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CRINOIDS OF THE HUNTON GROUP (DEVONIAN-SILURIAN) OF OKLAHOMA

by

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Foreword

The present report is one of a series on the rocks and fossils of the Hunton Group of Oklahoma, a sequence of rocks which contains well-preserved and important fossils. The articulate brachiopods have been described by Amsden in a series of reports. The only known graptolite was described by Decker. Two inarticulate brachiopods were made known by Ireland, who also described arenaceous Foraminifera. Lundin is currently completing a description of the ostracodes. Frederickson will describe the trilobites. Few of the mollusks have been investigated, and work on conodonts and on acid-resistant microfossils has scarcely begun.

The Hunton Group yields petroleum in several important fields. Fossils provide information valuable in the search for economic deposits. They help in determining the age of the rocks, and, through ecological studies, they show where to hunt for limestone banks or reefs, for ancient shore lines, and for porous rocks.

Carl C. Branson

CRINOIDS OF THE HUNTON GROUP (DEVONIAN-SILURIAN) OF OKLAHOMA

HARRELL L. STRIMPLE

ABSTRACT

Collections of 1,261 crinoid specimens from the Hunton Group of Oklahoma have been studied. The fauna consists in part of 31 genera, 45 species, and one subspecies from the Henryhouse Formation (Silurian), of which five genera, 20 species, and one subspecies are new. Two new families are proposed, neither of which has representatives in the Oklahoma material. The Haragan Formation (Devonian) yielded six genera and six species, of which one genus and one species are new. One genus and one species occur in the Bois d'Arc Formation (Devonian). Information is reported concerning parasitic attachment, newly observed morphologic features, aberrant specimens, effects of mechanical pressures, and various paleoecologic factors.

INTRODUCTION

Comprehensive studies of the rocks and fossils of the Hunton Group are being made by Dr. Thomas W. Amsden, Oklahoma Geological Survey. Already published are *Oklahoma Geological Survey Circular 38* (1956) a catalog of the fossils, and *Circular 44* (1957) on the stratigraphy. To a collector, the irregular distribution of surface fossils in the Henryhouse Formation of the Lawrence uplift is obvious. Good specimens of crinoids and blastoids are rare except for the small *Pisocrinus* and *Ollulocrinus*, and they normally occur in rather limited areas. So long as erosion takes place and new exposures are created, more echinoderm specimens will be exposed from time to time.

Amsden's comments on the Henryhouse and Haragan Formations and fossils in *Circular 44* are comprehensive and do not require additional consideration here.

Concerning relative age of the Henryhouse Formation, Amsden (1957) stated, "The Henryhouse fauna appears to be closely related in age to the Brownsport of western Tennessee, but its position in terms of eastern Silurian faunas is in question." It is my observation that the echinoderms of the two formations are fundamentally different. I believe that the Henryhouse is slightly younger than the Brownsport. In the Brownsport, the blastoid *Troostocrinus reinwardti* (Troost) and the cystoid *Caryocrinus bulbulus* Miller and Gurley are fairly common, but they do not occur in the Henryhouse. The blastoid *Polydeltoideus enodatus* Reimann and Fay is relatively common in the Henryhouse Formation and so is the eleutherozoan genus *Scyphocrinites,* but neither occurs in the Brownsport. Only a few crinoid species are common to the two formations and of these, two, *Ollulocrinus tennesseensis* (Roemer) and *O. quinquelobus* (Bather), have wide stratigraphic and geographic ranges. I favor the possibility of close affinity between Henryhouse crinoids and those of the Racine Dolomite of Illinois and Wisconsin, and/or the Decatur Limestone of western Tennessee.

Specimens used in the current study were collected by Carl C. Branson, T. W. Amsden, P. K. Sutherland, W. E. Ham, A. L. Loeblich, Richard Alexander, Allen A. Graffham, Harrell L. Strimple, Beverly Graffham, and Melba L. Strimple. The collections are in the Springer Collection, U. S. National Museum, Washington, D. C., and in the paleontological collection, The University of Oklahoma, Norman. Specimens in the Springer Collection are designated by numbers having the prefixes USNM, USNM S, and S. Specimens at The University of Oklahoma are designated by numbers having the prefix OU.

The use of symbols has been limited in the present study except for the plates of the posterior interradius. Where used, the symbols are those proposed by Moore and Laudon (1941, p. 421).

I am indebted in particular to Porter Kier, assistant curator of invertebrate paleontology and paleobotany, for furnishing the catalog numbers of various type specimens in the U. S. National Museum and for other assistance, especially in obtaining some rare literature.

Stratigraphic Tabulation of Hunton Crinoid Genera

	Number of Specimens: Current study	Number of Specimens: Previously reported
Bois d'Arc Formation (Helderbergian, Devonian)		
Myelodactylus (terminating bulb and cirri)	1	0
	1	0
Haragan Formation (Helderbergian, Devonian)		
Scyphocrinites	7	0
Liomolgocrinus	0	1
Clidochirus	1	0
Edriocrinus	6	0
Myelodactylus (columnar)	9	0
Lecanocrinus	0	1
	23	2
Henryhouse Formation (Niagaran, Silurian)		
Myelodactylus (columns)	3	0
Abyssocrinus	8	5
Stylocrinus	1	0
Pisocrinus	385	3
Ollulocrinus	635	0
Calceocrinus	2	0
Grypocrinus	6	0
Synchirocrinus	6	0
Parazophocrinus	2	0
Zophocrinus	4	2
Bactrocrinites	2	1
Botryocrinus	1	0
Euspirocrinus	1	0
Thalamocrinus	1	0
Gissocrinus (brachials)	4	0
Neoarchaeocrinus	1	0
Siphonocrinus	9	0
Elpidocrinus	15	0

	Number of Specimens	
	Current study	*Previously reported*
Lampterocrinus	9	0
Gazacrinus	1	0
Hexacrinites	3	1
Scyphocrinites (4 bulbs, 1 columnal mass)	10	0
Eucalyptocrinites	11	0
Marsupiocrinus	7	0
Macrostylocrinus	2	0
Allocrinus	3	1
Saccocrinus	5	0
Asaphocrinus	2	0
Ichthyocrinus	1	0
Lecanocrinus	93	12
Gnorimocrinus	1	1
	1,234	26

Portentum—Evolution vs. Aberration

Some so-called abnormalities may represent true evolutionary trends, reflecting in some instances new developments that have not yet occurred as "normal" features. Such a possibility warrants serious thought and consideration, and I propose the term *portentum* to cover such conditions.

As an example, let us consider the abnormal specimen of *Lecanocrinus pusillus* Hall of Silurian age (which Hall used as the type in his description of the species), which has three anal plates instead of the customary and typical two. The supernumerary plate is directly above anal X but is almost entirely within the cup. A form from the Devonian of Germany, described as *Lecanocrinus roemeri* Schultze, but subsequently designated as the genotype of *Geroldicrinus* Jaekel (1918), has two small plates in series above anal X. The Devonian form has a more advanced cup base, which is truncated at the proximal edges of the basals and has a sharply impressed basal area. The infrabasals are confined to the subhorizontal floor of the depression. In other regards, the cup outline does not display progressive evolution in that it remains conical. Some specimens of the species show a tendency toward absorption of RA, which is a progressive trend in this phyletic line. If the development shown by the specimen of *Lecanocrinus pusillus* is strictly adventitious, then it is remarkable to find an almost identical structure in a subsequently developed genus of the same phyletic line.

An even better example is afforded by comparing *Cibolocrinus* of Pennsylvanian age with *Lecanocrinus* of Silurian age. The relationship is well brought out by Moore and Laudon (1943, p. 76) in their discussion of the family Lecanocrinidae: "*Cibolocrinus* differs from *Lecanocrinus* only in lacking an RA, and probably is a direct descendant of the family type genus (*Lecanocrinus*)." Comparison of a large crown of *L. pisiformis* (Roemer), as figured by Springer (1920, pl. 1, figs. 7, 8), with a crown of *Cibolocrinus detectus* Strimple (1951, pl. 1, figs. 7, 8) readily verifies the relationship. Elimination of the RA in *Lecanocrinus pisiformis* must be considered an abnormality for the species and for the genus, yet it demonstrates the known evolutionary trend. Several examples are known and some were illustrated by Springer. A small specimen with the RA reduced to a triangle was figured by Springer (1920, pl. 1, fig. 27). Specimens in which the RA has completely disappeared were also illustrated by Springer (1920, pl. 1, figs. 28, 29).

I suggest that whenever the abnormality is known to be of evolutionary consequence (as with resorption of RA in *Lecanocrinus*) then a special term be applied to the occurrence, such as "portendo"=foretell, (n. portentum). In the absence of knowledge of evolutionary characters such terms as abnormality, aberration, and the like must be used.

Abnormalities

Few truly aberrant specimens were observed by me in the Henryhouse-Haragan crinoid faunas. One specimen of *Lecanocrinus erectus* Strimple (OU 4682) has a series of seven supernumerary plates interposed between the basal and the radial circlets in right posterior, right anterior, anterior, and left anterior radii and interradii. In the right posterior a plate obliquely to the right of RA and below RPR is in the position of an inferradial plate. Another plate rests in interradial position and is pentagonal. A small plate is at the truncate proximal edge of RAR and technically is in the position of an inferradial, but it shares the position with a quadrangular plate to its right. Next is a pentagonal plate in interradial position, then a pentagonal plate contacting the truncate proximal edge of the anterior radial. A rather large quadrangular plate is in interradial position between AR and LAR.

One crown of *Lecanocrinus papilloseous* Strimple (USNM 6272) has a small supernumerary plate in the right ray of the right anterior arm, just above the first bifurcation of the arm.

Associated Parasitic Life

A great amount of material is available for study, but there is little evidence of parasitic attachment or attack on the crinoids of the Hunton Group. Text-figure 24 is a drawing of the interradius and arm openings of a magnificent specimen of *Lampterocrinus fatigatus,* new species, in which three round borings, or pits, may be noted. They do not penetrate the calyx, yet all are affixed to adsutural areas. These pits are similar to those found on Pennsylvanian specimens figured by Moore and Plummer (1940, p. 290, 291, pl. 18, fig. 3) and attributed by them to gastropods.

The same type of round pits is found on the cups of five specimens of *Lecanocrinus papilloseous* (OU 4713) from the *Diacalymene* layer in the creek bed in C SW¼ sec. 4, T. 2 S., R. 6 E., Pontotoc County. In one specimen the attack is on the suture line between RAR and RAB (pl. 10, fig. 1). Another specimen has at least four pits of various sizes, but three of them do not appear to be directly upon the sutures. Two incipient pits on another cup are on the sutures, one at the upper corner of the RA and the other at the proximal end of the RAR.

Platyceras-type gastropods are associated with the colony of *Scyphocrinites gibbosus* from Hunton townsite near Clarita, Coal County. They are rather common on the upper side of the limestone layer, opposite the crowns. These gastropods attached themselves to the anal vents of crinoids and lived on the refuse of the animal. The relationship was passive. One is apparently attached to the anus of the large crown of *S. gibbosus,* figured herein (pl. 7, fig. 6), but not visible in the illustration.

Small bryozoans are in some cases found attached to crinoids of the Henryhouse Formation. In a few instances a groove indicates the former presence of a form such as *Serpula.*

Pronounced Protrusion of a Limited Cup Area

In numerous instances the pressure of the gut is reflected in the structure of the calyx. Among the Flexibilia, the protrusion of the area surrounding the radianal of *Lecanocrinus brevis* is a specific characteristic. One specimen of *Lecanocrinus waukoma,* figured by Weller (1900, pl. 5, fig. 10), has protrusion in the same area, but most figured specimens of that species are protruded in the left posterior. Although it is an inadunate crinoid, with certain fundamental differences, the cup structure of *Parethelocrinus ellipticus* Strimple (1961) from the Desmoinesian (Pennsylvanian) of Oklahoma reflects the same type of protrusion in the area of the radianal, and the condition is considered to be a specific character. Several other Pennsylvanian forms that protrude in the area of the radianal are *Ulocrinus caverna* Strimple, *Dicromyocrinus tapajosi* Strimple (1961), *Dicromyocrinus meadowensis* Strimple (1949) and *Ulocrinus elongatus* Strimple (1961).

Evidence of a Living Chambered Organ or Plexiform Gland

Observation of several isolated basal circlets of *Marsupiocrinus stellatus communis,* new subspecies, from the Henryhouse Formation of Oklahoma has disclosed a curious internal structure consisting of five cuplike processes surrounding the large opening in the base of the cup, the opening connecting with the axial aperture (lumen) of the stem. The structure is similar to the trilobed funnel present internally in many Flexibilia. In the present instance, one lobe may be considerably smaller (and of different shape) than the other four, with the difference in width being absorbed by the larger lobe to the left. In two specimens, where complete observation has been possible, the small lobe is in the smallest of the three basals and is probably posterior in position.

A view of the basal circlet from the exterior shows a projected area like a collar in the midsection, with the columnar scar limited to the rim surrounding the large quinquelobate opening. Thin partitions divide the lobes, which are contiguous with those previously mentioned in the interior, although they are more evenly spaced in the exterior. In large specimens one of the lobes generally appears to be slightly smaller than the other four and is connected with the smaller lobe (posterior) of the interior. Each lobe of the exterior is broad and in large specimens appears to comprise two coalescent lobes.

An explanation of the internal five-lobed funnel may be obtained from an excellent cross section of a living crinoid by Carpenter (1884, pl. 62), in which it is shown that the proximal end of the plexiform gland, the axial cords, and blood vascular system occupy a small chamber in the bottom of the dorsal cup. Springer (1920, p. 34, 35, text-figs. 1, 2) discussed and illustrated the trilobed funnel-type structure in many Flexibilia. He referred to the plexiform gland as the chambered organ and noted that it is lodged in the funnel with primary axial nerve cords proceeding from it. He observed that the cavities are prolonged downward in five peripheral vessels which surround the central vascular axis.

A plastocene squeeze has been made of the internal structure of *Marsupiocrinus stellatus communis* as reflected by paratype USNM 6242, and the illustration (pl. 6, fig. 8) reflects the structure of the living chambered organ.

Influence of Mechanical Factors

Wider cup bases and more invaginated stems than were possessed by their ancestors are considered by Bouška (1956, p. 134) to be caused among the Pisocrinidae by the influence of mechanical factors (streams). In this he followed an interpretation by Yakovlev (1947) for the Carboniferous genera *Endelocrinus* Moore and Plummer and *Plaxocrinus* Moore and Plummer.

Among the Lecanocrinidae, one species in the Racine Dolomite, *Lecanocrinus waukoma* (Hall), and one species in the Henryhouse Formation, *L. brevis* Strimple, have exceptionally broad bases and relatively low cups. Devonian species retain essentially conical dorsal cups, typical of the family, and so apparently these two species represent a temporary trend or condition which might have been due to the influence of currents.

Most species of *Elpidocrinus,* new genus, have shallow, broad dorsal cups. The tegmen is normally high and curved toward the posterior where the anus is located. An optimum food supply is indicated and the thickness of cup plates shows an abundant calcium supply.

Pisocrinus varus, new species, has a broad base, deeply impressed column, broad arm-articular facets, more or less conical cup, and strongly granular surface. The effect of current activity is indicated as well as is an abundant calcium supply.

Stylocrinus elimatus, new species, has a broad base and deeply impressed column, both of which features may be the result of stream action.

Strong currents are shown by the colonies of *Scyphocrinites* in the Henryhouse and Haragan Formations, where columnals are stacked in parallel rows like cordwood. Indication of current activity is given in the explanation by Kirk (1911, p. 55) for accumulation of the vast beds of bulbous terminations of *Scyphocrinites ulrichi* in the Haragan Formation.

Morphological Notes with Emphasis on an Eleutherozoic Existence

It is currently thought that new columnals are normally formed at the base of the dorsal cup, between the proximal columnal and the lowermost circlet of the cup. In the process of various crinoid studies, I have become increasingly aware of another condition in which some of the more proximal columnals have a distinctly different appearance from those of the main part of the stem. For those instances in which it is almost certain that the proximal columnals are indeed special and distinct from lower columnals I propose the term *basilarids,* from the Greek basilaris, meaning at the base, basal, base level.

Constriction at the base of the basal cavity of the cup is shown by text-figure 11b of *Ollulocrinus quinquelobus* (Bather) and text-figure 11d of *O. tennesseensis* (Roemer). Although Bouška did not comment on whether captured proximal columnals are present, a similar constriction of the opening of the basal concavity is shown by his cross sections of *Ollulocrinus ollula grandis* Bouška and *O. ollulo hlubocepensis* Bouška from the Silurian and Devonian of Czechoslovakia. I suspect that in many cases, among the pisocrinids, a few "captive" columnals have become fixed and should more properly be termed "basilarids," with new columnals added at their base rather than at the bottom of the cup proper.

I further suggest that "capture" of the more proximal columnals took place in order to create a heavy cup base when the crown detached from the column and floated or swam freely.

Another striking example of incorporation of proximal columnals into the cup base among Henryhouse crinoids is *Neoarchaeocrinus necopinus,* new species. It seems almost certain that the proximal columnals are permanently fixed and so would be basilarids. In this instance the infrabasals have strong projections surrounding and supporting the proximal columnals. Whether or not a permanent affinity is effected between the proximal columnals and the infrabasals, apparently the same purpose is served here as in the previously mentioned pisocrinids. That is, there was a tendency to retain some of the proximal columnals for ballast at the base of the cup during the eleutherozoic stage of the animal's life. The structure is illustrated by figure 20b.

Lampterocrinus has a sharply pentagonal or pentalobate column and a stout ridge passes from each infrabasal onto the adjacent corner of the columnals. The structure is almost identical with that of *Neoarchaeocrinus necopinus* as discussed above. The proximal columnals are therefore considered to be basilarids. Text-figure 23 shows the structure of *Lampterocrinus fatigatus,* new species.

Siphonocrinus dignus, new species, has projections on the basal plates that are obviously used in conjunction with the columns, but the arrangement is altogether different from that of *Lampterocrinus.* The column is round and is composed of alternatingly expanded columnals, with some of the expanded elements having a thin disklike scalloped edge that rests against the roughened inner sides of the projections (text-fig. 20a). The fact that the proximal columnals are absent in almost all specimens of *Siphonocrinus dignus* is sufficient evidence that they were not "captive," but I suspect that they acted to deter any sudden movement from side to side of the crown.

Most species of *Edriocrinus* are free in adult stage, and the related *Lodanella* is also free. The base appears to be rather heavy in some species, but Goldring (1923, pl. 58, figs. 3, 4) figured two fragmentary bases of *Edriocrinus sacculus* Hall in which the double wall has a cellular appearance because of the presence of a median wall and transverse partitions. A somewhat similar structure for *Lodanella mira* Keyser was illustrated by Schmidt (1941, text-fig. 52a, 52b), cross sections of basal circlets showing a double wall (no median wall) and transverse partitions. In the presently considered material a specimen of *Edriocrinus dispansus* Kirk (OU 10) shows fused basals rounded below with an indented cicatrix where the specimen was attached in a younger stage (pl. 10, fig. 6). Another excellent specimen (OU 4710) has fused basals and has outgrown the pelecypod shell to which it was attached in youth. These two specimens exhibit a vagrant habitus.

Myelodactylus is found both in the Henryhouse Formation and in the Haragan Formation. It seems rather strange to consider this form as having a free habitus, but such is apparently the usual condition. Reference is made to the crinoid figured by Springer (1926b, pl. 4, fig. 1) as *Myelodactylus brachiatus**. In this species the large cirri are thought to have grasped objects when the animal became static. The proximal columnals are wide relative to the cup width, and taper slowly for a considerable distance to what is termed the "neck," where there is a reverse curve and where the columnals commence widening and thickening to remarkably large size. In case the inference of this situation is not clear, one may visualize a columnal added at the base of the cup passing through a stage of resorption and then subjected to substantially increased secretion of stereom. Obviously this would not happen. The crown must have possessed a base only as wide as the narrowest columnal as the lower stem was formed. After that portion was completed, it formed the column above the narrow neck, and the columnals widened as the crown and base of the cup attained a larger size. This allowed new columnals to be formed, but only for the specialized section of the column. The lower stem no doubt continued to increase in size. If new columnals were added in the lower section, and it is possible that they were, they would have had to appear below the narrowest columnal in the neck. In so far as the entire stem is concerned, the upper section attained a static condition and the plates could be termed basilarids. It is not difficult to visualize the animal's breaking free under stress, or perhaps by choice, in the area of the "neck."

* This species has been designated the type species of *Crinobrachiatus* Moore (1962b, p. 43).

Numerous specimens of *Myelodactylus* have been found with the crown and proximal segments of the stem missing, yet with complete, complex cirri in place. If conditions had been turbulent one would expect the cirri, as well as the crown, to be torn free. In any event, the basilarids retained by the crown could easily have served in forming a new heavy columnar section up to the point of recurve where once again a thin neck, no wider than the base of the cup at that stage, could have been developed and above that a new section of basilarids could have been formed. The basilarids would also have acted as ballast during the free floating stage.

Myelodactylus nodosarius (Hall) is represented in the present study by several pointed terminating columnar sections (text-fig. 3a and pl. 1, figs. 1-4) and by two specimens having the unusually large cirri of the lower segments of the stem. All are from the Haragan and Bois d'Arc Formations (Helderbergian). It is thought the cirri acted as ballast, trailing below the crown, and when the animal attained a static habitus for a time, the heavy cirri could grasp some object.

One specimen from the Henryhouse Formation (USNM 6248c, text-fig. 3c) has a partly developed bulbous stem termination formed by the fusion of the cirri into the bulb. It seems likely that this crinoid had become free of its roots and was developing a ballast, or sea-anchor. Another good example of this type of structure is afforded by specimen USNM 6251a.

Specimen USNM 6255 (text-fig. 3b) consists of one stem coiled about another and fused together. This probably represents a case in which a vagrant crinoid with trailing stem established a sessile habitus by coiling the lowermost portion of its stem about another erect column.

Another type of bulbous termination is shown by specimen USNM 6251a in which all semblance of columnals has been obliterated by excessive secretion of stereom. The lower portion of the slightly elongate mass has irregular projections much like the roots of a human molar (pl. 11, fig. 1) The specimen is from the Henryhouse in SE¼ SW¼ sec. 10, T. 2 N., R. 6 E., Pontotoc County.

Numerous dissertations have appeared concerning the habit of *Scyphocrinites* and the question of whether the bulbous roots, "*Camarocrinus*," were indeed attached to *Scyphocrinites*. Springer (1917) established the relationship between the two forms beyond the shadow of a doubt. However, he disregarded the evidence of an eleutherozoic life given by Kirk (1911) and considered the bulbs to be roots and to have been buried in the mud (sessile habit). For comparative purposes Springer (1917) even figured a recent crinoid, *Ptilosarcus brevicaulis* Nutting, from the Sea of Japan, which has an elongate, tumid root shaped somewhat like a sweet potato. Kirk (1911) considered the bulb of *Scyphocrinites* to be a float and thought that the crown might have floated in an inverted position (with the arms down). It seems logical to consider the bulb as a float, with the partitions forming air pockets.

Bouška (1956, p. 133), considering *Scyphocrinites* to be a floating organism stated:

> The pelagically living genus *Scyphocrinites* had a great migration speed and was by its mode of life independent of the depth of the sea, as is indicated by its cosmopolitan distribution, its narrow vertical range, and its occurrence in different facies. Therefore this genus is a very reliable element for determining the age of the beds. The great majority of other crinoid groups is, on the contrary, from an ecological point of view sessile benthos, dependent on the facies, and is an indicator of bathymetrical conditions, and does not in any case equal in biostratigraphical value the genus *Scyphocrinites*, as K. Beyer (1951) assumed.

Considering the vast beds of bulbous roots in the Haragan Formation and elsewhere, Kirk (1911, p. 55) suggested, "Again, the segregation of bulbs indicates that they were pocketed, as it were, in an area of comparatively quiet water after having been transported by current or wind action." Some drastic turbulence must have separated the crowns and stems from the bulbs, in which case the bulbs would certainly have drifted off, and, as the soft parts of the axial canal decomposed, the water would have entered and the bulbs then would have settled to the bottom of the sea, with the large smooth side lowermost. One of the reasons Springer (1917) concluded that the bulbs were roots buried in the mud was that the smooth unstalked side is normally lowermost. Where colonies of complete crinoids are found, such as the colony of *Scyphocrinites elegans* from the Devonian of Missouri and the colony of *Scyphocrinites gibbosus* from the Devonian of Oklahoma, it is evident that the animals were suddenly killed by some change in the water or movement of the sea bottom and were embedded in soft mud without much disturbance by currents.

Further evidence of a vagrant habit is afforded by small root systems of *Scyphocrinites* attached to bulbs of *Scyphocrinites ulrichi* and other species. Springer (1917) noted the root systems and illustrated several with drawings. Under his concept, the bulbs were buried in the muck of the ocean bottom, and in such a condition the roots could not have attached themselves. It seems to me that the young specimens were "hitch-hiking" on the floating bulbs while they were attaining some growth and that later they became free and formed their own bulbous bases.

A development that is somewhat comparable to the condition found in *Lampterocrinus* is reported by Philip (1961), wherein a fusion of columnals with a calcite plug takes place within the deeply depressed basal part of the dorsal cup of *Eucalpytocrinites inchoatus* Philip (1961, text-fig. 8), from the Lower Devonian of Toongabbie, Gippsland, Victoria, Australia. In *Lampterocrinus* the immobilization of the proximal columnals apparently occurs at the mouth of the basal concavity, but in Philip's species it is at about midlength of the depression and is effected by a calcite plug which is in turn fused with calyx plates.

Scyphocrinites Colonies in the Henryhouse and Haragan Formations

Several years ago, Richard Alexander, while a student at The University of Oklahoma, noticed an accumulation of crinoid stems in the Henryhouse Formation in the Lawrence uplift area south of Ada, Oklahoma, and Allen Graffham subsequently excavated the colony. No well-preserved crowns were found because they were too compressed. Apparently the underlying marl did not afford the proper cushion to prevent the crinoids from being crushed in preservation.

The outcrop is a low scarp with a county road crossing it almost at right angles. At one time the general exposure yielded quite a few small trilobites and little grass was in the area. Early in 1962 I returned to the exposure and, although the exposure was thickly covered with vegetation, I was able to extract a small segment of the colony from a small cut on the south side of the road.

The limestone layer is about 5.5 cm thick and is almost entirely composed of columnals and segments of stems extending unbroken for considerable distances. The upper portion (about 2 cm thick) has columns stacked like cordwood. As many as 15 stems, having diameters of 3.5 mm to 6 mm, will occupy an area slightly more than 2 cm square. The calices and arms are on the underside of the layer.

The exposure is in NW¼ NW¼ SE¼ sec. 29, T. 3 N., R. 6 E., Pontotoc County, Oklahoma. The measured specimen is OU 4669.

A crinoid colony was discovered several years ago in the Haragan Formation at old Hunton townsite, west of Clarita, Coal County, Oklahoma, by Mr. and Mrs. Allen Graffham and Mr. and Mrs. Harrell Strimple. A magnificent crown in a small slab of thin limestone was found in a gulley. The crown was lying on the slab at right angles to a mass of columns which were lying parallel to one another. Mr. Graffham recognized the colonial nature of the preservation and found an exposure where the colony was in situ, and where some additional specimens were excavated. On one other occasion, we excavated a good many small slabs and found several crowns, although none was quite so well exposed as the original specimen, which is figured herein (pl. 7, fig. 6). The layer is relatively thin, at few places more than an inch thick, and when freshly exposed it breaks easily so that large sections cannot be obtained unless a substantial amount of overburden is removed. We did not find bulbs in association with the colony, although a few were found several feet below the zone. The crowns are attached to the underside of the limestone and are cushioned by an underlying clay marl. This is the same condition noted by Springer (1917) for the remarkable colony of *Scyphocrinites elegans* collected from the Devonian near Cape Girardeau, Missouri.

The average column in the Haragan colony has a diameter of about 4 mm and about 19 of them occupy an area 22 mm square. They are not stacked quite so closely together as in the *Scyphocrinites cinctus* colony in the Henryhouse Formation.

SYSTEMATIC PALEONTOLOGY

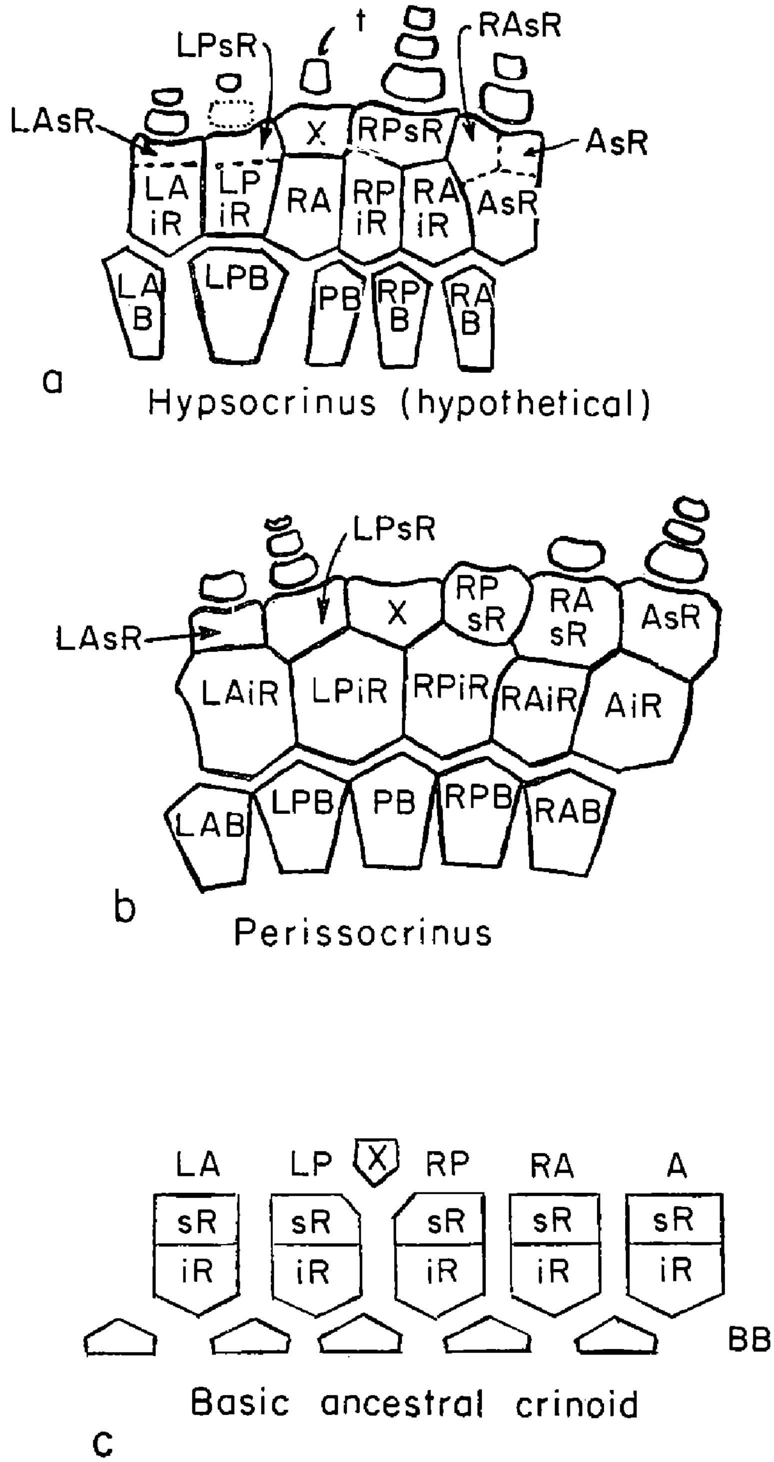
Class CRINOIDEA Miller

Subclass INADUNATA Wachsmuth and Springer

Order DISPARATA Moore and Laudon

In the course of the current studies, the form *Hypsocrinus* Springer and Slocum, 1906, attracted my attention, especially because of the second basal plate which is really in the right anterior position. This view is untenable and it is probably due to Springer and Slocum's interpretation of the plate directly below the left posterior radial as the "posterior" basal. To orient the plates of this circlet properly, the large basal is left posterior, the one to the right is posterior, next to the right is right anterior, and the last one (on opposite side of the diagram) is left anterior. I have shown all of the directional symbols on the analysis given herein (text-fig. 1a). A comparison of the figure with the diagram of *Perissocrinus papillatus* Goldring, 1936, readily substantiates the practicability of the new designations. A hypothetical ancestral form of *Hypsocrinus* was prepared some time before I compared the genus with *Perissocrinus*. In fact I was comparing *Hypsocrinus* with *Quiniocrinus* Schmidt with the idea that both evolved from a form having five compound radials. With the additional information afforded by *Perissocrinus*, it appears we are dealing here with such a phyletic line.

My first hypothetical ancestral form of *Hypsocrinus* provided for only five plates in the superradial field, and therein more or less followed the original five-radial interpretation (excluding an anal X). Three fallacies in this reasoning were: (1) the anterior radial is large and has a peculiar shape, especially in upper portion, (2) the first segment above "right posterior superradial" is narrow and elongate, as contrasted to the wide, low brachial segments in the other rays, (3) the arrangement of the supernumerary (radianal) in the inferradial circlet, already comprising five inferradials, implied the need for an anal plate above to make the cup normal. A new analysis has been drawn, with dashed lines showing the position



Text-figure 1. Diagrammatic drawings of *Hypsocrinus*, *Perissocrinus*, and a hypothetical ancestral form.

a. *Hypsocrinus* with the assumed fused plates outlined by dotted line. (Lower AsR should read AiR.)

b. *Perissocrinus* (modified after Goldring).

c. Basic ancestral form with five compound radials. This concept differs from the common one that the primitive form has only three compound radials, right posterior, right anterior, and left anterior.

of the fused plates. This interpretation allows for only four arms. One inferradial (right anterior) has no individual superradial above, and I suspect it was about to fuse with the adjacent right posterior inferradial. These two plates anchylose in the Pisocrinidae. This does not mean that I think the presently considered forms are closely related to the Pisocrinidae. I am, in fact, proposing a separate family as Perissocrinidae, new family.

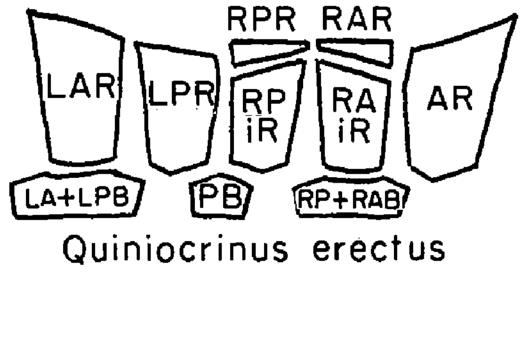
Family PERISSOCRINIDAE Strimple, new family

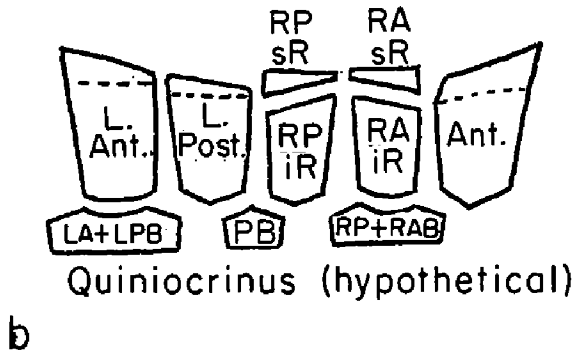
Diagnosis.—Monocyclic, cup conical, high, three to five basals, visible from side, five radials with two to five being compound, anals in cup none to two.

Range.—Devonian; North America, Europe.

Genera.—*Perissocrinus* Goldring, 1936, Hamilton, Devonian, New York; *Hypsocrinus* Springer and Slocum, 1906, Hamilton, Devonian, New York; *Quiniocrinus* Schmidt, 1941, Eifel, Devonian, Germany.

Remarks.—*Quiniocrinus* (text-fig. 2a, 2b) does not appear to be intimately related to either *Hypsocrinus* or *Perissocrinus,* but it has characters that lead me to believe they belong to the same general phyletic strain. This is because of the implication of a close ancestral form having five compound radials. In text-figure 2b I have indicated the immediate ancestral type to be expected. Among the possibly allied Pisocrinidae (to which family Schmidt referred his genus), certain more advanced characters had already appeared during Silurian time. Comparison of *Quiniocrinus* with *Pisocrinus* discloses that in the former the LAiR and LAsR have fused but that in the latter LAiR has been absorbed. It is also noteworthy that RPiR and RAiR are fused in *Pisocrinus* but are still divided in *Quiniocrinus.* A diagram of *Pisocrinus* is given in text-figure 9c for reference. No provision for an anal structure, or plate, appears in *Quiniocrinus.* The structure of the cup indicates the former presence of superradials in all rays similar to those preserved in the right posterior and right anterior rays. A diagram is included to demonstrate this feature, with dotted lines marking the presumably fused superradials. *Quiniocrinus* is more advanced than the other genera of this family as exhibited by the absence of anal plates, in





Text-figure 2. Diagrammatic sketch of *Quiniocrinus erectus* Schmidt and the hypothetical predecessor form.

a. *Quiniocrinus erectus* (modified from Schmidt).
b. Hypothetical predecessor form. Dotted lines indicate sutures for division of superradials in all rays.

having broad, long radial articular facets, and in having only three basals.

Moore and Laudon (1943, p. 30) discussed *Hypsocrinus* and *Perissocrinus* briefly under the family Pisocrinidae and referred to them as having uncertain affinities. These authors apparently were unacquainted with the genus *Quiniocrinus** at that time because no mention of it was made in their study. Neither is the genus listed in Bassler and Moodey (1943).

* Moore (1962b, p. 14, text-fig. 6a) included this genus under the Pisocrinidae, but the evidence does not alter my opinions given above.

Family HETEROCRINIDAE Zittel

Genus *MYELODACTYLUS* Hall, 1852

Myelodactylus nodosarius (Hall), 1859
Plate 1, figures 1-4; text-figure 3a

Considerable attention has been given to *Myelodactylus nodosarius* in the past. Kirk (1911) considered the species as distinct from "*Herpetocrinus*" (now *Myelodactylus*) on the basis of the direction of curvature in the distal extremity of the stem. He was of the opinion that the species was not permanently affixed and that the double row of cirri was for the purpose of grasping objects. Specimens of *Myelodactylus brachiatus** (Hall) figured by Springer (1926b, pl. 4), show that a certain amount of curvature is possible in the distal portion of the stem as well as in the proximal region. In *M. brachiatus* the column culminates in a point without any special swollen terminating device. No evidence refutes the concept of an eleutherozoic existence for these forms.

Most figured specimens of *Myelodactylus nodosarius* having the distal termination preserved show a rotund terminating segment. Springer (1926, pl. 5, fig. 2) figured one specimen with a pointed but swollen termination. Goldring (1923, pl. 41, fig. 4) also figured one specimen with a pointed and swollen termination. The specimens with a rotund or ball-like termination have only the one terminating columnal. Conversely, several swollen columnals are involved in the formation of the pointed-type swollen termination. In the material at hand from the Haragan Formation of Oklahoma, all terminations have a pointed extremity, or are obviously modified from such forms. Probably some fundamental difference is involved in these two types of endings. Hall (1859), in his original description of the species, figured both terminations.

