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CLASSIFICATION AND NOMENCLATURE OF FOSSIL CRINOIDS BASED ON STUDIES OF DISSOCIATED PARTS OF THEIR COLUMNS

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RAYMOND C. MOORE[1] and RUSSELL M. JEFFORDS[2]

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[Asterisk (*) indicates type species of genera]

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ABSTRACT

Disarticulated parts of skeletons constructed by crinoids of extinct species are extremely abundant in the fossil record, so much so that they are preponderant components of many sedimentary deposits. Their aggregate number amounts to uncounted trillions, whereas collected specimens of relatively complete fossil crinoid skeletons are measured in thousands. Disarticulated and dissociated crinoid skeletal remains in sedimentary formations, however, generally have been neglected by paleontologists because of the impossibility of identifying most of them reliably in terms of known more or less complete specimens.

This article reports methods of study devoted to parts of crinoid columns, neglecting for the present other skeletal elements which deserve similar consideration, with the purpose of demonstrating applicability of morphological characteristics observed in them to practicable discrimination of genera and species of the crinoid animals which produced them. The dissociated parts of crinoid columnals are severally assignable to once-living taxa in the same manner as more complete skeletal remains are utilized. The systematic part of the article contains descriptions and illustrations of fairly numerous crinoid taxa which can be allocated among recognized subclasses and orders distinguished on the basis of dorsal cups and crowns. Others are treated as new genera and species belonging to unknown suprafamilial assemblages of crinoids.

Studies on dissociated crinoid columns presented here constitute only an introduction to much needed research on these fossils. The results obtained, however, point out many techniques and concepts that should facilitate research by others in this phase of paleontology. The accumulation of detailed data on the distinguishing characteristics and age and environmental occurrences of crinoid columns through numerous, commonly unrelated, studies will add materially to the stratigraphic significance and usefulness of these abundantly occurring but neglected fossils. Such studies, moreover, will contribute importantly to increased understanding of biologic relationships and evolutionary trends among these echinoderms.

INTRODUCTION

NATURE AND OCCURRENCE OF FOSSIL CRINOID FRAGMENTS

Countless kinds and almost inconceivably large numbers of disarticulated skeletal remains of crinoids occur as fossils in Ordovician to Recent marine sedimentary deposits. They display distinctive morphological features which allow a large majority of them (though not all) to be classified in groups definable as representing different zoological units (taxa). This recognition of groups and the possibility for naming them depends on the fact that each skeletal fragment constitutes a record, however incomplete, of the crinoid animal from which it was derived.

Disarticulated remains differ in a qualitative way from articulated crinoid skeletons consisting of crowns (theca and attached arms) and stems serving for sea-bottom fixation considering degree of completeness, but only from this standpoint. All represent once-living organisms. Preservation of their remains varies greatly in completeness but not in perfection of individual parts, and, if these parts are disarticulated, commonly they reveal morphological features that are not discernible in study of articulated specimens.

In general, paleontologists working on crinoids have confined their attention almost exclusively to the comparatively rare, very locally distributed fossils consisting of more or less complete "heads," with or without attached portions of their columns. These are composed of thecal plates joined together in undisturbed or very little disturbed original relationships and in some specimens with attached more or less complete arms. A few examples of stalked crinoids are illustrated (Fig. 1). Relatively complete specimens that retain the mutual articulations of their skeletal parts are the basis for recognition of a little more than 90 percent of the approximate total of 1,000 genera and 6,500 species of crinoids which have been described to date. These are unevenly distributed throughout the post-Cambrian part of the geologic column (Fig. 2), most numerous species having been reported from North America and Europe. Very incomplete fossil remains of crinoids, some consisting of a few to several articulated skeletal parts but mostly comprising individual skeletal elements, have been neglected generally because of their unidentifiability.

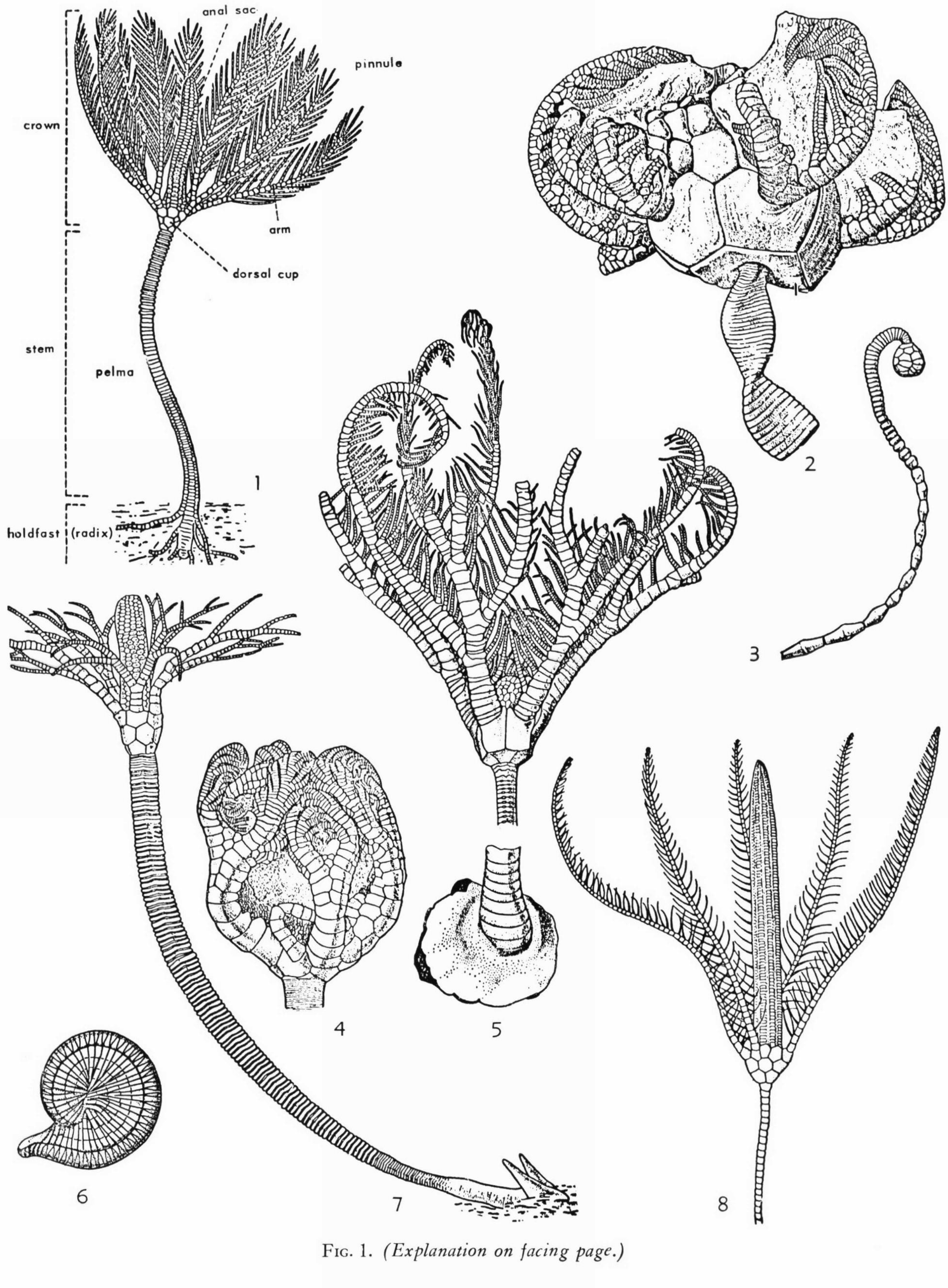

FIG. 1. *(Explanation on facing page.)*

DISSOCIATION OF SKELETAL REMAINS

When crinoids die, their skeletal parts are dissociated readily. Quickly they become scattered in the shallow marine environment, to which most stalked crinoids are confined in life. The impossibility of sorting out remains of single individuals from the myriads of mixed fragments is evident. The skeletal parts generally do not represent associated throngs of a single species but are derived from populations consisting of a few to many different genera and species. Customarily, all have been thrown aside as valueless, since only rarely are some considered to be identifiable with varying degrees of uncertainty in terms of whole-crinoid taxa. Efforts to reconstruct whole skeletons from collected fragments are not merely hopeless but are very ill-advised, because all such reconstructions are bound to be untrustworthy, possibly as spurious as deer antlers mounted on a mastodon skull.

What then? The premise on which research here reported has been undertaken is that a considerable majority of the skeletal crinoid fragments found in many sedimentary deposits are individually distinctive enough to permit reliable identification of them as markers of the animals that produced them. Observations already made not only by us, but by many others (see Tables 1, 2), serve to establish this premise as fact, thus calling attention to a large field of paleontological endeavor.

MATERIALS FOR STUDY

The quantity of well-preserved fossils available for study is almost beyond comprehension. Specimens already brought together in our collections, most of them rough sorted, are estimated to exceed 1 million, not counting microscopic forms. Approximately two-thirds of this material consists of the washed and sieved concentrates of crinoid fragments mostly parts of columns, obtained from about 15,000 pounds (7.5 tons or 7,500 kilos) of crinoid-rich samples collected by us in 1962-64 from 160 localities in Illinois, Indiana, Kentucky, Tennessee, Missouri, Kansas, Oklahoma, Arkansas, Texas, and New Mexico. In addition, approximately 5,000 specimens have been loaned to Moore by the U.S. National Museum and specimens collected by Moore from localities in Europe have been available for study. A very adequate sample of Paleozoic crinoid fragments is provided whereas post-Paleozoic forms now are very incompletely represented in collections available to us.

The potential value of research on disarticulated crinoid remains is indicated by the estimate that presently known genera and species of fossil crinoids probably amount to much less that one hundredth of actually existent taxa belonging to this group of echinoderms, skeletal parts of which are preserved in sedimentary deposits and which are findable and collectable by paleontologists. This is explained by the extreme rarity—repeat, extreme rarity—of well-preserved crinoid "heads" in comparison with trillions on trillions of discrete skeletal crinoid parts in accessible outcrops of fossiliferous marine strata, and it is explained further by certainty that parts of the readily dissociated skeletons of innumerable crinoid taxa unknown from "heads" may be found in collections of fragmentary remains. It is likely that some crinoid species represented by isolated remnants of their stem, theca, and arms may never be discovered and recognized on the basis of articulated "complete" fossils.

The abundance and variety of disarticulated crinoid parts make them immediately useful for purposes of stratigraphic paleontology and studies of paleoecology after they have been adequately described, illustrated, classified, and named, just as conodonts are found to be very useful fossils without knowing even the class of animals to which they belong.

SCOPE OF ARTICLE

The aim of this article in company with the preceding one by Moore, Jeffords & Miller, is to provide a foundation for researches on many assemblages of disarticulated crinoid remains by (1) describing work methods, (2) establishing principles applicable to classification and nomenclature, and (3) furnishing some examples of results which may be expected from investigations along this line. It must be recognized that the multitudinous dissociated fragments of crinoid skeletons found as fossils differ widely in distinctiveness of their morphological characters, many being of such generalized nature as to reduce usefulness of them almost or quite to a vanishing point, whereas others display features that make them readily identifiable. Knowledge of whole crinoids, supplemented by experience in working with disarticulated

Fig. 1. Articulated skeletons of crinoids.——*1. Dictenocrinus,* Silurian, showing crown composed of theca with dorsal cup and anal sac, outspread arms with pinnules, and pelma consisting of segmented stem and rootlike holdfast (reconstr.), ×5.5 (from Bather, 1900).——*2. Eucladocrinus,* Mississippian, crown and proximal part of twisted stem composed of narrowly elliptical columnals, ×5.5 (from Ubaghs, 1953).——*3. Mespilocrinus,* Mississippian, diminutive flexible crinoid with spheroidal crown and xenomorphic stem with distal columnals greatly elongated, ×0.8.——*4. Onychocrinus,* Mississippian, showing well-separated inrolled arms, bent anitaxis, and very thin columnals of top part of stem, ×5.5.——*5. Calamocrinus,* Recent, crown with attached proximal part of stem and discoid holdfast, ×1.5.——*6. Myelodactylus,* Silurian, coiled stem with inwardly directed cirri which entirely conceal crown, ×1.2.——*7. Ancyrocrinus,* Devonian, crown, xenomorphic column, and grapnel-like holdfast (reconstr.), ×0.8.——*8. Rhenocrinus,* Devonian, inadunate crinoid with tall, slender anal sac, ×0.8. (*1,* Bather, 1900; *2-4, 6-7,* Ubaghs, 1953; *5, 8,* Cuénot, 1948).

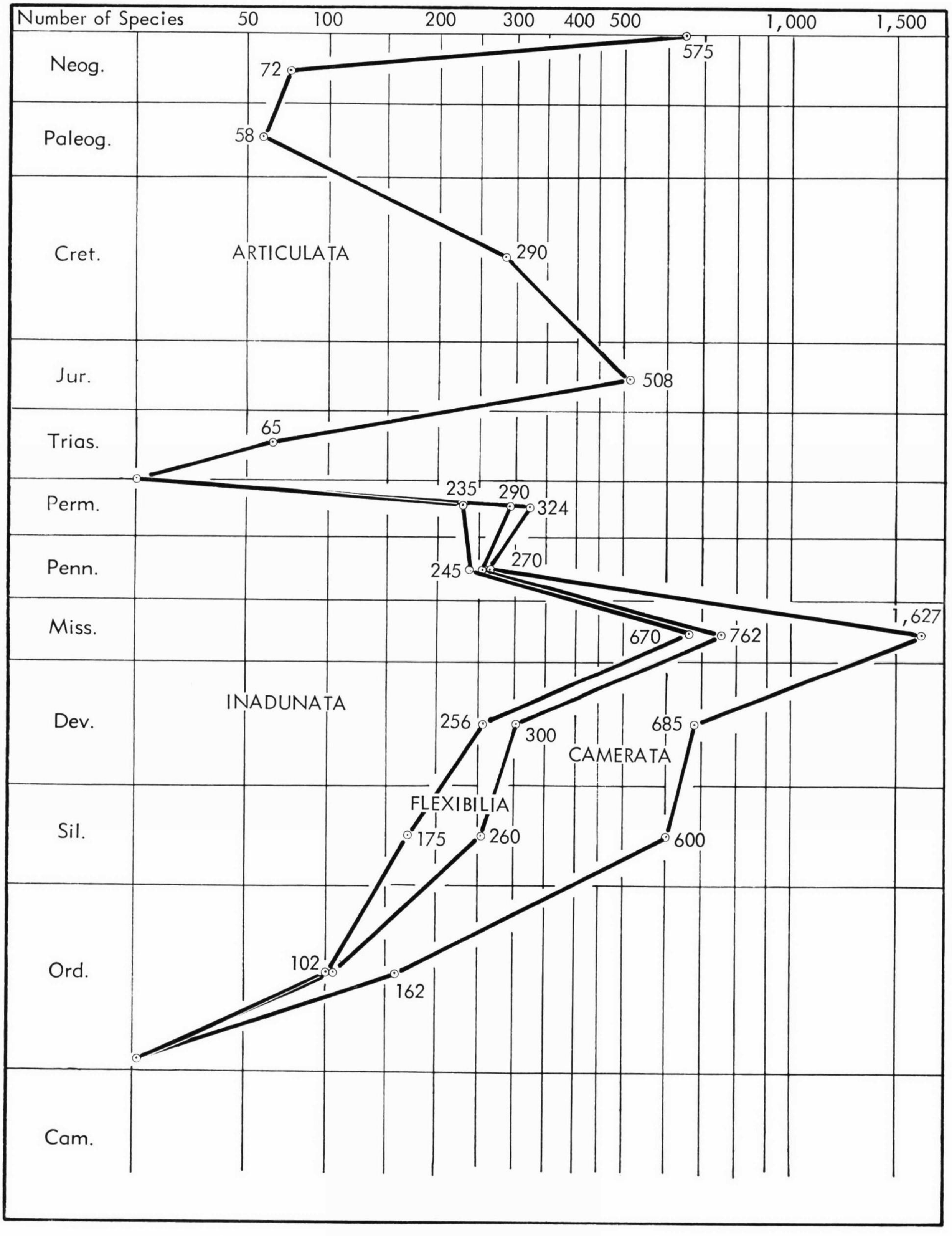

Fig. 2. Stratigraphic distribution of described species of crinoids.

skeletal remains, furnishes the best guide for recognizing the specimens in a collection which are highest in value and for putting aside those which are low in value.

ACKNOWLEDGMENTS

Numerous persons have aided in many ways during the progress of our studies on disarticulated crinoid remains and to all of them we express grateful appreciation. Some have furnished guidance for field collecting, others have assisted in the laboratory, sorting and preparing specimens, cutting sections, and making acetate peels and photographs; still others have given or loaned fossils for study. Without undertaking to record the precise nature of these contributions, we here sincerely thank: E. B. Branson and W. W. Hagen of the Kentucky Geological Survey; J. A. Conklin of the University of Louisville; G. A. Cooper and P. M. Kier of the U.S. National Museum; D. M. Delo, Eldine Doucet, Patricia Engler, Gary Gautier, Helen Gilles, Lavon McCormick, Rosalie Maddocks, J. E. Sorauf, R. S. Spencer, J. S. Van Sant, and R. B. Williams of the University of Kansas; D. E. Hattin of Indiana University; N. Gary Lane and G. D. Webster of the University of California (Los Angeles); A. C. MacFarlan of the University of Kentucky; T. H. Miller of the Esso Production Research Company (Houston); J. H. Quinn of the University of Arkansas; R. I. Roth of the Humble Oil & Refining Company; L. R. Wilson of the University of Oklahoma; W. F. Berry (formerly) of the University of Massachusetts; A. J. Rowell and A. J. Rundle of the University of Nottingham (England).

Colleagues among paleontologists of the Soviet Union who are specialists in studies of fossil crinoids, including dissociated remains such as columnals and pluricolumnals, have corresponded with us and kindly furnished numerous reprints of their publications. For their interest and help we thank N. N. Yakovlev (now deceased), R. F. Hecker, Yu. A. Arendt, R. S. Yeltysheva, G. A. Stukalina, and Yu. A. Dubatolova.

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ARTICULATED SKELETONS OF CRINOIDS

MAIN MORPHOLOGICAL FEATURES

As background for the subsequent discussion of classification and nomenclature of fossil crinoids based on studies of dissociated parts of their columns, a very brief review of the nature of reasonably complete articulated skeletons, known from abundant well-preserved specimens in paleontological collections, is desirable.

Complete crinoid skeletons are divisible into two main parts: the "head" or **crown**, and the stalk or **stem** by which the crinoid is attached to the substrate or other anchorage (Fig. 1). The crown, in turn, is divisible into the **theca** and appendages called **arms** extending upward or outward from theca. The chief soft parts of the animal, including the alimentary tract, are enclosed by the theca. The arms are food-gathering appendages provided with ciliated grooves that converge toward the mouth. The stem, which is a very prominent part of most Paleozoic and many later crinoids but present only in the larval existence of most modern, free-swimming crinoids, consists of a few to extraordinarily many superposed elements called **columnals**. The lower extremity of the stem, considered as distal, generally bears some sort of anchorage structure termed a **holdfast.**

THECA

The thecae of crinoids are extremely varied in shape, size, and complexity of structural arrangement of their plates (Fig. 1). Common shapes are globose, discoid, cylindroid, and erect or inverted conical. Some adult microcrinoids have a theca barely 1 mm. in diameter or height whereas others are as large as a small pea (e.g., the pea crinoid, *Pisocrinus,* Fig. 3). Maximum size of crinoid thecae is seen in such many-plated forms as *Scyphocrinites* (Fig. 3) with height to more than 130 mm. (5 in.) and maximum diameter of 100 mm. (4 in.).

Almost invariably two or more circlets of five plates each are seen on the lower (dorsal) side of the theca and these comprise the so-called **dorsal cup.** The upper (ventral) side of the theca (**tegmen**) may consist of a leathery cover containing very numerous spicules and minute plates or it may be a flat to arched roof of solidly united plates (Fig. 3). Extreme complexity of the thecal plate arrangement and greatest number of these plates are observed in such crinoids as *Scyphocrinites,* previously mentioned on account of its size (Fig. 3). Many crinoids characterized by relative simplicity of the lower plates of the theca (collectively forming the dorsal cup) possess very numerous plates on the upper surface, which may be extended strongly upward as an **anal sac** or tube (Fig. 1).

PELMA

The part of crinoid skeletons below the crown is termed the **pelma** (from Greek for sole, signifying base for attachment), and from it the name pelmatozoan, used for sessile echinoderms, is derived. The column is chief component of the pelma (Fig. 1). Holdfast structures at the base of the stem are the remaining part (Fig. 1). An initial survey of crinoid stems needs to notice

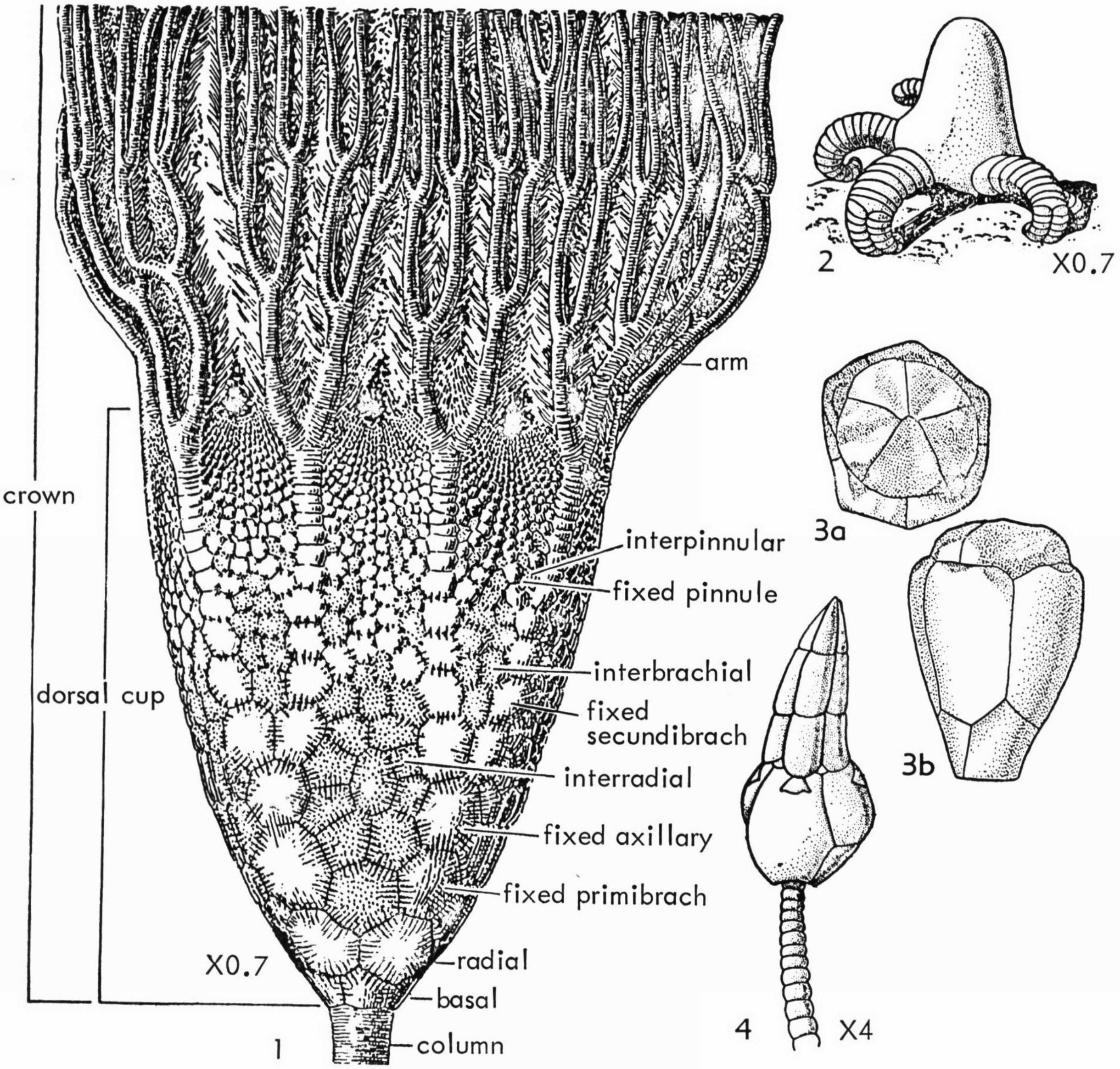

FIG. 3. Complex and simple types of crinoid skeletons.

1. Scyphocrinites, Lower Devonian of Europe and North America, with brachials (brachs), interbrachs, pinnulars, and interpinnulars incorporated with radials and basals in theca, ×0.7.——*2. Edriocrinus,* Lower Devonian reconstructed as crawling echinoderm, ×0.7.——*3. Hybochilocrinus,* Lower Mississippian, simply constructed microcrinoid, oral *(3a)* and side *(3b)* views, enlarged.——*4. Pisocrinus,* Silurian, diminutive inadunate crinoid with few plates in dorsal cup and short uniserial arm s,×4. (*1,* Moore, 1952; *2, 4,* Cuénot, 1948; *3,* Ubaghs, 1953.

little more that their great diversity in length and transverse shape, range in diameter from less than 1 mm. to nearly 50 mm. (2 in.), variety of characters shown by the articular surfaces of their component segments (columnals), and the presence in many but not all forms of laterally directed branches termed **cirri** (sing., cirrus) (Fig. 4). Examples of crinoid stems 50 to 70 feet in length have been reported, but these are very exceptional; most are within the range of 1 to 3 feet. A preponderant majority of crinoid stems are circular in cross section, but other shapes noted later are common. An axial canal runs longitudinally through all stem segments, providing passageway for nerves and nutrient carrying tubes extending from the theca. Branches of the canal, as might be expected, connect with the cirri and run through them.

A noteworthy feature of some crinoid stems is variation found in different parts between the crown and lower extremity of the stem attached to the substrate or

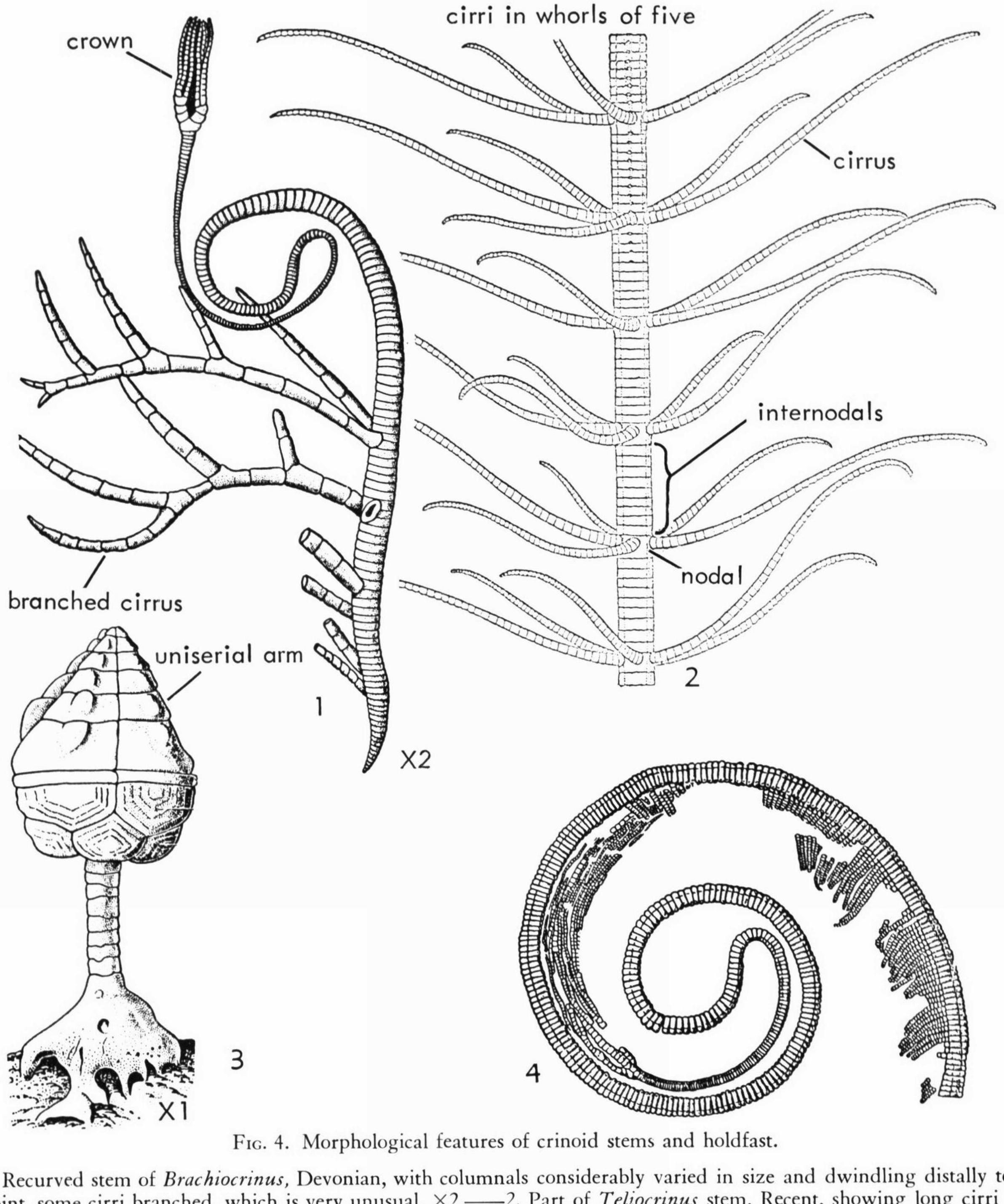

FIG. 4. Morphological features of crinoid stems and holdfast.

1. Recurved stem of *Brachiocrinus,* Devonian, with columnals considerably varied in size and dwindling distally to a point, some cirri branched, which is very unusual, ×2.——*2.* Part of *Teliocrinus* stem, Recent, showing long cirri arranged in whorls of five around nodals, ×2.——*3. Cupressocrinus,* Devonian, crown and stem with holdfast, ×1.——*4. Herpetocrinus,* Silurian, showing recurved coiled stem with inwardly directed cirri and slender crown, ×0.75. (*1,* Cuénot, 1948; *2,* Clark, 1915; *3-4,* Ubaghs, 1953).

holdfast (Figs. 1, 4). Naturally, separated fragments of such stems may be difficult to recognize as belonging to the same species, unless comparisons with whole specimens furnish a satisfactory guide.

Holdfasts commonly consist of a discoid expansion at the distal end of the stem, and these, like the holdfasts of larval free-swimming crinoids (Fig. 1), are found in many Paleozoic deposits, generally without adherent remnants of the stem. Specialized anchorage structures include such peculiar fossils as the grapnel hook of *Ancyrocrinus* (Fig. 1), known for a long time before its connection with a crown was discovered. A few crinoids have stems that taper distally serving for temporary attachment to suitable objects on the sea floor, such as branching bryozoans or corals or the stem of another crinoid. A common type of holdfast in some crinoid species (e.g., belonging to *Eucalyptocrinites* and *Dictenocrinus,* Fig. 1) consists of rootlike branching **radicular cirri** of the distal extremity of the stem, the branches being embedded in sediment of the sea bottom. Such a structure is termed **radix.**

MAIN TAXONOMIC GROUPS

Genera and species of crinoids described and named on the basis of articulated skeletal remains are almost universally discriminated on characteristics of the crown, such as the kinds and arrangements of plates in the theca and composing the arms. Among stem-bearing crinoids, the nature of the stem next to the crown commonly is noticed by authors but only in a minority of genera do features of the stem share significantly in defining them. Many genera of fossil crinoids considered to be validly established are as yet known only from features of the theca, no information being available concerning the arms and generally little or none with respect to the stem. The dorsal cup alone, without tegmen, arms, and evidence of the stem other than its impression on the base of the cup, represents many genera recognized in the literature. A handful of genera (but hundreds of species, chiefly from Jurassic and Cretaceous deposits in Europe) have been distinguished on characters of the stem alone, without knowledge of the dorsal cup and other parts of the crown borne by it during life.

All kinds of crinoids, including best to least known, are assigned to main groups (subclasses) named Inadunata, Flexibilia, Camerata, and Articulata or are left unclassified. The subclasses, in turn, may be divided into orders and these into superfamilies and families. The crinoids represented by varyingly complete articulated skeletons mostly can be assigned with confidence to one of the mentioned subclasses. Clearly, however, the Articulata, composed entirely of post-Paleozoic crinoids, is an essentially artificial assemblage of undifferentiated descendents of the Inadunata and Flexibilia. The camerates appear to have become extinct before the beginning of Triassic time. The crinoids represented by extremely incomplete articulated skeletal remains and those represented by entirely dissociated elements of the arms, theca, or stem generally have been considered to be unclassifiable, even though some can be recognized reliably as belonging to one of the four subclasses. It goes without saying that any crinoid (possibly excepting a member of the family Encrinidae) found in post-Permian strata must be an articulate, little as this means.

For purposes of the present study, it is unnecessary to describe diagnostic features of the subclasses and their scores of families containing hundreds of genera. The simplest procedure is to examine these only as occasion arises for comparing fragmentary crinoid remains with a part or parts of the skeletons of some already described and figured kinds of crinoids. In many instances a genus established in classification, if not some particular species belonging to it, can be recognized, and then the fragment, however incomplete, can be named accordingly, with or without an accompanying question mark to indicate uncertainty. The burdensome task of surveying all groups of crinoids known from articulated skeletons on the premise that some of them might be applicable to the subject of this article is avoided.

OCCURRENCE

Genera and species of species of crinoids described from more or less complete skeletal remains are distributed stratigraphically from lowermost Ordovician strata called Arenig (Ramsbottom, 1961, p. 6) to Recent (Fig. 2). The greatest variety and greatest number of individuals are recorded from the Lower Carboniferous (Mississippian). Crinoids are abundant in other divisions of the rock column, however, especially in formations that are mainly composed of their remains.

The geographic distribution of crinoids is worldwide, but the occurrence of well-preserved, reasonably complete crowns or whole skeletons is extremely localized and, as might be expected, the important collecting localities differ from system to system.

Ordovician crinoids have been obtained chiefly from Tennessee, Kentucky, southwestern Ohio, and New York, in the United States; from Ontario (Kirksfield, Ottawa), in Canada; from Scotland (Girvan), western England, and Wales, in Europe.

Famous Silurian crinoid localities are found in central Tennessee, southeastern Missouri, southern Indiana, western England (Dudley), Sweden (Gotland), and Czechoslovakia.

Rich Devonian collecting places for crinoids occur in northern Michigan, western Ontario (Thedford), New York, and the Eifel region of West Germany.

Crinoid cups, crowns, and complete skeletons in large numbers have been obtained from Mississippian-localities in New Mexico (Lake Valley), Missouri, Iowa, Illinois, Indiana (notably Crawsfordsville), Kentucky, Tennessee; and the Lower Carboniferous of Belgium, England, Scotland, and Eire.

Pennsylvanian crinoids are widely distributed but nowhere locally very abundant in Illinois, Iowa, Missouri, Kansas, Arkansas, Oklahoma, Texas, and New Mexico.

Much the largest number of discovered Permian crinoids comes from the island of Timor, East Indies, but other important localities have been found in southern Nevada, Texas, and Sicily.

Few Mesozoic crinoid crowns have been found in North America. Triassic crinoids are best known from western Germany; Jurassic from France, Germany, and England; and Cretaceous from France, Germany, Denmark, and England.

Cenozoic crinoids, chiefly free-swimming types, are mostly not abundant; they come mainly from western Europe. An exceptional occurrence of Paleogene stemmed crinoids—almost unique in the world—has been found in northwestern Oregon.

Approximately 650 species of modern crinoids have been described, world-wide in distribution, but only a few of these are stem-bearing. They chiefly inhabit shallow-sea areas.

A summary of information on the presently recorded occurrence of crinoid genera which have been differentiated on the basis of relatively complete crowns or dorsal cups is given in Table 1. It is derived from data published

TABLE 1.—*Distribution of Crinoid Genera by Geologic Systems and Occurrence in Continental Areas.*

[Genera here recorded are all based on specimens consisting of reasonably complete articulated dorsal cups with or without attached arms and part of the column. A few stemless Paleozoic crinoids and numerous post-Paleozoic forms of this type are included. Genera with type species differentiated solely on disarticulated skeletal remains, such as parts of the column (Table 4), are excluded.]

SYSTEM	NORTH AMERICA ONLY	EURASIA ONLY	BOTH AREAS	TOTAL	RESTRICTED TO SYSTEM	
					NO.	PERCENT
Neogene	19	112	43	174	156	90
Paleogene	1	13	10	24	3	13
Cretaceous	5*	32	14	51	19	37
Jurassic	–	42	8	50	27	54
Triassic	1	4	–	5	3	60
Permian	2	80	23	105	76	72
Pennsylvanian	36	13	32	81	40	49
Mississippian	71	51	53	175	123	70
Devonian	43	47	48	138	87	63
Silurian	44	32	48	124	57	55
Ordovician	43	15	9	67	59	88
Totals	265	441	288	994	650	66

*Includes genus from South America.

TABLE 2.—*Distribution of Devonian Crinoid Genera by Geologic Series and Occurrence in Continental Areas.*

SERIES	NORTH AMERICA ONLY	EURASIA ONLY	BOTH AREAS	TOTAL	RESTRICTED TO SERIES	
					NO.	PERCENT
Upper Devonian	16	6	27	59	11	19
Middle Devonian	23	25	37	85	22	26
Lower Devonian	23	31	39	93	18	19
Totals*	72	62	103	237	51	21

(*Includes duplications.)

by MOORE (1948), supplemented by records contained in WRIGHT's (1950-60) monograph of British Carboniferous crinoids, reports by YAKOVLEV & IVANOV (1956) on fossil crinoids of the Soviet Union, by RASMUSSEN (1961) on Cretaceous crinoids of the world, by RAMSBOTTOM (1961) on Ordovician crinoids from Britain, by BREIMER (1962) on Devonian crinoids from Spain, and papers chiefly concerned with North American crinoids by STRIMPLE (1961, 1962, 1963), MOORE (1962a, b, 1967), and LANE & WEBSTER (1966). The summary has not been checked rigorously, but is reasonably complete and therefore judged to be trustworthy as a guide in making at least two significant generalizations. These are that 1) at the generic level crinoids are very good indicators of the geologic systems in which they are found, for approximately 70 percent of them (729 out of 1,057 genera) are restricted to a single system; and 2) at the generic level crinoids are useful for intercontinental correlations, in addition to their well-known value for age determination and stratigraphic correlations within continental areas, for more than a quarter of them (295 out of 1,057 genera) are recorded from both North America and Eurasia.

STRATIGRAPHIC SIGNIFICANCE

Few, if any, index fossils rival crinoids as trustworthy indicators of geologic age and dependable markers for precise stratigraphic correlations. This is demonstrated by multitudinous empirical observations that apply not only to marine deposits of given regions, such as the Mississippi Valley of the United States, but to virtually all crinoid-bearing strata of a continent. Further, the succession of crinoid faunas is very similar in different continents and every post-Cambrian geologic system contains genera of crinoids that occur in two or more continents.

It should be emphasized that very many crinoid genera represented by well-preserved articulated skeletons are highly distinctive and thus can be recognized easily. Among these are Ordovician crinoids such as *Glyptocrinus, Iocrinus, Archaeocrinus,* and numerous others which are quite unlike any post-Ordovician forms. The Silurian crinoid fauna contains such specialized genera as *Synchirocrinus, Gissocrinus, Crotalocrinites* (Fig. 5,*4*), *Eucalyptocrinites* (Fig. 5,*1*), *Petalocrinus* (Fig. 5,*2*), *Dendrocrinus, Pisocrinus* (Fig. 3,*4*), and many more which not only differ strikingly from older and younger crinoids but are found in closely equivalent strata on opposite sides of the Atlantic. *Scyphocrinites* (Fig. 3,*1*), which is widespread and abundant in Lower Devonian rocks of the United States, is an example of exceptional complexity in skeletal organization unmatched by anything similar in the Silurian or other parts of the Devonian, though identical forms are prolific in limestones of Bohemia which have been classed as uppermost Silurian. Because close equivalence in age of the American and European *Scyphocrinites,* some of which belong to the same species, cannot reasonably be doubted, stratigraphic reclassifications in one region or the other seem to be demanded. In similar manner upward through the geologic column, each system offers excellent crinoid markers, including many that are known from both North America and Eurasia. They are too numerous for individual mention.

When the distribution of crinoids in divisions of geologic systems such as series or stages is studied, the generalizations previously stated are emphasized and sharpened, but difficulties of various sorts are encountered. Among these are problems of defining boundaries of the divisions and correlating them in different continents. Abundance of crinoids in some parts of a system, coupled with paucity of crinoid materials in others,

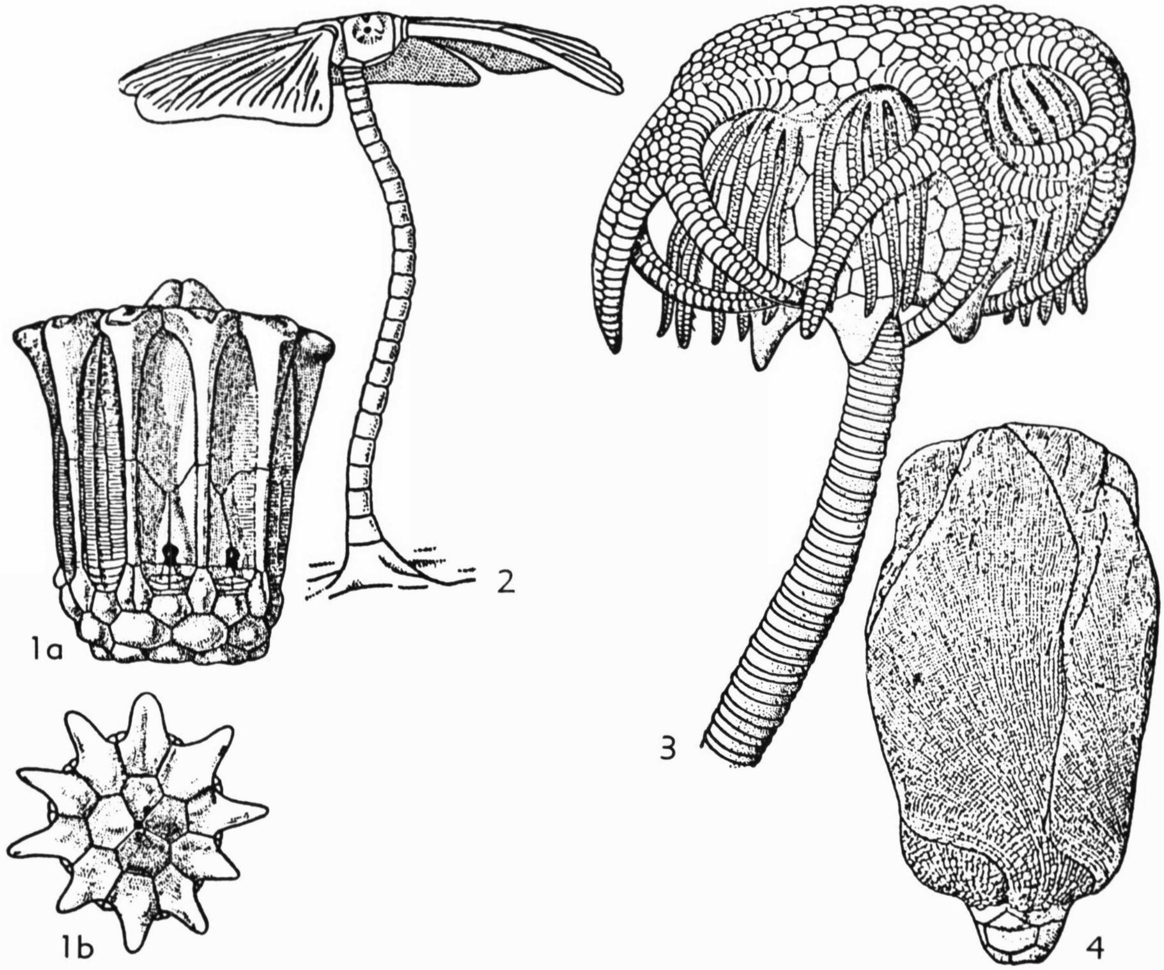

FIG. 5. Specialized types of widely distributed short-ranging Paleozoic crinoids, all from central and northwestern Europe.——*1. Eucalyptocrinites,* Upper Silurian-Middle Devonian, showing side view *(1a)* with arms at left in alcove-like recesses of tegmen, removed in middle and at right, and summit of tegmen *(1b)*, ×0.7.——*2. Petalocrinus,* Upper Silurian, side view of crown and column showing petal-like food-gathering plates derived from fused arm plates, plate in front removed, ×1.——*3. Gilbertsocrinus,* Middle Devonian-Lower Mississippian, showing peculiar pendent extensions of tegmen, ×1.——*4. Crotalocrinites,* Upper Silurian, showing flexible lateral connections of arm branches, ×0.7. (*1-4,* Ubaghs, 1953).

tends to give a distorted picture of probable realities. A tabulation of Devonian crinoids separated into Lower, Middle, and Upper Devonian is useful for comparison with the preceding table. Totals do not agree because various genera are repeated as components of the successive assemblages (Table 2).

PALEOECOLOGIC SIGNIFICANCE

A far-reaching generalization concerning the life habits of crinoids, based on a survey of the whole assemblage and including groups of all ages, emphasizes their adaptation to a shallow-water marine environment. This is demonstrated by their association with other invertebrates such as heavy-shelled bivalves abundant in nearshore areas, by sedimentary features of the deposits containing them, and by such stratigraphic evidence as association of crinoid-bearing beds with coals, deltaic deposits, and widespread sheets of current-spread clastic and calcareous sediments. In Pennsylvanian cyclic deposits of Kansas, excellently preserved crinoid cups and crowns have been collected from shaly beds resting directly on coal beds, the crinoids being accompanied by numerous ramose bryozoans, thick-shelled *Myalina,* and the typically very nearshore brachiopods *Derbyia* and *Juresania.*

Studies currently in progress by N. GARY LANE (University of California, Los Angeles) on the sedimentary environment and conditions of deposition of crinoid skeletons in the famous Crawfordsville, Indiana, beds of the Borden Group (Lower Mississippian) indicate burial of many crowns with long stems attached to them. The fine silty beds containing these fossils are evenly stratified, indicating deposition in very still water, as does also the undisturbed nature of the articulated crinoid skeletons, many with slender arms that bear a full complement of delicate pinnules. The crinoid beds pinch out abruptly on all sides, so far as observed, and the laterally contiguous strata that intertongue with them consist of unfossiliferous coarse silty shale and siltstone interpreted as deltaic in origin. Seemingly, these crinoid populations lived in shallow ponded embayments, probably along temporary margins of a delta or delta lobe; these ponds were comparable to the interdelta-lobe or delta-flank embayments of the present Mississippian delta region in Louisiana.

Several crinoids, both fossil and Recent, are specialized for life in a rough-water reef environment. They are cemented by the underside of the solidified theca to the rock substrate or are fastened in crannies of the reef surface. Their arms are much shortened.

Floating or planktonic crinoids occur in some deeper-water sediments; for example, crinoid fragments named *Lombardia* by authors (now known to represent the wide-spread Jurassic and Cretaceous genus *Saccocoma*) are found associated with planktonic foraminifers, tintinnids, and radiolarians. Likewise, *Somphocrinus* (Triassic), genera of the Roveacrinidae (Lower and Upper Cretaceous), and a host of free-swimming comatulid crinoids (Jurassic to Recent) were able to invade open seas and their thecae may be found in both deep- and shallow-water deposits. *Uintacrinus* is a free-floating crinoid with relatively large theca and slender arms that extend as much as 4 feet outward; it occurs in a narrow band of Upper Cretaceous (Santonian) strata in western and central United States, England, France, Germany, Italy, and Australia (Bather, 1895; Springer, 1901; Rasmussen, 1961). Another stemless crinoid found in the same beds is *Marsupites,* which in addition to localities just mentioned is found in Madagascar and India. Evidently these crinoids were adapted to a pelagic environment.

DISARTICULATED SKELETAL REMAINS OF CRINOIDS

NATURE AND USEFULNESS OF REMAINS

Disarticulated parts of crinoid skeletons are extremely abundant as fossils, probably outnumbering whole and nearly whole crinoids in the ratio of at least 100 million to one. In many formations these fragmentary remains are dominant components of the deposits, and in addition, their variety is almost limitless. The abundance of such fossil materials signifies, first, that populations of many kinds of crinoids in marine faunas of the geologic past were enormously large, and second, it reflects the ease with which crinoid skeletons fall apart.

The vast numbers of individual crinoid animals which inhabited the shallow seas during successive epochs and periods of earth history are attested by the gross volume of their remains. Disintegration of the skeletal parts is due to the prevailing lack of a firm bond between them. Individual elements of the arms, theca, and stem are held together by ligamentary strands, by muscular tissue, or merely by epidermis in which they are embedded, all of these connections consisting of organic substances that decay readily after death of the crinoid. In larval crinoids delicate plates of the theca and slightly calcified columnals of the stem barely touch one another or they are separated by soft tissue. In young postlarval crinoids and even in adults the skeletal elements are not strongly united. Consequently, the preservation of specimens with articulated arms, theca, and stem is statistically most rare. It depends mainly on unusual conditions of burial in sediment little disturbed by current action. The stratigraphic and geographic localization of crinoids with skeletons only slightly disarranged is accounted for in this way. Good examples of favorable environment for preservation are found in Mississippian silty deposits of the Crawfordsville, Indiana, area and in the Bundenbach Shale of Devonian age in the Hunsrück region of western Germany.

It is well known that characters of the stem are more important than any other skeletal features in differentiating rather numerous species of some Paleozoic crinoid genera (e.g., *Myelodactylus, Brachiocrinus, Herpetocrinus, Ammonicrinus, Camptocrinus*) and a majority of post-Paleozoic stalked species. Among Jurassic species of *Pentacrinites,* for example, nearly 80 percent (131 out of a total of 167 species described prior to 1935) are based solely on stem fragments and more than 90 percent (42 of 45 species) of forms assigned to *Balanocrinus* are discriminated similarly (Biese, 1935-37). In a recent comprehensive monograph on Cretaceous crinoids (Rasmussen, 1961) it is reported that some genera and a large number of species have been defined mainly or entirely on stem characters. Seventy-five species out of all described Cretaceous crinoids (216 species) have been based solely on dissociated skeletal fragments. We may conclude reasonably that all disarticulated crinoid columns (as well as other parts) merit study and that many of them will prove trustworthy for discrimination of generic and specific taxa.

