walls of the cavity. They curve upward gently to be visible in side view of the cup. There is a depression at the distal end of each basal and at the distal end of the interbasal suture. Radials are wide and reach into the basal plane. They have a rather gentle longitudinal curvature to just below the articular facet where they curve sharply upward to form an almost vertical, arcuate face below the outer ligament area. They are curved rather strongly transversely. When viewed from below, there is a distinct interradial notch between radials at the summit of the cup. The posterior interradius is rather narrow and concave in the large paratype. This is reflected in the anal plates which are all narrow elements. The posterior interradius is rather wide and concave in the holotype, with the anal plates proportionately wider than found in the paratype. There are three anal plates within the cup limits (X, RA, and RX) in normal arrangement (Primitive Type).

The first primibrachs are axillary and are low, elongate, spine-like elements. Their entire lengths are not preserved but they were obviously long. The entire outer faces of the plates participate in the spine-like projection. A second bifurcation takes place with about the fourth to sixth secundibrach. The axillary secundibrachs are mildly tumid but are not produced as spines. Brachials are low, quadrangular plates.

In the large paratype, a poorly developed and poorly preserved, thin internodal is in place and prevents close observation of the articulating surfaces of the proximal columnals that are preserved. The outer edges of the crenellae are visible on the underlying nodal. The crenellae extend to the exterior of the plates with faint ridges passing diagonally over the outer surface of the columnal from one facet to the other. The crenellae form an interlocking arrangement with the ridges and depressions on the adjacent columnal. There are about 29 crenellae on the columnar cicatrix of the holotype. Both specimens show a circular lumen.

The terminating platform of the anal sac is composed of a circlet of 7 plates, six surrounding a single plate in the center. The perimeter is composed of 6 flattened, spade-like plates with long spinose projections. Each spine-bearing plate is adjoined by 2 plates of the central circlet.

Measurements of the types in millimeters:

	Paratype	*Holotype*
Height of crown	44.7	23.0
Width of cup (posterior to anterior)	16.7	11.5
Width of cup (maximum)	19.2	12.5
Height of cup	4.6	3.4
Width of IBB circlet	?	2.6
Width of proximal columnal (or scar)	2.4	2.1
Length of basal (right anterior)	6.2*	3.4*
Width of basal (right anterior)	5.9*	3.8*
Length of radial (right anterior)	6.5*	4.6*
Width of radial (right anterior)	11.0*	6.6*
Length of PBr$_{1}$ax	12.3[1]	----
Width at base of PBr$_{1}$ax	9.6	5.5
Width of central disk of sac platform	11.2	11.5[2]

* Measurement taken along surface curvature.
[1] The termination is regenerated and not a true representative of the length.
[2] Slightly spread out in preservation.

REMARKS.—*Plaxocrinus octarius* is readily differentiated from associated species by the dimple-like depressions at the corners of

the cup plates and the presence of 6 spine plates in the terminating platform of the anal sac. Normal representatives of the genus have 7 spine plates. The shallow basal concavity with erect sides formed by the proximal tips of the basals is more like *Stenopecrinus* or *Metaperimestocrinus* than like *Plaxocrinus* but the general contour of the cup and nature of the primibrachs are typical of *Plaxocrinus*.

TYPES.—Holotype and paratype are deposited in the paleontological collections of The University of Oklahoma, numbers OU 4017, 4018.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County. Oklahoma.

Genus *Pirasocrinus* Moore and Plummer, 1940

GENOTYPE.—*Pirasocrinus scotti* Moore and Plummer, 1940.

GENERIC DIAGNOSIS.—(After Moore and Laudon, 1944) Cup low, characterized by deep basal concavity, IBB and BB not visible from side; PBr_1 axillary, isotomous divisions of rami at uniform heights, AxAx bulbous; anal sac reaching above arm tips, capped by plates bearing laterally directed spines; stem round.

RANGE.—Desmoinesian, Pennsylvanian; Oklahoma and Texas.

REMARKS.—There appear to be two contrasting evolutionary trends affecting the arm structure of Late Paleozoic inadunates. One trend is toward the addition of arms and the other trend is toward reduction in the number of arms. An example of the former is *Alcimocrinus,* in which the younger (Morrowan) *A. girtyi* has more numerous rami than *A. ornatus* from the late Chesterian. An example of pronounced reduction in the number of arms is *Allosocrinus* which has only five arms. *Pirasocrinus,* as represented by the genotype species, is apparently about the ultimate in the addition of arms. Moore and Plummer (1940) reported a maximum of 80 slender branches. Although the arm structure is rather unusual, I believe the lineage of *Pirasocrinus* is very close to that of *Plaxocrinus, Schedexocrinus,* and other closely comparable forms.

At this time, the genotype is the only species ascribed to the genus. A species is described herein as *Pirasocrinus depressus.* It has 30 arms that branch uniformly with the first two bifurcations

(isotomously), but the third branching is only in the outer rays (endotomously). There are seven large flat spines at the termination of the umbrella-like anal sac, as opposed to the four spines reported for *P. scotti*. The structure and contour of the dorsal cup and the primibrachs are almost identical for *P. depressus* as for *P. scotti*.

Pirasocrinus depressus Strimple, new species
Plate 14, figures 1, 2

The species is represented in the collections by three crowns. One specimen is on a rather large limestone slab that is darkish-brown and heavily endowed by various molluscan specimens. Two of the specimens, including the holotype, together with a partially preserved crown of *Stellarocrinus* and a large pelecypod, are imbedded in a nodular segment of darkish-brown limestone that is lithologically the same as the first-mentioned slab. These specimens were collected down stream from the main accumulation of crinoids and are not from the same bed.

The dorsal cup is low, truncate bowl-shaped with a rather deep basal concavity. The five infrabasals are confined to the bottom of the cavity. The five basals form erect, almost vertical sides of the cavity and curve sharply in distal portions to a sub-horizontal position. The tips of the basals may be visible in side view of the cup because of the deep impression of the interradial sutures. The basal plane is formed by the proximal bulges of the five radials. The five radials are tumid and are curved strongly longitudinally and transversely. The proximal tips are below the basal plane. They form the entire height of the cup and have an almost vertical face below the outer ligament area that almost reaches the basal plane. The anal plates are in normal arrangement (Primitive Type) in two of the specimens, but in one specimen the RA has lost contact with the right posterior (Normal Type A). The three plates (X, RA, and RX) are rather elongated, narrow elements. The entire posterior interradius is depressed, but the plates themselves are mildly tumid.

The primibrachs are large, tumid axillary plates, mildly extended as broadly blunted points. Other axillary brachials are mildly tumid but not spinose. The second branching takes place

with the fourth to sixth secundibrach. Nonaxillary secundibrachs, other than the large first secundibrachs, are relatively thin plates that are cuneiform, but may become biserial in isolated instances. After the second bifurcation, the arms lose considerable width and have rather flattened exteriors. They are fundamentally uniserial although the brachials are slightly wedge-shaped with a blunt termination rather than pointed.

The holotype has provision for 7 flat, spine-like plates at the distal termination of the umbrella-like anal sac, although one plate is missing. There are small polygonal plates forming the central disk of the terminating platform, but the exact number is not determinable.

Several proximal columnals are attached to one of the paratypes (OU 4048). They are in series of five with the two end ones wider than the others and girdled by a thin, sharp rim. The crenellae of the articular facets are visible in side view and interlock with those of the thinner adjacent columnals. These columnals are narrower and the lateral sides are flattened except for the longitudinally directed ridges that are outward manifestations of the crenellae. The central columnal of the series is not quite as thick or as wide as the two on the ends and it is girdled by a ridge that is not sharply produced. The ridge is mildly affected by the crenellae. The lumen appears to be round.

Measurements in millimeters:

	Holotype OU 4047	*Paratype OU 4049*
Height of crown	56.0	47.0
Width of crown	42.5	30.0[1]
Height of dorsal cup[2]	7.0	5.0
Width of dorsal cup (maximum)	23.0[1]	22.6
Height of basal concavity	3.0[1]	2.3+
Width of proximal columnals	3.8[3]	....
Length of basal*	7.8[3]	5.5[1]
Width of basal*	7.8[3]	5.6
Length of radial*	7.8	9.6
Width of radial*	11.7	13.7
Length of first primibrach*	9.8	....
Height of first primibrach	7.5	7.0[1]
Width of first primibrach*	9.6	11.0

* Measurement taken along surface curvature.
[1] Approximate.
[2] To transverse ridge.
[3] From paratype (OU 4048).

REMARKS.—This species differs from *Pirasocrinus scotti* in having a lesser number of arms, in having more numerous flat, spine-like plates at the termination of the anal sac, and in having the distal tips of the basal plates visible in side view of the cup. *P. depressus* differs from the associated *Schedexocrinus gibberellus* in having a lesser number of spinose terminating plates of the anal sac, and in having more bulbous radials. *Polygonocrinus multiextensus* has radials that are comparable to those of *Pirasocrinus depressus* but the basal invagination of that species is wider with gently sloping sides, and it has a much larger platform at the termination of the anal sac. *Plaxocrinus obesus* has a cup form that is more similar to the contour of the calyx of *Pirasocrinus depressus* than of most described species. *Plaxocrinus obesus* is reported to have a spinose primibrach and the basal concavity is not quite as narrow or as pronounced as in the present species.

TYPES.—Holotype and two paratypes are deposited in the paleontological collections of The University of Oklahoma, numbers OU 4047, 4048, and 4049.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Oklahoma.

Genus *Polygonocrinus* Strimple, new genus

GENOTYPE.—*Polygonocrinus multiextensus* Strimple, new species.

The crown is widely expanded and relatively short. There may be as many as 70 uniserial or partly biserial arms with isotomous branching. The anal sac has a wide terminating platform that is higher than the arms. The dorsal cup is low, broad, truncate bowl-shaped with a deep, broad basal concavity. The five infrabasals form a subhorizontal disk at the base of the concavity. The five basal plates are fundamentally confined to the basal concavity although their tips may be visible in side view of the cup, due to the deep, V-shaped depression between radial plates. There are three anal plates (X, RA, and RX) in normal arrangement (Primitive Type). The primibrachs are large, tumid, axillary elements. Second bifurcation is usually with the fourth secundibrach. The second and third secundibrachs are normally low and interlocking (biserial). Another regular branching takes place with about the

tenth tertibrach in most rays and there is further branching in some rays, in irregular pattern. Axillary brachials, above the first division, are mildly tumid with a small, nipple-like protrusion in midportion. Regular brachials are low elements that are in many cases interlocking (biserial). The brachials are transversely curved so that the arms have a rounded exterior for their entire length.

The terminating platform of the genotype species is composed of 32 small, polygonal plates surrounded by 14 large, flattened, latterally directed spine-like elements. The column is round.

REMARKS.—The genus has certain characteristics in common with several related genera. *Aatocrinus* is based on a dorsal cup and it has a profile in dorsal view that is comparable to that of *Polygonocrinus*. However, in the former the basal concavity is narrower and the cup is shallower. The basal plates are more prominent elements. *Schedexocrinus* has a different cup shape in profile when viewed from below or from the side, and the basals are tumid, relatively larger elements. The arms are endotomous but are otherwise rather similar in appearance and structure. The tegmenal spines have a longer base and typically taper more rapidly as they project from the base. The large size of the tegmenal platform and the expanded crown are elements in common with *Polygonocrinus*. *Sciadiocrinus* has a comparable terminating platform and the cup has a somewhat similar contour in cross section. However, the arms branch the second time with the second primibrach and the lateral sides of the brachials are of equal length, i. e., the sutures between brachials are subhorizontal. In *Polygonocrinus* the sutures are diagonal and the arms in many cases become biserial. *Pirasocrinus* has a deep basal concavity of the cup, tumid radials, tumid upper axillary brachials as well as the primibrachs and isotomous arms, all of which are also characteristic of *Polygonocrinus*. However, the crown of *Pirasocrinus* tapers appreciably to a small summit and a small tegmenal platform, quite unlike the broadly expanded crown of *Polygonocrinus* with its broad tegmenal platform. *Plaxocrinus* has endotomous arms, a relatively smaller tegmenal platform and the basals are usually visible in side view of the cup. *Metaperimestocrinus* develops a tegmenal platform that becomes comparable in size but it is elliptical and the spines are long and narrow at their flattened basal portion. The arms are also endotomous and the basal concavity covers a more limited

part of the cup. *Stenopecrinus* has endotomous arms, the basal plates are readily visible in side view of the cup and the tegmenal platform is much smaller.

In my opinion, the closest affinities are with *Schedexocrinus, Sciadocrinus,* and *Pirasocrinus.*

RANGE.—Desmoinesian; Oklahoma.

Polygonocrinus multiextensus Strimple, new species
Plate 2, figure 6; plate 11, figures 1, 2

The species is represented in the collections by three crowns and one dorsal cup with a small portion of the lower arms attached in some rays.

The dorsal cup is wide, low, truncate bowl-shaped with a broad basal concavity. It has a strongly pentagonal outline when viewed from below except for the depressed interradial areas and the posterior interradius. The concavity may be shallow or relatively deep. Five infrabasals occupy a subhorizontal plane at the base of the cavity and may be mildly downflared. Five basals are of medium size, are moderately depressed in mid-section and are usually entirely within the basal concavity. Five radials are large tumid plates. Their proximal tips are in the basal concavity and their lower portions form the basal plane. The distal portions curve sharply upward to become vertical below the summit of the cup. A deep notch is formed at the distal end of the interradial suture so that the articular facets do not fill the distal face of the plates. Five plates occupy the posterior interradius but only three are partially or entirely within the cup. Anal X, RA, and RX are in normal arrangement (Primitive Type), X_2 is directly above X and RX_2 is directly above RX. The summit of the anal pyramid is formed by X_2. RX is rather large, as well as is X_2. RX_2 is a narrower plate, and is not well preserved.

There are potentially 70 arms that are decidedly cuneiform and may become biserial. First primibrachs are axillary, large, tumid elements. The first secundibrachs are rather large, and quadrangular. The second and third secundibrachs are low and are normally interlocking (biserial). Second bifurcation is generally with the fourth secundibrach. The next bifurcation in most rays is with the tenth to twelfth tertibrach. In one arm it was observed

to take place with the sceond tertibrach in one ray. Another bifurcation takes place in some rays, at irregular heights. Axillary brachials are tumid and have nipple-like extensions in mid-portion. There is apparently one pinnule for each brachial. Segments of pinnules have been observed.

The distal, roof-like termination of the anal sac is made up of about 32 small plates surrounded by 14 flattened, spine-like, outward-directed, large plates. The broad bases of the flat spines are adjoined by two plates except in the right posterior where two spines are adjoined by three plates. Most of the smaller plates are in the posterior area, which indicates that new plates originate there and move toward the anterior. One of the paratypes has a unique tegmenal termination wherein the platform has regenerated for some reason, and a smaller platform, complete with spines, is immediately on top of the original platform, although it has not developed far enough to cover the original completely. Apparently the damaged area was in the central part of the platform and the main nerve cords were severed so that the animal's regenerative processes replaced the entire structure.

A few proximal columnals are poorly preserved in one paratype. They are alternatingly expanded, round segments with a small pentalobate lumen. The larger segments are not especially thickened and have rounded exteriors. The outward manifestations of the crenellae are visible at the sutures. The smaller segments are girdled by a thin undulating rim and the ridges and depressions of the crenellar markings are pronounced.

Measurements of the holotype in millimeters:

Length of crown	49.5
Width of the crown	65.5
Width of dorsal cup	33.4
Height of cup (to transverse ridge)	7.0
Width of infrabasal circlet	8.3
Length of basal (left anterior)	7.5*
Width of basal (left anterior)	7.7*
Length of radial (right anterior)	12.8*
Width of radial (right anterior)	17.8*

* Measurements along surface curvature.

REMARKS.—This species would be referred to *Sciadiocrinus* on the basis of the dorsal cup if the arms were not known, even though the radials do not closely approach the infrabasals as they normally

do in that genus. Differences with other forms have already been outlined under the generic remarks and need not be repeated here.

TYPES.—Holotype and three paratypes are deposited in the paleontological collections, The University of Oklahoma, Norman, Oklahoma, numbers OU 4059, 4062.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Family ADINOCRINIDAE Strimple, new family

Dicyclic; dorsal cup low, bowl shaped, pentagonal from above or below; IBB 5, small, confined to broad, shallow basal concavity; BB 5, small, confined to basal concavity, separated by proximal edges of RR; RR 5, large, reaching IBB circlet; anal plates 0 to 3; arms 10 to 40, isotomous, uniserial to biserial.

RANGE.—Mississippian and Pennsylvanian; North America and Russia.

GENERA.—*Adinocrinus* Kirk, 1938; *Protencrinus* Jaekel, 1918.

The genus *Adinocrinus* was placed under the family PIRASOCRINIDAE by Moore and Laudon (1943, p. 58). All other genera are of Pennsylvanian age and it would be inferred that *Adinocrinus* should reflect some antecedent characteristics. The genus is more advanced than most of the Pennsylvanian genera involved. Kirk (1938, p. 162) considered *Protencrinus* Jaekel from the Kohlenkalk, Miatschkowa, Russia, as a probable derivative of *Adinocrinus*. The anal plates have been entirely eliminated from the dorsal cup. It has 10 heavy, cuneate to biserial arms. The nodose, axillary PBrBr, shape of cup and separation of BB by RR are all closely comparable to characters of *Adinocrinus*. Moore and Laudon (1943, p. 59) place *Protencrinus* under the TIMORECHINIDAE Jaekel, 1918. All other genera under that family are from the Permian of the Island of Timor and typically have delicate arms in repose on a large, unique anal sac or tegmen.

Family CROMYOCRINIDAE Jaekel, 1918

A natural and phyletic grouping under the Cromyocrinidae is *Mantikosocrinus, Cromyocrinus, Dicromyocrinus, Ureocrinus, Cry-*

phiocrinus, Ulocrinus, and *Tyrieocrinus.* The arms of *Tyrieocrinus* are not known, but all the others have five or ten uniserial arms with the exception of *Ulocrinus* and a new genus to be described later as *Metacromyocrinus.* From material at hand, *Ulocrinus* is known to normally have ten biserial arms as has *Metacromyocrinus* also. All of the forms have two or three anal plates except *Tyrieocrinus* which has only one. The infrabasals are upflared in *Mantikosocrinus, Cromyocrinus, Tyrieocrinus, Ulocrinus,* and *Ureocrinus,* subhorizontal in *Dicromyocrinus* and *Metacromyocrinus,* and downflared in *Cryphiocrinus.*

PROPOSED CLASSIFICATION OF THE CROMYOCRINIDAE—

Genus: *Cromyocrinus* Trautschold

Genotype: *C. simplex* Trautschold—Upper Carboniferous, Russia.

Three anal plates, upflared infrabasals, five uniserial arms.

Genus: *Tyrieocrinus* Wright

Genotype: *T. laxus* Wright—Lower Carboniferous, Scotland.

One anal plate, upflared infrabasals, arms unknown.

Genus: *Dicromyocrinus* Jaekel

Genotype: *D. ornatus* (Trautschold) — Upper Carboniferous, Russia.

Three anal plates, subhorizontal infrabasals, ten uniserial arms.

Genus: *Ureocrinus* Wright and Strimple

Genotype: *U. bockschii* (Geinitz)—Lower Carboniferous, Scotland.

Three anal plates usually Advanced Type with radianal the dominant element, upflared infrabasals, five uniserial arms.

Genus: *Mantikosocrinus* Strimple

Genotype: *M. castus* Strimple—Lower Carboniferous, North America.

Three anal plates, upflared infrabasals, ten uniserial arms.

Genus: *Cryphiocrinus* Kirk

Genotype: *C. girtyi* Kirk — Lower Carboniferous, North America.

Three anal plates, downflared infrabasals (basal invagination of dorsal cup), ten uniserial arms.

Genus: *Ulocrinus* Miller and Gurley

Genotype: *U. buttsi* Miller and Gurley—Upper Carboniferous and Lower Permian, North America.

Two anal plates, upflared infrabasals, ten biserial arms.

Genus: *Metacromyocrinus* Strimple, new genus

Genotype: *M. holdenvillensis* Strimple, new species—Upper Carboniferous, North America.

Two anal plates, subhorizontal infrabasals, ten biserial arms.

Genus *Cromyocrinus* Trautschold, 1867

In order to verify the existence of *Cromyocrinus,* sensu stricto, in rocks of North America, it is necessary to have specimens with the arms attached. The genus is reported to have three anal plates in the posterior interradius, upflared infrabasal plates visible in side view of the dorsal cup, and five uniserial arms. The only North American species currently referred to the genus is *C. grandis* Mather, from the Morrow series, for which the arms are not known.

Species assigned to *Cromyocrinus:*

	Age	*Present Assignment*
Cromyocrinus simplex Trautschold	Upper Carboniferous (Moscovian), Russia	*Cromyocrinus* genotype
C. grandis Mather	Upper Carboniferous (Morrow), N. America	*Cromyocrinus*
C. globosus (Worthen)	Lower Carboniferous (Chester) N. America	*Agassizocrinus*
C. geminatus Trautschold	Upper Carboniferous (Moscovian), Russia	*Dicromyocrinus*
C. ornatus Trautschold	Upper carboniferous (Moscovian), Russia	*Dicromyocrinus* genotype
C. hemisphericus (Worthen)	Lower Carboniferous (Chester), N. America	Syn. *C. papillatus*
C. papillatus (Worthen)	Lower Carboniferous (Chester), N. America	*Agassizocrinus*
C. buttsi (Miller & Gurley)	Upper Carboniferous (Missouri), N. America	*Ulocrinus* genotype
C. sangamonensis (Meek & Worthen)	Upper Carboniferous (Missouri), N. America	*Ulocrinus*
C. kansasensis (Miller and Gurley)	Upper Carboniferous (Missouri) N. America	*Ulocrinus*

C. gracilis Wetherby	Lower Carboniferous (Chester), N. America	*Pentaramicrinus* genotype
C. nuciformis (McCoy)	Lower Carboniferous Scotland	Syn. *Ureocrinus bockschii*

Genus *Dicromyocrinus* Jaekel, 1918

Dicromyocrinus Jaekel (1918, p. 66) was introduced for "*Cromyocrinus nodosus* Traut. with ten arms," i. e., as distinct from forms with five arms. As there is no such species as "*C. nodosus* Trautschold" and there is a species *C. ornatus* Trautschold, it is apparent that Jaekel made a mistake in the specific name. However, the name *Dicromyocrnius* was a nomen nudum. Moore and Laudon accordingly listed (1943, p. 104) *Dicromyocrinus* among a series of unrecognizable genera for which no type species were known. The species *Cromyocrinus geminatus* Trautschold was taken as the genotype of *Mooreocrinus* Wright and Strimple (1945, p. 221). Wright and Strimple and Moore and Laudon had overlooked the fact that Moore and Plummer (1940, p. 367) had cited *Dicromyocrinus ornatus* (Trautschold) as type species. Wanner (in Hennig and Schindewolf, 1948, p. 336) pointed out that this selection is valid under Article 30 of the Rules of Zoological Nomenclature. *Mooreocrinus* is therefore a synonym of *Dicromyocrinus*.

At this time, there is no record of a form in North America having the cup shape and the three-plated anal arrangement of *Dicromyocrinus* for which ten uniserial arms are known. Several species have been assigned to the genus on the basis of cup shape and the primitive arrangement of the anal plates of the posterior interradius. With the discovery of a form in the Des Moines series having sixteen biserial arms, yet otherwise assignable to the genus, the impracticality of assignment of American species to the genus becomes apparent. The form with sixteen arms is considered further under the new family, ETHELOCRINIDAE.

Species assigned to *Dicromyocrinus:*

	Age	*Present Assignment*
Dicromyocrinus hemisphericus (Worthen)	L. Carboniferous, (Chester), Ill.	Syn. *Agassizocrinus papillatus*
Dicromyocrinus papillatus (Worthen)	L. Carboniferous, (Chester), Ill.	*Agassizocrinus*
Dicromyocrinus bowsheri (Strimple)	L. Carboniferous, (Chester), Okla.	*Cryphiocrinus*

Dicromyocrinus optimus (Strimple)	U. Carboniferous, (Morrow), Okla.	*Ataxiacrinus* Strimple, n. g.
Dicromyocrinus periodus Strimple	U. Carboniferous, (Missouri), Kans.	*Ataxiacrinus*
Dicromyocrinus meadowensis Strimple	U. Carboniferous, (Missouri), Nebr.	*Ataxiacrinus*
Dicromyocrinus geminatus (Trautschold)	U. Carboniferous, Russia and L. Carboniferous, Scotland	*Dicromyocrinus**
Dicromyocrinus ornatus (Trautschold)	U. Carboniferous, (Moscovian), Russia	*Dicromyocrinus* genotype

Genus *Cryphiocrinus* Kirk, 1929

In 1949, I described a species from the Hindsville formation (formerly termed Mayes formation), Chester series, as *Mooreocrinus bowsheri* Strimple. As explained in the discussion of *Dicromyocrinus, Mooreocrinus* is a synonym of *Dicromyocrinus.* The assignment of the species was rather arbitrary as many characteristics were more comparable to *Cryphiocrinus.* The existence of a column, primitive arrangement of the anal plates and lack of knowledge of the arm structure of *Cryphiocrinus* influenced my decision to place the species under *"Mooreocrinus."* Subsequent studies have convinced me that the species is referrable to *Cryphiocrinus,* although it is slightly more primitive than typical species.

Only two other species of the genus are known, *Cryphiocrinus girtyi* Kirk (1929), the genotype, from an unnamed horizon high in the Chester series of West Virginia, and *C. rotundus* Kirk (1929) which, according to Kirk, is from high in the Chester series of Breckenridge County, Kentucky. There is a tendency for the right tube plate to be eliminated from the dorsal cup, although it is present in two of the three known specimens. A columnar cicatrix

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* *Dicromyocrinus geminatus* (Trautschold) from the Kohlenkalk (Pennsylvanian) of Russia has ten heavy, uniserial arms with slightly cuneate brachials. The dorsal cup is rather large and the infrabasals more or less subhorizontally directed. Jaekel (1918, fig. 55) shows the tips of the infrabasals to be visible in side view of the calyx. The form from the Lower Carboniferous (Mississippian) of Scotland, assigned by Wright (1952, p. 111) to *Dicromyocrinus geminatus* is a thin-plated crinoid with ten delicate uniserial arms. The exact nature of the Scottish specimens is not known, i.e., for the basal area, due to lateral compression, but the anal plates are in normal, or primitive, arrangement as in the Russian specimens. It is rather doubtful that the older Scottish form is conspecific with *D. geminatus.*

is preserved and five infrabasals are known to be present in one specimen of *C. rotundus*. Kirk (1929, p. 156) noted, "Probably no column is present in the fully adult stage, though the presence of a column would not exclude a crinoid from the genus." If a column is present a centrale could not be developed. There is considerable constriction of the upper part of the cup in the two species.

Cryphiocrinus bowsheri (Strimple), new combination

This form has the large, long basals of the genus together with the deep basal invagination of the calyx. The upper portion of the cup is constricted. Although a column is present, it is too small to have acted as an effective stalk. The species was probably eleutherozoic in habit, as Kirk considered the genus to be. The infrabasals are small and the radials are relatively small. Three anal plates occupy the posterior interradius and are in normal, or primitive, arrangement. There are ten uniserial arms branching with the first primibrach in all rays. The arms have well-rounded exteriors.

Kirk considered *Cryphiocrinus* to belong under the family CROMYOCRINIDAE Jaekel, and I am in agreement.

Genus *Metacromyocrinus* Strimple, new genus

GENOTYPE.—*Metacromyocrinus holdenvillensis* Strimple, new species

The genotype of *Parulocrinus* is *Ulocrinus blairi* Miller and Gurley, for which the exact horizon and location is not known and of which only a dorsal cup is preserved. It is doubtful that topotype specimens will ever be found and therefore that the arm structure will ever be known. The species is not far removed from typical *Ulocrinus,* indeed it is so close that assignment to the genus is natural. Other forms that have been assigned to *Parulocrinus* are not too closely comparable with *Ulocrinus blairi.* For these reasons, I propose the genus *Parulocrinus* be suppressed.

The species that Moore and Plummer (1940) used as typical of *Parulocrinus* was *P. marquisi* Moore and Plummer (1940), for which species the stratigraphic horizon is unknown although it is inferred to be of Missourian age. The basal elements of the dorsal

cup and the anal plates are not preserved in place but a shallow basal concavity, with relatively large, subhorizontally directed infrabasals, and the existence of two anal plates is probably properly assumed. There are ten, heavy, biserial arms that branch with the axillary first primibrachials. The phyletic line to which this species belongs is known from the Morrowan (*Ethelocrinus oklahomensis* Moore and Plummer, 1938, after Strimple, 1940), and is now known from the Desmoinesian as represented by a new species described below.

The group could hardly have evolved from any form ascribed to the EUPACHYCRINIDAE, but is affiliated with the CROMYOCRINIDAE.