The largest distal termination found is 13.2 mm wide and 17.3 mm long. Almost all semblance of columnals has been obliterated by the heavy secondary deposition of stereom, and the placement of the two cirrus attachments and of the columnar attachment is not in the precise relationship found in smaller specimens. A specimen showing the pointed termination, as well as the attached,

* Taken as the type species of *Crinobrachiatus* Moore (1962b).

swollen cirri, is shown on plate 1, figures 3, 4. The pointed termination has a maximum width of 6.5 mm and is 9.6 mm long.

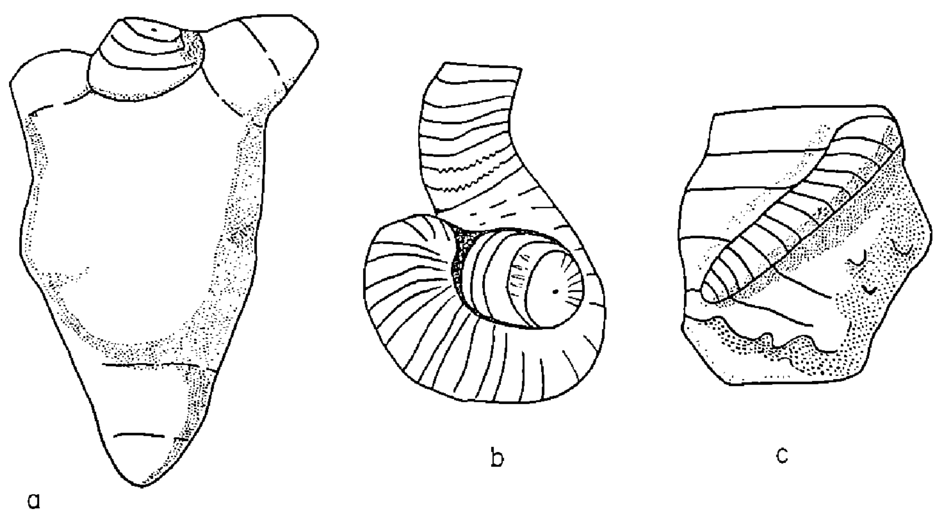
The species has been reported from the Devonian (Helderbergian); east of Clarksville, Helderberg Mountains, Albany County, New York (New Scotland Limestone); Schoharie, New York (Coeymans Limestone); old Hunton townsite, Coal County, Oklahoma (Haragan Limestone); and south of Sulphur, Oklahoma (Bois d'Arc Limestone).

Types and occurrence.—Hypotype OU 4703 is from the Bois d'Arc Limestone in the quarry on the east side of State Highway 18 in sec. 1, T. 2 S., R. 3 E., south of Sulphur, Oklahoma. Hypotypes OU 4663-4665 and 4700 are from the Haragan Formation at old Hunton townsite, west of Clarita, Coal County, Oklahoma.

Myelodactylus extensus Springer, 1926
Plate 1, figures 9, 10

The syntypes of *Myelodactylus extensus* comprise fragments of a few crowns. They are from the Beech River Member, Brownsport Formation, Niagaran, Silurian; Decatur County, Tennessee.

Two specimens representing the proximal coiled section of the stem ("closed coil" of Springer, 1926) have been observed in the Henryhouse Formation, Hunton Group, Niagaran, Silurian, Pon-



Text-figure 3. Drawings of three different types of columnal terminations made with the aid of a camera lucida.

a. A pointed terminal element of *Myelodactylus nodosarius* (Hall), OU 4664.
b. A stem coiled about and fused to another stem, USNM 6255.
c. The lower end of a stem swelling and fusing the columnals and incorporating the cirri in the element, USNM 6248c.

totoc County, Oklahoma. The column is broad and more or less elliptical; the inner side is concave and the outer side marked by two faint grooves, and the cirri are broad. In one hypotype (USNM 6237), the cirri are absent on one side and the faint outline of a minute, long-armed crown is present, but silicification prevents preparation for comprehensive study.

Types and occurrence.—Hypotype USNM 6237 is probably from SW¼ NW¼ NW¼ sec. 33, T. 3 N., R. 6 E. Hypotype OU 4721 is from near C sec. 10, T. 2 N., R. 6 E., Pontotoc County, Oklahoma.

Myelodactylus sp.
Plate 1, figure 5

A section of stem having a curvature somewhat like that of *Myelodactylus brachiatus** in its lower portion, and having a double series of short pointed cirri on one side, is figured herein as a probable representative of *Myelodactylus.*

Occurrence.—Specimen USNM 6255g is from the Henryhouse Formation in NW¼ SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma.

Family SYNBATHOCRINIDAE S. A. Miller

Diagnosis.—Monocyclic; crown tall and slender; cup subconical, small; basals 5 to 3; radials 5, subequal, may be compound in three rays, facets broad; anal X notches cup in most genera; arms unbranched, nonpinnulate.

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

Genera.—*Synbathocrinus* Phillips, 1836 (syn. *Synbathocrinites* Austin and Austin, 1842; *Symbathocrinus* d'Orbigny, 1849; *Donacicrinus* Bather, 1900; *Taidocrinus* Tolmachoff, 1924); *Phimocrinus* Schultze, 1866; *Stylocrinus* Sandberger and Sandberger, 1856; *Abyssocrinus* Strimple, new genus; *Theloreus* Moore, 1962b.

Remarks.—The genus *Stortingocrinus* Schultze (1866) was included in this family by Moore and Laudon (1943), but it has restricted arm-articulating facets on the radials, with projecting

* Now *Crinobrachiatus brachiatus* (Hall) (Moore, 1962b)

interarticulating areas, as found in *Haplocrinites.* The genus is referred herein to the family Pygmaeocrinidae.

The Silurian genus *Abyssocrinus* is known to have compound radials in three rays, although the sutures are not present in all specimens. The Lower Devonian species *Phimocrinus jouberti** Oehlert from Sable, France, is reported to have compound radials in three rays. Thus we know that the antecedent form of this family must have three compound radials (right posterior, right anterior, and left anterior).

Stylocrinus agrees with *Synbathocrinus* except in the articular extensions of the radials, which in the former extended only inward, not upward. No provision for an anal plate occurs in *Stylocrinus. Phimocrinus* is like *Synbathocrinus* in all respects except that it has five basal plates instead of three.

Genus *ABYSSOCRINUS* Strimple, new genus

Genotype.—*Synbathocrinus antiquus* Strimple, 1952.

Range.—Silurian; North America.

Diagnosis.—Calyx elongate, bell-shaped; 3 long basals readily visible in side view; 5 large radials, 3 of which are known to be compound and in most cases are fused (right posterior, right anterior, and left anterior); articular facets of radials are long, wide, slope inward and then sharply upward and almost close over the body cavity; a small oral pyramid is known but the details are obscure; anal X elongate, notching the right posterior and, to a lesser degree, the left posterior radials; first primibrachs quadrangular, nonaxillary, of medium length; proximal columnals elongate with swollen midsections.

Remarks.—The compound radials of the genotype species were reported by Strimple and Watkins (1961). They are normally fused, with the irregular suture line visible as a faint groove. The genera *Ectenocrinus* and *Haplocrinites* have compound radials in some rays. Moore and Laudon (1943, p. 27) considered *Ectenocrinus* to be remotely ancestral to *Synbathocrinus.* The new genus *Abyssocrinus* represents a stage between these two genera wherein the superradials and inferradials were becoming entirely anchylosed. Evolution from *Abyssocrinus,* with its long slender calyx and high

* Designated as the type species of *Theloreus* Moore (1962b).

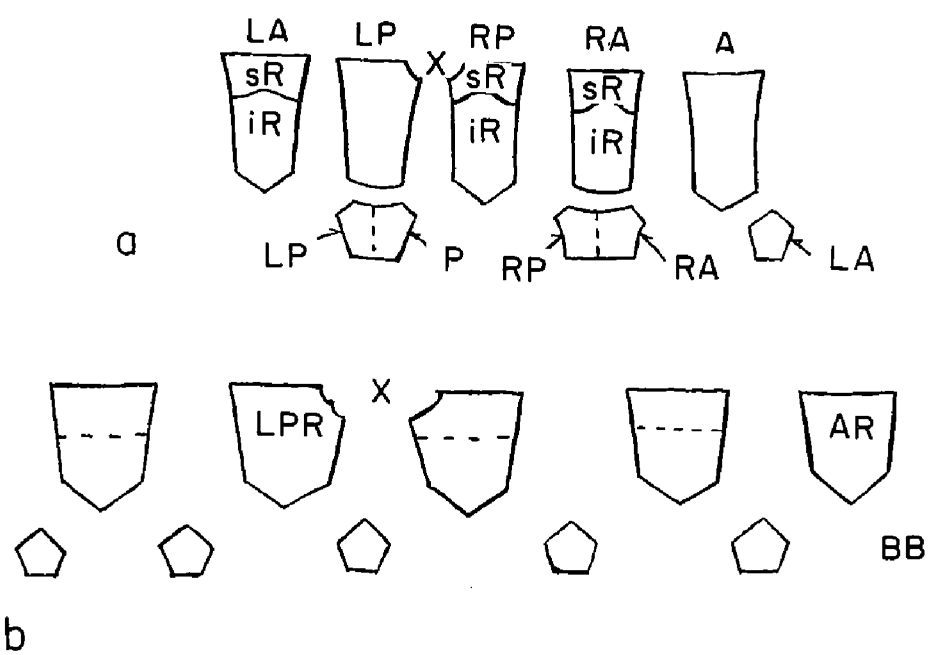
upflared infrabasals, to *Synbathocrinus,* with low wide calyx and infrabasals low (although still visible from side), is most likely and logical.

The generic name is derived from the Greek *abyssos,* meaning bottomless.

Abyssocrinus antiquus (Strimple), 1952
Text-figures 6a-d

Several additional specimens afford more comprehensive understanding of the species and therefore of the genus. The peculiar articular facets of the radial plates are well shown by Strimple (1952a, fig. 3) and the description is repeated here.

> Arm articulating facets are distinctive; the outer ligament furrow is very thin and is bordered to the exterior by a well-crenulated lip and to the interior by a slight ridge; muscle areas are shallowly depressed and thereafter the facets curve strongly upward so that a domelike structure is formed, almost covering the body cavity. In the uplifted area, a narrow slit divides each facet into equal parts. Unless carefully examined, the domelike structure has the appearance of an oral circlet.

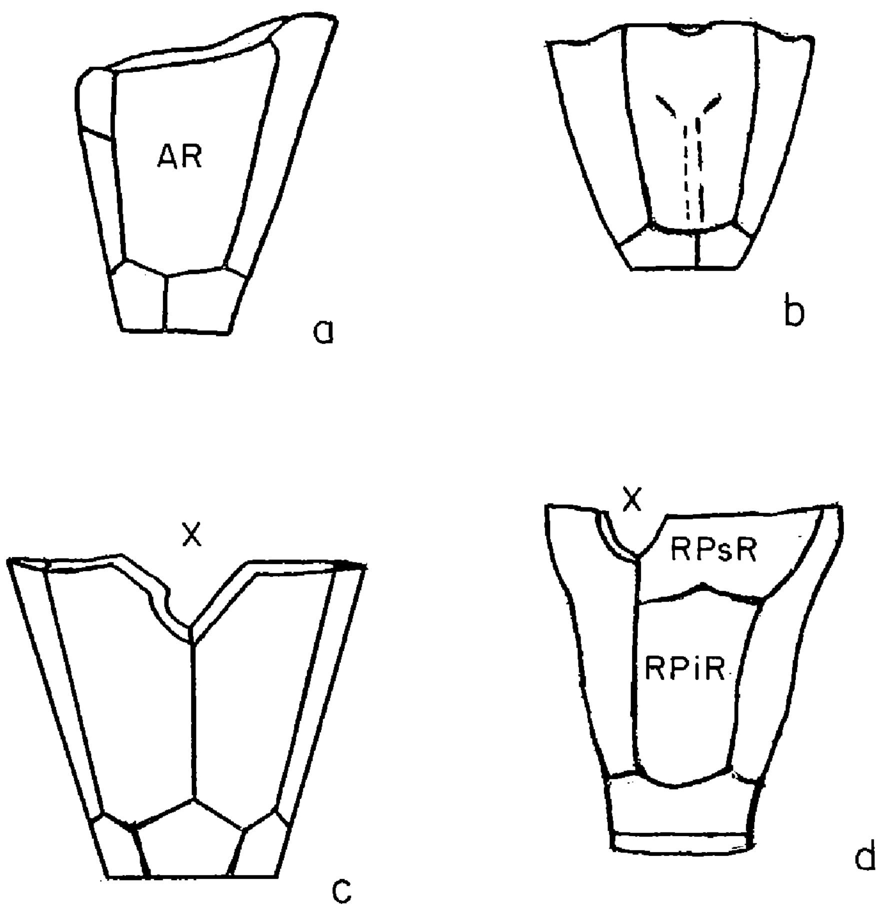


Text-figure 4. Diagrammatic sketches.
a. *Abyssocrinus antiquus* (Strimple).
b. *Theloreus jouberti* (Oehlert).

Wachsmuth and Springer (1886, p. 167) gave the following description of the facets of *Synbathocrinus* (as *Symbathocrinus*).

> The radials are provided with large articular facets, which, extending inward and upward, form jointly at the ventral side of the calyx a sharply angular pyramid with re-entering angles. The upper end of this pyramid is truncated, and contains a good-sized opening in the centre, which in perfect specimens is completely covered by the interradial and summit plates. . . . Each facet is divided vertically by a narrow sinus, and the two halves of the plates, or the limbs, at their upper ends form an ambulacral opening.

Although preservation is rather poor, the oral dome and indistinct interradial plates are preserved in one specimen of *Abyssocrinus antiquus* and illustrated by text-figure 6d. This is the same specimen that has the primibrachs preserved in most rays, showing



Text-figure 5. Sketches of *Quiniocrinus Stylocrinus?, Phimocrinus,* and *Abyssocrinus.*

a. *Quiniocrinus erectus* Schmidt (after Schmidt).
b. *Stylocrinus? canandaigua* Goldring (after Goldring).
c. *Phimocrinus americanus* Springer (after Springer).
d. *Abyssocrinus antiquus* (Strimple).

them to be nonaxillary, rather thick, with V-shaped ambulacral grooves.

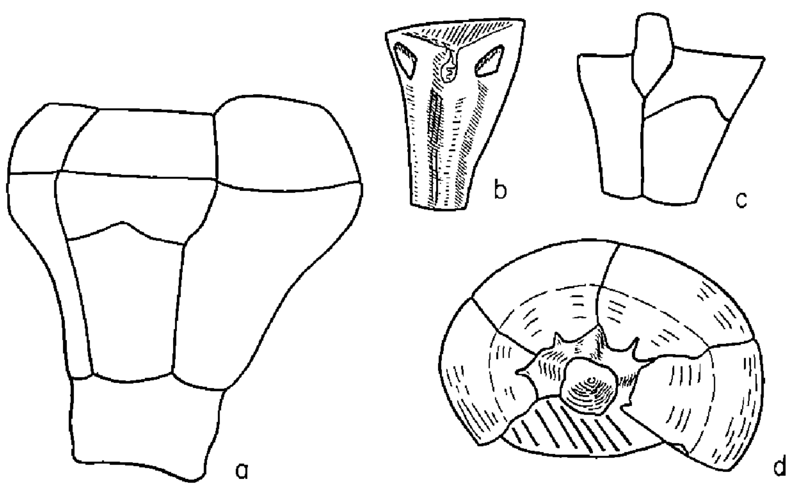
Another specimen has the anal plate which also has the typical appearance of X found in *Synbathocrinus* (text-fig. 6c).

A radial plate, with the inward extensions of the articular facets broken off, is illustrated (text-fig. 6b) from the interior to show the groove into the body cavity that originates at the base of the narrow slit, or sinus. Triangular depressions high on each side of the radial housed either ligaments or muscles, probably the former.

The smallest observed specimen to date (OU 3412) has a cup height of 3.7 mm and maximum width of 3.6 mm. In this specimen, the lateral sides of the cup rise evenly and do not flare near the summit as they do in typical (mature) specimens. The basal circlet is low, all three compound plates show the dividing sutures plainly, and the articular extensions are not flared upward.

The sutures between the three compound radial plates are not visible in all specimens. A tabulation of those observed in the eight specimens at hand is as follows:

1 specimen shows no sutures
1 specimen shows suture in left anterior only
1 specimen shows suture in right posterior only



Text-figure 6. *Abyssocrinus antiquus* (Strimple).

a. Hypotype in side view showing first primibrachs in place and one compound radial, USNM 6250.
b. Inner view of radial plate, USNM 6243b.
c. Posterior view of small specimen with anal X in place and compound right posterior radial with suture showing.
d. Summit view of USNM 6250 (fig. a) showing position of orals.

1 specimen shows suture in right posterior and left anterior only
1 specimen shows suture in right posterior and right anterior only
3 specimens show suture in right posterior, right anterior, and left anterior.

As noted elsewhere, all that is needed to produce *Synbathocrinus* out of *Abyssocrinus* is complete fusion of the compound radials and lowering the cup to a medium height, with a slightly wider base. The change from a high, conical cup to a low, more or less bowl-shaped cup is considered to be progressive evolution.

Types and occurrence.—All types and specimens are from the Henryhouse Formation in Pontotoc County, Oklahoma. Holotype S 4786 and metatypes OU 3412, OU 3911 (two specimens), and USNM 6258 (1) are from near C sec. 4, T. 2 N., R. 6 E. Metatypes OU 3911 are those of Strimple and Watkins (1961). Paratypes S 4737 and S 4738 are from SW¼ NW¼ NW¼ sec. 33, T. 2 N., R. 6 E. Hypotypes USNM 6243a, 6243b, 6243d, 6221b, and 6255c are from near C SW¼ NW¼ sec. 33, T. 3 N., R. 6 E.

Genus *STYLOCRINUS* Sandberger and Sandberger, 1856

Genotype.—*Platycrinites scaber* Goldfuss.

Range.—Silurian, Devonian; North America, Europe.

Diagnosis.—Calyx low, bowl-shaped; 3 or 5 basals with distal extremities visible in side view of cup; 5 large radials; articular facets developed inward; column circular; no anal plate.

Species assigned to Stylocrinus.—

	Occurrence
Stylocrinus ? canandaigua Goldring, 1923	Devonian (Hamilton-Moscow Sh.); N. Y.
Stylocrinus elimatus Strimple, new species	Silurian (Henryhouse-Niagaran); Okla.
Stylocrinus scaber (Goldfuss)	Devonian (Givetian-*Stringocephalus* ls.); Germany
Stylocrinus tabulatus (Goldfuss), 1839	Devonian (Eifelian); Germany
Stylocrinus tabulatus altus (Müller), 1855	Devonian (Eifelian); Germany

Stylocrinus tabulatus Devonian (Eifelian);
depressus (Müller), 1855 Germany

Remarks.—The primary difference between *Stylocrinus* and *Synbathocrinus,* given by Wachsmuth and Springer (1886) in their redefinition of *Stylocrinus,* is the absence of an upward extension of the articular facets, a feature which is present in *Synbathocrinus* as well as in the allied Silurian genus *Abyssocrinus.* A well-developed anal plate is present in each of these genera but is missing in *Stylocrinus.*

Little attention has been given to this ultra-simplified genus subsequently to the notations of Wachsmuth and Springer (1886, p. 170, 171). They referred all of the known species and varieties to one species, *Stylocrinus tabulatus* (Goldfuss); however, Bassler and Moodey (1943) listed them all as valid as I have shown herein.

Stylocrinus elimatus Strimple, new species
Plate 1, figures 6-8

The dorsal cup of *Stylocrinus elimatus* is low, wide, truncate conical, with broad basal plane. The basal area is deeply excavated, but the outer edges of basals extend out of the cavity and form the lower part of the calyx walls. Sutures between basals are obscure but there appear to be five. The erect sides of the cavity do not indicate abrasion nor, conversely, fusion with the column, yet the columnar scar is almost as wide as the cavity. Five large radials form most of the cup height. The articular extensions of the radials are inward, not upward, and form a plane with the edge of the radials. No provision for an anal plate is apparent. The columnar scar is circular and crenulate.

The cup is 8.7 mm wide and 4.3 mm high. The diameter of the basal concavity is 3.1 mm.

Remarks.—*S. elimatus* is atypical of the genus in having a basal concavity and in having what appears to be five basals. As the only available specimen has no column nor arms attached, a comprehensive study is not possible. It likely will be found to belong to an unknown genus.

The only other American species assigned to the genus is *Stylocrinus? canandaigua* and it with question. It has a narrow base, with basals visible from the side, a more primitive condition than that in *S. elimatus.*

Other forms in the Henryhouse Formation have structures to protect the proximal columnals, or to provide additional support for them. Some discussion of this fact is given early in this study under section, "Evidence of Mechanical Factors."

The specific name is the Latin adjective *elimatus,* meaning adorned.

Holotype and occurrence.—Holotype OU 4657 is from the Henryhouse Formation from a bench above the stream at C sec. 10, T. 2 N., R. 6 E., Pontotoc County, Oklahoma.

Genus *PHIMOCRINUS* Schultze, 1866

Genotype.—*Phimocrinus laevis* Schultze, 1866.

Range.—Devonian; North America, Europe.

Diagnosis.—Monocyclic; cup subconical, small; 5 basals; 5 radials, articular facets extend upward (as in *Synbathocrinus*); anal notch between posterior radials.

Known species.—

	Occurrence
Phimocrinus laevis Schultze, 1866	Devonian (Eifelian); Germany
Phimocrinus quinquangularis Schultze, 1866	Devonian (Eifelian); Germany
Phimocrinus jouberti Oehlert*, 1882	Lower Devonian; Sable (Sarthe) France
Phimocrinus americanus Springer, 1923	Devonian (Helderbergian); Tennessee

Remarks.—*P. americanus* is atypical and is more comparable to *P. jouberti* than to the German species, other than for the compound radials of *P. jouberti.* It is elongate, has a sharply notched incision for anal X, and lacks strong upwardly directed processes considered to be typical of the genus.

Bather (1900, p. 152) stated that *P. jouberti* ". . .shows clear traces of horizontal suture in right posterior, right anterior and left anterior radials."

* Designated as the type species of *Theloreus* Moore (1962b).

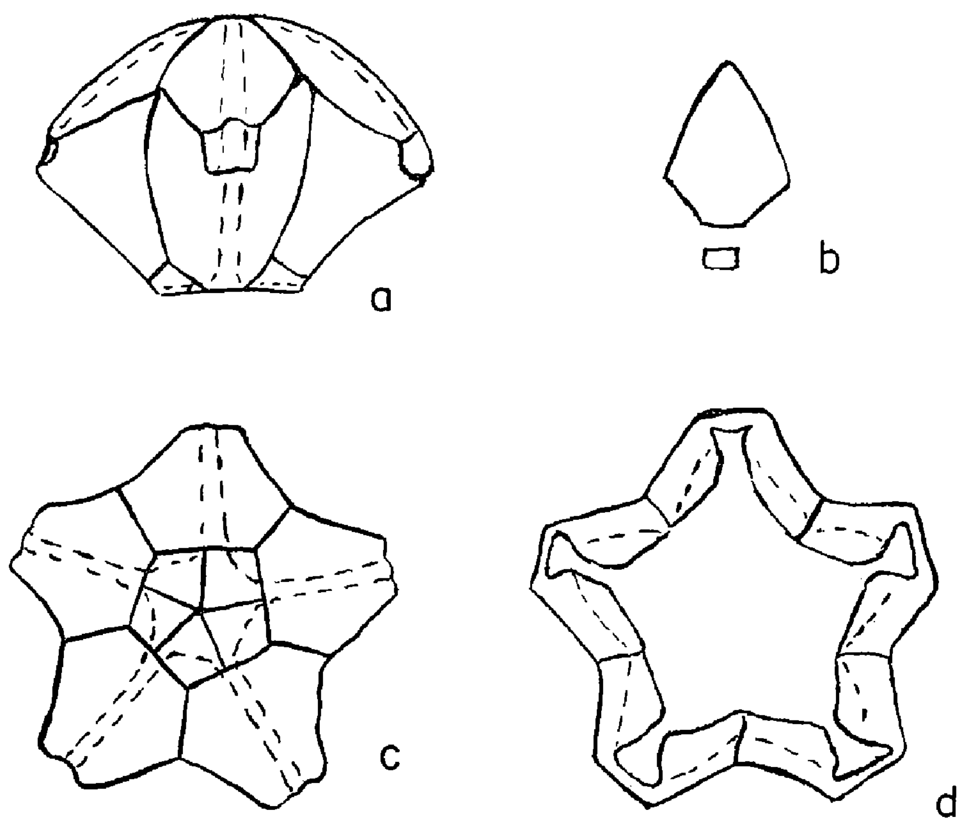
Family PYGMAEOCRINIDAE Strimple, new family

Diagnosis.—Monocyclic; 3 to 5 basals extending beyond columnar facet; 5 radials comprising most of cup height, arm articular facets restricted, interarticular areas extended upward; anal plate absent in *Pygmaeocrinus,* present in *Storthingocrinus.*

Range.—Devonian; Europe.

Genera.—*Pgymaeocrinus* Bouška, 1947; *Storthingocrinus* Schultze, 1866.

Remarks.—The minute form, *Pygmaeocrinus,* was assigned by Bouška (1947) to the Pisocrinidae, although he recognized that it was not a true representative of the family. From information at hand it is apparent that *Pygmaeocrinus* could not be ancestral to nor descended from the Pisocrinidae. It has some characters in common with *Haplocrinites,* but here again it could not have evolved from nor be antecedent to that genus. In the absence of any



Text-figure 7. Drawings of *Pygmaeocrinus kettneri* Bouška.
a. Crown from side.
b. Primibrachials.
c. Crown from below.
d. Crown from summit.

apparent affinities it seems desirable to place the form under a separate family. *Storthingocrinus* was assigned to the family Synbathocrinidae by Moore and Laudon (1943), but it is known to have the type of upper articular facets of the radials that is common to those of *Haplocrinites* or of *Pygmaeocrinus*. *Haplocrinites* has compound radials in some rays. The presence of three unequal basal plates in *Storthingocrinus* is only a slightly more advanced stage than is the presence of five equal plates in *Pygmaeocrinus*. Placement of the small, unfused basal in the left posterior interradius, and the angles of the columnar canal being radial in position are both unique features. The illustration (text-fig. 7) of *Pygmaeocrinus kettneri* Bouška (1947) indicates that the angles of the columnar canal are radial in position in that species.

Bouška (1947, p. 3) reported the abundant occurrence of *Pygmaeocrinus* in Devonian and Silurian rocks of Bohemia. It will be surprising if the minute forms are not eventually discovered in similar rocks of America.

Family PISOCRINIDAE Angelin

Diagnosis.—(After Moore and Laudon, 1943.) Monocyclic small crinoids; cup conical or globose; 3 to 5 radials; LAR and RAR much smaller than LPR and AR; sRA like small RR, obliquely at left above large iRA; arms unbranched, nonpinnulate, or divided isotomously once, pinnulate.

Range.—Silurian, Devonian; North America, Europe, Russia, Australia.

Genera.—*Pisocrinus* de Koninck, 1858; *Triacrinus* Münster, 1839 (syn. *Trichocrinus* Müller, 1856); *Cicerocrinus* Sollas, 1900 (syn. *Lagarocrinus* Jaekel, 1900); *Calycanthocrinus* Follman, 1887; *Ollulocrinus* Bouška, 1954 (syn. *Pisocrinus* (part) de Koninck); *Jaekelicrinus* Yakovlev, 1947, 1949.

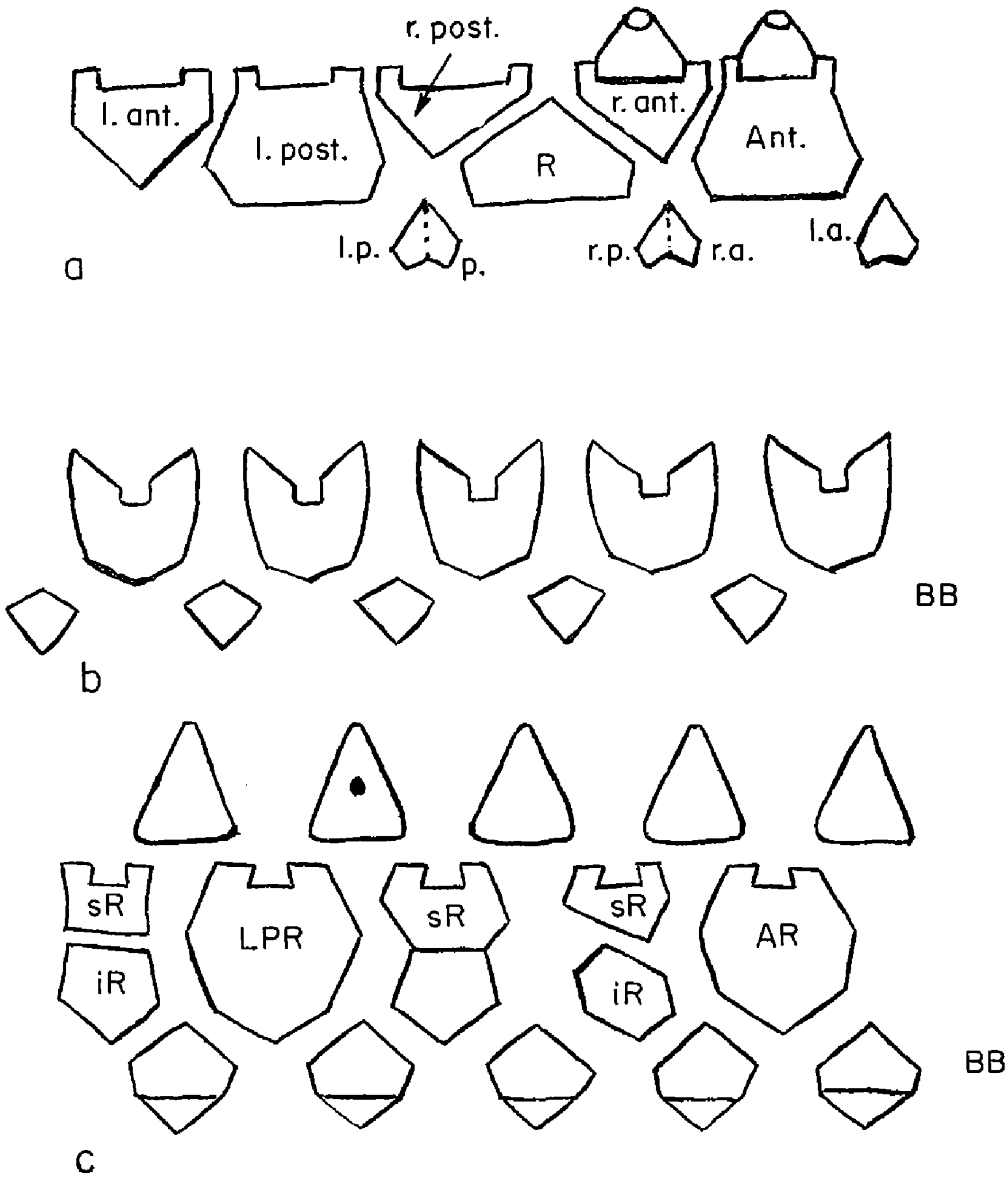
Genus *PISOCRINUS* de Koninck, 1858

Genotype.—*Pisocrinus pilula* de Koninck, 1858.

Range.—Middle and Upper Silurian, Lower Devonian; North America and Europe.

Diagnosis.—(As restricted by Bouška, 1956.) Five unequal basals; processes at upper angles of radials make partitions between arm bases; anal tube resembles arm; stem round. Basals form walls of the basal impression and in many cases are visible in lateral view of the cup, outline subtriangular.

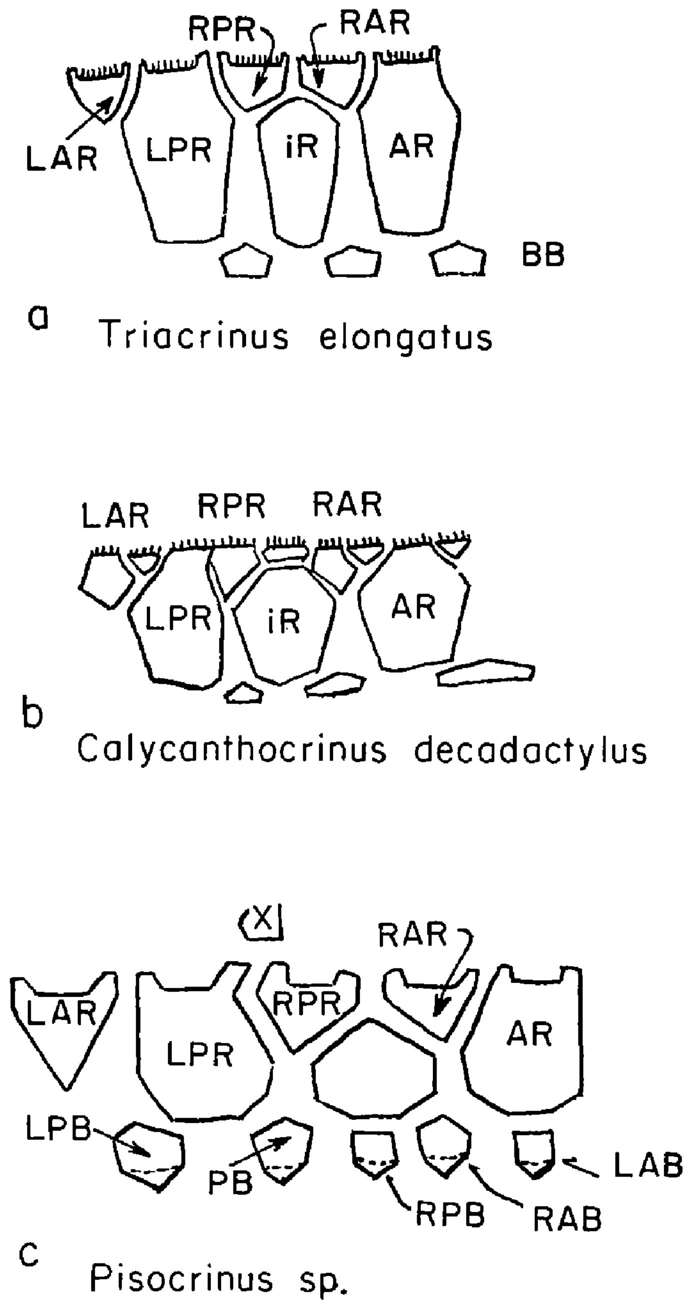
Remarks.—Moore and Laudon (1944) showed the range of this genus to be restricted to Middle Silurian, but Bouška (1956) described species from the Upper Silurian and Lower Devonian



Text-figure 8. Diagrammatic sketches of *Triacrinus, Pygmaeocrinus,* and *Haplocrinites.*

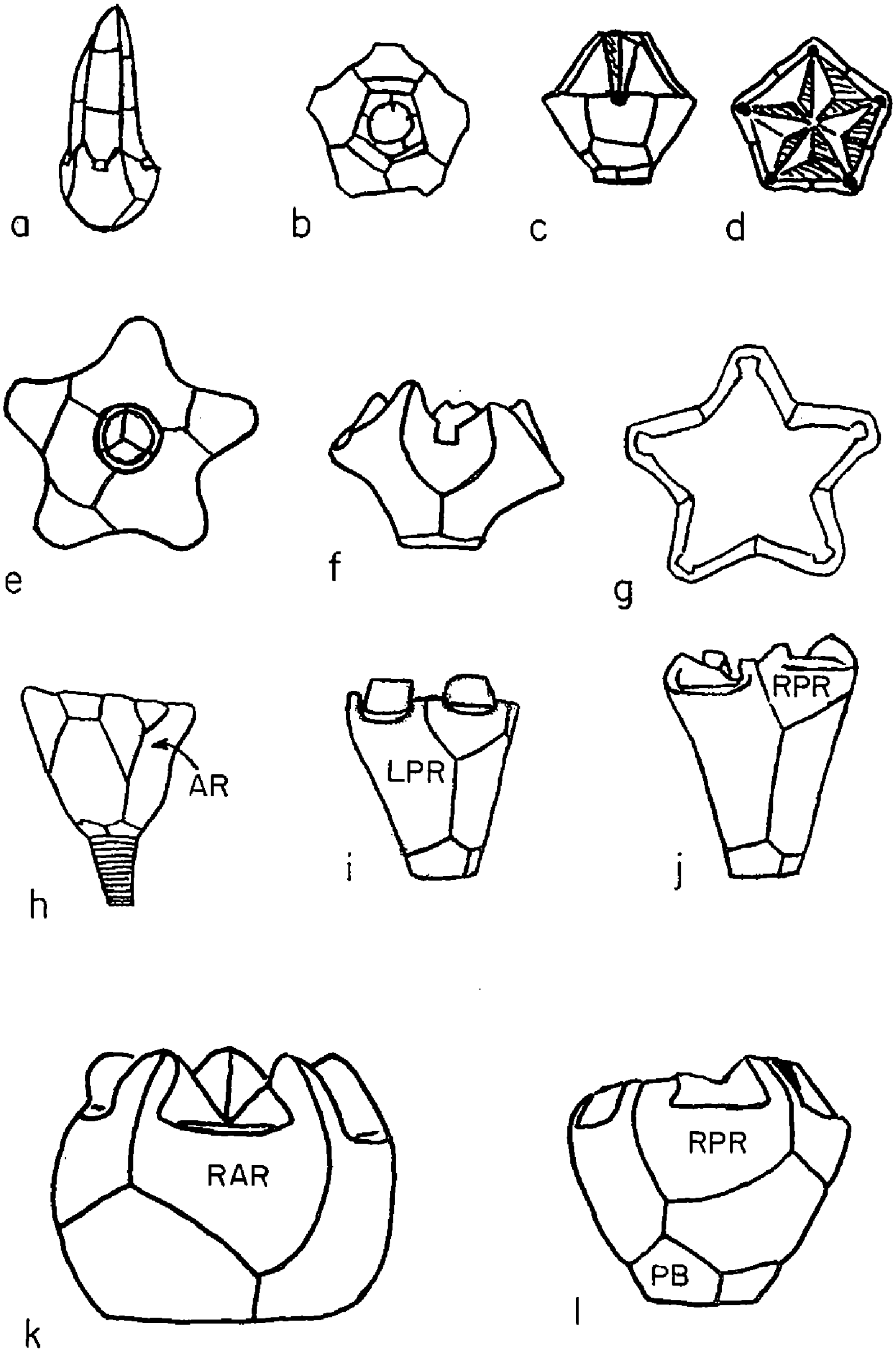
a. *Triacrinus* Münster (after Bather).
b. *Pygmaeocrinus* Bouška (modified after Bouška).
c. *Haplocrinites* Steininger (after Bather).

of Bohemia. The geographic range given by Moore and Laudon (1944) included Australia, but the species concerned is now assigned to the genus *Ollulocrinus*.



Text-figure 9. Diagrammatic sketches of *Triacrinus*, *Calycanthocrinus*, and *Pisocrinus*.

a. *Triacrinus elongatus* Follman (after Schmidt). The fine lines along the summit of plates represent a pitted condition.
b. *Calycanthocrinus decadactylus* Follman (after Schmidt). The fine lines along the summit of plates represent a pitted condition.
c. *Pisocrinus* sp. for comparison.