The classification of thecal plates and parts of arms generally is not difficult, except for kinds devoid of any diagnostic feature. The latter must be put aside as unclassifiable. In general, dissociated radials and primibrachs of inadunate crinoids are more distinctive than any other elements of the crown and the same may be true of stalked articulate crinoids. Among free-swimming articulates, the centrodorsal commonly is the most important skeletal element for classification and arm fragments are mostly unidentifiable. Fragments of the crown of most camerate and flexible crinoids are seldom distinctive enough to warrant much attention, even if several plates or arm ossicles remain united together. Exceptions to this generalization are some of the tegminal plates of genera such as *Eucalyptocrinites, Pterotocrinus,* and *Dorycrinus,* and possibly the dorsal-cup plates of hexacrinitids, dichocrinids, platycrinids, and few other camerates. Among flexible crinoids the dissociated radials of *Cibolocrinus, Lecanocrinus, Pycnosaccus, Mespilocrinus,* and a few other genera can be recognized, generally by their shape and the nature of their articular facets. Also, various arm plates of such flexible genera as *Forbesiocrinus, Taxocrinus, Onychocrinus,* and a few others may be determinable by their shape and peculiarities of their proximal, lateral, and distal facets.

Data are not now available for estimating the number of taxa which may be discriminated on the basis of crinoid fragments, but studies so far made indicate that they are likely to exceed by a very large amount the total number of genera and species now described in the literature, mostly on the basis of crinoid "heads" (dorsal cups and crowns). This is indicated by observation of very numerous sorts of crinoidal fragments that are yet unknown in relatively complete fossil crinoids, a situation not at all surprising in view of the ease with which the skeletal elements of most crinoids may become disarticulated. Only a small fraction of them are likely to remain attached together as dorsal cups and crowns with adherent stems, and further the chances of finding these are few.

Unquestionably, the study of disarticulated fossil skeletal remains of crinoids, particularly column parts of stalked forms, can be pursued with few difficulties in finding and classifying groups of them which have high utility to stratigraphic paleontology and which may add important knowledge of crinoid morphology and ontogeny.

Because crinoid stem parts are the chief type of disarticulated remains, at least in most Paleozoic and Mesozoic formations, they are chosen for consideration in this article. Such fossils include 1) individual columnals which have become separated from neighboring ones, and 2) stem parts of variable length composed of columnals joined together (pluricolumnals) (see Echinodermata, Art. 8). Many pluricolumnals consist of only 2 or 3 columnals but a majority of them have a larger number, commonly 6 to 10 or more. Some contain 20 to 30 columnals, though these are exceptional.

METHODS OF STUDY

Approach to the study of the disarticulated skeletal remains of crinoids, especially the extraordinarily abundant columnals and pluricolumnals of stalked crinoids, differ in various ways from that commonly employed in investigations of whole articulated skeletons, although both are aimed fundamentally at determining significant morphological features.

In work on more or less whole crinoid fossils, exterior surfaces when freed from matrix may be observed and the arrangement of different elements composing the theca, arms, and stem may be ascertained, though with greatly varying difficulty and completeness. Classification depends on the presence or absence of different kinds of plates, their relative size and shape, and especially the way in which they fit together. Generally unstudied and therefore unknown are all details of the inner sides and articulating edges of thecal plates and individual components of the arms. The outer appearance of at least part of the stem may be described and illustrated, but not the pattern of articular surfaces of its columnals or size and shape of its axial canal. Sections through skeletal parts are almost never cut, because this would irreparably damage the fossil. Therefore, one may search in vain through paleontological literature for information on the nature of individual skeletal parts of crinoids other than some exterior features.

Contrariwise, all aspects of disarticulated crinoid remains free of rock matrix are readily studied, not only allowing them to be used independently for purposes of stratigraphic correlation, but when correctly associated with equivalent parts of articulated crinoids, adding importantly to morphological knowledge of the latter.

Stem fragments, segregated from thecal and arm plates, should be classified first according to shape groups in which they belong. Single columnals may or may not be separated from multicolumnal stem fragments (pluricolumnals), for this is a matter of preference. The individual single columnals may be either nodals or internodals derived from heteromorphic stems or homeocolumnals derived from homeomorphic stems, and if their nature is recognized, this is likely to influence sorting of them. Heteromorphic pluricolumnals may be separated from homeomorphic ones, or initially they may be lumped together.

Characters of the articular facets of crinoid columnals are indispensable for classification. These include nature of the crenulae, features of areolae (if present), shape and relative size of the lumen, and the presence or absence of a perilumen. The nature of the lumen is likely to have value for classification, and if the axial canal contains claustra and jugula, these require observation even though stems may have to be sectioned in order to investigate their presence and characters. Whereas most of these features commonly are well shown by dissociated columnals and pluricolumnals, the same cannot be said of most relatively complete crinoid fossils, including type specimens and others displayed in museums and contained in best collections. Although side views of crinoid columnals are readily available, features of the articula are rarely determinable and are almost unnoticed in paleontological literature. Naturally, this impedes systematic studies of dissociated crinoid remains. The difficulty has not been overcome by examinations of the splendid Springer collection of fossil crinoids in the U. S. National Museum and by surveys of other large collections in universities, made in the course of work to produce the present report.

Measurements of the diameter of stems are not trustworthy guides for classification because 1) columnals present in different parts of individual complete or nearly complete stems attached to heads are found in some species to differ appreciably in size. Also, 2) juvenile representatives of any species must have been smaller than adults and some of them are very likely to have died before attaining maturity; the skeletons of such young crinoids are less stoutly knit together than those of fully grown individuals and therefore would more easily suffer disarticulation after premature death. It is a fact, generally unmentioned and unexplained, that diminutive specimens of almost any crinoid species described in the literature—specimens which could reasonably be interpreted as immature individuals—have been found only rarely. Their absence may be due to death and disarticulation along the way to becoming adults, and if this is true, study of crinoid fragments is likely to furnish needed information about them. Stem fragments and other remains derived from young crinoids may occur in any collection of dissociated fossil crinoid skeletons, being either a minor fraction of the whole (suggesting a possible low infant mortality), or approximately equal to or greater than the remains of adult individuals (signifying a relatively high infant mortality).

Dissociated columnals and pluricolumnals obtained at surface exposures differ markedly in preservation. Some are seemingly unaltered with features of the latera and articula clearly visible. Others are coated with matrix or incrusting fossils or have been corroded or replaced to differing degrees. A large proportion of columnals and pluricolumnals, therefore, provide either incomplete or misleading information if effects of weathering and other alteration are overlooked. Implanted culmina commonly are partly to completely destroyed along the periphery of articula, and culmina that bifurcate close to the periphery may be difficult to observe.

Sections commonly show that solution during weathering or replacement of the calcite, as by silica or limonite, is accompanied by loss or concealment of many morphological features. Longitudinal sections of pluricolumnals demonstrate that structures near the axial canal are removed very commonly (Echinodermata, Art. **10**, pl. 2, fig. 8) and replacement may conceal or confuse interpretation of structural features (Echinodermata, Art. **10**, pl. 4, fig. 6). In many assemblages, for example, the shape and size of the lumen and nature of adjacent structures is shown clearly by only a few of hundreds or thousands of specimens. Moreover, the lumen, as observed on a suite of specimens commonly differs markedly because (as result of weathering) it is being observed at slightly differing planes beneath the perfectly preserved articulum. Thus, especial attention needs to be directed to the rarely occurring exceptionally preserved specimens in order to understand details of the articulum. Also, many longitudinal sections of long pluricolumnals may be needed before an adequate insight is gained on the detailed features of the axial region.

PREVIOUS WORK

As early as 1821 J. S. Miller, at Bristol, England, published *A Natural History of the Crinoidea, or Lily-shaped Animals,* which contains reasonably accurate and adequate information on at least the gross characteristics of columns and holdfast structures belonging to seven Paleozoic and Mesozoic genera *(Poteriocrinites, Cyathocrinites, Actinocrinites, Rhodocrinites, Platycrinites, Eugeniacrinites,* and *Apiocrinites)* introduced by him, as well as the type species of now-defined additional genera *(Crotalocrinites, Parisocrinus, Temnocrinus, Bourgueticrinus).* Miller's work is noteworthy not only because of its date, but because, unlike very many later authors, he figured longitudinal sections of stems and holdfasts and illustrated the nature of columnal articular facets.

The most important publications recording observations on crinoid columns and columnals subsequent to Miller have been produced by Goldfuss (1826-44), Eichwald (1840, 1856, 1859-68), d'Orbigny (1840, 1849-51), F. A. Roemer (1836, 1840-41), Austin & Austin (1843), Hall (1843, 1852, 1859a,b, 1861, 1862, 1866a,b, 1872, 1882), Steininger (1853), de Koninck & Lehon (1854), C. F. Roemer (1860), Meek & Worthen (1860, 1865a,b, 1866a,b, 1868, 1873), Schultze (1867), Trautschold (1867, 1879, 1880), Meek (1872, 1873), S. A. Miller (1874, 1883, 1889), Angelin (1878), Wachsmuth & Springer (1879-85, 1886, 1897), de Loriol (1882-89, 1904), Bather (1893, 1900, 1917a-c, 1909), Waagen & Jahn (1899), Weller (1900, 1909), Miller & Gurley (1890, 1894), Springer (1909, 1911, 1913, 1917, 1920, 1921, 1922a,b, 1926a-c), Wanner (1916, 1924, 1929, 1931, 1937, 1938, 1940, 1949), Jaekel (1918), Goldring (1923, 1942), Gislén (1824), Biese (1927), Ehrenberg (1929), Schmidt (1930, 1931, 1934, 1942), Yakovlev (1933), Yakovlev & Faas (1938), Moore (1939a-c), Marez Oyens (1940), Moore & Plummer (1940), Moore & Laudon (1943, 1944), Wright (1950-60), Moore & Vokes (1953), Yakovlev & Ivanov (1956), Termier & Termier (1949, 1958), Sieverts-Doreck (1939, 1951a,b, 1953b, 1954, 1957), RAMSBOTTOM (1961), RASMUSSEN (1961), VAN SANT (1964), and ARENDT & GEKKER (1964).

Even before the time of LINNÉ (1758), names were given to some crinoids known only from single columnals or small portions of stems composed of attached columnals. Of course, these cannot be recognized in zoological nomenclature, but beginning with HOFER (1760) a vast amount of work which may qualify for taxonomic recognition under the zoological *Code* (1961) is recorded. This is incompletely summarized in Table 3, which lists 443 paleontologists who are authors of 698 papers containing named genera and species of crinoids distinguished in these publications solely on dissociated stem parts or holdfast structures. Table 4 provides information on the taxonomic distribution of these crinoids, with classification of them as to occurrence in the Paleozoic, Mesozoic, and Cenozoic erathems. Total numbers for the Paleozoic are 74 genera and 442 species, for the Mesozoic 21 genera and 359 species, and for the Cenozoic 5 genera and 22 species. Because of overlap in ranges of a few genera, the total of 823 species is distributed among 94 different genera. These tables sufficiently attest the volume of work already done on classification and nomenclature of crinoids based on dissociated parts of their columns and lack of newness in such studies. It should be pointed out that many nominal crinoid taxa of like nature have been omitted from consideration here because they do not conform to requirements of the zoological *Code*.

TABLE 3.—*Authors and Dates of Publications Containing Descriptions of Named Species of Fossil Crinoids (with or without Accompanying Illustrations) Based Solely on Dissociated Parts of Skeleton below Dorsal Cup, Preponderantly Designated as New Species.—Nearly All Names Available but Many Invalid.*

[Publications containing new genera of crinoids based on dissociated parts of stems or holdfast structures marked by asterisk (*) and author's name is printed in capital letters (e.g., HALL). References omitted from this paper are contained in volumes of the *Fossilium Catalogus* (BASSLER, 1938; BIESE, 1934, 1935-37; BIESE & SIEVERTS-DORECK, 1937, 1939a,b. References printed in boldface type are included in the Supplement to Echinodermata Articles 8-10, which follows Article 10.

Abich, 1899
Agassiz, **1835**, '45
Aguilera, 1893
Ahlburg, 1903, '06
Airagh, 1904
Alberti, 1864
Albus, 1930
Ammon, 1875, 1901
Andrea, 1763
Anthula, 1899
Archiac, d', 1846, '50, '59, '60
Arthaber, 1908
Assmann, 1914, '25
Austin, 1842
Austin & Austin, **1845**
Avrov & Stukalina, **1964**
Basset, 1866
Bateson, 1894
Bather, 1888, '89, **'93**, '97, **1909**, '17, '18, '29, '35
Baugier & Sauzé, 1856
Bayan, 1870
Behrenger, von, 1926
Beltrémieux, 1866, '68
Benecke, 1868
Benesch, 1914
Bessler, 1935
Bettoni, 1900
Beuth, 1776
Beyrich, 1857, '63
Biese, 1930
Billings, 1859
Bistram, 1903
Blanckenhorn, 1885
Böckh, 1873
Bogdanovich, 1890
Böhm, 1891, 1927
Bölsche, 1877, '82
Bonarelli, 1895
Bonney, 1896
Boué, 1826
Boule, 1928, '32
Boyle, 1893
Brändlin, 1911
Brauchli, 1921
Brauns, 1866, '69, '71, '75
Broili, 1904
Bronn, 1837, '49, '52
Bruder, 1885
Brydone, 1900
Byrne & Seeberger, **1942**
Buckland, **1836**
Campana, 1904
Canavari, 1880
Carez, 1881
Carpenter, 1880, '81, **'84**
Catullo, 1827, '46, '47
Cisneros, 1917
Clark, 1893, **1915**
Clark & Twitchell, **1915**
Collet, 1904
Collignon, 1931
Collins, 1896
Collot, 1880
Contejean, 1860
Coquand, 1880
Corti, 1892, '94
Cottreau, 1929
Couffon, 1918
Couch, 1855
Credner, 1864
Cumings, 1908
Dacqué, 1921, '34
Dalmer, 1877
Dames, **1885**
Darton, 1900, '01
Davis, 1928
Deecke, 1915
Depéret, 1903
Deslongchamps & Deslongchamps, 1858
Desio, 1927, '29
Desor, 1845, **'47**
Desor & Gressly, 1859
Dienst & Gothan, 1928
Dittmar, 1868
Dorn, 1926
Douvillé, 1916
Drevermann, 1902
Dubatolova, **1964, 1967**
Dubatolova & Shao, **1959**
Dubatolova & Yeltysheva, **1960**
Dujardin & Hupé, 1862
Dumortier, 1867, '69, '71, '74
Eaton, 1832
Eck, 1865, '72, '79, '88, '91
Ehrenberg, **1929**
EICHWALD, ***1840**, '51, ***'56, *'60, '68**
Emmrich, 1849, '53
Engel, 1869, '83, '92, 1904, '08, '11
Engster, 1923
Ernst, 1923
Étallon, 1857, **'59**, '60, '64
Etheridge, 1882
Faber, 1929
Fabiani, 1908
Fabiani & Ruiz, 1933
Fallot & Blanchet, 1923
Favre, 1880
Felix, 1891
Fenton, **1929**
Ferry, 1861
Fischer, 1912
Fischer de Waldheim, **1811**
Fitton, 1835
FOERSTE, 1914, '18, ***'19**, '24
Forbes, 1852
Fourtau, 1924
Fraas, 1856, '58, '78, '82, '90, 1910, '11
Frank, 1928
Frentzen, 1934
Freystadt, 1893
Frič, 1910
Fritel, 1903
Fucini, 1895
Fugger, 1907
Gabb, 1876
Gallinek, 1895
Gasche, 1938
Gastaldi, 1845, '46
Geinitz, 1837, '38, **'46**, '75
Gerber, 1925
Giebel, 1852
Girardot, 1895, '96
Gislén, **1924**, '38
Goldfuss, **1831, '33, '42**, '62
Goldring, **1923**
Göppert, 1832
Grabau & Shimer, 1910
Graff, 1885
GREGORIO, DE, 1894, ***1930**
Greppin, 1967, '93, 1900, '04
Grewingk, 1861
Grossouvre, 1901
Grupe, 1929
Guéranger, 1853
Guggenberger, 1929
Guiscari, 1874
Gümbel, 1861, '65, '77, '87, '88 '90, '94
Guppy, 1874
Haack, 1933
Hagenow, **1840**
Halaváts, 1916
HALL, ***1852, *'58, '62, *'66, '72, *'79**
Hall & Whitfield, 1877
Hantken, 1884
Hartmann, 1830
Hauer, 1851, '75
Haug, 1927
Herbig, 1931
Hildebrand, 1926
Hisinger, 1823
Hoernes, 1884
Hofer, **1760**
Hofmann, 1927
Holdefleiss, 1916
Holl, 1830

Hug, 1889, '99
Hutton, 1873
Ilovaisky, 1904
Jackson, 1899
Jacquot, 1868
JAEKEL, 1891, 1904, ***'18**
Janensch, 1902
Jaworskim, 1915
Jeannet, 1918
Jekelius, 1925
Jessen & Odum, 1923
Johnson, 1901
Jukes-Browne, 1900
Kamenov, 1936
Kiefer, 1931
Kirchner, 1924
Kirk, 1911
Kittl, 1903
Klipstein, 1845
Klöden, 1834
Klughardt, 1917
Knight, 1900
Knorr & Walch, 1773
Koenen, 1887
Koert, 1923
Koken, 1896, 1900
Kossmat, 1914
Krause, 1908
Krenkel, 1915
Krumbeck, 1913, '25
Kuhn, 1935, '36
Lahusen, 1883
LAMBE, ***1896**
Lambert, 1899
Langenhan, 1903
Lapparent, 1900
Laube, 1865
Lehner, 1934
Lehner & Dehm, 1937
Lennier, 1872
Leonhard, 1840
Leunis, 1856
Leuthardt, 1927
Lewinski, 1842
Leymerie, 1842
Lissajous, 1900, '06, '10, '12, '23
Logan, 1900
Lörcher, 1902
Lorenzo, 1893
Loretz, 1873, '75
Loriol, de, 1868, '71, '78, '79, **'82, '83, '84, '89,** '91, '93, **'97, 1904**
Loriol, de, & Gilliéron, 1869
Loriol, de, & Pellat, 1875
Löwe, 1913
Ludwig & Hamann, 1907
Madsen, 1904
Maire, 1905
Maire & Valette, 1928
Mallada, 1884
Mandelsloh, 1841
Mansuy, 1912, '19
Manzoni, 1874
Manzoni & Mazzetti, 1877
Marinelli, 1902
Matejka & Andrusov, 1931
Mauger-Patane, 1932
M'Coy, 1848
Meek, 1864, '66, **'73**
Meek & Hayden, **1858,** '65
Meneghini, 1876, '81
Merian, 1864
Meunier, 1893
Meyer, von, 1837, '47, '49
Michael, 1913, '14, '15
Michelotti, 1847, '61
Miller, **1821**
Miller, S. A., **1874,** '79, '80, '82, **'88**
Moberg, 1888
Moesch, 1857, '67, '74
Mojsisovics, 1869, '71
Moore, 1938, **'39b**
Moore & Laudon, **1944**
Morand, 1914
Moriere, 1879
Morris, **1843**
Moulins, 1872
Müller, 1859
MÜNSTER, ***1831,** '33, '34, **'39,** '41, '68
MURCHISON, ***1839**
Musper, 1920
Nagao, 1928
Neumayr, 1871
Neumayr & Uhlig, 1892
Nicholson, 1879
Nicklés, 1889, '91
Nicolas, 1897, '98
Nicoles & Parona, 1886
Nielsen, **1913**
Noelli, 1900
Noetling, 1887
Nöth, 1931
Novarese, 1894
Odum, 1926
Ogérien, 1867
Ogilvie-Gordon, 1893, 1927, '28
Omboni, 1882
Ooster, **1865,** '70, '71
Osterbaan, 1937
Oppel, 1854, '58
Oppel & Waagen, 1866
Oppenheim, 1901, '02, '03
Orbigny, d', **1840, '50,** '52
Osswald, 1929
Owen, 1860
Parona, 1893, 1903
Pasotti, 1929
Patte, 1922, '26
Peale, 1880
Pellat, 1897
Peron, 1872, '87
Peron & Bonarelli, 1897
Petitclerc, 1900
Philippi, 1895
PHILLIPS, 1829, *'31, '35, **'41**
Piaz, 1912
Pichler, 1869
Pictet, 1857, '65
Pictet & Renevier, 1858
Pillet, 1881, '90
Pillet & Fromentel, 1875
Pompeckj, 1897, 1913
Pratje, 1923
Puggard, 1851
PUSCH, ***1837**
Quaas, 1902
Quenstedt, 1835, '51, **'52,** '58, **'67,** '71, **'76, '85**
RAFINESQUE, ***1819**
Ramsbottom, **1961**
Rasmussen, **1961**
Ravn, 1908
Redlich, 1896
Reed, 1927
Remes, 1902, '05
Renevier, 1890
Repelin, 1899
Reuss, 1846
Riabinin, 1913
Riche, 1893, 1904
Riedel, 1931
Rigoux, 1892
ROEMER, F. A., **1836,** '39, **'40,** '43, '50, **'54,** *'60
Roemer, F., 1870
Roemer, J., 1911
Roig, 1926
Rollier, 1890, '98, 1911
Roman & Brun, 1910
Roman & Sayn, 1928
Romanovsky, 1890
Rothpletz, 1886, '88, '95
Rowe, 1904
Rühl, 1896
RUSCONI, *1951, '52, '53, **'55**
Salomon, 1895
Sandberger, 1890
SARDESON, ***1908**
Sauvage & Buvignier, 1842
Savi & Meneghini, 1851
Scalia, 1910
Schafhäutl, 1851, '52, '63, '65
Schardt, 1911
Schauroth, 1855, '59, '65
Schirardin, 1914
Schlippe, 1888
Schlönbach, 1863
Schlosser, 1925
Schlotheim, von, 1820, '22, '23, '32
Schlüter, 1897
Schmid, 1876
Schmid & Schleiden, 1846
Schmidel, 1780
Schmidt, 1909, '28, **'30**
Schnetzer, 1934
Schönfelder, 1933
Seebach, 1864
Seguenza, 1880
Sella, 1889
Shevchenko, **1964**
SHEVCHENKO, ***1966**
Siegert, 1898
Siemiradzki, 1903
Sieverts, 1933
SIEVERTS-DORECK, **1942, *1951a, 1951b**
Simonelli, 1889
Sinard, 1892
Sizova, **1960**
Skuphos, 1894
Slocom & Foerste, **1924**
Smith, J. P., 1914, '27
Sowerby, 1835
Springer, **1901, '09, '11,** '16, **'17, '22a,b,** '25, **'26a,b**
Staesche, 1932
Stahlecker, 1926
Stanton, 1899
Stefani, 1876, '89
Stefanini, 1932
Steinmann, 1907, '29
Stelzner, 1864
Stierlin, 1914
Stoliczka, 1865
Stolley, 1891, 1902
Stoppani, 1857, '65
Strangways, 1904
Strimple, **1962, '63**
Strombeck, 1849
Stromer von Reichenbach, 1909
Struckmann, 1878
Stuber, 1893
Studer, 1853
STUKALINA, **1960, *'61, '64a, '64b, *'65a, '65b, '65c, '66, '67**
STUKALINA & TUYUTYAN, ***1967**
Stur, 1868
Szalai, 1926
Taramelli, 1880, '82
Tate, 1875, '94
Tate & Blake, 1876
TERMIER & TERMIER, **1949, *1958**
Terquem, 1855
Terquem & Jourdy, 1873
Terquem & Piette, 1865
Thièry, 1910
Thirria, 1830
Thurmann, 1830
Thurmann & Etallon, 1864
Tillmann, 1916
Tornquist, 1874, 1909
Toula, 1876, '77, '79, '82, '85, '89, '90, '92, 1900, '13
Trautschold, 1861
Tribolet, 1873, '75
Tzankov & Ek. Bontev, 1932
Vacek, 1879
Vadász, 1911, '15
Valette, 1917, '24, '25, '27, '28, '32, **'34**
Valette in Roig, 1926
Vankov, 1892
Verri & Angelis d'Ossat, 1901
Vidal, 1921
Vinassa de Regny, 1902
Waagen, 1864, '67
Waagen & Jahn, **1899**
Wachsmuth & Springer, **1880, '86**
Wagner, 1923
Wahlenberg, 1820
Walther, 1886, 1906
Wanner, 1902, **'31, '37, '38**
Weerth, 1884
Wegner, 1905, '13
Weller, 1907, **'16**
Welsch, 1918
Wetherell, 1837
Whidborne, 1898

White, C. A., 1877
Whiteaves, 1889
Whitfield, 1880
Winkler, 1861, '71
Wöhrmann, **1889**, '94
Wollemann, 1902, '07
Woods, 1891
Woodward, 1893
Wright, T., 1854, '58, '69, 89
Würtenberger, 1868
Yakovlev, 1927, **'33**, '34, '53
Yakovlev & Ivanov, **1956**
YELTYSHEVA, **1955, '56, *'57, '59, '60, *'64a, '64b, '66**
Yeltysheva & Dubatolova, **1960**
YELTYSHEVA & STUKALINA, ***1963**
Yokoyama, 1911
Zeuschner, 1829
Zigno, 1845, '47
Zimmermann, 1892
Zittel, 1870, 1870, '80, **1900**
Zlatarski, 1904
Zugmeyer, 1875

Table 4.—*Named Genera and Species of Crinoids Based Solely on Stem Parts or Holdfasts*

[Genera with type species similarly based solely on such remains marked by asterisk (*); catchall genera of this sort considered to be valueless marked by double asterisk (**). Nominal genera classed as *nomina nuda, nomina vetita,* and junior homonyms enclosed by square brackets; they are unavailable and species referred to them are not included in totals. P—Paleozoic, M—Mesozoic, C—Cenozoic]

Genus	Number of Species P	M	C
Acrochordocrinus Trautschold, 1859	—	3	—
Actinocrinites Miller, 1821	7	—	—
**Adelocrinus* Phillips, 1841	1	—	—
**Ancyrocrinus* Hall, 1862	3	—	—
Angulocrinus d'Orbigny, 1840	—	1	—
**Anthinocrinus* Stukalina (*ex* Yeltysheva & Sisova, MS), 1961)	9	—	—
**Antunia* Rusconi, 1955	2	—	—
Apiocrinites Miller, 1821	—	16	—
**Asterocrinus* Münster, 1839	3	—	—
**Ascarum* de Gregorio, 1930	1	—	—
**Aspidocrinus* Hall, 1858 (holdfast)	5	—	—
**Astroporites* Lambe, 1896 (holdfast)	1	—	—
Austinocrinus de Loriol, 1889	—	5	—
Balanocrinus Agassiz in Desor, 1847	—	47	10
**Bornium* de Gregorio, 1930	1	—	—
Bourgueticrinus d'Orbigny, 1840	—	4	1
**Brachiocrinus* Hall, 1858	1	—	—
**Bystrowicrinus* Yeltysheva in Yeltysheva & Stukalina, 1963	3	—	—
**Camarocrinus* Hall, 1879 (holdfast)	7	—	—
Camptocrinus Wachsmuth & Springer, 1897	2	—	—
**Coenocrinus* Valette, 1934	2	—	—
**Concretum* de Gregorio, 1930	1	—	—
**Cophinus* Murchison, 1839	1	—	—
**Cristatum* de Gregorio, 1930	2	—	—
Crotalocrinites Austin & Austin, 1843	2	—	—
Ctenocrinus Bronn, 1840	1	—	—
Cupressocrinites Goldfuss, 1831	3	—	—
Cyathocrinites Miller, 1821	13	—	—
Cyclocrinus d'Orbigny, 1850	—	6	—
**Cyclocyclicus* Yeltysheva, 1955	12	—	—
[**Cyclopentagonalis* Yeltysheva, 1964]	[5]	—	—
**Cystocrinus* Roemer, 1860	1	—	—
**Decacrinus* Yeltysheva, 1957	4	—	—
Desmidocrinus Angelin, 1878	1	—	—
Doreckicrinus Rasmussen, 1961	—	4	—
[***Encrinites* Fischer de Waldheim, 1811[1]]	[51]	[21]	—
Encrinus Lamarck, 1801[2]	—	4	—
[***Entrochites* Pusch, 1837]	[34]	[14]	—
**Eomyelodactylus* Foerste, 1919	1	—	—
Eugeniacrinites Miller, 1821	—	5	—
**Grammocrinus* Eichwald, 1860	4	—	—
Haplocrinites Steininger, 1837	1	—	—
Hexacrinites Austin & Austin, 1843	5	—	—
Holocrinus Wachsmuth & Springer, 1887	—	1	—
**Idromecrinus* de Gregorio, 1930	2	—	—
**Imperatoria* de Gregorio, 1930	2	—	—
Isocrinus Agassiz, 1835 (1836)	—	55	3
Isselicrinus Rovereto, 1914	—	10	—
**Kasachstanocrinus* Shevchenko (*ex* Sisova, MS), 1966	1	—	—
**Kstutocrinus* Shevchenko, 1966	4	—	—
**Kuzbassocrinus* Yeltysheva, 1957[3]	5	—	—
**Leseus* de Gregorio, 1930	2	—	—
**Lichenocrinus* Hall, 1866a (holdfast)	23	—	—
Mariacrinus Hall, 1858	1	—	—
**Medinecrinus* Stukalina, 1965a	2	—	—
**Mediocrinus* Stukalina, 1965a	3	—	—
Melocrinites Goldfuss, 1826[4]	13	—	—
Millericrinus d'Orbigny, 1840	—	33	—
**Musivocrinus* Termier & Termier, 1958	1	—	—
**Myelodactylus* Hall, 1852	18	—	—
Myrtillocrinus Sandberger & Sandberger, 1856 (in 1850-56)	1	—	—
Nielsenicrinus Rasmussen, 1961	—	5	—
**Obuticrinus* Yeltysheva & Stukalina, 1963	2	—	—
**Orocrinus* Sieverts-Doreck, 1951a	4	—	—
**Pachycrinites* Eichwald, 1840	3	—	—
**Palermocrinus* Jaekel, 1918	1	—	—
**Pandocrinus* Stukalina, 1965a	2	—	—
Pentacrinites Blumenbach, 1804	—	117	7
[**Pentagonocyclicus* Yeltysheva, 1955]	[74]	—	—
[**Pentagonopentagonalis* Yeltysheva, 1955]	[32]	—	—
**Phialocrinus* Eichwald, 1856	1	—	—
Platycrinites Miller, 1821	2	—	—
**Plussacrinus* Yeltysheva, 1957	2	—	—
**Podoliocrinus* Yeltysheva, 1957	1	—	—
**Podolithus* Sardeson, 1908 (holdfast)	1	—	—
Poteriocrinites Miller, 1821	2	—	—
Rhizocrinus Sars, 1863	—	—	1
Rhodocrinites Miller, 1821	4	—	—
Ristnacrinus Öpik, 1934	2	—	—
**Salagastiana* Rusconi, 1951	1	—	—
Schizocrinus Hall, 1847	2	—	—
**Scillus* de Gregorio, 1930	1	—	—
Seirocrinus Gislén, 1924	—	2	—
**Sphenocrinus* Eichwald, 1856	5	—	—
Syndetocrinus (?) Kirk, 1933	1	—	—
**Tetragonocrinus* Yeltysheva, 1964	2	—	—
Thiolliericrinus Etallon, 1859	—	1	—
[**Tetragonocyclicus* Yeltysheva, 1956]	[10]	—	—
**Tetragonotetragonalis* Yeltysheva, 1964	7	—	—
Traumatocrinus Wöhrmann, 1889	—	5	—
Trigonocyclicus Yeltysheva, 1955	2	—	—
Vasocrinus Lyon, 1857	3	—	—
**Zeravschanocrinus* Shevchenko, 1966	6	—	—
TOTALS[5]	230	324	22
	[210]	[35]	—

[1]Junior homonym (*non Encrinites* Davila & Romé de l'Isle, 1767).
[2]Validated by ICZN (Bull. Zool Nomencl., v. 19, pt. 5, 1962, p. 262, Opinion 636).

[3]Synonymized with *Melocrinites* by Shevchenko (1966).
[4]Not including 5 species referred to *Kuzbassocrinus*.
[5]Studies made subsequent to preparation of Table 4 have led us to conclude that the nominal genera *Bystrowicrinus, Medinecrinus, Mediocrinus,* and *Obuticrinus* fail to comply with the zoological *Code* and therefore presently are unavailable for designation of crinoids. On the other hand, ***Trigonotrigonalis*** Dubatolova & Shao, 1959, is available, for this nominal genus was published with adequate diagnosis and figures for a single included species (genus monotypic). Computed totals for species need to be modified accordingly.

Inspection of Table 4 leads to a number of interesting observations: 1) the nominal "catchall" genera *Encrinites* and *Entrochites,* containing 85 named Paleozoic species and 35 named Mesozoic species, may be put aside as presently valueless; 2) so-called groups of crinoid stem parts named by MOORE (1939b) and four nominal genera proposed by YELTYSHEVA *(Cyclopentagonalis, Pentagonocyclicus, Pentagonopentagonalis, Tetragonocyclicus)* containing 121 named species in publications seen by us, are here classified as *nomina nuda* and most of the genera, lacking designated type species, are designated as *nomina vetita* (impermissible names); 3) named species of crinoids based solely on columnals or pluricolumnals which are identified as belonging to genera represented by relatively complete skeletons include 73 Paleozoic species (19 genera), 324 Mesozoic species (19 genera), and 22 Cenozoic species (5 genera); 4) remaining species considered to be validly distinguished and named, although assigned to genera having type species consisting only of stem parts or holdfasts, number 161[1] and all of them occur in Paleozoic formations.

Nine of the new crinoid genera with type species based on dissociated crinoid stem parts have been introduced from North America. They are *Ancyrocrinus, Aspidocrinus, Astroporites, Brachiocrinus, Camarocrinus, Eomelodactylus, Lichenocrinus, Myelodactylus,* and *Podolithus.* Two other similarly defined genera, *(Autunia, Salagastiana)* are from South America and two *(Coenocrinus, Musivocrinus)* from North Africa. The remaining 34 stem-based genera (not counting 5 *nom. nud.*) have been added from European and Asiatic (Siberian) sources.

Paleontologists who have described and illustrated new crinoid species based solely on dissociated stem parts found in post-Paleozoic strata likewise have not hesitated to place them in already known genera, although it is beyond doubt that many of these are wrongfully classified. Thirteen Mesozoic species have North American origin; these are referred to *Apiocrinites* (1), *Austinocrinus* (1), *Bourgueticrinus* (1), *Encrinus* (1), *Isocrinus* (3), and *Pentacrinites* (6). Two Mesozoic species of similar nature are recorded from South America, one placed in *Isocrinus* and the other in *Pentacrinites.* Four species of Cenozoic crinoids defined by stem-part characters have North American types; they have been assigned to *Balanocrinus* (1), *Pentacrinites* (2), and *Rhizocrinus* (1). Virtually all other Mesozoic and Cenozoic species similarly based on dissociated crinoid stem parts (346 in aggregate number) come from localities in Europe, for only 11 such species have been reported from Africa, Asia, East Indies, and Australia.

Included in this survey are results of studies by YELTYSHEVA (1957), YELTYSHEVA & STUKALINA (1963), STUKALINA (1960, 1961, 1964, 1965a,b, 1966), AVROV & STUKALINA (1964), DUBATOLOVA (1964, 1967), DUBATOLOVA & YELTYSHEVA (1960), SHEVCHENKO (1964, 1966), and STUKALINA & TUYUTYAN (1967) in which 14 new genera and 43 species from localities in the Soviet Union (chiefly Siberian) are distinguished by morphological features of their columns. With 27 species assigned to the long-known genera *Camptocrinus, Crotalocrinites, Cupressocrinites, Hexacrinites, Melocrinites, Myrtillocrinus,* and *Syndetocrinus,* a total of 70 species are reported. Not counted are four nominal genera named by YELTYSHEVA *(Cyclopentagonalis, Pentagonocyclicus, Pentagonopentagonalis, Tetragonocyclicus)* and 121 species referred to them, which in following discussion of classification and nomenclature are designated by us as *nomina nuda* and *nomina vetita.*

[1]This figure takes account of changes recorded in footnote (5) given with Table 4.

CLASSIFICATION AND NOMENCLATURE OF CRINOIDS BASED ON STUDIES OF DISARTICULATED STEM PARTS

OBJECTIVES AND PRINCIPLES

Fossil crinoid stem parts are more or less well-preserved remains of once-living echinoderms, just as fossil pedicle valves of brachiopods and fossil left valves of bivalves are incomplete remains of two other kinds of invertebrates. It follows without need for saying that the aims of classifying these objects zoologically are to identify species of animals, to assign them to genera, and possibly to recognize groupings of higher taxonomic rank. Distinction between classification of animal-produced objects, whether teeth, bones, shells, or birds' nests, and the animals themselves which are represented by these things is fundamental—not a matter of semantics. Likewise, the objectives and methods of nomenclature are controlled by viewpoints which recognize the difference between any assemblage of organically made things and the animals, plants, or protists which they represent as classified in taxonomic categories.

Because the concepts just stated bear importantly on paleontological treatment of disarticulated crinoid-stem parts, simple illustrations of through-going principles are warranted. Given a large collection of feathers, no ornithologist in right mind would undertake to sort these with the object of identifying the various species of birds from which they were derived. A segregated group of white feathers *(A-us albus)* might come from generically unrelated birds distributed in different families and orders. The classified feathers would be mere assemblages of bird-produced objects and scientific names for them would be meaningless. Of course, myriads of whole birds are available for study leading to zoological classification and nomenclature of them. Disarticulated fossil crinoid remains are analogous to feathers and the same principles of taxonomy apply to both, but in the case of fossil crinoids we lack hosts of complete specimens having kinds of stem parts, for example, found in collections of dissociated skeletal remains. Classification and nomenclature of the fossils must be directed to discrimination of the once-living echinoderms to which they belonged and not to the remnant parts as similar kinds of objects.

This leads to consideration of unacceptable and acceptable categories of taxonomic groups for use in classifying and naming genera and species of fossil crinoids which presently can be recognized only from studies of their scattered disarticulated skeletal parts.

UNACCEPTABLE TAXONOMIC GROUPS

Categories of taxonomic groups that are judged to be unacceptable for classification and nomenclature of crinoids based on studies of their dissociated remains include 1) so-called collective groups, 2) meaningless catchall genera, 3) artificial and hypothetical assemblages which are excluded from application of the zoological *Code,* 4) proposed second-class zoological units called parataxa, and 5) assemblages known as form-genera and form-species.

COLLECTIVE GROUPS

Collective groups are assemblages of organisms with latinized names treated as "genera of convenience." They are authorized by the zoological *Code* (Art. 42c) (ICZN, 1961) as groups of identifiable species having uncertain generic position. No type species is needed in defining a collective group. Parasitologists employ the concept of collective groups, but not zoologists generally, or paleontologists. A single example can be cited from the field of paleontology. This is the assemblage named *Ageneracrinus* by SUTTON & WINKLER (1940) who defined it as a collective group of fossil species (all Upper Mississippian) which severally are unassignable to described genera because arm structures are unknown. They included in *Ageneracrinus* two previously named species which had been referred to *Eupachycrinus* and seven new species.

No assemblages of disarticulated crinoid remains such as stem parts have been termed collective groups, with names chosen for them. VYALOV (1953) has proposed a classification in which all crinoid stems are placed together as Caulinaria and then divided into a heirarchy of diminishing groups, one line of which (Monocordalia, Centrocordalia, Planocaulacea, Planocaulidae) leads to family-rank assemblages. None of these are collective groups as defined by the *Code* and no other paleontologist so far has adopted VYALOV's suprageneric taxa. Named assemblages of fossil crinoid stems published by MOORE (1839b), YELTYSHEVA (1955, 1956, 1959, 1960, 1964), and associated Russian authors are discussed in considering artificial and hypothetical groups.

MEANINGLESS CATCHALL GENERA

At least 120 specific names have been introduced for fossils consisting of dissociated parts of columns designated generically as *Encrinites, Encrinus, Entrochites,* or *Entrochus,* in part interchangeably. Among these, it is evident that Paleozoic species called *Encrinus* do not belong to the Triassic genus known by this name. Of the species classed as belonging to *Encrinites* or *Entrochites (Entrochus),* distributed from Ordovician to Upper Cretaceous, 85 are recorded from Paleozoic rocks and 35 from Mesozoic rocks (Table 4). Self-evidently, the names signify only crinoid columnal or pluricolumnal. If one holds that *Encrinites* FISCHER DE WALDHEIM (1811) and *Entrochites* PUSCH (1837) meet requirements of the zoological *Code* in being monotypic genera published respectively for Carboniferous and Devonian crinoids, it follows that virtually all other species generically indicated by these names are classified incorrectly. They demand generic reassignment or may be neglected. Moreover, *Encrinites* FISCHER DE WALDHEIM (1811) appears to be a junior homonym of *Encrinites* DAVILA & ROMÉ DE L'ISLE (1767), and *Encrinites* BLUMENBACH (1804 [in 1802-04]).

ARTIFICIAL AND HYPOTHETICAL ASSEMBLAGES

Artificial classificatory schemes such as the assemblages proposed by CRONEIS (1938), arranged in a hierarchy comparable to that of species, genus, and family in zoological classification but with names derived from units of the Roman army are intentionally devised to be excluded from application of zoological rules. MOORE (1939b) explicitly stated this purpose in publishing descriptions and names for so-called groups and sections of groups of fossil crinoid fragments. His use of latinized binomina (e.g., *Cyclopentagonopa excentrica,* MOORE, 1939b, p. 191) for selected objects gave the appearance but not the substance of scientific names for animals in manner conforming to stipulations of the zoological *Code* (1961). The intent to provide designations for fossil objects thought to be potentially useful for stratigraphic correlation was emphasized when names were changed to combined vernacular-plus-latinized designations (e.g., *Columnal excentricus* MOORE & LAUDON, 1944, p. 203). Because artificial schemes for classifying and naming objects, including animal-formed ones, fail to comply with mandatory zoological rules for taxonomic and nomenclatural differentiation of animals, they lack scientific validity. In effect, all names falling in this category are *nomina nuda*[1] and so-called generic names may be also *nomina vetita*[2] in zoological nomenclature, even if they are classed as genera and species by an author.

Despite the unavailablity of crinoid-stem names published by MOORE (1939b) and by MOORE & LAUDON

[1]As defined in the *Treatise on Invertebrate Paleontology* (Part U, 1966, p. xiv), a *nomen nudum* is any "name that as originally published (with or without subsequent identical spelling) fails to meet mandatory requirements of the *Code* and having no status in nomenclature, is not correctable to establish original authorship and date ("naked name")."

[2]A *nomen vetitum* (same reference as for [1]) is a "name of genus-group taxon not authorized by the *Code* or, if first published after 1930, without definitely fixed type-species ("impermissible name")."

(1944), they have been employed in publications by some other authors (BYRNE & SEEBERGER, 1942; DEVONSHIRE, 1954; WARREN, 1962; STRIMPLE, 1963). This does not affect the status of the names as *nomina nuda.*

The scheme for classifying and naming crinoid columnals and pluricolumnals introduced by YELTYSHEVA (1955, 1956, 1959) and used in numerous Russian publications is admittedly arbitrary and artificial. In addition, it is very largely hypothetical, as indicated by the fact that only seven of 36 conceived form groups defined as genera have been recognized in published paleontological studies (Fig. 6). The concepts and nomenclature given by YELTYSHEVA are counter to the zoological *Code,* which stipulates (Art. 1) that "names given to hypothetical concepts . . . or names proposed for other than taxonomic use are excluded." Accordingly, all of these form groups with latinized names based on selected geometric features are considered by us to be *nomina nuda* and all except *Cyclocyclicus* and *Cyclopentagonalis* (type species by monotypy) to be *nomina vetita,* since no type species for them have been fixed. In the view of Russian workers (G. A. STUKALINA, personal communication, April, 1967), the crinoid-stem assemblages are not systematic units but artificial groups like collective groups which are authorized by the *Code* without the requirement of having designated type species (Art. 42c, 66). The crinoid-stem taxa, however, are not collective groups in the sense of the *Code.*

Not a few crinoid genera (e.g., *Decacrinus* YELTYSHEVA, 1957; *Kuzbassocrinus* YELTYSHEVA, 1967) are judged to be quite valid, although they are distinguished presently on pluricolumnals only. They are well described and illustrated and type species are explicitly designated for them. New species of *Decacrinus* and *Kuzbassocrinus* are chosen as type species of these genera, and no questions arise relating to them. For *Bystrowicrinus,* however, the type species was indicated to be *Pentagonopentagonalis quinquelobatus* YELTYSHEVA, 1955, and the type species of *Obuticrinus* was given as *Pentagonopentagonalis bilobatus* YELTYSHEVA, 1960. Since we judge these specific taxa to be *nomina nuda,* without any standing in zoological nomenclature, how can they serve as type species of genera? In our view, they cannot. Yet, because they are synonymized with *Bystrowicrinus quinquelobatus* and *Obuticrinus bilobatus,* respectively, the specific names become established as *B. quinquelobatus* YELTYSHEVA in YELTYSHEVA & STUKALINA, 1963, and *O. bilobatus* YELTYSHEVA & STUKALINA, 1963. Even so, requirements of *Code* Art. 13b for fixing type species of these genera have not yet been met.

Finally, it should be remarked that only unwieldiness can be urged against publication in manner complying with stipulations of the zoological *Code* of such names as *Tetragonotetragonalis* and *Pentagonopentagonalis* if an author chooses to adopt them for a genus of *animals,* living or extinct, and whether belonging to echinoderms, insects, or birds, provided that for such publication after 1930 the name satisfies *Code* Articles 13-16 in being accompanied by an "indication" and by the "definite fixation of a type species." Thus, either of the artificial crinoid-stem group names just cited, or others which now rank as *nomina nuda,* not preventing later valid use of them as generic names, could be proposed for a genus of crinoid animals, then taking authorship and date of such published proposal. As zoological names they could not be ascribed correctly to YELTYSHEVA (1955, 1956, etc.).

PARATAXA AND FORM-GENERA AND FORM-SPECIES

Parataxa were proposed (MOORE & SYLVESTER-BRADLEY, 1957a-c) to provide for zoological classification and nomenclature adapted to treatment of dissociated parts of animals independently of procedures stipulated by the zoological *Code* applied to whole animals. Although not recorded in published proceedings (XVI Internatl. Zool. Congress, 1964, v. 5), on recommendation of a committee chaired by MOORE, this proposal was rejected.

So-called form-genera and form-species have been described and named by several paleontologists on the premise that they discriminate useful taxonomic entities recognized by morphological features which are not admissible for classification and nomenclature of animals or parts of them as true genera and species (e.g., CRONEIS, 1938). The *Code* makes no provision for such taxonomic units and accordingly differentiation of fossil crinoids in this way based on studies of their disarticulated remains must not be accepted.

ACCEPTABLE TAXONOMIC GROUPS

Classification and nomenclature of fossil crinoids based on studies of their dissociated stem parts may be approached most satisfactorily by distinguishing within each major group defined by shape (Pentameri, Elliptici, Cyclici, and Varii) as many as seven subgroups described in following paragraphs. The groups and subgroups are designed to lead toward proper taxonomic placement and designation of all such fossil taxa. In this way many

FIG. 6. Artificial classification of crinoid columnals and nomenclature for them proposed by YELTYSHEVA (1955, 1956, 1959, 1964) and in part used by her and other authors in systematic descriptions (YELTYSHEVA, 1955, 1960, 1964; YELTYSHEVA & DUBATOLOVA, 1960 [1961]; YELTYSHEVA & STUKALINA, 1963; SIZOVA, 1960; AVROV & STUKALINA, 1964; DUBATOLOVA, 1964, 1967; DUBATOLOVA & SHAO, 1959, DUBATOLOVA & YELTYSHEVA, 1961a,b; STUKALINA, 1960, 1961, 1965a, 1966), columnals with simple types of axial canals in upper part of diagram, transverse shape variations and complex axial canals in lower part of diagram. Shaded forms have been recognized in publications, nearly all others hypothetical. Like similar artificial assemblage names for crinoid parts published by MOORE (1939a,b) and by MOORE & LAUDON (1944), they are *nomina nuda* without standing in zoological nomenclature. (Modified from Yeltysheva, 1956).

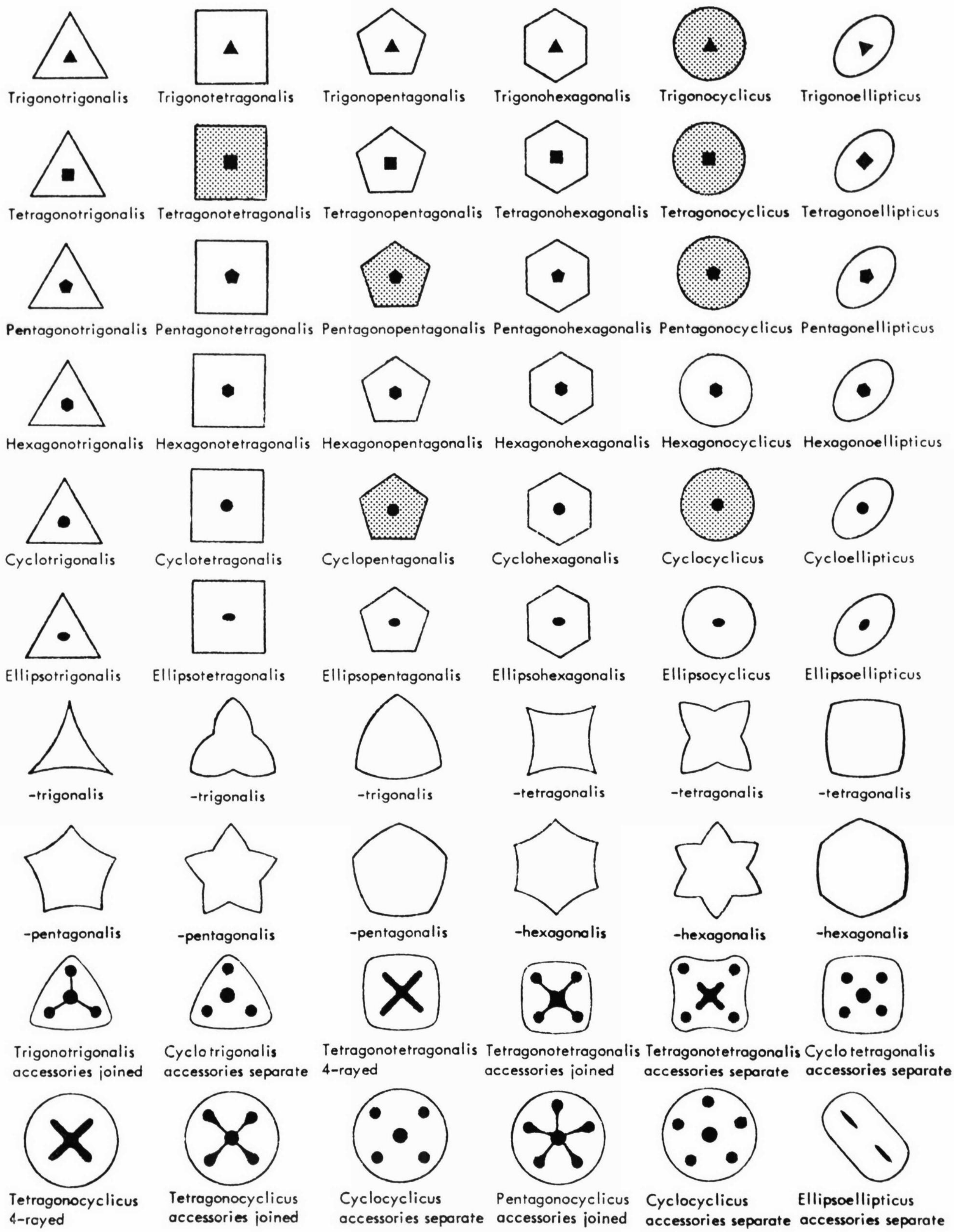

FIG. 6. *(Explanation on facing page.)*

incompletely known crinoids may be distributed in established subclasses, orders, suborders, and families, either as representatives of previously described genera and species or as new genera and species. A larger number of others will require taxonomic treatment under the category of "Subclass and Order Uncertain" until future discoveries of articulated more complete remains allow definite classification and possibly revised nomenclature of some of them.