Species assigned to *Metacromyocrinus*:

	Occurrence	*Remarks*
Metacromyocrinus holdenvillensis Strimple, n. sp.	Desmoinesian; Okla.	*Metacromyocrinus* genotype
Ethelocrinus oklahomensis Moore & Plummer, 1938	Morrowan; Okla.	*Metacromyocrinus*
Ethelocrinus sphaeri Strimple, 1949	Desmoinesian; Okla.	,,
Parulocrinus marquisi Moore & Plummer, 1940	Missourian; Tex.	,,

Regressive evolution is shown in that *Metacromyocrinus oklahomensis* has a shallow, but decided basal concavity, with mildly downflared IBB. In *M. holdenvillensis* the base is mildly convex and the IBB are wider, with a mildly upflared attitude. Progressive evolution is from upflared to subhorizontal to downflared IBB. *M. oklahomensis* has a unique development of the arms, slightly above mid-height, where the brachials expand into spine-like projections, but remain interlocked and do not bifurcate.

RANGE.—Pennsylvanian (Morrowan to Desmoinesian); Midcontinent region, North America.

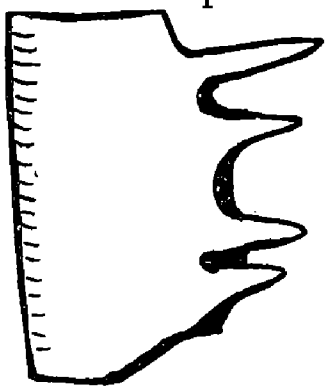
Metacromyocrinus holdenvillensis Strimple, new species
Plate 6, figures 1-3; text-figures 16-18

This species is based on eight crowns or partial crowns. The dorsal cup is medium globe-shaped, with sub-horizontal infrabasals. The distal tips of the infrabasals are visible in side view of the cup. One paratype has a cup height of 2.7 centimeters and cup width of 4.8 centimeters. There are ten thick, biserial arms that branch with

the first primibrach. A length of 9.9 centimeters has been noted for the arms of one smaller paratype, without indication of approaching termination.

Five infrabasals form a pentagonal disk. The mid-portion is sharply impressed for the reception of the proximal columnal. Distal portions of the infrabasals are mildly upturned and each plate is marked by prominent ridges that are more or less parallel to the sutures. There is also a longitudinal ridge down the center of the plate. Five large basals are almost as long as wide, and are strongly curved longitudinally as well as transversely. They are marked by prominent, round tubercles that do not appear to have any pattern. Five large radials are pentagonal and are strongly marked by prominent, round nodes that have no apparent pattern. A horizontal shelf, about 2.0 millimeters long, is to the fore of the outer ligament area. The shelf is not apparent in side view of the cup, although the primibrachs do appear to be set inward. The shelves are readily apparent from an oblique view. There are two large anal plates within the cup, arranged as Special Type C. RA is quadrangular. X is missing in the holotype but the outline is preserved. It is pentagonal but there are actually eight facets. Two of the facets are occupied by plates above, the left one being considerably larger than the right one.

First primibrachs are axillary, wide, low, and have strong transverse curvature in their upper portions, especially toward the lateral sides. They are marked by a double row of prominent, round nodes. The area below the proximal row of nodes is sharply depressed.



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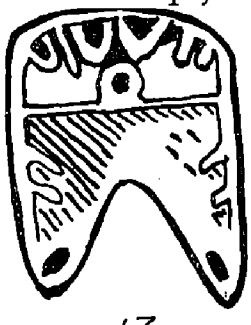

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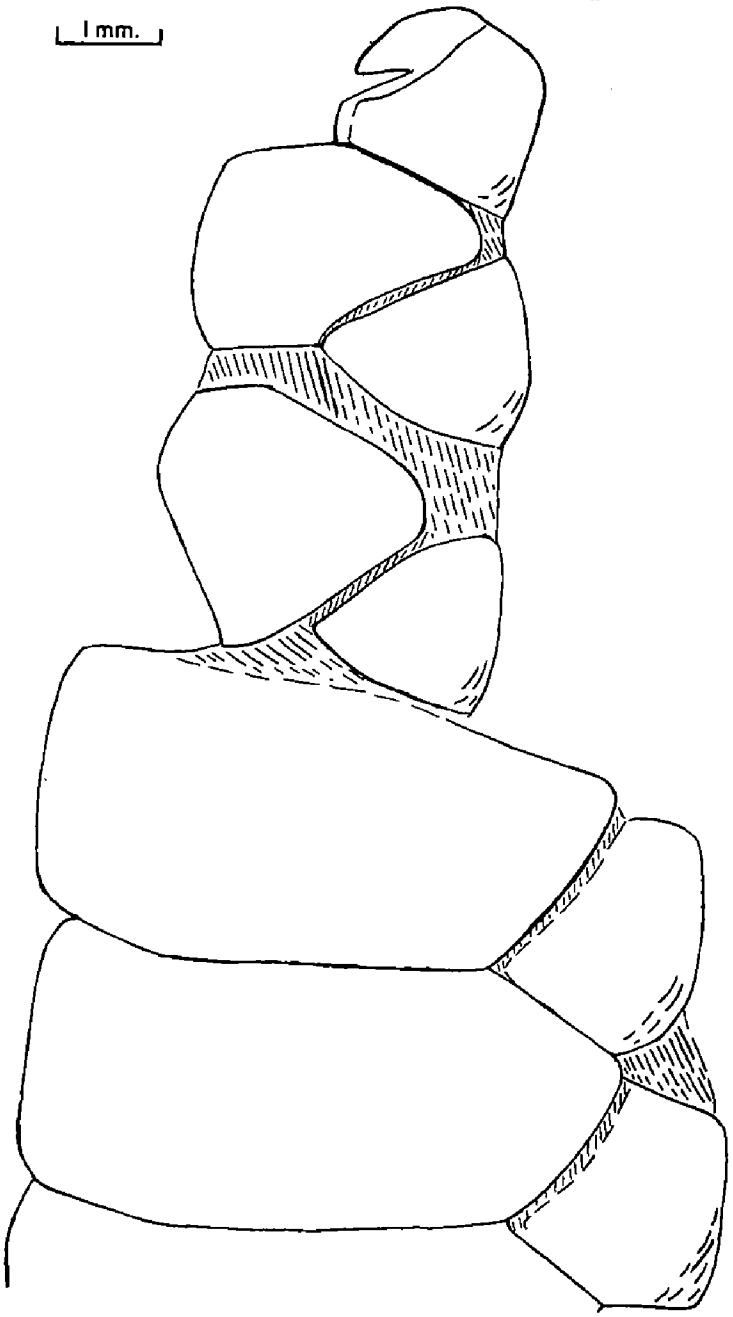
TEXT-FIGURES 16, 17. *Metacromyocrinus holdenvillensis*, n. sp. Drawing of a pinnular from the side and from below, enlarged x11. A pore just above the transverse ridge, in mid-section, probably represents the axial canal.

First secundibrachs are rather large, quadrangular elements and are marked by six or seven strong nodes that may become confluent. Following brachials are interlocking (biserial), and have double nodes, one near the outside and the other near the center of the arm. These nodes have a tendency to run together. Pinnules are present and are in many specimens preserved in place. They are narrow, long elements, with flattened exteriors in their proximal region but becoming keeled near their distal tips. Facets for their



TEXT-FIGURE 18. *Metacromyocrinus holdenvillensis*, n. sp. Drawing showing the regeneration of an arm of a paratype.

reception on the inner lateral sides of the brachials are well developed. The facets are high on the plate but do not affect the base of the plate above. The proximal pinnulars have long, inwardly directed extensions along both lateral sides and these extensions are grooved on the interior. Undoubtedly they are to serve the cilia. The articular facets between pinnulars are horse-shoe shaped and have a flattened surface that is divided from the ambulacral area by a transverse ridge. This surface has denticles around the outer sides, and in mid-section, just above the transverse ridge, there is a small, round opening that probably served the axial cord. The entire surface below the transverse ridge is depressed and the lateral edges are in many cases marked by denticles. The innermost areas, which are the two points of the horse-shoe, are markedly depressed in mid-portion, possibly representing points of attachment for ligaments.

In a large paratype, OU 4128, the upper arms have been lost and regenerated arms are present. The original arm has a width of 6.5 millimeters and the regenerated arm 3.2 millimeters. The new segments are set well back so that the ambulacral grooves are confluent. The new brachials have proportionately longer lateral sides, as one would expect, and are in biserial arrangement. Text-figure 18 illustrates a regenerated arm. In paratype OU 4127, the right ray of the anterior arm is partially preserved and is uniserial insofar as the three segments shown are concerned. Unfortunately none of the other arms is exposed and I was unable to uncover any.

The round column is rather small for such a massive crinoid. Proximal segments do not fill the impressed area provided for their reception in mid-portion of the infrabasal circlet. I suspect that this was to provide mobility from side to side. In the holotype, OU 4125, there are at least two proximal columnals within the impressed area. The segments are thin, annulated and they are alternatingly expanded. About six segments are preserved outside the impressed area at which point the wider columnals appear to attain more thickness, but they are still low elements. The crenellae are fine, long ridges and are well defined. In paratype OU 4130, there are 45 crenellae of the articular surface. The lumen is rather large and decidedly pentalobate.

Measurements of the holotype in millimeters:

Height of dorsal cup	22.3
Width of cup (maximum)	40.8
Width of cup (posterior to anterior)	36.6
Width of infrabasal circlet	17.2
Diameter of proximal columnals	5.0
Length of basal (right anterior)	20.0*
Width of basal (right anterior)	23.0*
Length of radial (anterior)	15.0*
Width of radial (anterior)	23.8*
Length of radianal	17.0*
Width of radianal	13.0*
Length of anal	13.1*
Width of anal	12.2*

* Measurement taken along surface curvature.

REMARKS.—In *Metacromyocrinus oklahomensis* the infrabasals are gently downflared and occupy a shallow basal concavity. The ornamentation is of two types, pronounced rounded nodes, and small rounded granules between nodes. The arms are strongly protruded just above mid-height by thickening and extension of the brachials. The species is quite unlike the present form. *M. sphaeri* has a lower calyx due to the basals participating in the basal area, and the ornamentation is not so pronounced as in *M. holdenvillensis*. It is possible that *M. marquisi* has a comparable cup shape but the holotype, and only known specimen, is too badly disarranged for one to be certain. The ornamentation is much weaker and is of a different nature than that of the present species. There is a girdle-like ridge below the outer ligament furrow of the radials that is quite unlike the horizontal shelf found in *M. holdenvillensis*. Aside from the differences given, the appearance of the arms, including the primibrachs, is almost identical for the two species.

TYPES.—Holotype (OU 4125) and seven paratypes are deposited in the paleontological collections of The University of Oklahoma, numbers OU 761, 4125-4131.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Genus *Ulocrinus* Miller and Gurley, 1890

GENOTYPE.—*Ulocrinus buttsi* Miller and Gurley, 1890.

It is my present thought that *Ulocrinus* evolved out of a Chesterian (Mississippian) form like *Mantikosocrinus* Strimple through a Morrowan (Pennsylvanian) species like *Cromyocrinus grandis* Mather. This concept was recently advanced (Strimple, 1961) under a discussion of *Mantikosocrinus castus* Strimple. The arms are not known for *C. grandis* and the species is therefore only tentatively ascribed to the genus.

Based on the characters of *Ulocrinus buttsi* and other valid representatives of the genus, we are dealing with a smooth, rather thin-plated form, with mildly upflared infrabasals that are visible in side view of the dorsal cup. There are only two anal plates in the posterior interradius. Considerable variation in the placement of the anal plates exists. The arms are ten and have been thought to be uniserial (Wright and Strimple, 1945) with cuneate brachials. This was based on two specimens from the Wann formation, Ochelata group, Missourian of northeastern Oklahoma. One was a young specimen ascribed to *U. convexus* (Strimple) with a portion of the arms preserved, and a large specimen with portions of all ten arms preserved, designated as *U. buttsi* by Wright and Strimple. A typical representative of *U. buttsi* has subsequently been reported from the Hogshooter formation, Skiatook group, Missourian of northeastern Oklahoma (Cronoble, 1960), and it now seems possible that the specimen from the Wann formation is not conspecific with *U. buttsi.* Although about 10 segments of the arms were preserved in one ray it is still possible that the arms became biserial in their upper portions. Or it may even be that slippage of the brachials caused a misinterpretation. In any event, the arms appear to be primarily biserial as shown by the new species described herein.

Species assigned to *Ulocrinus*:

	Age	*Present Assignment*
Ulocrinus buttsi Miller & Gurley	Pennsylvanian, Missourian; Mo. & Okla.	*Ulocrinus* genotype
U. sangamonensis (Meek & Worthen)	Pennsylvanian, Missourian; Ill.	*Ulocrinus*

U. kansasensis Miller & Gurley	Pennsylvanian, Missourian; Mo.	"
U. americanus (Weller)	Lower Permian; Texas	"
U. convexus (Strimple)	Pennsylvanian, Missourian; Okla.	"
U. occidentalis Miller & Gurley	Pennsylvanian, Missouri	? "
U. ? goliathus (Waagen)	Permian; India	? "
? U. indicus Wanner	Permian; Timor	? "
? U. conoideus Wanner	Permian; Timor	? "
U. uralensis Yakovlev	? Penn. (Permo-Carboniferous); Russia	"
U. blairi Miller & Gurley	Pennsylvanian, Missourian; Mo.	"
U. caverna Strimple	Pennsylvanian, Missourian; Kans.	"
U. elongatus Strimple, n. sp.	Pennsylvanian, Desmoinesian; Okla.	"
U. bockschii (Geinitz)	Mississippian; Germany & Great Britain	*Ureocrinus*
U. doliolus Wright	Mississippian; Scotland	"
U. globularis (de Koninck)	Mississippian; Great Britain	Syn. *Ureocrinus bockschii*
U. nuciformis (Mc Coy)	Mississippian; Great Britain	" "

Ulocrinus elongatus Strimple, new species
Plate 6, figures 5, 6

A partial crown in magnificent, undistorted preservation is selected as the holotype of this species. It is remarkable to find such a large cup of this genus because, in spite of its rugged appearance, the plates are thin, thereby affording little surface for holding the plates in position. Optimum conditions, or pure chance, are required for their preservation. The matrix surrounding the holotype was dense and most of the specimen was practically carved from the limestone. The longest section of arms is attached to a smaller paratype and is 8 cm long with no indication of approaching termination. As previously noted under the generic discussion, the arms

are ten, biserial, and branch with the axillary primibrachs in all rays. The first two secundibrachs are quadrangular (uniserial), thereafter the brachials are interlocking (biserial). The surfaces of the arms are strongly curved.

The cup expands uniformly for more than half its height, thereafter the lateral sides rise vertically with no further expansion. Five IBB are large elements, forming a petal-like, erect disk or cone, and are readily visible in side view of the cup. The base of the IBB disk is impressed for the reception of the proximal columnal. The disk expands evenly from the flattened proximal area. Five BB are large, elongate-appearing plates, but actually have a width only slightly less than the length. They are mildly tumid in upper portions. Five large radials are wider than long. Those of the right and left posterior are about 3 mm narrower than the other three radials. Articular facets have not been observed but there is a gap between the summit of each radial and the primibrach above. RA is a large quadrangular plate resting obliquely on the right shoulder of the posterior basal and supported to the right by the right posterior basal. It supports the lower left facet of the right posterior radial to the right above and the lower right facet of anal X to the left above. Anal X is pentagonal, large and rests solidly on the relatively short upper facet of the posterior basal. It does not extend above the summit of the cup in the holotype, but does so in one of the paratypes.

The articulating facet of the proximal columnal has been damaged in preparation of the specimen but the presence of strong crenellae is noted. The lumen is rather large and is strongly pentalobate.

Measurements of the holotype in millimeters:

Width of calyx (maximum)	44.7
Width of calyx (posterior to anterior)	42.1
Height of calyx	39.5
Ratio of height to width	0.88
Height of infrabasal circlet	10.2
Width of infrabasal circlet	25.6
Width of proximal columnal	7.7
Length of basal (right anterior)	30.0 *
Width of basal (right anterior)	26.2 *
Length of sutures between basals	16.7 *
Length of radial (right anterior)	15.8 *
Width of radial (right anterior)	26.2 *

Length of sutures between radials	10.5 *
Length of anal X	12.6 *
Width of anal X	12.6 *
Length of RA	17.3 *
Width of RA	13.5 *
Height of first primibrach	9.3
Width of arms 4.5 cm above cup	7.5

* Measurement taken along the surface curvature.

REMARKS.—All other species ascribed to the genus have a longitudinal curvature to the infrabasal circlet so that it is in the form of a bowl rather than conical as in *U. elongatus.* In the holotype of *U. buttsi* the base of the infrabasal circlet is missing but the curvature of the infrabasals is apparent and is substantiated by the specimen figured by Cronoble (1960) from the Hogshooter formation, Skiatook group, Missourian of northeastern Oklahoma. The contour of the infrabasals is also reflected by the angular meeting between the infrabasal circlet and the basal circlet. In *U. elongatus* the surface between the infrabasal and basal circlets is evenly confluent except for the groove-like impression of the sutures. The same comparison may be made with *U. sangamonensis, U. convexus,* and *U. kansasensis,* which species have lower and proportionately greater width to the dorsal cups, as well as other differences. *U. blairi* and *U. caverna* have a different cup shape, being more globular with low infrabasal circlets. The infrabasals have unflared attitudes in both species but there is no abrupt angle at the junction of infrabasals and basals, which junction is not visible in side view of *U. blairi.*

TYPES.—Holotype and one paratype are deposited in the paleontological collections of The University of Oklahoma, numbers 4040, 4041.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Okla.

Family ETHELOCRINIDAE Strimple, new family

GENERA.—	*Age*
Intermediacrinus Sutton and Winkler	Mississippian-Chesterian

Ethelocrinus Kirk	Pennsylvanian-Missourian
Parethelocrinus Strimple, n. g.	Pennsylvanian-Morrowan to Missourian
Aglaocrinus Strimple, n. g.	Pennsylvanian-Desmoinesian and Missourian
Ataxiacrinus Strimple, n. g.	Pennsylvanian-Morrowan to Missourian

Condensed analysis of the primary characteristics of Pennsylvanian genera are as follows:

I. a. Broad, low cup with deep basal invagination and downflared IBB.
   b. Two anal plates within cup.
   c. More than 10 biserial arms, bifurcating in proximal portions.
   d. Strong pustules and/or ridges ..... *Ethelocrinus*

II. a. Broad, rather low cup with shallow or no basal concavity and broad, subhorizontal infrabasal circlet.
   b. Two anal plates within cup.
   c. More than ten arms bifurcating in proximal portions.
   d. Smooth or granular surface.
   e. Sutures not appreciably impressed ..... *Parethelocrinus*

III. a. Same as II except surface mildly nodose and sutures deeply impressed ..... *Aglaocrinus*

IV. a. Broad, rather compact cup with shallow or no basal concavity and broad, subhorizontal infrabasal disk.
   b. Three anal plates within cup.
   c. More than ten biserial arms, bifurcating in proximal portions ..... *Ataxiacrinus*

The above division into genera is based on known forms that are in possession of their arms. It appears to be adequate for assignment of forms without arms; however, future discoveries will no doubt prove it to be inadequate. For example, the dorsal cup of *Metacromyocrinus marquisi* (Moore and Plummer) could be assigned to *Aglaocrinus* without knowledge of the arms. It is recognized that a further division might be desirable for the group

covered by *Ataxiacrinus,* as between those with nodose surfaces and those that are smooth. There are not enough complete specimens to establish the full characters at this time.

RANGE.—Mississippian (Chesterian) to Pennsylvanian (Missourian); Midcontinent region, North America, and South America.

Genus *Ethelocrinus* Kirk, 1937

GENOTYPE.—*Eupachycrinus magister* Miller and Gurley, 1890.

Consideration of the proposition that *Eupachycrinus* may be ancestral to *Ethelocrinus* leads to critical examination of the various species to establish the exact trend that might lead to the younger genus. Moore and Plummer (1940, fig. 69) published an excellent drawing of the typical arms of both *Ethelocrinus* and *Eupachycrinus.* A simplified chart showing the position of the arms is given below:

	left anterior		left posterior		right posterior		right anterior		anterior		Total
Ethelocrinus (typical)	1	1	2	2	2	2	1	1	2	2	16
Eupachycrinus (typical)	2	1	2	1	1	2	1	2	1	1	14

Without looking farther, it is obvious that *Ethelocrinus* did not evolve from a typical *Eupachycrinus* because the pattern of arm development does not agree. That is, one would expect *Ethelocrinus,* with a greater number of arms, to add to the more readily available rays. Instead, in some rays arms are dropped, and in the anterior ray, which one would expect to remain static, two extra arms are added. Fortunately there is a known species, *Eupachycrinus asperatus* Worthen, which might reprsent the trend leading to the Pennsylvanian forms. In this species there are only thirteen arms with the extra arms in the right posterior and left posterior rays, the remaining three rays having only two arms each. Under this arrangement, right and left anterior rays have only two arms each, which pattern is followed by most Pennsylvanian species of *Ethelocrinus.* In addition, the species has a somewhat advanced arrangement of the posterior interradius, wherein RA has become elongate to the point of pushing RX entirely above the summit of the calyx. The species was taken as the genotype of *Intermediacrinus* Sutton and Winkler (1940); however, those authors

did not believe the arrangement of the arms to be typical of the genus. They also assigned *Eupachycrinus spartarius* Miller, which has 14 arms in typical *Eupachycrinus* arrangement, to the genus. *E. asperatus* has another distinctive feature, which is not typical of *Eupachycrinus,* this being the existence of angular protruberances or nodes on the BB, RR and PBrBr. Moore and Laudon (1943) placed *Intermediacrinus* into synonomy under *Eupachycrinus* as well as did Bassler and Moodey (1943). In the light of the new evidence, I believe the genus to be valid, although I do not favor assignment of either *E. spartarius* or *E. tumidus* (Sutton and Winkler) to the genus.

The arm sructures of several known Pennsylvanian species of *Ethelocrinus* together with *Intermediacrinus* and some new genera are given below:

	left anterior		left posterior		right posterior		right anterior		anterior		Total
Intermediacrinus asperatus	1	1	2	2	3*		1	1	1	1	13
Parethelocrinus millsapensis	1	1	3*		3*		1	1	1	1	12
Parethelocrinus watkinsi	1	1	3*		2	1	1	1	1	1	12
Parethelocrinus plattsburgensis	1	1	2	2	2	2	1	1	2	2	16
Aglaocrinus magnus	1	1	2	2	2	2	1	1	2	2	16
Ataxiacrinus multiramus	1	1	2	2	2	2	1	1	2	2	16

There is another consideration which is the nature of the basal area of the dorsal cup. *Intermediacrinus* and *Eupachycrinus* have pronounced basal invagination, with infrabasals in downflared position and confined to the concavity. On the other hand, the species described as *Eupachycrinus modernus* Strimple (1951) has a rather shallow basal concavity, with more or less subhorizontal IBB and the arms reflect a partial transition in position of bifurcation, being closer to *Intermediacrinus* than to typical *Eupachycrinus*. The species is tentatively assigned to *Intermediacrinus*. Most ethelocrinids have a shallow basal concavity with IBB in subhorizontal position. It must be concluded that regressive evolution produced the forms lacking pronounced basal invagination.

* Exact position either not known or not given in descriptions.

Ethelocrinus magister, the genotype species, still retains a sharp basal invagination and downflared infrabasals. It is a highly ornate form which feature was taken as of generic importance by Kirk when he proposed the genus. Current studies support Kirk's concept and I believe we will eventually find forms from lower horizons that will lead directly back to the ornate *Intermediacrinus asperatus,* or to a closely comparable form. *Ethelocrinus ardmorensis* Strimple, 1949, from the Pumpkin Creek limestone, Big Branch formation, Desmoinesian, does not strictly follow the requirements of the genus in that it has a rough surface but is not highly ornate. But the strongly downflared infrabasals indicate close relationship. *Ethelocrinus sphaeralis* (Miller and Gurley) has even more rugose ornamentation than *E. magister.*

Genus *Intermediacrinus* Sutton and Winkler, 1940

GENOTYPE.—*Eupachycrinus asperatus* Worthen, 1882.

A rather comprehensive discussion of the genus, as modified, has previously been given under discussion of *Ethelocrinus* and will not be repeated here. I do want to emphasize that the new generic concept does not allow for inclusion of *Eupachycrinus spartarius* Miller which has bifurcation of the arms that is typical of *Eupachycrinus.*

Intermediacrinus modernus (Strimple), new combination, has a transitional stage of arm bifurcation, and the basal area is comparable to Pennsylvanian forms of the family. The arms branch once in all rays with PBr_1ax. The left anterior and anterior rays do not develop more arms. In the left posterior and right anterior rays a second branching takes place with the first SBr in anterior position. In the right posterior a second branching occurs with the first SBr in posterior position.

RANGE.—Mississippian, Chesterian; Illinois and Oklahoma, North America.

Genus *Parethelocrinus* Strimple, new genus

GENOTYPE.—*Parethelocrinus ellipticus* Strimple, new species.

The dorsal cup is broad, rather low, with shallow basal concavity, or none, and with broad subhorizontal infrabasal circlet

composed of five infrabasals. Five basals are large with lower portions in the basal plane and distal portions visible in side view of the cup. Five radials are large, wider than long, do not extend into the basal concavity. There are two anal plates (X and RA) within the dorsal cup. The arms are 12 to 16 in number, biserial, and bifurcate in all rays with the first primibrachs. A second bifurcation is with the first secundibrach in some rays of the left posterior and right posterior, and in some species in the anterior ray. The left anterior and right anterior rays remain unbranched above the first primibrach. The surface of the plates is smooth or slightly granular. Sutures between cup plates are not appreciably impressed. Column is round.

Intermediacrinus modernus, or some comparable smooth form, is thought to be ancestral to this genus.

The species *Ethelocrinus variabilis* is being referred to this genus. It was originally reported as being from the Otterville formation, which is currently considered to be of Morrowan age. Mr. Frank Crane, who found the holotype of that species, advises that the exposure is near C south line sec. 30, T. 3 S., R. 12 E., Carter County, north of Ardmore, Oklahoma. The exposure has been considered to be Pumpkin Creek in age but the abundance of the coral *Caninia torquia* suggests Frensley. From my personal observations in the area I am inclined to consider it to be the Frensley formation, Dornick Hills group, Desmoinesian.

Species assigned to *Parethelocrinus:*

	Occurrence	*Remarks*
Parethelocrinus ellipticus, n. sp.	Desmoinesian; Okla.	Genotype
Ethelocrinus varibilis Strimple, 1949	Desmoinesian; Okla.	*Parethelocrinus*
E. plattsburgensis Strimple, 1938	Missourian; Okla.	”
E. millsapensis Moore & Plummer 1940	Desmoinesian; Tex.	”
E. watkinsi Strimple, 1949	Desmoinesian; Okla.	”
Parulocrinus beedei Moore & Plummer, 1940.	Missourian; Tex.	”

RANGE.—Pennsylvanian (Desmoinesian, Missourian); Midcontinent Region, North America.

Parethelocrinus ellipticus Strimple, new species
Plate 8, figures 4, 5; plate 18, figures 1, 2; plate 19, figure 5

There are 46 specimens of the species in the collection. Six specimens that are remarkably similar in size and appearance were primarily considered in the description of the species. The protrusion of the area about and including the radianal is readily apparent in basal view of the calyx. If only one specimen were known I would consider this to be a more or less aberrant condition, but it is a normal character in fully mature specimens of the species. Not only is the cup protruded, it is also deeper in the right posterior-right anterior radii. To illustrate the effect, the suture between the right posterior and right anterior radials is 7.1 millimeters long, but in the left posterior and left anterior radial suture it is 4.9 millimeters long. The small size of the infrabasal disk as compared to the large size of the cup is also a distinctive feature.

There is a wide, shallow basal concavity with about one-third of the basals participating together with the entirety of the infrabasals. The five infrabasals project well beyond the column and form a pentagonal disk that is slightly downflared in some instances. There is a sharply impressed median area for the reception of the proximal columnal. Five basals are large plates with length only slightly greater than width. The curvature out of the basal concavity is gradual but about one-third of the length of the basals participates in the lateral walls of the calyx. There are five large radials that are considerably wider than long. The left posterior radial is not quite as wide as normal radials, although the right shoulder is extended higher than the normal cup height. The right posterior radial is narrower than any other radial and has a peculiar shape in the holotype because of the position of the large radianal, which has lost contact with the right posterior basal. In this instance, the posterior basal has an extension to join up with the right posterior radial. The radianal occupies a considerable part of the area that would normally be occupied by the left lateral side of the right posterior radial. In the paratypes, where the RA retains contact with the right posterior basal, the same fundamental structure exists, although a few of the special facets found in the holo-

type are of course missing. The posterior interradius is protruberant, as previously discussed, and is occupied by two large anal plates. The anal is six-sided, resting on the truncated distal face of the posterior basal. The right side of the facet is lower than the left, so that the suture is oblique rather than horizontal. The anal is adjoined on the left by the left posterior radial, above by two tube plates, to the right by a short section of the right posterior radial, and to the lower right by the large radianal. The RA in the holotype is more or less triangular, but in most paratypes it is slightly elongate, quadrangular.