Text-figure 10. Sketches of *Ollulocrinus, Haplocrinites, Triacrinus, Calycanthocrinus,* and *Pisocrinus.*

a. *Ollulocrinus quinquelobus* (Bather) (after Springer), side view of crown.
b, c, d. *Haplocrinites clio* Hall (after Goldring), basal view, side view, summit view.
e, f, g. *Triacrinus regnelli* Bouška (after Bouška), basal view, side view, and summit view.
h. *Calycanthocrinus decadactylus* Follman (after Schmidt), side view.
i. *Pisocrinus ubaghsi* Bouška (after Bouška), side view.
j. *Triacrinus elongatus* Follman (after Schmidt), side view.
k. *Ollulocrinus ollula ollula* Bouška (after Bouška), side view.
l. *Pisocrinus pilula* de Koninck (after Bouška), side view.

Pisocrinus spatulatus Strimple, 1954

Pisocrinus spatulatus, as represented by the original type specimens, is distinctive and not closely comparable to any other described species, especially because of the irregularity of outline exhibited in basal or summit view (Strimple, 1954, figs. 7, 8). Close examination of hundreds of specimens from the same formation discloses a fairly large representative group that agrees with *P. spatulatus* in having strong surface ornamentation (granulations) and in having points on the radials in midsection, just below the articular surfaces. These points may be little more than enlarged granules in some specimens, but a projection is involved. Normally a substantial portion of the radial plate is affected by the projection. Among these more numerous representatives of the species, the suture between the left anterior radial and the left posterior basal is normally short but is not entirely eliminated; in the holotype, the suture is longer than normal. Most specimens lack the sharp reduction in size of the right posterior and the anterior basal plates as is the case in the original types. The basal plates are not visible in side view of the original type specimens, but their outer edges are visible in most cases in the presently considered specimens.

As here emended, *Pisocrinus spatulatus* is closely related to *P. varus,* new species. The latter is typically a larger, taller form and does not have the pointed projection found on each radial of *P. spatulatus.*

Types and occurrence.—All types and specimens of *P. spatulatus* are from the Henryhouse Formation in Pontotoc County, Oklahoma. The original types came from a freshly bulldozed exposure in the escarpment in NW¼ SW¼ sec. 4, T. 2 N., R. 6 E. According to Porter Kier, associate curator, Division of Invertebrate Paleontology and Paleobotany, U. S. National Museum, (written communication, January 16, 1962) the types were never received by that institution. It therefore appears that I did not formally deposit them, but even so they must be included somewhere in the large collections that the museum subsequently acquired from me. I kept no specimens other than a collection of Morrowan crinoids previously committed to a study of those forms.

The exact collecting sites are not known for most of the specimens in the U. S. National Museum, other than that they are from the Lawrence uplift in sec. 4, T. 2 N., R. 6 E., and sec. 33, T. 3 N.,

R. 6 E. The number of specimens and the museum catalog numbers are:

Number of specimens	USNM number
2	6244
10	6258
4	6267
10	6218
5	6241
26	6244
6	6248
4	6255

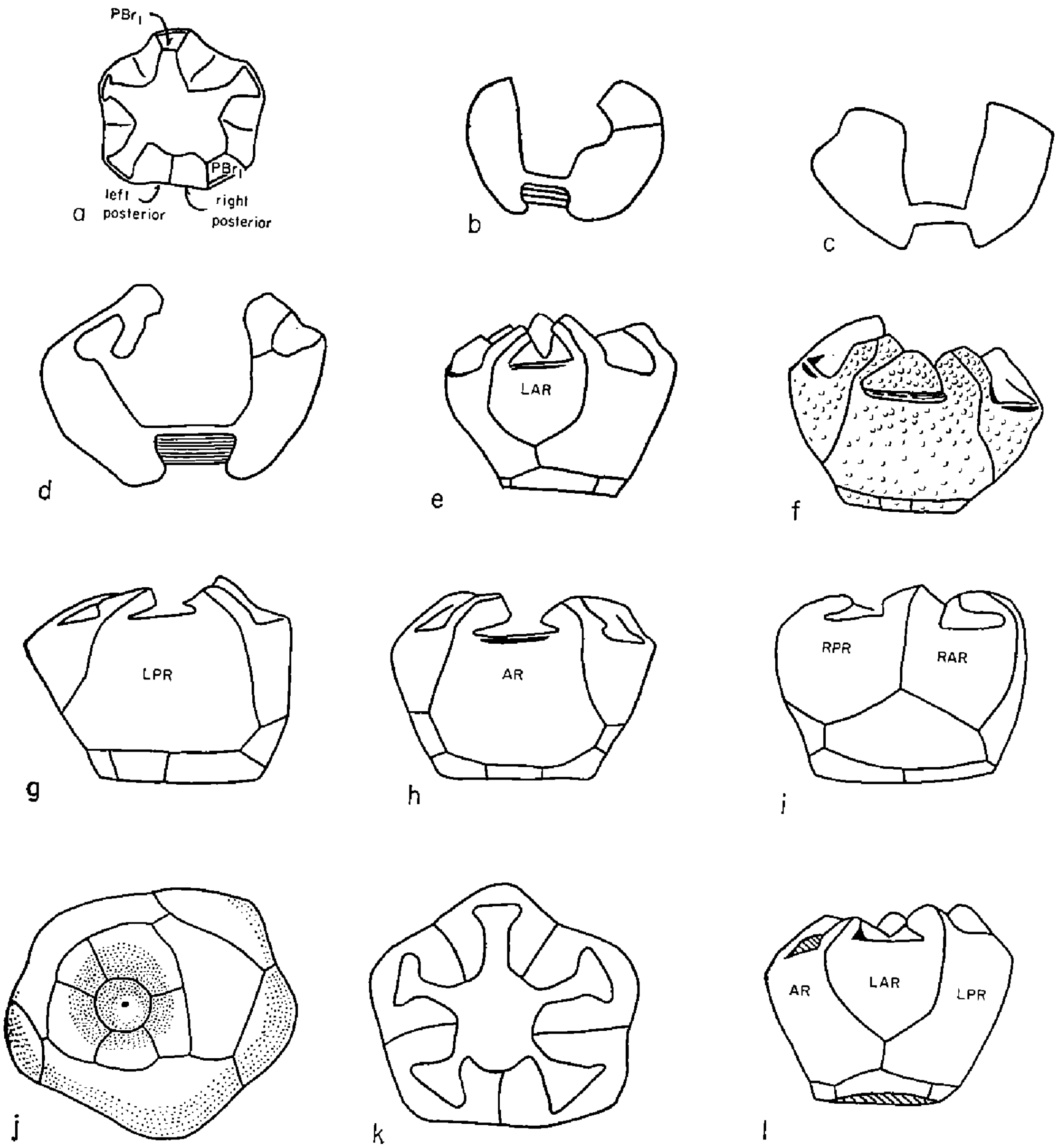
Six specimens (USNM 6255) are from NW¼ SW¼ sec. 4, T. 2 N., R. 6 E. OU 5013 is from this locality from the Henryhouse between 185 and 205 feet above its base. Twelve specimens (OU 5014) are probably from SW¼ sec. 4, T. 2 N., R. 6 E.

Pisocrinus varus Strimple, new species
Plate 1, figure 11; text-figures 11c, 11e-l

The dorsal cup of *Pisocrinus varus* is rather high, with erect sides and a broad base. The base is marked by a wide, deep basal impression. Five unequal basals curve out of the basal concavity and are visible in side view of the cup. The smallest basal is left posterior in position, and the other small basal is anterior. Of the five radials two are unusually large (LPR and AR); the left anterior radial is the smallest, and the right posterior and right anterior radials are of about equal size. A low, wide plate occurs below RPR and RAR and is usually termed the radianal. Moore and Laudon (1943) termed the right posterior radial the superradianal, but I have found no practical use for such a designation. The interbrachial projections of the cup are spear-shaped and prominent. The articular facets are wide, and the arms are long and slender. The cup of the holotype is 17.0 mm wide and 5.4 mm high.

Remarks.—The granular surface is the most distinctive character of *P. varus*. It differs from *P. spatulatus* in the absence of the strong projection of the radial plates that is typical of that species. Associated *Ollulocrinus tennesseensis* is a smooth form, typically larger than *Pisocrinus varus*. *Ollulocrinus quinquelobus* is a smooth form with even the sutures almost obliterated and typically smaller than those in *Pisocrinus varus*. The arms of *Ollulocrinus quinquelobus* are shorter and more tumid than those in *Pisocrinus varus*.

The specific name comes from the Latin noun *varus,* meaning pimple (used in apposition).



Text-figure 11. Drawings of various species of *Ollulocrinus* and *Pisocrinus* from the Henryhouse Formation.

a. Summit view of *Ollulocrinus quinquelobus* (Bather), USNM 6267b, with first primibrachs preserved in two rays.
b. Natural cross section of *O. quinquelobus*, USNM 6248b.
c. Natural cross section of *Pisocrinus varus*, new species, USNM 6267a.
d. Natural cross section of *Ollulocrinus tennesseensis* (Roemer), USNM 6225a.
e. View from left anterior side of *Pisocrinus varus*, new species, USNM 6267a, showing primibrach preserved in anterior ray.
f. View from anterior side of *P. varus*, USNM 6243a, showing primibrach in place and indicating the granulose ornamentation of this species.
g-l. Holotype of *P. varus*, USNM 6258a, from left posterior, anterior, right posterior-anterior, basal (posterior interray up), summit (posterior interray down), and left anterior.

Types and occurrence.—All types and specimens are from the Henryhouse Formation in Tps. 2, 3 N., R. 6 E., Pontotoc County, Oklahoma. Holotype USNM 6258a (text-figs. 11g-11l) is from NW¼ SW¼ sec. 4, T. 2 N., R. 6 E. Also from the same location are USNM 6258 (6 specimens), USNM 6225 (3 specimens), USNM 6255 (63 specimens), OU 5017 (1 specimen, 30 to 50 feet below top of the Henryhouse), OU 5019 (3 specimens, 185 to 205 feet above base), OU 5018 (1 specimen, 177 to 185 feet above base). Figured paratype OU 4680 (pl. 1, fig. 11) is from the upper 25 feet of the Henryhouse Formation in the glade west of the road in NE¼ SE¼ sec. 32, T. 3 N., R. 6 E. Specimens from T. 2 N., R. 6 E., include OU 5015 (1 specimen) from glade south side of road in SE¼ SW¼ sec. 4 and OU 5016 (26 specimens) probably from SW¼ sec. 4. Specimens from T. 3 N., R. 6 E., are USNM 6243 (18 specimens) and USNM 6243a (1 specimen, text-fig. 11f) from C SW¼ NW¼ sec. 33; OU 5020 (1 specimen) from glade 1,000 feet east of road, NW¼ NW¼ sec. 33; and OU 5021 (12 specimens) from road outcrops 900 feet south of NW cor. sec. 33. Specimens for which exact locations are not known are:

Number of specimens	USNM number
19	6244
10	6240
1	6237
1	6267a (text-figs. 11c, 11e)
14	6267
4	6218
21	6241
12	6242
33	6244
19	6248
1	6262
9	6264

Genus *OLLULOCRINUS* Bouška, 1956

Genotype.—*Pisocrinus ollula* Angelin, 1878.

Synonymy.—*Pisocrinus* (part).

Range.—Silurian, Lower Devonian; North America, Europe, Australia.

Diagnosis.—(After Bouška.) Genus close to and related to the genus *Pisocrinus,* in which the lower margin of the plates AR, iRA (radianal), and LPR reach to the stem facet; the basal circlet is discoid and as wide at the stem facet, and has in many specimens indistinct interbasal sutures. Cup generally of pentalobate outline in ventral view.

Known species.—

	Occurrence
Ollulocrinus ollula ollula (Angelin), 1878	Middle Wenlockian and Lower Ludlovian; Gotland, Sweden Lower Ludlovian; Bohemia
Ollulocrinus ollula grandis Bouška, 1956	Middle Ludlovian, Lower Devonian; Bohemia
Ollulocrinus ollula elegans Bouška, 1956	Lower Devonian; Bohemia
Ollulocrinus ollula hlubocepensis Bouška, 1956	Lower Devonian; Bohemia
Ollulocrinus pribyli Bouška, 1956	Lower Ludlovian; Bohemia
Ollulocrinus quinquelobus (Bather), 1893	Upper Ludlovian; Bohemia Niagaran; North America
Ollulocrinus rinosus Bouška, 1956	Lower Devonian; Bohemia
Ollulocrinus sphericus (Rowley), 1904	Niagaran; North America
Ollulocrinus tennesseensis (Roemer), 1860	Niagaran; North America
Ollulocrinus yassensis (Etheridge), 1904	Silurian (probably Lower Ludlovian per Bouška); Australia
Ollulocrinus? cf. *yassensis* (Etheridge), 1904	Lower Ludlovian; Bohemia

*Remarks.—*In observing the pisocrinids of the Henryhouse Formation, one should keep in mind the tendency for the stem to be deeply impressed and for the proximal columnals to be preserved in place, thus giving the impression of a shallow basal concavity. In some specimens (e. g., *Ollulocrinus quinquelobus,* text-fig. 11b) a constriction of the cavity, just above the basal plane, causes some proximal columnals to be captive. I have proposed, under "Morphological Notes," that such captive columnals are like permanent segments and could be termed basilarids. In *Ollulocrinus* few sutures are preserved between basal plates so that one generally is not able to tell whether a columnal or the basal disk is being observed. To further complicate matters some proximal columnals are quite narrow and by no means fill the full width of the basal concavity. It has been necessary to observe a large number of specimens to obtain some understanding of these forms.

Fully developed *Ollulocrinus tennesseensis* has a high, erect, robust-appearing calyx, and typical *O. quinquelobus* has a low, lobate-appearing cup. Such forms are readily separable, but unfortunately there are intermediate forms. I am certain that some specimens I have considered to be large *O. quinquelobus* are in reality small *O. tennesseensis.*

Ollulocrinus tennesseensis (Roemer), 1860
Text-figure 11d

Ollulocrinus tennesseensis is a robust species with an erect, relatively high calyx, and typically the fairly deep, broad basal concavity has sharply delineated sides. Three interradial sutures enter the concavity, and in no specimen have I been able to distinguish sutures between basal plates. The basals form a round circlet entirely covered by the proximal columnal. Springer (1926) reported five basals confined to the bottom of the sharply defined basal concavity. I suspect that Oklahoma specimens have fused basals, as is typical of the genus.

The interradial areas in the upper part of the cup are not appreciably impressed; hence the species lacks the lobate appearance that is typical of associated *Ollulocrinus quinquelobus*. Many of the Oklahoma specimens of *O. tennesseensis* do not show the sharply defined sides of the basal concavity and have instead a rather gentle curvature into the cavity, which is normally rather narrow at the mouth. In many cases proximal columnals are captive in the basal concavity, as has been previously discussed under "Morphological Notes."

A large specimen, USNM 6255, is 11.0 mm wide and 9.0 mm high.

Specimens and occurrence.—All specimens but one (OU 5025, from NW¼ SE¼ sec. 25, T. 2 S., R. 1 E., Carter County) are from Pontotoc County, Oklahoma. All are from the Henryhouse Formation in the Lawrence uplift.

From NW¼ SW¼ sec. 4, T. 2 N., R. 6 E., have come USNM 6255 (23 specimens), USNM 6225 (13 specimens), USNM 6225a (1 specimen, text-fig. 11d), OU 5022 (3 specimens from 177 to 185 feet above base of Henryhouse), OU 5032, 5033 (4 specimens from 185 to 205 feet above base), and OU 5034 (2 specimens from 30 to 50 feet above base). From SE¼ SW¼ sec. 4, T. 2 N., R. 6 E., have come OU 5024 (3 specimens from south side of road) and

OU 5027-5030 (15 specimens from 15 to 20 feet above base, south and east of road). Fifteen specimens labeled OU 5023 are probably also from SW¼ section 4.

Section 33, T. 3 N., R. 6 E., has yielded the following specimens: USNM 6243 (3 specimens from SW¼ NW¼, 3 specimens from C NW¼ SW¼), OU 5026 (1 specimen from 900 feet south of NW cor.), and OU 5031 (1 specimen from glade 1,000 feet east of road in NW¼ NW¼).

Three specimens (OU 5035) are from a glade on the north side of Chimneyhill Creek in SE¼ NE¼ sec. 5, T. 2 N., R. 6 E. Other specimens for which exact localities are not available are:

Number of specimens	USNM number
4	6218
4	6241
6	6242
9	6248
1	6262
24	6267
13	6258

Ollulocrinus quinquelobus (Bather), 1926
Text-figures 11a, b

Typical representatives of *Ollulocrinus quinquelobus* are rather small specimens with pronounced lobation. It is difficult to distinguish the larger, more mature specimens from small specimens of *O. tennesseensis,* a fact noted under the discussion of that species. The cup has thick walls. The opening at the mouth of the basal cavity may be constricted so that proximal columnals are captive, as previously noted under "Morphological Notes."

Specimens.—All specimens for which localities are known are from Pontotoc County, Oklahoma. Specimens from NW¼ SW¼ sec. 4, T. 2 N., R. 6 E., include USNM 6225 (8 specimens), USNM 6255 (73 specimens), OU 5038 (8 specimens from 185 to 205 feet above base of Henryhouse), OU 5039, 5040 (3 specimens from 177 to 185 feet above base), and OU 5042 (1 specimen from 30 to 60 feet below top on north side of Chimneyhill Creek). Other specimens from section 4 are OU 5036 (54 specimens probably from SW¼) and OU 5041 (2 specimens from 15 to 20 feet above base in glade south and east of road). Ten specimens (OU 5037) have come from road outcrops 900 feet south of NW cor., sec. 33, T. 3 N., R. 6 E.

Specimens for which exact localities are not available are:

Number of specimens	USNM number
2	6217
29	6218
8	6242
30	6243
1	6267b (text-fig. 11a)
45	6267
18	6258
97	6244
29	6248
1	6248a
1	6248b (text-fig. 11b)
2	6262
8	6264

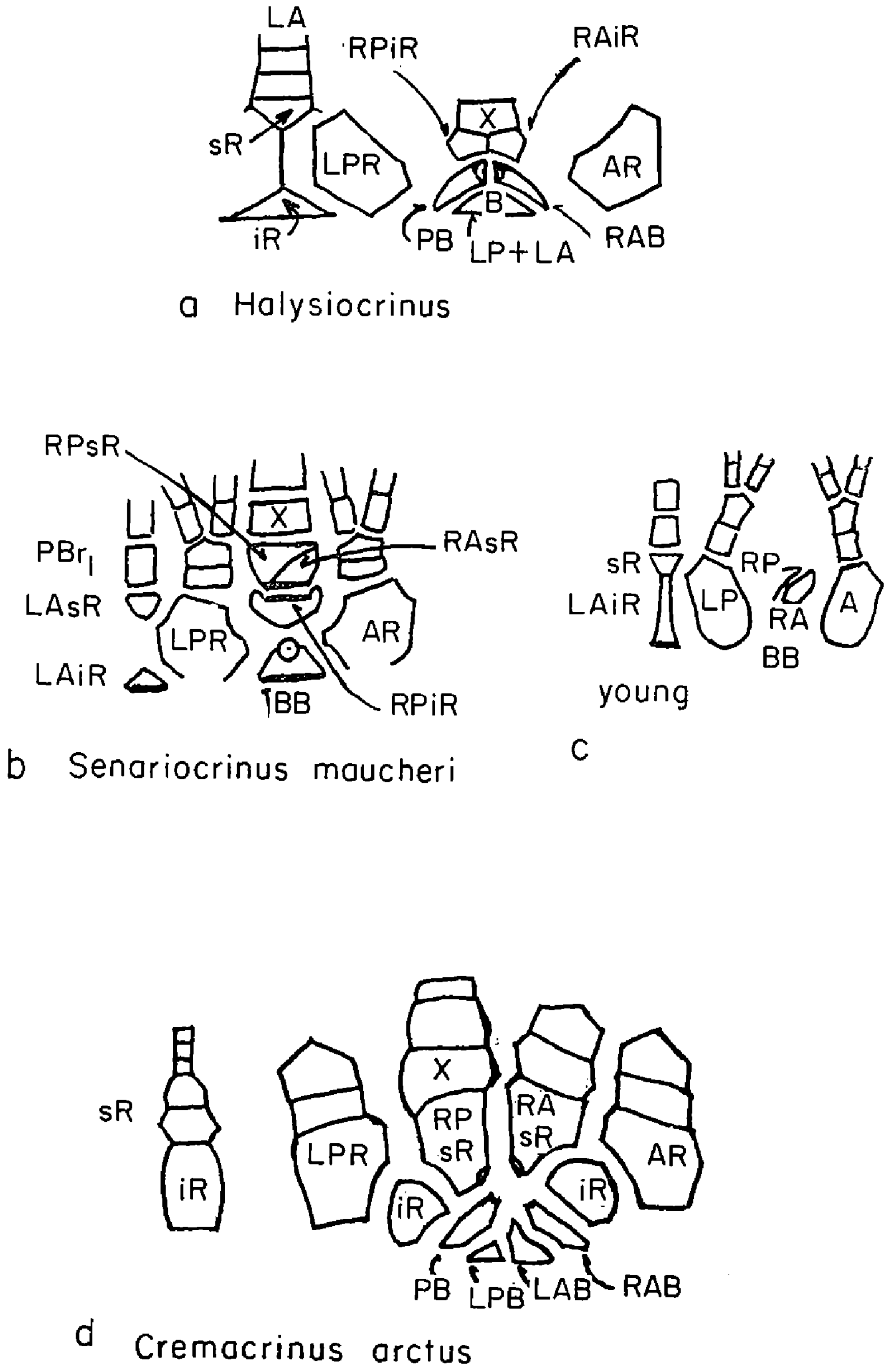
Family CALCEOCRINIDAE Meek and Worthen

Range.—Ordovician to Mississippian.

Diagnosis.—(After Moore and Laudon, 1944.) Monocylic; crown bent on stem; three or four basals, connected by muscular articulation with radials: LPR and AR simple, other radials compound; anal tube on side toward stem; arms uniserial, that on LAR unbranched, others branched.

Modification of the above diagnosis is required in respect to the arm of the left anterior, which is reported to be unbranched. It is normally unbranched and, in specimens in which it is branched, the bifurcation is at a considerable distance above the cup. A bifurcation takes place with the third primibrach in the holotype of *Calceocrinus humilis,* new species, and similar branching has been observed elsewhere. *Anulocrinus thraivensis* Ramsbottom, 1960, branches with the sixth primibrach in the left anterior ray and has an additional bifurcation above.

Genera.—*Cremacrinus* Ulrich, 1886 (syn. *Gastocrinus* Ringueberg); *Deltacrinus* Ulrich, 1886; *Calceocrinus* Hall, 1852 (syn. *Eucheirocrinus* Meek and Worthen, 1869, *Cheirocrinus* Hall, 1860, *non* Eichwald, 1856, *non* Salter, 1859, *Proclivocrinus* Ringueberg, 1889, *Euchirocrinus* Bather, 1893, *Cheirocrinus* Salter, 1859);*Chirocrinus* Angelin, 1878; *Synchirocrinus* Jaekel, 1918; *Halysiocrinus*



Text-figure 12. Diagrammatic drawings of *Halysiocrinus*, *Senariocrinus*, and *Cremacrinus*.

a. *Halysiocrinus* (modified after Springer).
b. *Senariocrinus maucheri* Schmidt (modified after Schmidt).
c. Specimen of a young individual.
d. *Cremacrinus arctus* Sardeson (modified after Sardeson).

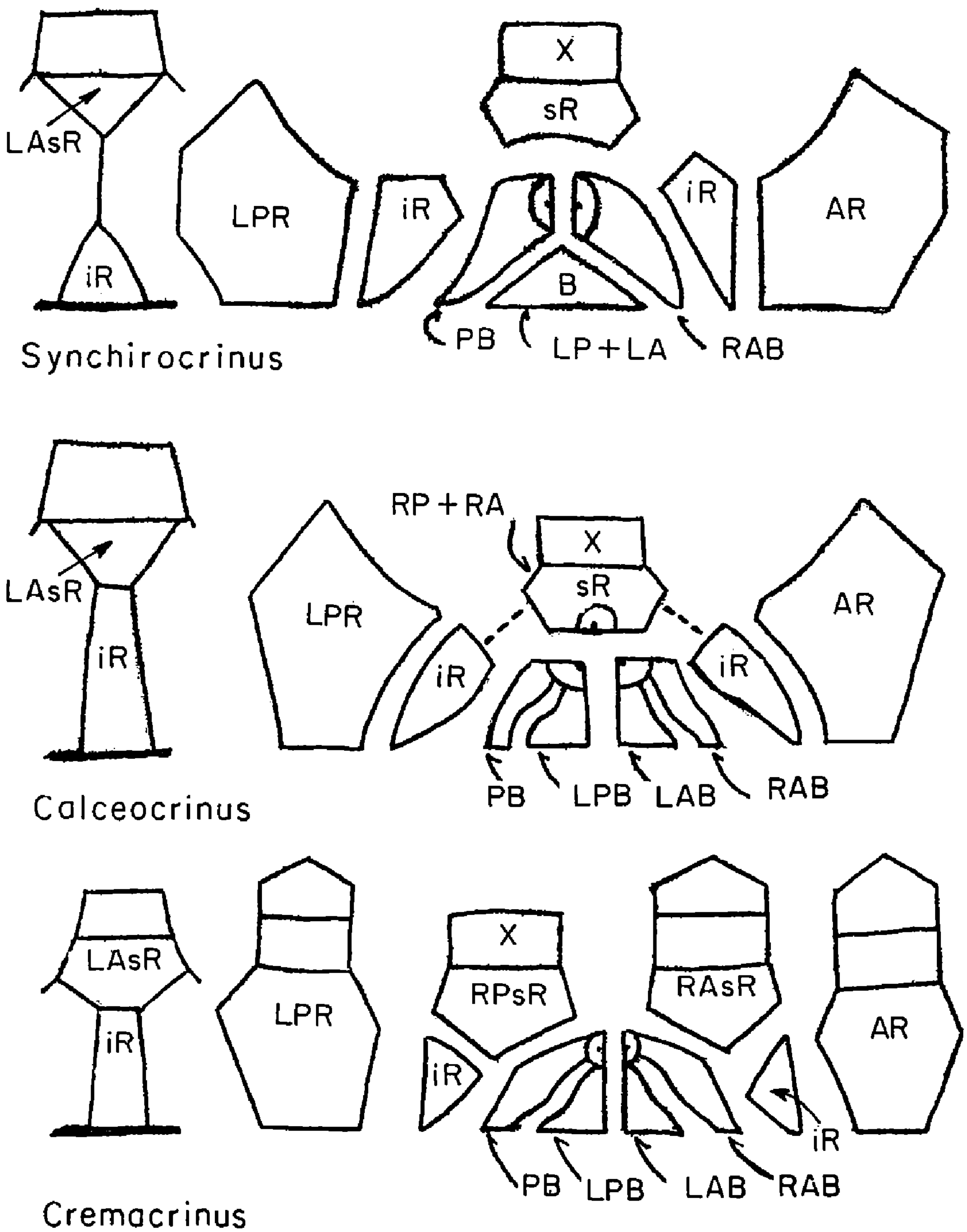
Ulrich, 1886; *Senariocrinus* Schmidt, 1934; *Grypocrinus* Strimple, new genus; *Anulocrinus* Ramsbottom, 1960.

Remarks.—This highly specialized family is so different from other forms of crinoids that specialized terminology and orientation are required. Springer (1926, p. 88-104, text-figs. 1, 2) gave a comprehensive account of the various developments, terminology, morphology, and modifications. The only abbreviation used by Springer that might be confused in modern terminology is IBr for primibrach (current usage is PBr).

I am avoiding needless repetition of all the details. The crown is to be viewed from the conspicuous median arm (left anterior), and, although the designation of the arm group to the left is anterior and to the right is left posterior (their original conventional position), the direction is given from the median arm outward and around toward the anal side. For arms of the anterior ray from median arm stemward, the terms "adanal," "outer" or "left' may be used, whereas those that lie toward the median arm, away from the stem and anal side, may be termed "abanal," "inner," or "right." In description of arms on the opposite side (left posterior) the right and left directions are reversed.

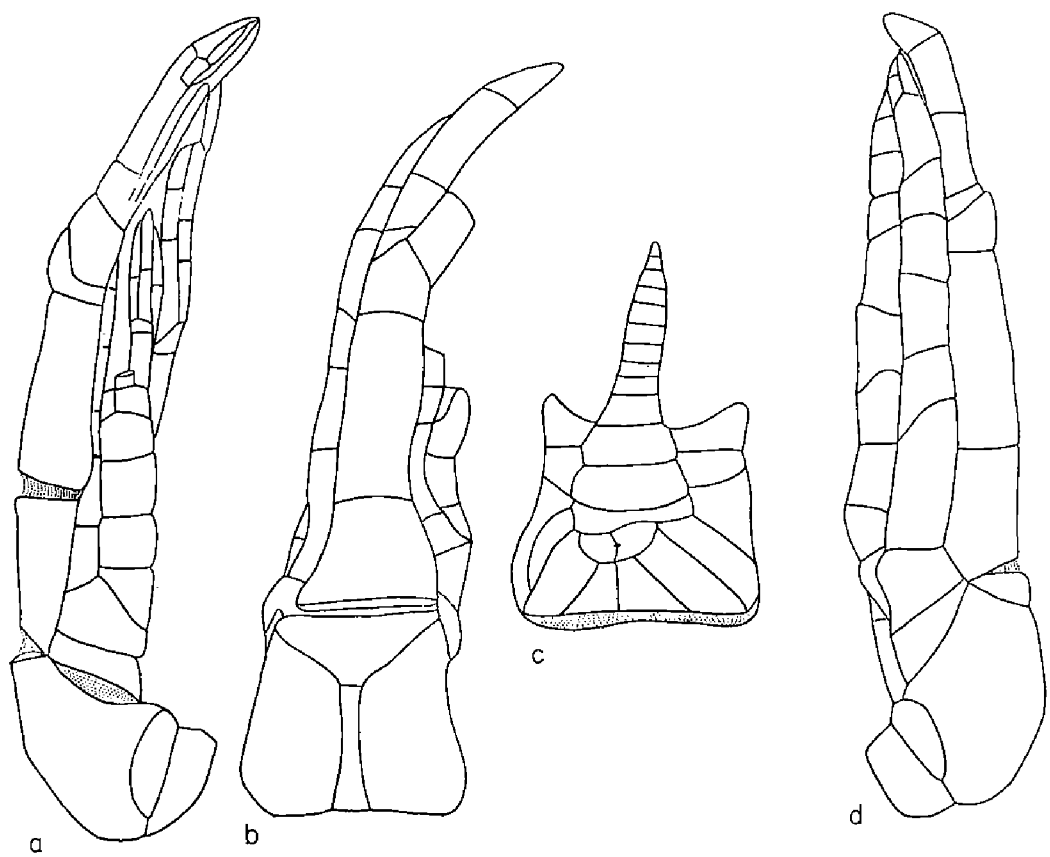
In *Cremacrinus* equal arms are developed from symmetrical PBrBr. Unsymmetrical PBrBr produce unequal rami in some forms (Springer, 1926, text-fig. 2a, for *Chirocrinus gotlandicus*). This unequal trend terminates in a condition of the arms called the axil-arm system. The axile arms are borne on the outer and shorter faces of the main axils and are composed of brachials in series of two or more each, termed by Springer "alphabrachs," "betabrachs," "gammabrachs," et cetera. The upper alphabrach is an axillary and its inner articulating facet bears a ramule, although it is rarely seen. Betabrachs then alternate, with the upper one axillary and its inner articulating facet out (visible side) to carry the third series of brachials, with its outer facet (inward side) carrying an unbranched ramule that is not visible when the arms are closed and in place. According to Springer (1926, p. 93) the condition continues—a ramule, then a continuation of the main arm, until the latter terminates with an equal bifurcation. It appears to me that the condition can and does terminate without an open, equal bifurcation in some instances. *Synchirocrinus divisus,* new species, lacks equal division of the main arms. In fact there is no visible division of the three rays, although the axile arms are present and at least three bifurcations have taken place.

In modification from *Cremacrinus* to *Calceocrinus* and *Synchirocrinus* the right anterior superradial, together with its arms, has been completely eliminated. It does not seem unreasonable to suppose that the complementary right posterior superradial could



Text-figure 13. Diagrammatic sketches of *Synchirocrinus*, *Calceocrinus*, and *Cremacrinus* (modified after Springer).

have been eliminated at the same time, even though the anal tube has been retained. The anal tube has moved to a true median position, and in both rays the inferradials have remained, albeit at this point they are more or less component parts of the large anterior radial and left posterior radial. The inferradials (right posterior and right anterior) adjoin a single plate above. The plate is directly below the anal X. The plate below anal X is considered by Springer (1926) as a subanal but is termed the superradianal by Moore and Laudon (1943). In other words, Springer did not appear to consider the "subanal" to be a modified superradial, but rather a modified anal-tube plate. The plate is the result of a fusion of the RPsR and RAsR and is therefore just a superradial, captured by the anal system. In many of the Disparata Moore and Laudon (1943) considered the RPR to be radianal by virtue of its connection with the tube. It will be difficult to find specimens showing the upper articulating facet of this particular plate. In one specimen of



Text-figure 14. *Calceocrinus humilis*, new species, holotype OU 4704.
a. View from left posterior.
b. View from left anterior.
c. Anal view.
d. View from anterior.

Grypocrinus genuinus, new genus, new species, the plate is preserved and shows a typical articular facet of a radial plate; i. e., two large muscle areas, a transverse ridge, intermuscular notch and furrow. *Grypocrinus* is an unusual intermediate form between *Calceocrinus* and *Synchirocrinus* (part), and there is no assurance that the condition would exist in either of those genera. The plate is replaced by the right posterior and right anterior inferradials in *Halysiocrinus.* It would be interesting to know whether the plate considered to be X in *Halysiocrinus* retains any characters of a radial plate. In *Senariocrinus,* a single basal plate is left in the position of the fused left posterior and left anterior basals of *Halysiocrinus* but differs from that genus in having the columnar attachment in midportion. Both posterior basal and right anterior basal appear to be absorbed in *Senariocrinus.* A plate termed right posterior inferradial is in direct posterior position (probably the right posterior and right anterior fused plate of *Calceocrinus* and *Synchirocrinus*), and above it Schmidt (1934) showed a compound plate with diagonal suture, which he considered to be the right posterior and right anterior superradials. This compound plate is also preserved in the young specimen. The anal X is therefore the third plate above the point of columnar attachment in this form.

A somewhat analogous condition exists in the base of the large median arm of the left anterior ray. In *Calceocrinus,* the left anterior superradial and inferradial plates are in contact. Examination of the upper articulating facet of the superradial of *C. humilis,* new species, has disclosed the true radial nature of the plate. The facet has a transverse ridge, two wide muscle fields, and a deep intermuscular notch. A form that has a small rudimentary piece homologous to a superradial and in contact with the inferradial in left anterior is described herein as *Grypocrinus,* new genus. It differs from *Calceocrinus* in that the primibrach has become a definite part of the calyx. In one specimen (USNM 6232) of *Grypocrinus genuinus,* the primibrach is missing and the upper face of the small triangular "superradial" is almost smooth without so much as a notch at its inner edge (pl. 2, fig. 9). It is obvious that the small triangular plate was in the process of being resorbed and that the remaining upper plate would, in the evolutionary process, become the equivalent of a superradial, although it is a primibrach. In most species of *Synchirocrinus* and subsequently developed genera the left anterior superradial has lost contact with the inferradial. Examination of the upper facet of the left anterior superradial of a specimen of *Synchirocrinus quadratus,* new species, disclosed that it has an almost plane surface such as would be expected in a brachial plate. This species is thought to be a derivative of *Grypocrinus* and very likely the "superradial" is a primibrach. Conversely, a calyx of *Synchirocrinus divisus* has the divided inferradial and superradial of the left anterior, and the upper facet of the superradial has all of the muscular fields, transverse ridge, and other features of a normal radial plate.

At least two phyletic lines are disclosed by the material discussed above. In the one line (*Calceocrinus-Grypocrinus-Synchirocrinus* [part]) the first primibrach of the left anterior arm has become a part of the cup, the true superradial plate has been absorbed (and ceased to function as a radial plate prior to disappearance). It may or may not be significant that *Grypocrinus* and *Synchirocrinus quadratus* (which reflect the trend) are ornate forms, covered by granules and/or small nodes. The other line of development is shown by *Calceocrinus,* with inferradial and superradial plates in contact, and *Synchirocrinus* (part), e. g., *S. divisus,* with inferradial and superradial separated but the upper facet of superradial showing normal muscular fossae for a radial plate. As these are the only forms available to me at this time, I am unable to pursue these comparisons further.

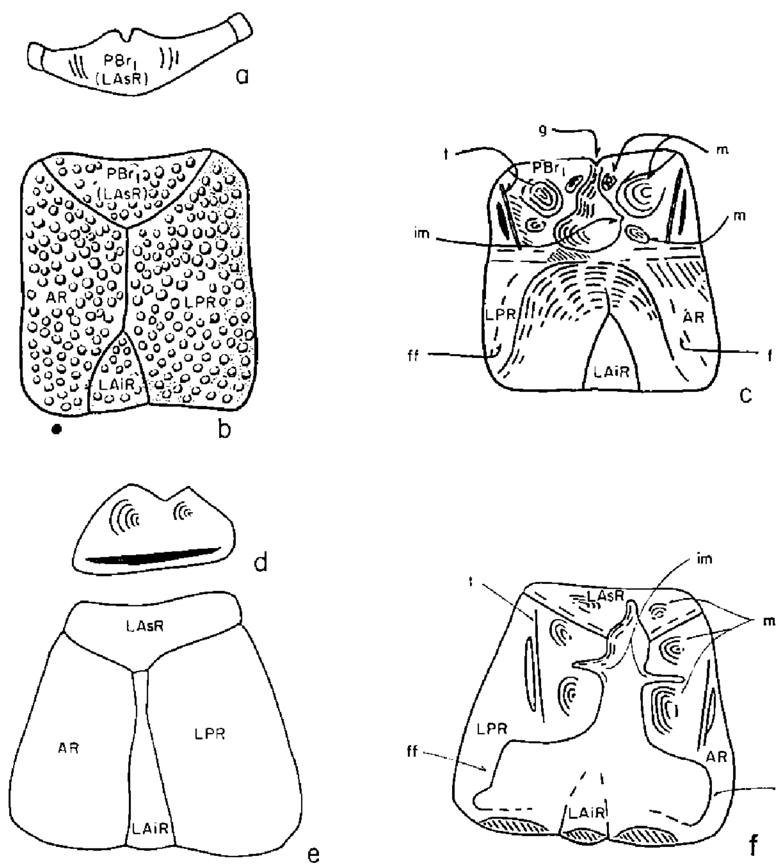
It is disturbing to note that a young specimen of *Senariocrinus maucheri* Schmidt has the long inferradial in contact with its superradial in the left anterior ray, yet in mature specimens the two plates are entirely separate. I have illustrated two specimens (after Schmidt) as sketches to demonstrate the above ontogenetic change and to show the advanced nature of this Devonian form.