1) GENERA AND SPECIES TRUSTWORTHILY IDENTIFIABLE

Highly distinctive dissociated parts of rather many crinoids (e.g., fused ray plates of *Petalocrinus mirabilis*, thecal plates of *Eucalyptocrinites caelatus*, tegminal wing plates of *Pterotocrinus bifurcatus* and *P. capitalis*, stem parts of *Myelodactylus ammonis* and *Herpetocrinus fletcheri*, holdfasts of *Ancyrocrinus bulbosus* and *Lichenocrinus crateriformis*, to mention only a few) can be classified and named reliably both as to genus and species. The known age and associated fossils discovered with some of these fossil fragments may help in determining their identity. Commonly, characteristic features of shape or ornamentation guide taxonomic discrimination of dissociated crinoid parts considered to be definitely identifiable. Examples of crinoids recognized by characteristics of pluricolumnals derived from them which are described and illustrated in this article are *Iocrinus *subcrassus* (type species of the genus) and *Lampterocrinus *tennesseensis* (also type species of the genus).

2) GENERA AND SPECIES DOUBTFULLY IDENTIFIED AS TO SPECIES

This taxonomic group is self-explanatory. The genus represented by observed disarticulated remains is unquestioned but specific identification is considered uncertain. An example in this paper is *Proctothylacocrinus *longus* KIER? (1952).

3) UNDESCRIBED SPECIES OF TRUSTWORTHILY IDENTIFIED GENERA

Many fossil crinoid fragments can be classified confidently as to the genus in which they belong without finding any described species to which they may be assigned even questionably. If considered worthy of recognition, a new species of crinoid needs to be described on the basis of its available remains and referred to the identified genus. Examples are *Pentacrinus* [*recte Pentacrinites*] *asteriscus* MEEK & HAYDEN (1858, p. 43), described from isolated columnals which are widespread in Jurassic deposits of western North America, and *Austinocrinus mexicanus* (SPRINGER) from Upper Cretaceous strata in Tamaulipas. The latter species was described and figured (SPRINGER, 1922b, p. 2, pl. 25, fig. 1) solely from well-preserved pluricolumnals, some with attached cirri. Other parts of this crinoid have not yet been found. The crinoid named *Camptocrinus beaveri* MOORE & JEFFORDS, n. sp., in this article belongs in this category. Others are *Gilbertsocrinus vetulus, G. aequalis, G. cassiope, G. concinnus, Dolatocrinus exculptus, D. avis,* and *Isselicrinus bermudezi,* all MOORE & JEFFORDS, n. sp.

4) GENERA AND SPECIES DOUBTFULLY IDENTIFIED AS TO BOTH

For the sake of completeness, this taxonomic group needs to be set up even though it may be little used.

5) UNDESCRIBED SPECIES OF DOUBTFULLY IDENTIFIED GENERA

Some fossil crinoid fragments such as dissociated columnals and pluricolumnals can be distinguished as belonging to an unknown species which can be classified in a recognized genus only with appreciable doubt. An example, among many found in the literature, is *Isocrinus? brotzeni* RASMUSSEN (1961, p. 113, pl. 18, fig. 12a-c). Others given in the present paper are *Platycrinites? irroratus* MOORE & JEFFORDS, n. sp., *Eucladocrinus? springeri* MOORE & JEFFORDS, n. sp., *E.? kentuckiensis* MOORE & JEFFORDS, n. sp., and *Eucalyptocrinites? shelbyensis* MOORE & JEFFORDS, n. sp.

6) PREVIOUSLY UNDESCRIBED GENERA AND SPECIES

Many fossil crinoids which at present can be distinguished only on the basis of dissociated parts of their skeletons are contained in this taxonomic group, which is ranked as entirely acceptable from all viewpoints. Scores of such new genera and species of crinoids have been described and illustrated in the literature (Table 4) and many more are published in this paper. A single example is *Platystela proiecta* MOORE & JEFFORDS, n. gen., n. sp., from the Middle Devonian of New York.

7) GENERA AND SPECIES UNIDENTIFIABLE EVEN TENTATIVELY

Fragmentary fossil crinoid remains which are too few, too poorly preserved, or too generalized in morphological attributes to warrant even tentative classification may be neglected or at least put aside to await the possible obtaining of better materials. In most instances little or nothing is gained in describing and illustrating specimens with designation as "Genus and species undetermined."

FUTURE STUDIES

In our opinion, extensive researches on disarticulated fossil remains of crinoids appear to be extremely worthwhile as future endeavors of numerous paleontologists and well suited for thesis work by candidates for advanced degrees at many institutions.

Materials available for study are virtually without limit. They vary from place to place in quantity, quality of preservation, and ease of collecting, but in general one may expect to find large numbers of good fossils of this sort in post-Cambrian marine deposits at innumerable places. Despite the surprising volume of endeavor during two centuries devoted to studies of fossil crinoid fragments, chiefly by European workers (Tables 3 and 4), it surely is true that vastly more remains to be learned than is contained in the sum of publications found in paleontological literature. Accordingly, present-day workers and some generations of future investigators may consider themselves to be pioneers. Especially required are advances in knowledge of morphological attributes of crinoid columnals and pluricolumnals, thecal plates, and arm parts, both for utilizing these independently in age determinations and stratigraphic correlations and for associating them reliably with relatively complete crinoid skeletons. Improved techniques applicable to understanding the ontogeny of species of fossil crinoids based on studies of their dissociated skeletal remains are needed and these in turn bear on problems of zoological taxonomy.

Morphological investigations of any given group of disarticulated crinoid remains, one differentiated from another by the precise or approximately known component of a complete skeleton to which they belong, inextricably intertwine with efforts to determine zoological affinities. We judge very strongly that purely utilitarian schemes of classification which give rise to arbitrary and artificial segregations of fossil objects, like nuts and bolts put in different containers according to shape, diameter, and coarseness of threads combined with their pitch, are valueless. Names for such assemblages begin and end as *nomina nuda* in so far as zoological classification is concerned. Above all, pigeonholes constructed and designated on the basis of hypothetical concepts must be rejected. Consequently, an indispensable aim of future studies of the fossil materials here discussed should be to recognize means of distinguishing many different kinds of once-living echinoderm animals. On the assumption that this is agreed to, we submit miscellaneous notes on some research areas which we judge to be worthy of consideration in undertaking future studies of disarticulated and dissociated fossil crinoid fragments. The suggested areas of investigation are obviously unequal in scope and importance.

1) Studies of local assemblages, each from a moderately restricted stratigraphic interval, as comprehensive and exhaustive as possible, with attention given to all observable morphological features of individual specimens, accompanied by careful descriptions and many illustrations adequately large in scale, are intrinsically useful for information they may yield which is applicable to other similar studies even in widely separated parts of the rock column. When combined with examination of several geographically and stratigraphically adjacent assemblages, material for useful comparisons becomes available and broader-scale paleontological characterization of crinoid-part fossils can be undertaken, with discrimination of the kinds (genera, species) more valuable and less valuable for age determination, correlation, and paleoecological interpretation. Trustworthy zonation in terms of crinoid fragments may be delineated. Depending on the magnitude and variety of particular local assemblages, unit studies may vary widely in scope and the time required to complete them satisfactorily. Almost any of them or selected parts of them furnish excellent materials for graduate-student training and may be shaped into master's or doctor's theses.

2) Researches outlined in 1) should be prepared for by bulk collecting methods, as described in this article, for an abundance of specimens is needed in order to observe variations and to select best-preserved fossils for close study. Poorer specimens commonly can be grouped according to morphological features seen in better ones and then can be used for cutting wanted sections, making acetate peels, and the like. Universities and other institutions equipped with storage facilities should encourage bulk collecting of crinoid-fragment and similar fossil materials in order to have them available for studies later on and to allow for possible exchanges. Fossil collectors who are mainly interested in noncrinoid invertebrates should not be reluctant to gather crinoid stems and other fragments on the premise that these fossils possess little or no value.

3) Investigations of particular problems of crinoid-skeleton morphology are advantageously pursued by using disarticulated fossil remains, for many features are more readily determinable from them than from articulated, relatively complete specimens. Such problems concerning stem parts include: a) the nature and significance of distinctions seen in dissimilar parts of xenomorphic crinoid columns; b) origin of morphological attributes characterizing heteromorphic and homeomorphic stems; c) essential distinguishing features of nodals in contrast to internodals and columnals of homeomorphic stems; d) divergent distribution arrangements of nodals in heteromorphic pluricolumnals and consistent or inconsistent differences in composition of noditaxes; e) significance of intranodal passageways (canaliculae) versus internodal or intercolumnal passageways (fossulae) leading to cirrus axial canals and origin of binodals (e.g., *Camptocrinus*); f) diagnostic distinctions, if any, between radicular cirri and "normal" ones; g) cause or causes of variation in number and arrangement of cirri borne by nodals; h) morphological significance of pseudocirri; i) function and taxonomic significance of cirripores; j) mode of intercalation of internodals, internodals confined to abaxial or adaxial parts of columns, variation in number and lateral persistence of internodals; k) origin of axial canal structures and their function, including development of accessory canals; l) variation in crystallographic orientation of calcite cleavage of nodals, priminternodals, and possibly other internodals, as well as in columnals of homeomorphic stems. These are examples of morphological problems which can be expanded greatly and many may

have important bearing on taxonomy. Studies of them are not confined to specified local crinoid-fragment assemblages but should draw on all available pertinent materials.

4) Future studies of disarticulated crinoid remains devoted to selected skeletal components (e.g., radials, anal-sac plates, columnals and pluricolumnals) in assemblages of crinoid fragments should lead to differentiation of forms having greater paleontological value than others. For example, if large numbers of radial plates collected from many localities in the Shawnee Group (Virgilian, Upper Pennsylvanian) of Kansas where crinoid fragments weather out abundantly are sorted and compared, they doubtless would furnish information as to the variety and generic (possibly also specific) composition of the crinoid fauna which presently is mostly unknown on the basis of dorsal cups and crowns. The disarticulated radials might serve to delineate evolutionary trends in different generic types, as well as to reflect different marine environments and to provide useful precise age markers. Researches of this sort differ from analyses of entire crinoid-fragment assemblages collected at given localities and representing restricted stratigraphic intervals, yet may be highly valuable.

5) Much future research is needed to ascertain growth characteristics of crinoid skeletal elements, how accretion of calcitic stereom is effected, and how changes in shape, as well as size, may occur during ontogeny. Criteria for recognition of juveniles and their dissociated parts is needed in order to associate them correctly with fully grown individuals and separate them from like-sized small adults of different species which they may resemble. In what way is the diameter of the axial canal of a pluricolumnal representing an adult individual of a given crinoid species enlarged to provide greater space than it possessed during early life? This question should relate to intermediate (mesistele) and distal (dististele) regions of a complete adult column, for they appeared in ontogeny before last-formed nodals originated at the base of the dorsal cup and before successive orders of internodals became inserted between adjacent nodal pairs—how long before is unknown. Most recently developed columnals (in the proxistele part of the stem) should have adult diameters or nearly so from the outset, later growing chiefly in height, whereas oldest-formed, representing a juvenile growth stage of the crinoid, show evidence in concentric growth rings of having steadily grown in diameter, and to some extent in height. A subject for investigation of ontogeny concerns microstructure of the juvenile columnals after growth to maturity and possibly considerable change affecting the axial canal. Numerous other studies of crinoid ontogeny based on examination of their disarticulated skeletal parts can be suggested.

6) Attention may be called to research on the ontogeny of crinoid columnals and pluricolumnals occurring together in the Wayland Shale and Gunsight Limestone members of the Graham Formation (Upper Pennsylvanian) of Texas, reported in Echinodermata Art. **10** which follows. This includes smooth straight-sided stem parts and more or less rugose beaded ones, both of which include specimens inferred to represent juveniles associated with a majority of well- to full-grown individuals. Similar studies have paleoecologic implications, for if a crinoid-fragment assemblage composed of column parts contains a goodly fraction of juvenile specimens, presumably the population is one preserved where it lived, whereas an assemblage made up almost entirely of juveniles, of intermediates, or of fully developed adults denotes sorting and possibly an appreciable amount of transport from the sea-bottom location occupied by the crinoids during life.

7) A virtually untouched field of inquiry consists of finding methods for correlating information derived from researches on crinoid-fragment fossils obtainable free from adherent sediment with needed knowledge concerning similar fragments firmly embedded in rock matrix. The latter are difficult to study, but the results of free-specimen investigations amply demonstrate need to extend work so as to deal with the fossils enclosed by solid rock. Crinoidal limestones can be examined in randomly oriented polished and thin sections, supplemented by sections in desired planes through the fossils. To some extent the weathered surfaces of such crinoidal limestones can be studied advantageously, especially if morphological features are so exposed as to allow comparison with free specimens. Crinoid plates and stem parts embedded in noncarbonate rocks, such as fine sandstone, siltstone, graywacke, flint or chert, can be studied most successfully by dissolving the calcite of the fossils and obtaining replicas of them as artificial casts. Techniques of this sort are comparatively easy to use and may be expected to yield very worthwhile results.

8) The development of concepts and techniques for applying them is highly desirable for application to diminutive fossil crinoid fragments, with maximum dimensions of less than 1 mm. to 3 or 4 mm. These are abundant in some bulk-collected samples and many display distinctive morphological features. They may include tiny columnals and pluricolumnals, cirrals and pluricirrals, pinnulars and pluripinnulars, brachs and pluribrachs, and thecal plates. Work by Sieverts-Doreck (1943, 1960) and Gislén (1934) demonstrates the potential value of studies on such fossil fragments. Also, they are observed in many well samples.

9) Amplification of numerical studies aimed at determining what parameters recorded by counts and measurements of dimensions are most useful is a task which needs attention by future workers. Little yet has been done along this line. Data compiled and analyzed by computer programs are likely to yield valuable information and to guide approaches to sound taxonomic conclusions.

10) Present-day and future workers concerned with researches on fossil crinoid fragments need constantly to review previously reported studies of such materials in order to evaluate their soundness from all points of view, including validity of taxonomic classification and nomenclature. Also, continuing appraisal of crinoid genera and species recognized by investigations of disarticulated and dissociated skeletal remains is required for comparing them with taxa distinguished in studies of complete or nearly complete specimens. Synonyms must be avoided wherever possible and it is to be remembered that the Law of Priority dictates that either a taxon originally differentiated on the basis of some one of its parts or a taxon described and named on the basis of available complete or nearly complete specimens must yield to the other if subjectively they are determined to be identical.

SYSTEMATIC DESCRIPTIONS

Following systematic descriptions of crinoid genera and species distinguished partly or solely on characteristics observed in disarticulated remains of their pelma are arranged by subclasses in customary manner, in so far as this is possible, and within each of these the fossil taxa are distributed among the practically useful form groups designated as Pentameri, Elliptici, Cyclici, and Varii wherever appropriate. These groups lack significance in formal taxonomy, of course, and thus are employed only for convenience. It is expectable that a preponderant majority of new crinoid taxa recognized from studies of dissociated parts of columns and holdfasts cannot now be assigned reliably to some one of the four defined subclasses and to orders distinguished within them, though future discoveries of stems attached to dorsal cups may allow this here and there. For the present, crinoid genera and species differentiated by attributes of disarticulated skeletal remains must be lumped together in the category of "Subclass and Order Uncertain." Until trustworthy regrouping of post-Paleozoic crinoids becomes possible, with or without taxonomic association of descendants with ancestors, post-Permian new crinoid genera and species (other than encrinids, which are assigned to the Inadunata) are automatically classifiable as belonging to the Articulata and depending on circumstances they may or may not be placed confidently in a specified order and family.

In the following descriptions and in illustrations, type species of genera and type specimens of species are marked by an asterisk (*) wherever referred to. Morphological terms are explained in the preceding article by MOORE, JEFFORDS, & MILLER, which also contains (in the section on Measurements and Indices of Columnals and Pluricolumnals) an alphabetical list of most commonly used terms with letter symbols adopted for them.

Subclass INADUNATA Wachsmuth & Springer, 1885

Crinoids characterized by dorsal cup composed of 2 or 3 circlets of plates with radials around upper margin, arms free above cup (except for proximal brachials in some early forms). Column chiefly circular in transverse section but may be pentagonal or subcrescentic, not evenly elliptical, some longitudinally divided into pentameres.

Occurrence.—Lower Ordovician-Triassic.

Order DISPARIDA Moore & Laudon, 1943

Disparata MOORE & LAUDON, 1943, p. 24; Disparida MOORE, 1952, p. 613.

Dorsal cup typically composed of basals, radials, and anals, but including proximal brachials in some; arms nonpinnulate.

Occurrence. Lower Ordovician-Permian.

[Group PENTAMERI]

Columns mainly characterized by fivefold development of morphological features; some structurally divided by longitudinal sutures into pentameres which may become separated, others distinguished by pentastellate to pentagonal or subpentagonal transverse section, and still others by dominant pentamerous arrangement of articular features. Disparid inadunates with divided longitudinal columnals include *Anomalocrinus* MEEK & WORTHEN *(U.Ord.)*, *Heterocrinus* HALL *(M.Ord.-U.Ord.)*, and *Ohiocrinus* WACHSMUTH & SPRINGER *(M.Ord.-U.Ord.)* and others occur in the order Cladida. Some genera (e.g., *Iocrinus*) have undivided columnals with sharply angular to round-cornered pentagonal transverse shapes.

Family IOCRINIDAE Moore & Laudon, 1943

Iocrinidae MOORE & LAUDON, 1943, p. 29.

Monocyclic inadunates having steeply conical dorsal cup with circlet of five subequal radial plates of similar form, that of *C* ray being actually an inferradial that supports an axillary superradial with anitaxis on its left shoulder; arms uniserial, bifurcating repeatedly; stem pentangular, lacking cirri.

Type genus.—*Iocrinus* HALL, 1866a, p. 5, from Upper Ordovician.

Discussion.—As now defined, this family includes only *Iocrinus* from Middle and Upper Ordovician rocks of North America and Lower and Middle Ordovician rocks of Great Britain and *Caleidocrinus* from Upper

Ordovician starta of Bohemia and Scotland. The British Lower Ordovician (lower Arenig) occurrence of *Iocrinus* is the oldest known for a crinoid.

Occurrence.—Lower Ordovician-Upper Ordovician.

Genus IOCRINUS Hall, 1866

Heterocrinus? (Iocrinus) HALL, 1866a, p. 5; HALL, 1872, p. 212.

Distinguished from *Caleidocrinus* by lack of interradial plates at arm bases.

*Type species.—Heterocrinus? (Iocrinus)*polyxo* HALL (1866a, p. 5) (=Hall, 1872, p. 212, pl. 5, fig. 1-4) (=*Heterocrinus *subcrassus* MEEK & WORTHEN, 1865b, p. 148; MEEK & WORTHEN, 1868a, p. 325, pl. 4, fig. 5a-d), type-species designation by monotypy.

IOCRINUS *SUBCRASSUS (Meek & Worthen), 1865

Heterocrinus subcrassus MEEK & WORTHEN, 1865b, p. 148; MEEK & WORTHEN, 1868a, p. 325, pl. 4, fig. 5a-d.

Stem pentagonal, distinctly heteromorphic, nodals and larger internodals tending to have swollen parts at angles, tertinternodals thin; noditaxes of 8 columnals with average internodal index (8, p. 21) of 81; articula with small circular lumen, petaloid areola with interradially directed rays (toward angles of columnals), crenularium with longest and largest culmina extending inward from midpoints of sides. Measurements (in mm.) and indices of typical (Oha10a) are as follows: F, 4.0; L, 0.3; Li, 7.5; A, 2.4; Ai, 60; C, 1.3; Ci, 32.5.

Figured specimen.—USNM Oha10a (Pl. 1, fig. 3).

Occurrence.—Cincinnatian, Upper Ordovician, in Ohio (locs. Ogz, Oha).

Illustrations.—Plate 1, figure 3. Specimen (USNM Oha10a from loc. Oha) of typical pluricolumnal associated with dorsal cup of *Iocrinus *subcrassus* showing (3a, ×11) features of nodal articulum with petaloid areola, moderately coarse crenulae, largest and longest culmina in radial position at middle of sides, lumen circular, and (3b, ×7) side view which clearly indicates heteromorphic nature of column, larger columnals (nudinodals, prim- and secundinternodals (with latera sloping almost imperceptibly downward-outward (orientation of column confirmed by associated specimens of cups with attached stems).

Family MYELODACTYLIDAE Miller, 1883

Myelodactylidae, MILLER, 1883, p. 278.

Monocyclic inadunates chiefly characterized by peculiarities of stem, in most genera composed of transversely flattened columnals with trapezoidal to subcrescentic outlines and bearing abundant paired cirri on one side of stem so as to cover crown, around which stem is coiled. Included in Pentameri because columnals are longitudinally divided into five separate segments, although these differ in shape and size.

Type genus.—Myelodactylus HALL (1852, p. 191) from Upper Silurian and Lower Devonian.

Occurrence.—Lower Silurian-Lower Devonian, ?Middle Devonian.

Genus MYELODACTYLUS Hall, 1852

Myelodactylus HALL, 1852, p. 191; SPRINGER, 1926a, p. 85; 1926, p. 6; MOORE, 1962b, p. 41.

Stem spirally coiled, columnals trapezoidal to subcrescentic in transverse outline, side facing interior of coil with double row of close-spaced parallel cirri, pairs of which are borne by successive columnals or by columnals alternating with noncirriferous ones, or successive columnals of cuneate form with single cirrus attached to wide margin so arranged that successve pairs of columnals bear paired cirri from opposite sides; columnals with small elliptical lumen located closer to edge facing interior of coil than exterior.

*Type species.—Myelodactylus *convolutus* HALL (1852, p. 191) from Upper Silurian (Niagaran) of New York; fixation by monotypy.

Discussion.—The transverse shape of columnals and distribution of cirri are constant specific characters, as in *Myelodactylus *convolutus,* for example, which has pairs of cirri borne on the concave side of each successive columnal, whereas in *M. ammonis* BATHER only alternate columnals bear cirrus pairs or successive cuneate columnals carry a single cirrus on the broad edge of each. BATHER (1893, p. 49) designated forms of *M. ammonis* with cirri-bearing columnals separated by noncirriferous columnals as *M. ammonis bijugicirrus* and forms with cuneate columnals having a single cirrus as *M. ammonis alternicirrus.* Because both types occur together in some specimens, distinction of them as subspecies is judged to lack validity. Described species of *Myelodactylus* come from Upper Silurian strata of central United States and the island of Gotland, Sweden, and from Lower Devonian formations of Tennessee and West Virginia; a species doubtfully assigned to the genus has been described from the Middle Devonian of West Germany.

Occurrence.—Upper Silurian-Lower Devonian, ?Middle Devonian.

MYELODACTYLUS AMMONIS (Bather), 1893

Herpetocrinus ammonis BATHER, 1893, p. 49, pl. 2, figs. 54-63; SPRINGER, 1926a, p. 10, pl. 2, figs. 1-9; SPRINGER, 1926b, p. 86, pl. 27, figs. 1-5a.

Short pluricolumnals longitudinally straight or nearly so, composed of ovoid to subtrapezoidal columnals which are flattened-convex on one side and medially concave on opposite side with laterally sloping parts that carry small elliptical cirrus scars on alternate columnals, noncirriferous intervening columnals with lenticular or hourglass outline on concave side of fragments but evenly rectangular appearance identical with that of cirrus-bearing columnals on convex side; articula nearly smooth, lacking crenulae, but showing narrowly elliptical lumen slightly closer to concave than convex margin of facet.

Figured specimens.—UKPI Sad1a and Sad1b from loc. Sad.

Occurrence.—Waldron Clay Member, Waynesville Formation, Niagaran, Upper Silurian, in Tennessee (loc. Sad).

Illustrations.—Plate 1, figures 1-2.——1a-d. Lateral, outer, lateral, and inner surfaces of nearly straight pluricolumnal (UKPI Sad1a, from loc. Sda), slitlike cirrus scars on inner surfaces of nodals visible in 1d; 1e, facetal view of nodal at extremity of this pluricolumnal, ×8.5. ——2a-e. Similar views of another specimen (UKPI Sad1b, from same locality), slightly curved pluricolumnal with cirrus scars not well marked, ×4.2, ×8.5.

Genus HYPEREXOCHUS Moore & Jeffords, new genus

Highly aberrant stems that are classifiable as heteromorphic on basis of their multiformed lateral protuberances developed seemingly from every columnal, protuberances single or branched, rather bluntly rounded at outer ends, internally with narrow axial canal connecting with axial canal of stem, structures thus having characteristics of cirri but unjointed; articula subcircular, with diminutive circular lumen, broad, flat areola, and narrow crenularium of very short, unevenly developed crenulae.

Type species.—*Hyperexochus *immodicus* Moore & Jeffords, new species, from Lower Devonian of Tennessee; designated herein.

Discussion.—The inclusion of this new genus in the Myelodactylidae is based on considerations stated under discussion of the type species.

Occurrence.—Lower Devonian.

HYPEREXOCHUS *IMMODICUS Moore & Jeffords, new species

Plate 1, figures 4-*7

With characteristics of genus. The type specimen has an articulum 3.6 mm. in diameter and greatest width of pluricolumnals, measured from extremities of branched cirri, of 17 mm.; height of a single columnal is approximately 3 mm.

Type specimen.—USNM *Dii3c from loc. Dii.

Discussion.—Collections of the U.S. National Museum contain several dozen specimens of *Hyperexochus *immodicus,* all from the Lower Devonian of Benton, Perry, Stewart, and Decatur counties, Tennessee, presumably from beds now included in the Birdsong Shale; most of these fossils were obtained from various localities in Benton County. They are generally similar in size but exhibit highly variable shapes. All have densely crowded cirrus projections resembling those here figured. The stems are unidentified except one lot labeled "stems of *Brachiocrinus,*" in handwriting and with initials of Charles Schuchert. This is an interesting but entirely inadmissible guess on the part of Schuchert, for comparison of the Tennessee specimens with excellent illustrations of *Brachiocrinus *nodosarius* given by Hall (1859b, pl. 5, fig. 5-7, pl. 6, fig. 1-3) and Springer (1962a, pl. 5, fig. 1-8), including the type specimen (here designated as the fossil among Hall's types that he illustrated in his original publication, 1859, pl. 6, fig. 1) reveals not even a vague similarity. *B. *nodosarius* has very low subcircular columnals, all clearly visible in side view of the stem, with 2 series of upwardly directed stout cirri composed of tall cirrals that diverge on opposite sides of the stem from randomly distributed columnals. Although Springer, (1926a, p. 20) assigned *B. *nodosarius* to *Myelodactylus,* it is at most an aberrant myelodactylid. Its occurrence in the New Scotland Limestone (Helderbergian, Lower Devonian) of New York, associated with *Pandocrinus *stoloniferus* (Hall), which is abundant in the Birdsong Shale of equivalent age in Tennessee, gives reason for comparing *Brachiocrinus* with *Hyperexochus* but this yields negative conclusions. It seems reasonable to admit *Hyperexochus* to a place in the strangely specialized family of crinoids named Myelodactylidae but not as a close relative of *Brachiocrinus.*

Occurrence.—Birdsong Shale, Helderbergian, Lower Devonian, in Tennessee (loc. Dii and others).

Illustrations.—Plate 1, figures 4-*7, specimens from loc. Dii.——4-5a,b-6a,b. Side and facetal views of medium-sized pluricolumnals of average appearance (USNM Dii2, Dii3a, Dii3), ×2.5.——*7a,b. Side and facetal views of type specimen (USNM *Dii3c), large pluricolumnal with tiers of close-spaced blunt lateral outgrowths interpreted to be aberrant cirrus-type structures; although unjointed, they are provided with a minute axial canal, ×4.2.

Order CLADIDA Moore & Laudon, 1943

Cladoidea Moore & Laudon, 1943, p. 32; Cladida Moore, 1952, p. 613.

Dorsal cup composed of infrabasals, basals, radials, and anals; arms pinnulate or nonpinnulate. Column mostly circular in transverse section, but may be pentagonal.

Occurrence.—Lower Ordovician-Upper Permian.

Suborder DENDROCRININA Bather, 1899

Cyathocrinoidea Bather, 1899, p. 922; Cyathocrinina Moore, 1952, p. 613.

Dorsal cup steeply conical to bowl-shaped, radials with narrow or wide articular facets bearing transverse ridge, anal sac prominent, arms nonpinnulate.

Occurrence.—Lower Ordovician-Devonian.

[Group PENTAMERI]

Characteristics of the group are stated under the inadunate order Disparida. Among Cladida several genera have columns divided by longitudinal sutures into pentameres: *Barycrinus* MEEK & WORTHEN *(Miss.)* and *Euspirocrinus* ANGELIN *(M.Sil.-U.Dev.), Glenprisia* MOORE *(M.Ord.), Mastigocrinus* BATHER *(U.Sil.), Ottawacrinus* W. R. BILLINGS *(M.Ord.), Streptocrinus* WACHSMUTH & SPRINGER *(U.Sil.),* and *Thenarocrinus* BATHER *(U.Sil.)* of the suborder Dendrocrinina. Most cladid genera of the Pentameri have transversely pentagonal stems or rounded stems having well-marked pentamerous features of the articula.

Family PROCTOTHYLACOCRINIDAE Kier, 1952

Proctothylacocrinidae KIER, 1952, p. 71 [=Decacrinidae YELTYSHEVA, 1957, p. 220].

Dicyclic cladid inadunates with small conical dorsal cup having 5 infrabasals with only their tips visible from side, radials with wide articular facets, radianal and anal X in cup; anal sac very tall, subcylindrical, thick-walled and strengthened by vertical ribs and diagonal costae, arms slender, uniserial, branching isotomously. Column subcircular, subpentagonal, or angularly pentagonal in transverse section, heteromorphic, columnal articula characterized mostly by distinctive 10-rayed pattern of areola and crenularium, axial canal transversely pentagonal, medium-sized to large.

Type genus.—*Proctothylacocrinus* KIER (1952, p. 72) from Middle Devonian.

Occurrence.—Middle Ordovician-Middle Devonian.

Genus PROCTOTHYLACOCRINUS Kier, 1952

Proctochylacocrinus KIER, 1952, p. 72.

With characteristics of family. Stem evenly circular in type species but with appearance of transverse and vertical fluting in *Proctothylacocrinus esseri* KESLING (1965) produced by 10 moderately deep indentations of internodals combined with decagonal outline of nodals.

Type species.—*Proctothylacocrinus* *longus* KIER (1952, p. 72, pl. 2, fig. 1-4, pl. 4, fig. 1), from Middle Devonian of northwestern Ohio; fixation by original designation.

Occurrence.—Middle Devonian.

PROCTOTHYLACOCRINUS *LONGUS Kier, 1952(?)

*Proctothylacocrinus *longus* KIER, 1952, p. 72, pl. 2, fig. 1-4, pl. 4, fig. 1.

With characteristics of genus, distinguished from *Proctothylacocrinus esseri* KESLING (1965) by narrower width of dorsal cup and details of plates, especially taller sac plates; stem without marked indentations of internodals and therefore more regular in side view than stem of *P. esseri,* average diameter of stem 3.5 mm. Measurements (in mm.) and indices of figured internodal (UKPI Dib3g) from New York are: F, 3.4; L, 0.7; Li, 20; A, 2.0; Ai, 2.8; Ai. 52; C, 1.71; Ci, 30.

Figured specimens.—UKPI Dib3g from loc. Dib, and UKPI Dia2d from loc. Dia.

Discussion.—First-published illustrations of *Proctothylacocrinus *longus* revealed features of the stem only in side view and KIER's description (1952, p. 73) stated merely that the column is "composed of round nodal and internodal columnals; nodal columnals thicker than internodal columnals and extending out beyond them." The information given was quite insufficient for identification of dissociated columnals such as those from the Middle Devonian of New York, for one could not even guess about generic relationships, let alone possible specific identity. KESLING's (1965, pl. 1-2) excellent figures of *P. esseri* (especially pl. 1, fig. 1, 5), supplemented by illustrations of several specimens of *P. *longus,* serve for guiding us to conclusion beyond doubt that a presumed new genus and species which we had distinguished on the basis of fossils from New York were superfluous. Therefore, names chosen by us have been discarded. The columnals in our collection correspond to both *P. *longus* and *P. esseri,* nodals being essentially identical with nodals of *P. *longus* and internodals being closely similar to those of *P. esseri.* We assign greater weight to characteristics of the nodals.

Subsequent to KIER's publication of *Proctothylacocrinus* as a new genus from the Middle Devonian, YELTYSHEVA (1957) described and figured new genera and species of Ordovician, Silurian, and Devonian crinoids from the USSR, chiefly in Siberia. These were all based on stem fragments having the peculiarity of 10-fold division of articular features of the columnals, a characteristic which is decidedly exceptional in crinoids. For the group YELGYSHEVA (1957, p. 220) erected the new family Decacrinidae. KESLING (1965) now has made known that *Proctothylacocrinus* possesses a stem of decacrinid type but he seems to have been unaware of YELTYSHEVA's work. It happens that one of her new genera, *Kuzbassocrinus,* from the Middle Devonian of Kazakhstan, the Kuznetsk basin, and Altai region of Siberia, is represented by stems closely similar to those of *Proctothylacocrinus.* Both in side view and articular facet views, *K. *bystrowi,* the type species of *Kuzbassocrinus,* strikingly corresponds to *P. esseri.* The North American and Siberian genera are not identical but they occur in deposits of similar age and must be interpreted to represent a common crinoid stock. On the basis of priority and vastly more adequate morphological information KIER's Proctothylacocrinidae should receive recognition as the name of a family assemblage containing as least *Proctothylacocrinus, Decacrinus, Kuzbassocrinus,* and the Upper Silurian *Podoliocrinus* YELTYSHEVA (1957) from the southwestern Ukraine. Appropriately included in the Proctothylacocrinidae also is *Plussacrinus* YELTYSHEVA (1957) from Middle Ordovician deposits of the Leningrad region, both characterized by transversely pentagonal stems.

Occurrence.—In addition to the type specimen and several other crowns from the Silica Formation, Middle Devonian, of northwestern Ohio, specimens here figured from the Wanakah Shale Member, Ludlowville Formation, Erian, Middle Devonian, in New York (locs. Dia, Dib).

Illustrations.—Plate 2, figures 4-5.——4. Facetal view of internodal (UKPI Dib3g, from loc. Dib) showing narrow crenularium bordering 10-rayed smooth areola and relatively large circular lumen, ×8.5.——5. Similar view of nodal (UKPI Dia2d, from loc. Dia) showing constricted areola surrounded by 10 petaloid depressions and rounded epifacetal surface beyond them, ×12.5.

PROCTOTHYLACOCRINUS ESSERI Kesling, 1965

Proctothylacocrinus esseri KESLING, 1965, p. 77, pl. 1, fig. 1-5, pl. 2, fig. 1-2, text fig. 1.

Crown generally similar to *Proctothylacocrinus* **longus* except for sharper and narrower ridges on thecal plates; column with nodals distinctly wider and higher than internodals and less strongly indented latera between 10-rayed projections, side view of column therefore appearing to be somewhat reticulate, marked by 10 alternating rows of vertical ridges and depressions; articular facet decastellate, with projecting tips more sharply pointed in internodals than nodals, very narrow crenularium bounding 10-rayed areola, lumen large and circular.

Type specimen.—Univ. Michigan Mus. Paleontology no. *51744.

Occurrence.—Silica Formation, Middle Devonian, near Sylvania, Lucas County, Ohio (Kesling 1965, loc. 1, Medusa Portland Cement Company quarry at Silica, near Sylvania, Ohio).

Illustrations.—Plate 2, figure *6, most proximal columnals (3 internodals, 2 nodals) attached to base of dorsal cup in type specimen; *6a, articulum of most distal internodal with epifacet of adjoining nodal appearing around it, ×5; *6b, side view of proximal columnals, ×5.

Genus DECACRINUS Yeltysheva, 1957

Decacrinus YELTYSHEVA, 1957, p. 221.

Stem angularly to rounded pentagonal, distinctly hetermorphic, chiefly characterized by articular facet which shows moderately large pentagonal lumen, areola with prominent lanceolate extensions toward sides of columnal, crenulae fine and grouped in distinct pentameres, culmina tending to bifurcate near facetal angles and near lumen midway between lanceolate rays of areola; distinct 10-fold pattern of areola and crenularium.

Type species.—*Decacrinus *pennatus* YELTYSHEVA, 1957, from Lower Devonian of eastern Kazakhstan; fixation by original designation.

Occurrence.—Lower Devonian.

DECACRINUS *PENNATUS Yeltysheva, 1957

*Decacrinus *pennatus* YELTYSHEVA, 1957, p. 221, fig. 1, pl. 1, fig. 1-4.

Stem pentagonal, with slightly rounded angles, areola with prominent alternation of sharp-pointed extensions toward facet angles and rounded outward bulges between them, crenulae fine, branching near tips of lanceolate extensions of areola and between bases of these and rounded bulges of areola.

Occurrence.—Lower Devonian, Kazakhstan.

Illustrations.—Plate 2, figure *2, diagrammatic views of articular facet and side view of pluricolumnal, former (*2a, ×4.5) showing pentagonal large lumen surrounded by 10-rayed areola, with long pointed extensions directed to angles (interradial) of columnal and shorter, round-ended ones between them (radial), part of distinctive crenularial pattern drawn at bottom and lower left; *2b, side view showing nodals with rounded projections at corners and thinner internodals, ×2.5 (after Yeltysheva, 1957).

DECACRINUS TENUICRENULATUS Moore & Jeffords, new species

Crenulae of facets fine and long, their outer extremities normal to edges of facet, median ones of each pentamere straight, whereas those on either side curve to meet border of areola at right angle, some culmina joining to form V's and Y's, approximately 40 crenulae along outer edge of each group; lumen large, pentagonal, bordered on all sdes by narrow areola which has sharp-pointed extensions toward angles of facet and small rounded ones midway between these in pattern characteristic of genus; nodals with modest swelling at columnal angles, extended laterally rather than produced into round tubercles, internodals thin and slightly irregular, noditaxes with average height of 1.6 mm., internodes 1.2 mm., internodal index 75. Measurements (in mm.) and indices of facetal ele- Ci, 41; FSI, 84.

Type specimen.—USNM 27756 from loc. Dii.

Discussion.—*Decacrinus tenuicrenulatus* differs from *D. *pennatus* only in such minor ways as smaller development of the rounded outward extenson of the areola midway between the long pointed ones and in less prominent development of nodes at angles of the nodal columnals. Size and proportions of the stem features are nearly identical (Pl. 2, fig. 1).

Occurrence.—Birdsong Shale (Helderbergian), Lower Devonian of Tennessee.

Illustrations.—Plate 2, figure *1, type specimen (USNM *27756, pluricolumnal from loc. Dii); *1a,b, side and facetal views showing relatively thick nodals with swollen parts at columnal angles and distinctive pattern of articulum, ×4.2, ×6; *1c,d, drawings of articulum and part of pluricolumnal side for comparison with *D. *pennatus* YELTYSHEVA, from beds of equivalent age in Kazakhstan, ×4.5, ×3.

Genus KUZBASSOCRINUS Yeltysheva, 1957

Kuzbassocrinus YELTYSHEVA, 1957, p. 223.

Column transversely circular, with even or slightly scalloped latera, heteromorphic, columnal articula marked by 10-rayed areola with outward extensions from small pentagonal lumen long and almost linear crenularium consisting of very fine culmina which may bifurcate outward from areolar rays, separated by equally fine crenellae, pattern of crenulae feather-like in each ray; indentations of edges of intercolumnals may produce 10 longitudinal rows of pits along sides of stem.

Type species.—*Kuzbassocrinus* *bystrowi YELTYSHEVA (1957, p. 223), from Middle Devonian of Siberia; fixation by original designation.

Occurrence.—Lower Devonian-Middle Devonian, Kuznetsk basin, Altai, central and eastern Siberia, Germany.

KUZBASSOCRINUS *BYSTROWI Yeltysheva, 1957

Kuzbassocrinus bystrowi YELTYSHEVA, 1957, p. 223.

Differs from other recognized species chiefly in narrowly lanceolate shape of elongate areolar rays, diminutive axial canal, and regularly pitted appearance of sides of column; diameter, 5 to 7.5 mm.

Discussion.—Rather striking resemblance of this species to *Proctothylacocrinus* *longus and *P. esseri* has been noted already and like them, *K.* *bystrowi and *K. binidigitatus* YELTYSHEVA are recorded from the Middle Devonian. The remaining two described species of *Kuzbassocrinus* occur in Lower Devonian deposits.

Occurrence.—South-central Siberia (Kuznetsk basin, Karachumsh) in Middle Devonian, Shandinskiy Stage.

Illustrations.—Plate 2, figure *3a,b, facetal and side views of type specimen showing abruptly depressed 10-rayed areola bordered by crenulae coarser than in *Decacrinus,* side view of pluricolumnal resembling that of *Proctothylacocrinus,* ×5 (after Yeltysheva, 1957).

Subclass CAMERATA Wachsmuth & Springer, 1885

Crinoids having ray plates above radials incorporated in theca as general rule, all stem-bearing, with columnals of Pentameri, Elliptici, or Cyclici type.

Occurrence.—Middle Ordovician-Permian.

Order DIPLOBATHRIDA Moore & Laudon, 1943

Diplobathra MOORE & LAUDON, 1943, p. 79; Diplobathrida MOORE, 1952, p. 614.

Dorsal cup including infrabasals.

Occurrence.—Middle Ordovician-Upper Mississippian.

[Group PENTAMERI]

Characteristics of this group have been stated under Inadunata.

Family LAMPTEROCRINIDAE Bather, 1899

Lampterocrinidae BATHER, 1899 (in 1898-99), p. 120.

Dicyclic camerates with relatively large thecal plates, radials in contact with each other except on posterior side where extra plates produce marked bulge; arms grouped; stem angularly pentagonal, lacking cirri.

Type genus.—*Lampterocrinus* ROEMER (1860, p. 37) from Upper Silurian of Tennessee.

Discussion.—The family includes one additional genus, *Siphonocrinus* MILLER (1888, p. 263), which somewhat resembles *Lampterocrinus.*

Occurrence.—Lower Silurian-Upper Silurian.

Genus LAMPTEROCRINUS Roemer, 1860

Lampterocrinus ROEMER, 1860, p. 37.

Theca biturbinate, dicyclic, with large radial plates in contact with each other except at posterior side (between *C* and *D* rays) where extra plates produce prominent bulge; single primibrach in each ray; stem sharp-angled pentagonal.

Type species.—*Lampterocrinus* *tennesseensis ROEMER (1860) from Upper Silurian of Tennessee; fixation by monotypy.

Occurrence.—Upper Silurian.

LAMPTEROCRINUS *TENNESSEENSIS Roemer, 1860

*Lampterocrinus *tennesseensis* ROEMER, 1860, p. 3, pl. 4, fig. 1a,b.

Stem heteromorphic, with noditaxes of 4 columnals, nudinodals commonly accented by rounded tubercles at angles of facets, strongly swollen in some specimens and others with tubercles on priminternodals as well as nodals; lumen small, pentastellate, with lobes directed toward sides of articulum between angles (radially), as is normal; crenularium filling remainder of articulum, with long straight crenulae divided into pentameres by their orientation and by ridges running from lumen to angles of articula; columnal latera smooth, straight and even, or somewhat convex in longitudinal profile, finely crenulate sutures generally distinct. Measurements (in mm.) and indices are tabulated as follows; also, observation of several specimens shows nearly constant height of noditaxes (1.75 mm.) and internodes (1.25 mm.), giving internodal index of 72.

*Measurements and indices of Lampterocrinus *tennesseensis*

Specimen	F	L	Li	C	Ci	FSi
Sdg4	5.3	0.6	11	4.7	89	91
Sdg10	6.3	0.7	11	5.6	89	96

Figured specimens.—UKPI Sdg3 (Pl. 2, fig. 8); Sdg2 (Pl. 2, fig. 9); Sdg4 (Pl. 2, fig. 10); Sdg10 (Pl. 2, fig. 11); all from loc. Sdg.

Occurrence.—Brownsport Formation, Niagaran, Upper Silurian, in Tennessee (loc. Sdg).

Illustrations.—Plate 2, figures 8-11.——8. Side view of pluricolumnal (UKPI Sdg3, from loc. Sdg) with exceptionally strong nodes at angles, ×3.5.——9a,b. Side and facetal views of specimen (UKPI Sdg2, from loc. Sdg) showing nodose angles of nodals and somewhat thinner internodals lacking nodose angles, articulum with pentamerously grouped long crenulae, ×7.5, ×3.5.——10, 11. Articula of two other specimens (UKPI Sdg4, Sdg10, from loc. Sdg) showing small pentalobate lumen and variation in outline from distinctly angular to subrounded, pentameres of crenularium set off from neighbors by low elevations, both ×7.

LAMPTEROCRINUS species undetermined (A)

Stem small, with facet diameter (Fx+Fy) of 3.5 mm., with noditaxes of 4 columnals 1.65 to 1.8 mm. in height, internodes 1.35 mm., internodal index, 83; similar to *Lampterocrinus *tennesseensis* except for much coarser crenulae and small size.

Figured specimen.—UKPI Sdg5, from loc. Sdg.

Occurrence.—Brownsport Formation, Niagaran, Upper Silurian, in Tennessee (loc. Sdg).

Illustration.—Plate 2, figure 7a,b, side and facetal views of pluricolumnal (UKPI Sdg5, from loc. Sdg) showing well-differentiated nodals and internodals with strongly crenulate sutures seen on somewhat weathered side, ×7.

LAMPTEROCRINUS species undetermined (B)

Stem very similar to that of *Lampterocrinus *tennesseensis* and possibly only a variant of this species; distinguished essentially by unusual development of priminternodals, which rival nodals in appearance, secundinternodals mostly interrupted on exterior at angles owing to thickness of nodal and priminternodal tubercles; internodal index 72.

Figured specimen.—UKPI Sdg1 from loc. Sdg.

Occurrence.—Brownsport Formation, Niagaran, Upper Silurian, in Tennessee (loc. Sdg).

Illustration.—Plate 2, figure 12, unusually nodose pluricolumnal (UKPI Sdg1, from loc. Sdg) with internodals visible only on sides between angles, ×3.5.

[Group CYCLICI]

Crinoid stems characterized by circular transverse section and articula with crenulae evenly distributed around margin, lacking distinctly pentamerous pattern of articular surfaces such as are found in some circular columns included in Pentameri. The overwhelming majority of stalked crinoids, including genera of all subclasses, belongs in the group of Cyclici, but mostly dissociated columnals and pluricolumnals cannot be placed reliably in assemblages as belonging to Inadunata, Camerata, and Flexibilia. Except for Encrinidae, any post-Paleozoic stem fragment represents some genus of the Articulata. Wherever possible, disarticulated stem parts are referred to genera, families, and subclasses defined on the basis of relatively complete skeletal remains. The remainder must be assigned to genera and families of uncertain subclass affinities.

Family RHODOCRINITIDAE Bassler, 1938 (1854)

Rhodocrinidae Roemer, 1854, p. 228.
Rhodocrinitidae Bassler, 1938, p. 25.

Dicyclic dorsal cup of subglobular form with radials separated all around by other plates.

Type genus.—*Rhodocrinites* Miller (1821, p. 15) from Middle Devonian-Lower Mississippian.

Occurrence.—Middle Ordovician-Lower Mississippian.

Genus ATACTOCRINUS Weller, 1916

Atactocrinus Weller, 1916, p. 239.

Globose rhodocrinitid with theca formed of subequal plates above infrabasal circlet, sutures between plates well indented, surface marked by fine striae normal to sutures. Barrel-shaped columnals associated with type specimen inferred to belong to it but not so proved.

Type species.—*Atactocrinus *wilmingtonensis* Weller (1916, p. 229, pl. 15, fig. 1-10) from Upper Ordovician of Illinois; fixation by original designation.

Occurrence.—Upper Ordovician.

ATACTOCRINUS? species undetermined

Smoothly rounded, barrel-shaped columnals with height greater than width, articular facets deep cup-shaped and approximately one-half of columnal in diameter, lumen hardly perceptible but identified in longitudinal sections. Measurements (in mm.) and indices of 2 columnals here figured, of 3 illustrated by Weller (1916, pl. 15, figs. 8-10) from Illinois (loc. Ogx), and of 3 illustrated by Slocum & Foerste (1924, pl. 30, fig. 23, 25, 27) from Iowa (loc. Ojg) are tabulated as follows.