There are 16 biserial arms, first bifurcation taking place with the axillary primibrach in all rays. Sutures between radials and first primibrachials are gaped. In the right posterior, anterior and left posterior there is a second branching with axillary first secundibrachs in both right and left rays. The nonaxillary secundibrachs of the right anterior and left anterior are large quadrangular elements, comparable in size to the axillary secundibrachs of the other arms. There is some tapering of the arms for a short distance above the bifurcations but thereafter the arms retain a uniform width, or even expand slightly, until they approach their distal ends where they taper rather slowly to their termination. The pinnules are long thin elements and are shown on plate 18, figure 2. They are apparently rather delicate and are seldom preserved in place.

Only short segments of the column are preserved in proximity to the crowns. The columnals are round, crenulated, and pierced by a rather large pentalobate lumen. They are alternately expanded with larger segments moderately thickened. The thin interposed element has an undulating surface that is also marked by the external manifestation of the articular crenellae. It appears that a series of five is developed with the center columnal not quite attaining the size of the two end segments.

The tegmen has not been observed. Sutures between cup plates are not appreciably impressed and there is no indication of any ornamentation on any plates of the crown. Some specimens show a hemstitched appearance along the sutures caused by small ridges and depressions that serve to hold the plates in place.

In young specimens, the infrabasal disk is relatively larger in

comparison to the size of the cup and the protrusion of the right posterior area is not noticeable. The cup is more compact and the lateral sides more erect. There may even be some tumidity of the cup plates in the youngest forms. The smallest specimen has a cup width of 12.2 millimeters by 6.7 millimeters high.

Measurements of holotype in millimeters:

Height of crown (as preserved)	70.5
Width of dorsal cup (maximum)	34.5
Width of dorsal cup (minimum)	32.4
Height of dorsal cup (maximum)	15.0
Width of infrabasal circlet	8.7
Width of proximal columnal	4.2
Length of basal (right anterior)	17.3*
Width of basal (right anterior)	16.8*
Length of radial (right anterior)	11.0*
Width of radial (right anterior)	19.7*
Length of RA	12.0*
Width of RA	9.6*
Length of anal X (estimated)	10.0
Width of X	10.5*
Height of PBr_1ax	6.1
Width of PBr_1ax	16.8*

* Measurement taken along the surface curvature.

REMARKS.—*Parethelocrinus watkinsi* and *P. millsapensis* have only twelve arms as compared to the sixteen arms of the present species. Their calyces are proportionately lower and wider than that of *P. ellipticus,* and *P. millsapensis* has a granular surface. *P. plattsburgensis* has sixteen arms with the same pattern of bifurcation as the present species, but the cup is proportionately wider and lower. *P. beedei* and *P. variabilis* have relatively larger infrabasal disks that are convex in the first species (though not visible in side view of the cup), and are flattened in *P. variabilis,* with no basal concavity at all.

TYPES.—Holotype (OU 4135) and paratypes are deposited in the paleontological collections of The University of Oklahoma, numbers OU 759, 764, 770, 778, 4135-4148, 4174-4183, 4188-4195.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Oklahoma.

Genus *Aglaocrinus* Strimple, new genus

GENOTYPE.—*Ethelocrinus magnus* Strimple, 1949.

The dorsal cup is broad, rather low with shallow or no basal concavity and broad, subhorizontally directed infrabasal circlet. Two anal plates (X and RA) are within the cup. There are more than ten biserial arms bifurcating with first primibrachs in all rays, right and left anterior rays do not branch further and other rays branch again with first secundibrachs. The surface of the dorsal cup and lower parts of the arms are mildly nodose or have roughened surfaces and the sutures are deeply impressed, with adsutural areas forming V-shaped notches. There are five large basals and five large radials.

Species assigned to *Aglaocrinus*:

	Occurrence	*Remarks*
Ethelocrinus magnus Strimple, 1949	Desmoinesian; Okla.	*Aglaocrinus* genotype
E. peridous Strimple, 1949	Desmoinesian; Okla.	Syn. *A. magnus*
E. iatani Strimple, 1949	Missourian; Nebr.	*Aglaocrinus*
E. expansus Strimple, 1938	Missourian; Okla.	,,
Parulocrinus compactus Moore & Plummer, 1940	Missourian; Kans., Tex.	,,
P. pustulosus Moore & Plummer, 1940	Missourian; Tex.	,,

REMARKS.—The only species in this group that is known to have arms is the genotype. *A. compactus* is a smooth form but the shape of the dorsal cup and the V-shaped notches marking the sutures makes it more comparable to *Aglaocrinus* than to other genera. The rough or nodose exteriors serve to separate the group from other genera. *Ethelocrinus* has an entirely different type of decoration, and the infrabasals of that genus are in downflared attitude.

RANGE.—Pennsylvanian (Desmoinesian and Missourian): Mid-continent region, North America.

Aglaocrinus magnus (Strimple) 1949, new combination
Plate 6, figure 4; plate 8, figures 1-3; text-figure 19
SYNONOMY.—*Ethelocrinus peridous* Strimple, 1949.

The form described as *Ethelocrinus peridous* was reportedly from the Otterville limestone, which is currently considered to be Morrowan. The specimen came from the same exposure that produced *Metacromyocrinus sphaeri* near C south line sec. 30, T. 3 S., R. 12 E., north of Ardmore, Carter County, Oklahoma. This horizon is currently thought to be the Frensley formation, Dornick Hills group, Desmoinesian. The upper portions of the cup are so badly weathered that the form has little use for comparative purposes, and since it is so close in general characters to *Aglaocrinus magnus* it is placed into synonomy.

Three excellent crowns from the Holdenville formation are referred to the species and description of the plesiotypes is given below.

The dorsal cup is in the form of a truncated globe with a more or less flat-bottomed basal depression. There are five infrabasals that form a large pentagonal disk at the bottom of the basal concavity. The proximal portions of five large basals form the sides of the basal concavity and curve out of the basal area to participate in the lateral walls of the cup. Their length and width are almost equal. Five large radials form most of the cup height. Except where affected by the anal plates, they are wide pentagonal elements. A sharp constriction is found at the distal extremities. There is also longitudinal curvature augmented by the sharply impressed adsutural areas. This has the effect of producing a ligament area that is narrower than the width of the plate. It also produces a gaping suture between the radial and primabrach, although the two elements are closely joined toward the interior in the position of the transverse ridge. The anal and radianal are large plates occupying the broad posterior interradius. The anal is six-sided, the proximal portion adjoins the oblique upper surface of the posterior basal, to the lower right the radianal, to the left and right sides the left posterior and right posterior radials, and above by two tube plates. Radianal is quadrangular, obliquely placed on the right shoulder of the posterior basal, supported by the right posterior basal and in

turn supporting the left lower side of the right posterior radial, and to the left the anal plate. This arrangement is termed Special Type C.

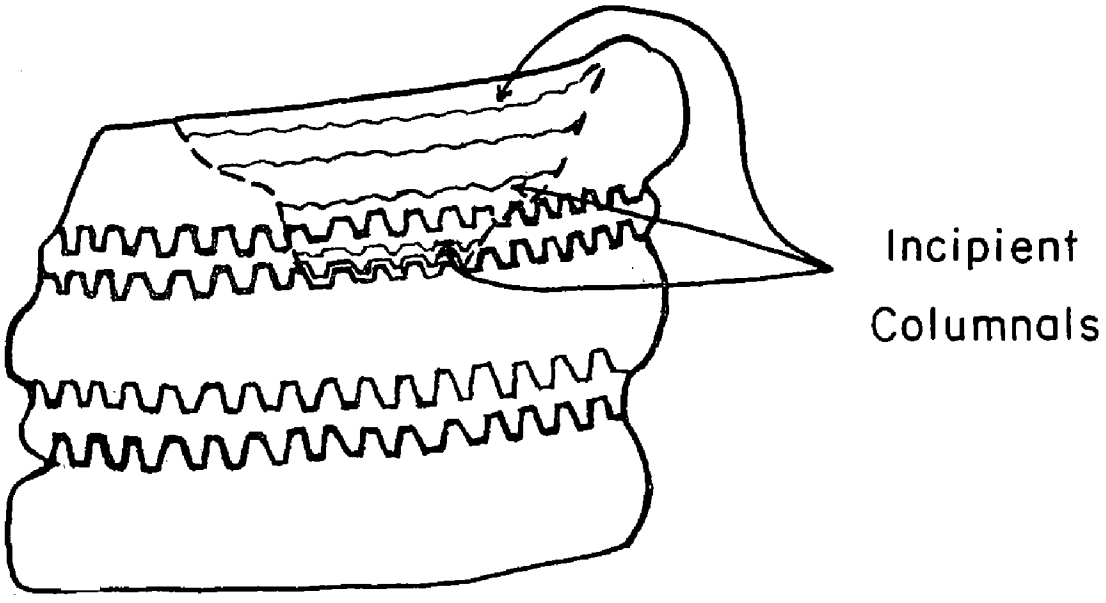
There are sixteen biserial arms, branching with the first primibrach in all rays and again with the first secundibrachs in the right and left posterior and the anterior rays. The axillary primibrachs are low, wide, and tumid in median portions.

Knowledge of the column is restricted to proximal columnals. It is round, crenulated, with the crenellae extending to the exterior and forming notches that are visible in side view. The columnals are alternatingly expanded, the largest having a thickness of 1.8 millimeters and the smallest 0.4 millimeters in a stem 4.4 millimeters wide. In paratype OU 4123 abrasion has worn away part of the outer surface and has exposed incipient columnals. Text-figure 19 illustrates this feature.

The tegmen has not been observed. All cup plates and axillary primibrachs are marked by nodes or tubercles. Weathering and the severe preparatory work required to remove the matrix has toned down the ornate nature of the surfaces.

Measurements of plesiotype (OU 4044) in millimeters:

Height of crown as preserved	74.5
Width of dorsal cup (maximum)	33.8
Width of dorsal cup (posterior to anterior)	31.8
Height of cup	14.0



TEXT-FIGURE 19. *Aglaocrinus magnus* (Strimple). Drawings of a section of the column with incipient columnals exposed through abrasion. Paratype OU 4123. Enlarged approximately x11.

Width of IBB circlet	10.9
Width of proximal columnals	4.0
Length of basal (right anterior)	16.0*
Width of basal (right anterior)	16.8*
Length of radial (right anterior)	10.0*
Width of radial (right anterior)	18.2*
Length of anal X	9.6*
Width of anal X	9.8*
Length of RA	12.8*
Width of RA	10.1*
Height of PBr_1ax	6.5
Width of PBr_1ax	17.0*

* Measurements taken along the surface curvature.

REMARKS.—This species is readily distinguished from the associated *Parethelocrinus ellipticus* by the compact nature of the cup, with erect lateral sides, as well as the ornate surface and V-shaped depressions of the adsutural areas. These same features serve to distinguish it from other species of *Aglaocrinus*.

TYPES.—The holotype is from the Pumpkin Creek limestone and is deposited in the Springer Collection, U. S. National Museum, Washington, D. C. The plesiotypes are deposited in the paleontological collections of The University of Oklahoma, numbers OU 4044, 4123, and 4124.

OCCURRENCE.—Holotype—Pumpkin Creek limestone, Dornick Hills group, Desoninesian; abandoned quarry on the west side of Lake Murray, south of Ardmore, in Love County, Oklahoma. The plesiotypes are from NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Genus *Ataxiacrinus* Strimple, new genus

GENOTYPE—*Ataxiacrinus multiramus* Strimple, new species

The dorsal cup is broad, rather compact with shallow or no basal concavity and broad subhorizontal infrabasal disk. There are five BB with distal portions visible in side view of cup, and five large RR that do not reach the basal concavity. There are three anal plates partially or entirely within the dorsal cup. The arms are biserial, more than ten, bifurcating with the most proximal segments. The column is round.

Species assigned to *Ataxiacrinus*:

	Occurrence	*Remarks*
Ataxiacrinus multiramus Strimple, n. sp.	Desmoinesian; Okla.	*Ataxiacrinus* genotype

Mooreocrinus meadowensis Strimple, 1949	Missourian; Nebr.	*Ataxiacrinus*
Dicromyocrinus optimus Strimple, 1951	Morrowan; Okla.	,,
Dicromyocrinus periodus Strimple, 1951	Missourian; Kans.	,,

REMARKS.—This genus is closely related to *Parethelocrinus* from which it differs mainly in having three anal plates within the cup rather than two as in that genus. Both forms have 16 biserial arms with comparable modes of bifurcation. It is recognized that a separate genus may be required for ornate forms such as *A. optimus* from the lowermost Pennsylvanian. *Dicromyocrinus* has an apparently comparable dorsal cup but it has only 10 arms which are uniserial. It is considered to belong to the phyletic line represented by the family CROMYOCRINIDAE, and has not been found with certainty in North America.

RANGE.—Pennsylvanian (Morrowan to Desmoinesian); Mid-continent region, North America.

Ataxiacrinus multiramus Strimple, new species
Plate 5, figures 1-3; plate 10, figures 1-3

This species is based on six crowns. The dorsal cup is medium high, globular with more or less flat-bottomed shallow basal depression. Five IBB are small elements that are mildly down-flared and form a subhorizontal disk above the basal plane. The center of the disk is sharply depressed for the reception of the proximal columnal. Five large BB are confluent with the IBB disk in their proximal extremities, form a broad base to the cup and curve upward to an almost vertical position at their distal ends. Five RR are wide plates that curve inward at their distal extremities to produce a mildly constricted condition at the summit of the cup. The posterior interradius is convex but does not protrude appreciably beyond the normal curvature of the cup. Three anal plates within the cup are in normal arrangement (Primitive Type); however, a trend toward elimination of RX from the cup is apparent and, in one paratype, RX has lost contact with RA (Special Type). This kind of trend is termed "Developmental Trend B" by Strimple (1960, p. 249-50, text-fig. 2). RA is large, fundamentally quadrangular except for the small facet for recep-

tion of RX. Anal X is large, pentagonal, does not extend appreciably above the summit of the cup and rests obliquely upon the posterior basal. RX is relatively small, elongate, hexagonal, upper half above the summit of the cup and proximal portion is narrow. X_2 rests evenly upon X, above the summit of the cup, is pentagonal-shaped and rather large. Sutures between all cup plates are well defined but are not impressed.

There are 16 biserial arms with no bifurcations above the first secundibrachs. First primibrachs are low, wide, pentagonal, and axillary in all rays. In the right and left posterior and anterior rays, the first secundibrachs are rather large, pentagonal, and axillary. In the right and left anterior rays, the first secundibrachs are rather large, quadrangular, and non-axillary. The arms of the right and left anterior taper rather rapidly to attain a reduced width equal to that of the other rays. There is a mild longitudinal curvature of the exterior of the arms, with flattened lateral sides, but the arms do not appear to have become tightly apposed when closed. Each brachial has a notch for pinnule attachment but the pinnules are in few cases in place. The segments are thin and are marked by a keel-like ridge.

There is no evidence of surface ornamentation on the crowns. The proximal columnal is round, marked by about 37 crenellae, and is pierced by a strongly quinquelobate lumen. The anal sac is unknown.

The smallest observed specimen (OU 4050) has a calyx 18 millimeters wide by 7.8 millimeters high. It does not differ appreciably from larger specimens except that the primibrachs are proportionately somewhat longer. The RX in this specimen has lost contact with the RA and has a pointed proximal end. The proximal column is in place, flush with the surface of the infrabasals. It has 27 short crenellae near the perimeter of the articular surface and has a mildly pentalobate lumen.

Measurements in millimeters:

	Paratype OU 4043	*Holotype OU 4042*
Length of crown as preserved	56.0	54.5
Width of crown	34.0	45.0
Height of dorsal cup	11.3	11.0
Width of dorsal cup (posterior to anterior)	24.0	26.0
Width of dorsal cup (maximum)	24.0	28.8

Width of IBB circlet	7.4	8.2
Length of basal (right anterior)	12.0*	13.0*
Width of basal (right anterior)	11.0*	13.5*
Length of radial (right anterior)	8.2*	8.2*
Width of radial (right anterior)	13.0*	17.0*
Width of RA	8.0*	7.5*
Length of RA	9.2*	11.0*
Width of X	6.7*	8.6*
Length of X	7.6*	7.8*
Width of RX	3.6*	4.0*
Length of RX	5.2*	6.2*
Width of X_2	4.7*	
Length of X_2	3.6*	

* Measurements taken along surface curvature.

REMARKS.—This species is closer to *Parethelocrinus ellipticus* than to other described forms. It has a higher calyx and three anal plates as compared to the two anal plates of *P. ellipticus*. *Ataxiacrinus optimus* has an ornate surface. *A. meadowensis* has a more pronounced basal invaginaton and the sutures are impressed in V-shaped notches.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

TYPES.—Holotype (OU 4042) and paratypes are deposited in the paleontological collections of The University of Oklahoma, numbers OU 4005-4007, 4019, 4042, 4043, and 4050.

FAMILY TEXACRINIDAE Strimple, new family

GENERA.—*Haeretocrinus* Moore and Plummer, 1940; *Texacrinus* Moore and Plummer, 1940; *Marathonocrinus* Moore and Plummer, 1940; *Schistocrinus* Moore and Plummer, 1940.

The genus *Texacrinus* was assigned by Moore and Laudon (1943, p. 56) to the PACHYLOCRINIDAE Kirk. The arms of that family are said to branch isotomously twice or more and trend in some forms oward endotomy. The arms of *Texacrinus gracilis* Moore and Plummer (1940), the genotype species, are exotomous.

Haeretocrinus was assigned by Moore and Laudon (1943, p. 55) to the BLOTHROCRINIDAE. This family is said by those authors to have isotomous branching. *Haeretocrinus missouriensis* Moore and Plummer (1940), the genotype species, is reported to have two isotomous branchings, but in *H. turbinatus* Strimple (1952) the arms branch isotomously only once and are exotomous thereafter.

These two genera are obviously closely related, the main difference being in the attitude of the infrabasals which are strongly upflared in *Haeretocrinus* but are confined to a basal concavity in *Texacrinus*. There is a tendency for the calyx of *Haeretocrinus* to be flared in its distal portion and conversely a tendency toward constriction of the distal portion of the cup in many species of *Texacrinus*. A new species of *Texacrinus* described herein is an exception to these observations.

The genus *Schistocrinus* is restricted herein to those species having the characters of the genotype species, and all other species are removed to *Sciadiocrinus*. The species thus retained are the genotype, *Schistocrinus torquatus,* and a form previously described as *Malaiocrinus azygous* Strimple, which species is herein referred to *Schistocrinus*. The genus is now considered to belong with the TEXACRINIDAE.

There are three anal plates partially or entirely below the summit of the cup. They may be in normal arrangement (Primitive Type), advanced (Extreme Type (1)), or (Primitive Type B). The arrangement in *Schistocrinus* is a modification of the Primitive Type, wherein X and RX are of equal height but do not form a common surface. The five infrabasals may be upflared (*Haeretocrinus*), subhorizontal (*Schistocrinus* and *Texacrinus*), or downflared (*Texacrinus*). Five BB are large plates in *Haeretocrinus* and *Texacrinus* but in *Schistocrinus* they are small elements. Five RR are large plates that vary somewhat among the various genera. They do not participate in the basal concavity when it is present, flare outwardly in some species and curve mildly inward in others. The arms may be as many as 50, are uniserial, bifurcate with $PBrBr_1ax$ in all rays, and are exotomous.

RANGE.—Pennsylvanian (Desmoinesian and Missourian); Midcontinent region, North America.

Genus *Texacrinus* Moore and Plummer, 1940

GENOTYPE.—*Texacrinus gracilis* Moore and Plummer, 1940.

The holotype and only known specimen of the genotype species is not adequately preserved, insofar as the dorsal cup is concerned, to be fully certain of the generic characteristics. The

exact nature of the basal area is questionable, but Moore and Plummer (1940) were of the opinion that a basal concavity existed. In the posterior interradius they were able to determine that RA rested obliquely across the distal face of the PB, with other anal plates above. It was on this basis, and the exotomous branching of the uniserial arms, that I assigned various other species to the genus (Strimple, 1952b), increasing the range of the genus into the uppermost Missourian.

There is now at hand a new species, *Texacrinus coniformis* from the Holdenville formation (top of the Desmoinesian) represented by excellently preserved crowns. There is a mild basal impression wherein the small IBB form a subhorizontal plane just above the basal plane. In Missourian species the basal concavity is more pronounced and alternatingly expanded proximal columnals almost always obliterate any view of the IBB.

Moore and Plummer reported rather thoroughly on the absence of notches between adjacent RR of *T. gracilis*. All other species referred to the genus have facets that do not fill the distal face of the radials. Some species are even more spectacular in that regard than in *Plummericrinus*.

Species assigned to *Texacrinus*:

	Occurrence	*Remarks*
Texacrinus gracilis Moore & Plummer, 1940	Desmoinesian; Tex.	Genotype
T. associatus Strimple, 1952	Desmoinesian; Okla.	*Texacrinus*
T. interruptus Strimple, 1952	Missourian; Okla.	,,
T. irradiatus Strimple, 1952	Missourian; Okla.	,,
T. compactus Strimple, 1952	Missourian; Okla.	,,
T. progressus Strimple, 1952	Missourian; Okla.	,,
T. coniformis Strimple, n. sp.	Desmoinesian; Okla.	,,
Pachylocrinus uddeni Moore & Plummer, 1940*	Desmoinesian; Tex.	,,

RANGE.—Pennsylvanian (Desmoinesian and Missourian); Midcontinent region, North America.

* Referred to the genus under present concepts as *Texacrinus uddeni* (Moore and Plummer), new combination.

Texacrinus coniformis Strimple, new species
Plate 1, figures 1-3; plate 16, figure 6

The dorsal cup is truncate conical. There is a slight basal impression, just deep enough to place the subhorizontal infrabasals above the basal plane. The five small IBB project slightly beyond the proximal columnal. Five BB are large and usually mildly tumid. They form a good portion of the cup height because only the proximal edge is involved in the impressed base. Small dimple-like depressions are usually formed at the distal angles. Five large RR are prominent cup elements, are mildly tumid and their articular facets do not quite fill the width of the plates. In some paratypes the lateral edges of the RR are actually projected into the interarticular area. Plates of the broad posterior interradius are in Extreme Type (1) arrangement. RA is large and lies obliquely across the distal face of the posterior basal. It supports a rather large anal X to the left above and a smaller RX to the right above. X and RX form a confluent plane at their summit.

As many as 55 uniserial arms are indicated that attain a length of 7.0 cm in a large paratype. The first and second bifurcations are isotomous, but the third, fourth and fifth bifurcations are with only the inner rays (exotomous). In one arm a sixth branching has been noted. No single specimen has all of the arms preserved in every ray. The first PBr is axillary in all rays. The second branching is with the SBr_3 to SBr_5. The third branching is with about the eighth or ninth TBr. Subsequent branching may take place at irregular heights, three more bifurcations having been observed in some rays. PBrBr do not fill the width of RR, in fact in some specimens the outer distal portions of RR extend above the articulating plane. The PBrBr are low, with short lateral sides. First secundibrachs are rather large plates. Subsequent brachials are thin, and even the axillary plates are low. The outer ray, formed at the second bifurcation, remains unbranched as do all subsequently developed outer rays. The arms are curved transversely and do not appear to have ever been closely apposed.

Knowledge of the column is restricted to proximal columnals that are usually entirely within the shallow impression specifically developed for their reception in the center of the IBB disk. The

column is round, pierced by a rather large pentalobate lumen, mildly crenulated and the internodal columnals are thin.

Measurements of holotype in millimeters:

Overall length of crown	45.5	
Width of crown	51.0	(distorted?)
Height of dorsal cup	7.1	
Width of dorsal cup (maximum)	14.2	
Width of dorsal cup (posterior to anterior)	14.0	
Width of IBB circlet	4.0	
Width of proximal columnal	3.0	
Length of basal (right anterior)	5.0*	
Width of basal (right anterior)	5.9*	
Length of radial (right anterior)	4.6*	
Width of radial (right anterior)	7.8*	
Length of RA	5.1*	
Width of RA	4.7*	
Length of X	4.0*	
Width of X	4.0*	
Length of RX	2.8*	
Width of RX	2.8*	

* Measurement taken along surface curvature.

REMARKS.—Some specimens show a more exaggerated restriction of the radial articular facets than others. In all specimens there is a notch between adjoining facets, but in some there is actually an extension of the radial above the normal summit of the cup. In this latter condition the primibrachs are appreciably narrower than the radials.

The most comparable described species is *Texacrinus compactus* in which species the calyx is not quite so elongate and the participation of the basals in the basal plane and concavity is greater than that found in *T. coniformis*. The calyces of *T. associatus, T. interruptus,* and *T. irradiatus* are shaped more like a truncated bowl and have pronounced basal concavities. The youngest known species, *T. progressus,* has a more advanced anal arrangement than those found in other species. *T. uddeni* has a comparable cup shape but the infrabasals are slightly higher above the basal plane than they are in *T. coniformis*.

TYPES.—Holotype (OU 4093) and paratypes are in the paleontological collections of The University of Oklahoma, numbers OU 758, 760, 765, 4093-4101, 4188, 4222, 4333, 4335, 4336.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Genus *Haeretocrinus* Moore and Plummer, 1940

GENOTYPE.—*Haeretocrinus missouriensis* Moore and Plummer, 1940.

The characters of the genus are well established and primary factors have been given herein under the discussion of the family. TEXACRINIDAE.

Species referred to *Haeretocrinus:*

	Occurrence	*Remarks*
Haeretocrinus missouriensis Moore & Plummer	Missourian; Mo.	Genotype
H. turbinatus Strimple	Missourian; Okla.	*Haeretocrinus*
H. magnus Moore & Plummer	Desmoinesian; Tex.	,,
H. intermedius Strimple, n. sp.	Desmoinesian; Okla.	,,
Scaphiocrinus washburni Beede	Virgilian; Kans.	,,

RANGE.—Pennsylvanian (Desmoinesian to Virgilian); Midcontinent region, North America.

Haeretocrinus intermedius Strimple, new species
Plate 15, figures 1-3

This species is represented in the collections by a single dorsal cup with a portion of the arms attached. The basal plane is formed by the five IBB as they curve distally to participate in the lateral walls of the calyx. The median portion of the infrabasal disk is sharply but shallowly impressed for the reception of the proximal columnal. This concavity is slightly wider than the cicatrix, indicating either that some of the columnals are larger than others, or that provision is made for a rocking movement. Five large basals are tumid and rise almost vertically so that the lower portion of the cup has the appearance of a rounded bowl. The upper portion of the cup flares sharply outward. The five radials and anal plates are in the upper portion of the cup. Distal facets of the radials do not fill the full width of the plates, so that moderate notches are formed between radials at their summits.

Plates of the posterior interradius are in Extreme Type (1) arrangement. The RA is usually large and rests obliquely across

the distal face of the posterior basal. Anal X and RX are of subequal size, the former being slightly larger. The right and left posterior radials slope upward so that the sides adjoining the posterior interradius are higher than the normal summit of the cup. This allows X and RX to be about half their lengths within the cup. Distal facets of X and RX are confluent and they are followed by subequal-sized X_2 and RX_2.

The first primibrachs are low, wide, and axillary. Those of the right and left posterior are slightly larger than the other three. The first secundibrachs are relatively large, quadrangular, nonaxillary elements. The right arm of the left posterior ray is preserved to the second tertibrach. In this ray the first secundibrach is missing. The following ossicles are much lower than first SBrBr as reflected in other rays. They are quadrangular but do have slightly oblique distal and proximal surfaces. The arrangement is not cuneate but is not evenly uniserial either. The sixth SBr is low and axillary.

Measurements of holotype in millimeters:

Width of cup (maximum)	17.2
Height of cup	8.9
Width of IBB circlet	7.2
Height of IBB circlet	2.5
Width of columnar cicatrix	3.7
Width of basal (right anterior)	5.7*
Length of basal (right anterior)	6.2*
Width of radial (right anterior)	8.0*
Length of radial (right anterior)	4.5*
Width of RA	6.0*
Length of RA	6.0*
Width of X	4.9*
Length of X	4.2*
Width of RX	3.2*
Length of RX	3.2*

* Measurement taken along surface curvature.

REMARKS.—This species has some characters of both *Haeretocrinus* and *Texacrinus,* and for that matter of *Plummericrinus.* All of these genera have a tendency for plates of the posterior interradius to be arranged as Extreme Type (1) or Primitive Type B, or more particularly for the distal facets of anal X and RX to form a confluent subhorizontal plane. The shape of the cup of *Haeretocrinus intermedius* is almost identical with that of *Plummericrinus mc-*

guirei, except for the upflared infrabasals of the former. Plates of the posterior interradius in the older species are in a more advanced arrangement than in *P. mcguirei.*

The existence of upflared IBB, visible in side view of the cup, excludes the present species from *Texacrinus. Haeretocrinus intermedius* differs from other species of *Haeretocrinus* in the distinctive shape of the cup and in the limited participation of the infrabasals in the lateral sides of the calyx.