Genus *SYNCHIROCRINUS* Jaekel, 1918

Synchirocrinus divisus Strimple, new species
Plate 2, figures 1-4; text-figure 16d

The dorsal cup of *Synchirocrinus divisus* has a divided compound radial in the left anterior radius. The inferradial is a small triangular piece on the hinge line and the superradial is a large, pentagonal plate at the top of the cup. A large AR is to the left and an LPR of equal size is to the right. On the anal side, the inferradials of the RPR and RAR are fairly large and assist in supporting the first primibrachs of the AR and LPR. The single plate which is the remnant of the superradials of the RPR and RAR is wide with each lateral side in contact with two brachials, the upper facet in broad contact with X and the lower facet in contact with the inferradials of the RPR and RAR. The columnar attachment does not affect the broad plate below X. Three basals are present, two of which adjoin the columnar attachment and the other forms a wide triangle with the hinge line as the lower edge.

The large arm of the left anterior radial has ten primibrachs preserved and has a more or less triangular outer surface. To the left in the anterior radius are eight axile arms. They bow out and



Text-figure 15. Drawings of *Synchirocrinus quadratus* and *Calceocrinus humilis* made with aid of camera lucida.

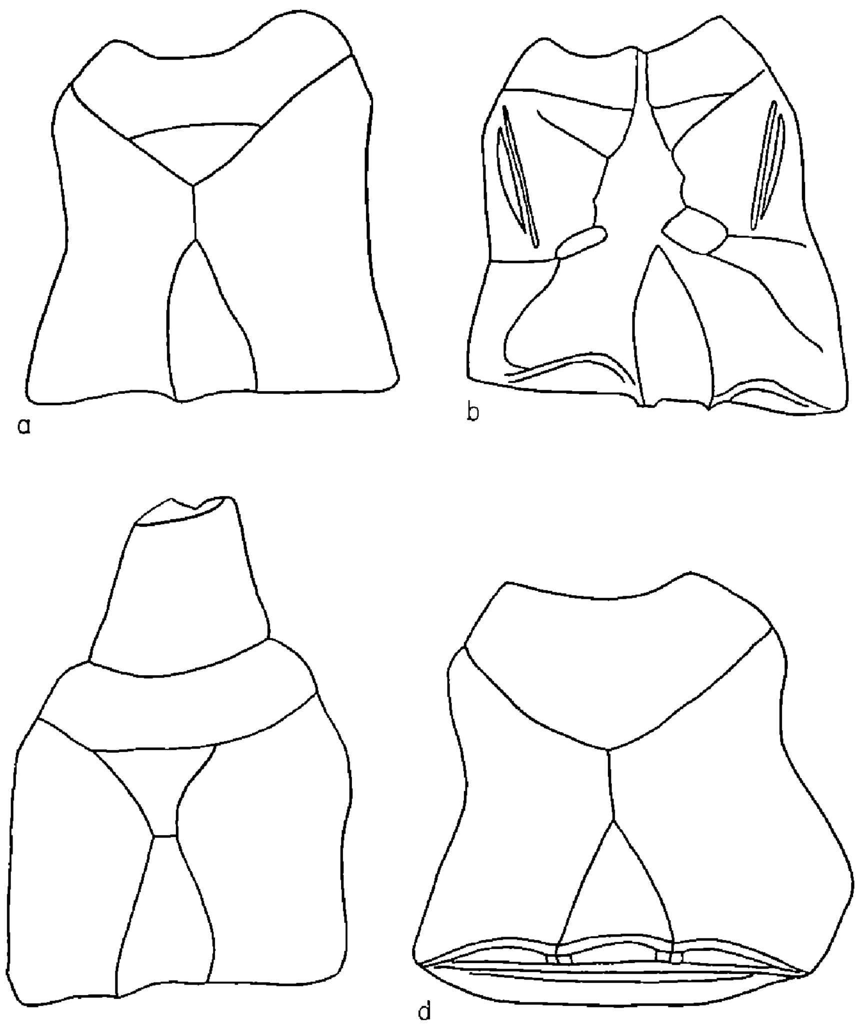
a-c. *Synchirocrinus quadratus,* new species, holotype OU 4602f. View of articular facet of PBr_1 (LAsR), view of cup from left anterior, and opposite (anal) view.

d-f. *Calceocrinus humilis,* new species, paratype OU 4602d. View of articular facet of LAsR, view of cup from left anterior, and opposite (anal) view; m, muscle scars; im, intermuscular notch; g, ambulacral groove; t, transverse ridge; f and ff, facets for reception of inferradials.

around, meeting the seven axile arms which curve to the right in the left posterior radius, at the apex of X. The arms are large toward the median ray and diminish considerably adanally. Oblique sutures indicate a series of at least three unequal arms which would be termed alphabrachs, betabrachs, and gammabrachs, as previously noted under the discussion of the Calceocrinidae.

Measurements in millimeters.

	Holotype
Length of crown (as preserved)	52.2
Width of crown (maximum)	12.3
Width of cup (maximum)	11.1
Length of cup (maximum)	12.3



Text-figure 16. Drawings of *Grypocrinus* and *Synchirocrinus* made with aid of a camera lucida.

a, b. Holotype OU 4602e of *Grypocrinus genuinus*, new species. Views from left anterior and from anal side.
c. Paratype of *G. genuinus* OU 4602b. View from left anterior.
d. Holotype OU 4692 of *Synchirocrinus divisus*, new species. Cup from left anterior.

Remarks.—This species is closely comparable to *Synchirocrinus bassleri* (Springer) from the Brownsport Formation of Tennessee. The Tennessee species has more arms, and one anal plate is exposed above the anal X. The holotype is from the same exposure that produced the holotype of *Lecanocrinus brevis* Strimple and *Euspirocrinus cirratus,* new species.

The specific name is the Latin noun *divisus* (used in apposition) meaning a division.

Types and occurrence.—Holotype OU 4692 (crown collected by Melba L. Strimple) is from NW¼ SW¼ sec. 4, T. 2 N., R. 6 E. Paratypes OU 4602f (two specimens collected by Allen Graffham) are from the bench above the stream at C sec. 10, T. 2 N., R. 6 E. All specimens are from the Henryhouse Formation, Pontotoc County, Oklahoma.

Synchirocrinus quadratus Strimple, new species
Plate 2, figures 5, 6; text-figures 15a-c

Synchirocrinus quadratus is represented by rather small, narrow dorsal cups having quadrangular outlines and heavily granular surfaces. Close examination of the upper facet of the plate that is similar to a superradial of the left anterior radius discloses that it is a brachial plate rather than a radial plate. It is not in contact with the inferradial plate. A large anterior radial is to the left and a left posterior radial is to the right. On the anal side, the lower body cavity is proportionately longer than that in associated *S. divisus* or in *Grypocrinus genuinus.* The articular facets of AR and LPR are not as wide as in those species.

Measurements in millimeters.

	Holotype
Length of cup	6.5
Width of cup	6.2

Remarks.—The interrelationship with *Grypocrinus genuinus* is discussed under remarks for the family.

The name of the species is the Latin adjective *quadratus,* meaning square, quadrate.

Types and occurrence.—Holotype OU 4602f and paratypes 4602a (two specimens) are from the Henryhouse Formation from the bench above the stream at C sec. 10, T. 2 N., R. 6 E., Pontotoc County, Oklahoma.

Genus *CALCEOCRINUS* Hall, 1852

Calceocrinus humilis Strimple, new species

Plate 1, figures 12-14; text-figures 14a-d, 15d-f

The dorsal cup of *Calceocrinus humilis* has the normal components of the genus. The left anterior radius is the dominant side and has the compound LAR in midsection with a long slender inferradial in contact with a broad superradial. A large anterior radial is to the left and a large left posterior radial is to the right. On the anal side, toward the hinge line, are narrow facets for the reception of a small inferradial plate on each side. Toward the upper end are broad facets for the reception of primibrachial plates. A transverse ridge, outer ligament furrow, and two large muscle areas, separated by long intermuscular furrows, are well defined. The upper facet of the left anterior superradial has the same type of articulating facet. Four basals are on the anal side of the cup, along the hinge line and in contact with the columnar attachment. The superradials of the right posterior and right anterior are missing but a single plate is present (subanal of Springer and others) that I believe is a remnant of the fusion of those two plates. The next plate above is considered to be anal X, above which, in the holotype, are eleven plates in a series.

Arms are borne in the anterior, left posterior, and left anterior rays. The largest is the left anterior, wherein are three primibrachs followed by three secundibrachs in the left ray, with only one secundibrach preserved in the right ray. In side view, ramules are visible in the upper portion of the arms on the inner side. Bifurcation is with the second secundibrach in the left posterior ray. The left arm is obscured in preservation past the fourth secundibrach. In the right arm is another branching with the fourth secundibrach. The resultant left arm is not preserved above the first tertibrach, and in the right ray the first tertibrach is axillary. Another bifurcation takes place with the second quartibrach, and the arms are more like ramules at this stage. A bifurcation occurs with the second primibrach in the anterior ray. Another branching takes place with the sixth secundibrach in the right ray, and the arms terminate with the first or second tertibrach. In the left ray a bifurcation takes place with the fifth secundibrach. About five tertibrachs are preserved in the resultant right ray. In the left ray another branching occurs with the second tertibrach, and again the arms are more like ramules.

Nine columnals are preserved in paratype OU 4711. They are rather large and round, and the midsection is marked by a keel.

Measurements in millimeters.

	Holotype
Length of crown	21.0
Length of cup (maximum)	5.8
Width of cup and/or crown (maximum)	5.7

Remarks.—*Calceocrinus humilis* is more comparable to *C. ontario* than to other described species. The English species *C. anglicus* Springer (1926) has numerous bifurcations of the left anterior arm, the first bifurcation taking place with the first primibrach. Only the one branching occurs in *C. humilis*, and it is well above the cup.

The specific name is the Latin adjective *humilis,* meaning low.

Types and occurrence.—Holotype OU 4704 (crown) and paratype 4602d are from the Henryhouse Formation from the bench above the stream at C. sec. 10, T. 2 N., R. 6 E., Pontotoc County, Oklahoma.

Genus *GRYPOCRINUS* Strimple, new genus

Genotype.—*Grypocrinus genuinus* Strimple, new species.

Range.—Silurian; North America.

Diagnosis.—As stated under discussion of the family Calceocrinidae, the genus *Grypocrinus* is an intermediate form between *Calceocrinus and Synchirocrinus* (part). In *Grypocrinus genuinus* the superradial plate has become a captive element, well on its way toward complete absorption, with the first primibrach becoming a cup element. In at least one species of *Synchirocrinus* (*S. quadratus*), the plate in position of the superradial is in reality a brachial plate.

The generic name *Grypocrinus* is derived from the Greek term *grypos,* meaning hook-nosed.

Grypocrinus genuinus Strimple, new species

Plate 2, figures 7-9; text-figures 16a-c

Grypocrinus genuinus is known only from dorsal cups; the arms, other than the first two segments of the left anterior ray, are unknown. As previously noted, the superradial of the left anterior is a small triangular piece which may or may not be in contact with the inferradial. A large, wide primibrach is a component of the dorsal cup in the position normally occupied by the superradial plate in this family. A robust second primibrach is present in two specimens. A large AR is to the left and a large LPR is to the right. On the anal side, the plate below anal X (subanal of Springer and others) is preserved in some paratypes and has an upper facet comparable to the structure of the articulating facets of the radial plates. This is not surprising when one considers that the plate is a fused remnant of the right posterior and right anterior superradials. The inferradials of the right posterior and left anterior are preserved in two paratypes and occupy the same position as those of *Calceocrinus*.

The entire surface of this species is ornamented by granules and in some specimens by nodes.

Measurements in millimeters.

	Holotype
Width of cup (maximum)	9.8
Length of cup	10.0

Remarks.—This species is more comparable to *Synchirocrinus quadratus* than to other described species. The latter has absorbed the small superradial plate found in *Grypocrinus genuinus*.

The specific name is the Latin adjective *genuinus*, meaning innate, natural.

Types and occurrence.—Holotype 4602e and paratypes OU 4602b and OU 4602c are from the bench above the stream at C sec. 10, T. 2 N., R. 6 E. Paratype USNM 6232 is from SW¼ NW¼ NW¼ sec. 33, T. 3 N., R. 6 E. All are from the Henryhouse Formation in Pontotoc County, Oklahoma.

Family ZOPHOCRINIDAE S. A. Miller

Genus *ZOPHOCRINUS* S. A. Miller, 1892

Zophocrinus angulatus Strimple, 1952

Currently observed specimens of *Zophocrinus angulatus* have afforded no additional information concerning this twisted, unique crinoid. I had had hopes of finding arm-articulating facets but was not successful.

Types and occurrence.—Holotype USNM S 4787, paratype USNM S 4739, and metatypes USNM 6243c, USNM 6218, USNM 6242, and OU 4681 are from the Henryhouse Formation near C SW¼ NW¼ sec. 33, T. 3 N., R. 6 E., Pontotoc County, Oklahoma.

Genus *PARAZOPHOCRINUS* Strimple, new genus

Genotype.—*Parazophocrinus callosus* Strimple, new species.

Range.—Silurian; North America.

Diagnosis.—Dorsal cup conical, composed of two circlets of plates which are five basals and five radials; no provision for anal plate; no provision for arm attachments; polygonal tegmen plates and five large oral plates forming an oral pyramid; round stem.

Remarks.—The genus *Zophocrinus* is apparently closely related; however, it has three basals, four radials, and five orals with no other tegmen plates. *Z. howardi,* the genotype of *Zophocrinus,* has multiple, thin brachial plates, several to each radial. Brachials have not been observed in *Z. angulatus,* and no provision for their attachment has been noted. Relationship with *Parazophocrinus* is indicated by the common existence of oral plates, the obscure nature of arm-articulating facets, and the upflared basal plates. *Parazophocrinus* is more primitive in having five basals and five radials. Possible affinity with *Platycrinites* has not been ruled out; however, that genus has only three basals, has well-defined narrow arm-articulating facets, and the five orals are obscure elements among the irregular polygonal tegmen plates.

The generic name *Parazophocrinus* is a combination of the Greek prefix *para* and the generic name *Zophocrinus.*

Parazophocrinus callosus Strimple, new species
Plate 2, figures 10, 11

The dorsal cup of *Parazophocrinus callosus* is composed of two circlets of plates and was conical although the specimens, as preserved, are horizontally compressed. Viewed from above or below, the outline of the cup forms a nearly perfect circle, with no interruptions for indentations at sutures or arm attachments. It has no anal plates. The five basals are elongate, narrow at the base and wide at the summit. The five radials are large plates. Although arrangement for attachment with other plates is lacking, the paratype shows that the form has an oral pyramid composed of numerous polygonal tegmen plates, as well as five large orals. All calyx plates are paper-thin. The column is round.

The holotype, as preserved, is 29.4 mm wide and about 2.7 mm high. The diameter of the stem is 2.5 mm. A radial is 9.3 mm long and is 16.6 mm at maximum width. A basal plate is 5.0 mm long and is 5.9 mm at maximum width.

The specific name is the Latin noun *callosus* (used in apposition), meaning hard skin.

Types and occurrence.—Holotype USNM 6224 is from NW¼ SW¼ sec. 4, T. 2 N., R. 6 E. Paratype USNM 6212a is from SW¼ NW¼ NW¼ sec. 33, T. 3 N., R. 6 E. Both are from the Henryhouse Formation, Pontotoc County, Oklahoma.

Order CLADOIDEA Moore and Laudon

Suborder DENDROCRINOIDEA S. A. Miller

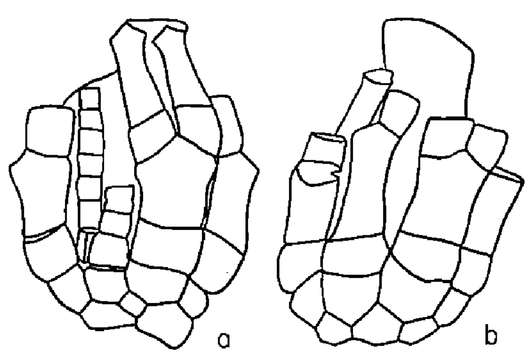
Family DENDROCRINIDAE S. A. Miller

Genus *BACTROCRINITES* Schnur, 1853

Bactrocrinites oklahomaensis Strimple, 1952

Two hypotypes of *Bactrocrinites oklahomaensis* have failed to disclose any additional information.

Types and occurrence.—Holotype USNM S 4788 is from NW¼



Text-figure 17. Camera lucida drawings of the holotype USNM 6260a of *Botryocrinus parcus*, new species.

a. Posterior view of crown.
b. Anterior view.

NW¼ SW¼ sec. 4, T. 3 N., R. 6 E. Hypotypes USNM 6221a and 6237 are from near C SW¼ NW¼ sec. 33, T. 3 N., R. 6 E. All are from the Henryhouse Formation, Pontotoc County, Oklahoma.

Family BOTRYOCRINIDAE Bather

Genus *BOTRYOCRINUS* Angelin, 1878

Botryocrinus parcus Strimple, new species

Text-figure 17a-b

The monotype of *Botryocrinus parcus* is a small crown, with the infrabasal plates missing. The dorsal cup is conical and is probably relatively low. The low nature of the infrabasals is inferred from the short basal plates. Five basals are wide and hexagonal except in the posterior and right posterior where they are affected by the RA and X. Five radials are pentagonal and are the largest plates in the cup. The articular facets do not fill the full width of the plates. A small quadrangular RA is placed obliquely on the left shoulder of the right posterior basal and the right shoulder of the posterior basal, with a relatively large X to the left above, resting solidly upon the posterior basal. A small plate is in contact with the left upper shoulder of X but is considered to be a tube plate. The upper facet of X is below the summit of the cup. Two rows of tube plates are visible. First primibrachs are low, wide, quadrangular elements. Second primibrachs are elongate, medially constricted, and axillary in all rays. The left posterior is slightly larger than others except the anterior which is almost half again as long, but is a narrower plate than the others. The average length of the axillary second primibrachs is 2.18 mm. Axillary secundibrachs are preserved only in the right posterior ray.

A short, quadrangular plate is followed by an elongate, medially constricted axillary secundibrach with equal facets above for reception of tertibrachs.

The crown, as preserved, has a length of 8.6 mm and a maximum width of 6.2 mm. The cup has an average width of 3.5 mm.

Remarks.—This is an ultrasimplified type of crinoid and therefore difficult to place taxonomically. The genotype, *Botryocrinus ramisissimus* Angelin, 1878, is a Silurian crinoid from Gotland and has a smooth calyx unmarked by the ridges and depressions at angles of the plates that become prevalent in many Devonian species, particularly in those from Germany. The genus is characterized by arms that develop ramules, which in turn develop smaller ramules or pinnules. In *B. ramisissimus,* a full bifurcation takes place on or after the fourth primibrach, with the first ramule appearing with the third or a later secundibrach. One would expect fewer primibrachs in younger species; however, with but a few exceptions, the Devonian forms branch even farther from the dorsal cup.

In general appearance, *B. parcus* is close to *Cyathocrinus wilsoni* Springer, 1926, from the Laurel Limestone at St. Paul, Indiana; however, some differences in generic characters prevent serious comparison. One primary character involved is the presence of both RA and X in the posterior interradius of the cup of *Botryocrinus,* whereas only X remains in *Cyathocrinus.* The species most comparable to *Botryocrinus parcus* appears to be *B. concinnus* Goldring, 1923, in which normally the first bifurcation is on the second but may be on the third primibrach and in which the first ramule is on the fourth or fifth secundibrach. The articular facets of the radials are rather wide. The monotype of *B. parcus* has axillary secundibrachs preserved in the right posterior. It has two secundibrachs, the second of which is elongate and axillary. The equal upper facets of each axillary secundibrach indicate the development of two arms rather than a continuation of the arm and a ramule, a condition typical of *Botryocrinus.*

It may be that more completely preserved specimens will provide a better comparative basis for *B. parcus.* Some affinity is probable with *B. tenuidactylus* Springer, 1926, from the Brownsport Formation of Tennessee, but that species is known only from a group of arms. As noted above, it appears that the arms of *B. parcus* bifurcate as arms rather than as arms and ramules with the latter developing even smaller ramules or pinnules. The latter condition is that found in *B. tenuidactylus.*

The specific name is the Latin adjective *parcus,* meaning scanty, small.

Holotype and occurrence.—Holotype USNM 6260a is from the Henryhouse Formation in NE¼ SE¼ sec. 32, T. 3 N., R. 6 E., Pontotoc County, Oklahoma.

Suborder CYATHOCRINOIDEA Bather

Family AMPHERISTOCRINIDAE S. A. Miller

Genus *EUSPIROCRINUS* Angelin, 1878

Euspirocrinus cirratus Strimple, new species

Plate 3, figures 1-4

Euspirocrinus cirratus has a small, conical dorsal cup. Infrabasals extend slightly beyond columnar attachment and are apparently fused. The structure of the proximal edges of basal plates implies only three infrabasals. Five small basals and five large radials are present. The lateral sides of the radials are impressed in a broad V-shape, except for the posterior interradius. First primibrachs do not fill upper facets of radials but no IR plates are present unless the small plates at the lateral sides of the three regular anal plates could be so termed. The small plate to the right of RX is the best preserved. The anal plates proper are mildly protuberant; RA is quadrangular and of moderate size; X is slightly larger than RA; and RX is the largest of the three. A series of tube plates continues upward and disappears under the arms. First primibrachs are quadrangular and are wider than long; second primibrachs are low, pentagonal, and axillary. Normally another even bifurcation occurs with about the fourth or fifth secundibrach. The next branching is not in all cases at the same height in various rays, but such a bifurcation appears to be in each ray. One more bifurcation is indicated by a few isolated instances. Apparently each ray has a minimum of eight rays to an arm, or a total of forty arms. The crown expands to a broadly turbinate shape; then the arms coil back upon themselves. I have been able to distinguish three complete convolutions of a ray after it disappears into the central area of the crown.

Measurements in millimeters.

	Holotype
Heigth of crown	20.0
Width of crown (as preserved)	28.5
Height of cup	5.0
Width of cup (maximum)	9.6

Remarks.—The only closely comparable species appears to be *Euspirocrinus spiralis* Angelin, 1878. In that species the bifurcation of the arms is uneven above the first dichotomy, the brachials are shorter and wider, and there appear to be fewer rays.

The cup of the holotype, with a large portion of the arms attached, was found by Melba Strimple, and a large segment of the arms was found nearby by the author. About a fourth of the arms is still missing. This is the same exposure that yielded the holotype crown of *Lecanocrinus brevis,* the crown of *Synchirocrinus divisus,* and the crown of *Asaphocrinus densus.*

The specific name is the Latin adjective *cirratus,* meaning fringed, curly.

Holotype and occurrence.—Holotype OU 4693 is from the Henryhouse Formation in NW¼ SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma.

Family PALAEOCRINIDAE Bather

Genus *THALAMOCRINUS* Miller and Gurley, 1895

Genotype.—*Thalamocrinus ovatus* Miller and Gurley, 1895.

Range.—(After Bassler and Moodey, 1943.) Silurian.

Known species.—*T. cylindricus* Miller and Gurley, 1895; *T. elongatus* Springer, 1926; *T. globosus* Springer, 1926; *T. ovatus* Miller and Gurley, 1895.

Remarks.—The above species are listed in Bassler and Moodey (1943) as being from the "Beech River formation," Niagaran, of Decatur County, Tennessee. In current usage this is the Beech River Member, Brownsport Formation, Niagaran, Silurian. However, Springer (1926, p. 132) gave the horizon and locality of *T. elongatus* as "Linden formation, Helderbergian, Lower Devonian; Benton County, Tennessee." Strata formerly termed "Linden formation" are currently divided with the lower half in the Decatur Formation (Silurian) and the upper half in the Lower Devonian. Thus it is likely that the specimen is actually Silurian in age, but probably from the Decatur rather than the Brownsport Formation. *T. elongatus* is of special interest because a specimen from the Henryhouse Formation of Oklahoma is assigned to the species.

Thalamocrinus elongatus Springer, 1926
Plate 3, figure 5

The monotype of *Thalamocrinus elongatus* is an incomplete dorsal cup with RA in place but with RR and X missing. The hypotype from the Henryhouse Formation is also an incomplete cup with the RA, as well as the RR and X, missing. In the present specimen, a wide stem cicatrix covers the entire width of the base. The cup widens and then constricts toward the summit.

Measurements in millimeters.

	Holotype
Width at summit of basals	4.9
Height to summit of basals	6.9
Maximum width of cup	5.1
Diameter of base	2.5

Hypotype and occurrence.—Hypotype OU 4661 is from the Henryhouse Formation near C west line sec. 32, T. 3 N., R. 6 E., Pontotoc County, Oklahoma.

Family CYATHOCRINITIDAE Bassler

Genus *GISSOCRINUS* Angelin, 1878

Gissocrinus quadratus Springer, 1926

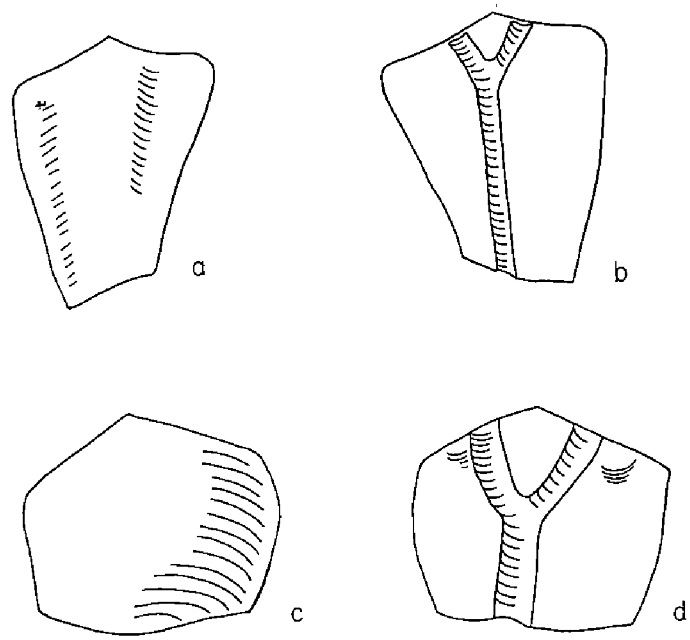
Text-figure 18a-d

The original description of *Gissocrinus quadratus* is so brief that it is repeated here (Springer, 1926, p. 137, pl. 32, figs. 10, 11).

> I figure under this name an axillary plate and the two following it which are nearly rectangular, and clearly devoid of any patelloid plates, and also a series of nearly square plates with the food-grooves covered. No other parts of this or the preceding species (*G. approximatus*) were found, but their occurrence is important as evidence of the wide distribution and variable nature of this peculiar type.

The types are from the Laurel Limestone at St. Paul, Indiana, and are brachial plates. The term "patelloid plates," used here by Springer, applies to small oval plates connecting plates at the brachial articulations, in some cases two or as many as three in succession and located where the food grooves cross the faces of the brachials. This type of structure is known from *G. magnibrachiatus* Springer (1926, pl. 32, figs. 3-6) of the Brownsport Formation in Decatur County, Tennessee.

Two axillary brachials and one nonaxillary brachial are in the presently considered collections. One axillary and the nonaxillary brachial are elongate and have rather flattened exteriors. The other



Text-figure 18. Drawings of hoypotypes of *Gissocrinus quadratus* Springer.
a, b. Elongate axillary brachial from exterior and interior.
c, d. Short axillary brachial from exterior and interior.

axillary is relatively short and has a convex exterior. The plates thicken toward the canals. Their outlines are closer to those of *G. quadratus* than to those of *G. magnibrachiatus*. The presence or absence of patelloid plates cannot be determined from the specimens at hand.

Holotypes and occurrence.—Hypotypes USNM 6243e, 6243f, and 6264 are from SW¼ NW¼ sec. 33, T. 3 N., R. 6 E. Hypotype USNM 6255a is from NW¼ SW¼ sec. 4, T. 2 N., R. 6 E. All are from the Henryhouse Formation, Pontotoc County, Oklahoma.

Subclass CAMERATA Wachsmuth and Springer

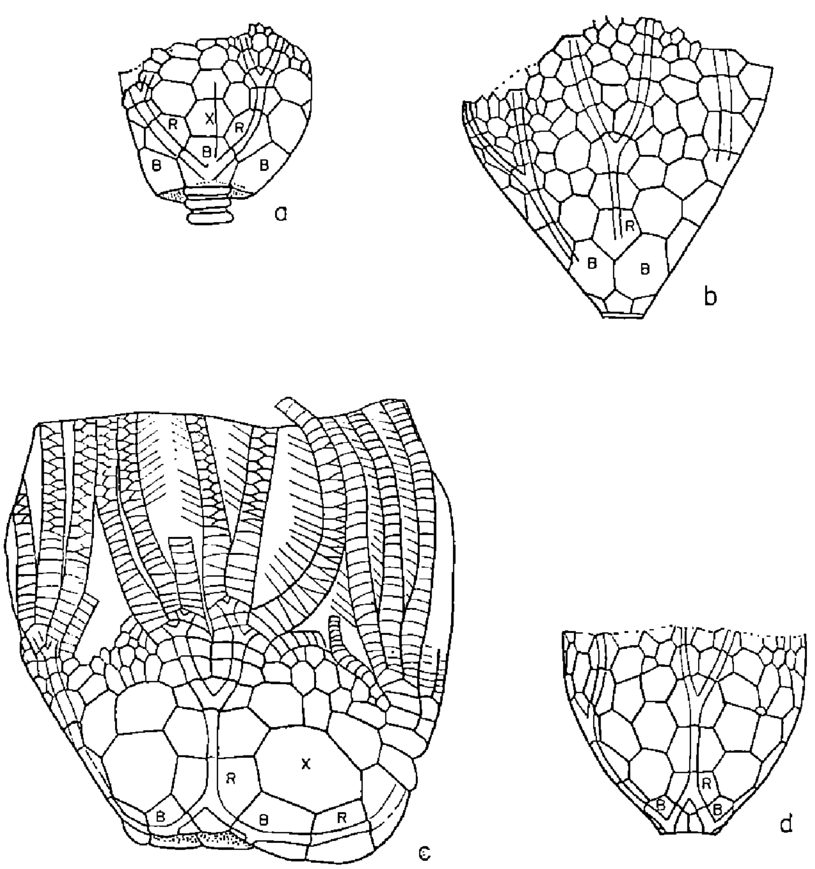
Order DIPLOBATHRA Moore and Laudon

Family ARCHAEOCRINIDAE Moore and Laudon

The exact status of the genus *Archaeocrinus* Wachsmuth and Springer, 1881, and to a lesser degree of the family Archaeocrinidae, remains somewhat obscure. Moore and Laudon (1943, fig. 13) illustrated an atypical calyx (apparently based on *Thysanocrinus pyriformis* Billings, 1857) as being a typical representative of the family. Then they illustrated another atypical form, *Archaeocrinus desideratus* Billings, on their plate 9, figure 2. The species *Thysano-*

crinus pyriformis has infrabasals visible in side view of the calyx and has been taken as the genotype of *Neoarchaeocrinus* Strimple and Watkins, 1955. The posterior view shown by Moore and Laudon (1943, fig. 13) is incorrect for any of the forms involved in having three anal plates in even contact with the posterior basal. In *Archaeocrinus* and *Neoarchaeocrinus* one plate (X) is in contact with PB from above. A form subsequently discovered, *Parachaeocrinus* Strimple and Watkins, 1955, has two (in some cases, three) anal plates meeting with the posterior basal, but unevenly.

Archaeocrinus desideratus has unusually large interradial plates succeeded by large interbrachial plates. No interbrachials are between the rays of any one arm. The rays form a tight cluster, and, although they are apparently fixed, they have the appearance of being free owing to the absence of IBrBr. In the wide interray areas are some pinnules, or ramules, that are fixed in proximal portions but are apparently free above. Somewhat similar structures are



Text-figure 19. Drawings of the holotypes of various archaeocrinids.

a. *Archaeocrinus lacunosus* (*Billings*). genotype.
b. *Neoarchaeocrinus pyriformis* (*Billings*), genotype.
c. *Archaeocrinus desideratus* Billings.
d. *Archaeocrinus subovalis* Strimple.

identified by weak median ridges in *Pararchaeocrinus decoratus* and illustrated by Strimple and Watkins (1955, text-fig. 2f). Eventually *Archaeocrinus desideratus* may be found to be more closely related to *Pararchaeocrinus* than to *Archaeocrinus*. It is this phyletic line that probably produced *Diabolocrinus*.

Drawings (text-fig. 19a-d) of the holotypes of *Archaeocrinus lacunosus* (Billings), the genotype species; of *Archaeocrinus desideratus* Billings; of *Archaeocrinus subovalis* Strimple; and of *Neoarchaeocrinus pyriformis* (Billings), the genotype, illustrated some of the differences outlined in the text.

An analysis of the calyx of *Siphonocrinus* (as emended) after Weller (1900) is shown by text-figure 26. This genus is assigned here to the Archaeocrinidae.

Genus *NEOARCHAEOCRINUS* Strimple and Watkins, 1955

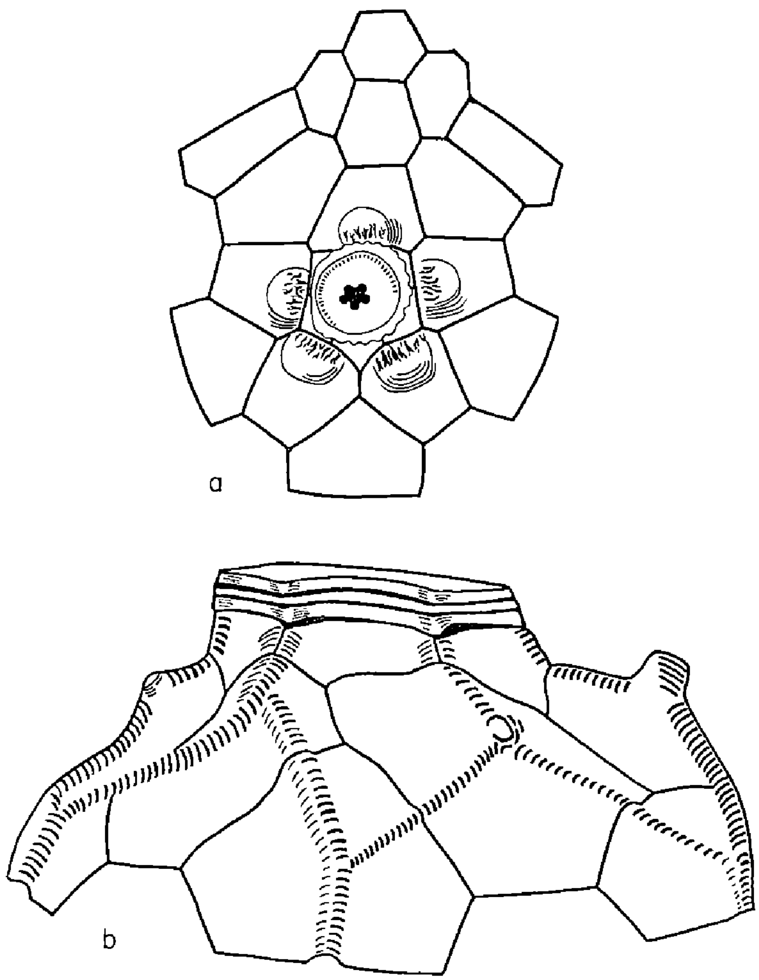
Genotype.—*Thysanocrinus pyriformis* Billings, 1857.

Range.—Ordovician, Silurian; North America.

Remarks.—Strimple and Watkins (1955) referred to a drawing given by Moore and Laudon (1943, text-fig. 13) as being representative of *Thysanocrinus pyriformis* Billings, which species was taken as the genotype of *Neoarchaeocrinus*. The drawing was used to illustrate characters of the genus *Archaeocrinus* and of the family Archaeocrinidae. In the current review of these forms, it became apparent to me that the posterior view given by Moore and Laudon does not agree in regard to the posterior interradius with any form known at that time; i. e., in showing three plates in contact with posterior basal and the center one marked X. In *Archaeocrinus* and *Neoarchaeocrinus* the anal X is normally the only interradial plate in contact with PB from above. The proper arrangement of anal plates was given in the word descriptions of Strimple and Watkins (1955) under "Notes on the Archaeocrinids."

Neoarchaeocrinus necopinus Strimple, new species
Plate 3, figure 8

Neoarchaeocrinus necopinus has a high, conical calyx with five infrabasals visible in side view. Fusion, or anchylosis, of infrabasals has taken place, but a suture is visible in an end view of the plates. An interesting arrangement in the proximal area of the calyx is a raised ridge that passes from a knoblike protrusion in lower midsection of each basal onto the suture area of the adjacent infrabasals. The ridge in turn meets the angular edges of the pentagonal stem and apparently interlocks. The five basals are of moderate size, slightly elongate, and in contact with a single interbrachial above. The five radial plates are pentagonal and are separated all around by interbrachial plates. The first primibrach is hexagonal and the second primibrach is pentagonal and axillary in the one ray in which one is preserved. Heavy median rays pass from the knoblike protrusion of the basal to midsection of each radial, and thence a single ridge follows the brachial plates.



Text-figure 20. Drawings of *Siphonocrinus* and *Neoarchaeocrinus*.

a. Paratype OU 4650 of *Siphonocrinus dignus*, new species. View of base to show five nodose protrusions and position of expanded proximal columnals.
b. Holotype OU 4608 of *Neoarchaeocrinus necopinus*, new species. Side view of base to show strong ridges and connection with proximal columnals. Sutures between infrabasals should be obliterated.

Measurement in millimeters.

	Holotype
Width of cup (as preserved)	35.0
Height of cup (as preserved)	20.0
Diameter of proximal columnals	7.5

Remarks.—This species is atypical of the genus *Neoarchaeocrinus* in possessing a pentagonal stem and may indeed represent an undescribed genus. The only specimen known is not preserved well enough for a comprehensive comparison. The knoblike protrusion on each basal plate is apparently a specific character.

The compatible relationship between the downward extensions of the raised ridges of the cup plates and the angles of the sharply pentagonal stem is a character that is shared with *Lampterocrinus.* I believe that *Neoarchaeocrinus necopinus* probably represents a form ancestral to *Lampterocrinus.* The infrabasals are fused on the exterior in *Lampterocrinus,* which also has the radials in contact except on the posterior side.

The proximal columnals of *Neoarchaeocrinus necopinus* are apparently captive and could be termed basilarids, as discussed earlier under "Morphological Notes."

The specific name is the Latin adjective *necopinus,* meaning unexpected.

Holotype and occurrence.—Holotype OU 4608 is from the Henryhouse Formation near C SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma.

Genus *SIPHONOCRINUS* S. A. Miller, 1888

Genotype.—*Glyptocrinus nobilis* Hall, 1861.

Range.—Silurian; North America.

Diagnosis.—(After Moore and Laudon, 1944.) Cup large, expanding rapidly; IBr area depressed; tegmen high, anal side greatly inflated, anal tube long; arms grouped, projecting.

Emendation.—Radials are not in contact on any side; arms branch twice within calyx walls; column is circular.