Measurements and indices of Atactocrinus? sp. undet., from Missouri (Oeb1a, Oeb1b), Illinois (Ogx1, Ogx2, Ogx3) and Iowa (Ojg1, Ojg2, Ojg3)

Specimen	KD	F	F(depth)	Fi	KH	KHi
Oeb1a	8.0	4.0	1.2	50	5.5	69
Oeb1b	6.2	3.1	1.0	50	7.5	120
Ogx1	9.0	6.0		67	7.0	78
Ogx2	7.5	5.0		67	5.5	73
Ogx3	7.0	3.0		43	7.0	100
Ojg1	10.0	6.0		60	7.0	200
Ojg2	10.0	6.0		60	8.0	80
Ojg3	9.0	6.0		67	11.0	120

Discussion.—In addition to several columnals from central Missouri (loc. Oeb), very similar ones from Minnesota (loc. Ogr), Illinois (locs. Ogv, Ogx), and southeastern Missouri (loc. Ogw) have been loaned for study from the U.S. National Museum. The average size of these is less than in the specimen described above, the smallest being 4 mm. in diameter and 3 mm. in height. All are low to tall barrel-shaped and have small cupped articular facets at each extremity. An especially interesting specimen in the lot from southeastern Missouri (loc. Ogw) consists of 2 columnals joined along a clearly visible suture; a large columnal with typical facet at its free end is 7.5 mm. wide and 9 mm. high, whereas its attached companion is a hemispherical columnal only 3 mm. high without a facet at its free end. Evidently, the pair of columnals comprise the distal extremity of an unattached stem borne by a free-swimming crinoid. The stem was not anchored to the substrate or to any foreign body.

Some of the Illinois specimens (loc. Ogx) closely resemble columnals figured by WELLER (1916) and considered by him to belong to *Atactocrinus* **wilmingtonensis*. The widely distributed Upper Ordovician columnals from Missouri, Iowa (SLOCOM & FOERSTE, 1924) Minnesota, and Illinois are easily recognized and trustworthy index fossils, although they cannot be identified reliably as belonging to *Atactocrinus*.

Occurrence.—Fernvale Limestone, Cincinnatian, Upper Ordovician, in Missouri (locs. Oeb, Ogw), also Upper Ordovician in Minnesota (loc. Ogr); Iowa (Fayette County), and Illinois (Ogr, Ogx).

Illustration.—Plate 2, figure 13, end view of typical barrel-shaped columnal (UKPI Oeb1b, from loc. Oeb) with longitudinally convex latus and relatively small, deeply concave articular facet, which lacks surface markings, lumen extremely minute, ×7.

Genus GILBERTSOCRINUS Phillips, 1836

Ollacrinus CUMBERLAND, 1826, appendix (no species) *(nom. nud.)*.
Ollacrinites DE BLAINVILLE, 1834, p. 659 (no species) *(nom. nud.)*.
Gilbertsocrinus PHILLIPS, 1836, p. 207; WACHSMUTH & SPRINGER, 1897, p. 233; GOLDRING, 1923, p. 96; GOLDRING, 1935, p. 350; GOLDRING, 1936, p. 15; WRIGHT, 1958, p. 316.
Goniasteroidocrinus LYON & CASSEDAY, 1859, p. 233.
Trematocrinus HALL, 1860, p. 70.
Goniastroidocrinus MARSCHALL, 1873, p. 400.

Highly distinctive dicyclic theca characterized by peculiar lateral extensions of tegmen above arm bases, these extensions branched or unbranched; stem circular, with alternate columnals slightly higher and wider than intervening ones.

Type species.—*Gilbertsocrinus* **calcaratus* PHILLIPS (1836), from Lower Carboniferous of England; subsequent designation by BASSLER, 1938, p. 103.

Discussion.—The stem of *Gilbertsocrinus* has been adequately illustrated in side view by WACHSMUTH & SPRINGER (1897, pl. 14-17) but without facetal views of columnals, although they described the facets as having "axial canal pentalobate or stellate, the angles directed radially." Additional information can be provided now, based on parts of columns attached to the theca of *Gilbertsocrinus tuberosus* in fine silty crinoid-bearing beds of Mississippian age at Crawfordsville, Indiana. These specimens were collected by Dr. N. GARY LANE, of the University of California (Los Angeles), who has worked several months in 1964 and 1965 on a layer-by-layer study of paleoecological aspects of the rich crinoid accumulations at and near Crawfordsville. Dr. LANE kindly gave us these stem fragments, which have special value in being separable into individual columnals or pluricolumnals showing articular-facet characteristics clearly. Prior to receiving this help, an examination of many specimens of *Gilbertsocrinus* and other genera in the large Springer collection of the U.S. National Museum had served only to allow observation of sides of stems—not features of columnal articula.

The previously given brief statement of articular characteristics of *Gilbertsocrinus* can now be supplemented. All of the facets bear a narrow crenularium containing numerous short, straight, even crenulae surrounded by a smooth rim, which on columnals identified as nodals (nudinodals) is equal in width to the crenularium but narrower on internodals; a wide, gently concave or flat, smooth areola extends from the crenularium to a narrow but prominent perilumen having minute, radially disposed denticles or granules on its summit; the lumen is rounded pentagonal or weakly pentalobate in outline and moderately large. Columnals are grouped in noditaxes of 4, with nodals distinctly or only slightly taller and wider than priminternodals; wafer-thin secundinternodals may not be visible externally in intermediate and distal parts of the stem.

The stems of *Gilbertsocrinus* most closely resemble those of *Elytroclon* MOORE & JEFFORDS, new genus, which are distinguishable by longitudinal sections. Also, facetal characteristics of *Gilbertsocrinus* are almost duplicated in *Dierocalipter* MOORE & JEFFORDS, new genus, but stems of the latter are differentiated readily by the longitudinal profile of their columnals and the wavy sutures between columnals.

Occurrence.—Middle Devonian-Lower Mississippian in North America, Lower Carboniferous in northwestern Europe.

GILBERTSOCRINUS VETULUS Moore & Jeffords, new species

Stem slender, with diameter (3.2 to 5 mm.) less than one-half that of observed Lower Mississippian species; noditaxes 2.2 or 2.3 mm. in height with internodes 0.9 to 1.1 mm., internodal index 45; articlular facets with typical characteristics of the genus, crenularium with 65 to 70 very short crenulae. Theca and arms unknown. Measurements (in mm.) and indices are given in (A) of the following tabulation.

Measurements and indices of Gilbertsocrinus vetulus (A) G. aequalis (B), G. cassiope (C), and G. concinnus (D)

Specimen	KD	F	Fi	L	Li	P	Pi	A	Ai	C	Ci
(A) *Dib1c	4.9	4.4	90	0.6	13	0.4	9	2.9	67	0.5	11
(A) Did1c	3.2	2.8	85	0.45	16	0.3	10	1.7	62	0.35	12
(B) *Ma85c	9.0	9.0	100	1.2	13	11.7	19	4.5	50	1.6	18
(C) *Mmf5	10.0	10.0	100	1.7	17	1.3	13	5.2	52	1.8	16
(C) Mfm7	12.0	12.0	100	1.7	14	1.3	11	7.4	62	1.6	13
(D) *Mec11	9.0	7.7	86	1.4	18	1.1	14	4.0	52	1.2	16
(D) Mec66	16.5	14.6	88	2.4	15	1.6	10	8.9	64	1.7	12

Type specimen.—UKPI *Dib1c from loc. Dib.

Discussion.—Among six Middle and Upper Devonian species of *Gilbertsocrinus* known from New York, some of which occur also in Michigan and Indiana, and one additional species from the Middle Devonian of Ohio, characteristic of the stems have not been described or figured. Therefore, it is impossible to compare the stem fragments named *G. vetulus* with any of these species defined on specimens of thecae.

Occurrence.—Wanakah Shale Member (loc. Dib) and Centerfield Limestone Member (loc. Did), Ludlowville Formation, Erian, Middle Devonian, in New York.

Illustration.—Plate 3, figure *1, articulum of type specimen (UKPI*Did1c, from loc. Did) showing narrow crenularium, rounded epifacet, broad, gently concave, smooth areola, and elevated perilumen, ×10.

GILBERTSOCRINUS AEQUALIS Moore & Jeffords, new species

Stem composed of subequal straight-sided columnals not divisible into noditaxes but having articular facets typical of the genus; crenularium with approximately 85 short, straight crenulae; height of columnals 0.65 mm.

Type specimen.—UKPI *Ma85c from loc. Ma.

Discussion.—No species of *Gilbertsocrinus* has been described from the New Providence Shale. The new species here described and figured, with measurements and indices given in a preceding tabulation differs from others observed chiefly in its straight-sided similar columnals.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, in Kentucky (loc. Ma).

Illustrations.—Plate 3, figure *5a,b, facetal and side views of type specimen, crenularium on raised rim with very even culmina and crenellae, abruptly depressed areola, and prominent perilumen, straight-sided columnals of even height, ×4.5.

GILBERTSOCRINUS CASSIOPE Moore & Jeffords, new species

Stem robust, distinctly heteromorphic, with crenulae somewhat finer and perilumen narrower than in *Gilbertsocrinus aequalis,* from which it is distinguished also by inequality of columnals; axial canal shown by longitudinal sections to be quite straight-sided and bordered by narrow band of dense, light-colored part of columnals representing differentiated perilumen; microstructure of columnals outside of perilumen showing division into subequal halves corresponding to inner areola and crenularium joined with outer areola, this unexpected divison being then correlatable with difference in inner and outer parts of areola seen in facetal view. Measurements and indices given in tabulation of other species with *G. vetulus.*

Type specimen.—UKPI *Maa5 from loc. Maa.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, in Kentucky (loc. Maa).

Illustrations.—Plate 3, figures *6-7.——*6a,b. Well-preserved pluricolumnal chosen as type specimen, facetal view showing outer and inner divisions of crenularium and side view showing noditaxes of 8 columnals with internodals of 3 orders distinguished by slightly smaller height than that of nudinodals, ×2.5.——7a,b. Similar, somewhat larger pluricolumnal (UKPI Maa7, from loc. Maa), ×2.5.

GILBERTSOCRINUS CONCINNUS Moore & Jeffords, new species

Robust stem ranging in diameter from approximately 8 to 17 mm., crenularium surrounded by smooth rim nearly equal to it in width, lumen pentalobate, perilumen with narrow inner and wider outer portions divided by linear furrow, both parts radially denticulate; sides of columnals smooth and rather strongly convex in longitudinal profile. Measurements and indices given in tabulation with *Gilbertsocrinus vetulus* and other species.

Type specimen—USNM *Mec11 from loc. Mec.

Discussion.—This species may prove to be a junior synonym of some one of the species described from the Burlington Limestone on the basis of thecae or crowns, the stems of which cannot now be differentiated. These species include *Gilbertsocrinus fiscellus* (Meek & Worthen), *G. tenuiradiatus* (Meek & Worthen), *G. tuberculosus* (Hall), *G. reticulatus* (Hall), and *G. typus* (Hall). Stems of *G. typus* figured in side view (Wachsmuth & Springer, 1897, pl. 14, fig. 2) and of *G. tuberculosus* (Wachsmuth & Springer, 1897, pl. 17, fig. 5a) generally resemble that of *G. concinnus* but are more slender, with respective diameters of 4 mm. and 7 mm. In both species approximately 17 columnals are counted in a height of 10 mm., whereas only 7 occur in *G. concinnus* in 10 mm. Facetal characteristics of none of the Burlington species are known, excepting the form here described.

Occurrence.—Burlington Limestone, Osagian, Lower Mississippian, in Iowa (loc. Mec).

Illustrations.—Plate 3, figure *12a,b, type specimen, facetal view showing typical features of genus with faintly pentalobate perilumen bordered by double row of fine granules forming ridge around lumen, broad, nearly flat areola, even crenularium, and rounded epifacet, side view showing seeming noditaxes of 4 but actually of 8, for wafer-thin tertinternodals are mostly not visible externally (edge of one seen next beneath topmost columnal), columnal latera well rounded, ×4.

Genus ELYTROCLON Moore & Jeffords, new genus

Stem rather closely similar to that of *Gilbertsocrinus* both in side and facetal views; columnals grouped in noditaxes of 4 with nodals and priminternodals much taller than secundinternodals; perilumen present but inconspicuous and not represented by dense narrow band at sides of lumen as seen in longitudinal sections, which, however, show sharply differentiated outer bands corresponding to crenularium, medullary columnal substance between areolae dark-colored. Crown unknown.

Type species.—*Elytroclon* *elimatus* Moore & Jeffords, new species, from New Providence Shale in Kentucky; designated herein.

Discussion.—This new genus is included in the Rhodocrinitidae because of similarity of the stem to that of *Gilbertsocrinus.*

Occurrence.—Lower Mississippan.

ELYTROCLON *ELIMATUS Moore & Jeffords, new species

With characteristics of genus; lumen and perilumen nearly circular in outline. Measurements (in mm.) and indices of the type specimen are as follows: F, 6.0; L, 0.8; Li, 13; P, 0.8; Pi, 13; A, 3.2; Ai, 50; C, 1.2; Ci, 24; NT, 3.5; IN, 2.5; INi, 72.

Type specimen.—UKPI *Ma132 from loc. Ma.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, in Kentucky (loc. Ma).

Illustrations.—Plate 3, figures *2-3.——*2a,b. Type specimen, side view of exterior showing alternate thick and thin columnals, ×1.7; median longitudinal section showing light-colored dense cortical zone corresponding to crenularium and dark-colored medullar region corresponding to areola and perilumen of articula.——3. Side view of specimen (UKPI Ma126), ×4.5.

Genus ILEMATERISMA Moore & Jeffords, new genus

Stem most closely similar to that of *Elytroclon,* especially in features shown by longitudinal sections, but subareolar (medullary) part of columnals having well-marked horizontal laminae; columnals much taller than in *Elytroclon* and *Gilbertsocrinus* and not definitely grouped into noditaxes, latera nearly straight, with indentations at sutures, which are finely crenulate; articula with relatively wide crenularium and proportionately reduced areola, perilumen weakly differentiated. Crown unknown.

Type species.—*Ilematerisma *enamma* Moore & Jeffords, new species, from Lower Mississippian of Kentucky; designated herein.

Occurrence.—Lower Mississippian.

ILEMATERISMA *ENAMMA Moore & Jeffords, new species

Characteristics of genus. Measurements (in mm.) and indices of the type specimen are as follows: F, 5.0; L, 0.9; Li, 18; P, 0.2; Pi, 4; A, 2.3; Ai, 42; C, 1.8; Ci, 36; KH, 1.2-2.3.

Type specimen.—UKPI *Ma134 from loc. Ma.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, in Kentucky (loc. Ma).

Illustrations.—Plate 3, figure *11a,b, exterior view and median longitudinal section of type specimen showing columnals unequal in height, nearly straight sutures in narrow grooves, and strongly differentiated cortical and medullar parts of columnals, ×2.8, ×3.5.

Order MONOBATHRIDA Moore & Laudon, 1943

Monobathra Moore & Laudon, 1943, p. 86; Monobathrida Moore, 1952, p. 614.

Dorsal cup lacking infrabasals.

Occurrence.—Middle Ordovician-Upper Permian.

[Group ELLIPTICI]

Crinoid stems having eliptical columnal articula. A fulcral ridge coincides in position with the long axis ot the facet and on either side of it are flat to concave, generally smooth bifascial fields. Short crenulae may be present along parts of the facetal rim, but mostly are lacking. Described genera having elliptical stem facets include only Camerata among fossils from Paleozoic rocks but several representatives of the Articulata which belong here are found in Mesozoic and Cenozoic formations, as well as in some extant stalked crinoids.

Family PLATYCRINITIDAE Bassler, 1938 (1842)

Platycrinoidea (family) Austin & Austin, 1842, p. 109.
Platycrinidae Austin & Austin, 1843 (in 1843-49), p. 199.
Platycrinitidae Bassler, 1938, p. 23.

Crown with rather simply constructed monocyclic dorsal cup containing 1 small and 2 large basal plates and 5 radials in contact with one another all around, primanal plate not incorporated in cup but may occur in notch at summits of *C* and *D* radials; strong tegmen composed of numerous irregularly shaped plates extending between arm bases, anus opening directly through it, with or without low elevation surrounding it; arms biserial, pinnulate. Stem may be circular in transverse section next below theca but mostly columnals are more or less compressed elliptical in outline, with well-developed fulcral ridges on their facets, those of opposite facets of each columnal being slightly to abruptly and strongly divergent in orientation so that the stem has a twisted form; columnals bearing cirri or lacking them.

Discussion.—Only Mississippian (Lower Carboniferous) and Permian platycrinitid genera so far have been distinguished in trustworthy manner on the basis of more or less complete articulated skeletal remains, but we have been informed by H. L. Strimple, of the State University of Iowa, that he has discovered well-preserved platycrinitid calices in Pennsylvanian deposits. Among pre-Carboniferous crinoids presumed to belong to *Platycrinites* but rejected from this assignment by us are 1) a single Ordovician fossil from Russia designated as *Platycrinus stellatus* Eichwald (1856, p. 117; Eichwald, 1860 in 1859-68, p. 603, pl. 31, fig. 21a-d) (*non Platycrinus stellatus* Weller, 1909a, p. 281, pl. 11, figs. 13, 14), based on a cylindrical stem fragment that surely does not belong to this genus; 2) 4 described and figured Silurian species—*Platycrinites siluricus* (Hall, 1882, p. 256, pl. 15, fig. 5), *P. corporiculus* (Ringueberg, 1886, p. 12, pl. 1, fig. 9), *P.? dubius* (Weller, 1900, p. 140, pl. 14, fig. 4), and *P. augusta* (Slocom, 1907, p. 292, pl. 86, fig. 5-7) —none of which is reliably referable even to the Platycrinitidae, as is true also of 3 unnamed species illustrated by Springer (1926a, p. 51, pl. 11, fig. 24-29) as undetermined members of the family from the Silurian of Indiana and Tennessee; and 3) 37 Devonian species originally assigned to *Platycrinus* [*Platycrinites*], of which all but 9 have been transferred to genera of families outside the Platycrinitidae, and the remaining 9 species are so dubious that they also should be excluded.

Silurian and Devonian genera formerly assigned to the Platycrinitidae by various authors now are differently classified—*Marsupiocrinus* MORRIS (1843) in the Marsupiocrinidae; *Culicocrinus* MÜLLER (1855), *Cordylocrinus* EICHWALD (1859), *Hapalocrinus* JAEKEL (1895), *Thallocrinus* JAEKEL (1895), *Amblacrinus* D'ORBIGNY (1850) (=*Coccocrinus* MÜLLER, 1855), and *Cyttarocrinus* GOLDRING (1923) in the Thallocrinidae. These families are not only older but are morphologically less advanced than the platycrinitids, and crinoids included in them lack stems with elliptical columnal articula. This led GOLDRING (1923, p. 266) to observe that "The entire absence of oval columnals in the Hamilton or elsewhere in the Devonian argues strongly for the possession of circular columns by members of the Platycrinidae [Platycrinitidae] antedating the Mississippian." She introduced the new genus *Cyttarocrinus* with HALL's (1862) *Platycrinus eriensis* as type species, which comes from the same Middle Devonian beds (Hamilton) that yielded elliptical columnals assigned by us to the new platycrinitid genus named *Platystela*.

The occurrence of platycrinitid columnals at various localities in Pennsylvanian deposits of the central United States has been known for a number of years, but to date only J. M. WELLER (1930) has described and illustrated some of them. His specimens were collected from western Indiana. No thecal plates belonging to a genus of the family have been found where they might be expected, such as our locality Pr in McCulloch County, Texas, which has yielded abundant columnals referred here to the new genus and species *Platyplateium *texanum*.

A single Permian species based on crinoid columnals has been described and figured by MOORE (1939a) under the name *Ellipsellipsopa latissima*. It is a platycrinitid with exceptionally narrow elliptical facets.

Occurrence.—Middle Devonian-Permian.

Genus PLATYCRINITES Miller, 1821

Platycrinites MILLER, 1821, p. 15; WRIGHT, 1955, p. 262.
Platycrinus AGASSIZ, 1835, p. 197; WACHSMUTH & SPRINGER, 1897, p. 647.
Centrocrinus AUSTIN & AUSTIN, 1843, p. 6.
Edwardsocrinus D'ORBIGNY, 1849 (in 1849-51), p. 157.
Medusacrinus AUSTIN, 1875, p. 91.

Dorsal cup and tegmen with characteristics of family, primarily distinguished by structure of arms, which bifurcate in one or more positions close to radials and have biserially arranged pinnule-bearing brachials. Stem transversely circular at and near base of dorsal cup, becoming elliptical within a short distance, articula of columnals with fulcral ridges, their orientation on opposite facets of each columnal sufficiently divergent to produce spiral twist of stem.

Type genus.—*Platycrinites* MILLER (1821) (type species, *P. *laevis* MILLER, 1821, p. 74, from Lower Carboniferous of England; subsequent designation by S. A. MILLER, 1889, p. 270).

Discussion.—Because *Eucladocrinus* and possibly other platycrinitid genera possess elliptical stems, *Platycrinites* cannot be recognized on this character alone. Generally, diminutive elliptical columnals, with or without cirrus scars, probably belong to a species of *Platycrinites,* rather than *Eucladocrinus,* but it is very possible that they represent some previously undescribed genus.

As noted in discussion of the Platycrinitidae, pre-Mississippian reported occurrences of *Platycrinites* have been rejected or they are so doubtful that the lower limit of range of the genus is given here as base of the Mississippian.

Occurrence.—Lower Mississippian-Permian.

PLATYCRINITES? IRRORATUS Moore & Jeffords, new species

Stem composed of uniform elliptical columnals of moderate size (short-axis width 4 mm., long-axis width 6.5 mm., height 3.7 mm.) with gently convex profile and surface marked by scattered but rather numerous coarse rounded tubercles, fulcral ridge of articula very narrow and low, bifascial fields smooth and flat; facetal shape index 62; no cirrus scars observed. Dorsal cup and arms unknown.

Type specimen.—USNM *Mec395 from loc. Mec.

Discussion.—Inasmuch as 47 species of *Platycrinites* are listed by BASSLER & MOODEY (1943) from the Burlington Limestone of the Burlington, Iowa, region, including northeastern Missouri, one might suppose with good reason that stems of the sort here described, figured, and named could belong to some one of these species, mostly known for 50 to 100 years. Surveys of the extensive Springer collection in the U.S. National Museum, similar large collections at the Universities of Illinois, Chicago, and Iowa, among which nearly all type specimens of described platycrinitid species are located, have failed to substantiate this expectation. Likewise, published literature yields no information on species having stems closely comparable to *Platycrinites? irroratus*.

Occurrence.—Burlington Limestone, Osagian, Lower Mississippian, from Iowa (loc. Mec).

Illustraiton.—Plate 3, figure *4, side view of type specimen, twisted pluricolumnal composed of moderately elliptical, evenly high columnals ornamented by scattered tubercles, ×1.7.

Genus PLATYSTELA Moore & Jeffords, new genus

Stem elliptical, as indicated by shape of articular facets, but only irregularly shaped nodals yet are known, some roughly elliptical in outline, some quadrangular in outline, and some with unevenly disposed projections on all sides; articula generally bordered by very short but well-defined crenulae, some with smooth rims, long axis of facets bearing narrow fulcral ridge which is strongly elevated above gently concave bifascial fields, ridges on opposite facets of nodals diverging at angle of 70° to 78° from one another; lumen very small, circular to slightly elliptical. Crown unknown.

Type species.—*Platystela *proiecta* MOORE & JEFFORDS, new species; designated herein.

Occurrence.—Middle Devonian of New York.

PLATYSTELA *PROIECTA Moore & Jeffords, new species

Stem diminutive, with characteristics of genus; fulcral ridges with rounded summit, with 2 or 3 exceptionally strong culmina and crenellae at each extremity; sides of columnals sloping and smooth, with spinose extensions that in part do not coincide with directions of fulcral ridges. Measurements (in mm.) of facetal and columnal diameters and height, indices, and angular divergence of opposite fulcral ridges are tabulated as follows.

*Measurements and indices of Platystela *proiecta*

Specimen	Fx	Fy	FSi	Kx	Ky	KH	F
*Dia2a	1.2	1.7	70	1.6	2.6	1.2	72°
Dib3j	2.4	3.2	77	3.4	3.7	1.7	78°
Dib3k	2.1	2.9	72	2.6	3.4	1.6	70°

Type specimen.—UKPI *Dia2a from loc. Dia.

Occurrence.—Wanakah Shale Member of Ludlowville Formation, Hamilton Group, Erian, Middle Devonian, from New York (locs. Dia, Dib).

Illustrations.—Plate 3, figures 8-*10.——8a,b. Views of opposite articula of small columnal (UKPI Dib3j, from loc. Dib) lacking prominent spinose projections, identically oriented in order to show different positions of fulcral ridges, ×8.5.——9a,b. Facetal view of opposite surfaces of columnal (UKPI Dib3k, from loc. Dib) showing 65° divergence of their fulcral ridges (ridge seen in 9a marked by θ-η and that seen in 9b by ϵ-ζ), ×8.5.——*10a,b. Opposite facets of identically oriented columnal (type specimen) showing 70° divergence in angle of fulcral ridge positions (ridge seen in 8a marked by α-β and that seen in 8b by γ-δ), ×17.

Genus EUCLADOCRINUS Meek, 1872

Eucladocrinus MEEK, 1871(1872), p. 373; WACHSMUTH & SPRINGER, 1897, p. 719.

Crown somewhat similar to that of *Platycrinites*, distinguished by tubular extensions which spread laterally from summit of theca, formed by brachials and tegminal plates, biserial pinnule-bearing arms given off from these extensions. Stem almost entirely composed of strongly elliptical columnals, not distinguishable from those of *Platycrinites* stems, except possibly on the basis of their generally large size and usual absence of cirrus scars.

Type species.—*Platycrinites (Eucladocrinus) *montanaensis* MEEK (1861 [1862], p. 373), from Madison Limestone, Lower Mississippian, of Montana; fixation by monotypy.

Occurrence.—Lower Mississippian.

EUCLADOCRINUS? SPRINGERI Moore & Jeffords, new species

Stem composed of decidedly compressed elliptical columnals of relatively large size, articular facets flat and smooth, without bordering crenulae or rim, fulcral ridge very narrow and barely raised above level of bifascial fields, its crest marked by a linear furrow which in slightly weathered specimens may be more evident than ridge; sides of columnals smooth, gently convex in longitudinal profile, many but not all columnals bearing small to moderately large circular cirrus scars at one or both extremities of long axis, but some specimens lacking cirrus scars. Measurements (in mm.) and indices of the type specimen and several others are tabulated as follows.

Measurements and indices of Eucladocrinus? springeri

Specimen	Fx	Fy	FSi	KH	KHi	Lx	Ly	cirrus scars
*Mec96	10	26	38	3.7	20.6	0.3	0.5	present
Mec96a	9	24	37	3.8	23	0.3	0.5	present
Mec96b	10	28	36	4.3	22.6			present
Mec96c	9	22	41	3.0	19.4	0.3	0.6	absent
Mec96d	7	20	35	3.5	24			absent
Mec96e	9	22	41	3.6	20			present
Mec96f	10	21	47	4.0	25.8			present
Mec96g	8	20	40	3.5	25			present
Mec96h	11	26	42	3.0	16			absent

Type specimen.—USNM *Mec96 from loc. Mec.

Discussion.—The generic placement of the pluricolumnals assigned to the new species *Eucladocrinus? springeri* is problematical in that no species belonging either to *Eucladocrinus* or *Platycrinites* is known to possess a column of comparable size, although both of these genera include species having columnals that approximately match the form here illustrated in shape. *Eucladocrinus? springeri* differs from *E. pleuroviminus* (WHITE), the most robust described species (also from the Burlington Limestone of the Iowa region), in its distinctly less compressed and larger columnals, as well as in the common presence of robust cirri on successive columnals; cirri seem to be lacking on most stems of *Eucladocrinus*. WACHSMUTH & SPRINGER (1897, pl. 2, fig. 11) illustrated a platycrinitid stem fragment with columnals 32 mm. wide along the long axis and a height of 6 mm.; they designated the specimen, which bears cirri like those of *E.? springeri*, as an undetermined species of *Platycrinus* [*Platycrinites*].

Occurrence.—Burlington Limestone, Osagian, Lower Mississippian, from Iowa (loc. Mec).

Illustrations.—Plate 4, figure *1. *1a,b. Side and facetal views of pluricolumnal (type specimen, USNM *Mec96) showing elongate elliptical outline of columnals and their slight, even twist; in *1a, cirrus borne by 3rd columnal from top, ×1.7.

EUCLADOCRINUS? KENTUCKIENSIS Moore & Jeffords, new species

Like *Eucladocrinus? springeri* in its robust size but columnals proportionally much wider transverse to long axis, which is marked by prominent fulcral ridge rising well above smooth-floored concave bifascial fields on either side and widening toward its extremities, in some specimens being divided in these regions into 3 or 4 minor ridges and grooves; narrow area surrounding diminutive elliptical lumen may be distinguished as perilumen with summit at same height as fulcral ridge; borders of facet lacking trace of crenulae and without distinct rim; sides of columnals typically marked by rounded elevation at mid-height continuous around columnal and with or without small tubercles along its crest. Opposite facets with fulcral ridges offset in orientation by 3° or 4°, which provides a gentle spiral twist of the stem; no differentiated nodals or cirrus-bearing columnals observed, in this respect dissimilar to *E.? springeri*. Measurements (in mm.) and indices of the type specimen and a few others are tabulated as follows.

Measurements and indices of Eucladocrinus? kentuckiensis

Specimen	Fx	Fy	FSi	KH	KHi	Lx	Ly
*Me11	14	25.5	55	6	30	0.5	0.75
Me21	16	25.5	63	5	24	0.5	0.8
Me59	14	25	56	5	25	0.6	0.75
Me60	11.5	24	48	5.2	29	0.5	0.8
Me130	7.5	11.5	65	4	42	0.2	0.5

Type specimen.—UKPI *Me11 from loc. Me.

Discussion.—Because specimens referable to *Eucladocrinus? kentuckiensis* have not been found in any of our large New Providence Shale collections from Indiana, Kentucky, and Tennessee, whereas they are widely distributed in higher strata of the Borden Group of this region, including the so-called Crawfordsville beds at Crawfordsville, Indiana, this easily recognized platycrinitid is judged to be a good stratigraphic marker. Also, it is recognized, though not common, in crinoid stem collections made by SPRINGER from the Burlington Limestone in southeastern Iowa, loaned from the U.S. National Museum to us for study.

Occurrence.—Brodhead Formation (locs. Mc, Md) and Floyds Knob Formation (loc. Me), Borden Group, Osagian, Lower Mississippian, from Kentucky; "Fort Payne Limestone" (Borden equivalent) (loc. Mdp) from Tennessee; Edwardsville Formation, Borden Group (locs. Mfm, Mfn), from Indiana; and Burlington Limestone, Osagian (loc. Mec), from Iowa.

Illustrations.—Plate 4, figure *7. Articulum of type specimen (UKPI *Me11, columnal from loc. Me) showing prominent, finely denticulate fulcral ridge and broad, distinctly concave ligament areas not bordered by rim, ×3.5.

Genus PLATYPARALLELUS Moore & Jeffords, new genus

Stem composed of elliptical columnals, most of which are so nearly circular that their identity as belonging to a platycrinitid genus depends essentially on observation of their bifascial articulation; fulcral ridges mostly not ridge-like but consisting of several fine parallel straight ridgelets barely raised above flat or gently concave and smooth bifascial fields, ridgelets converging toward lumen but remaining parallel or diverging slightly at outer extremities; borders of facets rimless or with very narrow band of extremely fine crenulae; height of most columnals nearly half of width and some exceeding thin. Orientation of fulcral ridges on opposite facets mostly divergent at angles ranging from 60° to approximately 90° but in some columnals orientation is same. Crown unknown.

Type species.—*Platyparallelus *parilis* MOORE & JEFFORDS, new species; designated herein.

Occurrence.—Lower Mississippian of Kentucky.

PLATYPARALLELUS *PARILIS Moore & Jeffords, new species

Characteristics of genus. Sides of most columnals smooth and longitudinally straight or very gently convex, but they may slope more or less strongly. Some well-preserved specimens bear fine granulose to slightly vermiculate surface ornament and a few have low rounded tubercles on latera. For the present all are placed together as variants of a single species. Measurements (in mm.) and indices of the type specimen and some others are tabulated as follows.

*Measurements and indices of Platyparalellus *parilis*

Specimen	Fx	Fy	FSi	KH	KHi	Divergence of fulcral ridges
*Ma134	11.0	11	91	5	48	0°
Ma134a	11.3	10.5	93	5.5	50	88°
Ma134b	12	10	83	4.5	41	75°
Ma134c	12.6	99.5	75	4.5	41	0°
Ma134d	9	8	89	3.7	44	65°
Ma134e	10.5	8.5	81	5	53	60°
Ma134f	10	8.5	85	4	43	85°
Ma134g	12	7.6	63	3.7	59	73°

Type specimen.—*Ma134 from loc. Ma.

Discussion.—This is a common species in our New Providence collections and it is of interest to observe that measurements of long and short axes of facets on opposite sides of most columnals having divergent orientation of the fulcral ridges are nearly identical in spite of the shift. The sides of such columnals slant sufficiently to accomodate the altered orientation of the facets.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, of Kentucky (loc. Ma).

Illustrations.—Plate 4, figure *3. Facetal view of type specimen (UKPI *Ma134, nodal from loc. Ma) showing broadly oval outline, 6 or more narrow ridges and furrows in position of fulcral ridge, converging toward elliptical lumen where they terminate, ligament areas nearly flat; fulcral ridges on opposite articulum similarly oriented, ×1.7.

Genus PLATYCLONUS Moore & Jeffords, new genus

Stem composed of elliptical columnals somewhat closely resembling those of *Platyparellelus* in being nearly circular, relatively tall, and in having fulcral ridges of articula divided into fine linear ridgelets. They differ in showing broad and asymmetrical expansion of at least one-half of ridge and in presence commonly of quite distinct fine crenulae around part of facetal margin; orientation of multilineate ridges on opposite articula either subparallel or strongly divergent. Sides of columnals smooth and longitudinally straight or sloping obliquely. Crown unknown.

Type species.—*Platyclonus *dispar* MOORE & JEFFORDS, new species; designated herein.

Occurrence.—Lower Mississippian of Kentucky.

PLATYCLONUS *DISPAR Moore & Jeffords, new species

Fulcral ridge compact and sharply elevated above bifascial fields adjacent to small elliptical lumen, one side of ridge tending to be nearly straight, whereas opposite side is moderately to very strongly angulated. Measurements (in mm.) of type specimen and a few others with indices and angular divergence of fulcral ridges on opposite facets are tabulated as follows.

*Measurements and indices of Platyclonus *dispar*

Specimen	Fx	Fy	FSi	KH	KHi	Divergence of fulcral ridges
*Ma40d	9	13.5	67	5.3	45	90°
Ma40m	10.5	12	88	5.2	46	0°
Ma40n	11.3	12	93	3.5	30	80°
Ma40p	8.6	9.6	90	3.8	42	0°
Ma40q	10.5	11.5	91	5	45	30°
Ma40r	8.5	12.5	68	4.5	36	0°
Ma40s	9	11	82	4.3	43	66°

Type specimen.—UKPI *Ma40d from loc. Ma.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, of Kentucky (loc. Ma).

Illustrations.—Plate 4, figure *2. Type specimen (UKPI *Ma40d, short pluricolumnal from loc. Ma). *2a,b. Slightly oblique views of articula at opposite extremities of specimen showing peculiar configuration of complex fulcral ridge with asymmetrical parts narrowed toward diminutive lumen on rounded elevation, orientation of ridges dissimilar on opposite articular facets. *2c. Oblique-view drawing of single columnal treated as though transparent, in order to show relationships of opposite articula. *2d. Side view of pluricolumnal. All ×3.5.

Genus PLATYPLATEIUM Moore & Jeffords, new genus

Stem composed of strongly compressed, elongate elliptical internodals, with or without cirrus scars at their extremities, and subquadrate nodals bearing divergently oriented elliptical facets on opposite sides and commonly bearing at least one cirrus scar, sides of nodals sloping strongly in region of their angles but subvertical and longitudinally convex like internodals along middle parts of nodal sides. Crown unknown.

Type species.—*Platyplateium *texanum* MOORE & JEFFORDS, new species; designated herein.

Discussion.—The large angular divergence of fulcral ridges on the opposite articula of nodals is much the same as in the Devonian *Platystela* and is comparable also to many columnals of *Platyparallelus* and *Platyclonus,* even though very unlike these latter in appearance. Internodals of *Platystela* are unknown. If columnals of the other two mentioned genera that have subparallel fulcral ridges on opposite facets are interpreted as internodals, no perceptible differences in shape separate nodals and internodals. In *Platyplateium* the contrast between internodals and nodals is very marked. Available pluricolumnals consisting of internodals attached to nodals indicate that noditaxes of *Plyplateium* probably contain not more than 6 or 7 columnals.

Platycrinites and *Eucladocrinus* lack nodals and the fulcral ridges on opposite facets of columnals diverge only slightly in orientation.

Occurrence.—Lower Mississippian-Middle Pennsylvanian.

PLATYPLATEIUM *TEXANUM Moore & Jeffords, new species

Plate 4, figures 3-7, plate 5, figure 5-8

Stem composed of elongate, much-compressed internodals and subquadrate nodals with elliptical articula divergently oriented on opposite sides of columnals, bifascial fields sloping rather strongly inward from rims which lack crenulae, fulcral ridges sharply raised above bifascial fields, narrowed to points at margins of moderately large elliptical lumen but expanding outward from lumen, summit of ridge denticulate and bearing median narrow furrow; latera of columnals subvertical around internodals, bulging at mid-height to form rounded convexity or slightly angulated, granule-marked crest, sides of nodals sloping obliquely from one facet to other. Measurements (in mm.) of type specimen and some others with indices are tabulated as follows.

*Measurements of indices of Platyplateium *texanum*

Specimen	Fx	Fy	FSi	KH	KHi	Divergence of fulcral ridges
Pr10	7.4	19.6	38	3.3	24	0° (IN)
Pr9	7	22	32	4.6	32	0° (IN)
Pr14	6	13.8	43	4.2	44	0° (IN)
*Pr6	3.8	13.5	28	3.2	38	0° (IN)
Pr4	7.6	17.5	43	4.4	35	72° (N)
Pr5	7.9	14.3	55	4.5	40	77° (N)
Prl	6	13	46	4	42	70° (N)

Type specimen.—UKPI *Pr6 from loc. Pr.

Discussion.—The presence of cirrus scars on many internodal columnals of *Platyplateium *texanum* is of interest and serves readily to distinguish them from species of *Platycrinites.*

If the nodals illustrated in Plate 4, figures 4 and 5 are examined, the angles of divergence (77°, 72°) between long axes of the visable articula and ones beneath are similar in position, whereas this angle (70°) for the nodal illustrated in Plate 5, figure 8a is on the opposite side of the fulcral ridge of the visible facet. Whichever facet of these columnals is viewed, the offset in orientation of the opposite facet is the same. Let the first two nodals be designated as right-hand types and the third as left-hand. When this classification was applied to a lot of 45 columnals from locality Pr, 20 proved to be right-hand nodals and the remainder left-hand. At first, this was construed to signify an almost equal division into groups corresponding to the dextral and sinistral coiling of gastropod shells, and since all of the columnals rather clearly belong to a single species, this would be explained as a random peculiarity of individuals, like right-handed and left-handed human beings. A bit of further study indicated that such an interpretation is false. Actually, the so-called right-hand nodals introduce an angular right-hand shift of 70° to 80° in orientation of an internodal series next beneath them and the lowermost internodal of this series articulates with a left-hand nodal, which in turn swings the internodals beneath it back left into line with the second set of internodals above it. In other words, alternate series of internodals differ in orientation and every other series has approximately the same azimuthal orientation. This is a somewhat unique peculiarity of the genus.

The observed minimum angular divergence of opposite fulcral ridges of nodals in *Platyplateium* **texanum* is 60° and the maximum is 80°; the mean represented by most specimens is 72°.

Occurrence.—Millsap Lake Formation, Strawn Group, Desmoinesian, Middle Pennsylvanian, in Texas (loc. Pr).

Illustrations.—Plate 4, figures 4-6; Plate 5, figures 5-*6-8.——Pl. 4, fig. 4. Nodal (UKPI Pr5, from loc. Pr); 4a,b, side and facetal views showing sloping to subvertical parts of epifacets, markedly elliptical, well-hollowed articulum with strong fulcral ridge disposed at an angle of 77° from axis of opposite facet (marked by heavy broken line), ×3.5.——Pl. 4, fig. 5. Specimen (UKPI Pr4, quadrangular nodal with single cirrus scar closer to one articulum than other, from loc. Pr), fulcral ridges of opposite articular facets diverging at angle of 72°, ×3.5.——Pl. 4, fig. 6. Specimen (UKPI Pr10, from loc. Pr), columnal classed as internodal in view of its narrowly elliptical articula with parallel fulcral ridges on opposite facets, despite presence of circular cirrus scar at one extremity; 6a-c, facetal, wide and narrow lateral views, ×3.5.——Pl. 5, fig. 5. Specimen (UKPI Pr9, from loc. Pr), facetal view of typical internodal lacking cirrus scar, ×3.5.——Pl. 5, fig. *6. Type specimen (UKPI *Pr6, pluricolumnal consisting of 5 internodals and nodal, next to lowermost in side views, from loc. Pr), cirrus scars present on 3 internodals and nodal but lacking on other columnals, abrupt twist of column at nodal clearly shown, ×3.5.——Pl. 5, fig. 7. Specimen (UKPI Pr4, internodal from loc. Pr); 7a,b, side and facetal views showing rounded keel at mid-height and fusiform outline of articular facet, ×3.5.——Pl. 5, fig. 8. Specimen (UKPI Pr1, nodal from loc. Pr); 8a,b, facetal and side views, angular divergence of fulcral ridges on opposite articula approximately 70°, ×3.5.

PLATYPLATEIUM sp.

One of several columnals designated as *Platyplateium* species undetermined is illustrated. These are characterized by much smaller size than columnals of *P. *texanum,* with very weak fulcral ridges, and presence of fine crenulae around edges of articula. The figured specimen has facets 4.5 by 7.3 mm. in diameter, indicating a shape ratio of 62, a height of 3.6 mm. and height ratio of 61, and angular divergence of opposite fulcral ridges amounting to 68°. The sides are distinctly granulose and marked by a sharp keel at mid-height. Circular cirrus-attachment scars are located opposite ends of fulcral ridges.

Figured specimen. UKPI Pr8 from loc. Pr.

Occurrence.—Millsap Lake Formation, Strawn Group, Desmoinesian, Middle Pennsylvanian, in Texas (loc. Pr).

Illustrations.—Plate 5, figure 9. Specimen (UKPI Pr8, small nodal from loc. Pr); 9a,b, side and facetal views showing sharp keel and mid-height of latus, lanceolate articulum with bordering narrow crenularium, and projections bearing cirrus scars, orientation of fulcral ridges accented by heavy lines (broken line for concealed facet), ×3.5.

PLATYPLATEIUM PROVIDENCENSE Moore & Jeffords, new species

Nodals rounded quadrangular in outline, moderately large, with broadly elliptical facets disposed at nearly 90° to one another; fulcral ridges very slightly raised above gently concave bifascial fields, narrow adjacent to small elliptical lumen and widening toward both extremities, surface divided into small vermiculiform rugosities which partly display a linear arrangement; borders of facet lacking crenulae and rimless. Sides of columnals sloping in areas of long and short axes of articula but subvertical midway between these areas, surface finely granulose. Measurements (in mm.) and indices of the type specimen are Fx, 15; Fy, 25; FSi, 60; KH, 5; KHi, 20; DFR, 82°.

Type specimen.—UKPI *Ma133 from loc. Ma.

Occurrence.—New Providence Shale, Bordon Group, Osagian, Lower Mississippian, from Kentucky (loc. Ma).

Illustration.—Plate 5, figure *4. Type specimen (UKPI *Ma133, nodal from loc. Ma), facetal view showing broadly oval outline of articulum and irregular granulose ridges of fulcrum, which widen away from small elliptical lumen, axis of concealed facet disposed at angle of 80° to that shown in view, ×2.5.

Genus PLATYCION Moore & Jeffords, new genus

Stem distinctly elliptical but tending toward circularity, homeomorphic, composed of straight-sided columnals with articular facets bordered by short, coarse crenulae distributed evenly around smooth bifascial fields, fulcral ridges prominent and widest next to large circular lumen, narrowing toward extremities, halves of ridges not in straight line but forming obtuse angle of approximately 160°; latera of columnals smooth, sutures rather strongly indented. Crown unknown.

Type species.—*Platycion *mingusensis* MOORE & JEFFORDS, new species, Middle Pennsylvanian of Texas; designated herein.

Occurrence.—Middle Pennsylvanian.

PLATYCION *MINGUSENSIS Moore & Jeffords, new species

Characteristics of genus. Measurements (in mm.) and indices of the type and another specimen are tabulated as follows.

*Measurements and indices of Platycion *mingusensis*

Specimen	Kx	Ky	Fx	Fy	KSi	FSi	KH	KHi	L
*Pak58	3.4	3.8	3.1	3.6	89	86	1.4	42	0.45
Pak56	3.6	4.4	3.3	4.0	82	82	1.5	41	0.45

Type specimen.—UKPI *Pak58 from loc. Pak.

Discussion.—The combination of morphological features exhibited by *Platycion *mingusensis* makes it distinguishable very easily from any other known platycrinitid.

Occurrence.—Mingus Shale, Strawn Group, Desmoinesian, Middle Pennsylvanian, in Texas (loc. Pak).

Illustrations.—Plate 5, figures *1-2.——*1a,b. Facet and side view of type specimen (UKPI *Pak58 from loc. Pak) showing bent position of fulcral ridge, large lumen, and very gentle twist of seemingly homeomorphic stem, ×4.2.——2a,b. Similar view of another specimen (UKPI Pak56 from loc. Pak), ×4.2.

[Group CYCLICI]

Characteristics of this group have been stated under Camerata (Diplobathrida).

Family EUCALYPTOCRINITIDAE Bassler, 1938 (1854)

Eucalyptocrinidae ROEMER, 1854, p. 229.
Eucalyptocrinitidae BASSLER, 1938, p. 27.

Monocyclic camerates with 3 unequal basals partly sunk in deep basal concavity, radial plates in contact with one another all around dorsal cup, arms in recesses between elongate terminal plates that form partitions; stem distinctly heteromorphic or seemingly homeomorphic (cryptoheteromorphic), with branching cirrus roots at distal extremity.

Type genus.—*Eucalyptocrinites* GOLDFUSS, 1831, from Silurian and Devonian of Europe and North America.

Occurrence.—Silurian-Devonian.

Genus EUCALYPTOCRINITES Goldfuss, 1831

Eucalyptocrinites GOLDFUSS, 1831 (in 1826-44), p. 214.
Eucalyptocrinus AGASSIZ, 1835 (1836), p. 197; WACHSMUTH & SPRINGER, 1897, p. 332; SPRINGER, 1926a, p. 35.
Hypanthocrinites PHILLIPS, 1839, p. 672.
Hypanthocrinus MORRIS, 1843, p. 59.
Eucalyptrocrinites GEINITZ, 1846, p. 551.
Crinocystites HALL, 1868, p. 317.
Crinocystis HAECKEL, 1896, p. 69.

Chiefly distinguished from other genera of family by tegminal partitions that provide compartments for reception of infolded arms.

Type species.—*Eucalyptocrinites *rosaceus* GOLDFUSS, 1831 (in 1826-44) (p. 214, pl. 64, fig. 7), from Middle Devonian of Germany; fixation by monotypy.

Occurrence.—Silurian-Devonian.

EUCALYPTOCRINITES? SHELBYENSIS Moore & Jeffords, new species

Stem strongly heteromorphic, with high rounded nudinodals that extend laterally well beyond thin internodals, sides of columnals smooth; articular facets with relatively large quinquelobate lumen surrounded by ill-defined narrow areola and moderately wide crenularium containing approximately 30 straight coarse crenulae; noditaxis with average height of 2.5 mm. nearly half of which consists of internode, internodal index 45; facets of internodals equal in width to those of nodals, but latter distinguished by projecting, evenly rounded epifacets and thickness.

Type specimen.—UKPI *Shg15d from loc. Shg.

Discussion.—Since the Waldron Shale, from which specimens of *Eucalyptocrinites? shelbyensis* were collected, contains numerous more or less complete crowns of *E. crassus* (HALL), *E. ovalis* (HALL), and 4 other less common recognized species, the stem fragments here designated as a new species could reasonably be supposed to belong to one of them, or conceivably to two or more different species defined by characteristics of the crown, if these have nearly identical stems. The suggested possibilities cannot now be assessed. Indeed, the queried assignment of the stems to *Eucalyptocrinites* is based entirely on their similarity in side view to figured specimens of *E. crassus* (HALL, 1882, pl. 17, figs. 5,9) and *E. ovalis* (HALL, 1882, pl. 17, figs. 1,2; WACHSMUTH & SPRINGER, 1897, pl. 81, figs. 1,2), other species lacking figured stems; also, relative abundance of *Eucalyptocrinites* in the Waldron fauna supports the questioned identification of *E.? shelbyensis*.

Occurrence.—Waldron Shale, Niagaran, Upper Silurian, in Indiana (loc. Shg).

Illustrations.—Plate 5, figure *3. Type specimen (UKPI *Shg15d, from loc. Shg); *3a,b, side view of pluricolumnal with 3 nudinodals (marked by small arrows) and much narrower, thinner internodals, ×7; *3b, articular facet of nodal showing slight rim, coarse crenulae, and relatively large quinquelobate lumen surrounded by ill-defined areola, ×8.5.

Family DOLATOCRINIDAE S. A. Miller, 1890

Dolatocrinidae S. A. Miller (1890), p. 344.

Monocyclic camerates with subglobular theca, which may be appreciably flattened, with three unequal basals or fused basal circlet, radial plates in contact with one another all around, no anal plates in dorsal cup.

Type genus.—Dolatocrinus Lyon (1857, p. 482), from Devonian of North America.

Discussion.—The family contains 8 described genera, some of which have stems of similar appearance in side view, whereas the stems of others are dissimilar.

Occurrence.—Devonian.

Genus DOLATOCRINUS Lyon, 1857

Dolatocrinus Lyon, 1857, p. 482; Wachsmuth & Springer, 1897, p. 310; Springer, 1921, p. 16.
Cacabocrinites Troost, 1849 (1850), p. 419 *(nom. nud.)*; Roemer, 1860, p. 31.
Cacabocrinus Hall, 1862, p. 109.