HOLOTYPE.—Deposited in the paleontological collections of The University of Oklahoma, number OU 4172.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Genus *Schistocrinus* Moore and Plummer, 1940

GENOTYPE.—*Schistocrinus torquatus* Moore and Plummer, 1940.

The genotype species is a distinctive, rare form that is not closely comparable to any other described species except *Malaiocrinus azygous* Strimple (1949c). Although the IBB are not visible in side view of the cup, the basal elements have a convex curvature. The BB are small triangular elements separated by the RR in both species. In the posterior interradius, anal X is followed to the left by a small X_2 (or none), and to the right by a large RX_2. RX attains a height equivalent to that of X and shares equally with X in support of RX_2. In both species the center of the IBB disk is sharply impressed for reception of rather small proximal columnals. *S. torquatus* has a stronger union between RR and IBB than does *S. azygous* (Strimple), new combination.

A hypotype of *S. azygous* from the Holdenville formation shows the tegmen to be in the nature of an expanded balloon, which indicates affinity with *Anobasicrinus.* But the arms of the specimen, which are not well preserved, are either isotomous or exotomous (the inner rays branch) and the arms of *Anobasicrinus* branch endotomously. The genus is referred to the TEXACRINIDAE.

Three other species have previously been referred to *Schistocrinus* although they all have characteristics more comparable to *Sciadiocrinus.* In particular, I refer to the nature of the roof-like distal termination of the anal sac, which is almost identical with that in

the genotype species of *Sciadiocrinus*. The nature of the calyxes and the structure of the arms are also comparable to those in *Sciadiocrinus*. *Schistocrinus confertus* Moore and Plummer, *S. parvus* Moore and Plummer, and *S. planulatus* Moore and Plummer are referred to *Sciadiocrinus*.

RANGE.—Desmoinesian, Pennsylvanian; Midcontinent region, North America.

Schistocrinus azygous (Strimple), new combination
Plate 9, figures 1, 2

The dorsal cup is low, truncate conical. IBB form a broad, subhorizontal disk. They project well beyond the proximal columns. Five BB are rather small, triangular-shaped plates. The right posterior basal has a short, extra facet for contact with RA. Five RR are rather wide plates. Those of the right and left posterior lose considerable size to the anal plates. Articular facets are poorly preserved, are directed outwardly, and have deep intermuscular notches. All radials attain contact with IBB plates except the RPR where the proximal end of RA is interposed and makes the contact with RPIB. The posterior interradius is not impressed and is composed of three plates within the cup, in normal arrangement (Primitive Type) except that anal X and RX attain a comparable height above the summit of the cup where they form a deep V-shaped notch for reception of a single tube plate (X_2). The plate is only partially preserved and has fallen inward.

The arms are poorly preserved. Axillary $PBrBr_1$ are low, pentagonal elements. Second bifurcation appears to be with the second and third SBr, which plates have short lateral sides. The BrBr are quadrangular, thick elements with strong transverse curvature. A third branching has been observed in the inner arm of the left ray of the left posterior radius with TBr_4.

The outline of the balloon-shaped tegmen is preserved in natural cross-section. It does not extend above the arms and has an outline comparable to that of *Anobasicrinus bulbosus*.

The proximal columnals are rather thin, round with a large pentalobate lumen. The crenellae have been weathered away.

Measurements of the hypotype in millimeters:

Height of crown	53.5
Width of crown	54.2

Height of tegmen above the cup	37.5
Width of cup (posterior to anterior)	15.7
Width of cup (maximum)	20.2
Height of cup	5.9
Width of IBB circlet	9.0
Width of proximal columnal	5.0
Length of basal	4.5*
Width of basal	5.5*
Length of radial	6.2*
Width of radial	10.6*

* Measurement taken along surface curvature.

REMARKS. — *Schistocrinus torquatus* is readily differentiated from the present species in having much stronger contact between radials and infrabasals.

PLESIOTYPE.—Deposited in the paleontological collections of The University of Oklahoma, number OU 4008. The holotype of this species is in the Springer collection, U. S. National Museum, Washington, D. C.

OCCURRENCE.—Plesiotype is from the Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma. Holotype is from the Pumpkin Creek limestone member, Dornick Hills group, Desmoinesian, on the southwest side of Lake Murray in abandoned quarry, Love County, Oklahoma.

Family AMPELOCRINIDAE Kirk, 1942

GENERA.—

Aesiocrinus Miller and Gurley, 1890
Syn. *Phialocrinus* Trautschold, 1879, not Eichwald, 1856; *Pentadelocrinus* Strimple, 1939
Moundocrinus Strimple, 1939
Oklahomacrinus Moore, 1939
Ampelocrinus Kirk, 1942
Cymbiocrinus Kirk, 1944
Polusocrinus Strimple, 1951
Allosocrinus Strimple, 1949

Genus *Polusocrinus* Strimple, 1951

GENOTYPE.—*Polusocrinus avanti* Strimple, 1951.

The genus *Polusocrinus* was proposed by Strimple (1951) for the reception of species of Pennsylvanian ampelocrinids that lacked

a basal concavity of the calyx, and in fact had broad, fundamentally upflared infrabasal circlets. All known species at this time are of Missourian age. It is therefore of much interest to have specimens in excellent preservation from the Holdenville formation.

Species assigned to *Polusocrinus*:

	Occurrence	*Remarks*
Polusocrinus avanti Strimple, 1951	Missourian & Desmoinesian; Okla.	Genotype
P. rosa Strimple, 1951	Missourian; Okla.	*Polusocrinus*
P. ochelataensis Strimple, 1952	Missourian; Okla.	”
Aesiocrinus tactilis Strimple, 1951	Missourian; Kans.	”

The holotype of *P. ochelataensis* is known to have the first bifurcation with PBr_2Ax in all rays with a second bifurcation in at least four rays, in the left arm only on the SBr_2ax or SBr_3ax. The specimens from the Holdenville formation have considerable lengths of arms attached and do not show a second branching of the arms. The specimens are considered to be conspecific with *P. avanti*. It appears that a trend toward the addition of arms has occurred in this line. The addition of arms as an evolutionary factor is not unknown; for example, *Alcimocrinus girtyi* Springer from the Morrowan has considerably more arms than *A. ornatus* Strimple from the Chesterian.

The form originally described as *Aesiocrinus tactilis* is referred here to *Polusocrinus tactilis* (Strimple), new combination. The description of the species was prepared some time before I developed the generic concept of *Polusocrinus* although both reached publication in 1951. The species is distinctive in having a narrow anal plate and a more nearly circular outline in side view of the cup than have other species of the genus.

RANGE.—Pennsylvanian (Desmoinesian and Missourian); Midcontinent region, North America.

Polusocrinus avanti Strimple, 1951

Plate 16, figure 1

By comparing *P. avanti* with other species of the genus, it is apparent that no appreciable change in form took place from

the Desmoinesian to the Missourian. There is remarkable similarity between the present specimens and typical *P. avanti,* although the older specimens are much larger. They are considered here to be conspecific.

Several columnals are preserved in one of the plesiotypes (OU 769) and show the stem to have a circular outline with a pentalobate lumen. There appears to be a series of nine nodals and internodals. The internodals are thin, have an undulating rim and are marked by the surface extension of the articular crenellae. In a series of nine, the first and last nodals are the largest and are marked by somewhat elliptical cirral cicatrixes. The central nodal of the series is larger than the balance of the columnals and also carries cirri. The two remaining segments that have the appearance of nodals do not appear to carry cirri.

As reported under the generic discussion, the present specimens have only ten arms, bifurcation taking place with the second primibrach in all rays.

Measurements of plesiotype in millimeters:

	OU 769
Maximum width of dorsal cup	34.0
Approximate height of dorsal cup	17.0
Width of IBB circlet	16.2
Width of proximal columnals	5.4
Length of basal (right anterior)	11.7
Width of basal (right anterior)	11.7
Length of radial (right anterior)	9.1
Width of radial (right anterior)	14.2
Length of anal plate	7.1
Width of anal plate	7.5

TYPES.—Plesiotypes are deposited in the paleontological collections of The University of Oklahoma, Norman, Oklahoma, numbers OU 769, 4185.

OCCURRENCE.—The holotype is from the Avant limestone member, Iola limestone formation, Skiatook group, Missourian, Pennsylvanian; the bed of Bird Creek under the bridge just south of Avant, Osage County, Oklahoma. The plesiotypes are from the Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Genus Allosocrinus Strimple, 1949

GENOTYPE.—*Allosocrinus bronaughi* Strimple, 1949.

There are relatively few Pennsylvanian crinoid genera known that have only five arms. In *Allosocrinus* the dorsal cup has a shallow basal concavity and there is a single anal plate within the cup. The column is round. The markings on the arm-articulating facets of the radials are somewhat comparable to those of *Rhabadocrinus* Wright (1944) from the Lower Carboniferous (Mississippian) of Scotland, being in the nature of fine striations running back from the front to the transverse ridge. This condition is especially well shown on brachial articular facets. In the presently considered species from the Holdenville formation, most of the articular surfaces are obscured by matrix or weathering but in a few instances the fine pattern is preserved and compares with that of *Allosocrinus bronaughi,* the genotype.

Only two species have been ascribed to the genus up to this time, *A. bronaughi* and *A. porus* Strimple, 1951. Both are from the Wann formation, Ochelata group, Missourian of northeastern Oklahoma. The existence of a species from the Holdenville formation, Marmaton group, Desmoinesian, is therefore of considerable importance. The dorsal cup of the Holdenville species is shallower and the basal concavity more pronounced than found in the Missourian species. This could represent a regressive trend because progressive evolution is toward basal invagination. There are several phyletic lines in the Pennsylvanian that demonstrate regressive evolution, the best known being the erisocrinids (Strimple, 1960a). There is a strong resemblance between the appearance of the calyx of the Holdenville species and *Cymbiocrinus gravis* Strimple (1951) from the Chesterian of northeastern Oklahoma. The older species has ten arms and the dorsal cup is somewhat shallower than the Holdenville species, *Allosocrinus libratus* Strimple, new species.

The small, round column of *A. libratus* could hardly have provided a stalk for the crinoid. It seems likely that the species was eleutherozoic to a degree. Possibly the column trailed along as it floated and curled around a larger object, such as another column, when the form became statozoic. The species is rather small as compared to the large forms found in association.

RANGE.—Pennsylvanian (Desmoinesian and Missourian); Oklahoma

Allosocrinus libratus Strimple, new species
Plate 5, figures 4-6; plate 15, figure 5

The dorsal cup is low, bowl-shaped, with a deep basal concavity. Infrabasals are five, confined to the concavity and are downflared. The five basals are rather large, longer than wide, tumid and proximal portions participate in the basal concavity. They curve sharply out of the concavity into a subhorizontal position. The basal plane is formed by the median portions of the basals and, because they are tumid, only five points touch the plane. The lateral sides of the calyx never become erect and are formed mainly by the five large radials. The radials are of equal size, even those of the posterior, and are about twice as wide as long. The anal plate is only slightly longer than wide and is a prominent cup element. It rests evenly on the truncated distal face of the posterior basal and extends slightly above the summit of the calyx. There are two, sub-equal facets for the reception of two tube plates above.

There are five broad arms. The nonaxillary primibrachs entirely fill the distal faces of the radials. They are low and taper sharply so that the following PBrBr have a considerably reduced width. Strong tapering continues distally but is not so pronounced as between the first and second brachials. Within six brachials the width of the arms has decreased 4 millimeters in one paratype. The lateral sides of each brachial are unequal in height and the following brachial has a complementary inequality in height. The segments are thus cuneiform but do not appear to attain a biserial status. The exposed joint surfaces between facets are weathered in most specimens, but in some instances there is evidence of the fine striations from front to back as found in the genotype species. The arms do not appear to have attained any substantial length. One paratype has eight brachials within 15 millimeters.

The proximal columnals are remarkably small and have a circular outline. As noted under the generic discussions, the column could hardly have served as a statozoic stalk.

Measurements of the holotype in millimeters:

Height of cup	5.6
Width of cup (maximum)	20.4
Width of cup (minimum)*	17.3
Width of IBB circlet	5.6

Width of proximal columnals	1.1
Length of basal (right anterior)	6.4
Width of basal (right anterior)	5.5
Length of radial (right anterior)	5.5
Width of radial (right anterior)	11.0
Length of anal plate	5.5
Width of anal plate	5.0

* The smallest observed specimen has a dorsal cup approximately 10 millimeters wide.

REMARKS.—*Allosocrinus libratus* is different from the Missourian representatives of the genus in having a pronounced basal concavity with the infrabasals in a downflared attitude. *A. bronaughi* has a high calyx with a shallow basal concavity. The IBB form a subhorizontal disk and the outer surface is strongly granulate. *A. porus* has tumid basals, as in the present species, but the IBB are subhorizontal. The surfaces of the cup and arms have a peculiar punctate appearance that is distinctive under slight magnification. In general appearance, *Cymbiocrinus gravis* Strimple (1951), from the Chesterian, is more like *Allosocrinus libratus* than other described forms. The older species has ten arms and a pentagonal stem. It probably represents the ancestral stock from which *Allosocrinus* evolved.

TYPES.—Holotype and paratypes are deposited in the paleontological collections, The University of Oklahoma, numbers OU 4102-4109, 4186 and 4187.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Genus *Oklahomacrinus* Moore, 1939

GENOTYPE.—*Oklahomacrinus supinus* Moore, 1939.

This genus has previously been given a range from upper Desmoinesian to upper Virgilian; however, there is no described species from the Desmoinesian. The genus is represented in the present collections of the upper Desmoinesian by two specimens with portions of the arms attached. The form is described as *Oklahomacrinus abruptus* Strimple, new species. The close relationship between *Allosocrinus* and *Oklahomacrinus* is more readily apparent in the Desmoinesian forms than in forms from younger horizons. Apparently there was regressive evolution in *Allosocrinus* that pro-

duced a rather high cup with slight basal concavity by middle Missourian time. *Oklahomacrinus* appears to evolve toward a highly invaginated cup that could be termed "inside out" by Virgilian time.

Species referred to *Oklahomacrinus:*

	Occurrence
O. supinus Moore, 1939	Virgilian; Okla.
O. loeblichi Moore, 1939	Missourian; Okla.
O. bowsheri Moore, 1939	*Missourian; Okla.
O. stevensi Moore, 1939	*Missourian; Okla.
O. regularis Strimple, 1951	Missourian; Okla.
O. discus Strimple	Virgilian; Kans.
O. abruptus Strimple, n. sp.	Desmoinesian; Okla.

Oklahomacrinus abruptus Strimple, new species
Plate 13, figures 1, 2

The dorsal cup has a mildly pentagonal outline when viewed from above or below. It is shallow with the entire IBB and most of the BB confined to the basal concavity. Only the tips of the IBB have been observed, in downflared attitude at the junction with the BB. The five BB are rather long with their proximal portions forming the steep walls of the cavity, yet curved upward in their distal portions to become visible in side view of the cup. The five RR are wide, pentagonal elements that are rather tumid in mid-portion, both longitudinally and transversely curved. The single anal plate (RA) is elongate, widening slightly to the cup summit and then becoming narrow rather rapidly for a short distance above the outer extremity of the cup. The posterior interradius is not depressed within the cup but the uppermost end of the anal plate is depressed longitudinally and curved sharply inward. The first primibrach is nonaxillary, quadrangular and considerably wider than long. The second primibrach is axillary and trapezoidal although the lateral sides are extremely short. Its width is appreciably less than the width of the PBr_1. First SBrBr are rather large, quadrangular plates.

In the small paratype, a poorly preserved columnal is present in the basal concavity. It is rounded-pentagonal, relatively large and has about 7 short crenellae on each of the five sides of the

* The horizon was formerly considered to be Virgilian, but is now considered to be uppermost Missourian.

segment. The depressed outer sides indicate facets for the attachment of five cirri, but this is only conjecture. On the nodule containing the holotype there is a section of a column that is placed in a manner indicating that it might have been connected to the cup. It has a circular outline and is composed of series of 6 to 9 columnals, with those at the ends of a series being rather large nodals. If it is associated with the specimen, it indicates that the stem loses its pentagonal outline not too far from the cup.

Measurements of holotype in millimeters:

Height of cup	3.0
Width of cup	17.2
Height of basal concavity (approximate)	2.5
Length of basal (left posterior)	4.8*
Width of basal (left posterior)	3.9*
Length of radial (left posterior)	5.0*
Width of radial (left posterior)	8.8*
Length of anal (RA)	4.2*
Width of anal (at base)	1.6
Width of anal (at cup summit)	2.7

* Measurement taken along the surface curvature.

REMARKS.—The species is distinguished from the associated *Allosocrinus libratus* in having a shallower cup, relatively larger stem, a narrower and more elongate anal plate, and in having ten arms that branch with the second primibrach. *Oklahomacrinus supinus* is the most closely comparable form, but *O. abruptus* differs from it and other described species in having a steep wall to the basal cavity with a resultant difference in the basal plates.

TYPES.—Holotype and paratype deposited in the paleontological collections of The University of Oklahoma, numbers OU 4045, 4046.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Oklahoma.

Family STELLAROCRINIDAE Strimple, new family

GENERA.—*Heliosocrinus* Strimple, 1951; *Stellarocrinus* Strimple, 1940.

In *Heliosocrinus,* the older genus, the column is stellate in outline, the three anal plates are in normal arrangement (Primitive

Type), and the first bifurcation takes place with the sceond primibrach. The younger *Stellarocrinus* has a column with a circular outline, but in one species (*S. petalosus* Strimple, n. sp.) the columnar cicatrix is pentagonal. Evolution of the anal plates to Extreme Type (2) may be considered as normal and progressive as well as the reduction of primibrachs from two to one, as found in *Stellarocrinus*. The change from uniserial (or cuneiform) brachials to biserial is also a normal, progressive change. One species, *Stellarocrinus distinctus* Strimple, retains the cuneiform characteristic of *Heliosocrinus*. The nature of the narrow, horseshoe-shaped articular facets of the radials, ornate exterior, arm structure, and general similarity of the two genera leaves little doubt as to their close affinity or the desirability of having a separate family for their reception.

RANGE.—Mississippian (Chesterian), Pennsylvanian (Desmoinesian and Missourian); Midcontinent region, North America.

Genus *Stellarocrinus* Strimple, 1940

SYNONOMY.—*Whiteocrinus* Strimple, 1939 (not Jaekel); *Apollocrinus* Moore and Plummer, 1940; *Brychiocrinus* Moore and Plummer, 1940.

The characters of this genus are well known and are not repeated here.

Species assigned to *Stellarocrinus*:

	Occurrence	*Remarks*
Cyathocrinus stillativus White, 1879	Virgilian; Kans.	*Stellarocrinus* genotype
	Missourian; Okla.	
Whiteocrinus exculptus Strimple, 1939	Missourian; Okla.	*Stellarocrinus*
Stellarocrinus distinctus Strimple, 1940	Missourian; Okla.	,,
S. texani Strimple, 1951	Missourian; Tex.	,,
S. virgilensis Strimple, 1951	Missourian; Okla.	,,
S. petalosus Strimple, n. sp.	Desmoinesian; Okla.	,,
Apollocrinus florealis Moore & Plummer, 1940	Desmoinesian; Tex.	,,
A. geometricus Moore & Plummer, 1940	Missourian; Kans.	,,

Aesiocrinus angulatus Miller & Gurley, 1894	Missourian; Mo.	*Stellarocrinus*
Brychiocrinus texanus Moore & Plummer, 1940	Desmoinesian; Tex.	"

RANGE.—Pennsylvanian (Desmoinesian to Virgilian); Mid-continent region, North America.

Stellarocrinus petalosus Strimple, new species
Plate 14, figures 3, 4; plate 15, figure 4; plate 16, figure 2; plate 19, figure 7

This species is based on ten crowns or partial crowns. The dorsal cup is shallow, bowl-shaped with a flat-bottomed basal concavity formed by the proximal edges of the basals. The cup is relatively high as compared to other species of the genus. Five IBB form a horizontal, pentagonal disk on the flat bottom of the concavity. They extend beyond the columnar scar. Five BB are rather small and are protruded in mid-section near the edge of the basal concavity. Ridges do not cross the interbasal sutures. The areas at angles of meeting with the radials are depressed, accentuating ridges that meet with more pronounced ridges on the radials. Five large, convex radials form most of the lateral sides of the calyx and do not reach the basal concavity. Arm segments are in place on the holotype but articulating facets are visible on some of the paratypes. The facets are somewhat smaller than in most species and are almost vertical. The ligament pit is short, well defined and is just outside the transverse ridge. It is about one-third the width of the facet. The inner ligament area is smooth, intermuscular notch is wide, muscular areas are ill defined. Three anal plates occupy the posterior interradius of the cup. The principal anal plate (RA) is in posterior position, resting evenly on the truncated upper facet of the posterior basal. Anal X is to the left above and RX to the right above, and these plates are barely within the cup. Anal X is slightly larger than RX. The median portion of RA is slightly protruded and the light ridges radiate from the area toward adjoining radial plates and to the posterior basal. Faint ridges pass toward the upper anal plates.

Axillary primibrachs occupy the full width of the articulating facets in each ray. They are low, with short lateral sides, and are

mildly tumid. The lower area is gaping due to distal curvature of the radial and proximal curvature of the primibrach. First secundibrachs are low, quadrangular elements succeeded by interlocking (biserial) secundibrachs. A second bifurcation is rather erratic but normally takes place with about SBr_6ax to $SBr_{10}ax$. These axillary plates are small, triangular and may carry a small spine. The first tertibrachs reach the last nonaxillary secundibrachs so that the axillary brachial is entirely surrounded. This same arrangement is found in the next bifurcation, if one occurs. Small nodes may be found on most of the brachials. There is no evidence of granular surface markings on any plates of the calyx or arms. Pinnules are seldom seen except as fragments. There is a weak facet on the inner side of each brachial for reception of a pinnule. The exterior surfaces of the arms are almost flat.

The anal sac is prominent. It is in the form of a long tube that was exposed in life since the arms expand in a sub-horizontal manner from the calyx, and do not close even in repose. There is a circlet of six plates, each plate being protruded as a short, blunt spine. Each lateral side of a plate appears to have three or four pore slits. It is indicated that the anal tube is longer than the arms when the arms are curved inward (in repose?).

The column is composed of series of five round segments. Each series is composed of a large nodal succeeded by a thin internodal, a medium-sized annulated internodal, another small thin internodal, and a large nodal. The edges of the internodals are strongly serrate. Attachments for round cirri have been observed in midportion of nodals about 11 millimeters below the cup. This general type of column is close to the form described as section *Cyclocyclopa acuticarinata* (Moore, 1938). The lumen is small and round in the column but may be pentagonal in the stem cicatrix of the IBB circlet. The columnar cicatrix on the IBB disk is also somewhat pentagonal.

Measurements of the holotype in millimeters:

Height of crown	41.0
Width of crown	58.7
Width of dorsal cup (posterior to anterior)	17.3
Width of dorsal cup (maximum)	20.0
Height of dorsal cup (to outer ligament area)	7.7
Height of cup (to interarticular area)	10.1
Width of IBB circlet	5.9
Width of columnar scar	3.6

Length of basal (left anterior)	7.1*
Width of basal (left anterior)	8.1*
Length of radial (left anterior)	5.5*
Width of radial (left anterior)	12.5*
Length of RA	4.5*
Width of RA	4.6*

* Measurement taken along surface curvature.

Axillary primibrachs of the left and right posterior and of the anterior are slightly larger than those of the right and left anterior. This is best reflected by the lengths of the lateral sides.

REMARKS.—All described species are reported to have a granular surface except *S. texanus* and *S. angulatus* and are thus readily separable from the present species. *S. angulatus* has a shallower dorsal cup and lacks the ridge-like protrusions of *S. petalosus*. *S. texanus* has more pronounced ridges than the present species.

TYPES.—Holotype and paratypes are deposited in the paleontological collections of The University of Oklahoma, numbers OU 4110-4122.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Family ZEACRINITIDAE Moore and Laudon, 1943

Genus *Neozeacrinus* Wanner, 1937

GENOTYPE.—*Neozeacrinus peramplus* Wanner, 1937.

The name *Neozeacrinus* was proposed as a subgenus of *Zeacrinus* Hall by Wanner (1937). The genotype species is *Neozeacrinus peramplus* Wanner (1937) of which only the holotype, a large crown, is known. The specimen is from the Permian of the island of Timor, East Indies. The definition emphasized characters of the arms. The form was elevated to full generic stature by Moore and Plummer (1940) and a composite definition of the genus was based on characters of *Hydreionocrinus uddeni* Weller from the Lower Permian of Texas, *H. kansasensis* Weller from the Upper Pennsylvanian of Kansas and *Neozeacrnius praecursor* Moore and Plummer (1940) from the Lower Pennsylvanian of Texas. The new definition covered the calyx as well as arm structure in detail, but did not specifically mention the anal sac. Consideration of the anal sac is to be found in the discussion by Moore and Plummer

of the species *N. praecursor* (for which species the anal sac is not known), where they pointed out that *Hydreionocrinus kansasensis* has an umbrella-like laterally directed termination of the sac overhanging the crown. Moore and Plummer considered this to be a feature of the genus because they assigned *H. uddeni* to *Neozeacrinus* under the assumption that the terminating spines that are common at the locality of the holotype (dorsal cup) represented segments of *Neozeacrinus,* and probably belonged to *H. uddeni.*

The termination of the anal sac of *Neozeacrinus* is not known. The structure of the arms is fundamentally different from that found in either *Hydreionocrinus kansasensis* or in *Neozeacrinus praecursor,* as outlined below.

The arms of *Neozeacrinus peramplus* are closely interlocked, with the brachial of one arm developed so as to meet the conditions of the complementary elements in adjacent arms. The sutures between arms are by no means even, but have a staggered appearance. This condition is not unique among crinoids but does not exist in either *N. praecursor* or *Hydreionocrinus kansasensis.* The lower branches of some species of *Plaxocrinus* or *Stenopecrinus* have a comparable structure, which may or may not indicate relationship between those forms and *Neozeacrinus* (sensu stricto). The arms of *N. praecursor* divide above the first or second secundibrach in such a manner that they could in no case become closely abutting.

In addition to the arm structure, it is highly improbable that, out of all of the crowns of *N. praecursor* that have been found, none has shown any evidence of the mushroom or umbrella-type anal sac. I have personally examined three crowns from the type locality. The wide expansion of the crown indicates the presence of a balloon-shaped sac as found in *Anobasicrinus* Strimple, new genus.

In view of this evidence the following changes are suggested: *Hydreionocrinus kansasensis* is referred to *Plaxocrinus. Hydreionocrinus uddeni* is referred to *Plaxocrinus. Neozeacrinus praecursor* is referred to *Anobasicrinus.*

A character that is unique in *Neozeacrinus peramplus* is the irregularity of the infrabasals and the strong tendency for the circlet to make contact with the radial plates. This feature is well shown by Moore and Plummer (1940, text-fig. 27a) and may provide a clue as to affinities of the species.

RANGE.—Permian, island of Timor, East Indies.

Family ANOBASICRINIDAE Strimple, new family

GENERA.—*Anobasicrinus* Strimple, new genus; *Plummericrinus* Moore and Laudon, 1943; *? Gloukosocrinus* Strimple, 1951.

This phyletic line is apparently derived from a form like *Coeliocrinus dilatatus* Hall from the lower Burlington limestone, Mississippian. The dorsal cup of that species is small, more or less conical with infrabasals plainly visible in side vew of the cup. The anal plates are three (X, RA, and RX) in normal arrangement (Primitive Type). There is a large, balloon-shaped anal sac. Although the arms are composed of brachials that in some become wedge-shaped, they are fundamentally uniserial. First bifurcation takes place with the first primibrach in each ray, with subsequent branching irregularly placed.

It is apparent from presently known forms, that the oldest representative of the Pennsylvanian has a flat-bottomed base (*Anobasicrinus braggsi* (Strimple), new combination) with the next older forms having upflared infrabasals (e.g., *A. bulbosus* Strimple, n. sp.), which is regressive. It is also apparent that another progressive trend, toward a deeply invaginated base produced such forms as *Plummericrinus mcguirei,* wherein there has also been a substantial reduction in the size of the robust, recurved anal sac.

The radial articulating facets of all the Pennsylvanian forms have a more or less restricted width so that they do not fill the distal faces of the radials.

RANGE.—Pennsylvanian (Morrowan to Virgilian) and Lower Permian; Midcontinent region, North America.

Genus *Anobasicrinus* Strimple, new genus

GENOTYPE.—*Anobasicrinus bulbosus* Strimple, new species.