Species that have been referred to Siphonocrinus.—

	Occurrence
*Siphonocrinus armosus** (McChesney), 1861	Racine Dol., Silurian; Wisconsin and Illinois

* *Ochlerocrinus.*

Siphonocrinus dignus, new species	Henryhouse Fm., Silurian; Oklahoma
Siphonocrinus nobilis† (Hall), 1861	Racine Dol., Silurian; Wisconsin and Illinois
*Siphonocrinus pentagonus** Wachsmuth and Springer, 1897	Racine Dol., Silurian; Wisconsin and Illinois

Remarks.—The genus *Siphonocrinus* was listed under the family Lampterocrinidae by Moore and Laudon (1943, 1944) even though their diagnosis of the family calls for radials to be in contact except on the anal side. Two species previously referred to the genus *Siphonocrinus* do have this condition, but the genotype species has the radials separated on all sides. Wachsmuth and Springer (1897) did not entirely overlook the fact that some species have radials in contact on all sides, other than the anal side, and that in some cases the radials are separated on all sides, but they apparently did not consider the condition of importance. In their monograph (1897, p. 10), under discussion of the genus, they stated, "The first plate of the regular sides (interbrachial) rests between sloping upper faces of two radials, its lower angle exceptionally touching the basals." It should be remembered that those authors at the time were considering *Eucalyptocrinus armosus* McChesney (1859) as the genotype, whereas *Glyptocrinus nobilis* is the correct genotype. Weller (1900) recognized the unique condition and under his discussion of *Siphonocrinus nobilis* noted that the species differs from *S. armosus* and *S. pentagonus* in having the distal ends of all of the basals truncated by the first interbrachials, so that none of the radials is in contact laterally. I consider the separation of the radials to be a generic character and have removed *S. armosus* and *S. pentagonus* to *Ochlerocrinus,* new genus, tentatively associated with the family Lampterocrinidae.

Siphonocrinus dignus Strimple, new species

Plate 3, figures 6, 7; text-figure 20a

The calyx of *Siphonocrinus dignus* is high, widely expanded, and conical, with IBB confined to the base and mainly covered by proximal columnal, but with the distal angles visible between the

* *Ochlerocrinus.*

† Genotype.

basals. The form lacks a basal depression. A knob is present on each basal in the proximal midportion and the side adjacent to the column has a roughened exterior, the nature of which is elusive until enough of the stem is present to show the expanded columnals with thin extensions. Apparently the thin expansions connected with the knobs and acted as shock absorbers whenever the crown tilted too far. The knobs connected with low, raised ridges, which are not prominent below the brachials. Five rather large basals are met above by interbrachial plates (that of the posterior side is anal X). Five radials are large, separated by a single interbrachial plate, and are fundamentally pentagonal (an extra facet is developed in left and right posterior positions owing to the third plate in the second series of this interray). The first primibrach is hexagonal and the second primibrach is axillary. Another branching takes place with the second fixed secundibrach. Interbrachials are between all arm rays. The arm rays are marked by prominent ridges, which are covered by thin, elongate ridges that are irregularly parallel with the direction of the primary ray. The primary ridges widen appreciably as the uppermost brachials are reached.

The tegmen and free arms are unknown. The column is circular in outline and is composed of two types of columnals for which the sequence of occurrence is not known. A small columnal of medium thickness bears fine crenulations marking the articular face. Some columnals are expanded with a thin extension making the increased width. As viewed from below, the outer edge of the expanded columnal is seen to have an irregular, wavy outer edge. The lumen is relatively large and markedly pentagonal.

Measurements in millimeters.

	Holotype
Width of calyx (as preserved)	31.5
Height of calyx	18.0
Inside diameter of 5 knobs	4.0

Remarks.—Although the tegmen of *Siphonocrinus dignus* is unknown, the arrangement of calyx plates is so similar to that of *S. nobilis,* the genotype, that close relationship seems likely. *S. nobilis* has a high tegmen and a pronounced anal tube projecting above the tegmen. *S. dignus* has interbrachial plates between the tertibrachs, but *S. nobilis* does not appear to have interbrachials above the axillary secundibrachs.

The character of marked widening of the primary ridges as the point is approached where the arms will become free has been noted in *Scyphocrinites*. Close relationship is not considered at this time because *Scyphocrinites* is monocyclic and *Siphonocrinus* is dicyclic. Even so, the factor might prove of importance in studies of apparently divergent phyletic lines, but with perhaps common primary stock.

The specific name is the Latin adjective *dignus,* meaning deserving.

Types and occurrence.—All specimens are from the Henryhouse Formation in sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma. Holotype OU 4696 and paratypes OU 4722, 4651 (two specimens), and 4650 are from near C SW¼; OU 4717 (three specimens) is from Cedar Hill, NE¼ SW¼ SE¼; specimen USNM 6217 is probably from NW¼ SW¼.

Family RHODOCRINITIDAE Bassler

Genus *DIABOLOCRINUS* Wachsmuth and Springer, 1897

The genus *Diabolocrinus* is considered here because some specimens of certain species resemble a form subsequently described herein as *Elpidocrinus,* new genus. Although some confusion exists as to horizons and localities for the various species ascribed to *Diabolocrinus,* Bassler and Moodey (1943) showed them all to be from the Heiskell Shale, Chazyan, Ordovician; Knox County, Tennessee.

Under their description of the genus, Wachsmuth and Springer (1897, p. 249) stated, "Arms two to the ray, free from the first or second distichals (secundibrachs) their structure unknown." On page 250, they stated, "The large plates between the radials are frequently surrounded by small supplementary or secondary pieces, which wholly or partly isolate them from the basals, radials and costals (primibrachs)."

Diabolocrinus perplexus Wachsmuth and Springer (1897) is the genotype. This species does have supplementary pieces surrounding the interradial plates, although they are not regular in number nor in position. The specimen figured by Wachsmuth and Springer (1897, pl. 11, figs. 1a, 1b), apparently the principal type specimen, shows a few small supplementary plates. The illustrations do not permit the determination of the number or the position of the secundibrachs.

Diabolocrinus vesperalis (White, 1880) is represented by Wachsmuth and Springer (1897, pl. 11, figs. 1d, 1c) either to have numerous supplementary plates surrounding the interradial plates (fig. 1d) or to possess no supplementary plates (fig. 1c). It is also of interest that the illustrations show as many as three fixed secundibrachs, whereas the generic concept is for two fixed secundibrachs. Without examination of White's type specimen, as well as the specimens studied by Wachsmuth and Springer, no true evaluation of the conditions is possible.

Further confusion may be noted. White (1880) stated that his specimen probably came from the Coal Measures, thirty miles west of Humboldt, Kansas. The original name was *Rhodocrinus vesperalis* White. S. A. Miller (1882) redescribed the species as *Lyriocrinus sculptilis,* but upon finding the name preoccupied, changed it to *L. sculptus* in his private edition. He gave Tennessee as the locality and Niagara Group as the probable horizon. Wachsmuth and Springer (1897, p. 252) reported that they compared Miller's specimen of *Lyriocrinus sculptus* with White's type of *Rhodocrinus vesperalis* and with their specimens from their locality near Knoxville, Tennessee, and concluded they were all "specifically identical" and probably all came from the same locality.

Diabolocrinus asperatus (Miller and Gurley, 1894), a highly ornate form originally under *Archaeocrinus,* is also from Knox County, Tennessee. Wachsmuth and Springer (1897) described a form as *Diabolocrinus hieroglyphicus* from the same general horizon and locality, a species which was placed in synonymy under *D. asperatus* by Bassler and Moodey (1943). In the illustration given by Wachsmuth and Springer (1897, pl. 10), it is obvious to me that the specimen shown by figures 5a and 5b is not typical of the genus, much less of the species. This is because of the three long, fixed secundibrachs, with no indication of the arms being free even at that point. The smaller specimen shown by them (1897, pl. 10, fig. 5e) is apparently typical of the species. It has two short secundibrachs, and apparently the arms were free at that point. It is certain the arms were directed outward in Miller and Gurley's specimen as well as in the small specimen figured by Wachsmuth and Springer (as *Diabolocrinus hieroglyphicus*).

The literature gives evidence of a *Diabolocrinus* with no supplementary small plates surrounding the interradial plates, but close study will probably show that it is a different genus. In any event it is this form that I consider most likely to be ancestral to the new Silurian genus *Elpidocrinus.* As reflected by Wachsmuth and Springer's small specimen, figured as *Diabolocrinus hieroglyphicus* (1897, pl. 10, fig. 5c), and their specimen figured as *D. vesperalis* (White) (see Wachsmuth and Springer, 1897, pl. 11, fig. 1c), the form has a rather deep cup and low tegmen. *Elpidocrinus* has a shallow, more or less conical cup and a high tegmen.

Genus *ELPIDOCRINUS* Strimple, new genus

Genotype.—Elpidocrinus tholiformis Strimple, new species.

Range.—Silurian; North America.

Diagnosis.—Shallow, conical cup; high tegmen; arm openings directed outward, paired but with single SIBr separating the arms of a ray; five infrabasals; five basals; five radials; radials separated all around; IR succeeded by two except in posterior where X is succeeded by three; infrabasals confined to small base, not visible in side view and probably entirely covered by proximal columnals where such are in place.

Remarks.—Comparison of the present form with other genera and species does not disclose closely comparable forms. The species *Mariacrinus rotundus* Springer, 1926, from the Decatur Limestone, Niagaran, Silurian of Tennessee, has an appearance close to *Elpidocrinus,* but the Tennessee form is monocyclic. Springer noted that his species probably belonged to another genus. *Mariacrinus* was subsequently placed in synonymy under *Ctenocrinus* Bronn, 1840, by Bassler and Moodey (1943). The species is assigned to *Abathocrinus,* new genus, as *A. rotundus* (Springer), new combination.

A form somewhat comparable to *Elpidocrinus* in calyx structure is *Paragazacrinus* Springer, 1926; however the latter has a peculiar and distinctive tegmen composed of five plates and a long spine, quite different from the numerous polygonal plates and high tegmen of *Elpidocrinus.*

As previously noted under discussion of *Diabolocrinus,* some specimens of this genus have calices of the same general plate pattern, but differ in having deeper and fuller bowl-shaped cups.

Emperocrinus Miller and Gurley (1895) might well be a derivative of *Elpidocrinus.* In the former the number of cup plates (interbrachials) is reduced.

The name *Elpidocrinus* is derived from the Greek term *elpis,* meaning expectation.

Elpidocrinus tuberosus Strimple, new species

Plate 4, figures 4-7; text-figure 21b-c

Only two specimens in the collections under study appear to belong to *Elpidocrinus tuberosus.* Tumidity, or even bulbosity, of the calyx plates provides the most obvious distinctive character. The dorsal cup is low, almost flat, in the holotype, but is somewhat higher and conical in the younger paratype. The tegmen rises almost vertically directly above the arm openings and is considerably larger than the cup. The anterior side is decidedly convex, but the posterior side is rather erect and has a distinctive anal opening that is well preserved in the holotype (text-fig. 21). Six plates surround the opening; the one in the posterior is smaller than the others and is the eighth plate of the anal series (X_8). The other five may therefore be considered equivalent to oral plates. No provision is made for extension as an anal tube.

There appear to be five infrabasals; five basals; five radials; radials separated all around; IR succeeded by two except in posterior where X is succeeded by three; infrabasals confined to small base, not visible in side view and entirely covered when proximal columnal is in place; IR in relatively broad contact with B; two PBr, the second being axillary; two SBr, the second apparently marking the start of the free arms; arm openings directed outward, paired but with lower extremity of one ISBr dividing them; and three tumid plates surrounding the opening, the lower being SBr_2.

The calyx of the holotype is 18.3 mm high and 22.8 mm wide; the height from the basal plane to arm openings is 3.5 mm; and the width of IBB circlet is 1.7 mm.

The columnar scar is round, the lumen small and pentalobate, with the lobes radial in position. The arms are unknown.

Remarks.—As noted above, the tumidity of cup plates and tegmen plates is a distinctive characteristic. A hint of raised ridges marking the rays of the arms is present, but tumidity is so pronounced as to obscure the structure. Three tumid plates surround the arm openings and restrict the size of the opening so that it is smaller than in other species. The high tegmen with swollen anterior, and fullness all around distinguish it from most specimens of *E. exiguus.* The tegmen of *E. tholiformis,* as reflected by the holotype, is even higher than in *E. tuberosus,* but the paratype of the former is about the same height and shape as in the holotype of *E. tuberosus.* The presence of a narrow axillary second primibrach is common to both *E. tuberosus* and *E. tholiformis.* This plate is broad in *E. exiguus.*

The specific name is the Latin adjective *tuberosus,* meaning full of protuberances.

Types and occurrence.—Both types are from the Henryhouse Formation in Pontotoc County, Oklahoma. Holotype OU 4601 is from near C sec. 10, T. 2 N., R. 6 E., and paratype OU 4705 is from near C sec. 4, T. 2 N., R. 6 E., Cedar Hill, blue zone in gulley north of road.

Elpidocrinus exiguus Strimple, new species

Plate 4, figures 1-3; text-figure 21a

The dorsal cup of *Elpidocrinus exiguus* is of medium height and conical, and the tegmen is normally inverted and conical, though asymmetrical, with the center (anal opening) to the posterior. The tegmen is generally slightly larger than the cup, but the tegmen may be quite high and pyramidal.

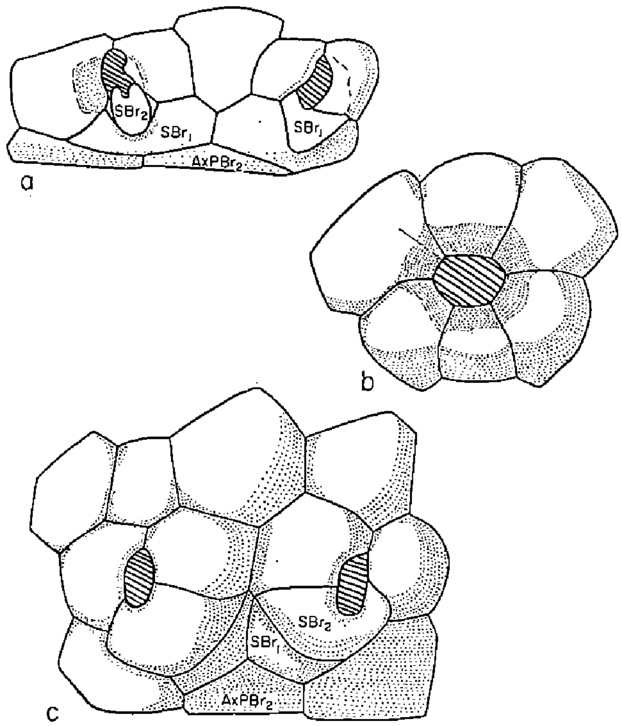
The species has five infrabasals; five basals; five radials; radials separated all around; IR succeeded by two except in posterior, where X is succeeded by three; infrabasals entirely covered by small proximal columnals, if such are preserved; IR in relatively broad contact with B; two PBr, with the second being axillary and wide; two SBr, with the second strongly projecting; arm openings directed slightly upward, surrounded by three plates (the lower being SBr_2); and arms paired but with single ISBr dividing them.

The columnar scar is round, and the lumen is small and pentalobate. The arms are unknown.

The cup of the holotype is crushed but the specimen is so well preserved that it has been taken as the holotype. The width of the calyx, at extensions of arm openings, is 22.0 mm; the height of tegmen, from base of arm openings, is 8.7 mm; and the width of the infrabasal circlet is 1.7 mm.

Remarks.—This species is characterized by smooth plates, wide appearance of interbrachial areas, and projection of the arm openings. Several well-preserved specimens have raised ridges passing from basals to radials and up the arms although the rays are not pronounced.

The specific name is the Latin adjective *exiguus,* meaning small, short, paltry.



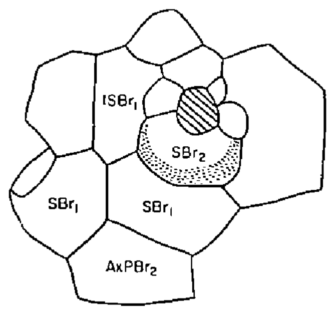
Text-figure 21. Drawings of arm openings of *Elpidocrinus* and anal opening of *E. tuberosus.*

a. Holotype OU 4667 of *Elpidocrinus exiguus*, new species. Arm openings.
b, c. Holotype OU 4601 of *Elpidocrinus tuberosus*, new species. Anal opening and arm openings.

Types and occurrence.—With the exception of two paratypes, all types are from the Henryhouse Formation in sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma. These include holotype OU 4667 and paratypes OU 4706 (three specimens), from SW¼ NE¼ SW¼, *Pisocrinus* zone about 50 feet below contact with Haragan Formation; paratype USNM 6246 (NW¼ SW¼); and paratypes USNM 6260b and 6265 (NW¼ SW¼). The paratypes, also from the Henryhouse, USNM 6212 (2 specimens) are from SW¼ NW¼ NW¼ sec. 33, T. 3 N., R. 6 E.; paratype USNM 6251c is from SE¼ SW¼ sec. 10, T. 2 N., R. 6 E.

Elpidocrinus tholiformis Strimple, new species
Plate 5, figures 4-7; text-figure 22

Elpidocrinus tholiformis has a low, broad, conical dorsal cup. Its tegmen is large and bulbous, with the posterior side rather erect and carrying the anal opening. Plates are smooth with no evidence of raised ridges.



Text-figure 22. Drawing of the arm opening of *Elpidocrinus tholiformis*, new species, from holotype OU 4702.

The species has five infrabasals; five basals; five radials; radials separated all around; IR succeeded by two except in posterior, where X is succeeded by three; infrabasals confined to small basal disk entirely covered by proximal columnal; IR that have almost lost contact with the basals in most rays of the large holotype, but are in broad contact in the smaller paratype; two PBr, the second being axillary and rather narrow; arm openings directed outward in pairs, with a narrow ISBr area occupied by the lower portion of a narrow $ISBr_1$ and with the lateral plates adjoining the arm openings; more than three plates surrounding the opening of arms (normally four); and ambulacral grooves marked by covering plates that are smaller than normal tegmen plates.

In the holotype the calyx is 24.6 mm high and 24.2 mm wide; the IBB circlet is 2.1 mm wide; and the cup at base of arm openings is 5.0 mm high.

Remarks.—Comparison with *Elpidocrinus tuberosus* and *E. exiguus* has been given under discussion of those species. *E. tholiformis* attains a greater size than do the other two, the plates are smooth, the arm openings are surrounded by more than three plates, and the large tegmen has an unusual humped appearance.

The specific name is a derived adjective from the Greek nouns *tholos* (dome) and *formis* (shape).

Types and occurrence.—Types are from the Henryhouse Formation in Pontotoc County, Oklahoma. Holotype OU 4702 is from C sec. 10, T. 2 N., R. 6 E. (about ten feet above *Lecanocrinus* zone); paratype USNM 6234 probably is from NW¼ SW¼ sec. 4, T. 2 N., R. 6 E.

Family LAMPTEROCRINIDAE Bather

Diagnosis.—(After Moore and Laudon, 1943.) Dicyclic; infrabasals, basals, and radials large; radials in contact except at anal side which has extra plates and which bulges markedly at arm levels and on tegmen; IBrBr few, small; anus opens through tube; arms grouped.

Range.—Silurian; North America.

Remarks.—*Siphonocrinus,* when restricted to characters of the genotype, *S. nobilis* (Hall), does not agree with the family diagnosis mainly because of two primary characters; i. e., the radials are separated in all rays by interbrachials and numerous interbrachials are present. The diagnosis given above states that the radials are in contact except at the anal side and that IBrBr are relatively few. *Siphonocrinus* is assigned herein to the Archaeocrinidae. Two species, formerly assigned to *Siphonocrinus,* have radials in contact all around except at the posterior, and they are assigned to *Ochlerocrinus,* new genus, a form tentatively assigned to the Lampterocrinidae. I expect that in time *Ochlerocrinus* will be found to have no more than distant relationship with *Lampterocrinus.* The latter is a simple form with upflared infrabasals and only five arm openings.

Bather (1899) incorporated *Siphonocrinus* into the family Lampterocrinidae primarily on the basis that the anal tube is to the fore of the tegmen with the mouth, of necessity, pushed to the anterior. *Ochlerocrinus* has most of the characters ascribed to *Siphonocrinus* without the nonconforming arrangement of radial plates.

Genus *LAMPTEROCRINUS* Roemer, 1860

Genotype.—*Lampterocrinus tennesseensis* Roemer, 1860.

Range.—Silurian; North America.

Diagnosis.—(After Moore and Laudon, 1944.) Cup high, subturbinate; anal interradius bulging, anal tube strong; IBrBr few; rays produced into five tubular extensions that bear uniserial pinnulate arms; column pentagonal.

Species that have been referred to Lampterocrinus.—

	Occurrence
*Lampterocrinus? comptus** Rowley, 1904	Upper Medinan, Silurian; Missouri
*Lampterocrinus? dubius** Weller, 1900	Racine Dol., Silurian; Illinois
Lampterocrinus fatigatus, new species	Henryhouse Fm., Silurian; Oklahoma
Lampterocrinus inflatus (Hall), 1861	Racine Dol., Silurian; Wisconsin
Lampterocrinus inflatus minor Foerste, 1917	Euphemia dol., Silurian; Ohio
Lampterocrinus parvus Hall, 1882	Waldron Sh., Silurian; Indiana
Lampterocrinus robustus Weller, 1900	Racine Dol., Silurian; Illinois
Lampterocrinus roemeri Springer, 1926	Brownsport Fm., Silurian; Tennessee
Lampterocrinus sculptus Springer, 1926	Brownsport Fm., Silurian; Tennessee
*Lampterocrinus? subglobosus** Weller, 1900	Racine Dol., Silurian; Illinois
Lampterocrinus tennesseensis Roemer, 1860	Brownsport Fm., Silurian; Tennessee

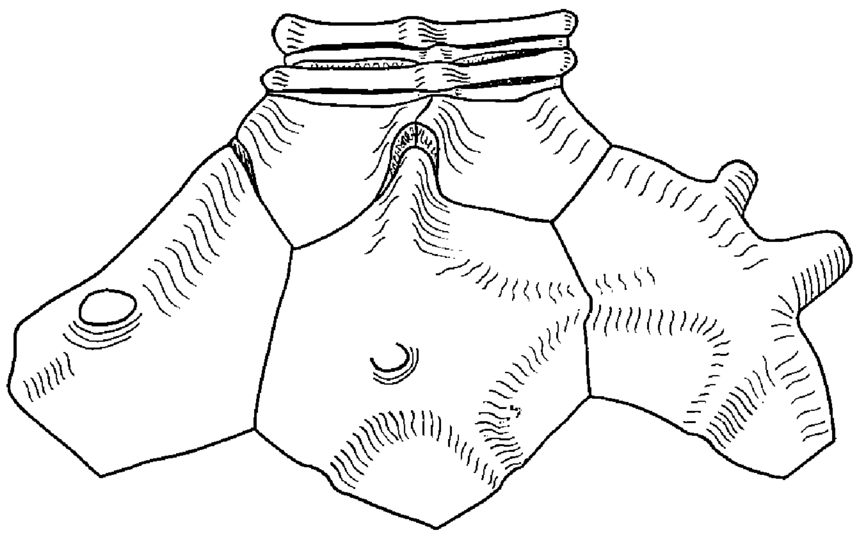
Lampterocrinus fatigatus Strimple, new species

Plate 5, figures 1-3; text-figures 23-25

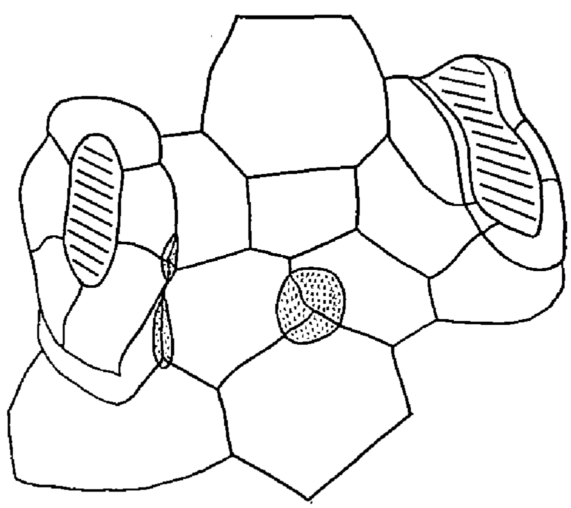
In *Lampterocrinus fatigatus* the cup is high and subturbinate, the anal interradius is bulging, and a single series of anal plates passes continuously from the posterior basal to the anal-tube opening. No specimens have been observed with a long anal tube preserved, and it is thought that the present species did not possess such a tube. Five infrabasals are anchylosed and form a rather

* Assignment questionable.

high cup, readily visible in side view of the calyx. A prominent ridge passes from the center of the basal plate onto the adsutural area of the adjacent infrabasals and onto the angles of the pentagonal proximal columnals. Five large basals are in contact all around and are hexagonal except for the posterior basal, which has an extra facet above for the reception of X. Ridges pass to each adjacent plate but are normally weakly defined from basal to basal. Five radials are in contact all around except where interrupted by anal X. The first primibrach is nonaxillary and hexagonal, and

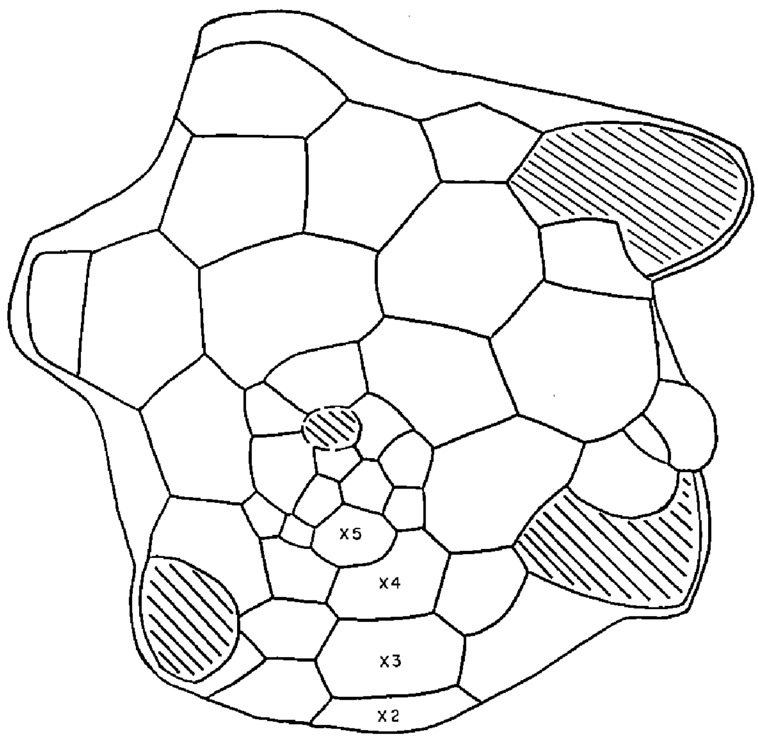


Text-figure 23. Drawing of the basal area of paratype OU 4668 of *Lampterocrinus fatigatus*, new species, to show the strong ridges and relationship with proximal columnals.



Text-figure 24. Drawing showing arm openings of holotype OU 4607 of *Lamptero-crinus fatigatus*, new species. Note pits made by parasites.

the second primibrach forms the proximal portion of an elongate opening for the tubular arm extension. The first interbrachials are hexagonal and are succeeded by two smaller plates in all except the posterior. Anal X is normally succeeded by a series of three plates, and at that point does not appear to be more than four small plates wide. Those of the median series are the largest. The tegmen is low and is composed of a relatively small number of plates. This fact is well shown by the drawing of the tegmen of the holotype (text-fig. 25).



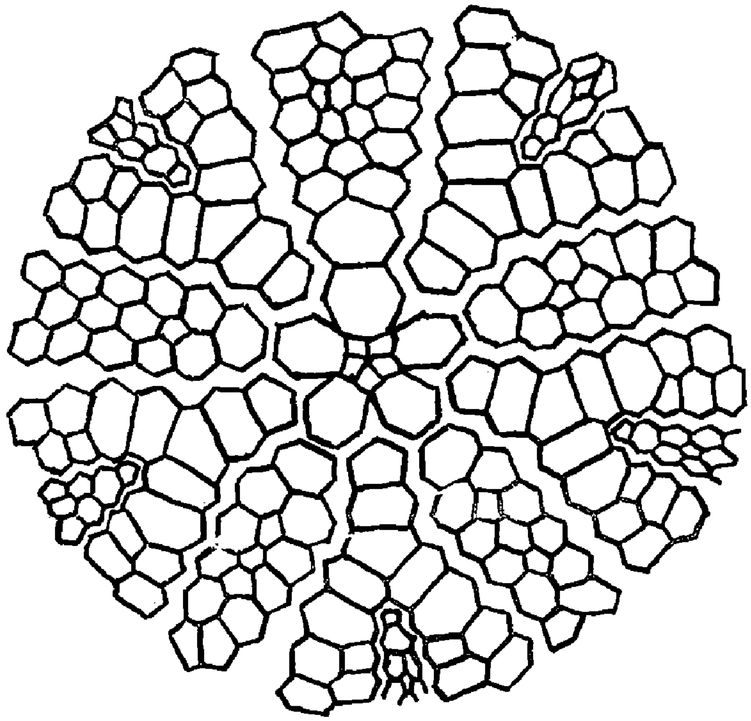
Text-figure 25. Drawing of tegmen of holotype OU 4607 of *Lampterocrinus fatigatus*, new species, made with the aid of camera lucida.

Older, fully mature specimens of *L. fatigatus* are marked so distinctly by heavy ridges and knobs that, upon first examination, they appear to be a different species.

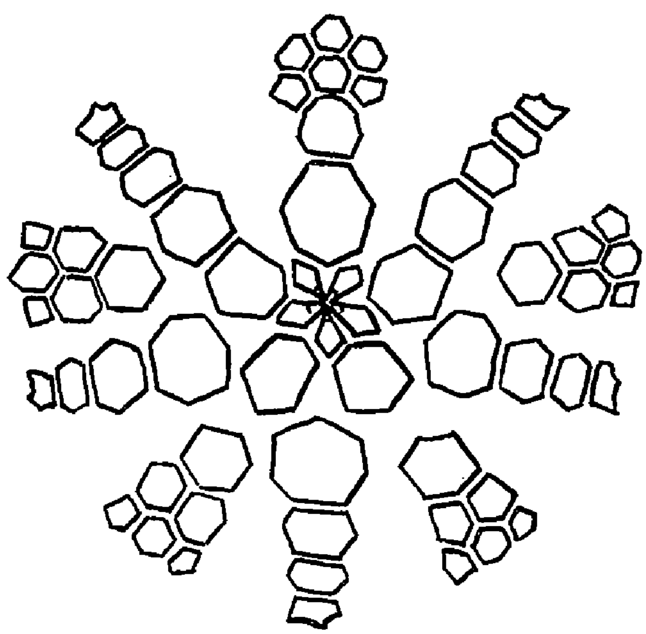
Measurements in millimeters.

	Holotype
Height of calyx	24.5
Height of cup (to base of arm openings)	17.0
Width of calyx (maximum)	18.7
Diameter of stem	4.0

Remarks.—The slender, elongate calyx and simplified ridges of *Lampterocrinus fatigatus* are much like those of *L. roemeri*;



Siphonocrinus



Lampterocrinus

Text-figure 26. Diagrammatic drawings of *Siphonocrinus* and *Lampterocrinus*.

however, in the latter species the tegmen is elongate and is composed of more numerous plates.

The specific name is a derived adjective from the Latin verb *fatigo,* meaning to grow weak, to tire.

Types and occurrence.—Types are from the Henryhouse Formation in sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma. Holotype OU 4607 and paratype OU 4668 are from C SW¼; paratype OU 4677 is from north side of Chimneyhill Creek, NW¼ SW¼; paratype OU 3424 is from C (35 feet above base); paratypes USNM 6223 and 6255 are from NW¼ SW¼; paratype USNM 6215 is from NE¼ SW¼.

Genus *OCHLEROCRINUS* Strimple, new genus

Genotype.—*Siphonocrinus armosus* (McChesney), 1861.

Range.—Silurian; North America.

Diagnosis.—Cup large, expanding rapidly; radials in contact except at anal side; anal side inflated; anal tube long; arms grouped, projecting.

Species referred to Ochlerocrinus.—

	Occurrence
Siphonocrinus armosus (McChesney), 1861	Racine Dol., Silurian; Wisconsin and Illinois
Siphonocrinus pentagonus Wachsmuth and Springer, 1897	Racine Dol., Silurian; Wisconsin and Illinois

Remarks.—These species have been removed from *Siphonocrinus* because the radials are in contact except at the anal side. In *Siphonocrinus,* and in the family to which it is assigned (Archaeocrinidae), the radials are not in contact. As previously noted under *Siphonocrinus,* the genotype, *S. nobilis,* has radials that are not in contact.

The generic name *Ochlerocrinus* is derived from the Greek term *ochleros,* meaning troublesome.

Family GAZACRINIDAE S. A. Miller

Genus *GAZACRINUS* S. A. Miller, 1892

Gazacrinus stellatus Springer, 1926
Plate 6, figures 3, 4

Gazacrinus stellatus is based upon a monotype reported by Springer (1926) to be from the Linden Formation, Helderbergian, Lower Devonian; Hardin County, Tennessee. If this were the proper designation, it would be the only species of the genus reported from Devonian rocks. Bassler and Moodey (1943) showed the species to be from the Decatur Limestone, Niagaran, Silurian; one mile east of Hardin postoffice, Hardin County, Tennessee. It is rather certain that the latter designation is correct.

Specimen and occurrence.—Specimen OU 4653 is from the Henryhouse Formation in Pontotoc County, Oklahoma, on bench above stream, near C sec. 10, T. 2 N., R. 6 E.

Order MONOBATHRA Moore and Laudon

Moore and Laudon (1943) recognized two groups of families under the Monobathra, although they did not formalize the division. One group they termed "tanaocrinid stock" and the other group "glyptocrinid stock." As generally considered, the first group has a hexagonal base, with anal X in broad contact with the posterior basal, and the second group has a pentagonal base, with the anal X almost entirely out of the radial circlet (the proximal apex notches the radial circlet). Moore and Laudon (1943, p. 88) stated:

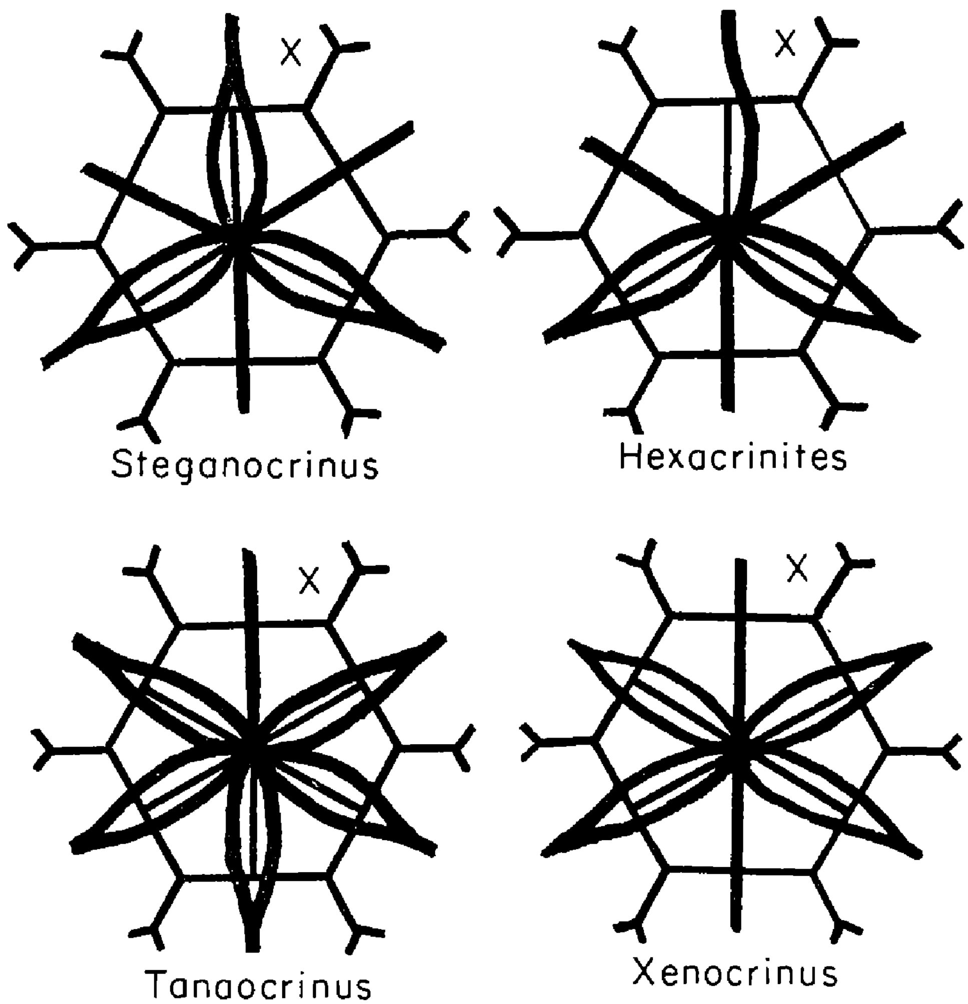
> The glyptocrinids are undoubtedly descendents of tanaocrinid-like ancestors, as is indicated by general form of the cup, prominent stellate plates, distinct median ray ridges, depressed interbrachial areas, and other structural resemblances. As a matter of fact, *Glyptocrinus* differs essentially from *Compsocrinus,* which is a tanaocrinid only in the upward displacement of the anal X to a position above the radials, permitting lateral contact of plates of the circlet all around.

The theory here is that anal X is being pushed out of the cup in *Glyptocrinus,* but it is generally conceded that anal X is not a primitive cup element. I suggest it has to be pressed down below the cup summit before it can be displaced out of the cup.

Spreng and Parks (1953, p. 590, fig. 7) pointed out that the large posterior basal in the Tanaocrinidae has a nerve-cord arrangement similar to that of a compound basal; i. e., the large anterior basal of *Xenocrinus* and *Compsocrinus*. They stated:

> This suggests that the large, posterior basal may be, in reality, a compound basal originating through the fusion of two small posterior basals of a hexapartite, hexagonal-based echinoderm, the ancestor of the Tanaocrinidae.

They introduced the concept of the posterior basal's being composed of two fused pieces—1 and 6. I have reillustrated their figure 7 herein, excluding the pentagonal-based *Glyptocrinus* and including *Hexacrinites* (as reflected by *H. carinatus,* new species), to demonstrate a weakness in this particular phase of their reasoning.



Text-figure 27. Nerve patterns of hexagonal-based Monobathra *Steganocrinus, Tanaocrinus,* and *Xenocrinus* (modified after Spreng and Parks). *Hexacrinites* based on ridge pattern of *H. carinatus*, new species.