Distinguished from other genera of family by regularity of somewhat flattened dorsal cup and details of plate arrangement; stem unknown in most species but in some is characterized by nodals with vertically extended flanges diverging at 120-degree angles.

*Type species.—Dolotocrinus *lacus* Lyon (1857) from Lower Devonian of Kentucky; fixation by monotypy.

Discussion.—Some species of *Dolatocrinus* (e.g., *D. spinosus* Miller & Gurley) have stems resembling those of *Himerocrinus* Springer in which nodal columnals bear more than 3 vertical flanges—up to 10—which extend only slightly beyond the proximal and distal edges of the nodals. Other species of *Dolatocrinus* in which characteristics of the stem are known (e.g., *D. grandis* Miller & Gurley) exhibit the 3-fold flanges with tendency to vertical elongation across part or all of internodal groups of columnals. Such stems seem to be reliably assignable to *Dolatocrinus*.

Occurrence.—Lower Devonian-Middle Devonian.

DOLATOCRINUS EXCULPTUS Moore & Jeffords, new species

Stem with internodes composed of more than 6 columnals (estimated 12) which are only slightly lower in height than nodals, latter distinguished by sharp-crested keel at mid-height crossed at 120-degree angles by narrow vertical flanges that have triangular profile next to nodal and low extensions across internodes, sides of internodals with gently convex longitudinal profiles, smooth; articular facets showing large circular lumen and crenularium marked by moderately fine, straight crenulae, which are divided into 3 groups by V-shaped junctions of crenulae opposite the vertical flanges. Measurements (in mm.) and indices of the facet of the type specimen are: F, 7.5; L, 3.2; Li, 43; C, 4.3; Ci, 57. Those of another specimen (Dib1d) are: F, 4.7; L, 1.8; Li, 38; C, 2.9; Ci, 62.

Type specimen.—UKPI *Ddx1 from loc. Ddx.

Discussion.—In facetal and side-view characteristics some specimens from the Silver Creek Limestone Member of the Sellersburg Limestone (Erian, Middle Devonian) in Clark County, southern Indiana, are nearly identical with the type specimen of *Dolatocrinus exculptus* from New York. The Indiana specimens (USNM S573) are labeled *Dolatocrinus* species undertermined in the Springer collection. Associated rather different Indiana specimens agree in having 3 extended vertical flanges but show internodes of 7 columnals with an enlarged priminternodal midway between pairs of nodals.

Occurrence.—Wanakah Shale Member, Ludlowville Formation, Erian, Middle Devonian, in New York (locs. Ddx, Dib).

Illustrations.—Plate 6, figures *12-13.——*12. Type specimen (UKPI *Ddx1, from loc. Ddx); *12a-c, facetal and 2 side views showing inconspicuous trimeral grouping of straight crenulae, large circular lumen, horizontally keeled nodal intersected by vertical flanges projecting outward at 120° angles and developed as triangular prominences at keel intersections, ×3.5.——13. Specimen (UKPI Dib1d, from loc. Dib), facetal view, ×8.5.

DOLATOCRINUS AVIS Moore & Jeffords, new species

Nodals similar to those of *Dolatocrinus exculptus* in having 3 prominent vertically compressed outward extensions at angles of 120 degrees but these are spinelike instead of developed as flanges; also articular facet is materially smaller in diameter than columnal and depressed, except for peripherally visible crenulae, its features obscured by weathering. Measurements (in mm.) and indices of the type specimen are: K, 6.0; F, 3.8; Fi, 64; KH, 1.2; Khi, 20.

Type specimen.—UKPI *Dia2i from loc. Dia.

Discussion.—Two species of *Dolatocrinus* have been described from the Middle Devonian of New York. They are *D. liratus* (Hall) and *D. springeri* Goldring. Characteristics of their stems are unknown.

Occurrence.—Wanakah Shale Member, Ludlowville Formation, Erian, Middle Devonian, in New York (loc. Dia).

Illustrations.—Plate 6, figure *14, facetal view of type specimen showing smoothly rounded rim and short crenulae, ×13.

[Group VARII]

Assembled under the designation Varii are diverse kinds of dissociated crinoid skeletal remains that are not accepted in any other group. The forms thus brought together are greatly varied in nature, as the name suggests, and consideration of them is purely for convenience. Fragments included in the group may belong to any morphological component of the crinoid animals from which they were derived—for example, holdfasts, portions of stems consisting of pluricolumnals or individual columnals, thecal plates and combinations of a few thecal plates, and fragments of arms—and representatives of all subclasses of crinoids are likely to be found here. In so far as possible, fragments of the Varii group are assigned to their appropriate subclass and family assemblage within the subclass. The residue is placed in "Subclass Uncertain."

Family DICHOCRINIDAE S. A. Miller, 1889

Dichocrinidae S. A. MILLER, 1889, p. 214.

Monocyclic camerates having only 2 equal plates in basal circlet, suture between them meeting middle of *A* radial; primibrachs excluded from dorsal cup.

Type genus.—Dichocrinus MÜNSTER (1839, p. 2), from Lower Carboniferous of Belgium.

Occurrence.—Mississippian-Permian.

Genus CAMPTOCRINUS Wachsmuth & Springer, 1897

Camptocrinus WACHSMUTH & SPRINGER, 1897, p. 779.

Crown diminutive, genus chiefly distinguished by its coiled stem composed of truncate elliptical columnals among which paired nodals bear unbranched or branched cirri directed toward inner side of coil so as to conceal crown partly or entirely, internodals lacking cirri, articular facets with low, straight or gently curved denticulate fulcral ridge, bordered on side away from small central lumen by deep ligament fossa parallel to rounded margin of columnal, which is toward inside of coil, opposite surface of columnal nearly straight and smooth.

*Type species.—Dichocrinus (Camptocrinus) *myelodactylus* WACHSMUTH & SPRINGER (1897, p. 779), from Lower Mississippian of Indiana; fixation by original designation.

Occurrence.—Lower Mississippian-Permian.

CAMPTOCRINUS BEAVERI Moore & Jeffords, new species

Articular facets rounded trapezoidal in outline, straight flat-topped, finely denticulate fulcral ridge between small elliptical lumen and deep, slightly arcuate ligament fossa, few obliquely disposed coarse crenulae near ends of fulcral ridge; facets for pairs of branched cirri located on sloping sides of nodal columnals, pair of small rounded nubbins in shallow furrow on opposite side of nodals inferred to represent abortive cirri, furrow marking vanished suture between original nodal pair. Measurements (in mm.) of the type specimen (nodal) are: maximum width parallel to fulcral ridge, 3.0; width of short axis, 1.7; height, 1.5; similar measurements of internodals, maximum width, 3.2; width of short axis, 2.0; height, 1.0.

Type specimen.—UKPI *Mey14a from loc. Mey.

Occurrence.—Paint Creek Formation, Chesteran, Upper Mississippian, in Illinois (loc. Mey).

Illustrations.—Plate 5, figure *10; Plate 6, figure 4.——Pl. 5, fig. *10a, side of binodal (type specimen) corresponding to lower edge of facetal view (*10a) with two pairs of cirrus sockets for juxtaposed cirri originating in circumferential depressed trace of fused suture between antecedent pair of columnals, ×7.——*10b. Facetal view showing deep ligament furrow on side of small lumen nearest inner side of stem coil and small oblique crenulae on part of sloping margins, ×7.——*10c. Side of binodal corresponding to wide (upper) edge shown in facetal view (*10a), with two cirrus nubbins along line of fused suture, ×7.——*10d. Side view of same specimen showing paired cirrus scars at right and one of cirrus nubbins at left, ×7.——Pl. 6, fig. 4a-d. Internodal (specimen UKPI Mey14b, from loc. Mey), views corresponding to those given in Pl. 5, fig. *10, ×7.

Subclass ARTICULATA Miller, 1821

Dicyclic or cryptodicyclic crinoids with mouth and food grooves open on surface of tegmen, anal plates lacking in adults, radials and brachials pierced by nerve canal, articulation of brachials highly varied, pinnules invariably present.

Occurrence.—Lower Triassic-Recent.

Order ISOCRINIDA Sieverts-Doreck in Ubaghs, 1953

Stalked articulate crinoids, column heteromorphic, composed of cirrinodals and internodals, columnal articulation synostosial or symplectial, not synarthrial, lacking proximale and radicular cirri; radial articular facets wide, arms uniserial, pinnulate, branching.

Occurrence.—Lower Triassic-Recent.

[Group PENTAMERI]

Characteristics of this group have been stated under Inadunata.

Family ISOCRINIDAE Gislén, 1924

Isocrinidae GISLÉN, 1924, p. 218.

Theca with concealed infrabasal plates, radials prolonged downward, and small tegmen; uniserial arms branching isotomously; stem pentagonal to subcircular with maximum number of internodals attained rapidly, nodals with circular to elliptical cirri, articular facets characterized by five-rayed areola with each petaloid part bordered by short crenulae.

Type genus.—Isocrinus AGASSIZ, 1835 (1836).

Occurrence.—Middle Triassic to Recent.

Genus ISSELICRINUS Rovereto, 1914

Isselicrinus ROVERETO, 1914, p. 177; RASMUSSEN, 1961, p. 43.
Lipocrinus RASMUSSEN, 1953.

Stem stellate, pentagonal, pentalobate or subcylindrical in section, articular facets of columnals with uniform crenulae around margin, inner (areolar) part with radially placed ridges that may bear fine crenulae, nodals with less than 5 cirrus scars located on lower margin of facet and directed downward obliquely. Theca relatively large, bowl-shaped.

*Type species.—Isselicrinus *insculptus* ROVERETO (1914, p. 177), from Oligocene of Italy; fixed by monotypy.

Discussion.—Features of the articular facets of *Isselicrinus* resemble those of *Balanocrinus* and to some extent of *Austinocrinus* also. A most distinctive characteristic of *Isselicrinus* is downwardly directed cirri on the nodals and their small number (restricted to 2 or 3) on any single nodal. The genus is included in the Isocrinidae and here placed in the group Pentameri, despite the circular outline of some columnals.

Occurrence.—Upper Cretaceous-Oligocene.

ISSELICRINUS BERMUDEZI Moore & Jeffords, new species

Articula with coarse peripheral crenulae, deep hollows between radial ridges, and pattern of narrowly lanceolate minute crenulae on radial ridges; type specimen (a nodal) with two oblique cirrus scars on margin of distal facet. Only columnals known.

Type specimen.—UKPI *Aig1a from Eocene of Cuba.

Occurrence.—Universidad Formation, lower Eocene, in Cuba (loc. Aig).

Illustrations.—Plate 6, figures *1-2.——*1a,b. Opposite articular faces of single columnal (type specimen), ×8.5. ——2. Articulum of another columnal (UKPI Aig12, from loc. Aig), ×8.5.

Genus AUSTINOCRINUS de Loriol, 1889

Austinocrinus DE LORIOL, 1889, p. 153.
Austinocrinus (Penroseocrinus) SIEVERTS-DORECK, 1953, p. 113.

Stem subpentagonal to circular in transverse shape, moderately stout, composed of low columnals, articular facets with fine peripheral crenulae and inner pattern of 5 petals bordered by crenulae or replaced by radial ridges similar to those of *Balanocrinus* and *Isselicrinus;* widely spaced nodals may bear 2 or 3 laterally directed subcylindrical cirri; sides of columnals even, smooth, and straight. Theca and arms unknown.

Type species.—*Austinocrinus *kamaroffi* DE LORIOL (1889, p. 153) (=*Pentacrinus *erckerti* DAMES, 1885) (DE LORIOL, 1889, p. 566) from Upper Cretaceous of southwestern Europe and Turkestan; fixed by monotypy.

Occurrence.—Upper Cretaceous.

AUSTINOCRINUS MEXICANUS (Springer), 1922

Balanocrinus mexicanus SPRINGER, 1922b, p. 1, pl. 1, fig. 1-10.
Austinocrinus mexicanus (SPRINGER), RASMUSSEN, 1961, p. 317, pl. 3, fig. 8-10.

Homeomorphic stem long and stout, composed of low, straight-sided, smooth columnals; articular facets with broad subtriangular interradial petals separated by wedge-shaped radial tracts bordered by narrow adradial ridges. Theca and arms unknown.

Type specimen.—USNM *75431, from Upper Cretaceous of Mexico.

Occurrence.—San Felipe Formation, Senonian, Upper Cretaceous, in Mexico (UKPI loc. Kix).

Illustrations.—Plate 6, figure *5a,b, side view of stem with cirrus scar and some attached cirri (type specimen, from loc. UKPI Kix) showing homeomorphic nature of column, and articular facet, ×1.3, ×1.7.

Order MILLERICRINIDA Sieverts-Doreck in Ubaghs, 1953

Infrabasals concealed in dorsal cup or lacking, radial articular facets commonly wide, arms uniserial, branching isotomously, pinnulate. Column circular or elliptical in transverse section, without true cirri but holdfasts consisting of radicular cirri or discoid to compact expansions at distal extremity of stem, columnal articulation synostosial, symplectial, or synarthrial.

Occurrence.—Middle Triassic-Recent.

Suborder MILLERICRININA Sieverts-Doreck in Ubaghs, 1953

Column circular in transverse section (except for subpentagonal proximal portion in some forms), articula bearing evenly distributed radial crenulae or disposed in pentameres, holdfast encrusting.

Discussion.—This suborder is most prominently represented in Jurassic deposits by representatives of the Millericrinidae and Apiocrinitidae. Species based solely on disarticulated stem parts have been referred to genera of these families, but none is described or illustrated here.

Occurrence.—Middle Triassic-Upper Cretaceous.

Suborder BOURGUETICRININA Sieverts-Doreck in Ubaghs, 1953

Infrabasals unknown except in *Dunnicrinus,* dorsal-cup plates separated by sutures or fused together; column circular or elliptical in transverse section, columnal articulation synostosial or synarthrial, but in proximal region several columnals may be solidly fused together and joined to cup as stout proximale; holdfast consisting of radicular cirri which may branch repeatedly.

Discussion.—Authors have variously classified genera of this suborder in families named Bourgueticrinidae, Bathycrinidae, and Rhizocrinidae. In our opinion only the Bourgueticrinidae call for recognition (MOORE, 1967, p. 8).

Occurrence.—?Middle Jurassic - ?Lower Cretaceous, Upper Cretaceous-Recent.

[Group ELLIPTICI]

Characteristics of this group have been stated under Camerata (Monobathrida).

Family BOURGUETICRINIDAE de Loriol, 1882

Bourgueticrinidae DE LORIOL, 1882 (in 1882-89), p. 64.

Theca generally composed of large proximale above which are circlets of basals and radials, infrabasals unknown except in *Dunnicrinus;* arms uniserial and pinnulate in *Dunnicrinus* but unknown otherwise; stem circular to elliptical transversely, with bifascial (synarthrial) articulation, lacking cirri but with branching rootlike distal bifurcations.

Type genus.—*Bourgueticrinus* D'ORBIGNY (1840, p. 95), described from Upper Cretaceous of England.

Occurrence.—Jurassic-Paleocene.

Genus BOURGUETICRINUS d'Orbigny, 1840

Bourgueticrinus D'ORBIGNY, 1840, p. 95; RASMUSSEN, 1961, p. 165.

Proximale large, basals and radials small; arms unknown; stem with characteristics of family.

Type species.—*Apiocrinites* **ellipticus* MILLER (1821, p. 13, figs. 1-7), from Upper Cretaceous of England; subsequent designation by D'ORBIGNY (1840, p. 95).

Occurrence.—Jurassic-Paleocene.

BOURGUETICRINUS ALABAMENSIS de Loriol, 1882

Bourgueticrinus alabamensis DE LORIOL, 1882, p. 118, pl. 5, fig. 1; RASMUSSEN, 1961, p. 171, pl. 29, fig. 19.

Only proximale known, its lower extremity gently concave and elliptical in outline, with fulcral ridge for articulation with topmost columnal reduced to pair of elongate tubercules, sides of proximale curved and smooth, its summit with moderately large circular cavity representing axial canal and 5 concave, outwardly sloping facets for reception of basal plates.

Type specimen.—Cincinnati Society of Natural History.

Occurrence.—Ripley Formation, Upper Cretaceous, in Alabama (UKPI loc. Kjc).

Illustrations.—Plate 6, figure *3a-c, side view, upper and lower surfaces of proximale (type specimen), ×4.2 (after Rasmussen, 1961).

Genus DUNNICRINUS Moore, 1967

Dunnicrinus MOORE, 1967, p. 9.

Differs from *Bourgueticrinus* in lacking proximale but showing circlet of low infrabasal plates beneath basals; arms uniserial, pinnulate; stem with characteristics of family.

Type species.—*Dunnicrinus* **mississippiensis* MOORE (1967) from Upper Cretaceous of Mississippi (loc. Kja) fixed by original designation.

DUNNICRINUS *MISSISSIPPIENSIS Moore, 1967

*Dunnicrinus *mississipiensis* MOORE, 1967, p. 9.

Proximal part of stem composed of subcircular low to relatively tall columnals, with synostosial articulation next to dorsal cup, distal region formed of nearly lozenge-shaped elliptical columnals, all with fulcral ridges and bifascial fields without bordering crenulae, orientation of long axes of opposite facets on distal columnals disposed approximately at right angles to each other, and because successive columnals are similar, stem turns abruptly at each pair of columnals; no columnals with cirri and none classifiable as nodals, except that distal extremity of stem bears stout branched and unbranched radicular cirri.

Figured specimens.—UKPI Kja-Kji (Pl. 6. fig. 6-11).

Occurrence.—Prairie Bluff Chalk, Upper Cretaceous, in northeastern Mississippi (loc. Kja).

Illustrations.—Plate 6, figures 6-11.——6. Pluricolumnal from mesistele region (specimen UKPI Kja58, from loc. Kja) showing moderately tall, broadly elliptical columnals with perceptible twist of long articular axes bearing fulcral ridges, ×8.5.——7. Distal extremity of robust stem with proximal parts of radicular cirri (specimen UKPI Kji, from loc. Kji), ×2.5.——8a,b. Facetal and side views of moderately tall columnal from gradational zone between mesistele and dististele (specimen UKPI Kji2c, from loc. Kji), ×6.7.——9. Facetal view of quadrangular nodal with elliptical facets bearing fulcral ridges that diverge at angle of 77° (specimen UKPI Kji1c, from loc. Kji), ×5.——10a,b. Side views of dististele region of specimen (UKPI Kja33, from loc. Kja) with stout branching radicular cirri shown in 10a, ×2.——11. Side view of typical short pluricolumnal, ×4.5.

Subclass and Order UNCERTAIN

[Group PENTAMERI]

Characterization of this group has been stated under Inadunata.

Family DIANTHICOELOMATIDAE Moore & Jeffords, new family

Stem resembling stack of flattened beads, circular in transverse section, each beadlike columnal with strongly rounded longitudinal profile and seeming to join contiguous columnals of similar size along deeply indented straight, noncrenulate sutures but actually separated by very thin internodals which have 5 teardrop-shaped thickened parts radially disposed around small circular axial canal, internodals barely visible from sides of some stems but not in others; stem classifiable as heteromorphic, with large beadlike columnals identified as nodals, although none bear cirri.

Type genus.—*Dianthicoeloma* MOORE & JEFFORDS, new genus, from Lower Ordovician of USSR and Upper Ordovician of Ohio.

Occurrence.—Lower Ordovician-Upper Ordovician.

Genus DIANTHICOELOMA Moore & Jeffords, new genus

With characteristics of family.

Type species.—*Dianthicoeloma* **insuetum* MOORE & JEFFORDS, new species, from Upper Ordovician of Ohio; designated herein.

Occurrence.—Lower Ordovician-Upper Ordovician.

DIANTHICOELOMA *INSUETUM Moore & Jeffords, new species

Characteristics of genus, sides of columnals smooth, height of nodals ranging from barely 1/5 to slightly more than 1/3 of diameter, which is 4 to 5 mm., thin internodals approximately 3 to 3.5 mm. in diameter.

Type specimen.—USNM *Ogq2c from loc. Ogq.

Discussion.—This new genus is not confined to Upper Ordovician strata of the Cincinnati region, as supposed by us on the basis of specimens available for study and from search through American paleontological literature.

Publication by YELTYSHEVA (1960, p. 18, pl. 1, figs. 5, 6; 1964 [1965], p. 75, pl. 15, figs. 11a,b) indicate that stem fragments from Lower Ordovician rocks of the Leningrad region and north-central Siberia, as well as reported occurrences in northwestern Yugoslavia, unquestionably represent a species of *Dianthicoeloma* that differs only in minor ways from *D.* **insuetum*. This species was first described and figured by EICHWALD (1856, p. 119; 1860 [in 1858-68], p. 580, pl. 31, figs. 4-9, 17-20, 29a-c) who named it *Haplocrinus monile*. It was based on dissociated columnals ("buttons") which surely cannot be identified reliably as belonging to *Haplocrinites*, as this genus properly is named. YELTYSHEVA designated EICHWALD's specimens and numerous others found by her as *Pentagonocyclicus monile* (EICHWALD), an unavailable and invalid name *(nom. nud., nom. vet.)* because *Pentagonocyclicus* is an artificial label for fossil objects having a specified shape, rather than for a genus of crinoid animals, and because no type species has been designated for use of it as a generic name in zoology (*Code*, 1961, Art. 11). On the other hand, EICHWALD's *Haplocrinus monile* refers to a species of crinoid and unacceptability of the generic name has no bearing on validity of the specific name. Thus, we may now recognize *Dianthicoeloma monile* as the correct name of the crinoid species represented by the Ordovician pluricolumnals found near Leningrad. In Siberia equivalent fossil remains have been collected from outcrops along a tributary of the lower Lena River, north of Yakutsk, in the Taimyr Peninsula, and on islands of North Land (Severnaya Zemlya) in the Arctic north of Taimyr.

Occurrence.—Blanchester Formation, Cincinnatian Series, Upper Ordovician, in Ohio (locs. Ogq, Oha).

Illustrations.—Plate 7, figures *1-3.——*1a,b. Facetal and side views of type specimen (USNM *Ogq2c, from loc. Ogq) showing petaloid elevations of internodal and rounded beadlike form of nudinodals, internodals not visible in side view of pluricolumnal, ×8.5.——2a,b. Facetal view of small petaloid internodals with rounded epifacet of nudinodal beyond it and side view of typical pluricolumnal (specimen USNM Ogq2e, from loc. Ogq), ×8.5, ×5.——3a,b. Facetal view of nudinodal showing petaloid depression for reception of internodal and side view of pluricolumnal (specimen USNM Oha6b, from loc. Oha), ×8.5, ×7.

DIANTHICOELOMA MONILE (Eichwald), 1856

Haplocrinus monile EICHWALD, 1856, p. 119; 1860 (in 1859-68), p. 580, pl. 31, fig. 4-9, 17-20, 29a-c.

Pentagonocyclicus monile (Eichwald, 1860 [in 1859-68]), YELTYSHEVA, 1960, p. 18, pl. 1, fig. 5-6 *(nom. nud., nom. vet.)*; 1964 (1965), p. 75, pl. 15, fig. 9-10 *(nom. nud., nom. vet.)*.

Differs from *Dianthicoeloma* **insuetum* in uneven shape and size of nodals, larger ones tending to have slight, irregular keel, diameter of stem also smaller, ranging from 1 to 4 mm.

Type specimen?—YELTYSHEVA, 1964 (1965), pl. 15, fig. 9.

Occurrence.—Lower Ordovician, Ustykutskian Stage, USSR (Leningrad region, lower Lena River basin, Severnaya Zemlya, Taimyr Peninsula in northern Siberia), northwestern Yugoslavia.

Illustration—Plate 7, figure *8, side view of pluricolumnal (presumed type specimen) from Leningrad region, ×3.8 (after Yeltysheva, 1964 [1965]).

DIANTHICOELOMA PENTAPORUS (Eichwald), 1840

Plate 7, figure 4

Cupressocrinites pentaporus EICHWALD, 1840, p. 171 (German edit.), p. 183; (French edit.); 1860 (in 1859-68), p. 600, pl. 31, fig. 16a,b, 55 a,b, 56a,b. [French], p. 168, pl. 10, fig. 55-56 [Russian].

Pentagonocyclicus pentaporus (EICHWALD, 1860 [in 1859-68]), YELTYSHEVA, 1960, p. 18, pl. 1, fig. 3, 4 *(nom. nud.)*; 1964 (1965), p. 80, pl. 15, fig. 11a,b *(nom. nud.)*.

Nearly identical to *Dianthicoeloma* **insuetum* but much smaller (diameter of nodals not exceeding 1.5 mm. and height 0.5 mm.), articular facet with proportionally larger lumen and very short, nearly circular hollows for reception of internodals; surface smooth.

Figured specimen.—YELTYSHEVA 1964 (1965), pl. 15, fig. 11a,b.

Discussion.—Only pluricolumnals are known and these afford no basis whatever for assignment of the species to *Cupressocrinites*, which has a very different sort of stem.

Occurrence.—Lowermost Middle Ordovician, Krivolutskian Stage, USSR (Leningrad region, rare in east-central Siberian Platform near Krasnoyarsk).

Illustrations.—Plate 7, figure *4a,b, facetal and side views of short pluricolumnal (presumed type specimen) showing specific but not generic differences from *Dianthicoeloma* **insuetum*, ×8.5 (after Yeltysheva, 1964 [1965]).

Family PENTACAULISCIDAE Moore & Jeffords, new family

Stem pentagonal in section, heteromorphic so far as known, with or without cirri.

Type genus.—*Pentacauliscus* MOORE & JEFFORDS, new genus.

Discussion.—Approximately a dozen crinoid genera from Devonian rocks of North America and Europe characterized by subpentagonal to angularly pentagonal stems have been described, 2 of them (*Thylacocrinus* and *Dimerocrinites*, the latter known also from Silurian beds) being Camerata and the remainder Inadunata. In addition, 15 Mississippian inadunates and 2 or 3 Pennsylvanian inadunates possess pentagonal stems. All of them, or virtually all, are heteromorphic. Some bear cirri and others do not. Facetal characters are undescribed and unfigured or so inadequately known that use of them for identification and classification is denied. The genera with pentagonal stems referred to are presently distributed in 13 different families, none of which can be utilized other than on a purely guesswork basis.

Therefore, it seems best to group the pentagonal-stemmed genera of this report into families of their own (Pentacauliscidae, Pentamerostelidae).

Occurrence.—Middle Devonian-Upper Pennsylvanian.

Genus PENTACAULISCUS Moore & Jeffords, new genus

Stem subpentagonal to angularly pentagonal, heteromorphic, with closely spaced nudinodals which are quite distinct even though inappreciably wider and taller than internodals, noditaxes of 4 columnals, nodals tending to be thickened at angles of stem and produced into rounded tubercles, all columnals low and some internodals waferthin; articular facets distinctive in fineness of their long crenulae grouped into pentameres by their arrangement and by outwardly pointed narrow extensions of smooth, flat areola; lumen relatively large, circular to subpentagonal in outline; sides of columnals straight or moderately convex in longitudinal profile, except nodals which may bulge rather strongly.

Type species.—*Pentacauliscus *nodosus* Moore & Jeffords, new species, from Lower Devonian of Tennessee; designated herein.

Discussion.—*Pentacauliscus* is distinguished from *Decacrinus* by the absence of areolar extensions midway between the pointed ones directed toward the articular facet angles. *Pentagonostipes* somewhat resembles *Pentacauliscus* in characteristics of the articula but these have a much larger areola and diminutive lumen. Other genera of the family obviously differ from *Pentacauliscus* in various ways, but this is not true of stems belonging to *Lampterocrinus,* at least in side views which show the nodose angles of the nodal columnals, thinness of all columnals, and low height of noditaxes. The articular facet of *Lampterocrinus* columnals lacks any trace of an areola and lines extending from the lumen to columnal angles are accentuated as elevations or depressions which divide the crenularium into pentameres.

Occurrence.—Lower Devonian.

PENTACAULISCUS *NODOSUS Moore & Jeffords, new species

Stem chiefly characterized by prominent development of rounded tubercles at angles of nodals and regularity of well-marked noditaxes of 4 columnals but showing tendency to suppress alternate nodals sufficiently to suggest noditaxes of 8 columnals, mean height of noditaxes 2.1 mm., internode 1.5 mm. on sides of stem but only 1 mm. along angles, internodal indices respectively 72 and 48, therefore; measurements (in mm.) of the type and another specimen are given with indices in following table.

*Measurements and indices of Pentacauliscus *nodosus*

Specimen	F	L	Li	A	Ai	C	Ci	FSi
*Di6b	7.5	1.8	24	2.2	29	3.5	47	88
Di8b	6.8	1.7	25	2.0	30	3.1	45	67

Type specimen.—UKPI *Di6b from loc. Di.

Occurrence.—Birdsong Shale, Helderbergian, Lower Devonian, in Tennessee (loc. Di).

Illustrations.—Plate 7, figures 6-*7.——6a-c. Side views and articulum of nodal at upper extremity (specimen UKPI Di8d, from loc. Di), ×3.5.——*7a-c. Facetal view of internodal at upper end of pluricolumnal (type specimen) shown in side views (*7b,c), nudinodals with large tubercles at columnal angles and priminternodals with small ones in this position, ×3.5.

PENTACAULISCUS *NODOSUS? Moore & Jeffords, new species

Stem identical in side views to *Pentacauliscus *nodosus* but articulum having distinct pentastellate lumen instead of large circular one; dimensions and indices closely similar to those of *P. *nodosus.*

Figured specimen.—UKPI Di8e from loc. Di.

Occurrence.—Birdsong Shale, Helderbergian, Lower Devonian, in Tennessee (loc. Di).

Illustrations.—Plate 7, figure 5a-c, side views and articulum of nudinodal (specimen UKPI Di8e, from loc. Di) showing distinctly stellate lumen, ×3.5.

Genus PENTAGONOSTIPES Moore & Jeffords, new genus

Stem ?homeomorphic, composed of angularly pentagonal columnals with straight sides and articular facets characterized by strongly stellate outline of smooth and flat or gently concave areola, each petal-like ray of which is bordered by narrow, gently curved crenulae with outer ends normal to side of facet and inner ends normal to edge of areola; lumen very small, circular.

Type species.—*Pentagonostipes *petaloides* Moore & Jeffords, new species, from Middle Devonian of New York designated herein.

Occurrence.—Middle Devonian.

PENTAGONOSTIPES *PETALOIDES Moore & Jeffords, new species

Characteristics of genus. Medial culmina of each pentamere group forming distinctive pattern of V's or Y's near angles between areolar rays. Measurements (in mm.) of the type and another specimen are tabulated as follows, with indices.

*Measurements and indices of Pentagonostipes *petaloides*

Specimen	F	L	Li	A	Ai	C	Ci	FSi
*Dia2g	4.8	0.2	4.2	2.8	58	1.8	38	89
Dia1z	5.5	0.2	3.6	3.3	60	2.0	36	83

The height of the type specimen is 0.8 mm. and of Dia1z 0.7 mm.

Type specimen.—UKPI *Dia2g from loc. Dia.

Occurrence.—Wanakah Shale Member, Ludlowville Formation, Erian, Middle Devonian, in New York (loc. Dia).

Illustrations.—Plate 8, figures *14-15, articular facets of type specimen and another columnal (UKPI Dia1z, from loc. Dia) showing typical pattern of crenularium, stellate areola, and diminutive round lumen, ×8.5.

Genus WANAKASTAURUS Moore & Jeffords, new genus

Stem composed of rounded pentagonal columnals, ?homeomorphic, facets characterized by long straight crenulae not extending to small circular lumen but leaving pentagonal flat areola somewhat less than 1/3 of facet diameter; sides of columnals smooth.

Type species.—*Wanakastaurus *delicatus* Moore & Jeffords, new species, from Middle Devonian of New York; designated herein.

Occurrence.—Middle Devonian.

WANAKASTAURUS *DELICATUS Moore & Jeffords, new species

Characteristics of genus. Measurements (in mm.) and indices of the type specimen and another columnal, each 0.8 mm. in height, are tabulated as follows.

*Measurements and indices of Wanakastaurus *delicatus*

Specimen	F	L	Li	A	Ai	C	Ci	FSi
*Dia1b	2.9	0.2	7	0.8	27.6	1.9	65	98
Dia1n	3.7	0.2	5.5	0.8	21.6	2.7	73	95

Type specimen.—UKPI *Dia1b from loc. Dia.

Occurrence.—Wanakah Shale Member, Ludlowville Formation, Erian, Middle Devonian, in New York (loc. Dia).

Illustrations.—Plate 8, figures 9-*10, facetal views of two columnals (specimen UKPI Dia1n and type specimen, from loc. Dia) showing nearly circular, slightly pentagonal outline, pentamerously groups crenulae, pentagonal smooth areola, and small circular lumen, columnals straight-sided, ×8.5, ×13.

Genus PETALERISMA Moore & Jeffords, new genus

Stem formed of straight-sided columnals with articula characterized by large petal-shaped smooth areola, short, coarse crenulae, and circular to subpentagonal medium-sized lumen.

Type species.—*Petalerisma *eriense* Moore & Jeffords, new species, from Middle Devonian of New York; designated herein.

Occurrence.—Middle Devonian.

PETALERISMA *ERIENSE Moore & Jeffords, new species

Each petal of areola bordered by 7 or 8 round-topped culmina. Measurements (in mm.) and indices of the type and another specimen are tabulated as follows.

*Measurements and indices of Petalerisma *eriense*

Specimen	F	L	Li	A	Ai	C	Ci	KH	KHi
*Dia2c	2.7	0.5	18	1.2	45	1.0	37	1.0	37
Dia1a	2.7	0.5	18	1.4	52	0.8	30	0.8	29

Type specimen.—UKPI *Dia2c from loc. Dia.

Occurrence.—Wanakah Shale Member, Ludlowville Formation, Erian, Middle Devonian, in New York (loc. Dia).

Illustrations.—Plate 8, figures *12-13, facetal views of type specimen and another columnal (UKPI Dia1a, from loc. Dia) showing broadly petaloid areola and coarse crenulae, columnals straight-sided, ×17.

Genus PENTAGONOMISCHUS Moore & Jeffords, new genus

Stem pentagonal, weakly to very distinctly heteromorphic, with cirriferous or noncirriferous nodals only moderately wider and taller than priminternodals, noditaxes of 4 columnals; articula with short strong crenulae directed straight inward from margin, areola broad and smooth, gently concave, extending to edge of large rimless circular lumen, axial canal containing thin claustra at mid-height of columnals, bordered by small stellate jugula; sides of columnals mostly with horizontal row of fine tubercles at mid-height or by transverse ridge which tends to swell at angles of pentagon into rounded nodes.

Type species.—*Pentagonomischus *plebeius* Moore & Jeffords, new species, from Upper Mississippian of Illinois; designated herein.

Occurrence.—Upper Mississippian.

PENTAGONOMISCHUS *PLEBEIUS Moore & Jeffords, new species

Sides of columnals finely granulose, nodals and taller internodals with finely denticulate, sharp-angled crest at mid-height or with only small rounded ridge in this position; some nodals lacking cirri, others with 1 to 3 small circular cirrus scars located entirely on epifacetal slope of crested rim and not interrupting it, scars with very short crenulae. Measurements (in mm.) and indices of 3 average specimens are tabulated as follows.

*Measurements and indices of Pentagonomischus *plebeius*

Specimen	F	Fi	Fs	L	Li	J	A	Ai	C	Ci	KH	KHi
*Mey7z (iN)	2.8		77	0.9	32.1	0.3	1.2	42.8	0.7	25.0	0.7	25
Mey6a (iN)	3.2		86	1.2	37.5	0.07	1.1	34.4	0.9	28.1	0.5	16
Mey6k (N)	3.5	75	89	1.1	31.4	0.2	1.5	43	0.9	25.6	1.5	43

[Diameter of Mey6k, 4.7 mm., indicating epifacet 1.2 mm.]

Type specimen.—UKPI *Mey7z from loc. Mey.

Occurrence.—Paint Creek Formation, Chesteran, Upper Mississippian of Illinois (loc. Mey).

Illustrations.—Plate 8, figures *1-7.——*1a-c. Facetal and side views of type specimen, facet showing large circular lumen, beneath which claustrum and small stellate jugulum can be seen in axial canal approximately at mid-height of columnal, ×13, ×8.5, ×8.5.——2, 5. Facetal views of two internodals (UKPI Mey6i, Mey6n, from loc. Mey), ×8.5.——3-4. Facetal views of two nodals (UKPI Mey6k, Mey7b, from loc. Mey), 3 showing two cirrus scars on sloping side not transgressing keel, ×8.5, ×13.——6. Facetal view of stelliform columnal (UKPI Mey6m, from loc. Mey), ×13.——7. Facetal view of normal angularly pentagonal columnal (specimen UKPI Mey6a, from loc. Mey) with large subpentagonal lumen and minute jugulum, ×13.

PENTAGONOMISCHUS *PLEBEIUS? Moore & Jeffords, new species

Columnals essentially same as typical ones except that lumen appears strongly stellate and bounded by circular rim, but this may represent simply an exceptionally reduced claustrum and enlarged jugulum. Measurements and indices within those applicable to species.

Occurrence.—Paint Creek Formation, Chesteran, Upper Mississippian, in Illinois (loc. Mey).

Illustration.—Plate 8, figure 8, facetal view of specimen (UKPI Mey6j, from loc. Mey) with much larger than normal pentalobate lumen, ×13.

Genus ASTEROMISCHUS Moore & Jeffords, new genus

Stem heteromorphic, with sharp-angled pentagonal internodals and cirrinodals or nudinodals markedly stellate in outline and considerably wider than internodals, with epifacets bearing pinnate pattern of rounded ridges, cirrus scars on nodals circular, equal to height of extended part of nodals or exceeding this, directed straight outward rather than obliquely, their facets with short stout crenulae; subpentagonal axial canal may have claustra and jugula.

Type species.—*Asteromischus *stellatus* Moore & Jeffords, new species, from Upper Mississippian of Illinois; designated herein.

Occurrence.—Upper Mississippian.

ASTEROMISCHUS *STELLATUS Moore & Jeffords, new species

Characteristics of genus. Measurements (in mm.) and indices of the type and another specimen are tabulated as follows.

*Measurements and indices of Asteromischus *stellatus*

Specimen	KD	F	KSi	Fi	FSi	L	Li	A	Ai	C	Ci	KH	KHi
*Mey5	4.7	2.3	62	49	83	0.8	35	0.3	12	1.2	53	0.6	26
Mey6p	3.8	2.2	71	58	85	0.4	18	1.5	68	0.3	14	0.5	23

Type specimen.—UKPI *Mey5 from loc. Mey.

Occurrence.—Paint Creek Formation, Chesteran, Upper Mississippian, in Illinois (loc. Mey).

Illustrations.—Plate 9, figures *1-3.——*1a-c. Type specimen showing facetal view of internodal attached to nodal with points projecting outward beneath it, side view of short pluricolumnal (internodal above cirrus-scar-bearing nodal), and facetal view of nodal, ×8.5.——2-3. Facetal views of two nodals (specimens UKPI Mey6m, Mey6p, from loc. Mey), ×14.

ASTEROMISCHUS *STELLATUS? Moore & Jeffords, new species

Thin stellate columnal doubtfully interpreted as nodal on account of its coarse pinnate ridges outside area of small pentagonal depressed facet, which has relatively large pentalobate lumen but no trace of crenulae.

Figured specimen.—UKPI Mey7a from loc. Mey.

Occurrence.—Paint Creek Formation, Chesteran, Upper Mississippian, in Illinois (loc. Mey).

Illustrations.—Plate 8, figure 11a,b, facetal and side view of questionably identified columnal (specimen UKPI Mey7a, from loc. Mey), ×13.

Genus PENTAGONOSTAURUS Moore & Jeffords, new genus

Stem heteromorphic, slender, composed of relatively tall pentagonal columnals with sharp to rounded angles, noditaxes of 4 columnals in which nodals may bear cirri or lack them; articula with very short wide crenulae that produce coarsely crenulate sutures between columnals, wide smooth areola surrounding tiny circular lumen; sides of columnals convex in profile, with tendency to develop horizontal ridge at mid-height, surface smooth.

Type species.—*Pentagonostaurus *leptus* Moore & Jeffords, new species, from Upper Mississippian of Illinois; designated herein.

Occurrence.—Upper Mississippian.

PENTAGONOSTAURUS *LEPTUS Moore & Jeffords, new species

Priminternodals nearly equal in height to nodals, other internodals distinctly lower; edge of each side of facets with 3 or 4 crenulae. Noditaxes 1.2 to 3.2 mm. in height, with respective internodal indices of 67 and 64; other measurements (in mm.) and indices of the type and another specimen are tabulated as follows.

*Measurements and indices of Pentagonostaurus *leptus*

Specimen	FD	L	Li	A	Ai	C	Ci
*Mey7m	1.04	0.01	1	0.58	56	0.45	43
Mey7i	1.35	0.005	0.6	0.94	70	0.4	29.4

Type specimen.—UKPI *Mey7m from loc. Mey.

Occurrence.—Paint Creek Formation, Chesteran, Upper Mississippian, in Illinois (loc. Mey).

Illustrations.—Plate 9, figures 4-*5.——4a,b. Facet and side view of pluricolumnal (UKPI Mey7i, from loc. Mey) with very coarse crenulae, ×21, ×13.——*5a,b. Facet and side view of type specimen showing noditaxes of 4 columnals, ×25, ×17.

Genus PENTARIDICA Moore & Jeffords, new genus

Stem heteromorphic, composed of straight-sided to gently convex pentagonal columnals with articular facets characterized by strongly pentagonal outline of large areola and even, straight crenulae normal to sides of facet, moderately large circular axial canal, typically with thin claustra at mid-height of columnals adjoined by stellate jugula.

*Type species.—Pentaridica *rothi* MOORE & JEFFORDS, new species, from Upper Pennsylvanian of Texas; designated herein.

Occurrence.—Middle-Upper Pennsylvanian.

PENTARIDICA *ROTHI Moore & Jeffords, new species

Columnals well rounded at angles, areola flat and smooth, crenulae regular, of intermediate size. Measurements (in mm.) of the type and another specimen are tabulated as follows.

*Measurements of Pentaridica *rothi*

Specimen	F	L	Li	A	Ai	C	Ci	KH	KHi
*Pbd43	6.6	1.0	15	3.3	50	2.3	35	1.0	18
Pbd42	6.0	0.7	12	3.9	65	1.4	23	1.0	17

Type specimen.—UKPI *Pbd43 from loc. Pbd.

Occurrence.—Blach Ranch Limestone, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (loc. Pbd).

Illustrations.—Plate 9, figures *12-13, facetal views of type specimen and another (UKPI Pbd42) (both from loc. Pbd) showing angularly pentagonal areola surrounded by pentamerously grouped straight crenulae, ×6.

PENTARIDICA SIMPLICIS Moore & Jeffords, new species

Noditaxes composed of 4 columnals, nodals distinguished by height and width greater than those of internodals, no cirrus scars observed on nodals; crenulae shorter and fewer than in *Pentaridica *rothi* and areola concave. Height of noditaxis 2.8 mm.; internodal index 68; other measurements (in mm.) of type specimen and indices are F, 3.4; L, 0.6; Li, 17; A, 2.1; Ai, 62; C, 0.7; Ci, 21.

Type specimen.—UKPI *Pak61 from loc. Pak.

Occurrence.—Mingus Shale, Strawn Group, Desmoinesian, Middle Pennsylvanian, in Texas (loc. Pak).

Illustrations.—Plate 9, figure *11, facetal and side view of type specimen, heteromorphic pluricolumnal with noditaxes of 4 columnals, ×8.5, ×7.

PENTARIDICA PENTAGONALIS Moore & Jeffords, new species

Columnals distinguished by their sharply angular outline, crenulae resembling those of *Pentaridica *rothi* in regularity but finer, areola sloping inward to large rounded lumen, axial canal with claustra and small stellate jugula; sides of columnals straight, smooth. Measurements (in mm.) and indices of the type specimen are as follows: F, 8.3; FSi, 68; L, 2.0; Li, 24; J, 0.4; A, 3.1; Ai, 3.7; C, 3.2; Ci, 39.

Type specimen.—UKPI *Piw1 from loc. Piw.

Occurrence. — Minturn Formation, Desmoinesian, Middle Pennsylvanian, in Colorado (loc. Piw).

Illustration.—Plate 9, figure *14, facetal view of type columnal showing fine straight crenulae, pentagonal concave areola, and small circular lumen, ×4.2.

Genus PENTAGONOPTERNIX Moore & Jeffords, new genus

Stem transversely weakly pentastellate, heteromorphic, with high nodals bearing 5 elliptical cirrus scars on their sides, nodicirral articula directed straight outward and with small lumen slightly nearer ?proximal than opposite edge of nodal, scars also bearing pairs of fulcral ridges that diverge laterally from lumen, internodal series comprising at least 14 columnals which alternate in size, boundaries between columnals deeply indented along sides to form pits that are wider than high but without development of radial pores; articular facets marked by star-shaped belt of medium-length straight crenulae with their outer ends aligned in inwardly bent curve and their inner ends abutting stellate areola with smooth concave floor; lumen moderately large, circular, axial canal containing claustra and jugula.

*Type species.—Pentagonopterni *insculptus* MOORE & JEFFORDS, new species, from Upper Pennsylvanian of Texas; designated herein.

Occurrence.—Upper Pennsylvanian.

PENTAGONOPTERNIX *INSCULPTUS Moore & Jeffords, new species

Slender stem with characteristics of genus and rather strikingly similar to some Mesozoic stems classed as belonging to *Isocrinus* and *Pentacrinites;* nodals nearly equal in height to 3 internodals but with diameter only slightly greater than them; sides of columnals granulose. Noditaxis 15+ mm. in height, with internodal index of approximately 84; other measurements (in mm.) and indices of the type specimen are as follows: F, 4.2; L, 1.2; Li, 29; J, 0.3; A, 1.8; Ai, 43; C, 1.2; Ci, 28.

Type specimen.—UKPI *Paw53 from loc. Paw.

Occurrence.—Chaffin Limestone, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (loc. Pak).

Illustrations.—Plate 9, figure *10.——*10a. Facetal view of internodal columnal (topmost in fig. *10b) showing inwardly curved band of crenulae along each side of articulum, ×8.5.——*10b. Side view of pluricolumnal showing tall nodal with elliptical cirrus scars (2 of 5) with tripartite fulcral ridge nearer ?proximal than ?distal margins, 14 internodals in specimen not separable into clearly defined different orders, deep pits developed along sutures between point of internodals, ×4.2.

Family PENTAMEROSTELIDAE Moore & Jeffords, new family

Stem weakly to distinctly pentalobate in facetal views, heteromorphic, sutures between pentameres perradial, extending outward from rounded angles of subpentagonal large axial canal which has gently concave sides; crenularium consisting of relatively narrow peripheral band of short, straight crenulae and strongly oblique thin crenulae bordering sutures between pentameres; areola divided into 5 gently concave smooth tracts, 1 on each pentamere, bounded by lumen on inner side and crenularium on other 3 sides. Epifacet distinct but not prominent; sides of nodals and priminternodals convex in profile, those of secundinternodals straight; surface granulose.

Type genus.—*Pentamerostela* MOORE & JEFFORDS from Lower Mississippian.

Occurrence.—Lower Mississippian.

Genus PENTAMEROSTELA Moore & Jeffords, new genus

Characteristics of family.

Type species.—*Pentamerostela *delicatula* MOORE & JEFFORDS, new species, from Lower Mississippian of Kentucky; designated herein.

Discussion. Among crinoid genera known to have longitudinally divided stems, as mentioned in the characterization of the Pentameri, only *Barycrinus* is a Mississippian form. In side view, the stem of some species of this genus—for example, *B. magister* (HALL), from the Keokuk Limestone of western Illinois, *B. thomae* (HALL), from the Warsaw Limestone, also of western Illinois, *B. wachsmuthi* (MEEK & WORTHEN), from the Burlington Limestone of Iowa, *B. bullatus* (HALL), from the Keokuk Limestone of Illinois, and *B. hoveyi* (HALL), from the Borden Group (Crawfordsville beds) of Indiana—is similar to that of *Pentamerostela.* What is known of the articular facets of columnals belonging to any of these species of *Barycrinus* does not correspond to those of *Pentamerostela.* Even so, N. GARY LANE, who recently has studied the Crawfordsville crinoid beds extensively, reports (personal communication) the presence of some *Pentamerostela*-type columnals in association with *Barycrinus* (presumably *B. hoveyi*) at Crawfordsville.

Occurrence.—Lower Mississippian.

PENTAMEROSTELA *DELICATULA Moore & Jeffords, new species

Distinguished by specially well-developed features of the crenularium, relatively large size, and coarseness of granulose ornament on sides of stem; each pentamere with 15 to 20 strong culmina along outer edge and 4 or 5 thin oblique culmina along sutures at sides; large subpentagonal lumen slightly more than 1/3 of facet width, which measures 10 to 12 mm. (lumen 3.6 to 3.8 mm.). Height of noditaxis is 3 to 3.2 mm. (nodal 1.4 to 1.6 mm. internode average 1.5 mm.), priminternodal 1 mm., secundinternodal 0.25 mm.; internodal index is 40 and that of shape of lumen 70. The facetal index is 96 to 98, for the epifacet is only 0.3 mm. or smaller in width. Measurements of facetal features (in mm.) are tabulated as follows with indices.

*Measurements and indices of Pentamerostela *delicatula*

Specimen	KD	F	L	Li	A	Ai	C	Ci
*Ma140	11.8	11.3	4.3	38	4.8	42	2.2	20
Ma39a	14.0	13.0	4.0	31	6.5	50	2.5	19

Type specimen.—UKPI *Ma140 from loc. Ma.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, in Kentucky (loc. Ma).

Illustrations.—Plate 9, figures *8-9.——*8. Articular facet of type specimen, short pluricolumnal divided longitudinally into pentameres, large subpentagonal lumen with concave sides, parts of areola entirely separated from each other, ×4.7.——9a,b. Specimen (UKPI Ma39, from loc. Ma), facetal and side view of pluricolumnal showing pentamerous longitudinal division of columnals, ×3.5.

PENTAMEROSTELA MINUTA Moore & Jeffords, new species

Outline of columnals pentalobate, diameter 4.5 to 6.5 mm., whereas facet is 4 to 5.5 mm. in diameter, signifying distinct epifacetal area; large subpentagonal lumen 1.8 to 2.2 mm. in width; outer band of crenulae very narrow, being only 0.2 to 0.5 mm. in width, crenulae along pentamere sutures inconspicuous; height of columnals variable, 0.2 to 0.8 mm., surface smooth. Measurements of facetal elements (in mm.) and their indices are tabulated as follows.