This genus is proposed to cover forms having a low, conical or bowl-shaped, dorsal cup with subhorizontal or mildly upflared infrabasal plates. There are five basal plates, five radial plates, and three anal plates (X, RA, and RX) that are partially or entirely below the summit of the cup. The articular facets do not fill the entire widths of the radials. The arms are slender, uniserial, with

isotomous or biendotomous bifurcation. All rays branch with a low first primibrach and branch evenly again with a second or third secundibrach. The arms are not abutting. The column is round. Anal sac is recurved, strongly expanded and does not extend above the distal extremity of the arms.

Species assigned to *Anobasicrinus*:

	Occurrence	*Remarks*
Anobasicrinus bulbosus, n. sp.	Desmoinesian; Okla.	Gentoype
Plummericrinus braggsi Strimple, 1951	Morrowan; Okla.	*Anobasicrinus*
P. granulosus Strimple, 1954	Missourian; Okla.	”
Aesiocrinus erectus Strimple, 1951	Desmoinesian; Okla.	”
Plummericrinus erectus Strimple, 1954	Missourian; Okla.	homonym
Neozeacrinus praecursor Moore & Plummer, 1940	Desmoinesian; Tex.	*Anobasicrinus*
Anobasicrinus perplexus new name	Missourian; Okla.	”
Anobasicrinus obscurus, n. sp.	Morrowan; Okla.	”

REMARKS.—Several species that have previously been referred to *Plummericrinus* are placed under *Anobasicrinus* on the basis of the attitude of the basal area of the cup. *Plummericrinus* is restricted to those forms having a decided basal concavity, as reflected by *P. mcguirei,* the genotype species. *Neozeacrinus praecursor* has been placed herein for the reasons outlined previously under the discussion of *Neozeacrinus.* The reasons for placing *Aesiocrinus erectus* under the genus are given under a discussion of the species. This has caused a preoccupation of the name *Anobasicrinus erectus* (Strimple, 1954), new combination, from the Missourian. The latter is redescribed herein as *Anobasicrinus perplexus* Strimple, new name.

RANGE.—Pennsylvanian (Morrowan and Desmoinesian); Oklahoma.

Anobasicrinus bulbosus Strimple, new species
Plate 3, figures 1-3; plate 7, figures 1-3; text-figure 21

The crown is elongate and widely expanded. The arms are long enough to close over the expanded balloon-shaped anal sac,

but they do not appear to have done so in any of the numerous crowns observed. The norsal cup is moderately low, conical. In most specimens the five IBB are mildly upflared and visible in side view of the cup, but in the holotype they have worn down by weathering. One paratype is unique in that the infrabasals are solidly fused and the sutures obliterated in all but one ray. The five basals are low, pentagonal plates that actually have six facets, the two in proximal position having a wide angle of meeting. Five radials are more than twice as wide as long and are pentagonal. The articular facets are not visible due to the presence of primibrachs, but are shorter than the full width of the plates. In most specimens there is a notch at the lateral summit edges between radials.

The posterior interradius is wide and is not depressed. Three anal plates are in normal arrangement within the cup (Primitive Type). RX is barely within the cup and there is normally a well-developed plate above the anal X (X_2). RA is a large pentagonal plate entirely within the cup. Anal X is a large hexagonal plate resting solidly upon the posterior basal, well within the cup. RX is slightly smaller and is pentagonal. X_2 is smaller than RX, is pentagonal, and has a narrow distal edge.

The anal sac is in the form of a large balloon. The outline indicates that the gut recurves from right to left. Sac plates are normally hexagonal and are often protruded in mid-section, especially on the distal surfaces of the sac. Pore slits are well developed, usually six primary canals to each plate. Narrow ridges and depressions mark the surfaces of the plates and appear to converged with the slits.

There may be as many as 60 long, relatively slender, uniserial arms. First bifurcation is with the first primibrach in all rays. The $PBrBr_1ax$ are rather wide, low, and pentagonal. The next branching is with $SBrBr_2ax$ or SBr_3ax but is usually with the third. One other bifurcation takes place in all rays but may be with the third to seventh tertibrach. From this point on the inner rays remain unbranched but the outer rays bifurcate again at irregular heights. The arms are rounded transversely and the nonaxillary brachials are slightly elongate, quadrangular elements. The pinnules are delicate and none has been found in place, although the facets for their reception are well-developed notches. I have not observed any

indication of syzygial union of brachials or hyperpinnulation. The arms are so developed that they could in no case be closely apposed.

Measurements in millimeters:

	Holotype	*Paratype*
Overall height of crown	93.7	101.0
Width of crown	113.0	113.0
Height of anal sac	60.0	64.0
Width of anal sac	44.5	45.5
Height of dorsal cup	11.5	13.7
Width of dorsal cup (maximum)	29.0	35.3
Width of dorsal cup (posterior to anterior)	26.8	28.2
Height of IBB circlet	?	3.0
Width of IBB circlet	12.8	13.2
Diameter of proximal columnal	?	8.2
Length of basal (right anterior)	9.2	9.4
Width of basal (right anterior)	12.0	11.6
Length of radial (right anterior)	8.0	8.8
Width of radial (right anterior)	16.4	18.2
Length of RA	9.6	11.7
Width of RA	8.1	9.1
Length of anal X	9.3	
Width of X	8.6	
Length of RX	9.3	
Width of RX	9.2	
Length of X_2	6.7	
Width of X_2	6.6	

The columnar union with the dorsal cup was apparently weak because there is not a single specimen with more than the proximal columnal (which occupies an impressed area of the infrabasal cone) attached. The proximal columnal is round, is marked by fine crenellae, and has a strongly pentalobate lumen.

REMARKS.—This species is more comparable to *Anobasicrinus praecursor* (Moore and Plummer) than to any other known form. The base of that species is reportedly flattened but the illustration of the holotype (Moore and Plummer, 1940, pl. 21, fig. 7), as well as personal observation of several topotypes, leads me to believe in at least some specimens the infrabasals do form a mildly convex base. As many as 80 arms are reported for *A. praecursor,* with bifurcation endotomous after the second isotomous division. The second branching is usually with the second secundibrach, whereas in *A. bulbosus* it is usually with the third secundibrach and endotomous division is not attained until after the next branching. Some rather minor differences are also indicated; e.g., Moore and Plum-

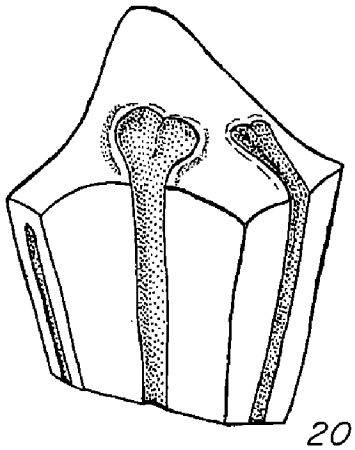
mer (1940) report some instances of hyperpinnulation, syzygial union and a longitudinal keel on the mid-line of the arms in the higher part of the crown of *A. praecursor*. None of these developments has been noted in *A. bulbosus*.

TYPES.—Holotype (OU 4030) and paratypes are deposited in the paleontological collections of The University of Oklahoma, numbers OU 762, 766, 768, 780, 4030-4039, 4196, and 4334.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Anobasicrinus erectus (Strimple, 1951), new combination

When I proposed the species *Aesiocrinus erectus* in 1951, I recognized that the form was close to *Plummericrinus* (Strimple, 1951d, p. 192, "Remarks"). I concluded that the presence of a pentagonal columnar scar, existence of a broad infrabasal circlet, and the apparent restrictive limitations of the posterior interradius (indicating room for only one anal plate), all pointed toward affinity with *Aesiocrinus* rather than *Plummericrinus*. When my study of *Plummericrinus* was made in 1954, the form was not considered and has not been to this time. *P. granulosus* has a broad



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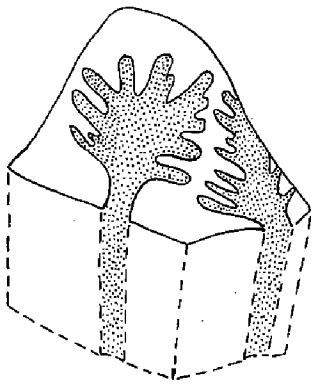

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TEXT-FIGURES 20, 21. Drawings of plates in the anal sacs of *Anobasicrinus*, new genus, showing the nature of the grooves on the external surfaces that pass to the interior of the sac, enlarged approximately x5.

(20), *Anobasicrinus obscurus*, n. sp. Plate showing two grooves that reach the exterior and have double terminations, and one groove that does not reach the exterior.

(21), *Anobasicrinus bulbosus*, n. sp. Plate showing the tree-like pattern of the multiple terminations on the exterior.

infrabasal circlet and is herein referred to *Anobasicrinus.* The columnar scar of *Anobasicrinus granulosus* has a mildly pentagonal outline as it has in several species of *Plummericrinus,* so that feature is now acceptable for these forms. It will be noted in forms such as *Anobasicrinus perplexus* (formerly *Plummericrinus erectus* Strimple, 1954, not 1951), the right posterior radial is reduced in size and its left side is elevated in such a manner as to create considerable space within the interradius, without increasing the diameter of the calyx. It is now thought that such a condition existed in *Anobasicrinus erectus.*

OCCURRENCE.—Oologah limestone formation, Marmaton group, Desmoinesian, Pennsylvanian; Chandler Materials Company, Garnett quarry, east of Tulsa, Oklahoma.

Anobasicrinus perplexus Strimple, new name

This name is proposed to replace the name *Plummericrinus erectus* Strimple (1954), which name has become a homonym through assignment of *Aesiocrinus erectus* Strimple (1951) to the genus *Anobasicrinus.* The description and illustrations as given for *Plummericrinus erectus* Strimple (1954, p. 206, pl. 23, figs. 9-12) are here referred to *Anobasicrinus perplexus* Strimple, new name.

REMARKS.—This species is referred to *Anobasicrinus* because of the broad, mildly upflared infrabasal circlet. It differs from other species of the genus in the exaggerated, notched development in distal portions of the interradial areas. The shape of the cup, wherein a bowl-shape is formed by the basal circlet with radial plates above flared outward, is much like the comparable condition that exists in *Haeretocrinus intermedius* Strimple, new species. The latter species has upflared infrabasals and a more advanced arrangement of anal plates.

TYPES.—Holotype and paratypes deposited in the Springer Collection, U. S. National Museum, Washington, D. C.

OCCURRENCE.—The holotype was collected in the excavation in the hill just west of Ochelata, Washington County, Oklahoma, near the Osage County line; and the paratypes in the hill, locally termed The Mound, just west of the city limits of Bartlesville, Washington County, Oklahoma, in a natural ditch actually located in Osage

County, Oklahoma; Wann formation, Ochelata group, Missourian, Pennsylvanian.

Anobasicrinus obscurus Strimple, new species

Plate 7, figures 4-7; text-figure 20

The dorsal cup is broad, with a subhorizontal, broad base. The sutures are deeply impressed and the cup is notched between radial plates. There are five infrabasals, forming a broad subhorizontal plane with a large portion of the mid-section shallowly impressed. Two small, round, thin proximal columnals occupy the central portion of the depression. The tips of the infrabasals are visible in side view of the calyx.

Three basal plates are preserved but the other elements of the cup are sufficiently well preserved to restore the two missing basals. They are of moderate size, slightly wider than high and are bulbous.

Five radials are the largest cup elements. They are almost twice as wide as high, have strong tumidity that is accentuated by the deeply impressed sutures, and are fundamentally pentagonal except where extra facets are required for the anal plates of the posterior interradius. The outer surfaces of the radials curve into the adsutural areas between arm-articulating facets. The outer ligament area slopes gently outward and is almost as large as the inner ligament area. A prominent ligament pit is to the fore of the broad, low, transverse ridge, and a wide, crenulated band forms a crescentic area bordered by a thin, long pit to the fore. The inner ligament is divided equally into two parts by the broad, shallow intermuscular furrow. There are well-developed lateral furrows but the muscle areas are ill defined. Adsutural slopes are steep and, as previously noted, are a continuation of the exterior surface of the plates. No crenulations appear on the inner ligament processes.

Three large anal plates are known to have been present in the cup although X is missing. They are X, RA, and RX and are in normal placement (Primitive Type).

The suture edges of all cup plates are strongly hollowed, each facet having one pit, apparently for the reception of ligament fibers. Denticles mark the raised surfaces surrounding the pits. Similar pits exist in *Plummericrinus mcguirei* but no denticles were reported for that species.

Four axillary first primibrachs are preserved, that of the left posterior being the one missing. They are rather low elements of approximately equal size, and have short lateral sides. There is some curvature longitudinally and transversely but there is no pronounced tumidity. As previously noted, there is a gap, or notch, between radial facets and this is not closed by the primibrachs. No more than two secundibrachs are preserved in any ray, and these are moderately long and mildly constricted. They have well-rounded exteriors. A facet for the reception of a pinnule has been observed on the inner side of one secundibrach. The upper facets of one primibrach have been observed and are rather unusual. There is a projection toward the front at the apex of the plate, separating the two facets; however, behind the projection there is an oval depression that must have housed a muscle. The regular articulating facets to the right and left have a ligament pit with crenulations, a transverse ridge and a shallow muscle area.

The anal sac is not completely preserved but when viewed from the right anterior its full contour is readily apparent. The lower portions are missing in one area, and indistinguishable in the vicinity of the arms, but the expansion and enlargement of tube plates, which are also protruded as spines, as the tube recurves toward the anterior, is well shown.

Ornamentation of the entire crown (excluding the anal tube) is visible to the naked eye and is composed of long, intertwining ridges. No definite pattern has been noted. There are about two ridges per millimeter. The markings are weak on the infrabasals and basals, and around the edges of the radials. The large, rugose spine plates of the anal sac are marked by sharp nodes or pustules.

Measurements of the holotype in millimeters:

Height of anal sac above the cup	34.0
Maximum width of anal sac	35.0
Height of dorsal cup	8.2
Width of cup (maximum)	26.0
Width of IBB circlet	9.0
Width of depressed basal area	5.1
Width of proximal columnals	2.7
Width of basal (right anterior)	9.5*
Length of basal (right anterior)	7.7*
Width of radial (right anterior)	13.8*
Width of articulating surface	12.1
Length of radial (right anterior)	7.3*
Width of PBr_1 (right anterior)	9.7*

Length of PBr_1 (right anterior)	5.5*
Length of lateral sides of PBr_1	2.5

* Measurements taken along surface curvature.

REMARKS.—*Anobasicrinus obscurus* is close to *A. braggsi,* which is probably a slightly older species. The present species has more tumid cup plates, more pronouncedly impressed sutures, and the radial articulating facets are not crenulated at the inner edges. Although it was not brought out in the description, there is a row of denticles along the inner edge of the articulating facets of the radials in *A. braggsi,* as shown by the illustration of the facet (Strimple, 1951b, pl. 3, fig. 10).

A. erectus has a narrower infrabasal disk, the cup surface is granular, and the columnar scar is pentagonal. *A. perplexus* is a smaller form, has a smooth surface, a more erect cup and does not have broad notches between plates of the basal and radial circlets, although the cup plates are tumid. *A. granulosus* has upflared IBB plates and a strongly granular surface.

HOLOTYPE.—Deposited in the paleontological collections of The University of Oklahoma, number OU 4167.

OCCURRENCE.—Blue-gray shale and limestone lentils at the base of the Wapanucka formation, Morrowan, Pennsylvanian; bank of Canyon Creek near C sec. 8, T. 1 N., R. 7 E., Pontotoc County, Oklahoma.

Family ERISOCRINIDAE S. A. Miller, 1889

About 30 partial or complete crowns of erisocrinids have been found in the excavations proper and the gravel bars of the Beggs, Oklahoma, locality. The absence of *Paradelocrinus* and *Erisocrinus,* is surprising, especially in the case of the former because it reached its maximum development in the Desmoinesian. One would expect smooth forms to be present because the horizon is near the top of the Desmoinesian, but all of the specimens are ornate. In the course of this and other studies, it has become apparent that ornamented *Delocrinus* is in effect, if not in fact, a separate phyletic line. In the Missourian and Virgilian, the smooth and ornate forms are found side by side, but in those ages the smooth forms are dominant. I am proposing *Graffhamicrinus,* new genus, for the reception of ornate forms formerly referred to *Delocrinus.*

Corythocrinus, new genus, is proposed for the reception of ornate forms previously considered to be *Endelocrinus,* primarily on the basis of the strong depressions at the angles of the cup plates.

Genus *Graffhamicrinus* Strimple, new genus

GENOTYPE.—*Graffhamicrinus acutus* Strimple n. sp.

The dorsal cup is low, truncate bowl-shaped with deep basal concavity. Five IBB occupy the bottom of the basal concavity, are normally mainly covered by the proximal columnal and are down-flared. Five BB are elongate, form most of the basal concavity and curve upward to become visible in side view of the cup. Five RR are large, pentagonal elements. There is a single anal plate, normally with the upper half above the summit of the cup and resting upon the truncated distal tip of the proximal basal. The anal plate is succeeded by a single plate above. There are ten biserial arms, bifurcating on the first primibrach in all rays. The primibrachs are usually rather short elements and may be mildly protruded and spine-like but do not develop long spines, as in *Delocrinus subhemisphericus.* The exterior of the lower arms are normally mildly rounded but the upper arms are almost flat. The lateral sides of the arms are flat so that the arms abut closely when in repose. All cup plates are marked by ornamentation in the form of pustules, nodes, tubercles, ridges, or strong granules, or a combination of any of these features, and the lower arms are also so marked. The column is round.

Species assigned to *Graffhamicrinus*:

	Occurrence	*Remarks*
Graffhamicrinus acutus Strimple, n. sp.	Desmoinesian; Okla.	Genotype
G. acutus spicatus Strimple, n. subspecies	Desmoinesian; Okla.	*Graffhamicrinus*
Delocrinus granulosus Moore & Plummer, 1940	Desmoinesian; Tex., Okla.; Atokan; Okla.	”
D. wolforum Moore & Plummer, 1940	Virgilian; Tex.	”
D. bispinosus Moore & Plummer, 1940	Desmoinesian; Okla., Tex.	”
D. bullatus Moore & Plummer, 1940	Desmoinesian; Tex.	”
D. nodosarius Strimple, 1939	Missourian; Okla.	”

D. aristatus Strimple, 1949(c)	Desmoinesian; Okla.	*Graffhamicrinus*
D. armatura Strimple, 1949(c)	Desmoinesian; Okla.	,,
D. subcoronatus Moore & Plummer, 1940	Missourian; Tex.	,,
D. granulosus var. *moniformis* Moore & Plummer, 1940	Desmoinesian; Tex.	,,
D. waughi Moore & Strimple, 1941	Lower Permian; Kans.	,,
D. stullensis Strimple, 1947	Virgilian; Kans.	,,
D. magnificus Strimple, 1947	Virgilian; Kans.	,,
D. paucinodus Moore & Plummer, 1940	Missourian; Tex.	,,
D. papulosus Moore & Plummer, 1940	Missourian; Tex.	,,
D. pictus Moore & Plummer, 1940	Desmoinesian; Tex.	,,
D. granulosus var. *zonatus* Moore & Plummer, 1940	Desmoinesian; Tex.	,,
D. graphicus Moore & Plummer, 1940	Missourian; Tex.	,,
Cyathocrinus somersi Whitfield, 1882	? Desmoinesian; Ohio	,,

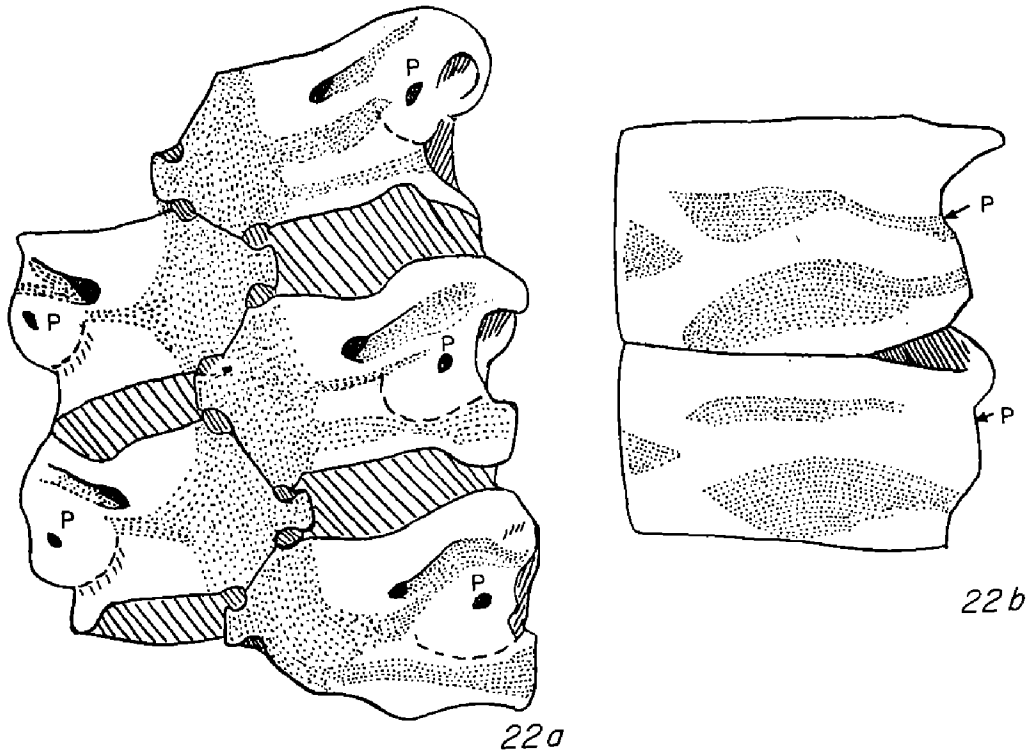
RANGE.—Pennsylvanian (Desmoinesian to Virgilian), Lower Permian; North America.

Graffhamicrinus acutus Strimple, new species
Plate 10, figures 4-8; plate 12, figures 4-6; plate 13, figure 7; plate 15, figure 6; plate 19, figure 2; text-figures 22a, b

Dorsal cup truncate bowl-shaped with steep lateral sides and deep basal concavity. Five small IBB downflared, confined to the bottom of the basal concavity and almost entirely covered by the proximal columnals. Five long BB form the sides of the concavity and curve sharply out of the concavity so that about one-third of their length participates in the outer calyx walls. Five large RR are pentagonal and are about twice as wide as long. In one ray, the outer ligament pit and part of the transverse ridge is visible. The ligament pit is sharply defined, occupies about one-third of the facet width and is well to the front of the transverse ridge. The facets appear to slope slightly outward. Anal X is relatively large

hexagonal and rests directly upon the posterior basal, well within the cup. About half its length extends above the summit of the cup. In a paratype, the succeeding anal plate is preserved in place. It appears to be a hexagonal element slightly smaller than the anal plate. The specimen is figured herein (pl. 15, fig. 6) because this is a rare occurrence. All cup plates have a slightly irregular surface and occasional low nodes are found on the basals. Two confluent nodes are present in the median upper portion of each radial.

All five first primibrachs are axillary, low elements, with short lateral sides. They are of equal height in the holotype but in one paratype the anterior PBr is quite large and the right and left posterior larger than those of the right and left anterior. In midsection of the distal portion of primibrach, there is a broad, blunt protrusion, flanked to the right and left below by a small node on each side. First secundibrach is a large quadrangular plate, with succeeding segments interlocking (biserial). There is a slight widening of the arms after a mild constriction in the lower portions. The SBrBr are marked by low nodes near the center of the arm to about the tenth SBr.



TEXT-FIGURES 22a, b. *Graffhamicrinus acutus*, n. sp. Paratype OU 4152. Camera lucida drawings enlarged approximately x5. Grooves are indicated by stippled areas and pores are shown in solid black. Diagonal lines indicate strongly depressed areas. Facets for attachment of pinnules are indicated by the letter P. (a), internal view of arm segment; (b), side view of two of the brachials.

Proximal colmunals show a series of two nodals with three thin internodals between, the middle internodal being slightly larger than the other two. Outer edges of the nodals have a rough appearance. Articular facet of a nodal is relatively small and marked by about 26 short crenellae. Lumen is small and round.

Pinnular facets are observed where the sides of the arms are visible. There is a notched platform at the top of one brachial that is continued upward at an angle into the next brachial above. In some of the lowermost secundibrachs there is a lower groove that is directed downward. I do not know the function of this latter groove, although one would assume it served as a pinnule socket, in which case it would represent hyperpinnulation.

Measurements of holotype in millimeters:

Overall length of crown as preserved	39.0
Height of dorsal cup	7.5
Width of dorsal cup	19.5
Length of basal (right posterior)	9.0*
Width of basal (right posterior)	7.7*
Length of radial (right anterior)	7.1*
Width of radial (right anterior)	11.6*
Length of anal	4.6*
Width of anal	4.6*
Diameter of proximal columnal	3.0

* Measurements taken along surface curvature.

REMARKS.—Comparison with the numerous other described species is simplified as much as possible by taking the most obvious differences. The nature of ornamentation is a basic factor in most instances. It is to be understood that there are other differences that are equally as important.

G. magnificus and *G. nodosarius* have more spectacular ornamentation (with nodes tending to be elongate in directions normal to the plate margins) than has *G. acutus*.

G. pictus, G. graphicus, G. papulosus, G. wolforum, and *G. stullensis* are marked by granules and do not produce nodes or tubercles.

G. granulosus, G. somersi, G. waughi, G. aristatus, G. granulosus var. *moniliformis,* and *G. granulosus* var. *zonatus* are marked by nodes, or tubercles, with interposed granules.

G. paucinodus, G. subcoronatus, G. bullatus, G. bispinosus, and *G. armatura,* in common with *G. acutus,* lack granular orna-

mentation. The ratio of height to width of the dorsal cup of *G. subcoronatus* is 0.43 as compared to 0.38 for *G. acutus*. There is also a continuous row of nodes forming a rim below the outer ligamental area of *G. subcoronatus*. *G. armatura* is a smaller species covered by irregularly spaced nodes. *G. paucinodus* is smaller than *G. acutus,* has a proportionately lower cup, and the sutures are marked by a faint ridge. *G. bullatus* is not ornate in the strict sense although there are bulges near the center of each radial and near the distal part of each basal. *G. bispinosus* has a narrower basal concavity than *G. acutus,* and each radial is marked distally by a single node at each lateral corner.

TYPES.—Holotype (OU 4150) and paratypes are deposited in the paleontological collections of The University of Oklahoma, numbers OU 763, 767, 4150-4154, 4156-4164, and 4174.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Graffhamicrinus acutus spicatus Strimple, new subspecies
Plate 17, figures 1-3

One specimen in the collection is the most spectacularly ornate representative of the genus known to me at this time. The dorsal cup is truncate bowl-shaped with a deep basal concavity. Infrabasals have not been observed because of the presence of proximal columnals. Five large basals curve evenly out of the concavity and form a petal-shaped circlet. As the perimeter of the basal plane is approached, heavy tubercles are formed which in some instances become confluent. The radials are about twice as wide as long and are marked by irregularly spaced, rounded nodes. The left anterior radial has 14 nodes. Anal X is a wide element with the upper portion curved sharply inward. A few prominent nodes are present on both the proximal and distal portions of the anal X. Sutures between all cup plates repose at the bottoms of furrow-like depressions.

The two posterior axillary first primibrachs are preserved in place. They are large plates and could be termed as short, blunt spines. Some irregular nodes are present. Portions of arms are preserved in a few rays. The first secundibrach has a heavy,

blunt spine and the succeeding brachials have a small node near the center of the arm. They are biserial and pinnule bearing. The arms have a width of 6 mm at about the eighth to tenth secundibrach. Fine ridge-like ornamentation is found in the lower parts of the arms along the lateral sides.

Proximal columnals are composed of nodals separated by three thin internodals, the middle one the largest of the three. The lumen is rather large and is pentalobate. Faint traces of crenellae are present but the removal of the dense matrix has almost obliterated them.

Measurements of holotype in millimeters:

Height of cup	8.2
Width of cup	21.6
Width of basal concavity	12.2
Length of basal (right postreior)	10.5*
Width of basal (right posterior)	8.9*
Length of radial (left anterior)	7.3*
Width of radial (left anterior)	14.2*
Width of anal X	5.8*
Length of anal X	6.4*
Width of proximal nodal	3.0

* Measurements taken along surface curvature.

REMARKS.—This subspecies is closely comparable to *G. granulosus* and to *G. somersi*. The latter species is reported to have a relatively wider and lower calyx. *G. granulosus* has a slightly wider and lower cup and there are pronounced granules between the nodes. The species also has a festoon of nodes across the distal portion of the radial plates and a paucity of nodes on the basal plates. In *G. acutus spicatus* the basal plates are heavily ornate.

HOLOTYPE.—Deposited in the paleontological collections of The University of Oklahoma, number OU 4155.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Genus *Corythocrinus* Strimple, new genus

GENOTYPE.—*Corythocrinus undulatus* Strimple, n. sp.