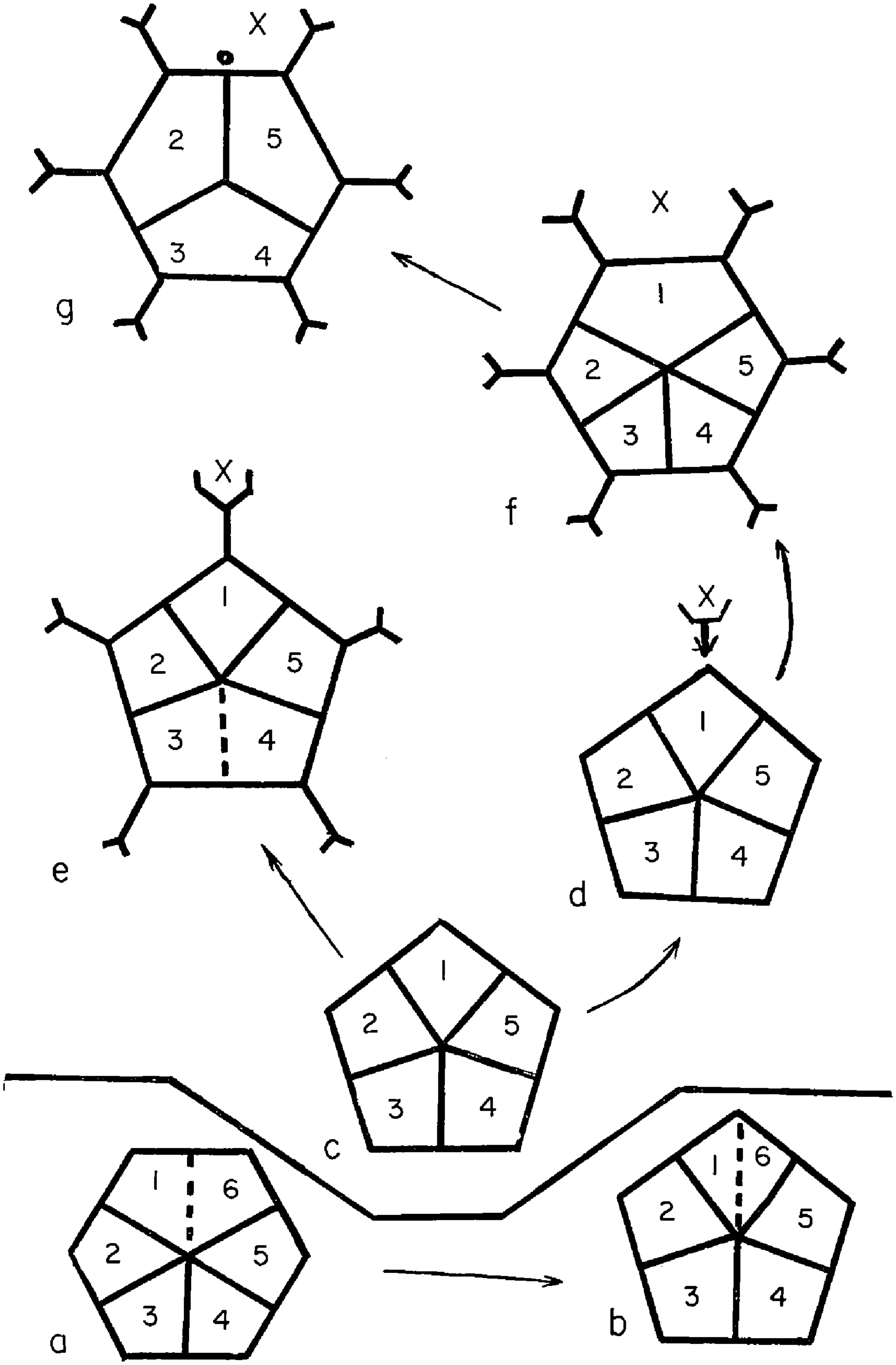
In *Hexacrinites* a suture line is in the position occupied by the nerve ridge of the Tanaocrinidae, but even so a single ray ridge is present, albeit slightly off center. The ridges shown by *Tanaocrinus* are readily explained in that two nerve cords are required to function with each of the arm systems, and one main cord serves the gut (which presses against the posterior wall of the cup). When two basals fuse, as in the anterior of *Xenocrinus,* there is no longer a suture and the nerve cords may share a common canal.

On the basis of evidence afforded by abnormal specimens illustrated by Wilson (1916, plates 1-3), one can visualize an ancestral form, like hexagonal-based monobathrids, with a hexapartite base, if careful comparison with later developments are not made. For example, the abnormal *Talarocrinus patei* Miller and Gurley (Wilson, 1916, pl. 3, fig. 8) has a small plate in the left posterior position, which is analagous with basal number 1 of Spreng and Parks (1953, fig. 8). However, the primary suture from posterior to anterior in *Talarocrinus* admittedly is a later developed suture, evenly separating basals numbered 2 and 5. It does not, therefore, follow that the supernumerary plate in this instance has to be the plate Spreng and Parks designated as basal number 1. It could just as well represent plate number 3 or 4, and more properly would do so.

In the past the probable pentamerous nature of the most primitive form has caused considerable discussion. I am quoting an interesting thought along that line by Clark (1915, p. 182):

> It has already been remarked that in a radially symmetrical animal divided by lines of weakness the body would naturally be expected to consist of an uneven number of segments so that none of the lines of weakness will pass directly through the animal in the same plane. The number five represents the optimum number of divisions for such an animal. It was probably the coincidence of this number with five segments usually incorporated in the crustacean thorax which originally permitted the formation of the echinoderms from the primitive crustacean ancestors.

Text-figure 28. Drawings showing possible development of hexagonal-based forms out of pentagonal-based forms. Figures a and b show the hypothesis of the development of a hypothetical echinoderm with six plates into glyptocrinid stock with a pentagonal base (after Spreng and Parks). This hypothesis is rejected in favor of one illustrated by figures c and d. Figure e shows the fusion of plates 3 and 4 to produce forms like *Scyphocrinites.* Figure f is a tanaocrinid formed, in my opinion, by pressure of X from above into a hexagonal-based form. Figure g shows development of the Desmocrinidae, etc., out of tanaocrinid stock (after Spreng and Parks). Dashed lines indicate former suture lines. o = suture developed by overdevelopment of plates 2 and 5.


X
2
5
3
4
g
X
1
2
5
3
4
f
X
1
2
5
3
4
e
X
1
2
5
3
4
d
1
2
5
3
4
c
1
6
2
5
3
4
a
1
6
2
5
3
4
b

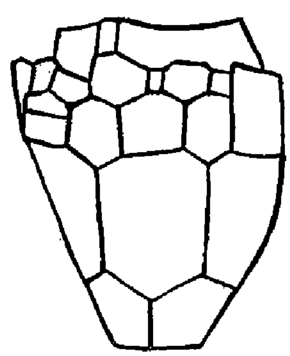
Note that a line of weakness is indeed created with the forms having the sixth basal facet in the posterior interradius.

The posterior side of almost all fossil crinoids is normally different from the other sides. This is due to special requirements incurred by the passage and pressure of the digestive tube or gut. It is noted in many cases that the weight of the anal tube affects the plates of the posterior side of the cup. For this reason it is logical for a large basal plate to be in the posterior of the basal circlet. In various evolutionary processes among crinoids, anal X originates above the dorsal cup (radial plates) and pressure or weight from above causes it to sink below the summit of the radials. Conversely, an evolutionary trend occurs wherein the anal X is forced upward out of the cup, but normally a reduction of pressure or weight from above accompanies this action.

The absence of a ray ridge in the posterior (anal series) of *Glyptocrinus* does not mean that the nerve cord is not present but only that it has probably moved inward and possibly has lost contact with the calyx wall.

I have reillustrated three figures after Spreng and Parks (1953, figs. 8a and/or b, c, and g) with the first two of which I do not agree as concerns the hypothetical plates 1 and 6, with a supposed suture lost through anchylosis, and have illustrated my concept with text-figure 28.

The proposal by Spreng and Parks (1953) that development of a tripartite, hexagonal base takes place through atrophy of the posterior basal, accompanied by a compensating overdevelopment of the adjacent lateral basals (2 and 5 in fig. 28g), appears to be sound. They also show that a bipartite base, as in the Dichocrinidae, may be developed by the same process in the anterior side.



Text-figure 29. Drawing of *Desmidocrinus springeri* (Thomas) (modified after Thomas).

Family DESMIDOCRINIDAE Angelin

Genus *DESMIDOCRINUS* Angelin, 1878

Desmidocrinus springeri (Thomas), 1924, new combination
Text-figure 29

In the course of study of the genus *Hexacrinites,* consideration was given to the form described by Thomas (1924) as *Hexacrinus springeri* from the Shell Rock Limestone (Devonian) on the left bank of Shell Rock River, NW¼ NE¼ sec. 4, T. 95 N., R. 18 W., Floyd County, Iowa. The depository is the State University of Iowa. Rigidity of the two primibrachs, interradial plates in normal interrays, and upper anal plates preserved in the posterior interray are characters atypical of *Hexacrinites,* but are typical of *Desmidocrinus.* In *Hexacrinites* the arms are free at the summit of the cup and no interradials are incorporated in the calyx.

Family HEXACRINITIDAE Bassler

Genus *HEXACRINITES* Austin and Austin, 1843

Genotype.—Platycrinites interscapularis Phillips, 1841.

Range.—Silurian, Devonian; Europe, North America.

Remarks.—The generic characters of *Hexacrinites* are well known and require no repetition here. The genus is represented in European rocks of Devonian age by 40 species and 4 subspecies. In North America five species are ascribed to the genus from Devonian rocks, of which one (*Hexacrinus springeri* [Thomas]) is currently referred to *Desmidocrinus.* One species of *Hexacrinites* was previously described from the Upper Silurian of Oklahoma (*H. adaensis* Strimple) and a new species from the same horizon is herein assigned to the genus. These two species are the only recorded species of the genus from Silurian rocks.

Species of Hexacrinites *in North America.—*

	Occurrence
Hexacrinites iowensis (Thomas), 1924	Shell Rock Ls., Devonian; Floyd County, Iowa
Hexacrinites humei (Springer), 1926	Upper Devonian; Root River Northwest Territory, Canada

Hexacrinites carinatus, new species	Henryhouse Ls., Silurian; Pontotoc County, Oklahoma
Hexacrinites leai (Lyon), 1869	Jefferson Ls., Devonian; Jefferson County, Kentucky
Hexacrinites occidentalis (Wachsmuth and Springer), 1897	Cedar Valley Ls., Devonian; Davenport, Iowa
Hexacrinites springeri (Thomas),* 1924	Shell Rock Ls., Devonian; Floyd County, Iowa
Hexacrinites adaensis Strimple, 1952	Henryhouse Ls., Silurian; Pontotoc County, Oklahoma

Hexacrinites carinatus Strimple, new species
Plate 6, figures 1, 2; text-figure 30

The most outstanding character of *Hexacrinites carinatus* is the striking ornamentation. Attention is directed to the sharp ridges that pass from the basal area onto the five radials and the anal X. Eight ridges converge to the columnar cicatrix; three ridges are on each of the three basals except the left posterior, which lacks one ridge parallel to the right interbasal suture. The other two interbasal sutures have a parallel ridge on each side of the suture; the ridges converge just under the articular facets of the right anterior and left anterior radials. The single ridge that extends up anal X, slightly off-center to the right, fades out before the distal end of the plate is reached. On the surface of the cup are innumerable ridges and intervening grooves, some twisting and twining in an apparently aimless fashion but some having surprising regularity. Short ridges and grooves are at right angles to the interradial sutures in some areas and are met by similar structures on the adjacent radials. The structure has the appearance of pore slits. Pronounced ridges are normally associated with and are just below the projecting proximal portion of the articular facet of each radial. The ridges are also more prominent in the proximal areas, near the columnar attachment. It is almost certain that a function is served by some of the structures, but I have been unable to discover it.

The articular facets of the radials are narrow, projected, and more or less horseshoe shaped. Few fossae are on their surfaces. Provision is shown for the attachment of primibrachs, interbrachials,

* Now assigned to *Desmidocrinus*.

and upper anal plates, but none of these elements is preserved in any of the specimens at hand.

The columnar scar is circular, fine crenulations mark the outer perimeter, and a small pentalobate lumen is present. The lobes of the lumen are not radial in position; i. e., a lobe is in posterior position but none is in anterior position.

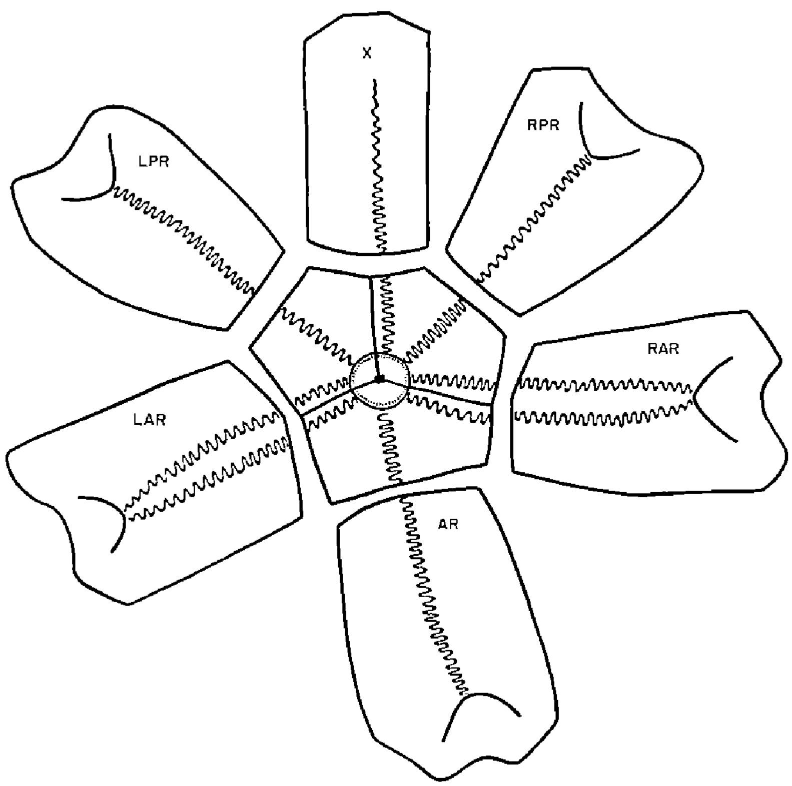
Measurements in millimeters.

	Holotype
Length of cup	12.2
Width of cup (average)	9.8
Diameter of columnar scar	2.2

Remarks.—*Hexacrinites carinatus* has distinctive keels and grooves, and is not closely comparable to any other form known to me. The associated *H. adaensis* is a smooth form quite different from the present species.

The specific name is the Latin adjective *carinatus,* meaning keeled.

Types and occurrence.—Types are from the Henryhouse Formation in Pontotoc County, Oklahoma. Holotype OU 4604 is from a bench above stream at C sec. 10, T. 2 N., R. 6 E.; paratype OU



Text-figure 30. *Hexacrinites carinatus*, new species. Diagrammatic sketch of holotype OU 4604 prepared with aid of a camera lucida. The sharp, irregular ridges are shown by uneven lines.

4603 is from NW¼ NW¼ SW¼ sec. 4, T. 2 N., R. 6 E. (near Haragan contact; collected by Graffham); OU 4719 is from C N½ SW¼ sec. 4, T. 2 N., R. 6 E.

Hexacrinites adaensis Strimple, 1952

No additional specimens of *Hexacrinites adaensis* have been found and the holotype remains a monotype. The long, narrow cone formed by the basals of this species is atypical of the genus. Probably it will be found that neither of the species referred to *Hexacrinites* from the Henryhouse Formation is a true representative of the genus.

Type and occurrence.—Holotype USNM S 4785 is from the Henryhouse Formation in SW¼ NW¼ NW¼ sec. 33, T. 3 N., R. 6 E., Pontotoc County, Oklahoma.

Family MELOCRINITIDAE Bassler

Genus *SCYPHOCRINITES* Zenker, 1833

Synonymy.—*Camarocrinus* Hall, 1879; *Lobolithus* Barrande, 1868; *Scyphocrinus* Roemer, 1855.

Genotype.—*Scyphocrinites elegans* Zenker, 1833.

Range.—Silurian, Devonian; Europe, India, North America.

Remarks.—Prior to the current study, no species of *Scyphocrinites* seems to have been recorded from Silurian rocks of North America. Springer (1917) stated that *S. mutabilis* (Springer) was from the Decatur Formation, Silurian, as well as from the Linden Formation, Devonian of Tennessee. However, Bassler and Moodey (1943) recognized only the Devonian occurrence of the species. It is strange that no representative has appeared in the prolific crinoidal faunas of the Brownsport Formation (Niagaran) of Tennessee, yet the genus appears in the Henryhouse Formation (Niagaran) of Oklahoma.

Waagen and Jahn (1899) reported the presence of from 15 to 25 secundibrachs among the various species and subspecies from the Silurian of Bohemia. Springer (1917) reported 18 to 20 secundibrachs for specimens from the Devonian of Missouri that are assigned to *S. elegans*. The species that Springer (1917) described from Tennessee does not have more than 15 secundibrachs, and the specimen he figured from West Virginia as *Scyphocrinus stellatus* (Hall) has only about 10 secundibrachs. The specimen Springer (1917) figured as *Scyphocrinus ulrichi* (Schuchert) from the Devonian of Oklahoma has 9 or 10 secundibrachs, but it is herein reconsidered as *Limolgocrinus dissutus,* new genus, new species.

Springer (1917, p. 54), in giving reasons for assignment of the calyx collected by Ulrich from "*Camarocrinus*" beds near Dougherty, Murray County, Oklahoma, to the species described by Schuchert (1903), based upon bulbous roots, as *Camarocrinus ulrichi,* stated:

> This species is represented by a single calyx, found in the talus of beds containing numerous "*Camarocrinus,*" to which Mr. Schuchert has given the above specific name. As many of these are large, it is assumed they appertained to individuals of this species rather than of the smaller *S. gibbosus.*

The holotype of *Scyphocrinites ulrichi* is a bulbous root designated by Schuchert. If Schuchert were aware of the calyx collected by Ulrich, he did not associate it with the bulbous root. Assignment of the calyx to the species by Springer is an arbitrary action and Springer's premise that *S. gibbosus* is a small species no longer holds true. The crown figured herein from the old Hunton townsite has a calyx width of 47.2 mm. Large calices of *S. gibbosus* have also been found south of Fittstown in Pontotoc County, Oklahoma, but none of them is at hand. Pending further information, the name *Scyphocrinites ulrichi* is restricted to bulbous roots from the Haragan Formation.

Species assigned to Scyphocrinites.—

	Occurrence
Scyphocrinites asiaticus[1] (Reed), 1906	Silurian?; India
Scyphocrinites cinctus Strimple, new species	Silurian; Oklahoma
Scyphocrinites clarkii[1] (Hall), 1879	Devonian; Tennessee
Scyphocrinites decoratus (Waagen and Jahn), 1899	Silurian; Bohemia
Scyphocrinites elegans[2] Zenker, 1833	Silurian; Bohemia Devonian; Missouri

[1]Bulbous root.
[2]Genotype.

Scyphocrinites excavatus[3] (Schlotheim), 1820	Silurian; Bohemia
Scyphocrinites excavatus schlotheimi (Waagen and Jahn), 1899	Silurian; Bohemia
Scyphocrinites excavatus schröteri (Waagen and Jahn), 1899	Silurian; Bohemia
Scyphocrinites gibbosus (Springer), 1917	Devonian; Oklahoma
Scyphocrinites mutabilis (Springer), 1917	Devonian; Tennessee
Scyphocrinites pratteni (McChesney), 1860	Devonian; Tennessee and Alabama
Scyphocrinites pyburnensis (Springer), 1917	Devonian; Tennessee
Scyphocrinites quarcitarum[1] (Fritsch), 1905	Silurian; Bohemia
Scyphocrinites saffordi[1] (Hall), 1879	Devonian; Tennessee
Scyphocrinites spinifer (Springer), 1917	Devonian; Tennessee
Scyphocrinites stellatus[4] (Hall), 1879	Devonian; New York and West Virginia
Scyphocrinites subornatus[1] (Barrande), 1880	Silurian; Bohemia
Scyphocrinites ulrichi[5] (Schuchert), 1904	Devonian; Oklahoma
Scyphocrinites ulrichi stellifer[1] (Schuchert), 1904	Devonian; Oklahoma
Scyphocrinites zononis (Waagen and Jahn), 1899	Silurian; Bohemia

[1]Bulbous root.
[3]Fragment.
[4]Original specimens were bulbous roots but Springer (1917) assigned a partial calyx from West Virginia to the species.
[5]Original specimens were bulbous roots and the species has been restricted to the original concept.

Scyphocrinites cinctus Strimple, new species

Plate 7, figures 4, 5; plate 8, figure 11; plate 10, figure 7; plate 12, figure 3

In *Scyphocrinites cinctus* the calyx is narrowly elongate and the middle ridges are indistinct except in young specimens and on upper secundibrachs. Four basals form an erect cup readily visible in side view. The five radials are large and in contact all around. The posterior interradius is slightly protuberant and anal X is large and is succeeded by three plates. In the other four interrays the lower plate is somewhat smaller and only two plates are in the next range above. Numerous sharp costae pass from cup plate to cup plate. The large holotype has fifteen secundibrachs. The lower SBrBr have the appearance of ordinary cup plates until the rays abruptly change direction, with about the fourth or fifth SBr, and shortly thereafter the brachials lose most of their height and become wedge shaped. Interbrachial areas are mildly to decidedly depressed. The interbrachial pavage is best shown by young specimens. In paratype OU 4715, a young specimen, the pavage is of the peculiar structure with plates in parallel, crescentic, rope-like rows, arching downward as if suspended from the arms. The term "pavage" is applied to the morphological feature of these forms where the interbrachial network, connecting the lower portion of the arms, has a deceptive, superficial aspect due to rugose surface growth. The main components of these areas are modified pinnules that have become fixed into the calyx wall. Springer (1917, pl. 4) has shown the proper relationship of interbrachial plates for *Scyphocrinites elegans* from Missouri. The free arms have well-rounded exteriors and the low, wide brachials appear to be uniserial; however this appearance is superficial because the arms are in effect biserial. The pointed termination of alternating brachials is at the lateral sides of the arms and is obscured from ready observation. The adjacent two brachials utilize the space afforded for expansion to provide a wider base for the attachment of long, slender pinnules with well-rounded exteriors.

A small paratype, OU 4605, has only twelve secundibrachs. Another paratype, OU 4606, consisting of some arms down to the third or fourth secundibrach, indicates the existence of 22 or 23 secundibrachs. The specimen would not have been much larger than paratype OU 4605. In the specimen having an appreciable portion of the arms, the next bifurcation in most rays is with about the forty-sixth tertibrach. One outer ray does not bifurcate, but the two inner rays and the other outer ray do.

Considerable attention has been given to the column of *Scyphocrinites elegans*. In his study of *"Camarocrinus,"* Schuchert (1904, text-fig. 42) showed transverse sections through the stalk near the calyx of *Scyphocrinites elegans* from Bohemia and of a thick stem of *Camarocrinus ulrichi* near the roots (which merge into the bulbous structure). In the former is a large quinquelobate canal, but in the latter, which is about half the diameter of the former, the axial canal is small and sharply stellate. On this basis Schuchert concluded that it did not appear the two parts could belong to one animal. But Springer (1917) showed the above condition to be typical for the stem of *Scyphocrinites elegans* as represented by specimens from the Devonian of Missouri. He showed the axial canal to be large and obtusely pentagonal in the upper part of the stem, and to be small and sharply stellate in the distal part of the stem. The canal is composed of a series of circular, biconcave chambers, or lenses, separated by thin partitions, which are pierced by the pentagonal or stellate canal. The axial canal is well defined in the base of one paratype and in the fourth columnal of another paratype of *Scyphocrinites cinctus*. It is of medium size with a decidedly quinquelobate outline. The lobes do not reflect either radial or interradial positions. In the alternating columnals the shorter segments have almost the same width as the longer segments. In some specimens a sharp-crested ridge marks the midsection of the segment. In paratype OU 4605, the crown is definitely tilted on the stem, with the shorter angle on the posterior side. Four well-developed columnals are visible on the anterior side with only three, plus the incipient tips of the proximal columnal, showing on the posterior side.

The holotype has a calyx length of 84 mm to the axillary secundibrach, and an average width of 46 mm. Paratype OU 4605 has a length of 29.5 mm to the axillary secundibrach and an average width of 25 mm. Paratype USNM 6211 appears to be undistorted (but with lowermost portion of calyx missing), and it has a maximum width of 63 mm and minimum width of 46 mm.

The specific name *cinctus* is a Latin adjective meaning girded.

Types and occurrence.—Types are from the Henryhouse Formation in Pontotoc County, Oklahoma. Holotype USNM 6210 is from SE¼ NE¼ SE¼ sec. 5, T. 2 N., R. 6 E.; paratype USNM 6211 is from east roadside ditch, SE¼ SE¼ NE¼ sec. 5, T. 2 N., R. 6 E.; paratype USNM 6273 is from SW¼ SE¼ SW¼ sec. 33, T. 2 N., R. 6 E.; paratypes OU 3642 and 4715 are from Cedar Hill near C SE¼ sec. 4, T. 2 N., R. 6 E.; paratype OU 4605 is from bench above stream near C sec. 10, T. 2 N., R. 6 E.; paratype OU 4606 is from SW¼ SW¼ SW¼ sec. 32, T. 3 N., R. 6 E.; paratype OU 4673 is from glade on south side of creek, SE¼ SE¼ sec. 28, T. 3 N., R. 6 E.

Fragmentary specimens and occurrence.—Specimens are from Henryhouse Formation in Carter County, Oklahoma. OU 4674, three plates of a large *Scyphocrinites* sp., is from U. S. Highway 77, west of Tulip Creek, NW¼ SE¼ sec. 25, T. 2 S., R. 1 E.; OU 4675, partial calyx of *Scyphocrinites,* is from glade west side of Henryhouse Creek, SE¼ sec. 30, T. 2 S., R. 1 E.; OU 4676, large *Scyphocrinites* is from Sparks Ranch, SE¼ SE¼ sec. 35, T. 1 S., R. 2 W.

Scyphocrinites cinctus? Strimple

Plate 11, figures 2, 3; plate 12, figure 5

Bulbous roots, formerly known as *Camarocrinus,* occur in the Henryhouse Formation, although they do not seem to have been nearly so prolific as in the Haragan Formation. They appear to be more or less limited to a specific zone over a wide area, high in the formation. Two years ago I found two small bulbs, each approximately 9.5 cm wide, just below the zone that produced the magnificent crowns that are holotypes of *Synchirocrinus divisus, Asaphocrinus densatus, Euspirocrinus cirratus,* and *Lecanocrinus brevis.* These are from the NW¼ SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma. OU 4699 is a small specimen collected by Amsden in the upper scarp in NW¼ SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County. In past years I have observed large bulbs a few hundred feet to the east of the exposure that produced the crowns, and at approximately the same level. A zone of the bulbs has been observed in the exposure opened in recent years for road metal in the SE¼ SE¼ sec. 31, T. 3 N., R. 6 E., Pontotoc County. I did not find a complete specimen, and several that were in situ were imperfect. In former years I have seen the large bulbs along the road in the SE¼ SE¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County.

The bulbs in the Henryhouse Formation have nowhere been found in association with calices or crowns, so assignment to *Scyphocrinites cinctus* is made with reservation.

No confusion is likely in distinguishing between the bulbs from the Henryhouse Formation and those of the Haragan Formation. The large bulbs of the Henryhouse are particularly distinctive. *Scyphocrinites ulrichi,* of the Haragan, has three well-defined lobes, is rather high, and typically has a wide collarlike development surrounding a well-defined root system that connects to the base of the column. *Scyphocrinites cinctus*? has no lobate structure and is wide and low; a large segment, where the root system and connection with the column is located, is invariably collapsed and so is poorly defined.

OU 4698, a large specimen from above Bois d'Arc Creek in SE¼ NE¼ sec. 10, T. 2 N., R. 6 E., Pontotoc County, is 16.5 cm wide and 8.5 cm high. Amsden places this specimen in the upper 50 feet of the Henryhouse Formation.

Scyphocrinites gibbosus (Springer), 1917
Plate 7, figure 6

The calyx of *Scyphocrinites gibbosus* is broad and relatively short in contrast to the elongate *Scyphocrinites elegans* or *S. cinctus.* It is widest at about midheight, contracting slightly toward the arm bases. The base is rather small, the interbrachials are not protuberant, and the plates are highly tumid with strong connecting ridges and pits. Four basals form an upflared basal cup. Five radials are in contact all around. Interradials are one in each interray followed by two plates above except the posterior where anal X is followed by three plates above. The first branching is with the second primibrach, the second bifurcation is with the eleventh or twelfth secundibrach, a third branching takes place in all rays, and a fourth branching occurs in most rays at irregular heights. The arms become narrow and are 12.5 cm long in the figured crown. The calyx of the figured crown, USNM 6245, has a width of 46.8 mm and a height to last secundibrach of 42.4 mm.

Hypotypes and occurrence.—Hypotypes USNM 6245, USNM 6214 (five crowns), and OU 4609 are from the Haragan Formation in NE¼ SE¼ sec. 8, T. 1 S., R. 8 E., just south of Hunton townsite, Coal County, Oklahoma.

Genus *LIOMOLGOCRINUS* Strimple, new genus

Genotype.—*Liomolgocrinus dissutus* Strimple, new species.

Range.—Devonian; North America.

Diagnosis.—Calyx ovoid, rapidly expanding base; contraction just above the first secundibrachs. Wide interbrachial areas, about 10 secundibrachs fixed in the calyx; fixed pinnules undifferentiated from intersecundibrachs; lower angle of anal X in notch between right and left posterior radials; wide posterior interradius.

Remarks.—The genus *Liomolgocrinus* is readily differentiated from *Scyphocrinites* by its more simple upper interbrachial areas and the structure of the fixed secundibrachs. In *Scyphocrinites* the pinnules, together with a few interbrachials, form a spectacular network referred to by Springer and others as pavage. In *Liomolgocrinus* the pinnules have lost their identity and appear as ordinary interbrachial plates. The fixed arms of *Scyphocrinites* have four or five long secundibrachs, after which the rays change direction, or jog, and shortly above that point the brachials are short, with strongly rounded exteriors. The arms of the present form do not abruptly change course, and neither do the brachials change their structure to any appreciable degree. *Liomolgocrinus* probably evolved from a form like *Scyphocrinites pratteni.*

The generic name *Liomolgocrinus* is derived from the Greek terms *leios* (smooth) and *molgus* (hide).

Liomolgocrinus dissutus Strimple, new species

The calyx of *Liomolgocrinus dissutus* is large, long, and larger below than above, with the base forming a broad angle. Plates are low or mildly convex; light median ridges are indicated but the brachials do not project appreciably. The posterior interradius is rather wide with two large anal plates in contact with the left posterior radial, but only one is in contact with right posterior radial. The species lacks the pronounced change of direction, or jog, of the secundibrachs such as has *Scyphocrinites* with the fourth or fifth secundibrach. The upper secundibrachs retain a moderate length with only nine or ten SBrBr to a ray. The fixed pinnules are not differentiated from normal interbrachial plates. The calyx of the holotype is 62 mm high; its greatest width is 50 mm and its width toward arm bases is 43 mm (Springer, 1917).

The specific name is the Latin adjective *dissutus,* meaning unstitched, opened.

Holotype and occurrence.—The holotype, figured by Springer (1917, pl. 9, figs. 2a, 2b) is from the Haragan Formation near Dougherty, Murray County, Oklahoma.

Family EUCALYPTOCRINITIDAE Bassler

Genus *EUCALYPTOCRINITES* Goldfuss, 1826

Eucalyptocrinites pernodosus (Springer), 1926

Plate 7, figures 1, 2

Some specimens of *Eucalyptocrinites pernodosus* from Oklahoma are more spectacular in the protrusion, or knoblike projection, of various cup plates than are the type specimens from the Brownsport Formation of Tennessee, but they all have in common the deep basal invagination with the large basal plates curving out of the concavity to become large protuberant elements.

The smallest observed hypotype from Oklahoma, USNM 6242, has a cup width of 11.1 mm and a height of 6.1 mm to the top of the interbrachial partitions. The largest observed hypotype from Oklahoma, USNM 6231a, has a cup width of 33.2 mm and a height of 19.6 mm to the top of interbrachial partitions.

A basal view of hypotype OU 4708 (pl. 7, fig. 1) shows long, groovelike ornamentation on the basal plates. This feature has not been observed on other specimens.

Hypotypes and occurrence.—Hypotypes are from the Henryhouse Formation in Pontotoc County, Oklahoma. USNM 6231a and probably USNM 6228 and 6242 are from SW¼ NW¼ NW¼ sec. 33, T. 3 N., R. 6 E.; USNM 6213 is probably from the NW¼ SW¼ sec. 4, T. 2 N., R. 6 E.; USNM 6212 and 6219 are from SW¼ NW¼ NW¼ sec. 33, T. 3 N., R. 6 E.; OU 4708 is from SW¼ NE¼ SW¼ sec. 4, T. 2 N., R. 6 E.; OU 4709 is from a road ditch in center west line of sec. 32, T. 3 N., R. 6 E.

Eucalyptocrinites milliganae (Miller and Gurley), 1895
Plate 7, figure 3

The high cup with an even cup expansion and deep basal impression readily distinguishes *Eucalyptocrinites milliganae*. The type level and locality are the Beech River Limestone Member, Brownsport Formation, Niagaran, Silurian, Decatur County, Tennessee. Three specimens have been found in the Henryhouse Formation of Oklahoma.

Hypotypes and occurrence.—Hypotypes are from the Henryhouse Formation in T. 2 N., R. 6 E., in Pontotoc County, Oklahoma. OU 4671 is from Chimneyhill Creek, NW¼ SW¼ sec. 4 (185 feet to 205 feet above base of formation); OU 3636 is from NE¼ SE¼ SE¼ sec. 4; OU 4672 is from NW¼ sec. 33.

Family MARSUPIOCRINIDAE Jaekel

Genus *MARSUPIOCRINUS* Morris, 1843

Marsupiocrinus stellatus communis Strimple, new subspecies
Plate 6, figures 5-9

Specimens of *Marsupiocrinus stellatus communis* from the Henryhouse Formation of Oklahoma are close to, but not identical with, *Marsupiocrinus stellatus* (Troost) from the Beech River Member, Brownsport Formation at Tuck's Mill, Decatur County, Tennessee. The Oklahoma specimens attain a greater size, and have larger and fewer plates in the tegmen, with the ambulacra poorly defined. In addition, the Oklahoma specimens have a proportionately deeper dorsal cup and a lesser arched tegmen than have typical representatives from Tennessee. Oklahoma specimens may represent another species, probably closely related to a form figured by Springer (1926, pl. 17, fig. 10). Springer noted of this specimen, in the plate explanation, ". . . figure 10 may not belong here, dorsal side not being exposed." It was figured as *M. stellatus* but is atypical. Because this genus has so many species, a comprehensive resurvey of the entire group should be made before another species is proposed, and therefore I have isolated the Oklahoma form as a subspecies, *M. stellatus communis*.

The smallest observed specimen, USNM 6255a, has a cup width of 16.0 mm, a height to arm facets of 2.0 mm, and a height to top of tegmen of 8.8 mm. The largest observed undistorted specimen has a cup width of 36.8 mm, a height to arm facets of 7.0 mm, and a height to top of tegmen of 20.4 mm.

A discussion of the internal structure of the basal circlet is given under the section, "Evidence of the Living Chambered Organ or Plexiform Gland."

The name of the new subspecies is the Latin adjective *communis,* meaning common, general.

Types and occurrence.—Types are from the Henryhouse Formation in Pontotoc County, Oklahoma. Holotype USNM 6222a and paratypes USNM 6222b and 6242 (basal disk) are from NW¼ NW¼ sec. 33, T. 3 N., R. 6 E.; paratypes USNM 6226, 6255a, 6255b, and 6225 (basal disk) are from NW¼ SW¼ sec. 4, T. 2 N., R. 6 E.; paratype OU 4716 is from C N½ SW¼ sec. 4, T. 2 N., R. 6 E.

Family PATELLIOCRINIDAE Angelin

Genus *ALLOCRINUS* Wachsmuth and Springer, 1889

Allocrinus irroratus Strimple, new species

Plate 8, figures 3-7

Allocrinus irroratus, represented in the collections by two specimens, has a low, basin-shaped cup. Because the base of the holotype appears concave whereas that of the paratype is mildly convex, the base of the holotype must have collapsed during preservation. Three basals are of equal size and five large radials are marked by pronounced ridges, or elongate nodes. The lateral sides of each radial project above the articular facets, and the holotype has a node on each extension. Articular facets do not fill the widths of the radials. One facet is exposed in the holotype and shows no fossae for muscles or ligaments. Some fine crenulations are at right angles to the edge of the plate. A shallow notch is present for the food groove. Each interray has one interbrachial plate. In the holotype the interbrachials are well above the articular facet, but in the paratype their proximal angles extend below the level of the articular facet. In the holotype, the IBrBr are marked by two or three sharp spines and several tegmen plates have fine, spinelike nodes. The tegmen is low except for the extension of the anal opening, which is to one side (posterior?) and is surrounded by minute plates. The tegmen plates are relatively large. Food grooves, with minute covering plates, extend from the arms onto the outer portions of the tegmen. Branching takes place with the first primibrach in all rays. Only two secundibrachs are preserved, but the arms separate after the first secundibrach. From all indications the arms extended outward and might have been more or less recumbent, though of course they might have curved upward.

Measurements in millimeters.

	Holotype	*Paratype*
Width of cup	10.4	8.2
Height of cup (to base of IBr)	1.8	1.5
Over-all height of calyx (including tegmen)	7.3	6.2

Remarks.—*Allocrinus irroratus* is atypical of the genus and agrees with the species *A. divergens* Strimple (1952) in branching with the first primibrach rather than with the second. *A. divergens* has a smooth, unornamented cup as contrasted to the highly ornate cup of *A. irroratus.*

The specific name is the Latin adjective *irroratus,* meaning covered with granules.

Types and occurrence.—Types are from the Henryhouse Formation in Pontotoc County, Oklahoma. Holotype OU 4655 is from the bench above the stream near C sec. 10, T. 2 N., R. 6 E., and paratype OU 4662 is from near center west line sec. 32, T. 3 N., R. 6 E.

Allocrinus divergens Strimple, 1952

The holotype (a monotype) of *Allocrinus divergens* is a crown, USNM S 4789, from the Henryhouse Formation in NW¼ SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma. No additional material has been found.

Allocrinus globulus Strimple, new species

Plate 10, figures 2-4

Allocrinus globulus is represented by a single incomplete dorsal cup, with the lower segments of the arms attached. The contour of the cup, as preserved, is globular and the arms are directed outward. The outer surfaces of the radials, interbrachials, and brachials are covered by fine vermicular markings at right angles to the interradial sutures. The radials are large, the articular facets are narrow, and the lateral sides extend above the facets. A single, interbrachial occupies each interray and extends below the level of the articular facet of the radial. In one interray, a rather large second IBr and two small IBrBr are present in the next series, indicating the probable posterior nature of the interray. The anal opening appears to have been small and to have been toward the anterior side of the tegmen. The food grooves are raised and have minute covering plates. First branching of the arms takes place with the second primibrach.