Measurements and indices of Pentamerostela minuta

Specimen	KD	F	L	Li	A	Ai	C	Ci
*Ma43a	7.0	6.0	2.5	42	2.3	38	1.2	20
Ma45c	5.0	4.5	2.0	45	1.9	42	0.6	13

Type specimen.—UKPI *Ma43e from loc. Ma.

Discussion.—The possibility that the small stem fragments described are juvenile representatives of *Pentamerostela *delicatula* has been considered but for the present is rejected, partly because of the seemingly significant morphological differences and partly because intermediates between the two forms have not been found in very large collections.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, from Kentucky.

Illustrations.—Plate 9, figures *6-7.——*6. Facetal view of type specimen showing typical features of genus but sides slightly extended in angular flange at midheight, ×3.5.——7a,b, Facetal and side views of pluricolumnal (UKPI Ma45c, from loc. Ma), ×3.5.

Genus FLORIPILA Moore & Jeffords, new genus

Stem composed of pentastelliform columnals, ?heteromorphic; articular facets rounded pentagonal to weakly quinquelobate, characterized by peripheral band of short, strong crenulae, by division of areola into shallowly concave pentameres separated by faint ridges that may bear obliquely disposed fine crenulae, and by relatively large subpentagonal lumen or star-shaped with broad rays.

Type species.—*Floripila *florealis* MOORE & JEFFORDS, new species, from Middle Devonian of New York; designated herein.

Discussion.—This genus strikingly resembles *Pentamerostela* in appearance of the articular facets. It is distinguished in having no sign of sutural partition between the pentameres.

Occurrence.—Middle Devonian.

FLORIPILA *FLOREALIS Moore & Jeffords, new species

Stem slender, 4.5 to 5 mm. in diameter and articulum 3.3 to 4 mm. across, the difference comprising a sloped epifacet; lumen, areola, and crenularium with respective indices of 33, 37 to 43, and 25 to 30; height of columnal, 1 to 1.3 mm. and index of 25 to 39; shape index of columnal, facet, and lumen all 73 to 78, which differs little from that of a regular pentagon (80).

Type specimen.—UKPI *Dia3d from loc. Dia.

Occurrence.—Wanakah Shale Member, Ludlowville Formation, Erian, Middle Devonian, in New York (locs. Dia, Dib).

Illustrations.—Plate 10, figures *7-8.——*7a,b. Opposite articula of type specimen showing peripheral girdle of short crenulae and obliquely disposed still shorter ones in radial extensions of pentagonal lumen, dividing areola into 5 gently concave sections, columnal not divided longitudinally, ×8.5.——8. Articular facet of another specimen (UKPI Dib3b, from loc. Dib), ×8.5.

[Group CYCLICI]

Characteristics of this group have been stated under Inadunata.

Family CYCLOPAGODIDAE Moore & Jeffords, new family

Stems strongly heteromorphic, nodals commonly projecting much beyond edges of internodals and appreciably taller; articular facets characterized by well-developed crenularium surrounding large circular or pentalobate lumen, areola and perilumen lacking.

Type genus.—*Cyclopagoda* MOORE & JEFFORDS, new genus, from Upper Ordovician.

Occurrence.—Middle Ordovician-Lower Mississippian.

Genus CYCLOPAGODA Moore & Jeffords, new genus

Nodals widely expanded or projecting only moderately beyond internodals, latera rather evenly rounded or sloping asymmetrically outward-downward (as determined from pluricolumnal attached to basal circlet of dorsal cup), internodals thin and seemingly variable in number; facets with wide crenularium bearing many fine, straight crenulae, lumen large, quinquelobate.

Type species.—*Cyclopagoda *alternata* MOORE & JEFFORDS, new species, from Upper Ordovician of Ohio; designated herein.

Occurrence.—Upper Ordovician.

CYCLOPAGODA *ALTERNATA Moore & Jeffords, new species

Sides of nodals and internodals smooth, noditaxes variable in height in different specimens, ranging from average of 1.4 mm. in type specimen (IN, 0.4 mm.; INi, 28) to 2.0 mm. (IN, 0.9 mm; INi, 45); facet with very large pentalobate lumen, crenularium with fine crenulae. Measurements (in mm.) of the type specimen are: KD (nodal), 4.8; F, 3.4; Fi, 71; L, 1.6; Li, 47; C, 1.8; Ci, 53.

Type specimen.—USNM *Oha2b from loc. Oha.

Occurrence.—Cincinnatian, Upper Ordovician, in Ohio (loc. Oha).

Illustrations.—Plate 10, figures *5-6.——*5a,b. Facetal and side views of type specimen, *5a showing large petaloid lumen and fine, straight crenulae, epifacet of large nodal visible beyond it, ×8.5; *5b showing small, thin internodals between large nudinodals, ×7.——6. Side view of moderately long pluricolumnal (USNM Oha2c, from loc. Oha), ×7.

CYCLOPAGODA COSTATA Moore & Jeffords, new species

Nodals projecting less strongly than in *Cyclopagoda *alternata* and marked on sides by riblike corrugations, outward-downward slopes well marked; large pentalobate lumen similar to that of *C. *alternata* but crenulae somewhat coarser; average height of noditaxes 1.0 mm., internodes 0.25 mm., internodal index 25; measurements of facetal features and width of nodals (in mm.) and indices are as follows for the type specimen: KD, 3.8; F, 2.8; Fi, 74; L, 1.0; Li, 36; C, 1.8; Ci, 64.

Type specimen.—USNM *Oha3c from loc. Oha.

Discussion.—Pluricolumnals nearly identical to those of *Cyclopagoda costata* in side view have been described and figured by YELTYSHEVA (1960, p. 24, pl. 6, figs. 5-7) from rocks classed as Silurian (Wenlock) in eastern Siberia, north of Yakutsk. They were designated by the artificial name *Cyclocyclicus scalariformis*. The nodals display the same asymmetry of outer sides which is seen in *Cyclopagoda* and which to YELTYSHEVA suggested the name *scalariformis*. She illustrated the stems with the sloping sides of the nodals directed outward-downward, as we have done. Facetal characteristics of the Siberian fossils are not well indicated.

Occurrence. — Cincinnatian, Upper Ordovician, in Ohio (loc. Oha).

Illustrations.—Plate 10, figures *1-2.——*1a,b. Side and facetal views of type specimen showing ribbed nudinodals separated by groups of 3 thin internodals, *1b showing large pentalobate lumen surrounded by crenularium, no areola, ×7, ×10.——2. Side view of long pluricolumnal (USNM Oha3b, from loc. Oha), presumed proximal extremity at top, based on flaring sides of nudinodals, ×4.2.

Genus CYCLOMONILE Moore & Jeffords, new genus

Stem rather similar to that of *Cyclopagoda* except for the beaded necklace-like appearance of nodals, noditaxes of 8 columnals; crenularium in form of band 1/4 of articular facet in width, surrounding large circular lumen.

Type species.—*Cyclomonile *monile* Moore & Jeffords, new species, from Middle Ordovician of Tennessee; designated herein.

Occurrence.—Middle Ordovician.

CYCLOMONILE *MONILE Moore & Jeffords, new species

Available specimens are gently curved pluricolumnals which display alternation of relatively large and small nodals, as well as variation in height of noditaxes from average of 3 mm. to approximately 5 mm. Measurements (in mm.) and indices of the type specimen are: KD, 5.1; F, 3.8; Fi, 75; L, 2.8; Li, 74; C, 1.0; Ci, 26; another specimen is almost identical.

Type specimen.—UKPI *Ogg1a from loc. Ogg.

Occurrence.—Catheys Limestone, Trentonian, Middle Ordovician, in Tennessee (loc. Ogg).

Illustrations.—Plate 10, figures *3-4.——*3a,b. Facetal and side views of type specimen showing band of fine straight crenulae around large circular lumen, sides of nudinodals strongly beaded, separated by thin internodals, ×4, ×5.5.—4a,b. Similar views of another specimen (UKPI Ogg1b, from loc. Ogg), ×6.5, ×4.2.

Genus APIASTRUM Moore & Jeffords, new genus

Nodals markedly pentastellate, with outer points curved from plane of facets, presumably downward as in slope of nodal sides in *Cyclopagoda,* internodals much smaller than nodals, subequal and even, with gently convex longitudinal profile; articular facets showing large circular lumen surrounded by crenularium with moderately fine straight crenulae; noditaxes of 8 columnals with height of nodals slightly greater than that of internodals, indices 68 to 73.

Type species.—*Apiastrum *candidum* Moore & Jeffords, new species, from Lower Devonian of Tennessee; designated herein.

Occurrence.—Lower Devonian.

APIASTRUM *CANDIDUM Moore & Jeffords, new species

With characteristics of genus; noditaxes ranging in height from 1.8 to 2.0 mm., internodes 1.3 to 1.35 mm., internodal indices 68 to 73. Measurements (in mm.) and indices of the type and 2 other specimens are tabulated as follows.

*Measurements and indices of Apiastrum *candidum*

Specimen	KD	F	Fi	L	Li	C	Ci
*Dh6a	5.5	4.0	73	1.2	30	2.8	70
Dh6	5.0	2.8	56	1.3	46	1.5	54
Dh5b	4.8	2.6	54	1.0	38	1.6	62

Type specimen.—UKPI *Dh6a from loc. Dh.

Occurrence.—Birdsong Shale, Helderbergian, Lower Devonian, in Tennessee (loc. Dh).

Illustrations.—Plate 10, figure *9; Plate 11, figures *2-3.——Pl. 10, fig. *9a,b. Facetal and side views of type specimen showing distinctive features of articulum with large circular lumen and 5-spined epifacet of nudinodals, ×10, ×7.——Pl. 11, fig. *2a,b. Type specimen showing internodal facet (lowermost columnal in *2b) with spurs of nodals in background, side view showing spinose projections downpointed, probably as in living crinoid, ×7. ——Pl. 11, fig. 3a,b. Side and facetal view of nodal (UKPI Dh5b, from loc. Dh), ×7.

Genus EULONCHEROSTIGMA Moore & Jeffords, new genus

Nodals spread out laterally as thin flange with circular outline, internodals much narrower and lower than nodals; articular facets showing crenularium with radial width approximately equal to diameter of large circular lumen, crenulae straight and moderately coarse.

Type species.—*Eulonchosterigma *impunitum* Moore & Jeffords, new species, from Lower Mississippian of Kentucky; designated herein.

Occurrence.—Lower Mississippian.

EULONCHOSTERIGMA *IMPUNITUM Moore & Jeffords, new species

With characteristics of genus; crenularium with approximately 60 crenulae which do not branch between lumen and periphery; outer surface of columnals finely and evenly granulose. Measurements (in mm.) and indices of the type specimen are: KD (nodal), 12.7; F, 6.7; Fi, 53; L, 3.5; Li, 52; C, 3.2; Ci, 48.

Type specimen.—UKPI *Ma141 from loc. Ma.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, in Kentucky (loc. Ma).

Illustrations.—Plate 11, figure *6a,b, facetal and side views of type specimen showing (*6a) large circular lumen and straight, moderately coarse crenulae of internodal with projecting flange of nodal in background, (*6b) edges of thin internodals above and below nodal, ×5.

Family CYCLOMISCHIDAE Moore & Jeffords, new family

Stems typically heteromorphic but some genera with seemingly homeomorphic stems included; characterized chiefly by articular facets consisting essentially of broad crenularium surrounding large, generally circular lumen but somewhat pentalobate in a few genera, areola and perilumen lacking or insignificant.

Type genus.—*Cyclomischus* Moore & Jeffords, new genus, from Upper Silurian.

Occurrence.—Middle Silurian-Upper Pennsylvanian.

Genus CYCLOMISCHUS Moore & Jeffords, new genus

Stem weakly heteromorphic or homeomorphic; large lumen circular to broadly rounded subpentagonal or very faintly pentalobate, crenularium with fine straight crenulae reaching from periphery to lumen; sides of columnals straight or with gently convex longitudinal profile.

*Type species.—Cyclomischus *shelbyensis* Moore & Jeffords, new species, from Upper Silurian of Indiana; designated herein.

Occurrence.—Upper Silurian.

CYCLOMISCHUS *SHELBYENSIS Moore & Jeffords, new species

Stem composed of straight-sided equal columnals with smooth surface, thus appearing perfectly cylindrical; large circular lumen very slightly indented by 5 points that produce a faintly pentalobate outline, crenularium bearing closely spaced, even, straight crenulae. Measurements (in mm.) and indices of the type specimen are: FD(=KD), 4.2; L, 2.5; Li, 36; C, 2.7; Ci, 64; KH, 0.4; KHi, 9.5.

Type specimen.—UKPI *Shg22g from loc. Shg.

Occurrence.—Waldron Shale, Niagaran, Upper Silurian, in Indiana (loc. Shg).

Illustrations.—Plate 11, figure *4a,b, articular and side views of type specimen showing (*4a) faintly lobate lumen, fine straight crenulae, and lack of areola, side (*4b) showing homeomorphic succession of straight-sided columnals, ×8.5, ×7.

CYCLOMISCHUS ALTERNATUS Moore & Jeffords, new species

Differs from *Cyclomischus *shelbyensis* in having lower columnals with longitudinally convex profiles which show slight but distant alternation in height, so that the stem may be classed as weakly heteromorphic; facetal characteristics closely similar to those of *C. *shelbyensis*. Measurements (in mm.) and indices of the type specimen are: F, 5.2; L, 2.4; Li, 46; C, 2.8; Ci, 54; KH (av.), 0.3; KHi, 5.8. Noditaxes of 8 columnals seem to be recognizable but are too weakly indicated to include as a characteristic of the species.

Type specimen.—UKPI *Shg5c from loc. Shg.

Occurrence.—Waldron Shale, Niagaran, Upper Silurian, in Indiana (loc. Shg).

Illustrations.—Plate 11, figure *1a,b, facetal and side view of type specimen showing numerous fine, straight crenulae, large subpentagonal lumen, and thin columnals slightly alternating in thickness, ×8.5, ×7.

CYCLOMISCHUS TENNESSEENSIS Moore & Jeffords, new species

Stem similar to *Cyclomischus alternatus* in facetal characteristics and side view of columnals on first inspection, but closer examination reveals that seemingly very thin, slightly round-sided columnals are actually halves of columnals comparable in relative height to those of *C. *shelbyensis*, their division surficially being explained by a narrow furrow at mid-height girdling each columnal and clearly visible in longitudinal sections of stems, which also show axial canal constricted by pointed claustra alternating with wide, low spatia. Measurements (in mm.) and indices of the type specimen are: F, 7.5; L, 2.2; Li, 30; C, 5.3; Ci, 70; KH, 0.9; KHi, 12.

Type specimen.—UKPI *Sad151 frcm loc. Sad.

Occurrence.—Waldron Clay Member, Waynesville Formation, Niagaran, Upper Silurian, in Tennessee (loc. Sad).

Illustrations.—Plate 12, figure *1a,b, median longitudinal section and side view of type specimen, appearance of very thin columnals in latter shown in *1a to be due to annular indentations of moderately thick, even-sized columnals, axial canal wide, ×3.5, ×2.

Genus HATTINANTERIS Moore & Jeffords, new genus

Stem weakly heteromorphic, nodals very slightly taller than priminternodals and secundinternodals not much lower than either, some forms included in genus seemingly homeomorphic; lumen very large, weakly pentalobate to circular, crenularium with numerous fine, straight crenulae.

*Type species.—Hattinanteris *indianensis* Moore & Jeffords, new species, from Upper Silurian of Indiana; designated herein.

Discussion.—This generic name incorporates the surname of Dr. Donald E. Hattin, stratigrapher and paleontologist of Indiana University, who assisted us in obtaining large collections of dissociated crinoid remains from several localities in Indiana.

Occurrence.—Upper Silurian.

HATTINANTERIS *INDIANENSIS Moore & Jeffords, new species

Columnals medium in height, with gently convex longitudinal profile, noditaxes of 4 columnals; large, faintly pentalobate lumen surrounded by crenularium with well-defined, very numerous straight crenulae, sides very finely granulose, nearly smooth. Measurements (in mm.) and indices of the type specimen are: F, 4.8; L, 2.4; Li, 50; C, 2.4; Ci, 50; KH(N), 0.85; IN, 1.85; NT, 2.7; INi, 69.

Type specimen.—UKPI *Shg15f from loc. Shg.

Occurrence.—Waldron Shale, Niagaran, Upper Silurian, in Indiana (loc. Shg).

Illustrations.—Plate 11, figure *5a,b, side and facetal views of type specimen showing (*5a) noditaxes of 4 columnals with priminternodal nearly equal to nodals in size, articulum (*5b) showing even crenularium surrounding large, weakly pentalobate lumen, ×8.5.

HATTINANTERIS REGULARIS Moore & Jeffords, new species

Differs from *Hattinanteris *indianensis* in homeomorphic nature of columnals; large circular axial canal constricted to half its diameter by claustra at mid-height of columnals. Measurements (in mm.) and indices of the type specimen are: F, 4.3; L, 2.0 (to 1.0 at columnal mid-height); Li, 46; C, 2.3; Ci, 54; KH, 1.15; KHi, 27.

Type specimen.—UKPI *Sad113 from loc. Sad.

Occurrence.—Waldron Clay Member, Waynesville

Formation, Niagaran, Upper Silurian, in Tennessee (loc. Sad).

Illustrations.—Plate 12, figure *2a,b, median longitudinal section and side view of type specimen showing widening of axial canal opposite internal sutures, ×3.5.

Genus AMSDENANTERIS Moore & Jeffords, new genus

Stem composed of even columnals with longitudinally straight sides except for randomly distributed small tubercles which tend to be elongate in direction transverse to sutures, articula entirely formed of wide crenularium and moderately small circular lumen.

Type species.—*Amsdenanteris *tennesseensis* MOORE & JEFFORDS, new species, from Upper Silurian of Tennessee; designated herein.

Occurrence.—Upper Silurian.

AMSDENANTERIS *TENNESSEENSIS Moore & Jeffords, new species

Crenulae very long and so fine as to be difficultly visible, sides of columnals smooth except for low tubercles, approximately 10 of which are distributed around circumference of each, sutures straight or very faintly fine-crenulate, slightly indented. Measurements (in mm.) and indices of the type and another specimen are tabulated as follows.

*Measurements and indices of Amsdenanteris *tennesseensis*

Specimen	F	L	Li	C	Ci	KH	KHi
*Sdg7	6.6	0.6	9	6.0	91	1.55	23
Sdg6	7.0	0.75	11	6.25	89	1.6	23

Type specimen.—UKPI *Sdg7 from loc. Sdg.

Occurrence.—Brownsport Formation, Niagaran, Upper Silurian, in Tennessee (loc. Sdg).

Illustrations.—Plate 11, figures 7-*8——7. Side view of specimen (UKPI Sdg6, from loc. Sdg) with scattered vertically elongate tubercles on sides of columnals, ×3.5. ——*8a,b. Facetal and side views of type specimen showing nearly smooth appearance of articulum and homeomorphic nature of stem, ×7, ×3.5.

Genus RHYSOCAMAX Moore & Jeffords, new genus

Stem homeomorphic, medium-sized to large, characterized by low columnals and facet with relatively large circular lumen and crenularium with long straight crenulae; sides of columnals longitudinally rounded or bearing low keels, sutures distinctly crenulate.

Type species.—*Rhysocamax *cristata* MOORE & JEFFORDS, new species, from Lower Mississippian of Iowa; designated herein.

Occurrence.—Lower Mississippian.

RHYSOCAMAX *CRISTATA Moore & Jeffords, new species

Stem medium-sized, with low columnals bearing narrow keel at mid-height, surface smooth, sutures strongly crenulate; facet with circular lumen somewhat smaller in diameter than in other species, crenularium distinguished by coarse, straight crenulae, nearly all of which extend from periphery to lumen without branching. Measurements (in mm.) and indices of the type specimen are: F, 16.0; L, 4.4; Li, 27; C, 11.6; Ci, 73; KH, 2.4; KHi, 15.

Type specimen.—USNM *Mec56 from loc. Mec.

Occurrence.—Burlington Limestone, Osagian, Lower Mississippian, in Iowa (loc. Mec).

Illustrations.—Plate 12, figures *3-4.——*3a,b. Facetal and side views of type specimen showing long, even crenulae, circular lumen, and homeomorphic nature of keeled columnals joined by strongly crenulate sutures, ×2.——4a,b. Facetal and side views of another specimen (UKPI Mc33, from loc. Mc), latter showing faint vertical ribs on slopes of latera, ×4.2, ×3.5.

RHYSOCAMAX GRANDIS Moore & Jeffords, new species

Stem exceptionally large, composed of columnals nearly 20 times wider than high, all nearly identical and thus indicating classification among homeomorphic stems, but disposition of slightly larger columnals suggests existence of noditaxes of 16 columnals; sides of columnals rather evenly rounded, some showing trace of keel; facet characterized by very large circular lumen and broad crenularium with border next to lumen simulating areola but under lens showing faint extensions of crenulae. Measurements (in mm.) and indices of the type specimen are: F, 36.0; L, 17.0; Li, 47; C, 19.0; Ci, 53; KH (av.), 1.9; KHi, 5.3.

Type specimen.—USNM *Mec2 from loc. Mec.

Discussion.—The 2nd and 18th columnals, counting downward on the side view of the type specimen (Pl. 12, fig. 9b), seem to be nodals and the 10th a priminternodal. The axial canal is entirely open from one end of the type pluricolumnal to the other and thus its edges are visible without cutting a section. Each columnal terminates inward in a knife-sharp edge, which projects approximately 2 mm. from the intercolumnal suture; accordingly, the sides of the axial canal are strongly and evenly saw-toothed in profile.

Occurrence.—Burlington Limestone, Osagian, Lower Mississippian, in Iowa (loc. Mec).

Illustrations.—Plate 12, figure *9a,b, facetal and side views of type specimen showing narrow areolar band around very large circular lumen and moderately even crenulae, side view (*9b) showing relatively thin and nearly uniform nature of columnals but with faintly indicated noditaxes of 16 (nodals 2nd and 18th from top, priminternodal 10th from top), sutures distinctly crenulate, ×1.7.

RHYSOCAMAX TUBERCULATA Moore & Jeffords, new species

Homeomorphic large stem resembling other species of the genus in proportions of columnals and in having articula mainly formed by broad crenularium around circular lumen, distinguished from these species by nodose nature of keels around columnals and granulose surface, sutures distinctly crenulate. Measurements (in mm.) and indices of the type specimen are: KD, 23.0; F, 21.0; Fi, 91; L, 5.2; Li, 26; C, 13.8; Ci, 74; KH, 2.3; KHi, 9.

Type specimen.—USNM *Mec60 from loc. Mec.

Discussion.—The inner part of the crenularium resembles a granulose areola but this appears to represent only weakening and interruption of culmina.

Occurrence.—Burlington Limestone, Osagian, Lower Mississippian, in Iowa (loc. Mec).

Illustrations.—Plate 12, figure *8a,b, facetal and side views of type specimen showing homeomorphic columnals with tuberculate keels, ×2.

Genus LOMALEGNUM Moore & Jeffords, new genus

Stem mostly homeomorphic in appearance but presence of some columnals higher than others and bearing cirrus scars indicates that the stem is heteromorphic; columnals straight-sided, granulose, and characterized especially by the beaded appearance of sutures produced by slight enlargement of terminations of culmina peripherally, sutures finely crenulate; facet nearly identical with that of *Rhysocamax.*

Type species.—*Lomalegnum *hormidium* Moore & Jeffords, new species, from Lower Mississippian of Iowa; designated herein.

Occurrence.—Lower Mississippian.

LOMALEGNUM *HORMIDIUM Moore & Jeffords, new species

With characteristics of genus; measurements (in mm.) and indices of the type specimen are: F, 14.5; L, 6.0; Li, 41; C, 8.5; Ci, 59; KH, 1.9; KHi, 13.

Type specimen.—USNM *Mec4 from loc. Mec.

Occurrence.—Burlington Limestone, Osagian, Lower Mississippian, in Iowa (loc. Mec).

Illustrations.—Plate 13, figure *2a,b, facetal and side views of type specimen showing culmina wider than crenellae and distinctive beaded appearance of columnal margins along sutures, ×3.5.

Genus STIBEROSTAURUS Moore & Jeffords, new genus

Stem homeomorphic in appearance but distinguished as weakly heteromorphic, with noditaxes of 4 columnals not recognizable in some species and specimens; columnals chiefly characterized by rounded to somewhat angular elevated mid-portions of latera, indentations along sutures also rounded or angular; articular facet similar to that of *Cyclomischus, Rhysocamax,* and other genera of the family in having broad crenularium around moderately large circular lumen.

Type species.—*Stiberostaurus *aestimatus* Moore & Jeffords, new species, from Lower Mississippian of Kentucky; designated herein.

Occurrence.—Lower Mississippian.

STIBEROSTAURUS *AESTIMATUS Moore & Jeffords, new species

Sides of columnals rounded at mid-height in form of prominent girdling ridge that is accentuated by flatly rounded depression along sutures, surface smooth; articular facets with characteristics of the genus. Median longitudinal sections show coarsely sawtoothed pattern of sides of axial canal, each columnal being extended inward in middle part into sharp-edged claustrum, nodals with incompletely developed claustra and no evident jugula. Measurements (in mm.) and indices of the type specimen are: KD, 30.0; F, 28.0; Fi, 93; L, 6.3; Li, 22.5; C, 21.7; Ci, 77.5; KH, 3.7; KHi, 13. Other specimens do not show appreciable differences.

Type specimen.—UKPI *Ma115 from loc. Ma.

Discussion.—A longitudinally sectioned specimen (Ma 152, 7) consisting of a pluricolumnal with very large radicular cirri is of interest in showing the course of the cirrus canal to an articular facet between two columnals which together form a binodal. The cirrus scar extends into adjacent internodals. The continuation of the canal into the axial canal of the stem is marked on the columnal facets by apposed furrows termed fossulae; these are parallel to neighboring crenellae but much larger.

Occurrence.—New Providence Shale, Borden Group, and Edwardsville Formation, Osagian, Lower Mississippian, in Kentucky (locs. Ma and Mfm).

Illustrations.—Plate 12, figures 5-7; Plate 13, figures 4-*5.——Pl. 12, fig. 5a,b. Side view and median longitudinal section of specimen (UKPI Mfm57, from loc. Mfm) showing barely distinguishable nodals in section but not in side view, ×1.7.——Pl. 12, 6. Median longitudinal section of another specimen (UKPI Mfm17, from loc. Mfm) resembling fig. 5b, ×1.7.——Pl. 12, 7a,b. Side view and median longitudinal section of pluricolumnal (UKPI Ma221, from loc. Ma) judged to belong near distal extremity of stem as indicated by large radicular cirri with axial canal connecting with axial canal of stem in intercolumnal position, ×1.7.——Pl. 13, fig. 4a,b. Facetal and side view of pluricolumnal illustrated in Pl. 12, fig. 6, ×1.7.——Pl. 13, fig. *5a,b. Facetal and side views of type specimen showing long, fairly regular crenulae, circular lumen, and rounded longitudinal profiles of columnal latera, ×2.

Genus GRAPHOSTERIGMA Moore & Jeffords, new genus

Stem heteromorphic, although most specimens are superficially homeomorphic, moderately robust, all columnals nearly identical in height, chiefly characterized by their slight keel at mid-height of the latera varyingly developed as a crinkly or finely tuberculate ridge; articular facet typical of family, with broad crenularium surrounding large circular lumen.

Type species.—*Graphosterigma *scriptum* MOORE & JEFFORDS, new species, from Lower Mississippian of Kentucky; designated herein.

Occurrence.—Lower Mississippian.

GRAPHOSTERIGMA *SCRIPTUM Moore & Jeffords, new species

Stem composed of columnals with narrow, strongly crenulate or crinkly ridge running transversely at mid-height of latera; crenularium with straight culmina that increase by implantation and bifurcation peripherally and adjacent to lumen become appreciably finer, sloping into bowl-shaped depression. Measurements (in mm.) and indices of the type specimen are: KD, 11.3; F, 10.5; Fi, 94; L, 2.5; Li, 24; C, 8.0; Ci, 76; KH (av.), 2.0; KHi, 17.5.

Type specimen.—UKPI *Maa19 from loc. Maa.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, in Kentucky (loc. Maa).

Illustrations.—Plate 13, figure *3a,b, facetal and side views of type specimen showing bowl-shaped depression of inner crenularium and convoluted narrow keels on columnal latera, ×3.5.

GRAPHOSTERIGMA SYNTHETES Moore & Jeffords, new species

Sides of columnals marked by closely spaced, vertically elongate ridgelike tubercles, some irregular in pattern; nodals identified by greater-than-average height and by presence of small circular cirrus scars, internodes composed of 3 columnals, making noditaxes of 4; articular facet characteristic of the genus. Measurements (in mm.) and indices of the type specimen are: F, 25.0; L, 8.0; Li, 32; C, 17.0; Ci, 68; KH (av.), 4.0; KHi, 16; NT, 16.0; IN, 9.5; INi, 59.

Type specimen.—UKPI *Ma103 from loc. Ma.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, in Kentucky (loc. Ma).

Illustrations.—Plate 13, figure *1a,b, side and facetal views of type specimen showing distinctive ornament of close-spaced vertical or irregular narrow ridges on columnal latera and wide crenularium of facet abutting on subpentagonal lumen, ×2.

GRAPHOSTERIGMA GRAMMODES Moore & Jeffords, new species

Stem relatively large, even-sided except for low, finely tuberculate keels at mid-height of columnal latera; noditaxes of 4 columnals showing nodals barely larger than internodals, none with cirrus scars in most specimens but these scars present on some nodals in others; median longitudinal sections showing rounded inner edges of columnals bordering axial canal, rather than sharp-pointed claustra; facets with large circular lumen and finely crenulate crenularium. Measurements of the type specimen are almost identical to several others; they are reported (in mm.) with indices as follows: F, 21.0; L, 6.5; Li, 31; C, 14.5; Ci, 69; KH(av.), 2.1; KHi, 10; NT, 8.3; IN, 6.1; INi, 73.

Type specimen.—UKPI *Mfm10 from loc. Mfm.

Discussion.—This species is widespread and abundant in beds of the Borden Group above the New Providence Shale but it has not been found in the New Providence collections.

Occurrence.—Edwardsville Formation ("Crawfordsville beds"), Borden Group, Osagian, Lower Mississippian, in Indiana (loc. Mfm).

Illustrations.—Plate 13, figure *6; Plate 14, figures 1-3. ——Pl. 13, fig. *6a-c. Facetal and side views of type specimen with median longitudinal section of it, showing very fine long crenulae, slightly interrupted low keels at mid-height of latera, and obscurely distinguishable nodals, ×1.7.——Pl. 14, fig. 1a,b. Side view and longitudinal section of another specimen (UKPI Mfm42, from loc. Mfm) showing slightly wavy raised lines on columnal latera and weakly developed flanges of nodals (cirrus scar visible in fig. 1a, ×1.7.——Pl. 14, fig. 2a-c. Median longitudinal section, side view, and articulum of typical pluricolumnal (UKPI Mfm16, from loc. Mfm) with adaxial edges of columnals rounded to pointed, ×1.7.——Pl. 14, fig. 3a-c. Side and facetal views and longitudinal section of large specimen (UKPI Mfm8, from loc. Mfm) with exceptionally wide axial canal, ×1.7.

Genus CYLINDROCAULISCUS Moore & Jeffords, new genus

Stem heteromorphic, nodals generally bearing one or more cirrus scars, noditaxes of 4 columnals, which have smooth, very gently convex longitudinal profiles; articular facets with large circular lumen surrounded by narrow, slightly elevated perilumen and broad crenularium with moderately coarse, straight crenulae.

Type species.—*Cylindrocauliscus *fiski* MOORE & JEFFORDS, new species, from Middle Pennsylvanian of Texas; designated herein.

Occurrence.—Middle Pennsylvanian.

CYLINDROCAULISCUS *FISKI Moore & Jeffords, new species

With characteristics of genus; stem medium-sized; crenularium with implanted and bifurcated culmina. Measurements of the type specimen (in mm.) and indices are: F, 9.5; L, 2.8; Li, 30; P, 1.3; Pi, 14; C, 5.4; Ci, 56; KH (av.), 2.3; KHi, 24; NT, 10.0; IN, 6.7; INi, 67.

Type specimen.—UKPI *Pak1 from loc. Pak.

Occurrence.—Mingus Shale, Strawn Group, Desmoinesian, Middle Pennsylvanian, in Texas (loc. Pak).

Illustrations.—Plate 14, figure *5a,b, facetal and side view of type specimen showing large circular lumen, narrow areola, and moderately strong culmina of articulum, cirrinodals and 3 internodals forming noditaxes of 4 columnals, ×5, ×2.

Genus CYPHOSTELECHUS Moore & Jeffords, new genus

Stem obscurely heteromorphic, seemingly with noditaxes of 4 columnals, which are very gently convex in longitudinal profile and smooth-surfaced, sutures very finely crenulate, somewhat indented; articular facet with outer band of crenularium characterized by evenly disposed, straight crenulae in plane of facet and inner band with continuation of these crenulae bent abruptly downward from facetal plane into edge of lumen, which is relatively large and circular.

Type species.—*Cyphostelechus *claudus* MOORE & JEFFORDS, new species, from Middle Pennsylvanian of Texas; designated herein.

Discussion.—The fact that every specimen among many which have been collected is in a collapsed condition, evidently as result of the relatively large size of its axial canal, aids in easy recognition of the genus. Larger-than-average columnals are identified as nodals, despite lack of observed cirrus scars on their sides, because they are uniformly separated by 3 smaller columnals, interpreted as internodals, but difference in size of inferred nodals suggests that noditaxes may include more than 4 columnals.

Occurrence.—Middle Pennsylvanian.

CYPHOSTELECHUS *CLAUDUS Moore & Jeffords, new species

With characteristics of the genus; measurements (in mm.) and indices of the type specimen, based partly on restoration of collapsed condition to original roundness, are: F, 8.0; L, 4.0; Li, 50; C, 4.0; Ci, 50; KH (av.), 1.6; KHi. 20; NT, 6.0; IN, 4.3; INi, 72.

Type specimen.—UKPI *Pak7 from loc. Pak.

Occurrence.—Mingus Shale, Strawn Group, Desmoinesian, Middle Pennsylvanian, in Texas (loc. Pak).

Illustrations.—Plate 14, figure *4a,b, facetal and side views of type specimen showing straight, even crenulae, very large collapsed axial canal (all observed specimens in this condition), and gently convex columnal latera, stem interpreted as weakly heteromorphic, with nodals (tallest columnals) lacking cirrus scars, noditaxes of 8 columnals, ×5, ×2.5.

Genus CATHOLICORHACHIS Moore & Jeffords, new genus

Stem very peculiarly heteromorphic in that virtually every columnal bears cirrus scars of varying size and position around the circumference, some of them very evident and others no larger than pinhead-sized, sides of columnals gently convex longitudinally, sutures indented, surface smooth; articular facet with broad crenularium bearing coarse, straight crenulae, small somewhat asymmetrical areola, and circular lumen.

Type species.—*Catholicorhachis *multifaria* MOORE & JEFFORDS, new species, from Middle Pennsylvanian of Texas; designated herein.

Occurrence.—Middle Pennsylvanian.

CATHOLICORHACHIS *MULTIFARIA Moore & Jeffords, new species

With characteristics of genus; measurements (in mm.) and indices of the type specimen are: F, 5.0; L, 0.6; Li, 12; A, 1.1; Ai, 22; C, 3.3; Ci, 66; KH(av.), 1.4; KHi, 28.

Type specimen.—UKPI *Pak21 from loc. Pak.

Discussion.—Only the bottom-most columnal in the figure (Pl. 14, fig. 8b) of the type specimen lacks cirrus scars, whereas on other columnals these range from 2 to 5. Also, the scars are aligned vertically in a systematic manner, for successive rows show counts of 9, 11, 14, 7, and 11 scars within the length of a pluricolumnal. The described and illustrated features of this species are unique, not only among presently known Pennsylvanian forms but in comparison with stem fragments from other geologic systems.

Occurrence.—Mingus Shale, Strawn Group, Desmoinesian, Middle Pennsylvanian, in Texas (loc. Pak).

Illustrations.—Plate 14, figure *8a,b, facetal and side views of type specimen showing coarse culmina of articulum and convex longitudinal profile of latera, each columnal with cirripores or cirrus scars, ×8.5, ×4.2.

Genus BLOTHRONAGMA Moore & Jeffords, new genus

Stem heteromorphic, characterized by round-sided cirrus-bearing nodals and priminternodals of nearly equal size, nodals with 5 cirrus scars tending to have subpentagonal outline transversely, noditaxes of 4 columnals, all smooth-surfaced; articular facets with broad crenularium, inner part on weathered specimens resembling ill-defined areola owing to fineness of crenulae and their partial obliteration, lumen relatively large, subcircular, axial canal with claustral constrictions at mid-height of columnals.

Type species.—*Blothronagma *cinctutum* MOORE & JEFFORDS, new species, from Middle Pennsylvanian of southern Oklahoma; designated herein.

Discussion.—Cirrus scars are arranged in vertically aligned rows, as many as 5 in some specimens but fewer in others, the latter showing concentration of the rows on one side of the stem rather than random distribution. Claustra are developed on all columnals, including secundinternodals, but specimens with interior walls of the axial canal exposed by weathering almost invariably have lost even traces of the claustra. These are best seen in longitudinal sections.

Occurrence.—Middle Pennsylvanian.

BLOTHRONAGMA *CINCTUTUM Moore & Jeffords, new species

With characteristics of the genus. Measurements (in mm.) and indices of the type and three other specimens, tabulated as follows, show the nature of variations.

*Measurements and indices of Blothronagma *cinctutum*

Specimen	KD	F	Fi	L	Li	C	Ci	NT	IN	INi
Pca18b (Pl. 15, fig. 4)	16.0	13.0	82	5.0	38	8.0	62	7.0	4.5	64
*Pca18a (Pl. 15, fig. *2)	15.5	12.0	78	4.4	37	7.6	63	7.5	2.5	33
Pca19c (Pl. 15, fig. 5)	15.0	12.7	85	3.8	30	8.9	70	6.0	2.5	42
Pca19b (Pl. 15, fig. 1)	14.0	12.5	90	3.2	26	9.3	74	9.0	5.0	55

Type specimen.—UKPI *Pca18a from loc. Pca.

Discussion.—In spite of variations, *Blothronagma *cinctutum* is readily identifiable even in fragments consisting of no more than one or two columnals. The tendency toward grouping of cirrus scars on one side of stems is well illustrated by Echinodermata Article 8, Pl. 2, fig. *5, in which vertical rows of 5 scars are seen in two positions, 3 in another, and none in the remaining 2/5 of circumference.

Occurrence.—Pumpkin Creek Limestone Member, Dornick Hills Formation, Atokan, Middle Pennsylvanian, in southern Oklahoma (loc. Pca).

Illustrations.—Plate 15, figures 1-6; Plate 16, figures 12-15; all from loc Pca.——Pl. 15, fig. 1a-c. Opposite sides (×1.7) and articulum (×2.5) of specimen (UKPI Pca19b) showing priminternodals nearly equal in size to nodals, cirrus scars grouped on one side of stem.——Pl. 15, fig. *2a-c. Opposite sides (×1.7) and articulum (×2.5) of type specimen (UKPI *Pca18a) showing uneven distribution of cirrus scars, which is better illustrated in **8**, Pl. 2, fig. *5.——Pl. 15, fig. 3a,b. Longitudinal section and side view of specimen (UKPI Pca103) showing claustral projections into axial canal (3a), ×1.7.——Pl. 15, fig. 4a-c. Opposite sides (×1.7) and articulum (×2.5) of typical specimen (UKPI Pca18b).——Pl. 15, fig. 5a,b. Side and facetal views of short pluricolumnal (UKPI Pca19c), ×1.1, ×2.5.——Pl. 15. fig. 6. Side view of average specimen (UKPI Pca114), ×1.7.——Pl. 16, fig. 12a,b. Side view and longitudinal section of specimen (UKPI Pca107) with low convexity of columnal latera, ×1.7.——Pl. 16, fig. 13. Side view of pluricolumnal (UKPI Pca19c) without cirrus scars on side shown, ×1.7.——Pl. 16, fig. 14. Side view of specimen (UKPI Pca113) with large priminternodals, ×1.7.——Pl. 16, fig. 15. Longitudinally cut specimen (UKPI Pca111) showing appearance of interior of axial canal, ×1.7.

Genus BARYSCHYR Moore & Jeffords, new genus

Stem heteromorphic, medium-sized, characterized by superficially homeomorphic appearance of subequal columnals which generally are strongly tuberculate on their latera; articular facet consisting of medium to very large lumen which is variably quinquelobate to circular in outline, surrounded by crenularium with straight, moderately fine crenulae, interior of axial canal slightly constricted by bulges of claustra.

Type species.—*Baryschyr *anosus* Moore & Jeffords, new species, from Middle Pennsylvanian of southern Oklahoma; designated herein.

Discussion.—A decidedly variable feature of this genus is the presence or absence of cirrus scars and irregularity of their placement on stems having them. In most specimens noditaxes of 4 columnals can be discriminated but not in all.

Occurrence.—Middle Pennsylvanian.

BARYSCHYR *ANOSUS Moore & Jeffords, new species

Characteristics of the genus; variability is shown by illustrations and measurements (in mm.) with indices of the type and several other specimens, tabulated as follows.

Type specimen.—UKPI *Pca21b from loc. Pca.

Occurrence.—Pumpkin Creek Limestone Member, Dornick Hills Formation, Atokan, Middle Pennsylvanian, in southern Oklahoma (loc. Pca).

Illustrations.—Plate 14, figures *6-7; Plate 15, figures 7-11; Plate 16, figures 1-11; all from loc. Pca.——Pl. 14, fig. *6. Side view of type specimen (UKPI *Pca 21b) showing some nodals with prominent cirrus scars, distribution of these around stem well illustrated in 8, Pl. 2, fig. *6, ×1.7.——Pl. 14, fig. 7. Side view of specimen (UKPI Pca20d) with weak development of tubercles on latera, ×1.7; replica showing all sides of this pluricolumnal shown in 8, Pl. 2, fig. 7.——Pl. 15, fig. 7a,b. Side view and articulum of specimen (UKPI Pca20c) showing average characteristics, ×1.7, ×2.5.——Pl. 15, fig. 8a,b. Side and facetal views of specimen (UKPI Pca22d) with higher-than-average columnals, ×1.7, ×2.5.——Pl. 15, fig. 9a,b. Side and facetal views of exceptionally rugose specimen (UKPI Pca20a), ×1.7, ×2.5.——Pl. 15, fig. 10. Side view of specimen (UKPI Pca24a) with weak tubercles, ×1.7.——Pl. 15, fig. 11. Facetal view of specimen (UKPI Pca20d) shown in Pl. 14, fig. 7, ×2.5.——Pl. 16, fig. 1a,b. Side view and longitudinal section of specimen (UKPI Pca101), ×1.7.——Pl. 16, fig. 2a,b. Similar views of another specimen (UKPI Pca104), ×1.7.——Pl. 16, fig. 3a,b. Side view and longitudinal section of specimen

*Measurements and indices of Baryschyr *anosus*

Specimen	KD	F	Fi	L	Li	C	Ci	KH	KHi	NT	IN	INi
Pca24c (Pl. 16, fig. 8)	16.6	14.0	85	7.0	50	7.0	50	2.6	15.7	10	7.5	75
Pca21c (Pl. 16, fig. 10)	16.0	14.7	92	3.7	25	11.0	75	1.7	10.5	8	5.5	69
Pca23 (Pl. 16, fig. 9)	16.0	14.3	90	4.7	37	9.6	63	2.4	15.0	9	6.5	68
Pca24d (Pl. 16, fig. 6)	15.7	14.3	91	3.3	23	11.0	77	1.8	11.5	8	5.0	63
Pca22d (Pl. 15, fig. 8)	15.7	13.3	85	5.6	42	7.7	58	3.0	19.1	12	8.3	69
*Pca21b (Pl. 14, fig. *6)	15.5	13.6	88	5.5	40	8.1	60	1.8	11.3	7	5.0	67
Pca20d (Pl. 14, fig. 7)	15.1	14.3	95	3.7	26	10.6	74	2.4	15.6	10	6.5	65
Pca22c (Pl. 16, fig. 7)	13.3	11.7	88	3.3	28	8.4	72	2.0	15.0	8	5.5	69
Pca20c (Pl. 15, fig. 7)	13.3	11.6	87	3.3	28	8.3	72	2.5	18.3	10	6.5	65
Pca24a (Pl. 15, fig. 10)	13.1	12.7	97	5.0	39	7.7	61	2.1	16.5	8	6.0	75

(UKPI Pca112) with prominent cirrus scar, ×1.7.——Pl. 16, fig. 4a,b. Similar views of short pluricolumnal (UKPI Pca110), ×1.7.——Pl. 16, fig. 5. Articular facet of specimen (UKPI Pca24a) shown in Pl. 15, fig. 10, ×1.7.——Pl. 16, fig. 6a,b. Facetal and side views of typical specimen (UKPI Pca24d), ×2.5, ×1.7.——Pl. 16, fig. 7a,b. Side and facetal views of specimen (UKPI Pca22c) with nodal at mid-height, ×1.7, ×2.5.——Pl. 16, fig. 8a,b. Side and facetal views of specimen (UKPI Pca24c) with decidedly uneven articula and prominent tubercles on thick parts of columnals, ×1.7, ×2.5.——Pl. 16, fig. 9a,b. Side and facetal views of specimen (UKPI Pca23), ×1.7, ×2.5.——Pl. 16, fig. 10a,b. Facetal and side views of very rugose specimen (UKPI Pca21c), ×1.7, ×2.5.——Pl. 16, fig. 11. Exterior of specimen (UKPI Pca111), ×1.7.

Genus CYCLOCAUDEX Moore & Jeffords, new genus

Stem heteromorphic, straight-sided or faintly convex longitudinally, nodals commonly with cirrus scars, not wider than internodals but slightly taller; chiefly characterized by very broad crenularium with long, straight crenulae, areola small or lacking or with its inner edge having characteristics of perilumen, lumen typically small and circular in outline but may be moderate in size and subpentagonal to weakly quinquelobate.

*Type species.—Cyclocaudex *typicus* Moore & Jeffords, new species, from Upper Pennsylvanian of Texas; designated herein.

Occurrence.—Lower Mississippian to Upper Pennsylvanian.

CYCLOCAUDEX *TYPICUS Moore & Jeffords, new species

Stem moderately large for genus; articular facet characterized by small but not diminutive circular lumen and areola with approximately equivalent index, crenularium with straight rather than flexuous crenulae. Measurements (in mm.) and indices of this species may be compared with those of other species in the following composite tabulation.

Type specimen.—UKPI *Pdq9 from loc. Pdq.

Occurrence.—Belknap Limestone Member, Thrifty Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (locs. Pdq, Paw, Pbd).

Illustrations.—Plate 17, figures *1-5.——*1a,b. Facetal and side views of type specimen showing large circular lumen surrounded by granulose periluminal rim, internodal latera straight-sided, nodal with circular cirrus scar, ×3.5.——2a,b. Facetal and side views of short pluricolumnal (UKPI Paw35, from loc. Paw) showing moderately large granulose areola and normal appearance of crenularium, ×3.5.——3. Facetal view of specimen (UKPI Pbd14, from loc. Pbd) with subpentagonal lumen, ×3.5.——9a,b. Facetal and side views of incomplete noditaxis (UKPI Paw6, from loc. Paw) showing culmina shorter and stouter than usual, large granulose areola, weakly pentalobate lumen with surface of claustrum visible beneath it, ×3.7, ×1.7.——5a,b. Facetal and side views of specimen (UKPI Paw9, from loc. Paw) showing characteristic features of crenularium, areola, and subcircular lumen, ×3.5, ×1.7.

CYCLOCAUDEX CONGREGALIS Moore & Jeffords, new species

Slightly larger than *Cyclocaudex *typicus,* this species displays characteristic features of the genus, seemingly with noditaxes of 4 columnals but possibly of 8, inner edges of columnals along lumen bluntly rounded, outer sides straight, sutures crenulate; crenulae somewhat coarser than in Pennsylvanian species. Measurements and indices tabulated above.

Type specimen.—UKPI *Maa2 from loc. Maa.

Measurements and indices of species of Cyclocaudex

Species	Specimen	F	L	Li	A	Ai	C	Ci	KH	KHi
C. congregalis	*Maa16	15.3	3.3	22			12.0	78	2.0	13
*C. *typicus*	Paw6	12.7	3.8	30	3.4	27	5.5	43	2.3	18
"	Pbd14	12.5	2.2	18	2.6	21	7.7	61		
"	Paw35	12.4	2.5	20	4.0	32	5.9	48	2.0	16
"	*Pdq9	12.0	3.8	32	2.0	17	6.2	51	2.5	21
"	Paw7	9.0	1.5	17	1.9	21	5.6	62	2.2	24
"	average	11.7	2.8	24	2.8	24	6.2	52	2.2	19
C. plenus	Pdq6	14.0	1.8	13	1.2	9	11.0	78	1.8	13
"	Pdq13	12.0	1.3	11	1.2	10	9.5	77	1.8	15
"	Pbd5	11.0	0.7	6	0.8	7	9.5	87	1.2	11
"	Paw33	10.5	1.7	16	1.5	14	7.3	70	2.0	19
"	*Paw39	10.0	1.0	10	0.2	2	8.8	88	1.7	17
"	average	11.5	1.3	11	1.0	9	9.2	80	1.7	15
C. aptus	*Maa16	13.3	3.0	23			10.3	77	2.1	16
C. insaturatus	*Phu10d	8.4	2.2	26	0.8	9	5.4	65	2.0	24
C. jucundus	Pdq25	8.2	1.0	12	3.5	43	3.7	45	1.8	22
"	*Paw34	8.0	1.8	23	1.9	24	4.3	53	2.3	29
C. costatus	*Pba59	5.0	1.0	20	0.7	14	3.3	66	1.7	33

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, in Kentucky.

Illustrations.—Plate 17, figure *10a-c, facetal view, median longitudinal section, and side view of type specimen, ×2.5.

CYCLOCAUDEX APTUS Moore & Jeffords, new species

Closely similar to *Cyclocaudex congregalis,* distinguished by absence of distinguishable noditaxes, noncrenulate sutures, and finer crenulae on articular facet.

Type specimen.—UKPI *Maa16 from loc. Maa.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, in Kentucky (loc. Maa).

Illustrations.—Plate 17, figure *9a-c, facetal and side views and median longitudinal section of type specimen, ×2.5.