This genus is proposed for the reception of those forms previously assigned to *Endelocrinus* or *Delocrinus* having a nodose surface, tumidity of BB and RR plates accentuated by circular (or dimple-like) depressions at the angles of the plates in their circlets. Strongly granular forms would also be included in the new genus.

Endelocrinus matheri (Moore and Plummer) has a shagreen surface consisting of delicate, irregularly winding fine ridges and depressions. I do not consider it to belong to the genus *Corythocrinus* although the genus is no doubt a derivative of the species, or of a closely related form.

Species assigned to *Corythocrinus*:

	Occurrence	*Remarks*
Corythocrinus undulatus Strimple, n. sp.	Desmoinesian; Okla.	Genotype
Endelocrinus bifidus Moore and Plummer, 1940	Missourian; Tex.	*Corythocrinus*
Endelocrinus rectus Moore and Plummer, 1940	Desmoinesian; Tex.	,,
Delocrinus parinodosarius Strimple, 1940	Desmoinesian; Okla.	,,

RANGE.—Pennsylvanian (Desmoinesian and Missourian); Mid-continent region, North America.

Corythocrinus undulatus Strimple, new species
Plate 13, figures 3-6

Only three crowns of this species have been observed. It has characters that are ascribable to both *Endelocrinus* and *Graffhamicrinus;* i. e., the surface of the cup and lower arms is marked by nodes, and plates of the B and R circlets are tumid with sharply impressed areas at the angles of the plates of circlets. The arms do not expand appreciably at mid-length as they normally do in *Graffhamicrinus* and the primibrachs are more like those of *Endelocrinus.* On the other hand, the first secundibrach becomes interlocking (biserial) with the next brachial, which is more comparable to *Graffhamicrinus* than to *Endelocrinus.*

The dorsal cup is low, truncate bowl-shaped, with a relatively broad and deep basal concavity. A low ridge parallels the sharply indented sutures between the radial and basal circlets, and sporadic, low, rounded nodes are present. The lateral sides of the cup are erect. The IBB have not been observed but are obviously confined to the bottom of the basal concavity. Five BB are long plates with proximal portions confined to the basal concavity. They curve sharply upward in distal portion to participate in the lateral sides of the cup. Five RR are slightly wider than long and have an arcuate, swollen area just below the outer ligament areas. Anal X is elongate, hexagonal, rests evenly upon the truncated upper

surface of the posterior basal, and the upper half extends above the summit of the cup.

In some cases the sutures are seen to be marked by fine grooves that are at right angles to the sutures. Thirty-two such grooves mark the suture between the right anterior radial and the anterior basal.

First primibrachs are axillary in all rays and are rather elongate. Those of the right and left posterior and the anterior are considerably longer than those of the right and left anterior. The elongate PBrBr have long lateral sides, slope evenly outward and have a node just below the distal apex. First secundibrachs are large, quadrangular, but interlock with the succeeding secundibrach (biserial). Pinnules are known only from disarticulated segments and the facets for their reception.

Proximal columnals are circular in outline and are small. Exact observation is not possible because I could not remove the hard matrix without destroying some of the specimen.

Measurements of the holotype in millimeters:

Overall length of crown	41.9
Height of dorsal cup	6.8
Width of dorsal cup	15.2
Width of basal concavity (approximate)	11.3
Length of basal (right posterior)	8.7*
Width of basal (right posterior)	7.5*
Length of radial (right anterior)	6.3*
Width of radial (right anterior)	10.3*
Diameter of column	1.8

* Measurements taken along surface curvature.

REMARKS.—The general contour of the crown in side view, nature of the first primibrachs, and the cup shape are more comparable to *Endelocrinus grafordensis* Moore and Plummer (1940) than to other described species. The deep furrows, marking the sutures between the basal and radial circlets, nodose and ridge-like ornamentation, deep basal concavity, and biserial nature of the most proximal secundibrachs all serve to distinguish *Corythocrinus undulatus* from *Endelocrinus grafordensis* or other described species.

TYPES.—Deposited in the paleontological collections of The University of Oklahoma, numbers OU 4169-4171.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

Family SCYTALOCRINIDAE Moore and Laudon, 1943

SYNONYM—Scytalecrinidae Bather, 1890.

There is a surprisingly small number of Pennsylvanian forms described that belong under this family. This is probably due to their relatively small size and delicate nature. A small group has been described under the genus *Elibatocrinus* Moore (1940). Moore and Laudon (1943) placed the genus under their family BLOTHROCRINIDAE. I am unable to visualize any relationship between *Elibatocrinus* and *Blothrocrinus* and refer the genus here to the SCYTALOCRINIDAE.

RANGE.—Devonian-Pennsylvanian.

Genus *Elibatocrinus* Moore, 1940

GENOTYPE.—*Elibatocrinus leptocalyx* Moore, 1940.

In the brief generic description given by Moore and Laudon (in Shimer and Shrock, 1944, p. 159) a description of the arm structure is given as follows: "arms branch isotomously on PBr_1, BrBr cuneate, elongate, keeled, pinnules large . . . ". This description must have been taken from an undescribed specimen because no other reference to the arm structure has been founnd by me in the literature. It is correct as shown by the species described here as *Elibatocrinus hoodi* Strimple, new species, from the Holdenville formation, Marmaton group, Desmoinesian. The species is the oldest known representative of the genus and the only species reported to date from Oklahoma.

Species assigned to *Elibatocrinus*:

	Occurrence	*Remarks*
Elibatocrinus leptocalyx Moore, 1940	Missourian; Kans.	Genotype
E. notabilis Moore, 1940	Missourian; Kans.	*Elibatocrinus*
E. concinnulus Moore, 1940	Virgilian; Kans.	*Elibatocrinus* (IBB circlet)
E. catactus Moore, 1940	Virgilian; Kans.	*Elibatocrinus* (IBB circlet)
Elibatocrinus sp. Strimple, 1951	Missourian; Tex.	*Elibatocrinus* (IBB circlets)
E. hoodi Strimple, n. sp.	Desmoinesian; Okla.	*Elibatocrinus*

RANGE.—Pennsylvanian (Desmoinesian to Virgilian); Mid-continent region, North America.

Elibatocrinus hoodi Strimple, new species
Plate 16, figures 4, 5; text-figure 23

Preservation of this small form, with almost tissue-thin plates, is remarkable, and its existence among the relatively gigantic crinoids of the present fauna indicates that our knowledge of the complete group, as it must have existed in life, is indeed limited. Three partial crowns were found, one by my friend Mr. Jack Hood, Tulsa, Oklahoma, from whom the species takes its name.

The crown is composed of a small, elongate, conical cup and ten thin, cuneiform arms of unprecedented length. Long, thin pinnules are prominent elements of the arms. Articulation between the calyx and arms, and between brachials, is accomplished by exterior as well as interior expansion of the thin plates to form shelves for the reception of ligaments and/or muscles. Structural reinforcement of the arm elements is apparently also accomplished by thickening of the segments in mid-portion into vertically directed keel-like ridges.

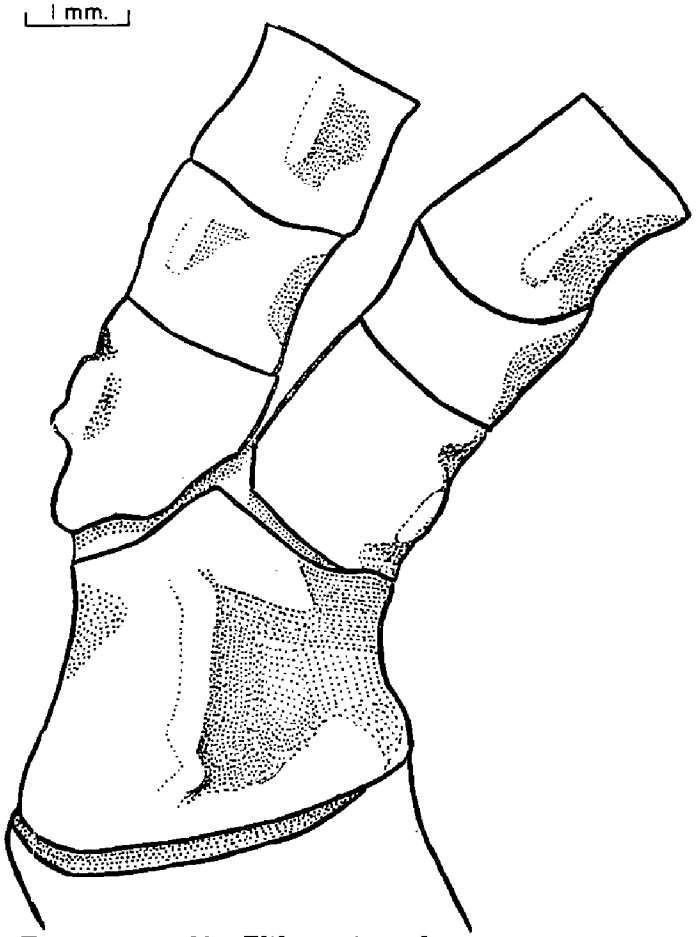
Three infrabasals rise evenly from the columnar attachment. The smaller IB is known to be in right posterior position through observation of the positions of the two larger IBB. Five large basals are mildly protruded in mid-section just above their mid-length. Five large radials curve outward, or flare slightly, in mid-section as the summit is approached, but the lateral sides remain normal. This causes the outer ligament area to be forward, with transverse ridge shorter than the width of the plate. The outer ligament area is directed outward and has a relatively large ligament pit.

There are three anal plates in normal arrangement (Primitive Type). Anal X and RA are of about equal size, but RX is a smaller plate. The dorsal cup is devoid of surface decoration unless the ridge below the outer ligament area of the radials is so considered.

Although the width of the articular facets of the radials is decidedly less than the distal width of the plates, the width of the primibrachs is fully equal to the width of the radials. The first primibrachs are axillary in all rays. They have an hour-glass appearance, which is an optical illusion caused by the strong, keel-like protrusion of the mid-portion of the plate. The lateral sides rise evenly and almost vertically. In some rays the truncation of the

distal edge is at a low angle, but is normally pointed. Secundibrachs are rather elongate, narrow plates, each marked by a vertical keel-like protruberance in mid-portion. The protruberances do not reach the proximal or distal extremities of the brachials. The plates are decidedly cuneiform. The pinnules are long, slender, prominent elements.

The column is strongly annulated and is composed of alternately expanded, large and small segments, that have curved longitudinal profiles. The columnals are marked by vertical ridges and grooves that are outward extensions of the weak articulating crenellae. In the holotype, there is little tapering of the stem as preserved, but in one of the paratypes the column tapers rather rapidly for a short distance, thereafter, the columnals gradually show a tendency to thicken and internodals become discernable. The internodals are known to exist in the most proximal portion of



TEXT-FIGURE 23. *Elibatocrinus hoodi*, n. sp. Drawing of the lower portion of the arms to show the nature of the first primibrach and the keel-like extensions of the brachials.

the stem but they are so thin and narrow that they do not appear on the exterior. At a distance of about 9.5 millimeters from the cup, the pattern is one nodal succeeded by seven internodals. The first internodal is thin and rather narrow, the next wider and a little thicker, then thin again and narrow, etc., ending with another nodal. No cirri have been observed, but some nodes have been observed on the nodals. The lumen is quite large and circular.

The presence of a delicate but prominent anal tube is known from fragmentary evidence. A cluster of tube plates is present high above the cup of the holotype and a few of the lower tube plates are preserved in one paratype. The plates are small, thin and have pore-slits along their edges.

Measurements of the holotype in millimeters:

Width of cup	8.5
Height of cup	8.1
Width of IBB circlet	3.6
Height of IBB circlet	2.1
Length of basal	3.8
Width of basal	3.7
Length of radial	2.2
Width of radial	3.8
Length of anterior PBr_1	3.1
Width of anterior PBr_1	3.7
Length of lateral side PBr_1	2.5
Width of proximal columnals	2.2
Width of columnals about 17 mm below the cup	1.8

REMARKS.—Only two species are known for which complete dorsal cups are preserved. These are *Elibatocrinus catactus* and *E. leptocalyx*. No forms have been described with the arms attached. *E. catactus* is delicately decorated by low, slightly uneven elevations and depressions. *E. leptocalyx* has a smooth exterior. *E. hoodi* is readily distinguished from either species by the transverse ridge near the summits of the radials, below the outer ligament areas.

E. notabilis and *E. concinnulus* are each based on a single infrabasal circlet with a portion of the column attached. Strong emphasis is given to the interior structure by Moore (1940). Fortunately comparison is possible, even without knowledge of the interior nature of the circlet of *E. hoodi*. *E. notabilis* is marked externally by rather coarse, rounded tubercles and the column is smooth, with the surfaces of adjoining columnals confluent. As previously noted *E. hoodi* has no surface decoration, and the stem is strongly annu-

late. The column of *E. concinnulus* is strongly annulate and is composed of alternately expanded large and small segments that have curved longitudinal profiles. The columnals are also marked by vertical grooves and ridges. This is almost identical to the column of *E. hoodi*. The lumen of *E. concinnulus* is not reported so that comparison of this feature is not possible. The infrabasal circlet of *E. concinnulus* is reportedly decorated by a roughness that is shagreen in appearance and the outline of the circlet in side view is slightly bowl shaped. In *E. hoodi* the IBB circlet is erect, conical.

TYPES.—Holotype (OU 4002) and two paratypes are deposited in the paleontological collections of The University of Oklahoma, numbers OU 4001, 4002, 4003.

OCCURRENCE.—Holdenville formation, Marmaton group, Desmoinesian, Pennsylvanian; NE¼ sec. 24, T. 15 N., R. 11 E., about 4 miles northwest of Beggs, Okmulgee County, Oklahoma.

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Plate 1

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Texacrinus coniformis, n. sp. 95

Figures 1-3. Holotype (OU 4093) crown viewed from the posterior, base, and anterior, x1.5.

Stenopecrinus planus (Strimple) 40

Figures 4, 5. Metatype (OU 4165) crown viewed from anterior and posterior, x1.5.

PLATE 1

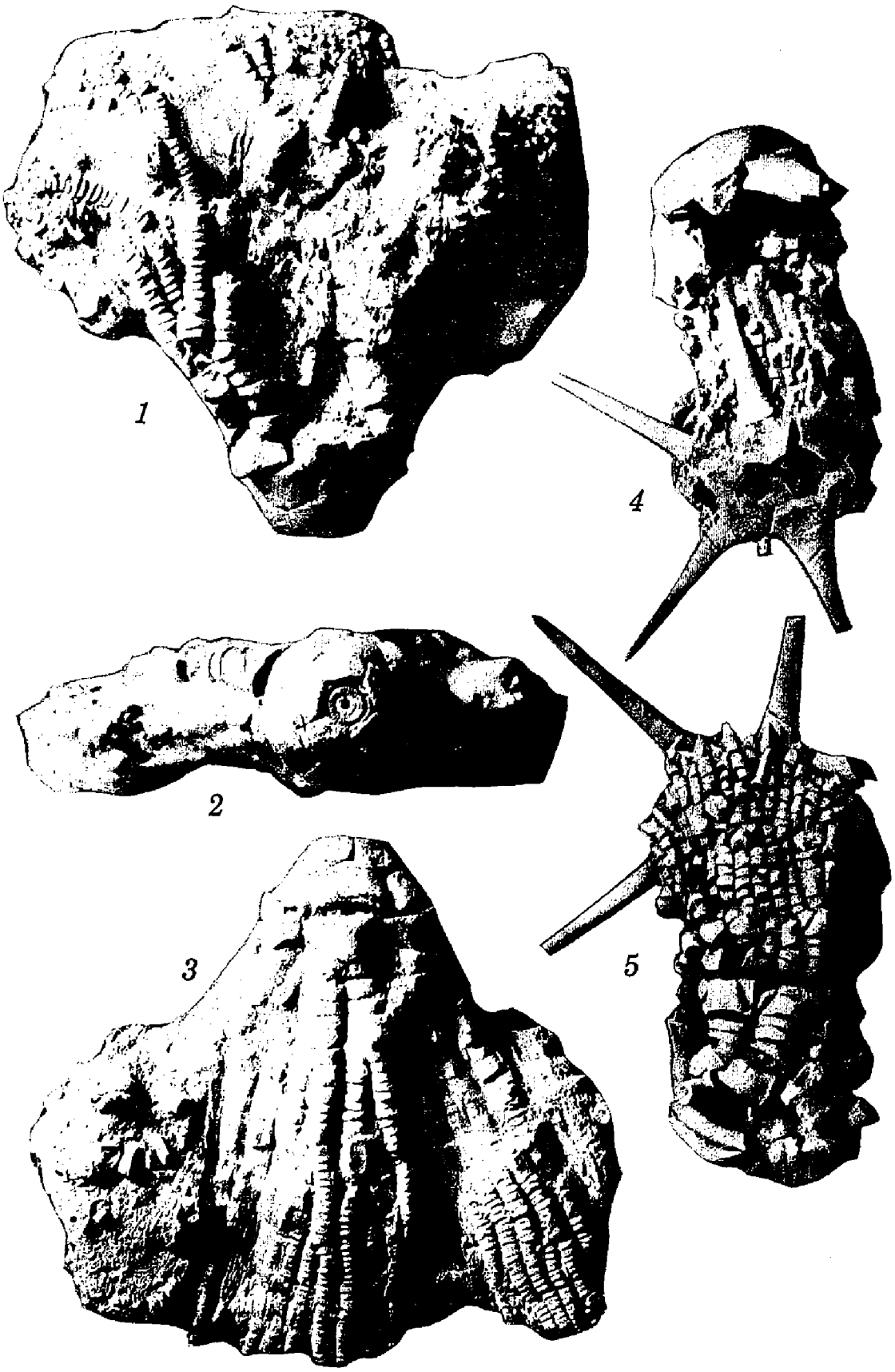

PLATE 2

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Schedexocrinus gibberellus, n. sp. 29

FIGURE 1. Paratype (OU 4029) dorsal cup viewed from anterior to show articular facet, ca. x1.

FIGURES 2, 3. Paratype (OU 4027) crown viewed obliquely from base and from summit, x0.77.

Stenopecrinus rugosus, n. sp. 42

FIGURES 4, 5. Holotype (OU 4166) crown viewed from left posterior, x1, and from base, x3.2.

Polygonocrinus multiextensus, n. sp. 61

FIGURE 6. Paratype (OU 4060) crown viewed obliquely from anterior, x1.

PLATE 2

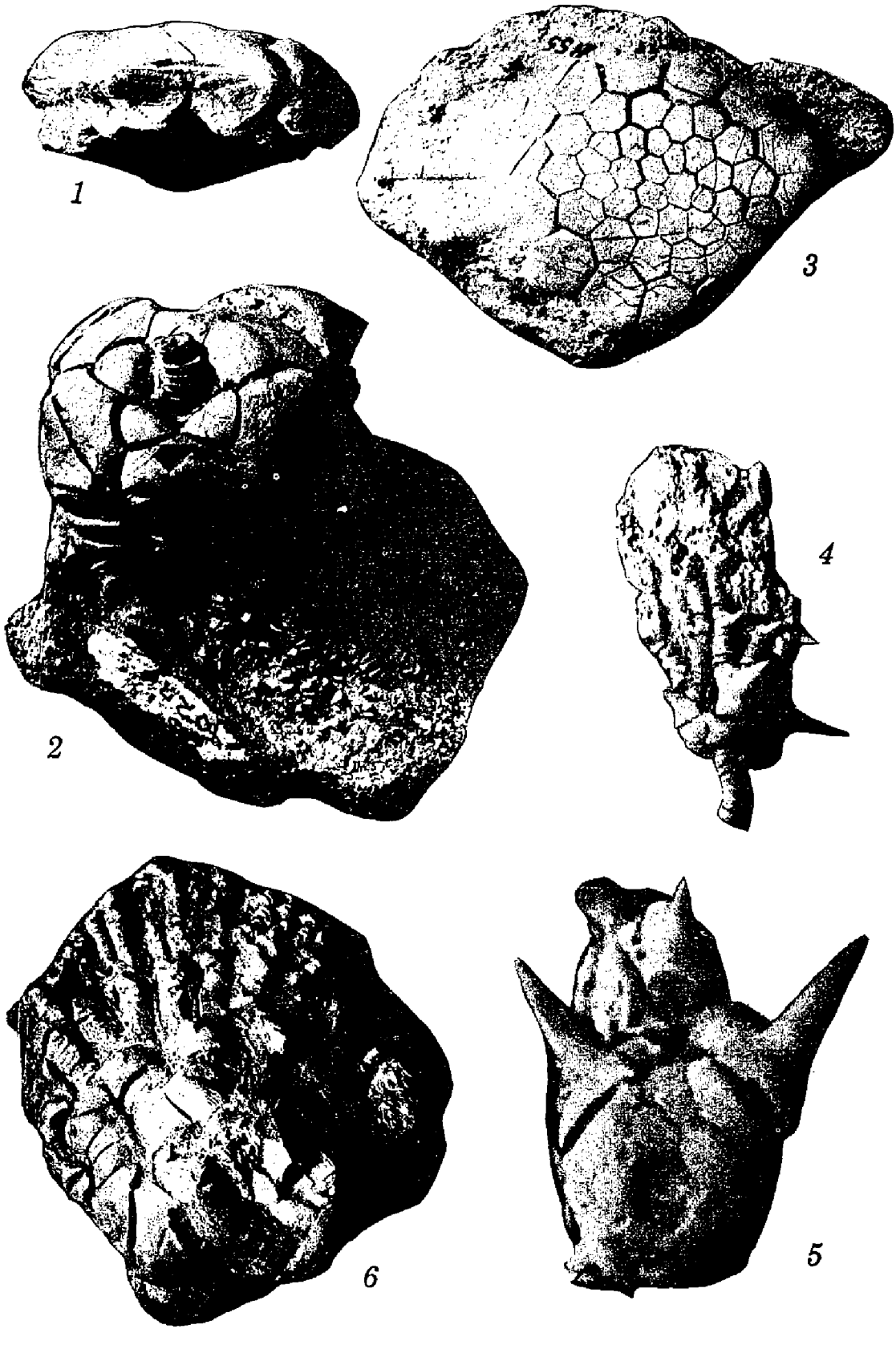

PLATE 3

Page

Anobasicrinus bulbosus, n. sp. 115

FIGURES 1-3. Holotype (OU 4030) crown viewed from anterior, base, and posterior, x0.66.

Paianocrinus aptus Strimple 22

FIGURES 4, 5. Plesiotype (OU 4168) crown viewed from anterior, x2.6, and obliquely from summit, x1.5.

PLATE 3

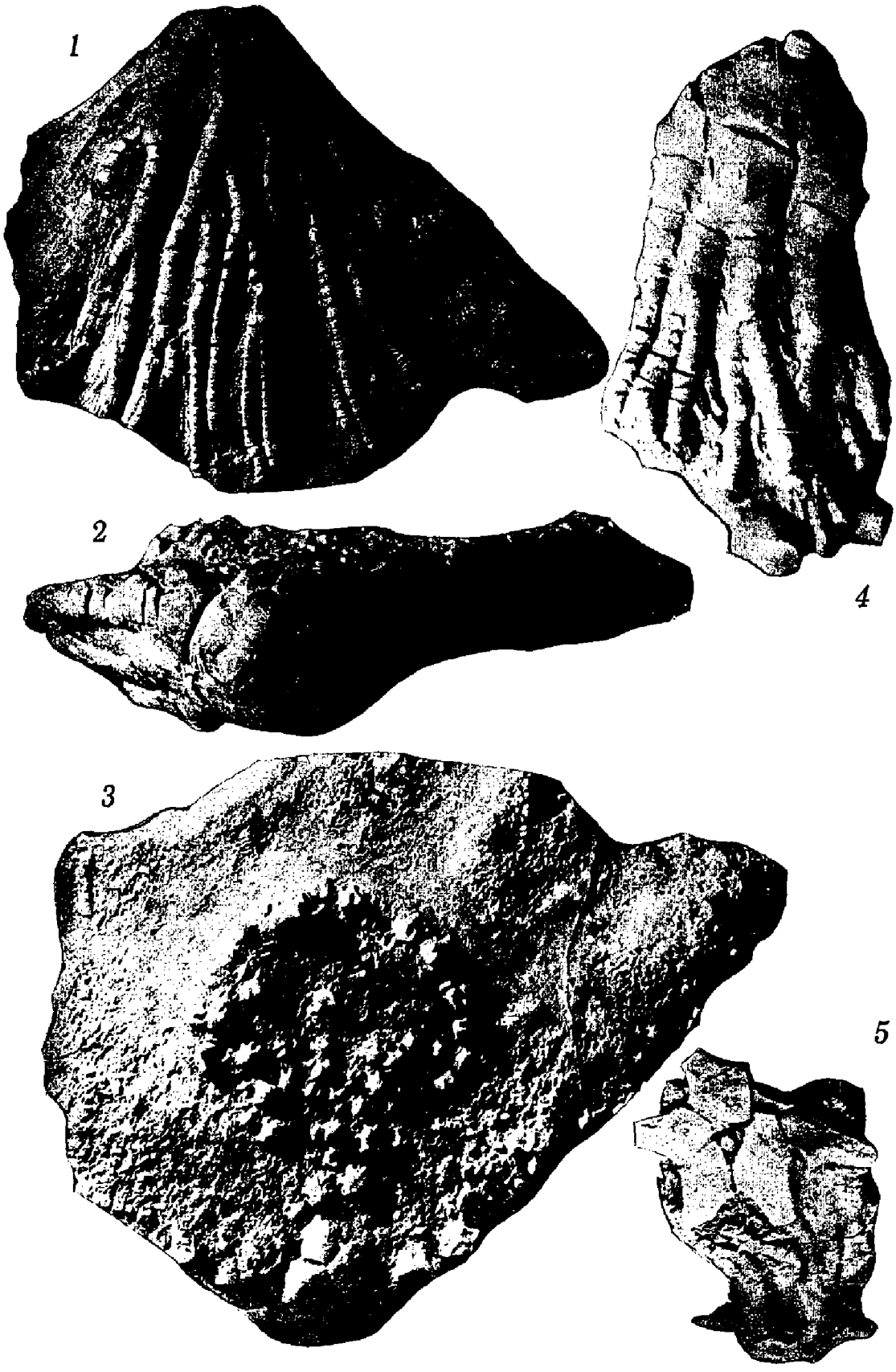

Plate 4

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Plaxocrinus octarius, n. sp. 54

Figures 1, 2. Holotype (OU 4017) crown viewed from below and from summit, x2.

Metaperimestocrinus spiniferus, n. sp. 37

Figures 3, 4. Holotype (OU 4015) crown viewed from below and from summit, x1.7.

Figures 5-7. Paratype (OU 4013) partial crown viewed from posterior, base, and anterior, x1.7.