Measurements in millimeters.

	Holotype
Width of cup	8.8
Height of cup (to base of IBr, as preserved)	2.0
Over-all height of cup (including tegmen, as preserved)	6.8

Remarks.—*Allocrinus globulus* is readily distinguished from *A. divergens* and *A. irroratus* in having two primibrachs and a wide posterior interradius. The latter two species are atypical of the genus and probably represent an undescribed genus.

Holotype and occurrence.—Holotype OU 4652 is from the Henryhouse Formation near C sec. 10, T. 2 N., R. 6 E., Pontotoc County, Oklahoma.

Genus *MACROSTYLOCRINUS* Hall, 1852

Macrostylocrinus laevis Springer, 1926
Plate 8, figure 1

Macrostylocrinus laevis is a smooth form reported by Springer to be plentiful in the Beech River Member, Brownsport Formation, Niagaran, Silurian, in Decatur County, Tennessee. In my limited collecting in the glades of western Tennessee, I do not recall finding a specimen. Allen Graffham found one specimen (hypotype OU 4656) in the Henryhouse Formation, in the prolific yellow zone on a bench above the stream at C sec. 10, T. 2 N., R. 6 E., Pontotoc County, Oklahoma.

Macrostylocrinus striatus Hall, 1864
Plate 8, figure 2

Macrostylocrinus striatus has a wide distribution, having been reported from the Waldron Shale, Niagaran, near Waldron, Indiana, and Iron City, Tennessee, and from the Racine Dolomite, Niagaran, Bridgeport (now part of Chicago), Illinois. A single specimen, OU 4714, was found in the Henryhouse Formaton by Allen Graffham near C N½ SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma.

Family PERIECHOCRINITIDAE Bassler

Genus *SACCOCRINUS* Hall, 1852

Saccocrinus benedicti S. A. Miller, 1892
Plate 10, figures 8, 9

The status of the genus *Saccocrinus* is questionable. The species *S. benedicti* is distinctive and widespread, having been reported as follows: Laurel Limestone, Niagaran, St. Paul, Indiana; Racine Dolomite, Niagaran, Bridgeport (now part of Chicago), Illinois, and Muncie, Indiana; and currently Henryhouse Formation, Niagaran, south of Ada, Oklahoma.

Hypotypes and occurrence.—Hypotypes are from the Henryhouse Formation in Pontotoc County, Oklahoma. OU 4712 is from center south line sec. 32, T. 3 N., R. 6 E.; USNM 6231b is from SW¼ NW¼ NW¼ sec. 33, T. 3 N., R. 6 E.; and USNM 6223 (three specimens) are from NW¼ SW¼ sec. 4, T. 2 N., R. 6 E.

Family CLONOCRINIDAE Bather

Genus *ABATHOCRINUS* Strimple, new genus

Genotype.—*Mariacrinus*? *rotundus* Springer, 1926.

Range.—Silurian; North America.

Diagnosis.—Cup shallow, conical; tegmen high; arm openings directed outward, paired but with a single IBr separating each arm of a ray; basals small, confined to small concavity, number not known; five radials, large, in contact all around; large, first interbrachials (including the posterior interradius) succeeded by two plates above; two first primibrachs fixed; two second primibrachs fixed.

Remarks.—Springer (1926, p. 29) noted that the form he described as *Mariacrinus? rotundus* was ". . . placed here [under *Mariacrinus*] with much doubt." *Mariacrinus* was subsequently referred to synonymy with *Ctenocrinus* Bronn (1840) by Bassler and Moodey (1943), but the species is still listed by those authors as *Mariacrinus? rotundus.* In other words they did not consider that this species should be referred to *Ctenocrinus.*

The only closely comparable form is *Elpidocrinus,* as previously discussed. However *Elpidocrinus* is a dicyclic form. The shallow, small cup with high tegmen is unusual and distinctive.

The generic name *Abathocrinus* is derived from the Greek prefix *a* (without) and the noun *bathos* (depth).

Abathocrinus rotundus (Springer), 1926, new combination

All characters previously ascribed to the genus *Abathocrinus* also apply to *A. rotundus* because it is the genotype and only known species. The holotype is well illustrated by Springer (1926, pl. 5, figs. 12, 12a). The level and locality given by Springer (1926) are Decatur Limestone, Niagaran, below Grandview in the bluffs of the Tennessee River, Perry County, Tennesssee.

Subclass FLEXIBILIA Zittel

Order *SAGENOCRINOIDEA* Springer

Family HOMALOCRINIDAE Angelin

Genus *ASAPHOCRINUS* Springer, 1920

Genotype.—*Asaphocrinus bassleri* Springer, 1920.
Range.—Silurian; North America.
Diagnosis.—RA present; X in line with radials, succeeded by a vertical series of plates; R facets narrow; two PBr in each ray, arms branching isotomously.
Species referred to Asaphocrinus.—

	Occurrence
Asaphocrinus bassleri Springer, 1920	Brownsport Fm.; Tennessee
Asaphocrinus densus, new species	Henryhouse Fm.; Oklahoma
Asaphocrinus excavatus (Ringueberg), 1886	Rochester Sh.; New York
Asaphocrinus incisus (Ringueberg), 1886	Rochester Sh.; New York
Asaphocrinus minor Springer, 1926	Laurel Ls.; Indiana
Asaphocrinus ornatus (Hall), 1852	Rochester Sh.; New York

Asaphocrinus densus Strimple, new species
Plate 9, figures 3-5

Asaphocrinus densus is based upon a magnificent, slightly silicified crown and a completely silicified partial crown. The dorsal cup is conical, with low IBB visible in side view. Sutures between IBB are obliterated in preservation. Five basals are rather small and pentagonal appearing, but they have six sides. The five radials are the dominant cup elements and are wide and essentially pentagonal. The right posterior radial is quadrangular and is smaller than other radials because of the encroachment of a radianal plate, below, and anal X to the left. The RA, showing its primitive inferradial origin in being below RPR, extends across to the LPR so that anal X has no contact with PB. Anal X is pentagonal and is succeeded above by a single series of four plates. The arms branch with the second primibrach in all rays, and another equal branching takes place with the second secundibrach in all rays except the left arm of the right posterior, where a third secundibrach is axillary, and with the left arm of the left anterior, where the first primibrach is axillary. No further branching occurs except in a few inner rays. In the right posterior, the fourth tertibrach is axillary in the inner branch of the left ray. In the right anterior, the third tertibrach is axillary in the inner branch of the left ray. In the anterior, the fourth tertibrachs are axillary in both inner branches. A sharp keel extends the length of each arm. The uneven, or wavy, sutures between brachials, common among the Flexibilia, have not been observed in this species.

Measurements in millimeters.

	Holotype
Height of crown	20.0
Width of crown	19.7
Length of cup (distorted)	8.7
Width of cup (computed average)	12.5

Remarks.—Compared with other species, the arms of *Asaphocrinus densus* appear relatively heavy and have a sharp keel extending their full length. Arrangement and appearance of the plates in the posterior interradius are distinctive.

The specific name is the Latin adjective *densus,* meaning dense, compact.

Types and occurrence.—Holotype OU 4694 and paratype OU 4694a, collected by Melba L. Strimple, are from the Henryhouse Formation, NW¼ SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc Couty, Oklahoma.

Family ICHTHYOCRINIDAE Angelin

Genus *ICHTHYOCRINUS* Conrad, 1842

Ichthyocrinus corbis Winchell and Marcy, 1865
Plate 9, figure 6

One specimen of *Ichthyocrinus corbis* is represented in the collections considered here. It is a magnificent crown, but the basals and infrabasals are not preserved. Because of the limited area involved, they would of necessity be smaller than those of any other figured specimen.

The holotype of the species is from the Racine Dolomite, Niagaran, Silurian, near Bridgeport (now part of Chicago), Illinois. The hypotype, considered here, is OU 4720 from the Henryhouse Formation in SE¼ SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma.

Genus *CLIDOCHIRUS* Angelin, 1878

Clidochirus gratiosus Strimple, new species

Plate 8, figures 9, 10; plate 9, figure 7

Clidochirus gratiosus is represented in the collections at hand by one crown. The base of the cup is broad, the infrabasal plates are covered by the proximal columnal, and the larger portion of the five basal plates participate in the basal area but curve sharply upward to be visible in side view of the cup. Five radials, wider than high, are pentagonal. One large anal X extends well up into the interbrachial area. Both primibrachs are low and wide, but the first is nonaxillary and the second is axillary. A second bifurcation takes place with the third to fourth secundibrach. A fracture of the brachials in the left posterior arm produces an appearance of a series of anal plates.

Measurements in millimeters.

	Holotype
Height of crown (as preserved to sixth tertibrach)	12.0
Width of crown (as preserved)	15.2
Height of cup	3.0
Width of cup	7.5
Width of proximal columnal	2.1

Remarks.—I have been unable to distinguish a radianal plate in *Clidochirus gratiosus,* a feature which is shared with *C. keyserensis,* if valid for the present species. The cup plates and brachials of the latter species are quite tumid and give a distinctive, grooved appearance to the crown. *C. keyserensis* also has a series of anal plates, in contrast to the single anal plate of *C. gratiosus.* Other species of the genus have upflared infrabasals and narrow bases.

The specific name is the Latin adjective *gratiosus,* meaning popular, acceptable.

Holotype and occurrence.—Holotype OU 4707 is from the Haragan Formation at Hunton townsite, sec. 8, T. 1 S., R. 8 E., near Clarita, Coal County, Oklahoma.

Family LECANOCRINIDAE Springer

Subfamily LECANOCRININAE Bowsher

Bowsher (1953) proposed Lecanocrininae as a subfamily of Lecanocrinidae with only the genus *Lecanocrinus* Hall, 1852, and three subgenera, *Lecanocrinus* (sensu stricto) Hall, 1852, *Geroldicrinus* Jaekel, 1918, and *Miracrinus* Bowsher, 1953. Bowsher diagnosed the subgenus *Geroldicrinus* as "lecanocrinids with the anal X well developed but RA much reduced by resorption, IBB subhorizontal and nearly confined to the basal concavity. The arms are short, not coiled upon themselves at distal ends, and divide only twice isotomously."

Although the "principal" type specimen of *Geroldicrinus roemeri* (Schultze) has a small triangular RA (obviously reduced by resorption), of the two other type specimens figured by Springer (1920, pl. 3, figs. 31, 32) one has a normal RA and the other a long narrow RA. Springer (1920) reported that only seven specimens were found by Schultze. It seems to me that the abrupt excavation of the base, with the IBB confined to the basal concavity, is a far more important feature and should be carefully designated in any definition of the species or genus. This same condition prevails in Bowsher's subgenus *Miracrinus,* and he carefully explained the abrupt excavation and that IBB would be entirely covered if the proximal columnal were present for this form.

Bowsher (1953, p. 7, 8) assigned *Lecanocrinus soyei* Oehlert to *Geroldicrinus.* In this species the IBB extend out of and beyond the basal impression but are still not visible in side view of the cup. This same type of base is found in the Silurian species *Lecanocrinus pisiformis* (Roemer) and another Devonian species, *L. huntonensis* Strimple. I suggest that *L. soyei* remain under *Lecanocrinus* pending additional information.

The IBB of *L. magniradialis* (Weller) is entirely covered by the column and therefore the species could be referred either to *Geroldicrinus* or to *Miracrinus,* as currently defined. Bowsher

(1953, p. 7) tentatively referred it to *Miracrinus,* which seems satisfactory from existing evidence, although, of course, the arms of the species are unknown.

Bowsher (1953) placed considerable stress upon a condition of the arms which he considered to be suturally united for a considerable portion of their length. Examination of his illustration of *Miracrinus perdewi* Bowsher (1953) discloses the irregularity of the lateral sides of brachials that are closely met by compensating projection or retraction of the lateral sides of adjoining brachials, whether they are of the same ray or of adjacent rays. One would assume that rigidity was attained through close sutures, and I believe that such was the case in this instance. My only hesitation is due to observation of similar structure in the arms of some Pennsylvanian inadunate crinoids, wherein the brachials of one ray fit close to the irregular lateral sides of adjoining rays. Proof that true rigidity, or close suture, was not attained is obvious when specimens are preserved with the arms slightly separated (see Strimple, 1961, pl. 11, fig. 7, for *Plaxocrinus normalis* Strimple).

I believe that the arms of *Lecanocrinus brevis* Strimple probably are rigid in their proximal portions.

I agree completely with Bowsher (1953) in assuming that *Miracrinus* probably evolved from a species like *Lecanocrinus macropetalus.* The arms of *Miracrinus perdewi* are much like those of the latter species, other than for close sutures in the lower arms and greater length with more coil in distal portions of the arms of *M. perdewi.* To produce the cup structure of *Miracrinus,* it is only necessary to truncate the base of *Lecanocrinus macropetalus* at the proximal edges of the basals and to lift the IBB slightly into the sharp basal impression, which is a normal, progressive evolutionary action.

It is not my intention to review the entire family at this time, but I am opposed to a subgeneric concept, because it is so unwieldy in systematic usage, if for no other reason. In this particular group, Bowsher (1953) proposed a subgenus *Lecanocrinus* (sensu stricto) Hall (1852), defining it as "IBB erect and visible from sides." This leaves no provision for the species *Lecanocrinus pisiformis, L. waukoma,* or *L. meniscus.* Bowsher was also unaware of the species *L. brevis* and *L. invaginatus* (Silurian) and *L. huntonensis* (Devonian), the IBB of which are neither erect nor visible from the side. If the subgeneric concept were followed, two more subgenera would be required. Instead I propose that *Lecanocrinus* and *Geroldicrinus* be returned to full generic stature and that *Miracrinus* be elevated to full generic stature.

Several factors among representatives of the Lecanocrininae that are not adequately accentuated in comparative studies appear to me to be of primary concern. These are in connection with the shape and structure of the base of the cup and with the absence of extension of the anal X into the area above the summit of the cup. A typical representative of *Lecanocrinus* is a more or less conical cup with IBB plainly visible in side view of the cup. Within this generalized group are three species, *L. fascietatus, L. papilloseous,* and *L. lindenensis,* having low IBB circlets. The anal X of most of the species extends well above the summit plane of the radials, but in two species from the Silurian of Gotland, *L. fascietatus* and *L. lindströmi,* the summit of anal X is an obtuse angle with only the low apex extending above the cup summit so that the first primibrachs of the right and left posterior rays meet over the anal X. The three previously mentioned Silurian species of this group and the following listed Silurian species of the group have the anal X extending well above the cup summit: *L. erectus, L. billingsi, L. angulatus, L. bacchus, L. solidus, L. pusillus,* and *L. macropetalus.*

In the next group, we are dealing with a medium or high conical cup in which the IBB are not visible in side view of the cup but nevertheless extend beyond the columnar impression of the base. One Silurian species, *Lecanocrinus pisiformis,* and two Devonian species, *L. huntonensis* and *L. soyei,* have this pattern. Each of the Devonian species has the anal X only slightly above the summit plane of the radials with right and left posterior first primibrachs meeting above. Anal X of *L. pisiformis* extends well above the summit of the cup in most specimens.

The most distinctive group has a low, broad cup with the IBB and a good portion of the basals participating in a broad, shallow basal concavity. Also present is a sharply impressed area for the columnar attachment that may or may not cover the IBB. The species are *L. brevis, L. waukoma, L. meniscus,* and *L. invaginatus,* all of Silurian age.

This leaves a group having a more or less conical cup with IBB confined to a sharply depressed basal area. All of the forms, *Miracrinus magniradialis, M. perdewi,* and *Geroldicrinus roemeri,* are of Devonian age. The latter species has anal X with an obtuse angle above, but the "principal" type figured by Springer (1920) has the X succeeded by a single series of small anal plates.

Genus *MIRACRINUS* Bowsher, 1953

Genotype.—*Lecanocrinus* (*Miracrinus*) *perdewi* Bowsher, 1953.

Diagnosis.—A lecanocrinid with bowl-shaped cup, IBB hidden in basal concavity by the column, with the arms suturally united laterally for nearly half of their length, arms long, with considerably reduced TBrBr series in the inner part of each ray, and arms tightly coiled upon themselves at distal ends.

Occurrence.—Lower Devonian; New Jersey.

Remarks.—*Miracrinus* was proposed by Bowsher (1953) as a subgenus and is here elevated to full generic status.

Genus *LECANOCRINUS* Hall, 1852

Genotype.—*Lecanocrinus macropetalus* Hall, 1852.

Range.—Silurian, Devonian; North America, Europe, Australia.

Diagnosis.—Crown short, rotund; IBB extending beyond stem; radials in contact except in posterior interradius; arms incurving at tips; RA present.

Species assigned to Lecanocrinus.—

	Occurrence
Lecanocrinus angulatus Springer, 1920	Gotlandian, Silurian; Dalheim, Gotland
Lecanocrinus bacchus (Salter), 1873	Wenlock Ls., Silurian; Dudley, England
Lecanocrinus billingsi Angelin, 1878	Gotlandian, Silurian; Wisby, Gotland
Lecanocrinus breviarticulatus Chapman, 1934	Silurian; Yass, New South Wales, Australia
Lecanocrinus brevis Strimple, 1952	Henryhouse Ls., Silurian; Ada, Oklahoma
Lecanocrinus elongatus Springer, 1926	Laurel Ls., Silurian; St. Paul, Indiana
Lecanocrinus erectus Strimple, 1952	Henryhouse Ls., Silurian; Ada, Oklahoma
Lecanocrinus fascietatus (Angelin), 1878	Gotlandian, Silurian; Gotland

Lecanocrinus huntonensis Strimple, 1952	Haragan Ls., Helderbergian, Devonian; Clarita, Oklahoma
Lecanocrinus invaginatus Strimple, 1952	Henryhouse Fm., Silurian; Ada, Oklahoma
Lecanocrinus lindenensis Strimple, 1952	Lobelville Ls., Brownsport, Silurian; Linden, Tennessee
Lecanocrinus lindströmi Springer, 1920	Gotlandian, Silurian; Hoberg, Gotland
Lecanocrinus macropetalus Hall, 1852	Rochester Sh., Silurian; Lockport etc., N. Y., and Grimsby, Ontario, Canada Louisville Ls., Silurian; Louisville, Ky.
Lecanocrinus magniradialis (Weller), 1905*	New Scotland Ls., Helderbergian, Devonian; Nearpass quarry, Delaware Valley, New Jersey
Lecanocrinus meniscus Springer, 1920	Beech River Memb., Brownsport Ls., Silurian; Decatur Co., Tennessee
Lecanocrinus papilloseous Strimple, 1954	Henryhouse Fm., Silurian; Ada, Oklahoma
Lecanocrinus pisiformis (Roemer), 1860	Niagaran, Silurian; Decatur, Perry, and Wayne Counties, Tenn. (Beech River Ls., Brownsport Fm.); Lockport, N. Y. (Rochester Sh.); Racine, Wis. (Racine Dol.); near St. Marys, Mo. (Bainbridge Ls.); near Linden, Tenn. (Lobelville Sh.); Newsom, Tenn. (Waldron Sh.); Louisville, Ky. (Louisville Ls.); St. Paul, Ind. (Laurel Ls.).
Lecanocrinus pusillus (Hall), 1863	Niagaran, Silurian; Waldron, Ind.; Newsom, etc. Tenn. (Waldron Sh.); Racine, Wis. (Racine Dol.)

* Currently assigned to *Miracrinus*.

Lecanocrinus solidus Ringueberg, 1886	Silurian; Lockport, N. Y. (Rochester Sh).
Lecanocrinus soyei Oehlert, 1882	Devonian; Sable, Sarthe, France
Lecanocrinus waukoma (Hall), 1865	Racine Dol., Silurian; Racine and Waukesha, Wis. Bridgeport, etc. near Chicago, Ill.

Remarks.—The genus has been discussed under the remarks for the subfamily earlier in the study under the section "Portentum." I expect that more comprehensive studies will disclose the existence of several genera within the species currently assigned to *Lecanocrinus*.

A few specimens have been noted containing depressed strips or depressions that follow the outline of cup plates. The illustration of the type figured by Angelin as *Cyrtidocrinus fascietatus* shows this feature. According to Springer (1920), the type specimen cannot be identified. Angelin thought the species had four "basalia" (infrabasals) and therefore proposed the genus *Cyrtidocrinus* for its reception. The species is probably not valid. A specimen of *Lecanocrinus macropetalus* figured by Springer (1920, pl. 3, figs. 8a, 8b) shows the depressed strips. Springer (1920, p. 135) noted that the principal specimen of *L. lindströmi* Springer has the same type of depressed strips. Depressions on the basals of one specimen of *L. bacchus* (Salter) are of the nature under consideration. The same type of grooves is present on the figured metatype of *Lecanocrinus brevis* (pl. 9, fig. 1). Probably these grooves were caused by differential weathering as a result of semistationary stages in the growth of the plates.

Despite the differences in cup shapes, *L. brevis* and *L. erectus* have certain features in common. Each has rather short arms that rise vertically and then curve sharply inward, almost at right angles, to produce a nearly horizontal summit. Possibly the brachials forming the lateral sides of the arm-dome are united by rigid suture. The radial plates, lacking lateral surface curvature, have acute angles at their suture lines. Each species has a relatively large radianal plate. Essential differences lie in the broad, low calyx, with the protruded posterior area of *L. brevis* in contrast to the high, erect cup of *L. erectus*. A broad, low cup may be the result of mechanical activity, as discussed in the earlier part of this study. The results of stream or current activity have been noticed among other forms. No intermediate forms between *L. brevis* and *L. erectus* have been observed, so apparently no cross breeding occurred. Even though they are found preserved together, they might have lived in different bathymetric conditions, or they could have had different mating periods.

A small selection of five dorsal cups (OU 4713) was collected in situ by Allen A. Graffham from the *Diacalymene* layer of the Henryhouse Formation in the creek bed at C SW¼ sec. 4, T. 2 S., R. 6 E., Pontotoc County, Oklahoma. These specimens have been mentioned under the section on "Associated Parasitic Life" because they all show traces of attack by boring organisms. They are neither weathered nor silicified and therefore disclose delicate surface ornamentation and well-defined sutures between plates. Almost all of the specimens are larger than the original types of *Lecanocrinus papilloseous,* but all except one have the granular-type ornamentation. One specimen has a vermicular-appearing surface, much like the surfaces of some crinoids from the Brentwood Limestone (Morrowan) of northeastern Oklahoma. The specimens could be referred to *L. invaginatus* if that species concept were slightly modified.

Lecanocrinus angulatus Springer, 1920

Lecanocrinus angulatus presents an interesting situation because it is based upon a single specimen (monotype), which is abnormal in having four basals rather than five, the latter number being typical of the genus. The abnormality does not enter into the specific characters given by Springer; nevertheless a mutant stands as the only type of the species. It seems desirable for a search to be made of all collections from the type locality, "Silurian, Wenlock Group, horizon d: Dalheim, Gotland," in an effort to find additional specimens of *L. angulatus* in order to give it a thoroughly valid standing.

Springer (1920, pl. 11, fig. 24a) showed a well-defined row of interbrachials from the secundibrachs upward in one interray, which is atypical for the genus. Springer considered the occurrence to be a sporadic condition. I have observed an occasional sporadic, single interbrachial, or supernumerary plate, in crowns of *L. papilloseous* from the Henryhouse Formation of Oklahoma.

Lecanocrinus invaginatus? Strimple, 1952

Lecanocrinus invaginatus?, a rather large cup (OU 4695) from the type locality, is atypical in that the tip of one infrabasal plate extends beyond the large basal invagination. In the original types, the lower edges of the basals entered the basal concavity. The present cup is 8.9 mm high and 19.6 mm wide.

Types and occurrence.—Holotype USNM S 4801; paratype USNM S 4802, and atypical specimen OU 4695 are from the Henryhouse Formation, NE¼ SW¼ sec. 10, T. 2 N., R. 6 E., Pontotoc County, Oklahoma.

Lecanocrinus papilloseous Strimple, 1954
Plate 10, figure 1

Lecanocrinus papilloseous has much in common with *L. pisiformis;* however the latter species is reported to be smooth, with fewer arms even among specimens larger than typical specimens of *L. papilloseous.* Springer (1926) reported a range in width of 3.5 to 11 mm for dorsal cups of *L. pisiformis,* but it is to be remembered that he had one collection of 225 specimens made by Professor Pate. The average-sized cup that I found in the Brownsport was about 5.7 mm wide at the summit. The normal size of *L. pisiformis* is somewhat smaller than that of *L. papilloseous.*

Some additional information is gained by observation of new material. A small cup of *L. papilloseous* (USNM 6255f) is 4.9 mm wide by 4.1 mm high. In a slightly larger specimen, a crown (US NM 6272), the cup is 7.5 wide by 4.7 mm high. This shows that the cup width increases at a more rapid rate than does its height and that the increase is probably due to the mechanical pressure of the increasing weight of the arms.

The partial crown (USNM 6272) has eight proximal columnals attached. The proximal segment is 1.7 mm wide, and the lowermost segment is 0.7 mm wide. The segments are thin but the eighth has started to thicken. The right anterior arm of the crown has a minor aberration, a supernumerary plate in the position of first secundibrach in the right ray. No plate is preserved in the left ray.

Analysis of the arms is as follows:

	left anterior	left posterior	right posterior	right anterior	anterior
SBr	4 4	4 2+	2+ 3	? 3	1 1
PBr	2	2	2	2	2

The crown has an over-all height of 8 mm of which 4.7 mm is the cup. It has a width of 7.5 mm.

Types and occurrence.—All types and specimens are from the Henryhouse Formation, Pontotoc County, Oklahoma. The holotype and figured paratype (Strimple, 1954) cannot be found in the Springer Collection of the U. S. National Museum where they were supposedly deposited (Porter Kier, written communication). Apparently they were not formally deposited and probably are somewhere in the large collections acquired at a later date. The holotype is from SW¼ NW¼ NW¼ sec. 33, T. 3 N., R. 6 E.; the paratype is from NW¼ SW¼ sec. 4, T. 2 N., R. 6 E.

Hypotypes USNM 6255f (crown) and 6255 (2 cups) are from NW¼ SW¼ sec. 4, T. 2 N., R. 6 E.; USNM 6243 and 6269 (3 cups) are from near C SW¼ NW¼ sec. 33, T. 3 N., R. 6 E.; USNM 6272 (crown), 6242 (3 cups), 6244, 6267, and 6272 (3 cups) are probably from SW¼ NW¼ sec. 33, T. 3 N., R. 6 E.; OU 4690 and 4691 are from SE¼ SW¼ sec. 4, T. 2 N., R. 6 E.; and OU 4713 (5 cups) is from C SW¼ sec. 4, T. 2 N., R. 6 E.

Specimens OU 5043 and 5046 are from a road cut, 900 feet south of NW cor. sec. 33, T. 3 N., R. 6 E.; OU 5044 and 5045 are from 15 to 25 feet above base, glade in SE¼ SW¼ sec. 4, T. 2 N., R. 6 E.; and OU 4713 (5 cups) are from Chimneyhill Creek, probably SW¼ sec. 4, T. 2 N., R. 6 E.

Lecanocrinus brevis Strimple, 1952
Plate 9, figures 1, 2

Lecanocrinus brevis is one of the more distinctive and important crinoids in the presently considered faunas and is rather well distributed over the Lawrence uplift. When one is aware of the characters of the species, it is easily identified upon casual examination. Its importance lies in the distinctive cup shape. It is quite different from any other lecanocrinid other than *L. waukoma* from the Racine Dolomite of Illinois. This difference is in the low nature of the cup, with IBB not visible in side view and the area about the

RA protruded. More comprehensive discussion is given under the generic remarks and elsewhere.

Analysis of arm structure:

	left anterior	left posterior	right posterior	right anterior	anterior
(OU 4678)					
QBr	1 1 2 1				
TBr	2 3 2 3	2 2 2 2	3 3		2 2 2 1
SBr	3 3	3 3	2 7	2? 3	3 4
PBr	2	2	2	2	2
(USNM 6247a)					
TBr		1 1	2 2 1? 1?	1 1	1 1
SBr		2 3	4 5?	4 3	3 2
PBr		3	2	3	2

Considerable variation in the number of brachials and points of bifurcation occurs in this species.

Types and occurrence.—Types are from the Henryhouse Formation, R. 6 E., Pontotoc County, Oklahoma. Holotype USNM S 4799 and paratype S 4728 are from NW¼ SW¼ sec. 4, T. 2 N.; paratype USNM S 4725 is from SW¼ NW¼ NW¼ sec. 33, T. 3 N.; and paratypes USNM S 4726 and S 4727 are from NE¼ SW¼ sec. 10, T. 2 N.

Hypotypes USNM 6217 (4 cups), 6231, 6247 (2 cups), and 6247a are from SW¼ NW¼ NW¼ sec. 33, T. 3 N.; USNM 6230 (2 cups) and 6255 (2 cups) are from NW¼ SW¼ sec. 4, T. 2 N.; USNM 6266 is from SE¼ SW¼ sec. 10, T. 2 N.; USNM 6270 (2 cups) is from NE¼ SE¼ sec. 32, T. 3 N.; USNM 6269 and 6272 are probably from NW¼ NW¼ sec. 33, T. 3 N.; OU 205 is from SE¼ SE¼ sec. 3, T. 2 N.; OU 4678 (figured crown) is from NE¼ SE¼ sec. 32, T. 3 N.; OU 4688 is from glade south of creek, SE¼ SE¼ sec. 28, T. 3 N.; and OU 4689 is from glade on north side Chimneyhill Creek, SE¼ NE¼ sec. 5, T. 2 N.

Lecanocrinus erectus Strimple, 1952

The original description of *Lecanocrinus erectus* was based upon a cup or cups with the first primibrachs attached. A small crown is now available (USNM 6242) and is described below. Although the present specimen of *L. erectus* is smaller than the holotype of *L. papilloseous,* it has more brachials.

Analysis of arm branching:

	left anterior	*left posterior*	*right posterior*	*right anterior*	*anterior*
TBr	2 3 3 2	2			
SBr	2 2	4 4	4 5	XX	3 3
PBr	2	2	2		2

The center of each group of arms is slightly projected just above the first bifurcation, just below the point at which they curve over to form an almost flat roof to the dome. A ridge occurs at the meeting of the main arms, a feature much like the structure found in *L. brevis.*

Types and occurrence.—All types are from the Henryhouse Formation and, with one exception (hypotype 4686 from upper 12 feet of the formation on the Lykies Ranch, NE¼ NE¼ sec. 2, T. 2 S., R. 2 E., Murray County), from Pontotoc County, Oklahoma. Holotype USNM S 4800 and paratype USNM S 4729 are from SW¼ NW¼ NW¼ sec. 33, T. 3 N., R. 6 E. Paratype USNM S 4730 is from NW¼ SW¼ sec. 4, T. 2 N., R. 6 E.

From sec. 4, T. 2 N., R. 6 E., have come the hypotypes USNM 6230 (2 cups), USNM 6256, and OU 4683 (between 177 and 185 feet above base at Chimneyhill Creek), all from NE¼ SW¼; and OU 4685 from SW¼ SE¼.

From sec. 33, T. 3 N., R. 6 E., have come hypotypes USNM 6247 (3 cups) and OU 3425, from SW¼ NW¼ NW¼; and USNM 6242 and USNM 6272, probably from SW¼ NW¼.

USNM 6270 is from NE¼ SE¼ and OU 4679 (2 specimens from upper 20 feet of the Henryhouse) is from NE¼ NE¼, both from sec. 32, T. 3 N., R. 6 E. OU 4682 (abnormal) is from yellow scarp in NE¼ SW¼ sec. 10, T. 2 N., R. 6 E.; OU 4686 is from SW¼ SW¼ sec. 3, T. 2 N., R. 6 E.; and OU 4687 is from SE¼ SE¼ sec. 28, T. 3 N., R. 6 E.

Lecanocrinus huntonensis Strimple, 1952

The holotype of *Lecanocrinus huntonensis* (USNM S 4803) remains a monotype. Discussion of the genus, including this species, is under the remarks for the subfamily and genus. The type locality of this species is the lower portion of the Haragan Formation, about 15 feet above the *Camarocrinus* (*Scyphocrinites*) *gibbosus* colony zone, Devonian, near Hunton townsite, sec. 8, T. 1 S., R. 8 E., west of Clarita, Coal County, Oklahoma. Discussion of the *Scyphocrinites* colony is given early in this paper, and *S. gibbosus* is considered under specific descriptions.

ORDER TAXOCRINOIDEA SPRINGER

Family TAXOCRINIDAE Angelin

Genus *GNORIMOCRINUS* Wachsmuth and Springer, 1880

Gnorimocrinus pontotocensis Strimple, 1952
Plate 8, figure 8

Gnorimocrinus pontotocensis was proposed for a well-preserved monotype (USNM 136479) from the Henryhouse Formation, SW¼ NW¼ NW¼ sec. 33, T. 3 N., R. 6 E., Pontotoc County, Oklahoma. Another specimen, OU 4654, was found by Allen A. Graffham on the bench above the stream near C sec. 10, T. 2 N., R. 6 E., Pontotoc County. The specimen does not reveal additional information and is designated as a metatype.

Family EDRIOCRINIDAE S. A. Miller

Genus *EDRIOCRINUS* Hall, 1858

Edriocrinus dispansus Kirk, 1911
Plate 10, figures 5, 6

The original type of *Edriocrinus dispansus* Kirk is reportedly from the Linden Formation, Lower Helderbergian, Devonian; Big Sandy River, Benton County, Tennessee. The utter simplicity of these dorsal cups makes identification occasionally difficult, but the low, broad nature of this species is distinctive. Of the six cups under study, two are excellently preserved. One specimen is figured to show the indented cicatrix of the base where it was no doubt attached in a younger stage (pl. 10, fig. 6).

Types and occurrence.—Hypotypes are from the Haragan Formation in Oklahoma. OU 10 and 4660 (4 cups) are from near old

Hunton townsite, sec. 8, T. 1 S., R. 8 E., west of Clarita, Coal County; OU 4658 is from 2.2 miles south, ½ mile east of Fittstown, Pontotoc County.

Fragmentary Remains

Moore and Laudon (1944, p. 207-209) proposed a classification for crinoid fragments, which is used in part here to present four different types of columns. The group designation of *Columnals* is used, but letters rather than names have been adopted to prevent any future reference to the material as species.

Group *COLUMNALS* Moore and Laudon, 1944

Columnal a
Plate 12, figure 1

Columnal a is a circular stem with numerous lateral ridges on the exterior surface. The depressions of the exterior are reflected on the articular surfaces by raised areas with "bundles" of crenulations, and the raised areas of the exterior are reflected as decided grooves, or valleys, on the articular surfaces. The lumen is composed of five groups of more or less double lobes. This is the same type of lumen found in *Marsupiocrinus stellatus communis.*

Figured specimen OU 4697 is from a glade on the north side of Chimneyhill Creek, SE¼ NE¼ sec. 5, T. 2 N., R. 6 E., Pontotoc County, Oklahoma; Henryhouse Formation.

Columnal b
Plate 12, figure 2

This pentagonal stem is figured to illustrate a type in which the lumen is large and pentagonal and in which the surrounding midsection of the articular surface is depressed. The depression of midsection on each side indicates the existence of a pocket between each two columnals.

Figured specimen USNM 6255h, NW¼ SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma; Henryhouse Formation.

Columnal c
Plate 12, figure 4

This pentagonal stem is apparently an internodal plate and is figured to illustrate the quinquelobate lumen and the lack of depression in the area surrounding the lumen. In most respects it is close to *Columnal b.*

Figured specimen USNM 6255i, NW¼ SW¼ sec. 4, T. 2 N., R. 6 E., Pontotoc County, Oklahoma; Henryhouse Formation.

Columnal d
Plate 11, figure 4

This section of a circular stem has ten rows of nodes on the exterior, every other row being the more protuberant. The articular surfaces are poorly preserved, but it appears that the pronounced nodes of the exterior are met by a raised section on the articular surface with the intervening areas (subdued nodes on the exterior) depressed as broad valleys. The lumen of this specimen is rather small and quinquelobate. In some respects the form is comparable to *Columnal a.*

Figured specimen USNM 6251b, SE¼ SW¼ sec. 10, T. 2 N., R. 6 E., Pontotoc County, Oklahoma; Henryhouse Formation.

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Plate 1

Figures 1-4. *Myelodactylus nodosarius* (Hall). 26

1. Hypotype OU 4665, x2.2. Side view of a pointed columnar termination; a cirral cicatrix is in upper left corner.
2. Hypotype OU 4664, x1.5. Oblique side view of a pointed columnar termination.
3, 4. Hypotype OU 4703, x2.2. Side view of pointed columnar termination and view from above showing two rows of large cirri attached.

Figure 5. *Myelodactylus* sp. Specimen USNM 6255g, x1.2. Side view of stem with double row of cirruslike projections. 28

Figures 6-8. *Stylocrinus elimatus*, new species. Holotype OU 4657, x2.5. Dorsal cup viewed from above, side, and base. 34

Figures 9, 10. *Myelodactylus extensus* Springer. Hypotype OU 4721, x1.4. Two views of closed coil. 27

Figure 11. *Pisocrinus varus*, new species. Paratype OU 4680, x1.2. Crown viewed from side. 42

Figures 12-14. *Calceocrinus humilis*, new species. 58

12. Holotype OU 4704, x1.3. Crown viewed from left anterior.
13, 14. Paratype OU 4711, x2. Partial crown viewed from left anterior and left posterior. Proximal columnals are well shown above.