CYCLOCAUDEX PLENUS Moore & Jeffords, new species

Stem medium-sized to large, characterized by relatively low columnals of subequal diameter grouped in noditaxes of 4 to 8, nodals generally bearing 1 or 2 circular cirrus scars; lumen smaller than in most other species, bordered by very narrow areola having some aspects of perilumen, crenulae moderately fine, long, and straight; sides of columnals tending to be slightly convex longitudinally, sutures noncrenulate.

Type specimen.—UKPI *Paw39 from loc. Paw.

Occurrence.—Chaffin Limestone, Blach Ranch Limestone, and Belknap Limestone Members of Thrifty Formation, and Gunsight Limestone and Wayland Shale Members of Graham Formation, all Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (locs. Paw, Pbd, Pdq, E 5, E 675, E 682, E 705, E 706, E 722, E 732-E 734, E 790).

Illustrations.—Plate 17, figure 12; Plate 18, figures *1-5.——Pl. 17, fig. 12. Side view of typical pluricolumnal (UKPI Pbd5, from loc. Pbd) showing noditaxes of 4 columnals, ×1.7.——Pl. 18, fig. *1a,b. Facetal and side views of type specimen showing exceptionally long crenulae and very narrow, granulose areola around circular lumen, side view showing part of cirrus scar on topmost columnal (internodal), ×3.5, ×3.3.——Pl. 18, fig. 2a,b. Facetal and side views of short pluricolumnal (UKPI Pdq6, from loc. Pdq) with normal features of articulum, ×3.5.——Pl. 18, fig. 3a,b. Facetal and side views of specimen (UKPI Pdq13, from loc. Pdq) with cirrus scar impinging on 3 columnals, ×3.5.——Pl. 18, fig. 4a,b. Facetal and side views of another typical pluricolumnal (UKPI Paw33, from loc. Paw), ×3.5.——Pl. 18, fig. 5. Facetal view of specimen (UKPI Pbd5) with exceptionally small circular lumen surrounded by narrow granulose rim, ×3.5. [Additional illustrations of this species are given in Echinodermata Art. **8**, Pl. 2, fig. 1-4, Pl. 3, fig. 9, and Art. **10**, Pl. 1, fig. 1-12.]

CYCLOCAUDEX JUCUNDUS Moore & Jeffords, new species

Small stems with small circular lumen surrounded by areola broader than in other species and showing tendency to depressed, bowl-shaped surface; noditaxes of 4 columnals, some nodals cirrus-bearing, sutures may be distinctly crenulate.

Type specimen.—UKPI *Paw34 from loc. Paw.

Occurrence.—Chaffin Limestone and Belknap Limestone Members of Thrifty Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (locs. Paw, Pdq).

Illustrations.—Plate 17, figures 6-*7.——6a,b. Facetal and side views of specimen (UKPI Pdq25, from loc. Pdq) showing relatively wide, slightly depressed areola and crenulate sutures between evenly tall columnals, ×3.5.——*7a,b. Facetal and side views of type specimen showing distinctly concave areola and evenly tall columnals, ×3.5.

CYCLOCAUDEX INSATURATUS Moore & Jeffords, new species

Stem similar in size and height of columnals to *Cyclocaudex jucundus,* distinguished by its larger circular lumen, lack of areola, and presence of single internodal between successive cirrus-bearing nodals; crenulae moderately fine, straight.

Type specimen.—UKPI *Phu10d from loc. Phu.

Occurrence.—Cabaniss Formation, Cherokee Group, Desmoinesian, Middle Pennsylvanian, in southeastern Kansas (loc. Phu).

Illustrations.—Plate 17, figure *11a,b. Side and facetal views of type specimen showing general characters typical of genus, side view showing single internodal between pair of cirrus-bearing nodals, ×4.2.

CYCLOCAUDEX COSTATUS Moore & Jeffords, new species

Small stem with small circular lumen surrounded by perilumen-like areola, crenulae exceptionally coarse and few; sides of columnals straight, nodals with or without cirri, height of columnals relatively greater than in other species, as indicated in tabulation of measurements given above.

Type specimen.—UKPI *Pba59 from loc. Pba.

Occurrence.—South Bend Shale Member, Graham Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (loc. Pba).

Illustrations.—Plate 17, figure *8a,b, facetal and side views of type specimen showing exceptionally coarse culmina, narrow areola, and smooth-rimmed circular lumen, side view showing nodals 3rd from top and 2nd from bottom, ×8.5, ×3.5.

Genus MOOREANTERIS Miller, new genus

Stem small comprising circular, longitudinally straight-sided to convex columnals. Homeomorphic columnals have 5 evenly spaced pores (approximately 72° apart) at mid-height in vertical rows, with a sporadic cirrus scar replacing a pore on some specimens; all assumed to be nodals. Columnals are smooth, considerably greater in diameter than height. Lumen centrally located, circular to oval, and small. Crenularium asymmetric to symmetric with bifurcating, straight to implanted culmina. Axial canal in longitudinal median section straight-sided in available specimens, lacking claustra; transverse sided at mid-height of columnals show 5 canaliculae extending from axial canal to cirrus pores on latera.

*Type species.—Mooreanteris *waylandensis* MILLER, new species, from Upper Pennsylvanian of Texas; designated herein.

Discussion.—The columnals of *Mooreanteris* average about 5 mm. in diameter and occur in the small size fraction of collections. Specimens initially may be overlooked or included with juveniles of other species. Identification is not difficult, however, because columnals are characterized chiefly by the 5 vertical rows of pores. On weathered specimens, visibility of pores is increased by staining or application of a light coat of oil. Further proof may require a transverse section to show the 5 canaliculae.

Nodals of other genera bearing 5 pores are rare in available collections. They occur with internodals that lack pores or canaliculae and are considered to be juveniles. Adult specimens do not demonstrate that all 5 pores develop into cirrus indicators. Nodals of specimens of *Floricyclus granulosus* MOORE & JEFFORDS observed in the Wayland Shale of Texas have 5 canaliculae in transverse section terminating in cirrus scars on the exterior. These specimens, however, have internodals lacking pores, canaliculae, and cirrus scars.

The articular surface of *Catholicorhachis multifaria* MOORE & JEFFORDS has an asymmetrical crenularium that is very similar to type species of *Mooreanteris* except that 5 cirrus indicators are not present on each columnal. MOORE & JEFFORDS state that "the scars are aligned vertically in a systematic manner, for successive rows show counts of 9, 11, 14, 7, and 11 scars within the length of the fragment." This suggests that pores also may be present but not externally visible. A median transverse section (not available) is necessary to show the number of canaliculae.

Strong possibility exists that specimens assigned to this genus primarily on constant characters such as 5 pores and small size are juveniles. Transitional forms, however, have not been found, even during detailed examination of thousands of Wayland and Gunsight columnals and pluricolumnals.

Mooreanteris species A is unique in that pores develop a weakly crenulate periphery on the 4 pluricolumnals in the collection referred to it, become slightly larger, and grade into crenulate cirrus scars having a very small central opening.

Undescribed specimens closely resembling the type species but with a slight tendency toward a pentagonal instead of circular outline occur in two collections from the Winchell Formation, Canyon Group, Missourian, Upper Pennsylvanian, and in the Waldrip Shale, Lower Permian, in Texas.

Occurrence.—Upper Pennsylvanian-Lower Permian.

MOOREANTERIS *WAYLANDENSIS Miller, new species

Longitudinal profile straight, lumen oval to circular, areola of moderate width with smooth or rough floor; crenularium asymmetrical, with coarse culmina. Inner edge of columnals in longitudinal median section forming nearly straight axial canal.

Type specimen.—E *732-82 from locality E 732 in Coleman County, Texas.

Discussion.—This species distinguished easily by the asymmetrical crenularium and areola. The lumen commonly is oval rather than circular. The inner edges of culmina (nearest areola) generally are thicker and fewer than the outer edges; sporadically they appear beaded and separated from the crenularium by a narrow, circular, weathered or crushed zone. Pores are typically circular but may be weakly crenulate with or without small plug-like protrusions. Outer culmina become more numerous with an increase in columnal diameter, whereas inner culmina (near areola) change little in numbers with increase in columnal diameter.

Occurrence.—Wayland Shale Member, Graham Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (locs. E 675, E 705, E 732, E 733, E 734).

Illustrations.—Plate 18, figures 7-11.——7. Facet of specimen (E 675-5, from loc. E 675) showing oval lumen and rough floor of areola, ×7.——*8a,b. Facetal and side views of type specimen showing asymmetrical crenularium and small centrally placed lumen, exterior showing 1 of 5 vertical rows of cirripores (all shown by transverse sections of other specimens to be connected with columnal axial canal), ×12.——9a,b. Side view and median longitudinal section of specimen (E 733-31, from loc. E 733), exterior showing 2 of 5 vertical rows of cirripores and section showing straight-sided axial canal, ×3.5.——10. Facetal view of specimen (E 734-32, from loc. E 734) showing moderately coarse crenulae, culmina blunt adjoining areola and bifurcating peripherally, ×7.——11. Facetal view of specimen (E 732-52, from loc. E 732) showing asymmetrical crenularium and areola, ×10.

MOOREANTERIS PERFORATUS Moore & Jeffords, new species

Small stem with very diminutive circular lumen; crenulae somewhat flexuous, areola lacking; chief characteristic of columnals additional to those of facet is presence of 5 vertical rows of pinprick perforations at mid-height of columnals, slightly irregular rather than perfectly aligned, and in some specimens marked by small pimple-like projections instead of tiny openings; grouping of columnals in noditaxes not observed.

Type specimen.—UKPI *Pdq16 from loc. Pdq.

Discussion.—Differs from the type species of the genus chiefly in its large crenularium and absence of an areola on articular facets.

Occurrence.—Belknap Limestone Member, Thrifty Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (loc. Pdq).

Illustrations.—Plate 18, figure *6a,b, side and facetal views of type specimen, aligned cirripores well shown, ×3.5.——Plate 27, figure 10a,b. Facetal and side view of specimen (UKPI Pdq15, from loc. Pdq) showing vertically aligned pimple-like protuberances instead of cirripores, ×3.5.

MOOREANTERIS species undetermined (A), Miller

Longitudinal profile convex, crenularium slightly asymmetrical, lumen oval, medium areola with rough floor. Inner edge of columnals in longitudinal median section forming straight axial canal.

Figured specimen.—E 675-3.

Discussion.—Only 4 of these pluricolumnals were found in the collection. Distinguishing features are the 5 vertical rows of pores and the convex longitudinal profile of columnals. Preservation is fair.

Occurrence.—Wayland Shale Member, Graham Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (loc. E 675).

Illustrations.—Plate 19, figure 13a,b, side views of pluricolumnal (E 675-3, from loc. E 675) showing aligned cirripores, some weakly crenulate, specimen shown in fig. 13b slightly rotated with respect to view given in fig. 13a, ×3.5.

Family EURACIDAE Moore & Jeffords, new family

Stems characterized by asymmetry of transverse outline but general circularity in section with rugose development of multiple abortive cirri (pseudocirri) on one side of stem, as well as by tendency toward excentric location of lumen, which may be pentalobate or perfectly circular.

Type genus.—*Eurax* Moore & Jeffords, new genus, from Upper Silurian and Lower Devonian.

Occurrence.—Upper Silurian-Middle Devonian.

Genus EURAX Moore & Jeffords, new genus

Stem moderately small, composed of circular to asymmetrically ovoid columnals which appear nearly uniform in height and straight-sided profile around ½ or ¾ of their circumference but variable and marked by warty protuberances on remaining part of stem; articular facets with very small to moderately large lumen, quinquelobate or circular in outline, entire area outside of lumen occupied by crenularium with very fine to medium-sized crenulae.

Type species.—*Eurax* **ethas* Moore & Jeffords, new species, from Upper Silurian of Tennessee; designated herein.

Occurrence.—Upper Silurian-Lower Devonian.

EURAX *ETHAS Moore & Jeffords, new species

Stem small, circular in transverse section except for irregularity on side bearing rugose abortive cirri, columnals rather clearly grouped in noditaxes of 4; facet with subcentral quinquelobate lumen and moderately strong crenulae. Measurements (in mm.) and indices of the type specimen are: F, 4.2; L, 1.1; Li, 26; C, 3.1; Ci, 74; KH (av.), 0.15; KHi, 3.6; NT, 0.7; IN, 0.35; INi, 50.

Type specimen.—UKPI *Sdg10 from loc. Sdg.

Discussion.—Considerable variation in appearance of the rugose side of stems placed in *Eurax *ethas* is observed, many specimens closely resembling the type in having subdued warty projections from nodals, whereas some (e.g., Sdg15) exhibit an extreme development of these prominences in which some of them extend outward a distance nearly equal to the stem diameter. Diagnostic characteristics of the species appear to be the shape and position of the lumen, coupled with moderate coarseness of the crenulae.

Occurrence.—Brownsport Limestone (loc. Sdg) and Waldron Shale (loc. Shg), Niagaran, Upper Silurian, in Tennessee and Indiana.

Illustrations.—Plate 19, figures 7-10.——7. Side view of average pluricolumnal (UKPI Shg8, from loc. Shg) showing projecting pseudocirri on one side, ×3.5.——8a,b. Two side views of moderately long, slender pluricolumnal (UKPI Shg9d) from slightly different angles, ×3.5.——*9a,b. Facetal and side views of type specimen showing centrally placed pentalobate lumen, ×7.5, ×3.5.——10a,b. Similar views of another specimen (UKPI Sdg11, from loc. Sdg), ×7.5, ×3.5.

EURAX EUGENES Moore & Jeffords, new species

Stem comparable in most respects to *Eurax *ethas* but in general larger and distinguished especially by asymmetrical ovoid transverse section, excentric location of small circular to pentalobate lumen, and extremely fine crenulae. Measurements (in mm.) and indices of the type specimen are: F, 6.2; L, 0.6; Li, 10; C (av.), 5.4; Ci, 88; KH (av.), 0.55; KHi, 9.2; NT, 2.2; IN, 1.5; INi, 68.

Type specimen.—UKPI *Di7w from loc. Di.

Discussion.—This species exclusively represents the genus, so far as observed, in Lower Devonian beds but it is identified as an uncommon constituent of Upper Silurian collections also.

Occurrence.—Birdsong Shale, Helderbergian, Lower Devonian, in Tennessee (loc. Di) and Brownsport Formation, Niagaran, Upper Silurian (loc. Sdg), in Tennessee.

Illustrations.—Plate 19, figures 1-6.——1a,b. Facetal and side views of short pluricolumnal (UKPI Sdg17, from loc. Sdg) showing extremely fine crenulae radiating from excentric circular lumen, side view showing straight-sided smooth columnals, some of which bear pseudocirri on one side of stem, ×7, ×3.5.——*2a-c. Side view and facets of opposite columnals at ends of type specimen showing excentric small stellate lumen, ×4.——3, 4. Facetal views of other specimens (UKPI Di6c, Di8a, from loc. Di), ×3, ×4.——5a-c. Facetal and two side views of typical pluricolumnal (UKPI Di8a, from loc. Di), ×3.5.——6a,b. Two side views of large specimen (UKPI Di7a, from loc. Di) showing straight-sided columnals and many short excrescences on one side, ×3.5.

Genus PANDOCRINUS Stukalina, 1965

Pandocrinus STUKALINA, 1965a, p. 138.

Stem similar to *Eurax* but characterized by its much larger size, relatively larger lumen, which is uniformly circular and located quite excentically, crenularium of very fine, evenly radiate crenulae, no areola; growth habit in colonies of stems appressed to one another so as to induce deformation of transverse shapes, warty cirri tending to occur mainly on sides of stems that are closest to lumen but not invariably so; grouping of columnals in noditaxes not observed.

*Type species.—Pandocrinus *pandus* STUKALINA (1965a) from Upper Silurian of Kazakhstan; original designation.

Discussion.—STUKALINA's description and illustrations of *Pandocrinus *pandus* agree so closely with the features observed by us in very numerous pluricolumnals from the Lower Devonian of central Tennessee and illustrated by HALL (1859b) and GOLDRING (1923) for dissociated pluricolumnals collected in the Lower Devonian of New York that one can hardly doubt the generic identity of the fossils from North America and Kazakhstan. Likewise the occurrence of closely similar pluricolumnals in strata of Czechoslovakia which must be the same or nearly the same in age reinforces recognition of *Pandocrinus.* STUKALINA (1965a, p. 138) also refers to the Bohemian fossils, citing them incorrectly as *Encrinites ivanensis* BARRANDE, rather than *E. St Ivanensis* as given in WAAGEN & JAHN (1899), and in our view properly referred to as *Pandocrinus saintivanensis* (BARRANDE in WAAGEN & JAHN, 1899). *P. *pandus* appears to lack stolon-like pseudocirri on one side of the column, as well developed in *P. stoloniferus* (HALL) (=*P. saintivanensis*).

Occurrence.—Upper Silurian-Lower Devonian.

PANDOCRINUS STOLONIFERUS (Hall), 1859

Mariacrinus stoloniferus HALL, 1859b, p. 112, pl. 3A, fig. 2; pl. 3B, fig. 3-7; GOLDRING, 1923, p. 113, pl. 59, fig. 1-5.
Encrinites St Ivanensis BARRANDE in WAAGEN & JAHN, 1899, p. 152-154, pl. 76, fig. 4-25.

Differs from *Pandocrinus *pandus* chiefly in development of generally numerous short abortive cirri on one side of column. Measurements and columnal height index of type specimen (in mm.) are: F, 15; KH, 0.9; KHi, 6. Measurements (in mm.) and indices of a typical specimen from Tennessee (UKPI Di1b) are: F, 22; L, 5; Li, 23; C, 17; Ci, 77; KH, 1.1; KHi, 5.

Type specimen.—Am. Mus. Nat. Hist. 2298/1, one of Hall's syntypes figured by GOLDRING (1923, pl. 59, fig. 1), here designated.

Discussion.—Only pluricolumnals of this species ever have been found, the theca and arms being unknown. HALL classified his specimens unqualifiedly as belonging to the camerate genus *Mariacrinus* but solely on the basis of "the general similarity of these columns to others of the Genus *Mariacrinus*" (HALL, 1859b, p. 112), though comparison by us with illustrations of other species supports HALL's conclusion only as regards approximate size of some stems in side view, not in any definitive characteristics. Concerning the stems called *Mariacrinus stoloniferus,* HALL wrote: "Their mode of occurrence indicates that they have grown irregularly over the surface [of the substrate], bending according to its inequalities and sending off, principally upon one side, numerous small rootlets or branches, which are embedded in the surrounding rock. Where the column is curved, these stolons are chiefly from the inner side of the curve and very rarely upon the outer side. Whether we regard the columns in these parts as having grown in an erect or recumbent position, the circumstance that these appendanges grow only from one side is equally interesting and remarkable. . . . The great uniformity in the columns, though of extremely different size, together with the characteristic appendages, renders the species readily recognizable; for which reasons I have designated it, although not knowing the structure of the body." (HALL, 1859b, p. 112).

The common occurrence of *Pandocrinus stoloniferus* in Helderbergian deposits of both New York and Tennessee, coupled with ease in identification of the species, indicates the stratigraphic value of these stem fragments.

Dissociated pluricolumnals described by BARRANDE and illustrated by WAAGEN & JAHN (1899) from beds classed as Upper Silurian (e2 Stage) at St. Ivan in Czechoslovakia, as previously noted, are so similar in appearance and dimensions to specimens of *Pandocrinus stoloniferus* from the Lower Devonian of eastern North America that with little question they are identified not only as being congeneric but as belonging to the same species. In both regions these unusual sorts of crinoid columns are associated with varyingly common species of *Scyphocrinites* which have exceptionally distinctive highly organized large crowns, narrowly restricted in stratigraphic range. Occurrences of this genus in Bohemia are recorded as Upper Silurian, whereas all species found in North America come from formations classed as Lower Devonian. In our view it is hardly conceivable that these crinoid-bearing deposits on opposite sides of the Atlantic actually differ in age. Instead, they must be exactly or almost exactly contemporaneous. SPRINGER (1917, p. 30) wrote concerning *S. *elegans* ZENKER, type species of *Scyphocrinites*: "After the most careful comparison with the prevalent Bohemian form, not only from the figures and descriptions of WAAGEN and JAHN, but with four good specimens of my own from Bohemia, I am unable to point out a single diagnostic character by which the [Helderbergian] Cape Girardeau [Missouri] specimens can be distinguished from it."

Occurrence.—New Scotland Limestone, near Clarkville and Schoharie, New York; Birdsong Shale, Helderbergian, Lower Devonian, in Tennessee (locs. Dh, Di); beds classed as Upper Silurian (e2 Stage) in Czechoslovakia.

Illustrations.—Plate 19, figures 11-12; Plate 20, figures 1-3; Plate 21, figures 14-15.——Pl. 19, fig. 11-12. Side and facetal views of two pluricolumnals from reported Upper Silurian of Bohemia and figured by WAAGEN & JAHN (1899), all ×0.85.——Pl. 20, fig. 1a,b. Side views of typical large pluricolumnal (UKPI Di4a, from loc. Di) from slightly different angles, one (1a) showing subequal columnals with slightly wavy convex latera and sutures in furrows, other (1b) showing short rootlike excrescences called pseudocirri, ×2.5.——Pl. 20, fig. 2a,b. Side views of another robust pluricolumnal (UKPI Di1a, from loc. Di), ×1.7.——Pl. 20, fig. 3a,b. Facetal views, opposite ends of a typical specimen (UKPI Di1b, from loc. Di), large circular lumen located excentrically nearest side bearing pseudocirri, ×2.5, ×1.7. ——Pl. 21, fig. 14-15. Facetal views of two specimens (UKPI Di1a, Di1b, from loc. Di) shown from side in Pl. 20, fig. 2a,b, 3a,b, ×1.7.

Genus AVICANTUS Moore & Jeffords, new genus

Similar to *Pandocrinus* in ribbed appearance of its circular stems and average large size, although not attaining dimensions of robust specimens of *P. stoloniferus,* distinguished by lack of wartlike rugosities on one side of stem and by central location of its large circular lumen, moderately fine crenulae straight and regular; stem heteromorphic, as shown by presence of very thin columnals between thicker ribbed ones, clearly demonstrated by longitudinal sections which show subequal thickness of all columnals bordering lumen, whereas externally thinned columnals may fail to reach stem periphery, ribbed columnals then being joined to one another along finely crenulate sutures with appearance of complete homeomorphy in stem structure.

Type species.—*Avicantus *dunbari* MOORE & JEFFORDS, new species, from Lower Devonian of Tennessee; designated herein.

Occurrence.—Lower Devonian.

AVICANTUS *DUNBARI Moore & Jeffords, new species

With characteristics of genus. Measurements (in mm.) and indices of the type specimen are: KD, 9.3; F, 8.0; Fi, 86; L, 2.2; Li, 27; C, 5.8; Ci, 73; KH (nodals only), 0.9; KHi, 9.7. Two unfigured specimens have respective measurements of (1) F, 12; L, 6.7; Li, 55; C, 5.3; Ci, 45; and (2) F, 10.5; L, 6.0; Li, 57; C, 4.5; Ci, 43; in both the lumen is materially larger than in the type specimen.

Type specimen.—UKPI *Di7a from loc. Di.

Discussion.—The peculiarity of internodals that are invisible externally is shown by several specimens or it is found only on parts of specimens. None of the relatively thick-ribbed columnals bear cirrus scars; they are denominated as nodals only because of their size in relation to the intercalated thin columnals. A longitudinal section of one specimen shows 16 sharp-pointed inner edges of the 2 sets of columnals in 10 mm. and bordering the lumen they are nearly equal in thickness.

Occurrence.—Birdsong Shale, Helderbergian, Lower Devonian, in Tennessee (locs. Dh, Di).

Illustrations.—Plate 20, figures 4-6.——4, 6. Facetal views of two specimens (UKPI Dh1a, from loc. Dh, Di4b, from loc. Di), ×3.5, ×2.5.——*5a,b. Facetal and side views of type specimen showing homeomorphic appearance of pluricolumnal which actually is heteromorphic, ×4.2.

Genus DESIDIAMPHIDIA Moore & Jeffords, new genus

Stem composed of columnals with transverse ovoid outline, distinguished especially by very excentric location of their diminutive circular lumen and pattern of mostly curved crenulae resembling venation of leaves; sides of columnals straight and smooth.

Type species.—*Desidiamphidia *frondea* MOORE & JEFFORDS, new species, from Middle Devonian of New York; designated herein.

Occurrence.—Middle Devonian.

DESIDIAMPHIDIA *FRONDEA Moore & Jeffords, new species

With characteristics of genus. Measurements (in mm.) of the type specimen with indices are: F (av.), 5.2; L, 0.2; Li, 3.8; C (av.), 5.0; Ci, 96.2; KH, 0.8; KHi, 15. Similar records for another specimen (Dib3f) are: F (av.), 3.9; L, 0.1; Li, 2.5; C (av.), 3.8; Ci, 97.5; KH, 1.0; KHi, 25.

Type specimen.—UKPI *Dib3c from loc. Dib.

Occurrence.—Wanakah Shale Member, Ludlowville Formation, Erian, Middle Devonian, in New York (loc. Dib).

Illustrations.—Plate 20, figures *9-10, facetal views of type specimen and another columnal (UKPI Dib3f, from loc. Dib) showing strongly excentric location of small circular lumen and pattern of culmina and crenellae resembling veins of leaf, ×8.5.

Family FLUCTICHARACIDAE Moore & Jeffords, new family

Stem homeomorphic or obscurely to distinctly heteromorphic, chiefly characterized by coarse straight crenulae and prominent perilumen of articular facets and wavy crenulate sutures between columnals; stems mostly slender but some medium-sized.

Type genus.—*Flucticharax* MOORE & JEFFORDS, new genus, from Lower Mississippian.

Occurrence.—Upper Silurian-Lower Mississippian.

Genus FLUCTICHARAX Moore & Jeffords, new genus

Stem homeomorphic, medium-sized; moderately thick columnals with longitudinally convex sides joined along broadly wavy sutures; articular facets with coarse straight crenulae surrounding narrow areolar band or abutting on prominent perilumen which is relatively wide and marked on its summit by fine vermiculate grooves and ridges, lumen very small, circular.

Type species.—*Flucticharax *undatus* MOORE & JEFFORDS, new species, from Lower Mississippian of Kentucky; designated herein.

Occurrence.—Lower Mississippian.

FLUCTICHARAX *UNDATUS Moore & Jeffords, new species

Characteristics of genus. Measurements (in mm.) of the type species and another specimen are tabulated with indices as follows.

*Measurements and indices of Flucticharax *undatus*

Specimen	F	L	Li	P	Pi	A	Ai	C	Ci	KH	KHi
*Ma156	10.3	0.5	5	3.5	34	3.1	30	3.2	31	2.7	26
Ma109	8.6	0.5	6	3.3	38	0.3	4	4.5	52	2.5	29

Type specimen.—UKPI *Ma156 from loc. Ma.

Discussion.—This species, represented by numerous specimens in our collections, seems to be a very good stratigraphic marker, for it occurs also in New Providence deposits of Indiana and is not found in younger Borden strata.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, in Kentucky (locs. Ma, Maa).

Illustrations.—Plate 20, figures *7-8.——*7a,b. Facetal and side views of type specimen showing distinctive appearance of coarse simple crenulae inside rim, narrow depressed areola, wide tabular form of perilumen with vermiculate markings, and small circular lumen, side view showing homeomorphic nature of stem with columnals girdled by broadly rounded ridge and joined along coarsely wavy sutures, ×2.5.——8. Facetal view of another specimen (UKPI Ma9, from loc. Ma), ×3.5.

Genus FABALIUM Moore & Jeffords, new genus

Stem heteromorphic, slender, nodals noncirriferous, distinguished by their height which is appreciably greater than that of intervening columnals, sutures resembling those of *Flucticharax;* articular facet with exceptionally coarse culmina and crenellae, in this respect corresponding to other genera placed in family, but lacking areola or perilumen, lumen very minute, circular.

Type species.—*Fabalium *fabale* MOORE & JEFFORDS, new species, from Upper Silurian of Tennessee; designated herein.

Occurrence.—Upper Silurian.

FABALIUM *FABALE Moore & Jeffords, new species

With characteristics of the genus, sides of columnals smooth. Measurements (in mm.) and indices of the type specimen are: F, 2.5; L, 0.1; Li, 4; C, 2.4; Ci, 96; KH (av.), 1.1; KHi, 44; NT (av.), 5.0; IN (av.), 3.2; INi, 61.

Type specimen.—UKPI *Sdg20 from loc. Sdg.

Occurrence.—Brownsport Formation, Niagaran, Upper Silurian, in Tennessee (loc. Sdg).

Illustrations.—Plate 21, figure *7a,b, facetal and side views of type specimen showing very coarse simple culmina and strongly crenulate sutures, ×7.5, ×3.5.

Genus CRENATAMES Moore & Jeffords, new genus

Stem slender, composed of straight-sided smooth columnals characterized by exceptional coarseness of culmina and crenellae of articular facets and by presence of circular perilumen with rugose surface surrounding small circular lumen.

Type species.—*Crenatames *amicabilis* MOORE & JEFFORDS, new species, from Middle Devonian of New York; designated herein.

Occurrence.—Middle Devonian.

CRENATAMES *AMICABILIS Moore & Jeffords, new species

Characteristics of genus, facets with 13 to 15 broad, rounded crenulae, which do not quite extend to perilumen, leaving narrow areolar band. Measurements (in mm.) and indices of the type and another specimen are tabulated as follows.

*Measurements and indices of Crenatames *amicabilis*

Specimen	F	L	Li	P	Pi	A	Ai	C	Ci	KH	KHi
*Dib1z	2.7	0.1	4	1.0	37	0.2	8	1.4	51	1	37
Dib4a	2.5	0.1	4	0.9	36	0.2	8	1.3	52	1	40

Type specimen.—UKPI *Dib1z from loc. Dib.

Occurrence.—Wanakah Shale Member, Ludlowville Formation, Erian, Middle Devonian, in New York (loc. Dib).

Illustrations.—Plate 21, figures *8-9, facetal views of type specimen and another columnal (UKPI Dib4a, from loc. Dib) showing exceptionally coarse nature of crenulae and moderately elevated rugose perilumen surrounding small circular lumen, ×13.

Genus LAUDONOMPHALUS Moore & Jeffords, new genus

Stem heteromorphic, nodals noncirriferous, distinguished by height greater than for internodals, sides of larger columnals rather strongly asymmetrical, sloping from sharp-edged keel located well ?below mid-height of columnals, sutures finely to somewhat coarsely crenulate; articular facet characterized by long, straight, moderately coarse crenulae terminating inward against well-elevated small perilumen with finely denticulate summit, lumen diminutive, circular.

Type species.—*Laudonomphalus *regularis* MOORE & JEFFORDS, new species, from Middle Devonian of Michigan and New York; designated herein.

Discussion.—The occurrence of *Laudonomphalus* in Middle Devonian strata of the Kuznetsk basin, near Novo Sibirsk, in south-central Siberia (YELTYSHEVA, 1964,

p. 80, pl. 15, fig. 23), is of considerable interest, for it supplements the evidence offered by other genera and species of crinoids recognized on the basis of distinctive stem fragments. In none of these, excepting *Proctothylacocrinus,* have characteristics of the dorsal cup or crown yet been discovered. Even so, the dissociated skeletal remains are indicated to have value for age determination and very wide stratigraphic correlation. The Kuznetsk species of *Laudonomphalus* is named *L. tuberosus* and despite present inability to locate the original publication in which it was described, we include it here for comparison with the North American forms.

Occurrence.—Middle Devonian.

LAUDONOMPHALUS *REGULARIS Moore & Jeffords, new species

Sides of columnals smooth, gently convex longitudinally on small ones, quite asymmetrical on large ones (nodals, priminternodals), with noditaxes of 4, sutures distinctly crenulate; facet with medium to coarse crenulae which are unbranched or branched near periphery, perilumen strongly umbilicate, with small tubercles or denticles on summit. Measurements (in mm.) and indices of the type specimen are: KD, 6.7; F, 6.5; L, 0.2; Li, 3; P, 1.3; Pi, 19; C, 5.0; Ci, 68; KH (av.), 1.0; KHi, 15; NT, 15.5; IN, 10.0; INi, 65. Other specimens are nearly identical in these features, largest observed specimen with diameter of 8.2 mm.

Type specimen.—UKPI *Ddt1a from loc. Ddt.

Discussion.—Specimens referred to this species from New York (e.g., Dib3a, pl. 9, fig. 2) are indistinguishable from those collected in Michigan.

Occurrence.—Bell Shale (loc. Ddt) and Rockport Limestone (loc. Ddv), Traverse Group, Erian, Middle Devonian, in northern Michigan; and Wanakah Shale Member, Ludlowville Formation, Erian, Middle Devonian in New York (loc. Dib).

Illustrations.—Plate 21, figures 1-*4.——1a,b. Facetal and side views of specimen (UKPI Ddv2, from loc. Ddv) having columnals subequal in height, latera with characteristically asymmetrical slopes, ×4.2.——2. Facetal view of columnal (UKPI Dib3a, from loc. Dib), ×8.5.——3a,b. Facetal and side views of typical pluricolumnal (UKPI Ddt1b, from loc. Ddt) showing prominent umbilical mound and noditaxes of 4 columnals (nodal 4th from top), ×4.2.——*4a,b. Facetal and side views of type specimen showing prim- and secundinternodals distinctly smaller and lower than nodals, ×3.5.

LAUDONOMPHALUS ORNATUS Moore & Jeffords, new species

Articular facet nearly identical to that of *Laudonomphalus *regularis* columnals but sides with narrow, more symmetrically placed keels, those of nodals bearing tubercles; measurements and indices inappreciably different from those of *L. *regularis,* diameter of type specimen 7.5 mm.

Type specimen.—UKPI *Ddv1 from loc. Ddv.

Occurrence.—Rockport Limestone, Traverse Group, Erian, Middle Devonian, in Michigan (loc. Ddv).

Illustrations.—Plate 21, figure *5a,b, facetal and side view of type specimen showing nodose nudinodals, ×3.5.

LAUDONOMPHALUS TUBEROSUS (Yeltysheva), 1961

Hexacrinites tuberosus YELTYSHEVA in DUBATOLOVA & YELTYSHEVA, 1960 (1961); YELTYSHEVA, 1964 (1965), p. 80, pl. 15, fig. 23a,b.

Closely similar to *Laudonomphalus *regularis* and *L. ornatus* in nature of articular facet, including bowl-shaped depression of inner part of crenularium next to protuberant perilumen; nodals relatively tall, with sides bearing broad rounded nodes, summits of which slope asymmetrically outward-?downward, successive nodals separated by single low internodal with gently convex longitudinal profile. Measurements (in mm.) and indices of figured specimen (?type) are: KD, 7.5; F, 6.7; L, 0.2; Li, 3; P, 1.3; Pi, 20; C, 5.2; Ci, 77; KH (N), 1.5; KHi(N), 20; KH (IN), 0.5; KHi (IN), 7.

Figured specimen.—YELTYSHEVA, 1964 (1965), pl. 15, figs. 23a,b.

Discussion.—Near identity in size and values of facetal indices of *Laudonomphalus tuberosus* and *L. *regularis* are worthy of notice, but the Siberian species is readily distinguished from both *L. *regularis* and *L. ornatus* by features seen in side view of the pluricolumnals. Part of the stems belonging to a few hexacrinitid species, including forms referred to both *Hexacrinites* and *Arthroacantha,* have been illustrated from the side but none giving views of articular facets. In side view *H. exsculptus* (GOLDFUSS) (1839, in 1826-44), from Middle Devonian strata of the Eifel region in West Germany, has a stem resembling that of *L. *regularis,* judging from figures given by SCHULTZE (1867, pl. 9, figs. 2d,e), whereas the stems of other species of the same age and region, as well as Middle Devonian forms from North America, differ from *Laudonomphalus.* No basis at all is seen for YELTYSHEVA's assignment of the Kuznetsk species to *Hexacrinites.*

Occurrence.—Middle Devonian (Couvinian Stage), in the Kuznetsk basin, south-central Siberia.

Illustrations.—Plate 21, figure *6a,b, facetal and side views of type specimen, ×4.5 (after Yeltysheva, 1964).

Genus DILANTERIS Moore & Jeffords, new genus

Resembles *Flucticharax* but has much coarser crenulae and perilumen is lacking, part of columnals beneath crenularium differentiated from central portion around lumen, which in longitudinal sections is dark-colored and horizontally laminated, as well as extended outward near sutures, producing wedge-shaped appearance of columnal parts between crenularia; sides of columnals smooth.

Type species.—*Dilanteris *trestes* MOORE & JEFFORDS, new species, from Lower Mississippian of Kentucky; designated herein.

Occurrence.—Lower Mississippian.

DILANTERIS *TRESTES Moore & Jeffords, new species

Characteristics of genus. Measurements (in mm.) and indices of the type specimen are as follows: F, 5.1; L, 0.1; Li, 2; A, 2.4; Ai, 47; C, 2.6; Ci, 51; KH, 1.1; KHi, 22.

Type specimen.—UKPI *Maa135 from loc. Maa.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, in Kentucky (loc. Maa).

Illustrations.—Plate 21, figure *13a,b, side view and median longitudinal section of type specimen showing convex profile of columnals and broad wavy sutures, ×3.5.

Genus DIEROCALIPTER Moore & Jeffords, new genus

Stem resembling *Flucticharax* but more slender, with finer crenulae and narrower cranularium, perilumen narrow, with crenulate summit, large circular lumen containing thin septa and jugula; parts of columnals between crenularia and outer areolar tracts of opposite facets sharply differentiated (dense, light-colored in sections) from inner areolar zone and this in turn from parts bordering lumen between opposite perilumina, which correspond in structure to peripheral portions of columnals; side of columnals smooth, gently convex in longitudinal profile.

Type species.—*Dierocalipter***doter* MOORE & JEFFORDS, new species, from Lower Mississippian of Kentucky; designated herein.

Occurrence.—Lower Mississippian.

DIEROCALIPTER *DOTER Moore & Jeffords, new species

Characteristics of genus. Measurements (in mm.) and indices of the type specimen are as follows: F, 6.4; L, 1.0; Li, 15.5; P, 0.8; Pi, 12.5; A, 3.1; Ai, 48.5; C, 1.5; Ci, 23.5; KH, 1.7; KHi, 27.

Type specimen.—UKPI *Ma136 from loc. Ma.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, in Kentucky (loc. Ma.).

Illustrations.—Plate 21, figure *10a-c, facetal and side views and median longitudinal section of type specimen, facet resembling those of *Gilbertsocrinus* and *Elytroclon* but nature of columnal latera, sutures, and tripartite differentiation of columnals internally quite dissimilar, inner medulla of columnals (light-colored) beneath perilumen and bordering axial canal composed of dense stereom, adjoined laterally by somewhat spongy, iron-stained outer medulla (dark-colored) beneath central part of areola, and peripheral cortex (light-colored) beneath crenularium and outer part of areola, ×3.5.

Family EXAESIODISCIDAE Moore & Jeffords, new family

Stem strongly heteromorphic, nodals considerably wider and taller than internodals; articular facets with very narrow crenularium, perilumen present or absent, lumen commonly quinquelobate or pentastellate but may be circular, medium-sized to small.

Type genus.—*Exaesiodiscus* MOORE & JEFFORDS, new genus, from Upper Silurian and Middle Devonian.

Occurrence.—Upper Silurian-Lower Mississippian.

Genus EXAESIODISCUS Moore & Jeffords, new genus

Characterized by small internodals and moderately to greatly expanded nodals, which generally have central depression for reception of internodals; articular facet with crenularium consisting of very short crenulae, proportionally broad areola, and only exceptionally with perilumen, lumen circular or quinquelobate.

Type species.—*Exaesiodiscus *acutus* MOORE & JEFFORDS, new species, from Upper Silurian of Indiana; designated herein.

Occurrence.—Upper Silurian to Middle Devonian.

EXAESIODISCUS *ACUTUS Moore & Jeffords, new species

Nodals greatly expanded, in some specimens more than 10 times width of internodals, rims sharp-angled, facets of nodals in deep central concavity but not depressed on internodals, no cirri present; crenularium very narrow, lumen relatively large, quinquelobate or pentastellate; sides of columnals smooth. Measurements (in mm.) and indices of the type specimen are: KD, 11.0; F, 1.7; Fi, 15.4; L, 0.65; Li, 38; A, 0.75; Ai, 45; C, 0.3; Ci, 17; KH (nodal), 3.0; KHi, 27; width of internodals, 2.0 to 2.8 mm. Many other specimens are similar but large nodals (e.g., Shg2, pl. 5, fig. 4) are 35.0 mm. or more in diameter with facet only 3.0 to 3.5 mm. across, height 8 mm.

Type specimen.—UKPI *Shd1a from loc. Shd.

Discussion.—The collection from which the type specimen was selected contains more than 100 nodals but no separate internodals, although a few of these latter may be attached to a nodal. No stem fragments containing two or more nodals have been observed; thus the height of noditaxes is conjectural.

Occurrence.—Waldron Shale, Niagaran, Upper Silurian. in Indiana (loc. Shd).

Illustrations.—Plate 22, figures *4-6.——*4a-c. Opposite facetal and side views of type specimen, small internodals of 2 orders shown attached to wide nodal, ×5.——5. Facetal view of typical nodal (UKPI Shd1c, from loc. Shd) showing facet for attachment of internodal less than 0.2 width of nodal, ×1.7.——6a,b. Facetal and side views of uneven-edged nodal (UKPI Shg2, from loc. Shg), ×1.7.

EXAESIODISCUS TRUNCATUS Moore & Jeffords, new species

Similar to *Exaesiodiscus *acutus* except in having truncate periphery on nodals and in showing proportionally less expanded nodals in comparison with internodals, those attached to nodals not in deep concavity; surface smooth. Measurements (in mm.) and indices of the type specimen are: KD, 5.5; F, 2.3; Fi, 42; L, 0.7; Li, 30; A, 1.4; Ai, 60; C, 0.2; Ci, 10; KH (nodal), 1.2; KHi, 22. Indices for a smaller specimen (Sfr8f, pl. 22, fig. 1) with nodal diameter of 4.4 mm. and facet 1.4 mm. wide are nearly identical.

Type specimen.—UKPI *Sfr4c from loc. Sfr.

Occurrence.—Waldron Shale, Niagaran, Upper Silurian, in Indiana (loc. Sfr).

Illustrations.—Plate 22, figures 1-3.——1a,b. Facetal and side views of thin nodal with attached internodals (UKPI Sfr8f, from loc. Sfr), ×8.5, ×7.——*2a,b. Facetal and side views of type specimen, without attached internodals, ×8.5, ×7.——3a,b. Facetal and side views of nodal (UKPI Sfr5, from loc. Sfr) with well-rounded longitudinal profile of latus, ×7.

EXAESIODISCUS MINUTUS Moore & Jeffords, new species

Nodals rounded and somewhat thickened outward from depressed facet for articulation with internodals, much smaller than average specimens of *Exaesiodiscus *acutus* but nearly equal in size to *E. truncatus;* facet with circular lumen. Measurements (in mm.) and indices of the type specimen are: KD (nodal), 4; F, 2.5; Fi, 63; L, 0.5; Li, 20; A, 1.6; Ai, 64; C, 0.4; Ci, 16; KH, 0.9; KHi, 22. Similar data for a smaller specimen (Dib4g, pl. 7, fig. 9) are: KD (nodal), 3.0; F, 1.4; Fi, 47; L, 0.1; Li, 7; A, 1.0; Ai, 72; C, 0.3; Ci, 21; KH, 1.0; KHi, 33.

Type specimen.—UKPI *Dib3h from loc. Dib.

Occurrence.—Wanakah Shale Member, Ludlowville Formation, Erian, Middle Devonian, in New York (loc. Dib).

Illustrations.—Plate 22, figures 7-*8.——7. Facetal view of nodal without attached internodals (UKPI Dib4g, from loc. Dib), ×13.——*8. Facetal view of type specimen showing internodal attached to nodal, ×8.5.

Genus SCELIDIOPTERNIX Moore & Jeffords, new genus

Stem heteromorphic, with noncirriferous nodals distinctly taller and wider than internodals, with noditaxes seemingly composed of 8 columnals but possibly only of 4, sides of nodals rounded and of internodals (?except priminternodals) straight; articular facet with moderately large pentalobate lumen, broad and smooth areola, and very narrow crenularium.

Type species.—*Scelidiopternix *norops* Moore & Jeffords, new species, from Upper Silurian of Indiana; designated herein.

Occurrence.—Upper Silurian.

SCELIDIOPTERNIX *NOROPS Moore & Jeffords, new species

With characteristics of genus. Measurements (in mm.) and indices of the type specimen are: F, 2.7; L, 0.75; Li, 28; A, 1.5; Ai, 55; C, 0.45; Ci, 17; KH (av.), 0.16; KHi, 59; NT (8 columnals), 1.25; IN, 0.85; INi, 68. A smaller specimen (Shg24a, pl., fig.) with nodal diameter of 2 mm. differs little from the type except in its lower noditaxes.

Type specimen.—UKPI *Shg7c from loc. Shg.

Occurrence.—Waldron Shale, Niagaran, Upper Silurian, in Indiana (loc. Shg).

Illustrations.—Plate 21, figures *11-12.——*11a-d. Facetal views (×10) and side views (×7) of type specimen.——12a,b. Facetal and side views of another specimen (UKPI Shg24a, from loc. Shg), ×8.5, ×7.

Genus CLEMATIDISCUS Moore & Jeffords, new genus

Stem heteromorphic, with round-sided nodals distinctly wider than internodals, each nodal bearing 5 circular cirrus scars which truncate nodal margin in fashion that produces subpentagonal to decagonal outline; articular facet with blunt- or sharp-pointed stellate lumen which in some specimens appears superficially circular owing to infilled points of lumen, areola broad and smooth, crenularium narrow, with numerous very short crenulae.

Type species.—*Clematidiscus *denotatus* Moore & Jeffords, new species, from Middle Devonian of New York; designated herein.

Occurrence.—Middle Devonian.

CLEMATIDISCUS *DENOTATUS Moore & Jeffords, new species

With characteristics of genus. Measurements (in mm.) and indices of the type specimen (nodal with attached internodal) are: KD (nodal), 3.1; F, 1.85; Fi, 60; L, 0.65; Li, 35; A, 0.8; Ai, 44; C, 0.4; Ci, 21; KH, 0.9; KHi, 29.

Type specimen.—UKPI *Dib4j from loc. Dib.

Occurrence.—Wanakah Shale Member, Ludlowville Formation, Erian, Middle Devonian, in New York (loc. Dib).

Illustrations.—Plate 22, figures 9-11.——9, 11. Facetal views of typical nodals (UKPI Dib4d, Dib4e, from loc. Dib), ×13.——*10. Facetal view of type specimen with 5 cirrus scars on periphery, circular facet for articulation with internodal marked by short crenulae, broad areola, and stellate lumen, ×13.

Genus EXEDRODISCUS Moore & Jeffords, new genus

Stem heteromorphic, with much-expanded noncirriferous nodals which become thin and irregularly circular in outline peripherally; articular facet with short, straight crenulae, narrow depressed areola and mound-shaped perilumen surrounding medium-sized circular lumen; nature of noditaxes unknown.

Type species.—*Exedrodiscus *excussus* Moore & Jeffords, new species, from Lower Mississippian of Kentucky; designated herein.

Occurrence.—Lower Mississippian.

EXEDRODISCUS *EXCUSSUS Moore & Jeffords, new species

With characteristics of the genus, surface of nodals distinctly granulose. Measurements (in mm.) and indices of the type specimen, a nodal, are: KD, 16.5; F, 6.2; Fi, 37; L, 1.0; Li, 16; P, 2.6; Pi, 42; A, 1.0; Ai, 16; C, 1.6; Ci, 26; KH, 2.0; KHi, 12.

Type specimen.—UKPI *Ma38a from loc. Ma.

Occurrence.—New Providence Shale, Borden Group, Osagian, Lower Mississippian, in Kentucky (loc. Ma).

Illustrations.—Plate 23, figure *9, facetal view of type specimen, nodal with small facet for articulation with internodal and very broad, thin, granulose epifacet terminating peripherally in uneven sharp edge, ×3.5.

Genus AMPHOLENIUM Moore & Jeffords, new genus

Stem heteromorphic, nodals noncirriferous, with part beyond facet subcircular in vertical section, resembling inflated tire surrounding facet, which is characterized by its narrow crenularium, depressed areola, prominent but narrow perilumen, and large circular lumen.

*Type species.—Ampholenium *apolegma* Moore & Jeffords, new species, from Lower Mississippian of Kentucky; designated herein.

Occurrence.—Lower Mississippian.

AMPHOLENIUM *APOLEGMA Moore & Jeffords, new species

With characteristics of genus, surface smooth. Measurements (in mm.) and indices of the type specimen, a nodal with internodal attached to one side, are: KD, 16.0; F, 12.0; Fi, 75; L, 5.5; Li, 45; P, 1.3; Pi, 11; A, 3.2; Ai, 27; C, 2.0; Ci, 27; KH, 2.5; KHi, 15.

Type specimen.—UKPI *Me120 from loc. Me.

Occurrence.—Floyds Knob Formation, Borden Group, Osagian, Lower Mississippian, in Kentucky (loc. Me).

Illustrations.—Plate 23, figure *2a,b, facetal views of opposite sides of type specimen, one (*2a) showing attached internodal, both showing rounded epifacet of nodal, narrow crenularium, and large circular lumen with periluminal rim, ×3.5.

Genus GONIOSTATHMUS Moore & Jeffords, new genus

Stem heteromorphic, flangelike nodals lacking cirrus scars, noditaxes of eight columnals in which internodals are very thin, those adjoining nodals commonly overlapped by them so as not to be visible externally articular facet characterized by very regular, extremely narrow crenularium, wide flat areola and medium-sized circular lumen.

*Type species.—Goniostathmus *annexus* Moore & Jeffords, new species, from Lower Mississippian of Iowa; designated herein.

Occurrence.—Lower Mississippian.

GONIOSTATHMUS *ANNEXUS Moore & Jeffords, new species

With characteristics of genus, surface smooth. Measurements (in mm.) and indices of the type specimen are: KD (nodal), 19.0; KD (internodal), 14.2; F, 14.0; Fi, 74; L, 3.2; Li, 23; A, 8.8; Ai, 63; C, 2.0; Ci, 14; NT, 5.0; IN, 2.4; INi, 48.

Type specimen.—USNM *Mec28 from loc. Mec.

Occurrence.—Burlington Limestone, Osagian, Lower Mississippian, in Iowa (loc. Mec).