PLATE 4

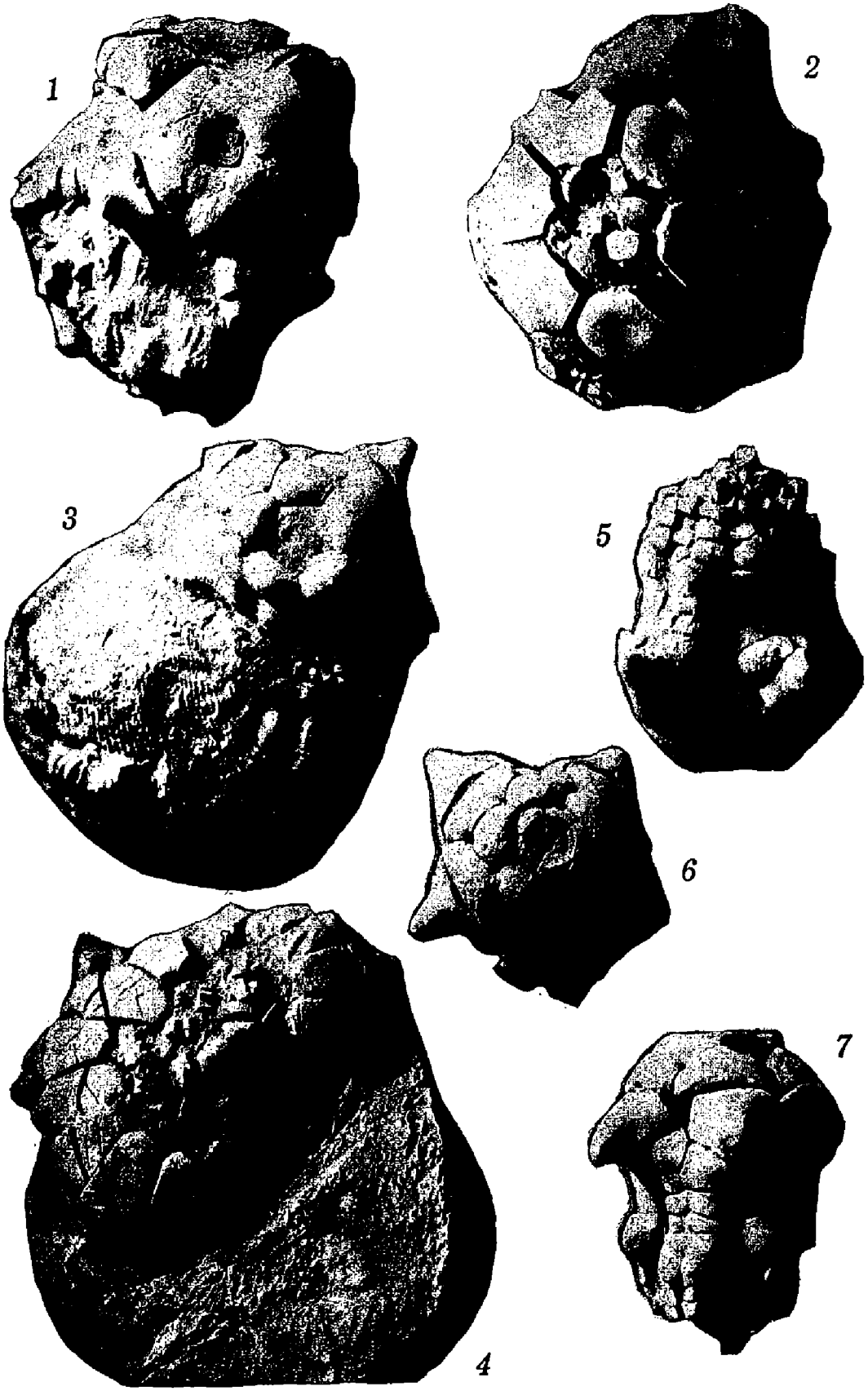

PLATE 5

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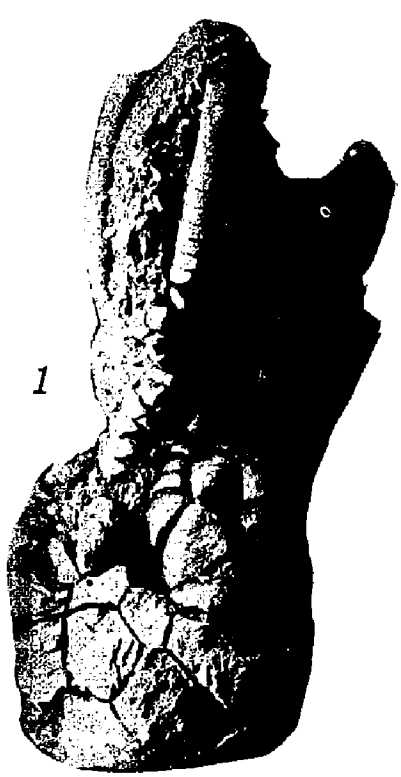
Ataxiacrinus multiramus, n. sp. 90

FIGURES 1-3. Paratype (OU 4043) crown from posterior, right posterior, and base, x1.2.

Allosocrinus libratus, n. sp. 105

FIGURES 4-6. Holotype (OU 4102) viewed from posterior, anterior, and base x2.

PLATE 5



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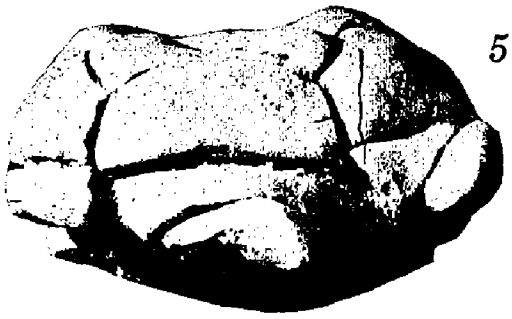

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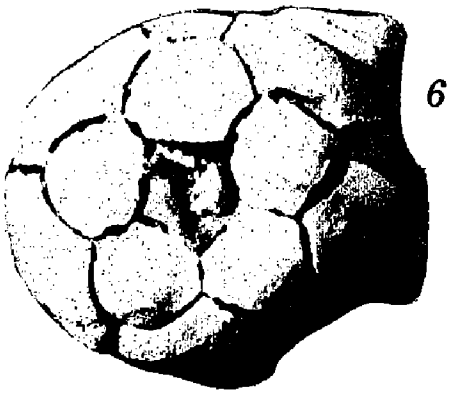

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PLATE 6

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Metacromyocrinus holdenvillensis, n. sp. 69

FIGURES 1-3. Holotype (OU 4125) crown viewed from posterior, base, and right posterior, x0.86.

Aglaocrinus magnus (Strimple) new combination 87

FIGURE 4. Plesiotype (OU 4123) crown viewed from posterior, x0.86.

Ulocrinus elongatus, n. sp. 75

FIGURES 5, 6. Holotype (OU 4040) crown viewed from posterior and right posterior, x0.77.

PLATE 6

PLATE 7

Page

Anobasicrinus bulbosus, n. sp. 115

FIGURES 1-3. Paratype (OU 4032) viewed from posterior, base, and anterior, ca. x1.

Anobasicrinus obscurus, n. sp. 120

FIGURES 4-7. Holotype (OU 4167) oblique side view of left anterior radial to show ligamental depressions, view from above to show articular facets, view of calyx with partial arms and bulbous anal sac from right anterior-anterior interradius, and view from below, x1.5.

PLATE 7

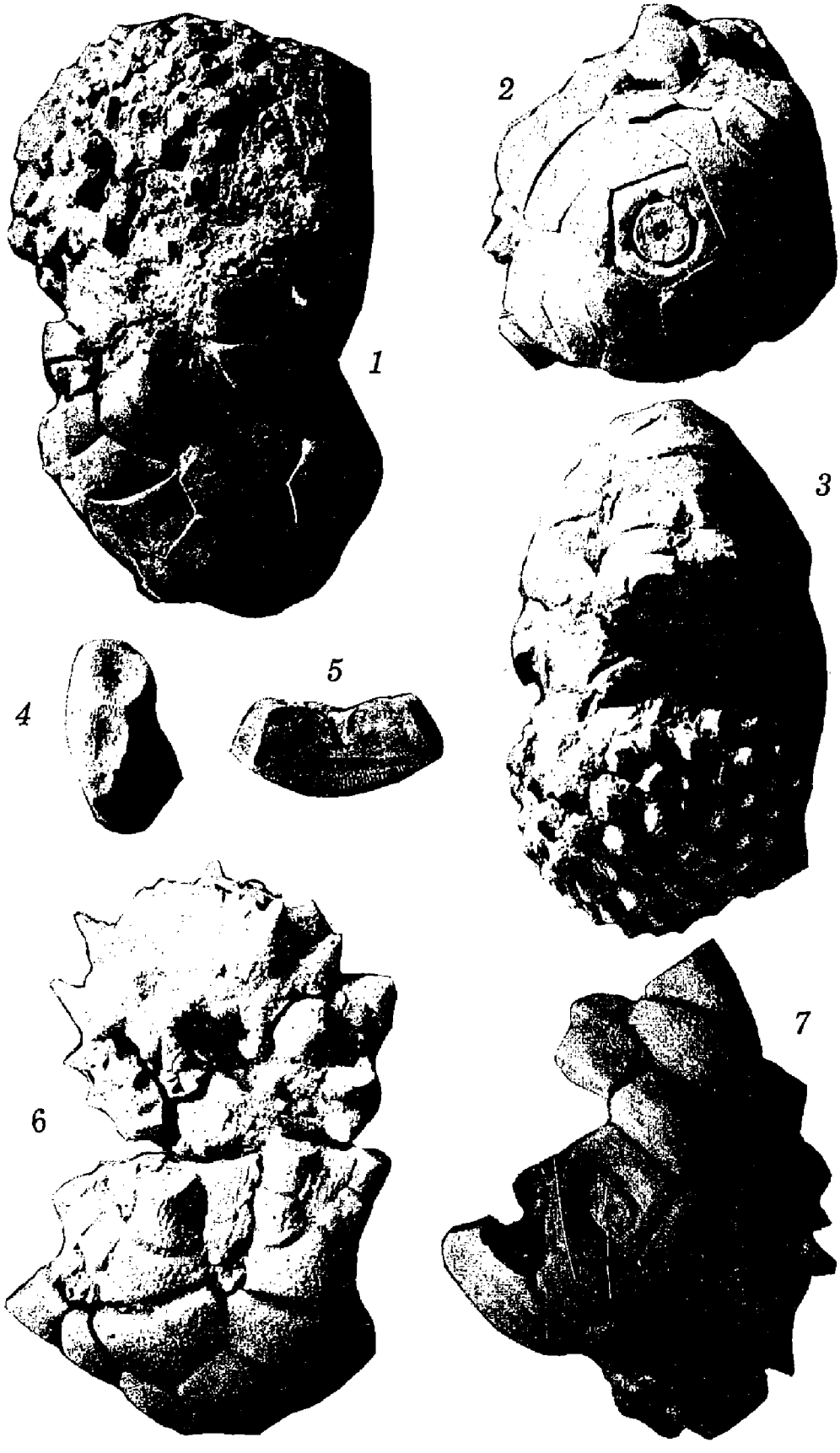

PLATE 8

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Aglaocrinus magnus (Strimple) new combination 87

FIGURES 1-3. Plesiotype (OU 4044) crown viewed from right anterior-anterior interray, from base, and from left posterior, x0.71.

Parethelocrinus ellipticus, n. sp. 83

FIGURES 4, 5. Holotype (OU 4135) crown viewed from base and from right posterior, x1.

PLATE 8

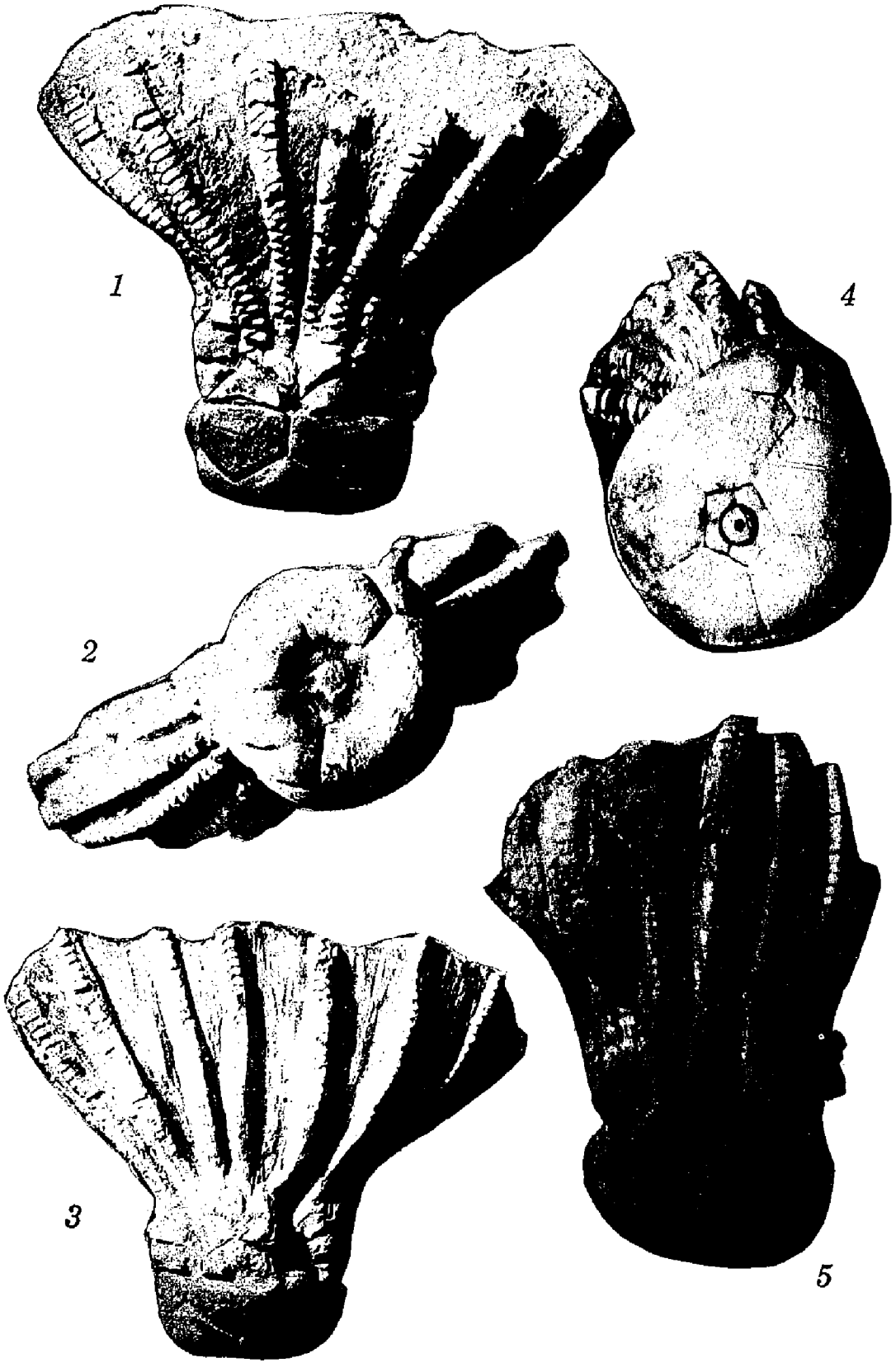

PLATE 9

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Schistocrinus azygous (Strimple) new combination 100

FIGURES 1, 2. Plesiotype (OU 4008) crown viewed from below and from posterior side. Definitely identifiable sac plates inked to show bulbous nature of the anal sac, x0.83.

Schedexocrinus gibberellus, n. sp. 29

FIGURE 3. A paratype viewed from below but showing arm structure, x.85.

FIGURE 4. Paratype (OU 4029) viewed from summit to show inner ligament development between articular facet of the anterior and the two adjacent facets, x0.80.

FIGURE 5. Paratype (OU 4021) crown viewed from anterior showing extensions toward the inside of arms, as well as extended axillary brachials, x0.75.

PLATE 9

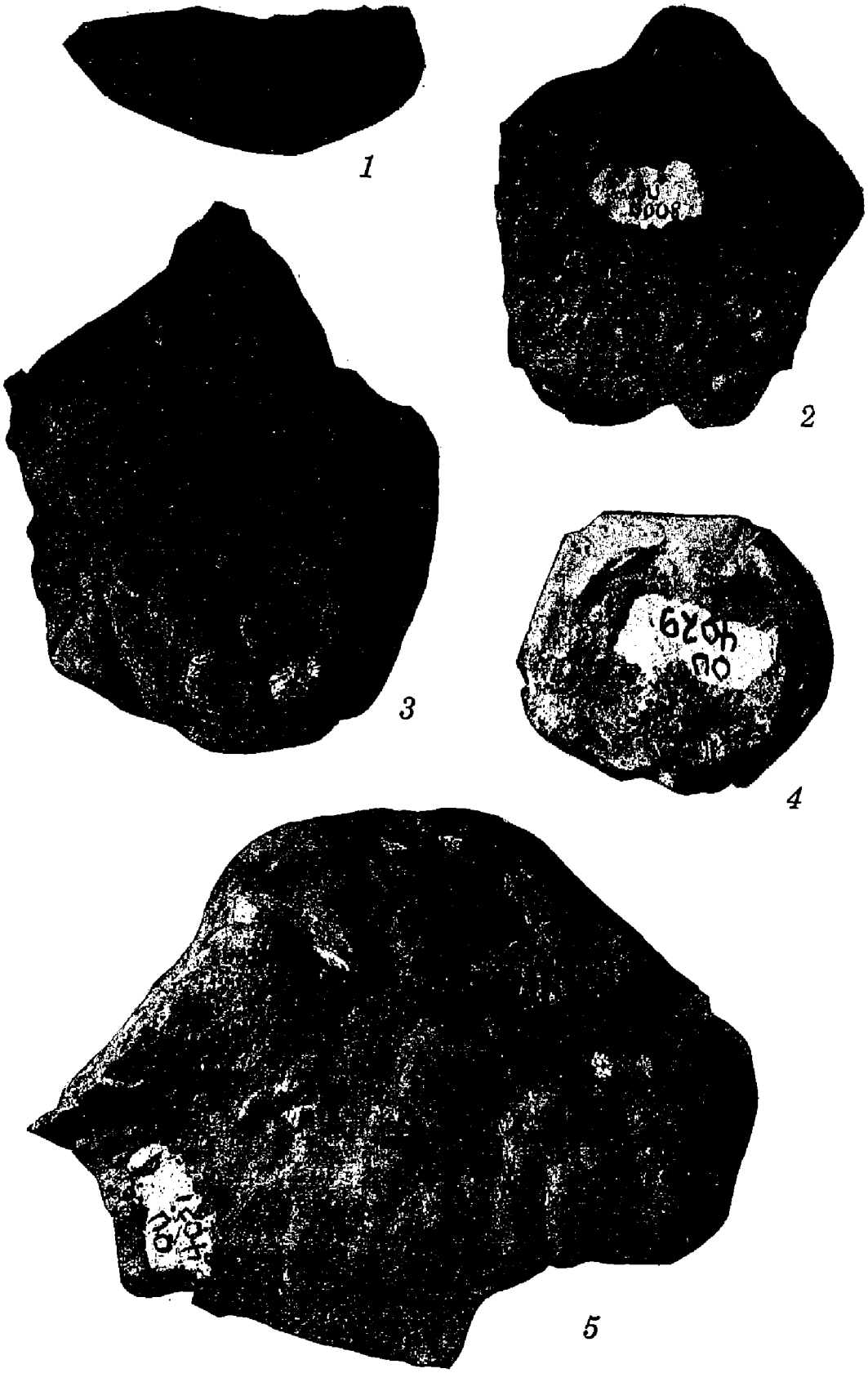

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PLATE 10

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Ataxiacrinus multiramus, n. sp. 90

FIGURES 1-3. Holotype (OU 4042) crown viewed from anterior-right anterior, from base, and from posterior, x0.90.

Graffhamicrinus acutus, n. sp. 124

FIGURES 4, 5. Paratype (OU 4151) viewed from posterior and base, x1.8.

FIGURE 6. Paratype (OU 4152) viewed obliquely from the posterior, showing interior of arms, x1.

FIGURES 7, 8. Holotype (OU 4150) viewed from anterior and base, x1.8.

PLATE 10

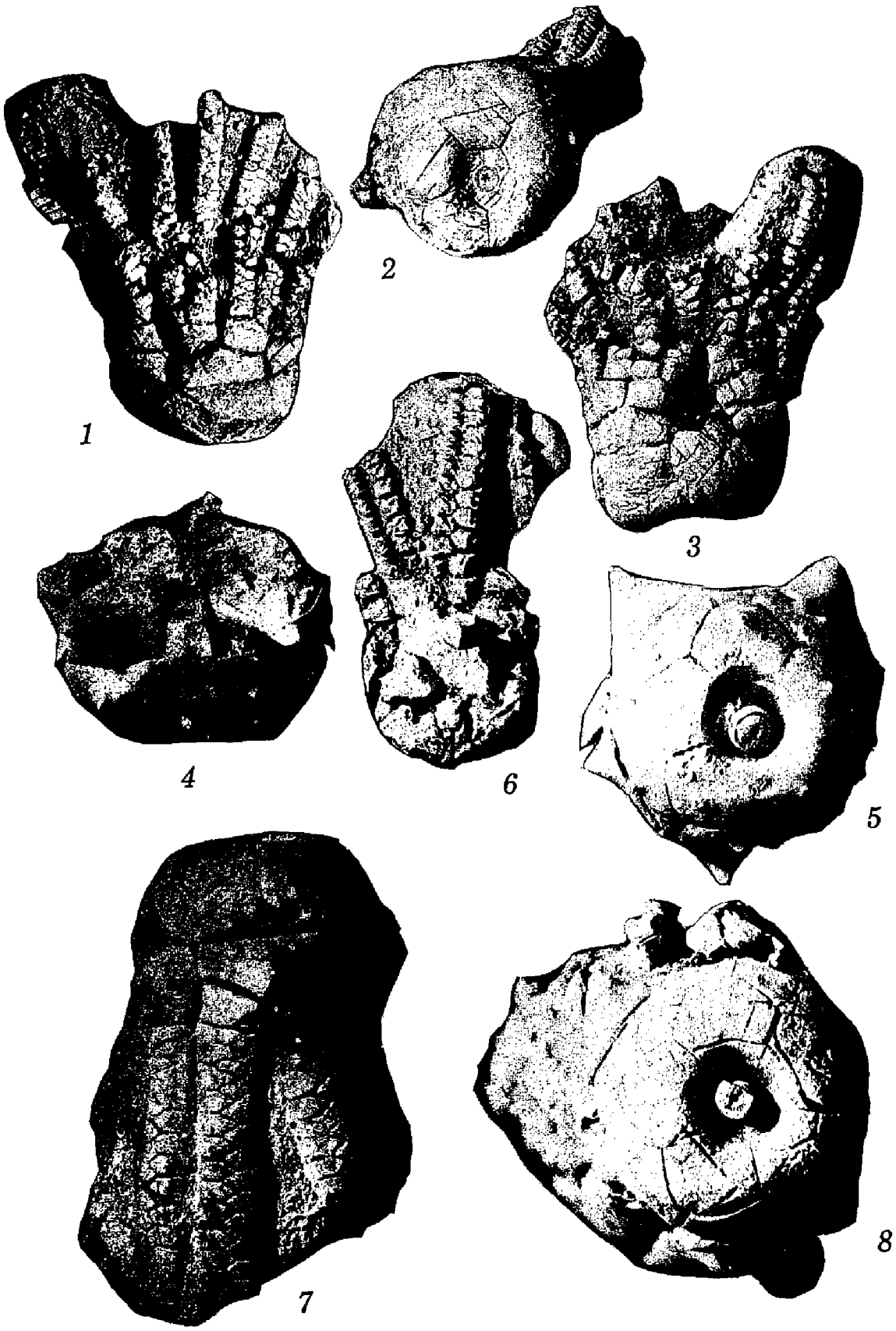

PLATE 11

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Polygonocrinus multiextensus, n. sp. 61

FIGURES 1, 2. Holotype (OU 4059) crown viewed from summit and from base, x0.70.

Schedexocrinus gibberellus, n. sp. 29

FIGURES 3, 4. Paratype (OU 757) crown viewed from base and from posterior, x0.92. Note evidence of parasitic attack on arms.

Plaxocrinus normalis, n. sp. 48

FIGURES 5-7. Holotype (OU 4066) crown viewed from base, summit, and left anterior, x0.92. Note evidence of parasitic attachment on arms.

PLATE 11

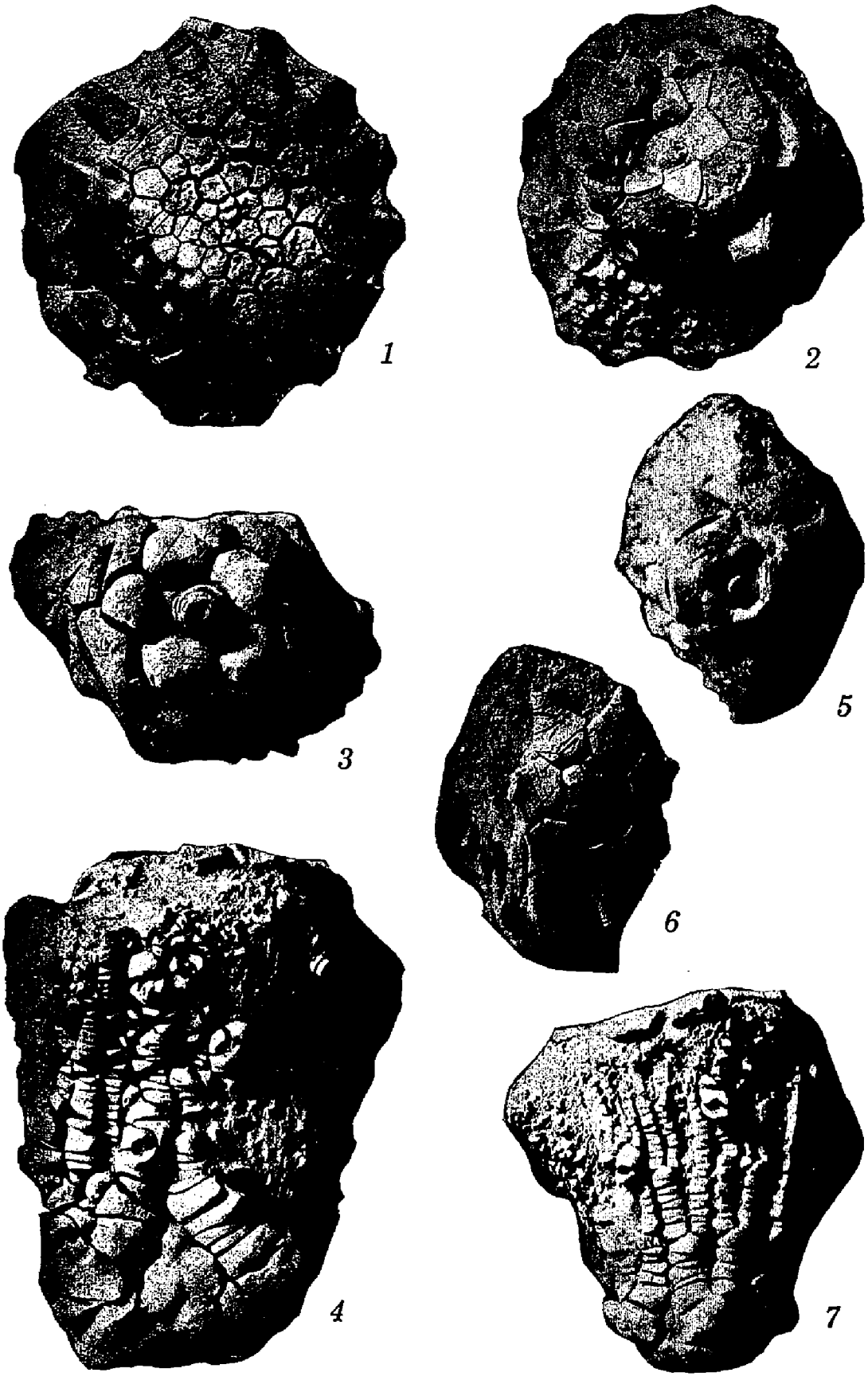

PLATE 12

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Plaxocrinus beggsi, n. sp. 52

FIGURES 1-3. Holotype (OU 4004) crown viewed from posterior and summit, x2, and from anterior, x1.5.

Graffhamicrinus acutus, n. sp. 124

FIGURES 4-6. Paratype (OU 4157) viewed from summit, posterior, and base, x2.

PLATE 12

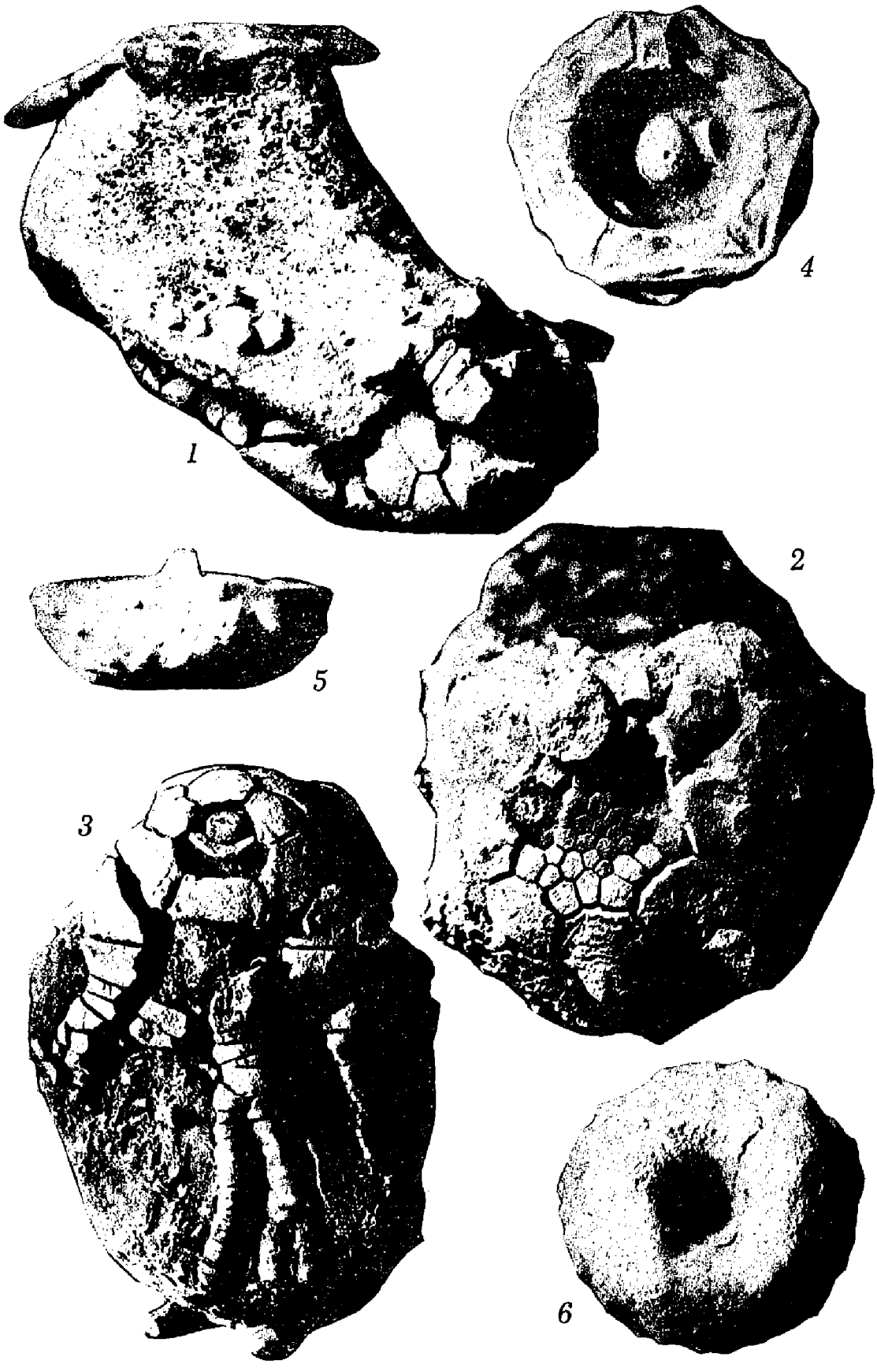

PLATE 13

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Oklahomacrinus abruptus, n. sp. 107

FIGURES 1, 2. Holotype (OU 4045) viewed from posterior (base upward to facilitate photography) and from base, x2.