PLATE 1

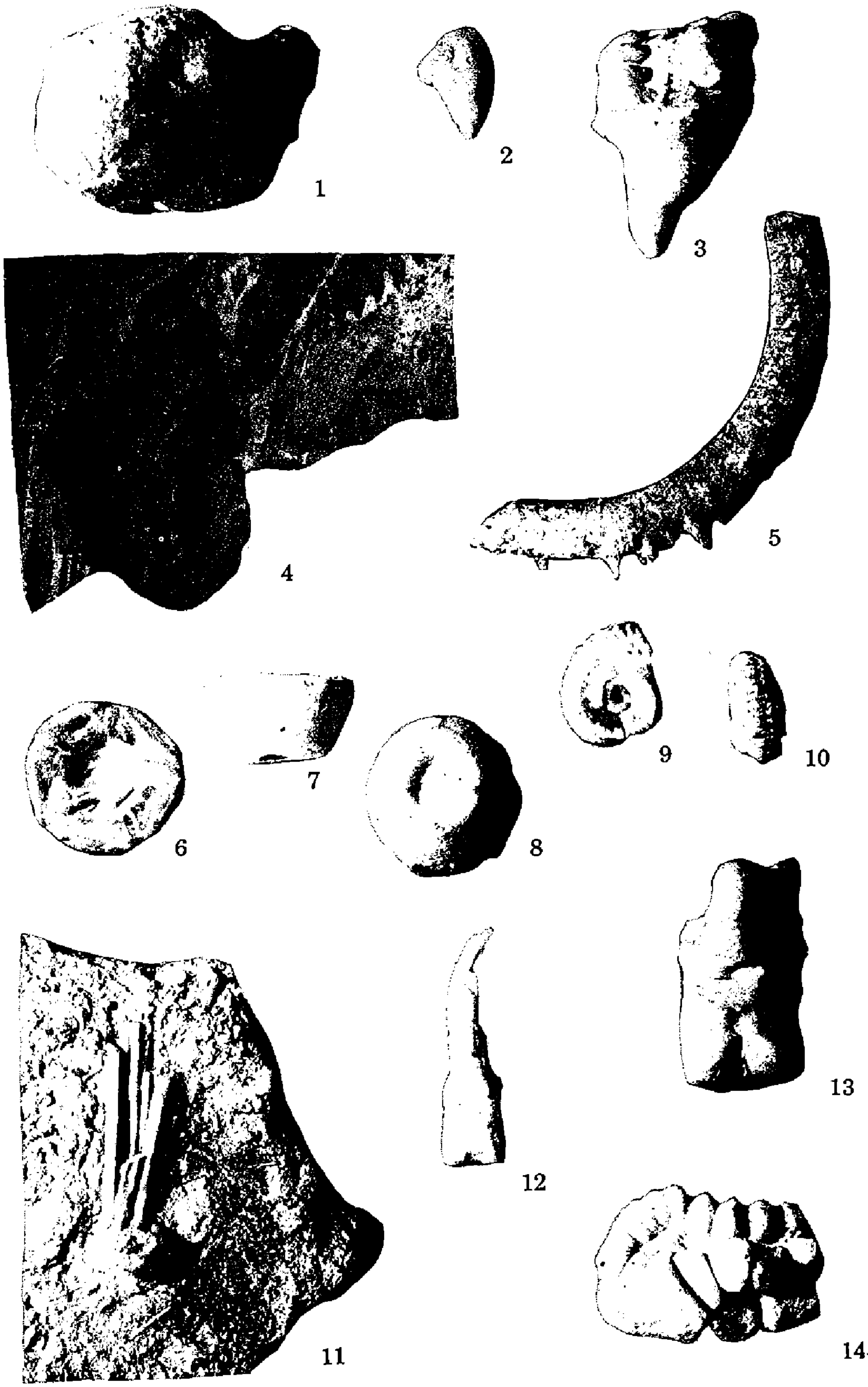

Plate 2

Figures 1-4.	*Synchirocrinus divisus,* new species. Holotype OU 4692, x1.5. Crown viewed from left anterior, anal side, end view of hinge and anal area, and left posterior view. Most sutures are inked.	54
Figures 5, 6.	*Synchirocrinus quadratus,* new species. Holotype OU 4602f, x2.2. View of anal side and left posterior view.	57
Figures 7-9.	*Grypocrinus genuinus,* new species. 7, 8. Holotype OU 4602e, x2.2. View of anal side and left anterior view. 9. Paratype USNM 6232, x2.2. Left anterior view with first primibrach missing.	59
Figures 10, 11.	*Parazophocrinus callosus,* new species. 10. Paratype USNM 6212a, x2.3. View from summit showing oral pyramid. Smooth curved edge of radial plate is at lower extremity. 11. Holotype USNM 6224, x1.2. Basal view.	61

Plate 2

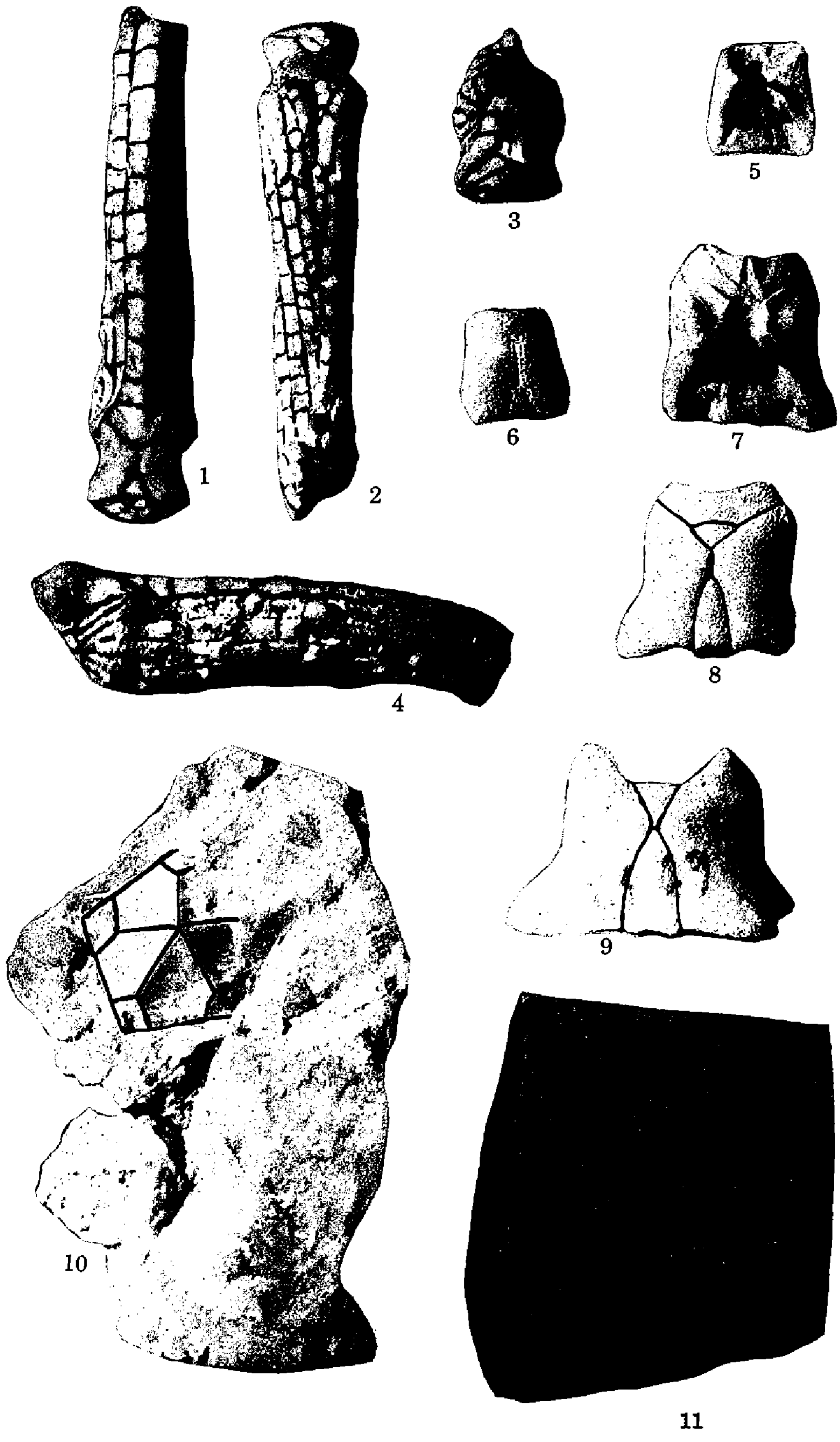

PLATE 3

Figures 1-4.	*Euspirocrinus cirratus*, new species. Holotype OU 4693, x1.2. Crown from posterior, summit, anterior, and base.	65
Figure 5.	*Thalamocrinus elongatus* Springer. Hypotype OU 4661, x2.3. Side view of partial cup.	66
Figures 6, 7.	*Siphonocrinus dignus*, new species. 6. Holotype OU 4696, x1.3. Basal view with posterior interray up. 7. Paratype OU 4650, basal view.	73
Figure 8.	*Neoarchaeocrinus necopinus*, new species. Holotype OU 4608, x1.3. Basal view, posterior interray to upper right.	70

PLATE 3

PLATE 4

Figures 1-3.	*Elpidocrinus exiguus,* new species. Holotype OU 4667, x2.2. View of calyx from summit (tegmen), from right side (anal vent in upper right), and basal view.	79
Figures 4-7.	*Elpidocrinus tuberosus,* new species. Holotype OU 4601, x2.2. View from right side (anal vent in upper right), view from posterior side, summit (tegmen) view, and basal view.	78

PLATE 4

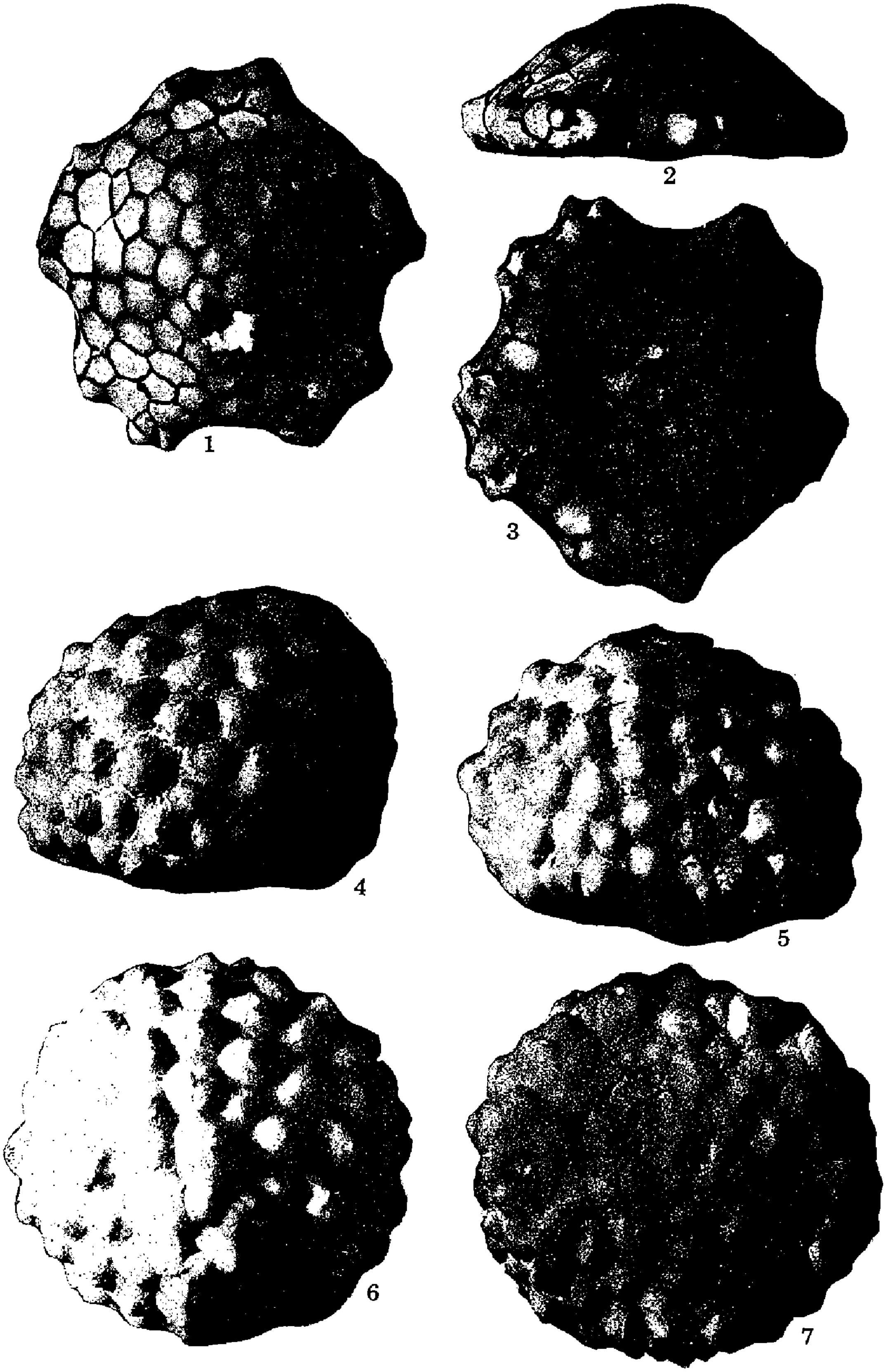

PLATE 5

Figures 1-3.	*Lampterocrinus fatigatus*, new species. 1, 3. Holotype OU 4607, x1.5. From summit (tegmen), and posterior. 2. Paratype OU 4668, x1.5. Side view.	83
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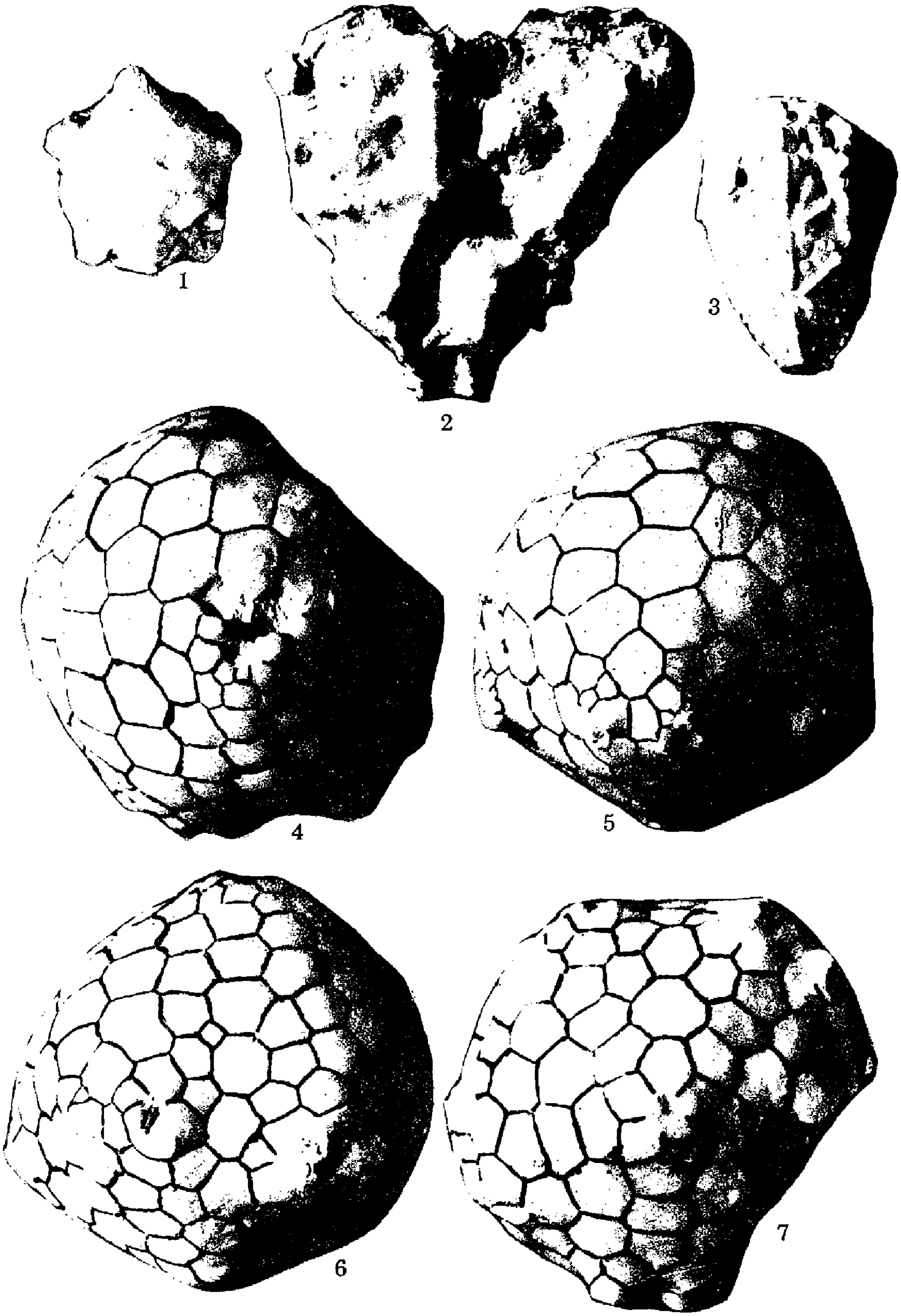

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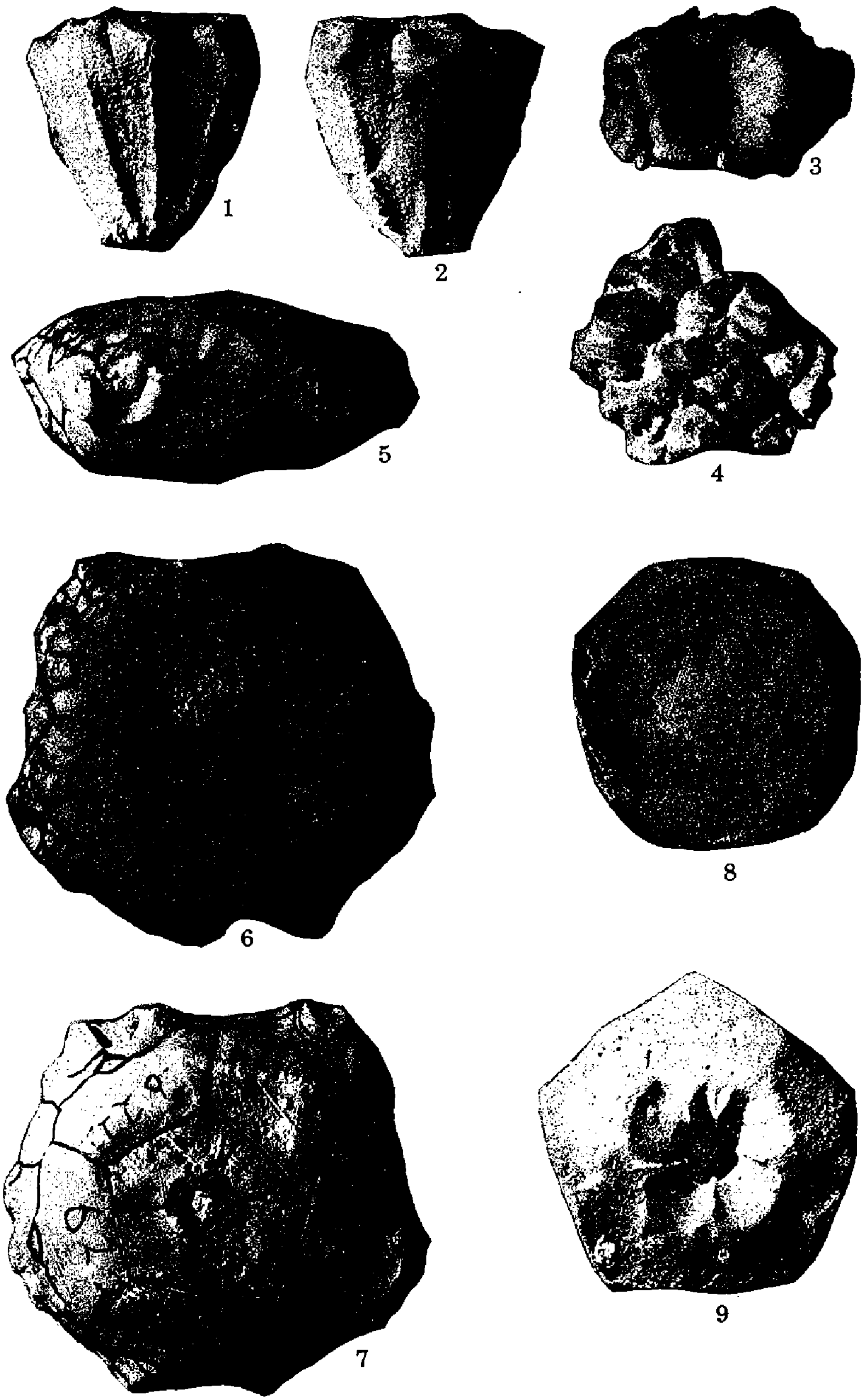

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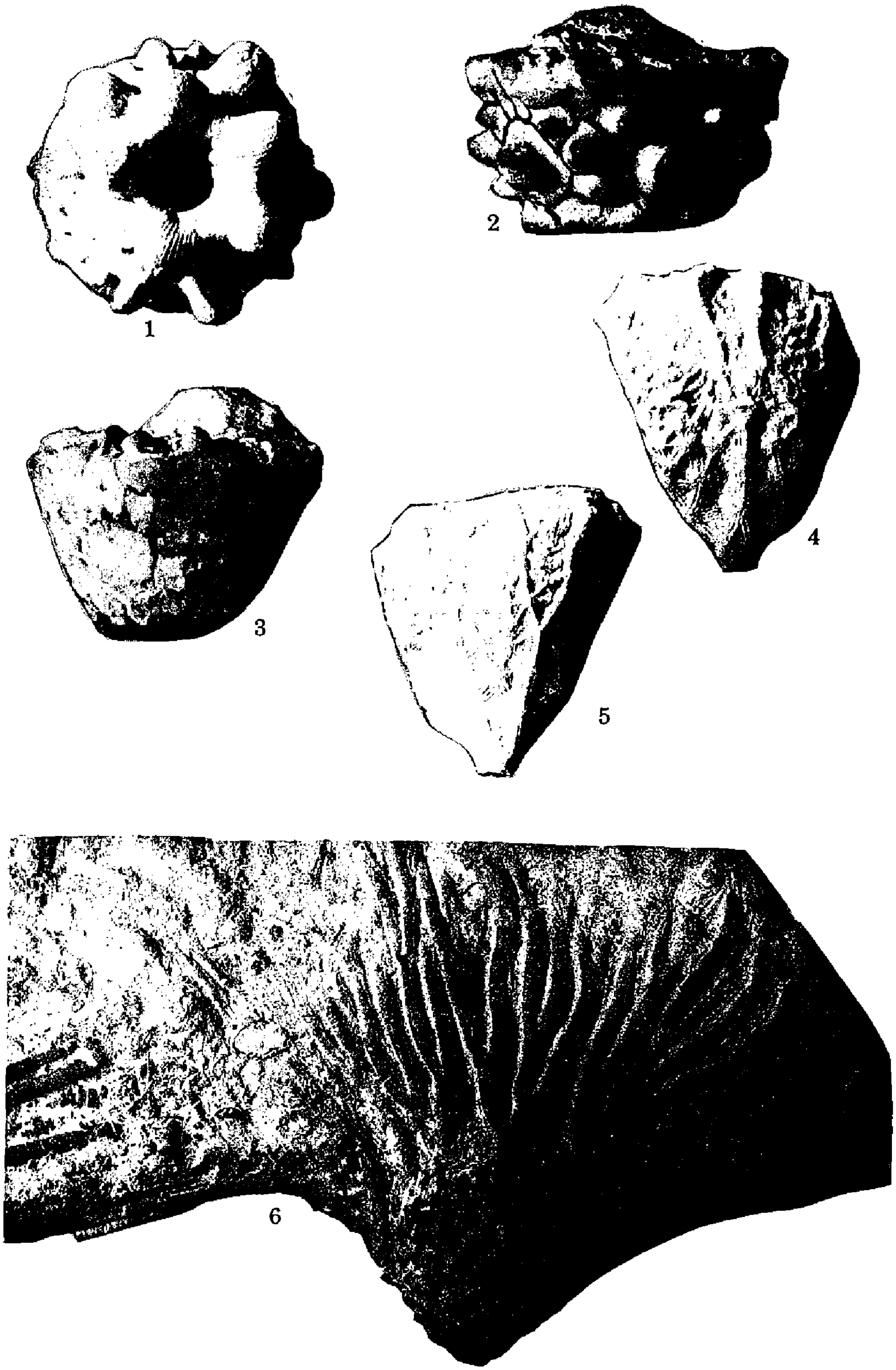

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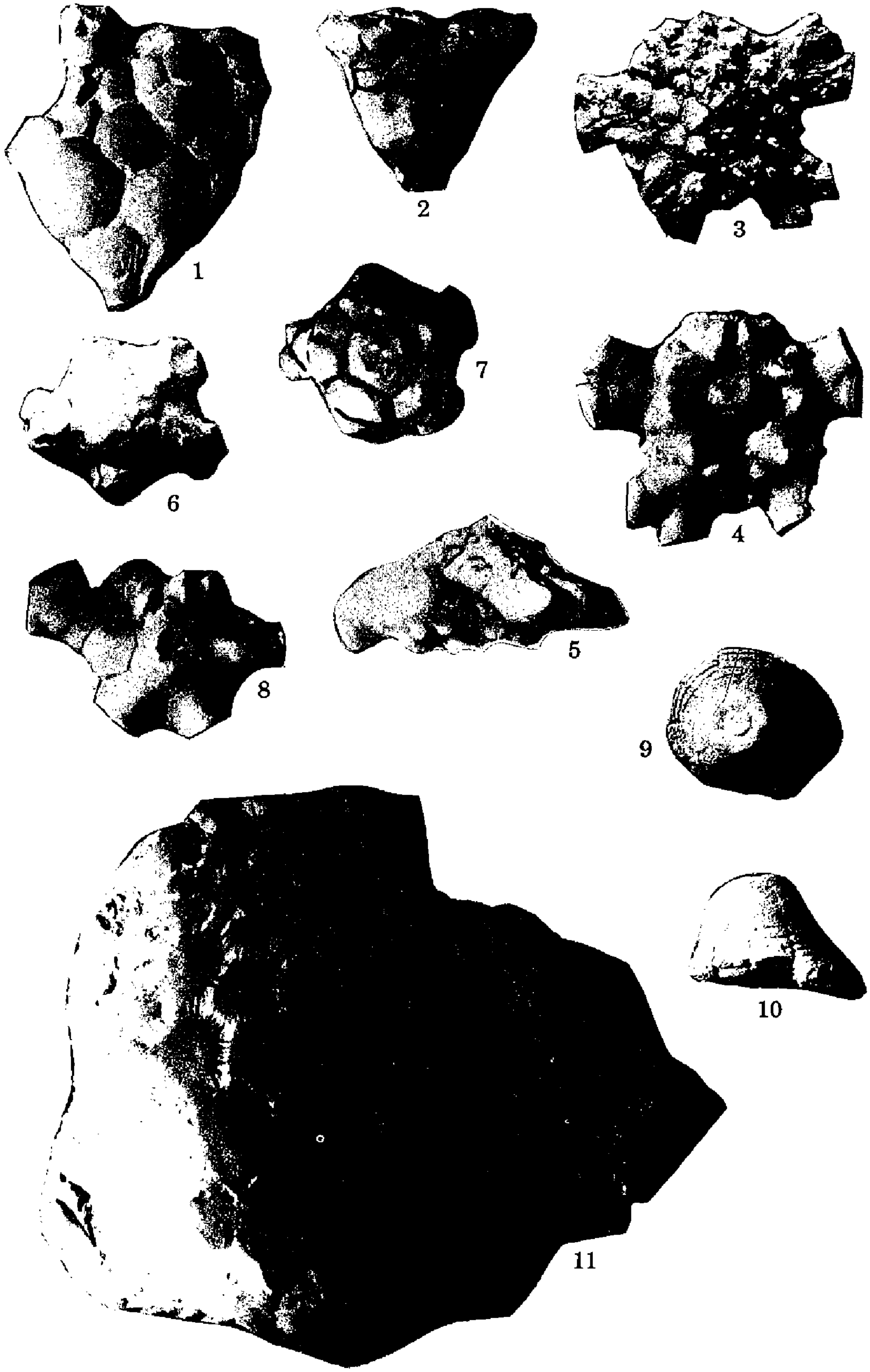

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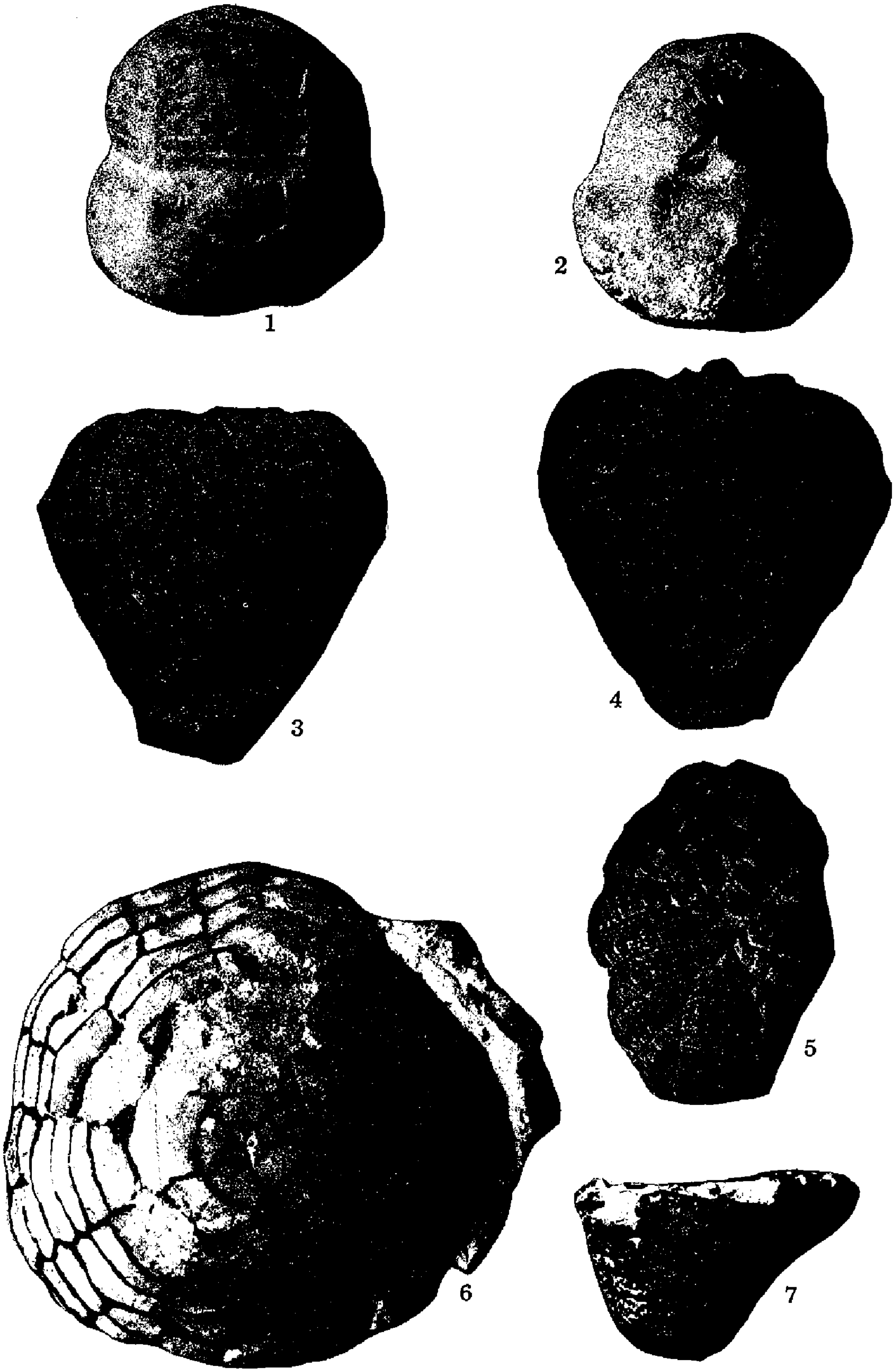

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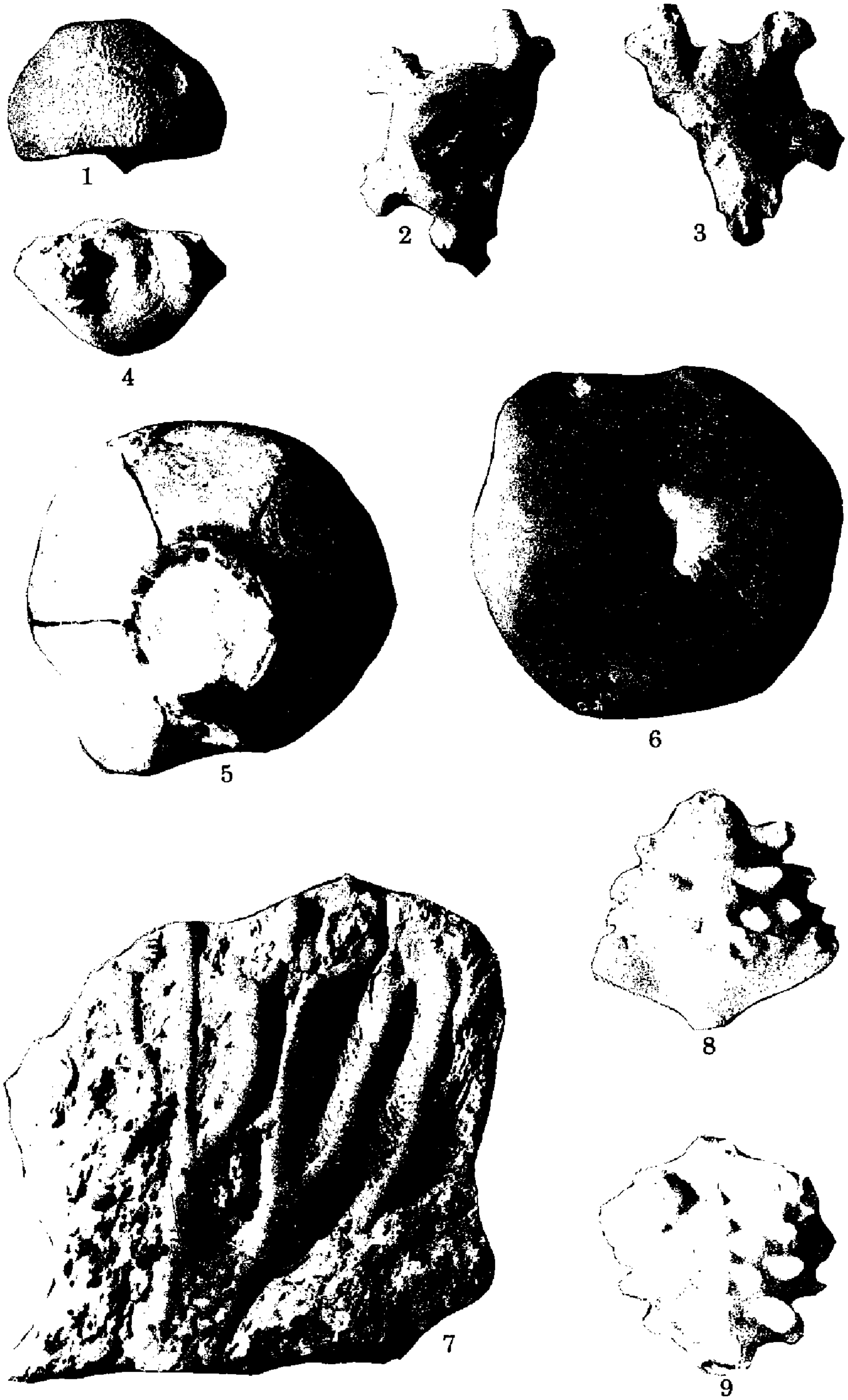

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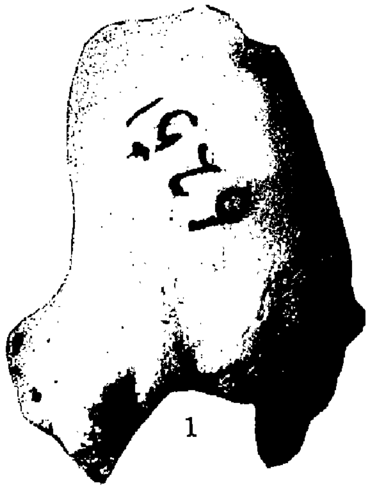

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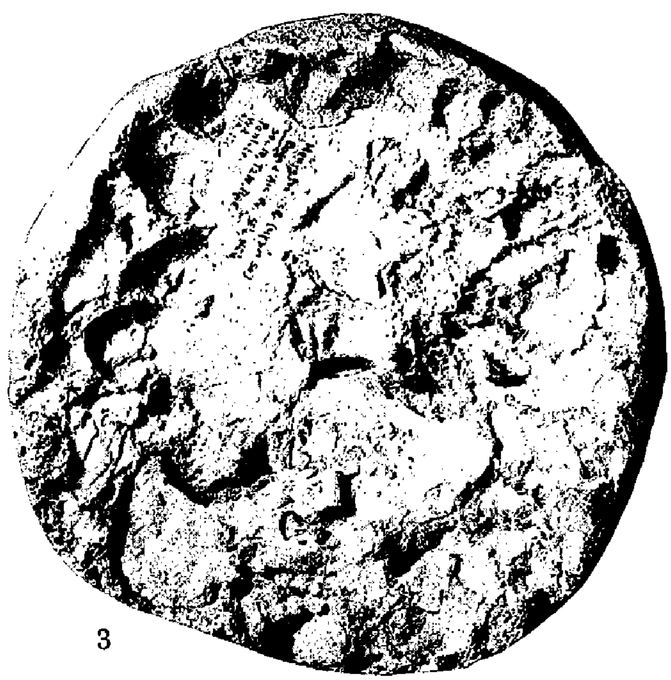

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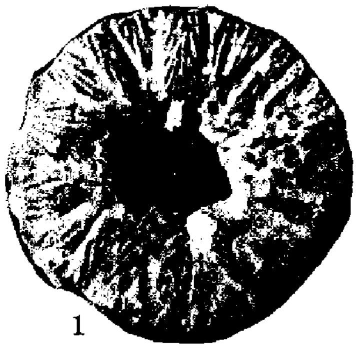

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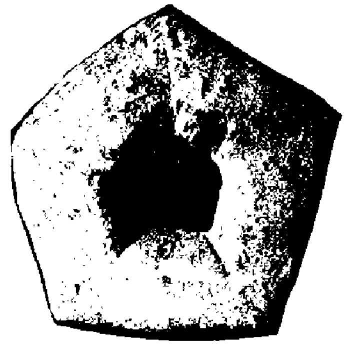

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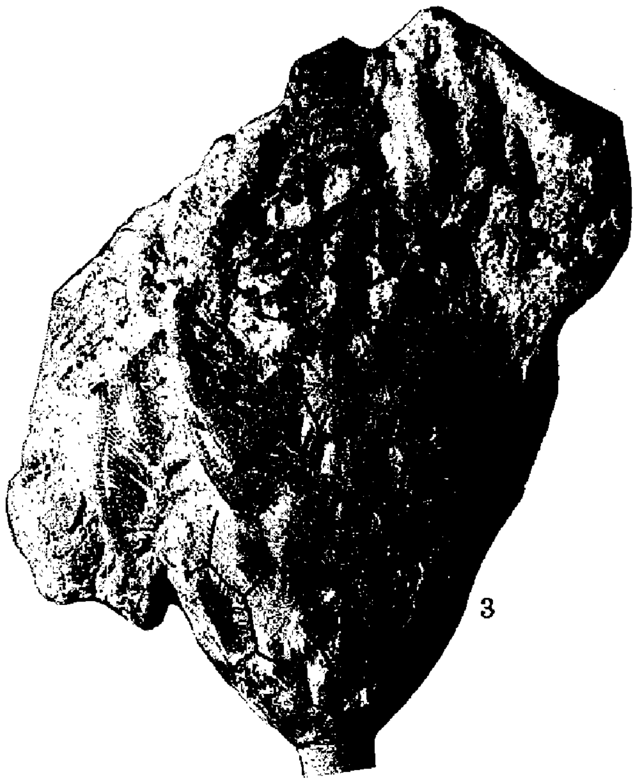

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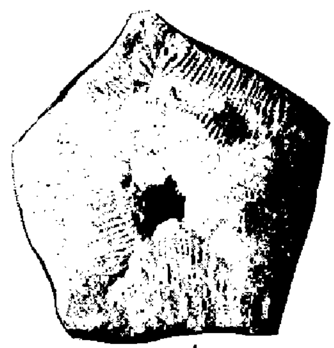

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