Corythocrinus undulatus, n. sp. 129

FIGURES 3-5. Holotype (OU 4169) crown viewed from left anterior, base, and posterior, x1.8.

FIGURE 6. Paratype (OU 4179) viewed from right anterior, x1.8.

Graffhamicrinus acutus, n. sp. 124

FIGURE 7. Side view of crown of a paratype, ca. x1. Note the difference in size of stem as compared to mature *Corythocrinus*.

PLATE 13

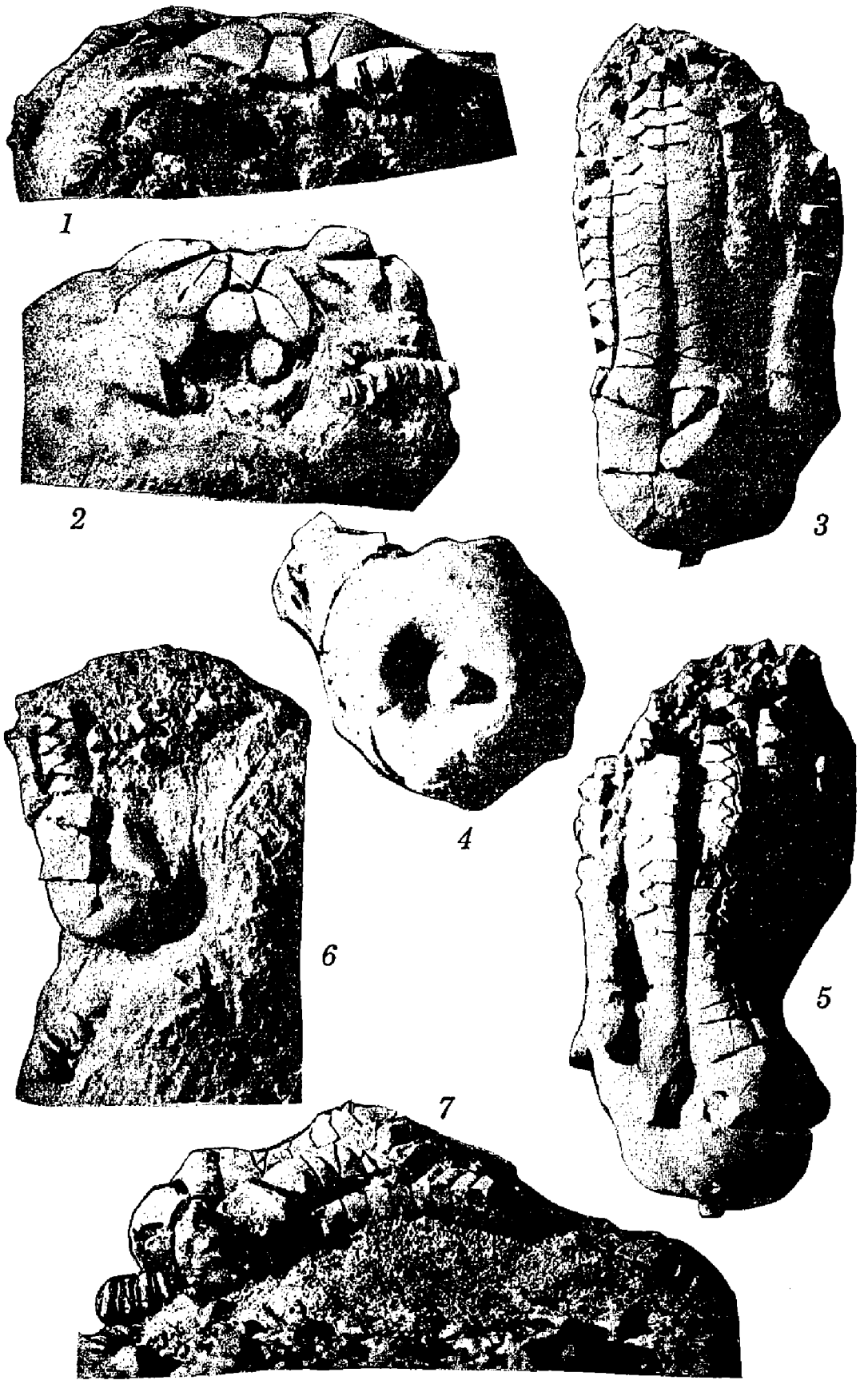

PLATE 14

Page

Pirasocrinus depressus, n. sp. 57

FIGURE 1. Paratype (OU 4049), slightly oblique posterior view, ca. x1.

FIGURE 2. Holotype (OU 4047) crown from posterior, ca. x1. The terminating spinose platform of anal sac of paratype (OU 4048) is visible to lower right.

Stellarocrinus petalosus, n. sp. 110

FIGURES 3, 4. Holotype (OU 4110) crown viewed from base, x1, and from anterior, x1.4.

Plaxocrinus aff. *P. dornickensis* Strimple 51

FIGURES 5, 6. Calyx (OU 4016) viewed from base and posterior, x1.8.

Stenopecrinus rugosus, n. sp. 42

FIGURE 7. View of a terminating spine of anal sac of the holotype, x2.3.

PLATE 14

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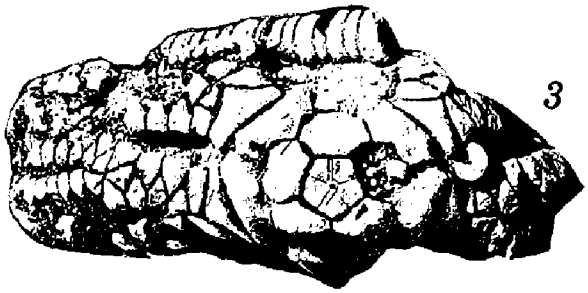

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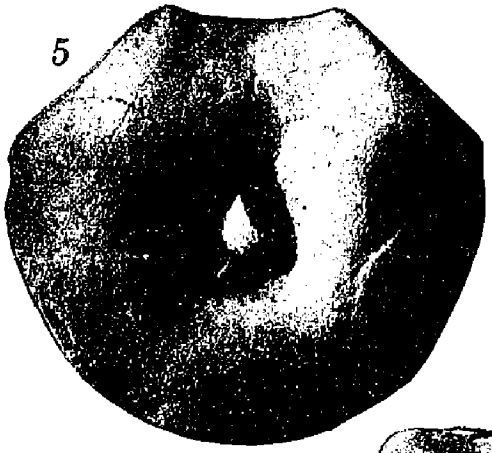

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PLATE 15

Page

Haeretocrinus intermedius, n. sp. 97

FIGURES 1-3. Holotype (OU 4172), partial crown viewed from base, anterior, and posterior, x2.

Stellarocrinus petalosus, n. sp. 110

FIGURE 4. Abnormal specimen (OU 4121) with supernumerary anal plate, x2.

Allosocrinus libratus, n. sp. 105

FIGURE 5. Paratype viewed from the base, x2. Spines of the terminating platform of the anal sac of *Plaxocrinus normalis* to the upper left.

Graffhamicrinus acutus, n. sp. 124

FIGURE 6. Paratype (OU 4154) crown viewed from the posterior, x1.3. Note the plate above the anal plate in place.

PLATE 15

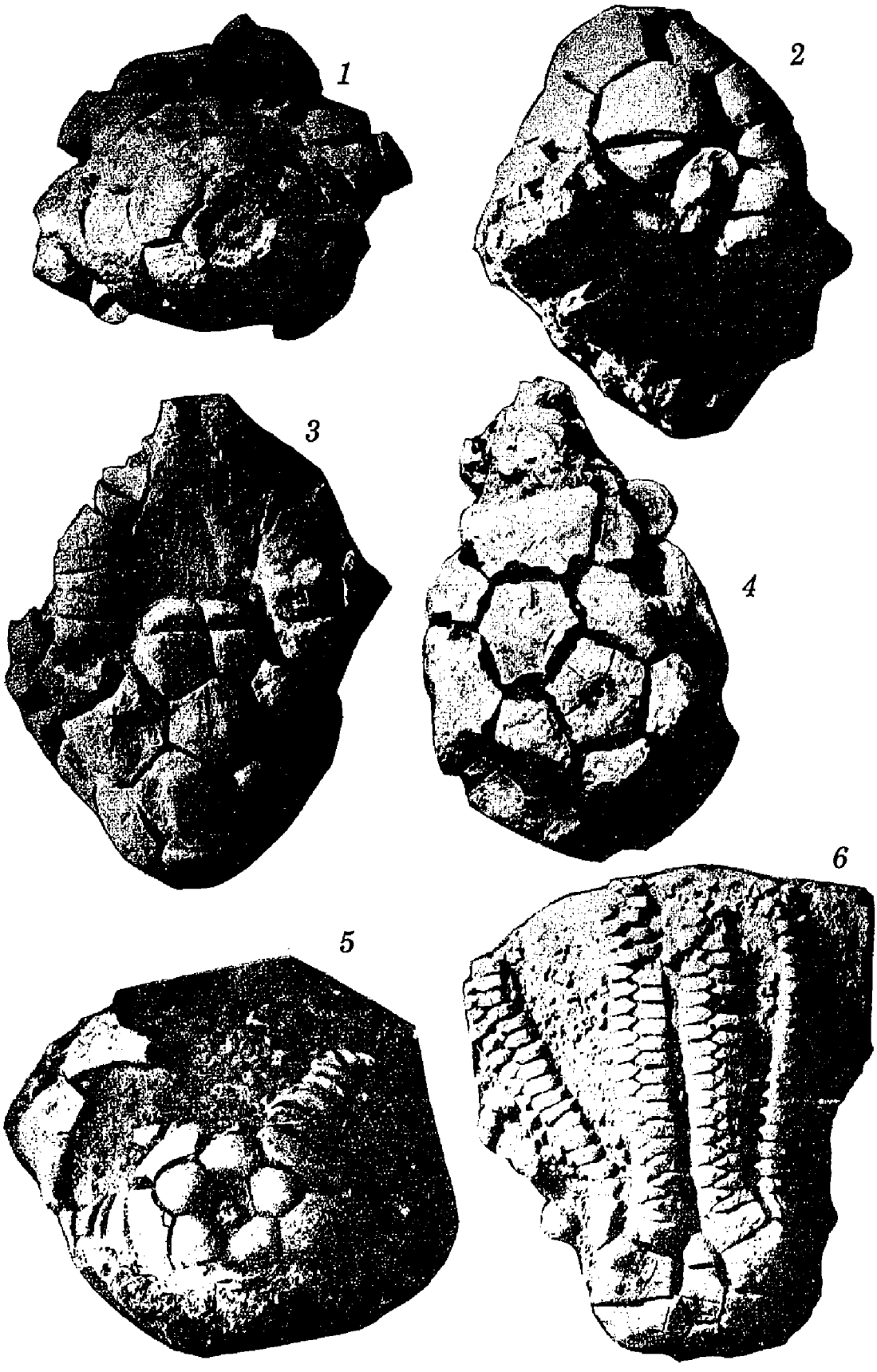

PLATE 16

Page

Polusocrinus avanti Strimple 102

FIGURE 1. Plesiotype (OU 769) viewed from posterior, ca. x1.

Stellarocrinus petalosus, n. sp. 110

FIGURE 2. Holotype (OU 4110) crown viewed obliquely from posterior, ca. x1.

Plaxocrinus aff. *P. obesus* Moore and Plummer 47

FIGURE 3. Plesiotype (OU 4173) basal view, ca. x1.

Elibatocrinus hoodi, n. sp. 132

FIGURE 4. Paratype (OU 4001) viewed from side to show extraordinary length of arms, and pinnules, x0.88.

FIGURE 5. Holotype (OU 4002) anterior view, x2.

Texacrinus coniformis, n. sp. 95

FIGURE 6. Paratype (OU 4094) viewed from side, x0.77.

PLATE 16

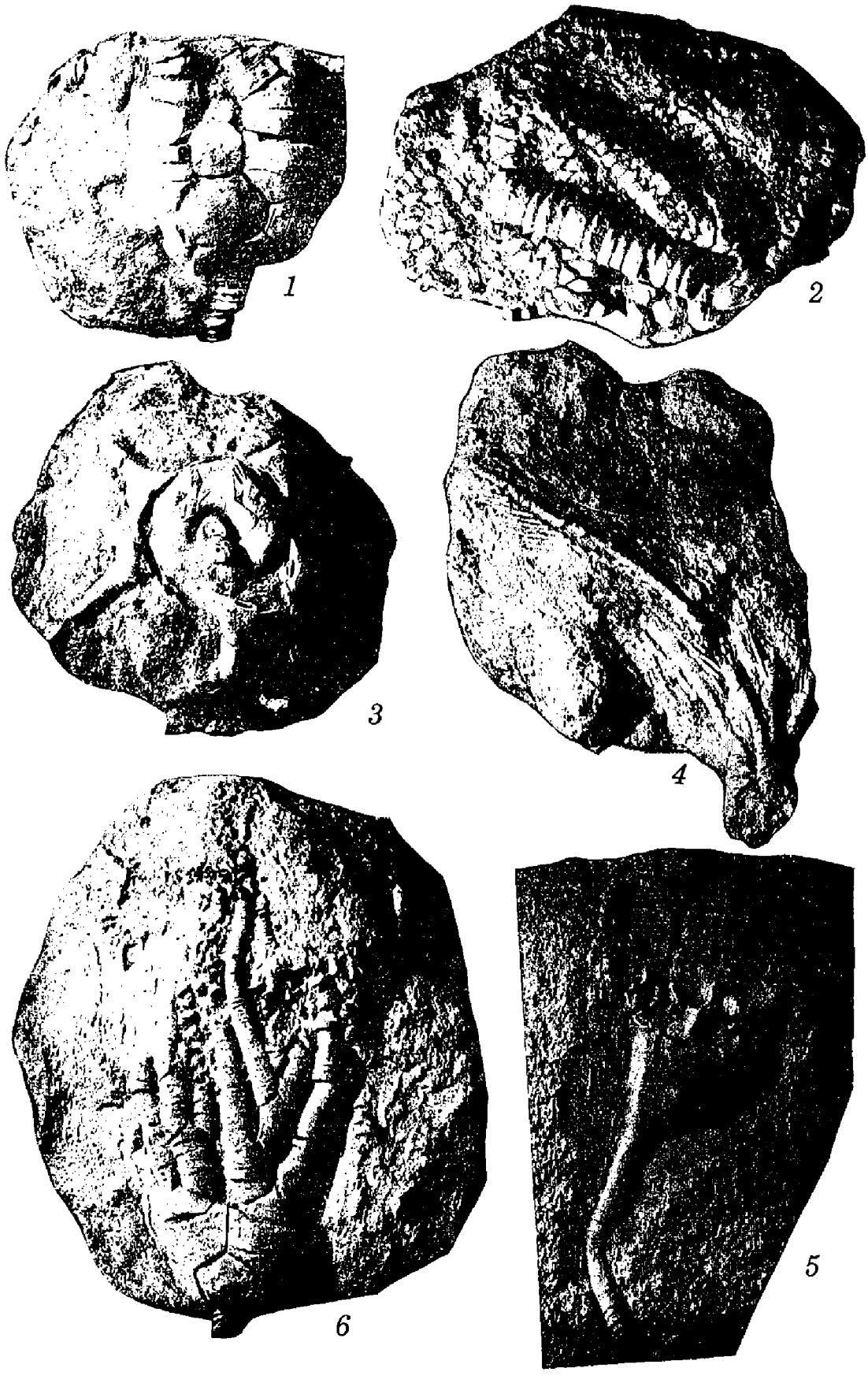

PLATE 17

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Graffhamicrinus acutus spicatus, n. subsp. 127

FIGURES 1-3. Holotype (OU 4155) viewed from posterior, base, and anterior, x1.5.

Schedexocrinus gibberellus, n. sp. 29

FIGURES 4-6. Holotype (OU 4020) crown viewed from base, summit, and right anterior, x0.66.

PLATE 17

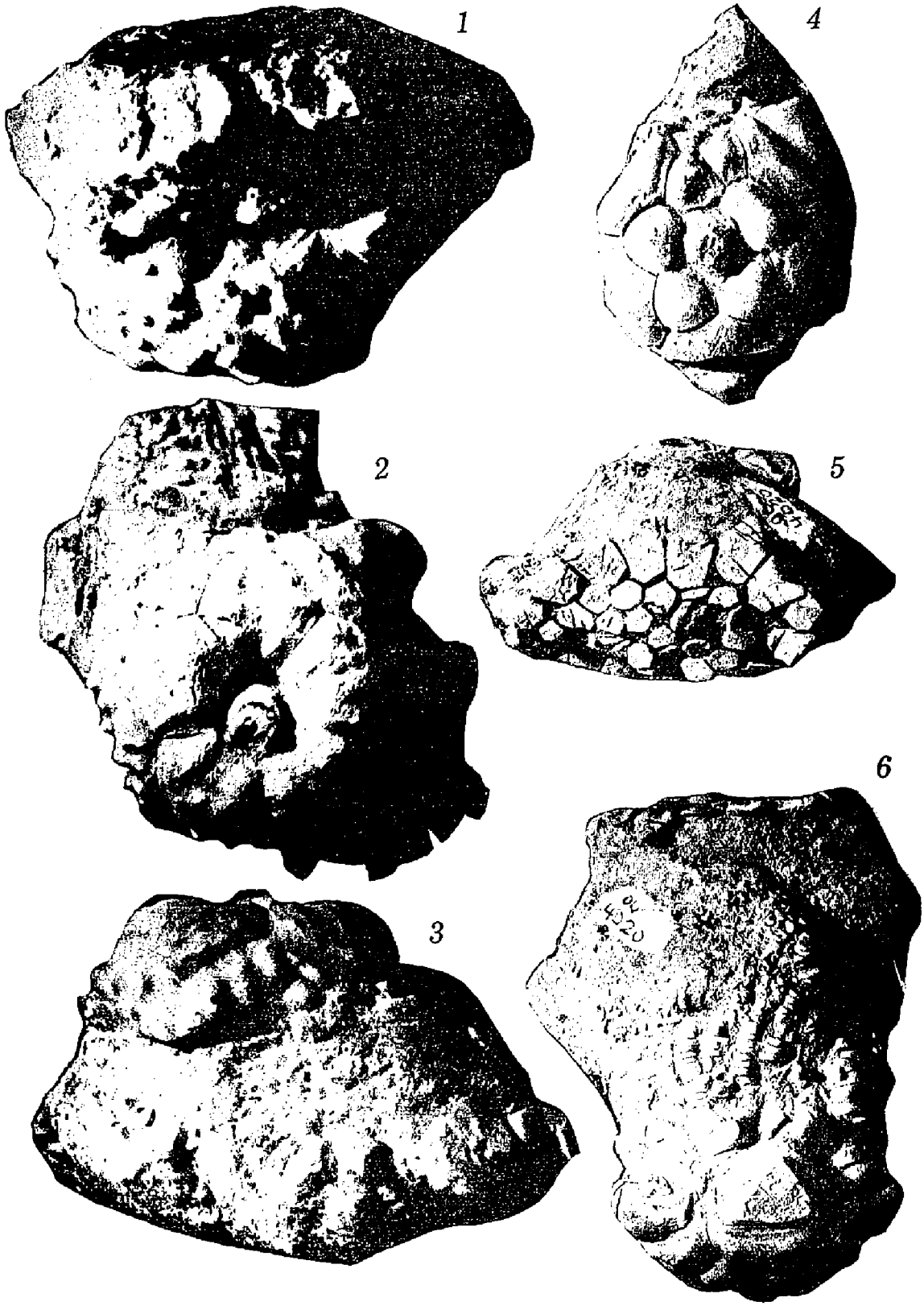

PLATE 18

Page

Pœrethelocrinus ellipticus, n. sp. 83

FIGURE 1. Paratype (OU 4147) crown in side view, x0.71.

FIGURE 2. Tips of arms of paratype (OU 4148) showing pinnules, x0.66.

Plaxocrinus normalis, n. sp. 48

FIGURE 3. Paratype (OU 4149), side view showing atypical primibrach in profile.

FIGURE 4. Paratype (OU 4005), summit view of well-preserved spinose, terminating platform, or roof, of anal sac, ca. x1.

Metaperimestocrinus spiniferus, n. sp. 37

FIGURE 5. Paratype (OU 4012), summit view of large, spinose, terminating roof of anal sac, x1.2.

PLATE 18

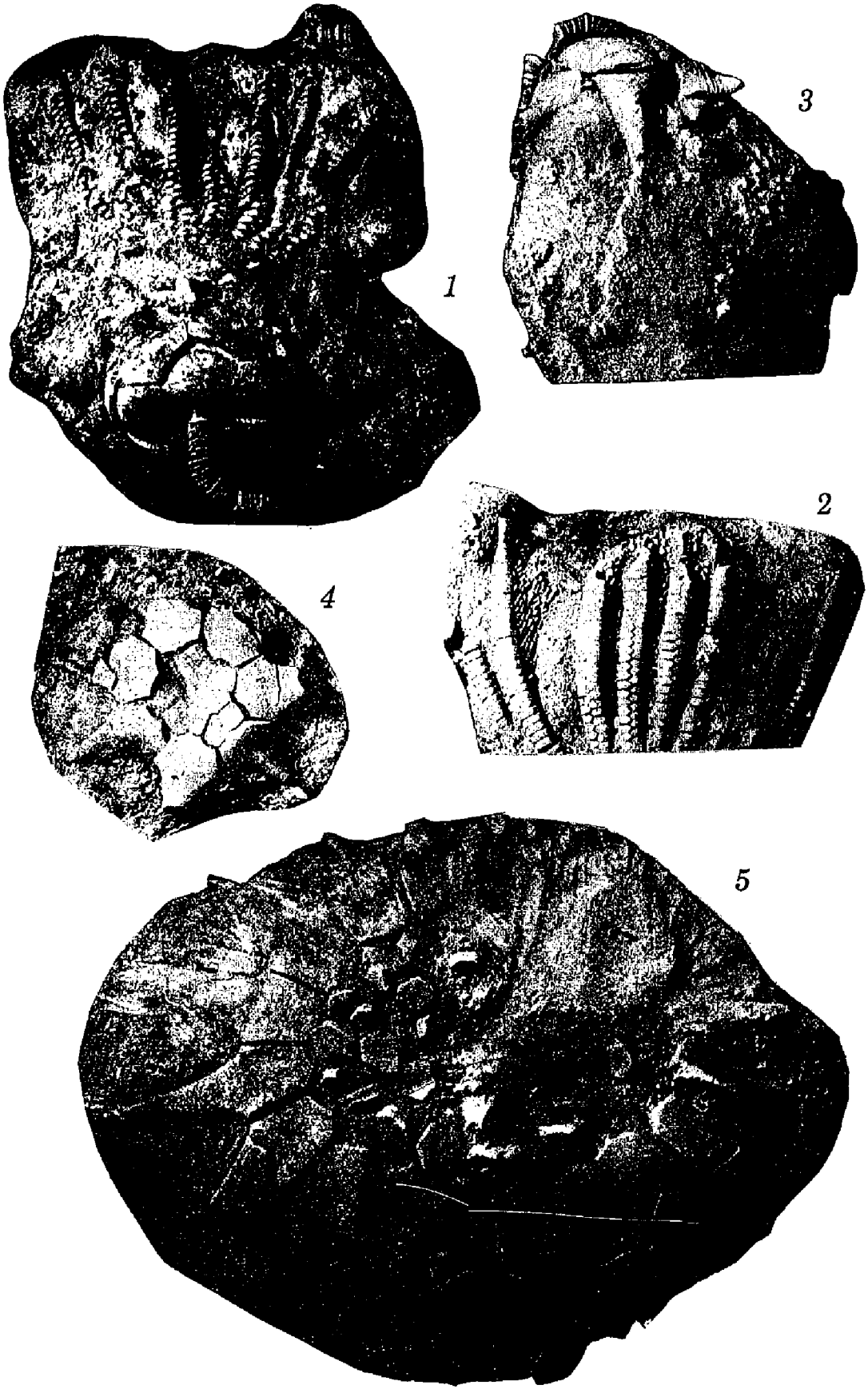

PLATE 19

Page

Plaxocrinus normalis, n. sp. 48

FIGURE 1. Terminating roof of the anal sac that is atypical for the species (OU 4075), xl.

Graffhamicrinus acutus, n. sp. 124

FIGURE 2. Paratype (OU 4153), oblique view of crown showing small single terminating spine of anal sac, xl.

Plaxocrinus normalis, n. sp. 48

FIGURE 3. Paratype (OU 4009), side view of exposed anal sac, xl.

Plaxocrinus aff. *P. obesus* Moore and Plummer 47

FIGURE 4. Pleisotype (OU 4173), summit view, ca. xl.

Parethelocrinus ellipticus, n. sp. 83

FIGURE 5. Partial crown illustrated to show interior of arms, x0.66.

Schedexocrinus gibberellus, n. sp. 29

FIGURE 6. Crown illustrated to show abnormal structure of upper arms caused by parasitic action, x0.86.

Stellarocrinus petalosus, n. sp. 110

FIGURE 7. View of crown (OU 4122) from above to show internal structure of arms and a portion of the anal sac, xl.

PLATE 19

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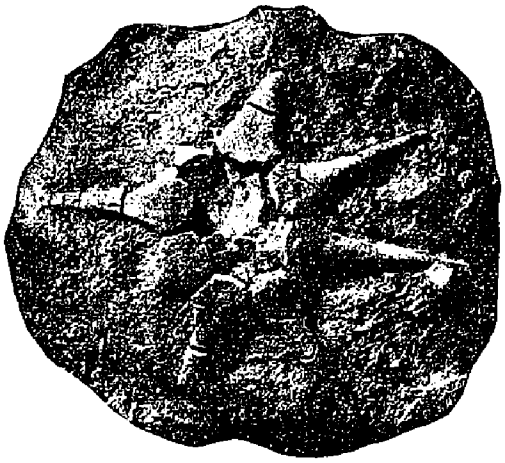

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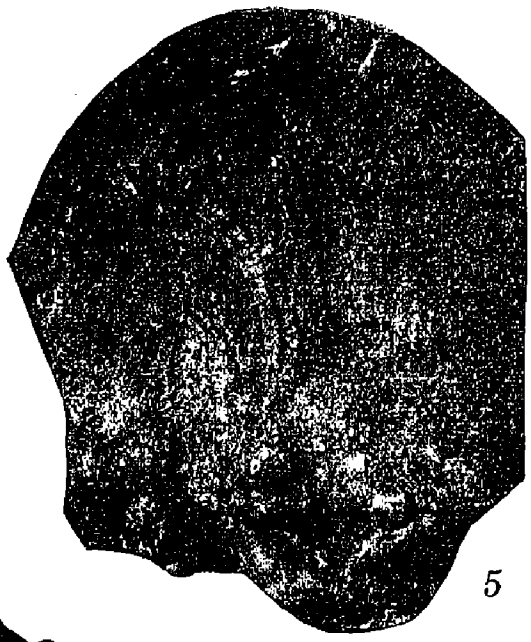

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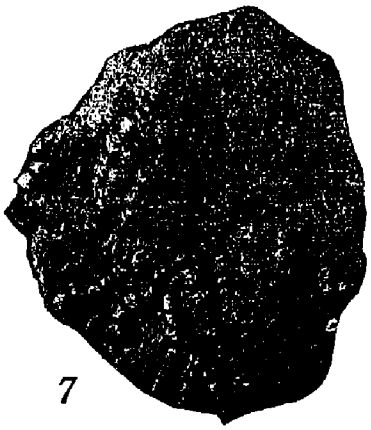

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(Main references are in boldface)