Illustrations.—Plate 22, figure *12a,b, facetal view of secundinternodal (topmost in *12b) with nodals seen beneath, showing short crenulae, flat areola, and round lumen, side of pluricolumnal showing flangelike projecting nodals with convex latera, 7 internodals (not all visible) making noditaxes of 8 columnals, ×2.

Genus GONIOCION Moore & Jeffords, new genus

Stem strongly heteromorphic, although some specimens having only juxtaposed nodals visible externally seem to be homeomorphic, nodals with sharply angulated longitudinal profile, much taller than internodals, cirri lacking; articular facet with narrow crenularium, broad and flat areola, and small circular lumen.

*Type species.—Goniocion *gonimus* Moore & Jeffords, new species, from Lower Mississippian of Iowa; designated herein.

Discussion.—A chief peculiarity of *Goniocion* is partial or complete concealment of internodes by the nodals, articular facets of which are deeply recessed in vertical-walled cups each fitted to embrace approximately half of the internodals of an internode. In some specimens the nodals are sufficiently separated to reveal internodals but not all of them—surprisingly, a total of 7, which signify noditaxes of 8 columnals.

Occurrence.—Lower Mississippian.

GONIOCION *GONIMUS Moore & Jeffords, new species

With characteristics of the genus but commonly revealing parts of internodes externally. Measurements (in mm.) and indices of the type specimen are: KD (nodal), 14.8; KD (internodal), 10.5; F, 10.5; Fi, 75; L, 1.4; Li, 13; A, 7.5; Ai, 72; C, 1.6; Ci, 15; KH (nodal), 3.2; NT, 4.0; IN, 2.4; INi, 60.

Type specimen.—USNM *Mec20 from loc Mec.

Occurrence.—Burlington Limestone, Osagian, Lower Mississippian, in Iowa (loc. Mec).

Illustrations.—Plate 23, figure *6a,b, facetal and side views of type specimen (*6a showing topmost columnal in *6b), noditaxes of 8 uneven-sized columnals with priminternodals nearly matching nodals, ×2.

GONIOCION TURGIDUS Moore & Jeffords, new species

Mainly characterized by tall nodals which may conceal internodes entirely, sides of columnals smooth. Measurements (in mm.) and indices of the type specimen are: KD (nodal), 16.0; KD (internodal), 11.0; F, 11.0; Fi, 69; L, 1.0; Li, 9; A, 8.0; Ai, 73; C, 2.0; Ci, 18; KH (nodal), 6.0; NT, 8.0; IN, 4.3; INi, 54.

Type specimen.—USNM *Mec24 from loc. Mec.

Occurrence.—Burlington Limestone, Osagian, Lower Mississippian, in Iowa (loc. Mec).

Illustrations.—Plate 23, figure *4a,b, facetal and side views of type specimen (*4a showing thin internodal attached to nodal seen behind it), side view showing even succession of nodals with internodals not visible, ×2.

Genus CYCLOSTELECHUS Moore & Jeffords, new genus

Stem heteromorphic, with laterally expanded sharp-edged nodals which lack cirrus scars, noditaxes of 8 columnals, internodals rounded in longitudinal profile; articular facet with moderately large pentalobate lumen, flat areola of medium width, and narrow crenularium.

Type species.—*Cyclostelechus* **turritus* MOORE & JEFFORDS, new species, from Lower Mississippian of Iowa; designated herein.

Occurrence.—Lower Mississippian.

CYCLOSTELECHUS *TURRITUS Moore & Jeffords, new species

With characteristics of genus, sides of columnals smooth. Measurements (in mm.) and indices of the type specimen are: KD (nodal), 10.8; KD (internodal), 5.4; F, 5.4; Fi, 50; L, 1.8; Li, 33; A, 2.4; Ai, 45; C, 1.2; Ci, 22; NT, 14.0; IN, 11.0; INi, 79.

Type specimen.—USNM *Mec19 from loc. Mec.

Occurrence.—Burlington Limestone, Osagian, Lower Mississippian, in Iowa (loc. Mec).

Illustrations.—Plate 23, figure *3a,b, facetal and side views of type specimen showing incompletely developed noditaxes of 8 columnals, ×4.5.

Family CYCLOCHARACIDAE Moore & Jeffords, new family

Stem homeomorphic or weakly heteromorphic, mostly straight-sided, columnals relatively low; articular facets characterized by pentalobate to pentastellate lumen generally surrounded by crenularium only but in some forms small areola may be present; no perilumen.

Type genus.—*Cyclocharax* MOORE & JEFFORDS, new genus, from Upper Silurian.

Occurrence.—Upper Silurian-Middle Pennsylvanian.

Genus CYCLOCHARAX Moore & Jeffords, new genus

Stem homeomorphic, with low straight-sided columnals joined by fine wavy sutures, articular facets with medium-sized to large pentastellate lumen surrounded only by crenularium, which has numerous moderately coarse, straight crenulae.

Type species.—*Cyclocharax* **fasciatus* MOORE & JEFFORDS, new species, from Upper Silurian of Indiana; designated herein.

Occurrence.—Upper Silurian.

CYCLOCHARAX *FASCIATUS Moore & Jeffords, new species

Stem small, composed of very low columnals; facet with large star-shaped lumen, crenulae moderately coarse, with 20 to 25 in half circumference. Measurements (in mm.) and indices of the type specimen are: F, 6.4; L, 2.0; Li, 31; C, 4.4; Ci, 69; KH, 0.46; KHi, 6.4. Other specimens are essentially identical.

Type specimen.—UKPI *Shg13 from loc. Shg.

Occurrence.—Waldron Shale, Niagaran, Upper Silurian, in Indiana (loc. Shg).

Illustrations.—Plate 23, figures 7-*8.——7a,b. Side and facetal views of average specimen (UKPI Shg20c, from loc. Shg) showing relatively large pentalobate lumen and absence of areola, stem homeomorphic, ×10, ×7.——*8. Side view of type specimen, facets (not shown) essentially identical with 7b, ×6.

CYCLOCHARAX MODESTUS Moore & Jeffords, new species

Stem slender, approximately one-half narrower in diameter than *Cyclocharax* **fasciatus*, otherwise distinguished mainly by its smaller sharp-pointed stellate lumen, finer crenulae, and relatively much taller columnals, which have smooth, straight sides. Measurements (in mm.) and indices of the type specimen are: F, 3.3; L, 0.6; Li, 18; C, 2.7; Ci, 82; KH, 0.6; KHi, 18.

Type specimen.—UKPI *Shg4a from loc. Shg.

Occurrence.—Waldron Shale, Niagaran, Upper Siluruian, in Indiana (loc. Shg).

Illustrations.—Plate 23, figure *1a,b, facetal and side views of type specimen showing angularly stellate lumen, wide crenularium, and straight-sided homeomorphic column, ×7.

Genus CIONERISMA Moore & Jeffords, new genus

Stem homeomorphic, resembling *Cyclocharax* except for its longitudinally convex, relatively taller columnals, which are joined by distinctly crenulate sutures; articular facet closely similar to that of *Cyclocharax modestus*.

Type species.—*Cionerisma* **exile* MOORE & JEFFORDS, new species, from Upper Silurian of Indiana; designated herein.

Occurrence.—Upper Silurian.

CIONERISMA *EXILE Moore & Jeffords, new species

With characteristics of the genus, sides of columnals smooth. Measurements (in mm.) and indices of the type specimen are: F, 3.9; L, 0.9; Li, 22; C, 3.0; Ci, 78; KH, 0.7; KHi, 18.

Type specimen.—UKPI *Shg9d from loc. Shg.

Occurrence.—Waldron Shale, Niagaran, Upper Silurian, in Indiana (loc. Shg).

Illustrations.—Plate 23, figure *5a,b, facetal and side views of type specimen showing gently convex columnals of homeomorphic stem, ×7.

Family FLORICYCLIDAE Moore & Jeffords, new family

Stem heteromorphic, although superficially homeomorphic in some genera, composed of straight-sided or longitudinally convex columnals, nodals commonly cirriferous; mainly distinguished by features of articular facet, including strongly floriform outline of lumen bordered by distinct, denticulate or tuberculate perilumen in most but not all genera, areola present, crenularium mostly quite narrow and composed of short, moderately coarse crenulae.

Type genus.—*Floricyclus* MOORE & JEFFORDS, new genus, from Mississippian and Pennsylvanian.

Occurrence.—Lower Mississippian - Upper Pennsylvanian.

Genus FLORICYCLUS Moore & Jeffords, new genus

Stem rather weakly heteromorphic, with nodals distinguished by greater-than-average height and in some forms by presence of cirrus scars; sides of columnals mostly almost straight but tending toward gently convex longitudinal profile, sutures generally not indented or crenulate; articular facet characterized by proportionally large pentalobate to strongly floriform lumen with narrow points between petaloid rays, presence of perilumen and comparatively narrow areola, crenularium of short, moderately coarse crenulae.

Type species.—*Floricyclus *hebes* MOORE & JEFFORDS, new species, from Middle Pennsylvanian of Texas; designated herein.

Occurrence.—Lower Mississippian - Upper Pennsylvanian.

FLORICYCLUS *HEBES Moore & Jeffords, new species

Columnals relatively wide and very low, with gently convex sides; articular facet with narrow crenularium forming raised rim around depressed, smooth areola, large pentalobate lumen with rounded to somewhat truncate extremities of rays, bordered by prominent denticulate perilumen. Measurements (in mm.) and indices of the type specimen are given with those for other species in the following tabulation, which readily provides for comparisons.

Type specimen.—UKPI *Pak13 from loc. Pak.

Occurrence.—Mingus Shale, Strawn Group, Desmoinesian, Middle Pennsylvanian, in Texas (loc. Pak).

Illustrations.—Plate 24, figure *5a,b, facetal and side views of type specimen showing depressed areola, large pentalobate lumen surrounded by prominent granulose perilumen, latera of columnals gently convex, ×3.5, ×2.5.

FLORICYCLUS WELLERI Moore & Jeffords, new species

Resembles *Floricyclus angustimargo* rather closely but crenulae coarser and denticles on summit of perilumen somewhat larger.

Type specimen.—UKPI *Md43 from loc. Md.

Occurrence.—Brodhead Formation, Borden Group, Osagian, Lower Mississippian, in Kentucky (loc. Md).

Illustrations.—Plate 24, figure *8a,b, facetal and side views of type specimen showing culmen-like tubercles of perilumen and straight columnal latera slightly uneven in height, ×5, ×2.5.

FLORICYCLUS ANGUSTIMARGO Moore & Jeffords, new species

Mainly distinguished by narrow, denticulate perilumen with sharp points projecting between petaloid rays of lumen, in some specimens nearly meeting one another, areola smooth to faintly granulose.

Type specimen.—UKPI *Piw2 from loc. Piw.

Occurrence. — Minturn Formation, Desmoinesian, Middle Pennsylvanian, in Colorado (loc. Piw).

Illustrations.—Plate 24, figures *6-7, facetal views of type specimen and another columnal (UKPI Piw1, from loc. Piw) showing petaloid lumen bordered narrow beaded perilumen, points between lobes of lumen very sharp, ×4.5.

FLORICYCLUS KANSASENSIS Moore & Jeffords, new species

Similar to *Floricyclus angustimargo* in long sharp points between petaloid rays of lumen, perilumen less compact, floor of areola quite smooth; sides of faintly convex columnals markedly granulose.

Type specimen.—UKPI *Phu1c from loc. Phu.

Occurrence.—Cabaniss Formation, Cherokee Group, Desmoinesian, Middle Pennsylvanian, in southeastern Kansas (loc. Phu).

Illustrations.—Plate 24, figure *9a,b, facetal and side views of type specimen showing coarse, short crenulae, clustered small rubercles of inner part of areola, and sharp points between petals of lumen nearly meeting one another, columnal latera unequal in height, with granulose surface, sutures crenulate, ×4.5.

FLORICYCLUS PULCHER Moore & Jeffords, new species

Most closely resembling *Floricyclus angustimargo* but with proportionally larger floriform lumen bordered by very sharp, narrow perilumen with fine summit denticulation, crenularium reduced to bare rim; sides of columnals straight and smooth.

Type specimen.—UKPI *Phu1d from loc. Phu.

Occurrence.—Cabaniss Formation, Cherokee Group, Desmoinesian, Middle Pennsylvanian, in southeastern Kansas (loc. Phu).

Illustrations.—Plate 24, figure *4a,b, facetal and side view of type specimen showing culmina of crenularium reduced to circle of small beads, areola smooth and concave, bluntly pentalobate lumen surrounded by narrow ribbed perilumen, columnal latus straight and smooth, ×2.5.

FLORICYCLUS GRANULOSUS Moore & Jeffords, new species

Lumen relatively smaller than in other species, with rounded or truncate extremities of its rays, perilumen not well differentiated from coarsely granulose areola,

*Measurements and indices for Floricyclus *hebes and other species*

Species	Specimen	F	L	Li	P	Pi	A	Ai	C	Ci	KH	KHi
*F. *hebes*	*Pak13	13.5	5.0	37	3.5	26	3.0	22	2.0	15	2.5	18
F. welleri	*Md43	8.8	2.5	28	1.7	19	2.6	30	2.0	23	2.0	23
F. angustimargo	*Piw2	10.0	3.0	30	0.9	9	3.5	35	2.6	26	2.2	22
"	Piw1	12.5	4.0	32	1.8	14	4.1	33	2.6	21	2.4	19
P. kansasensis	*Phu1c	7.6	1.8	24	1.7	22	2.5	33	1.6	21	1.7	22
P. pulcher	*Phu1d	13.0	4.7	36	1.7	13	5.4	42	1.2	9	2.0	15
F. granulosus	*Pba4	7.0	1.7	24	1.5	21	2.0	29	1.8	26	1.7	24
"	Pba68	7.8	2.4	31	1.8	23	1.6	20	2.0	26	1.8	23

crenulae with tendency to greater length than in other species.

Type specimen.—UKPI *Pba4 from loc. Pba.

Occurrence.—South Bend Shale Member, Thrifty Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (loc. Pba).

Illustrations.—Plate 24, figures 1-3; Plate 26, figures 9-16.——Pl. 24, fig. 1-*2. Rugose facet of columnal (UKPI Pba7, from loc. Pba) and facetal view of type specimen, ×4.5, ×5.——Pl. 26, fig. 9-10, 13. Facets of fully grown columnals (E 682-5, E 682-9, E 682-8, from loc. E 682) showing rough areolar floor and variations in shape of lumen, ×4.5.——Pl. 26, fig. 11-12. Facetal views of inferred juvenile columnals (E 682-10, E 682-11, from loc. E 682), ×4.5.——Pl. 26, fig. 14. Transverse median section of nodal (E 682-2, from loc E 682) showing 5 canalicula leading to cirri, ×3.5.——15-16. Side views of two pluricolumnals (E 733-29, from loc. E 733, and E 734-1, from loc. 734) showing straight-sided columnals and noditaxes containing 1 or 2 internodals, both ×1.7.

Genus CYCLOCION Moore & Jeffords, new genus

Stem heteromorphic, but with nodals not well differentiated in width or height from internodals, cirrus scars or nubbins of small cirri commonly present on nodals, however; chiefly characterized by articular facets with large stellate lumen, broad smooth areola, and very narrow crenularium; sides of columnals gently convex in longitudinal profile, joined along distinctly crenulate sutures.

Type species.—*Cyclocion *distinctus* Moore & Jeffords, new species, from Upper Mississippian of Illinois; designated herein.

Occurrence.—Upper Mississippian.

CYCLOCION *DISTINCTUS Moore & Jeffords, new species

With characteristics of the genus; sides of columnals ranging from smooth to distinctly granulose, with tendency to develop faint ridge at mid-height of columnals, many internodals wafer-thin and with aligned positions of crenulae on opposite facets, giving wavy appearance to entire edge of columnal. Measurements (in mm.) and indices of the type specimen and another representative one (Mey1j, fig. 25,*2,* for which data are enclosed by brackets) are: F, 5.3 [6.8]; L, 2.2 [2.4]; Li, 41 [35]; P, 1.0 [0.8]; Pi, 19 [12]; A, 1.4 [2.9]; Ai, 27 [43]; C, 0.7 [0.7]; Ci, 13 [10]; KH (av.), 0.9; KHi, 17; NT, 4.6; IN, 3.2; INi, 70.

Type specimen.—UKPI *Mey1a from loc. Mey.

Occurrence.—Paint Creek Formation, Chesteran, Upper Mississippian, in Illinois (loc. Mey).

Illustrations.—Plate 24, figures 15-16; Plate 25, figures *1-7; [all from loc. Mey].——Pl. 24, fig. 15a,b. Facetal and side views of average short pluricolumnal (UKPI Mey8a), ×7, ×4.5.——Pl. 24, fig. 16a,b. Similar views of another specimen (UKPI Mey1h), ×8.5.——Pl. 25, fig. *1a,b. Facetal and side views of type specimen, ×6, ×3.5.——Pl. 25, fig. 2a,b. 3a,b. Similar views of short pluricolumnals (UKPI Mey1j, Mey1i), ×6.——Pl. 25, fig. 4a,b. Facetal and side view of specimen (UKPI Mey1b) resembling type, ×6, ×4.5.——Pl. 25, fig. 5a,b, 6a,b. Specimens (UKPI Mey1e, Mey1f), facetal views ×7, side views ×4.5.——Pl. 25, fig. 7a,b. Facetal and side view of another specimen (UKPI Mey1d), ×7, ×4.5.

Genus PLUMMERANTERIS Moore & Jeffords, new genus

Stem medium-sized, weakly but definitely heteromorphic, with noditaxes of 8 columnals, nodals higher and slightly wider than internodals, noncirriferous, sides of columnals gently convex longitudinally, with noncrenulate sutures in sharp-angled depressions between columnals; articular facets with prominent crenularium composed of coarse, straight crenulae extending to margin of granulose or finely denticulate perilumen, strongly floriform lumen with thin divisions between petals almost meeting at center of lumen; inner edges of columnals bordering lumen rounded-truncate providing lateral expansions of lumen at intercolumnal positions.

Type species.—*Plummeranteris *sansaba* Moore & Jeffords, new species, from Middle Pennsylvanian of Texas; designated herein.

Occurrence.—Middle Pennsylvanian.

PLUMMERANTERIS *SANSABA Moore & Jeffords, new species

With characteristics of genus; sides of columnals smooth. Measurements (in mm.) and indices of type specimen are: KD, 12.0; F, 11.0; L, 3.0; Li, 27; P, 3.3; Pi, 30; C, 4.7; Ci, 43; KH, 3.2; KHi, 27.

Type specimen.—UKPI *Peg3 from loc. Peg.

Occurrence.—Marble Falls Limestone, Atokan, Middle Pennsylvanian, in Texas (loc. Peg).

Illustrations.—Plate 24, figures *10-14.——*10a,b. Side view and median longitudinal section of type specimen, ×1.7.——11a,b, 12a,b. Similar views and sections of two other specimens (UKPI Peg1, Peg5, from loc. Peg), nodals barely larger than internodals, ×1.7.——13-14. Facetal views of two specimens (UKPI Peg6, Peg7, from loc. Peg) showing moderately coarse, straight crenulae, finely ridged to granulose perilumen, and very strongly petaloid lumen with points between lobes nearly meeting one another, ×2.5.

Genus LAMPROSTERIGMA Moore & Jeffords, new genus

Stem homeomorphic or very weakly heteromorphic, columnals low, with straight or gently convex profile longitudinally, sutures noncrenulate, unindented; articular facet characterized by moderately broad crenularium of straight crenulae set off on inner side by knife-sharp boundary from bowl-shaped, smooth-floored areola, which extends to edge of pentalobate large lumen or is faintly separated from it by very narrow, weak perilumen.

Type species.—*Lamprosterigma* **mirificum* Moore & Jeffords, new species, from Middle Pennsylvanian of Kansas; designated herein.

Occurrence.—Middle Pennsylvanian.

LAMPROSTERIGMA *MIRIFICUM Moore & Jeffords, new species

Stem moderately large, columnals straight-sided; crenulae tending to bifurcate near periphery of crenularium, large lumen without perilumen. Measurements (in mm.) and indices of type specimen are: F, 14.7; L, 5.0; Li, 34; A, 3.7; Ai, 25; C, 6.0; Ci, 41; KH, 4.0; KHi, 27.

Type specimen.—UKPI *Phu5 from loc. Phu.

Occurrence.—Cabaniss Formation, Cherokee Group, Desmoinesian, Middle Pennsylvanian, in southeastern Kansas (loc. Phu).

Illustrations.—Plate 25, figure *10a,b, facetal and side views of type specimen showing even width of crenularium with strikingly sharp boundary around smooth, gently concave areola, and relatively large pentalobate lumen, ×2.5.

LAMPROSTERIGMA ERATHENSE Moore & Jeffords, new species

Stem similar to *Lamprosterigma* **mirificum* but larger and with proportionally much lower columnals, which are slightly convex in longitudinal profile; facetal characteristics also similar except for presence of inconspicuous, weakly developed perilumen around very large lumen. Measurements (in mm.) and indices of type specimen are: F, 20.0; L, 6.7; Li, 34; A, 4.1; Ai, 20; C, 9.2; Ci, 46; KH, 1.6; KHi, 8.

Type specimen.—UKPI *Pak15 from loc. Pak.

Occurrence.—Mingus Shale, Strawn Group, Desmoinesian, Middle Pennsylvanian, in Texas (loc. Pak).

Illustrations.—Plate 25, figure *15a,b, facetal and side view of type specimen, very robust homeomorphic pluricolumnal, ×3.5, ×2.5.

Family LEPTOCARPHIIDAE Moore & Jeffords, new family

Stem distinctly heteromorphic, medium-sized to slender, generally very similar to Leptocremastridae both in side view and features of articular facets except for circular outline of lumen and tendency to develop perilumen; nodals commonly cirriferous, whereas in leptocremastrid genera they are not.

Type genus.—*Leptocarphium* Moore & Jeffords, new genus, from Middle Pennsylvanian.

Occurrence.—Middle Pennsylvanian-Lower Permian.

Genus LEPTOCARPHIUM Moore & Jeffords, new genus

Stem slender, with longitudinally rounded or somewhat angularly convex profile of columnals, which vary considerably in height with nodals widest and tallest, diminishing in prim-, secund-, tert-, and quartinternodals, noditaxes of 16 columnals; articular facet with narrow crenularium of short, straight crenulae around concave areola extending to circular lumen, no perilumen.

Type species.—*Leptocarphium* **gracile* Moore & Jeffords, new species, from Middle Pennsylvanian of Texas; designated herein.

Occurrence.—Middle Pennsylvanian.

LEPTOCARPHIUM *GRACILE Moore & Jeffords, new species

Nodals resembling flattened beads with small circular cirrus scars at mid-height, internodals of different orders narrower and progressively lower, wavy sutures between all columnals very evident. Measurement (in mm.) of columnal widths in type specimen and another example (Pak39, Pl. 25, fig. 12) are: N, 3.4-4.0; 1IN, 3.0-3.6; 2IN, 2.8-3.2; 3IN, 2.4-2.8; 4IN, 2.3-2.5. Height of these columnals is: N, 1.6-2.0; 1IN, 0.9-1.4; 2IN, 0.7-1.2; 3IN, 0.6-1.0; 4IN, 0.2-0.3; NT, 8.4-9.5; ĪN, 6.5-8.0; INi, 77-84. Facetal features of the type specimen (and Pak39, given in brackets) have measurements (in mm.) and indices as follows: KD, 3.0 [3.2]; F, 2.3 [2.5]; Fi, 77 [78]; L, 0.4 [0.5]; Li, 17 [20]; A, 1.5 [1.4]; Ai, 66 [66]; C, 0.4 [0.6]; Ci, 17 [24].

Type specimen.—UKPI *Pak38 from loc. Pak.

Occurrence.—Mingus Shale, Strawn Group, Desmoinesian, Middle Pennsylvanian, in Texas (loc. Pak).

Illustrations.—Plate 25, figures *11-12, facetal and side views of type specimen and another pluricolumnal (UKPI Pak39, from loc. Pak) showing strongly heteromorphic nature of stem, large nodals cirrus-bearing, noditaxes of 16 columnals, sutures markedly crenulate, facets (*11a, 12a) ×8.5, side views (*1b, 2b) ×4.5.

LEPTOCARPHIUM REGULARE Moore & Jeffords, new species

Stem wider and composed of more even-sized columnals than in *Leptocarphium* **gracile*; nodals with one or two cirrus scars. Average width of columnals (in mm.) is: N, 5.0; 1IN, 4.8; 2IN, 4.7; 3IN, 4.5; 4IN, 4.3. Average height, similarly, is: N, 1.8; 1IN, 1.4; 2IN, 1.25; 3IN, 1.1; 4IN, 0.4. Measurements (in mm.) and indices of the facet of the type specimen are: KD, 5.2; F, 4.4; Fi, 80; L, 0.5; Li, 11; A, 3.2; Ai, 73; C, 0.7; Ci, 16.

Type specimen.—UKPI *Pak24 from loc. Pak.

Occurrence.—Mingus Shale, Strawn Group, Desmoinesian, Middle Pennsylvanian, in Texas (loc. Pak).

Illustrations.—Plate 25, figures *8-9.——*8a,b. Facetal and side views of type specimen showing heteromorphic pattern of columnals and strongly crenulate sutures between them, nodal with cirrus scar 3rd from top, noditaxes of 8 columnals, ×8.5, ×4.5.——9. Side view of another typical specimen (UKPI Pak25, from loc. Pak), ×4.5.

Genus CYCLOCRISTA Moore & Jeffords, new genus

Stem slender to medium-sized, noditaxes of 4 to 8 columnals, nodals with 1 to 3 cirrus scars or none, sides of columnals with narrow sharp keel or strong angulation at mid-height; articular facet with narrow crenularium of short, coarse, straight crenulae, separated from areola by declivity, areola generally somewhat concave but may be raised to resemble very broad perilumen around circular to quinquelobate lumen; sutures between columnals not indented, distinctly crenulate.

Type species.—*Cyclocrista* **lineolata* Moore & Jeffords, new species, from Upper Pennsylvanian of Texas; designated herein.

Occurrence.—Upper Pennsylvanian-Lower Permian.

CYCLOCRISTA *LINEOLATA Moore & Jeffords, new species

Stem slender, nodals and internodals nearly identical in width (3.6 to 5.5 mm. in different stems) but with height (2.0 to 4.5 mm.) approximately twice average height of internodals (1.1 to 2.5 mm.), nodals commonly with pair of cirrus scars but ranging from 0 to 3; articular facet with 16 to 22 short crenulae in half-circumference, areola raised in inner part resembling broad perilumen, circular lumen small to medium-sized. Measurements (in mm.) and indices of the type and another specimen (Paw88, Pl. 25, fig. 14, given in brackets) are: F, 5.0 [4.3]; L, 0.25 [0.5]; Li, 5 [12]; ?P+A, 3.35 [2.3]; ?P+Ai, 67 [53]; C, 1.4 [1.5]; Ci, 28 [35]; KH (av.), 2.4 [2.1]; KHi, 48 [49].

Type specimen.—UKPI *Paw74a from loc. Paw.

Occurrence.—Chaffin Limestone Member, Thrifty Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (loc. Paw).

Illustrations.—Plate 25, figures *13-14, facetal and side views of type specimen and another pluricolumnal (UKPI Paw88, from loc. Paw) showing moderately tall granulose columnals with narrow keel at mid-height, ×3.5.

CYCLOCRISTA CHENEYI Moore & Jeffords, new species

Stem larger and with more angularly-sided columnals than in *Cyclocrista *lineolata,* nodals commonly cirriferous; articular facet with average of 22 straight crenulae in half-crenularium, moderately large circular lumen with or without very narrow perilumen, areola broad, concave; sides of columnals with scattered coarse granules or small tubercles. Measurements (in mm.) and indices of the type and another specimen (Pl. 26, fig. 8, figures enclosed by brackets) are: FD, 13.0 [7.9]; F, 11.3 [5.7]; Fi, 87 [72]; L, 1.3 [1.3]; Li, 12 [23]; P, 1.3 [0]; Pi, 12 [0]; A, 6.5 [2.8]; Ai, 57 [49]; C, 2.2 [1.6]; Ci, 19 [28].

Type specimen.—UKPI *Qry5 from loc. Qry.

Occurrence.—Waldrip Shale Member, Pueblo Formation, Wolfcampian, Lower Permian, in Texas (loc. Qry).

Illustrations.—Plate 26, figures *7-8.——*7a,b. Facetal and side views of type specimen showing keeled columnals with rows of sparse tubercles on slopes of latera, sutures distinctly crenulate, ×3.5.——8a,b. Similar views of a longer pluricolumnal (UKPI Qry4, from loc. Qry) showing coarse, straight crenulae, concave areola, subcircular lumen, latera of columnals keeled, tallest columnals being nodals, some with cirrus scars, ×7.5, ×5.

CYCLOCRISTA MARTINI Miller, new species

Stems slender to medium-sized; noditaxes of 6 to 8 columnals with angular sides sparsely ornamented with nodes and granules; angulation, height, and diameter decreasing with order of insertion; nodal largest, 3IN smallest; angulation of 3IN weakly developed to nodular, nodals with 1 to 3 cirrus scars; lumen small to medium in diameter and circular to quinquelobate; areola concave, in median longitudinal section sloping to straight-sided or slightly rounded inner columnal edges. Inner columnal edges cellular in juveniles but apparently simple; cirral canals angled into axial canal.

Type specimen.—E *5-16 from Wayland Shale in McCulloch County.

Discussion.—This species is easily distinguished from *Cyclocrista *lineolata* Moore & Jeffords, which occurs in the Chaffin Limestone, Upper Pennsylvanian, by greater angulation of the sides.

Culmina are moderately numerous and increase in number with growth. They may be almost as long on small as on large specimens. Areola and lumen on most specimens are indistinct and poorly preserved. The area underlying the areola, as viewed in median longitudinal section, also is poorly preserved. Axial-canal width, measured between mid-heights of inner columnal edge, is variable and rarely is greater in smaller specimens than in larger ones. Most noditaxes have 7 internodals.

Cirrus scars range from fully crenulate circular facets to small button-like nodes located near the apex of angular columnal sides. No cirrus scars were noted at nodal mid-height but all are off-centered and angled with a sporadic short (2 to 3 mm.) cylindrical projection instead of typical cirral ossicles.

Occurrence.—Wayland Shale Member, Graham Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (locs. E 5, E 675, E 705, E 722, E 732, E 733, E 734).

Illustrations.—Plate 26, figures 1-6.——1a,b. Side and facetal views of specimen (E 734-35, from loc. E 734) showing strongly keeled columnals, nodals with attached proximal cirrals, ×3.5, ×5.——2. Long, slender pluricolumnal (E 734-306, from loc. E 734) showing button-like cirrus markings on columnals, ×5.——*3a,b. Facetal and side views of type specimen showing finely granulose columnal latera and cirripores on nodal (bottom columnal), ×3.5, ×5.——4-5. Side views of well-preserved specimen (E 5-15, from loc. E 5), ×3.5, ×7.——6. Median longitudinal section of specimen (E 734-300, from loc. E 734) showing simple nature of axial canal, ×5. [Additional illustrations of this species are given in Echinodermata **10**, Plate 4.]

Genus PREPTOPREMNUM Moore & Jeffords, new genus

Stem medium-sized, with articular facets slightly narrower than greatest width of columnals, which have gently to rather strongly rounded longitudinal profile; crenularium narrow, with medium to coarse crenulae well set off from broad areola, which is flat, slightly concave, or weakly convex, invariably marked by fine granulose or vermiculate irregularities; lumen large, circular, bordered by narrow perilumen or accentuated edge of areola resembling perilumen, lumen containing claustra at midheight of columnals, in well-preserved specimens showing minute stellate jugulum and jugular ramparts centrally located on claustra. Noditaxes of 4 columnals.

Type species.—*Preptopremnum *rugosum* MOORE & JEFFORDS, new species, from Upper Pennsylvanian of Texas; designated herein.

Occurrence.—Middle Pennsylvanian-Upper Pennsylvanian.

PREPTOPREMNUM *RUGOSUM Moore & Jeffords, new species

Stem medium-sized, with longitudinally well-rounded columnals, sides finely granulose and bearing scattered low or protuberant tubercles, sutures crenulate and indented; nodals bearing one or two circular cirrus scars which generally have smaller diameter than height of nodal but which may exceed this so as to impinge on contiguous internodals; articular facet with typical features of the genus, including development of indistinct perilumen that grades into areola, large circular lumen in several specimens showing claustra, jugula, and jugular ramparts. Measurements (in mm.) and indices of the type and another specimen (Paw26, Pl. 27, fig. 6, figures enclosed by brackets) are: KD, 7.5 [8.0]; F, 7.0 [6.8]; Fi, 94 [85]; L, 2.4 [2.5]; Li, 34 [37]; P, 0.9 [0.9]; Pi, 13 [13]; A, 1.8 [1.6]; Ai, 26 [24]; C, 1.9 [1.8]; Ci, 27 [26]; NT, 8.5; IN, 6.0; INi, 71.

Type specimen.—UKPI *Paw12 from loc. Paw.

Occurrence.—Chaffin Limestone Member, Thrifty Formation, and Gunsight Limestone and Wayland Shale Members of Graham Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (loc. Paw, E 5, E 705, E 706, E 722, E 732).

Illustrations.—Plate 27, figures 1-9.——1. Facetal view of average columnal (UKPI Paw98, from loc. Paw), ×3.5. ——*2a,b. Facetal and side views of type specimen, surface of claustrum and small stellate jugulum visible below circular lumen, side view showing cirrinodals and noditaxes of 4 columnals, columnal latera tuberculate, ×3.6, ×1.7.——3. Facetal view of pluricolumnal (E 672-31, from loc. 672) showing large crenularium with worn culmina near lumen, ×5.——4-5. Facetal views of specimens (E 722-4, E 722-25, from loc. E 722) showing typical features of articula and with claustra and jugula visible beneath circular lumen, ×5.——6a,b. Facetal and side view of small pluricolumnal (UKPI Paw 26, from loc. Paw) showing rather narrow crenularium, wide granulose areola sloping to weak perilumen, claustrum and jugular ramparts visible beneath rim of circular lumen, side view showing 3 internodals and cirrus-bearing nodal, surface of latera more nodose than usual, ×3.5, ×1.7.——7a,b. Facetal and side views of specimen (UKPI Paw59, from loc. Paw), rounded latera of internodal and nodal ornamented by fine granules and low tubercles, ×3.5.——8-9. Median longitudinal section and side view of pluricolumnals (E 672-71 and E 672-75, from loc. E 672) showing internal features of columnals and complex axial canal and noditaxes of 4 columnals, ×1.7, ×3.5. [Additional illustrations of this species are given in Echinodermata Art. **8**, Pl. 3, fig. 4-8; Pl. 4, fig. 7, and Art. **10**, Pl. 2, fig. 1-10.]

PREPTOPREMNUM LAEVE Moore & Jeffords, new species

Very similar to *Preptopremnum *rugosum* but much more slender and with smooth, longitudinally nearly straight columnals, sutures not indented, distinctly crenulate; crenulae somewhat coarser than in *P. *rugosum* and vermiculate markings on areola coarser also, weak perilumen present, large circular lumen with septa but jugula not clearly discernible. Measurements (in mm.) and indices of the type specimen are: F, 3.8; L, 1.2; Li, 31; P, 0.5; Pi, 13; A, 1.1; Ai, 29; C, 1.0; Ci, 26; NT, 10.8; IN, 9.0; INi, 83.

Type specimen.—UKPI *Pak45 from loc. Pak.

Occurrence.—Mingus Shale, Strawn Group, Desmoinesian, Middle Pennsylvanian, in Texas (loc. Pak).

Illustrations.—Plate 27, figure *11a,b. Facetal and side views of type specimen showing very gently convex, smooth surface of columnals, nodals 2nd from top and bottom, noditaxes of 8 columnals, ×4.5.

Genus HETEROSTELECHUS Moore & Jeffords, new genus

Stem heteromorphic, columnals well rounded in longitudinal profile, sutures indented and crenulate, nodals with one or more circular cirrus scars, distinctly taller than internodals but not much wider; articular facet with coarse straight crenulae of medium length, areola somewhat concave, grading into elevated tract around circular lumen, this area being classifiable as perilumen or merely inner part of areola.

Type species.—*Heterostelechus *texanus* MOORE & JEFFORDS, new species, from Upper Pennsylvanian and Lower Permian of Texas; designated herein.

Occurrence.—Upper Pennsylvanian-Lower Permian.

HETEROSTELECHUS *TEXANUS Moore & Jeffords, new species

Characteristics of genus, surface rugose, with unevenly distributed rounded or pointed tubercles which tend toward vertical alignment in some specimens; axial canal constricted by claustra consisting of moderately thick, bluntly truncate extensions of mid-parts of nodals and larger internodals but thin flanges on inner sides of small internodals, all pierced by moderately small jugula; noditaxes of 8 columnals. Measurements (in mm.) and indices of type specimen are: KD, 8.0; F, 6.7; Fi, 84; L, 2.0; Li, 30; P+A, 1.8; P+Ai, 27; C, 2.9; Ci, 43; NT, 13.0; IN, 8.5; INi, 65. Similar data for a Lower Permian specimen (Pl. 28, fig. 7) are: KD, 8.1; F, 7.3; Fi, 90; L, 1.2; Li, 16; P, 2.2; Pi, 30; A, 0.7; Ai, 10; C, 3.2; Ci, 44; NT, 17.5; IN, 13.5; INi, 78.

Type specimen.—UKPI *Pdq212 from loc. Pdq.

Occurrence.—Belknap Limestone Member, Thrifty Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (loc. Pdq); Waldrip Shale Member, Pueblo Formation, Wichita Group, Wolfcampian, Lower Permian, in Texas (loc. Qry).

Illustrations.—Plate 27, figure *16; Plate 28, figures 1,7.——Pl. 27, fig. *16a,b. Side view and median longitudinal section of type specimen showing strongly convex, somewhat nodose surface of columnals, noditaxes of 4 columnals, and features of complex axial canal, ×1.7.——Pl. 28, fig. 1a,b. Side view and median longitudinal section of typical specimen (UKPI Pdq229, from loc. Pdq), ×3.5.——Pl. 28, fig. 7a,b. Side and facetal views of Lower Permian pluricolumnal (UKPI Qry2, from loc. Qry) showing noditaxes of 8 columnals ×3.5, ×7.5.

HETEROSTELECHUS JEFFORDSI Miller, new species

Stem slender, columnals gently rounded in longitudinal profile; sutures wavy to blocky. Noditaxes commonly 4 or 8 columnals; nodals distinctly taller than internodals, height of internodals decreasing with order of insertion; nodals with 1 to 3 cirrus scars, also with noncrenulate, button-like mounds or short, undeveloped cirrus attachments. Crenularium moderately wide, composed of coarse, straight, implanted or bifurcated culmina; areola of nodal and internodals 1IN and 2IN elevated, declining into circular, medium-size lumen, areola depressed in 31N. Axial canal in section view indented sharply at suture intercepts.

Type specimen.—E *672-26 from Wayland Shale in Brown County, Texas (loc. E 722).

Discussion.—Columnals of this species are characterized by the axial canal and frequently must be sectioned, particularly when comparisons are made between small specimens of *Preptopremnum *rugosum* Moore & Jeffords which have similar longitudinal profiles but a different interior. The major difference between this species and the type species, *Heterostelechus *texanus* Moore & Jeffords, is that the type is ornamented with nodes, whereas *H. jeffordsi* is smooth.

The areola differs considerably in shape depending on which columnal is observed. Nodals and internodals 1IN and 2IN have areolae that bulge upward, clearly seen (**10**, Pl. 3, fig. 5) in median section. The 31N internodals have concave areolae conforming to the shape of adjacent bulged columnals. Culmina are moderately abundant when compared with the columnal diameter. Traces of very fine culmina, unlike coarse ones of the crenularium, may be preserved (Pl. 28, fig. 2b) on the areola surfaces of a few specimens. Lengths of culmina are inexactly related to diameter of columnals. Noditaxes with 1 or 2 internodals were not noted although this may be because specimens were only moderately abundant in the collection. Noditaxes with 3 internodals are common and insertion rapidly proceeds to an observed maximum of 7 internodals.

Occurrence.—Wayland Shale Member, Graham Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (locs. E 5, E 675, E 682, E 705, E 706, E 722, E 732, E 733, E 734).

Illustrations.—Plate 28, figures 2-6.——2a,b. Side and facetal views of average pluricolumnal (E 5-6, from loc. E 5) showing noditaxis of 8 columnals, fig. 2b showing attached zygocirral, ×3.5, ×5.——3a,b. Side and facetal views of slender pluricolumnal (E 672-28), from loc. E 672), normal noditaxes but cirrus scars on nodals weak, ×3.5.——*4a,b. Side and facetal views of type specimen, which has only 6 columnals in noditaxis, however, ×3.5, ×5.——5. Side view of specimen (E 5-50, from loc. E 5) with noditaxis of 8 columnals, ×3.5.——6. Side view of specimen (E 732-42, from loc. E 732) with noditaxes of 4 columnals, ×3.5. [Additional illustrations of this species are given in Echinodermata Art. 10, Pl. 3, fig. 1-9.]

HETEROSTELECHUS KEITHI Miller, new species

Stems medium-sized, columnals strongly rounded in longitudinal profile, noditaxes commonly exceed 8 internodals that decrease in height with order of insertion. Nodals with 1 or 2 medium to broad cirrus scars which may incorporate several adjacent columnals. Crenularium moderately broad, composed of straight, implanted or rarely bifurcating colmina; areola medium-sized, with rough floor, circular to quinquelobate; axial canal in section has median lateral extensions.

Type specimen.—ERP *706-14 from the Gunsight Limestone in McCulloch County (loc. 706).

Discussion.—The majority of specimens identified as belonging to this species are from the Gunsight Limestone and only a few are adult specimens. The crenularium, areola, lumen, and shape of columnals in longitudinal profile are nearly identical to other species in this genus. The shape of the axial canal in median longitudinal section, however, is entirely different, indicating possibly that this species may belong elsewhere. Columnal inner edges are laterally extended (8, Pl. 3, fig. 1b) narrowly constricting the axial canal. Claustra are poorly preserved and partly replaced by calcite; where they are visible in transverse section, microlamellae are penetrated by tiny pores.

Cirrus facets are generally large, with well-developed crenulation (**8**, Pl. 3, fig. 2b) and large cirrus canal openings. Rarely a small plate occurs with the usual single cirral plate (zygocirral) joining cirri to the stem.

Occurrence.—Graham Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas. Gunsight Limestone Member in McCulloch County (loc. E 706) and Wayland Shale Member in McCulloch County (loc. E 5).

Illustrations.—Plate 28, figures 8-*10.——8. Facetal view of specimen (E 706-2, from loc. E 706) showing coarse crenulae, rough-surfaced areola, circular lumen, beneath which clustrum and jugulum are visible in axial canal, ×5.——9. Side view of specimen (E 5-51, from loc. E 5) showing abnormal noditaxis of 10 columnals, nodals

3rd from top and 5th from bottom, ×3.5.——*10. Side view of type specimen showing normal noditaxis of 8 columnals, ×3.5. [Additional illustrations of this species are given in Echinodermata Art. 8, Pl. 3, fig. 1-3.]

Genus HETEROSTAURUS Moore & Jeffords, new genus

Generally similar to *Heterostelechus* but heteromorphic nature of stem much less evident, with noditaxes of four columnals, nodals with cirrus scar or noncirriferous, sides of columnals very gently convex in longitudinal profile, their inner edges extended as claustra constricting axial canal, each perforated by small circular jugulum, sutures slightly indented, noncrenulate; articular facet with crenularium of medium width composed of fine straight crenulae, terminating evenly against raised smooth annulus interpreted as wide perilumen but equally classifiable as transversely convex areola with crest bordering lumen, which is large and circular, with claustrum and jugulum visible in well-preserved specimens.

*Type species.—Heterostaurus *belknapensis* MOORE & JEFFORDS, new species, from Upper Pennsylvanian of Texas; designated herein.

Occurrence.—Upper Pennsylvanian.

HETEROSTAURUS *BELKNAPENSIS Moore & Jeffords, new species

With characteristics of the genus, surface smooth but somewhat rugose. Measurements (in mm.) and indices of the type specimen are: F, 9.5; L, 4.0; Li, 42; P, 1.5; Pi, 16; C, 4.0; Ci, 42; NT, 6.0; IN, 3.5; INi, 58.

Type specimen.—UKPI *Pdq213 from loc. Pdq.

Occurrence.—Belknap Limestone Member, Thrifty Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (loc. Pdq).

Illustrations.—Plate 27, figure *14,a,b. Side view and longitudinal section of type specimen showing alternation of slightly convex thick and thin columnals, section showing claustra and spatia of axial canal, ×1.7.

Genus CYCLOSCAPUS Moore & Jeffords, new genus

Stem heteromorphic, columnals grouped in noditaxes of 8, with prim- and secundinternodals equal in height to some nodals but lower than others, nodals commonly with 3 to 5 circular cirrus scars; articular facets with very uniform coarse, straight crenulae forming moderately wide crenularium, areola concave and somewhat bowl-shaped, lumen circular, relatively large.

*Type species.—Cycloscapus *laevis* MOORE & JEFFORDS, new species, from Middle Pennsylvanian of Texas; designated herein.

Occurrence.—Middle Pennsylvanian.

CYCLOSCAPUS *LAEVIS Moore & Jeffords, new species

With characteristics of the genus; sides of columnals smooth, with gently convex longitudinal profile, sutures indented, noncrenulate; articular facet with approximately 20 culmina in half-crenularium, facets of cirri 2.0 to 2.3 mm. in diameter, with short straight crenulae. Measurements (in mm.) and indices of type specimen are: F, 9.0; L, 2.0; Li, 22; A, 3.2; Ai, 35; C, 3.8; Ci, 43; NT, 14.0; IN, 11.4; INi, 82.

Type specimen.—UKPI *Pak9 from loc. Pak.

Occurrence.—Mingus Shale, Strawn Group, Desmoinesian, Middle Pennsylvanian, in Texas (loc. Pak).

Illustrations.—Plate 27, figure *15a,b. Side and facetal views of type specimen showing culmina stronger and longer than in *Cyclocrista* but otherwise similar, side view showing 2 cirrinodals and noditaxis of 8 columnals, ×5, ×2.5.

Genus CYCLOCAUDICULUS Moore & Jeffords, new genus

Stem heteromorphic, straight-sided columnals in noditaxes of 4, nodals commonly with single cirrus scar; articular facet similar to that of *Cycloscapus* in coarse, straight crenulae but areola flat, circular lumen moderately large.

*Type species.—Cyclocaudiculus *regularis* MOORE & JEFFORDS, new species, from Upper Pennsylvanian of Texas; designated herein.

Occurrence.—Upper Pennsylvanian.

CYCLOCAUDICULUS *REGULARIS Moore & Jeffords, new species

With characteristics of the genus; sides of columnals smooth, sutures slightly indented, crenulate, priminternodals nearly equal in height to nodals (3 mm.) but secundinternodals much lower (1.2 mm.). Measurements (in mm.) and indices of type specimen are: F, 6.2; L, 1.0; Li, 16; A, 1.7; Ai, 27; C, 3.5; Ci, 57; NT, 7.7; IN, 4.8; INi, 62.

Type specimen.—UKPI *Paw66 from loc. Paw.

Occurrence.—Chaffin Limestone Member, Thrifty Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (loc. Paw).

Illustrations.—Plate 27, figure *12a,b. Facetal and side views of type specimen showing coarse, straight crenulae, areola, and circular lumen, noditaxes of 4 columnals, ×3.5.

Genus NOTHROSTERIGMA Moore & Jeffords, new genus

Stem heteromorphic, columnals identical in width but nodals and priminternodals taller than secundinternodals, noditaxes of 4, nodals distinguished by presence of 1 or 2 large circular cirrus scars; articular facet resembling that of *Cyclocaudiculus* except for transversely convex annulus occupying space between lumen and inner margin of crenularium, interpreted as broad perilumen rather than areola.

Type species.—*Nothrosterigma* **merum* MOORE & JEFFORDS, new species, from Upper Pennsylvanian of Texas; designated herein.

Occurrence.—Upper Pennsylvanian.

NOTHROSTERIGMA *MERUM Moore & Jeffords, new species

With characteristics of the genus; sides of columnals very slightly convex in longitudinal profile, smooth, sutures crenulate, not indented. Measurements (in mm.) and indices of type specimen are: F, 4.5; L, 0.5; Li, 11; P, 1.2; Pi, 27; C, 2.8; Ci, 62; NT, 10.0; IN, 6.2; INi, 62.

Type specimen.—UKPI *Paw82 from loc. Paw.

Occurrence.—Chaffin Limestone Member, Thrifty Formation, Cisco Group, Virgilian, Upper Pennsylvanian, in Texas (loc. Paw).

Illustrations.—Plate 27, figure *13a,b. Facetal and side views of type specimen showing stout crenulae, evenly rounded perilumen, noditaxis of 4 columnals, ×3.5.

EXPLANATION OF PLATES

[Asterisk (*) indicates type species of genera]

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1-2. *Myelodactylus ammonis* (BATHER), U.Sil., Tenn. (p. 32).
3. *Iocrinus *subcrassus* (MEEK & WORTHEN), U.Ord., Ohio (p. 32).
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1. *Decacrinus tenuicrenulatus*, new, L.Dev., Tenn. (p. 35).
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1-3. *Dianthicoeloma *insuetum*, new, U.Ord., Ohio (p. 50).
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PLATE 11

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1. *Graphosterigma synthetes*, new, L.Miss., Ky. (p. 62).
2. *Lomalegnum *hormidium*, new, L.Miss., Iowa (p. 61).
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4-5. *Stiberostaurus *aestimatus*, new, L.Miss., Ky. (p. 61).
6. *Graphosterigma grammodes*, new, L.Miss., Ind. (p. 62).

PLATE 14

1-3. *Graphosterigma grammodes*, new, L.Miss., Ind. (p .62).
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6-7. *Baryschyr *anosus*, new, M.Penn., Okla. (p. 64).
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1-6. *Blothronagma *cinctutum*, new, M.Penn., Okla. (p. 63).
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1-11. *Baryschyr *anosus*, new, M.Penn., Okla. (p. 64).
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9. *Cyclocaudex aptus*, new, L.Miss., Ky. (p. 66).
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11. *Cyclocaudex insaturatus*, new, M.Penn., Kans. (p. 66).
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12. *Goniostathmus *annexus*, new, L.Miss., Iowa (p. 75).

PLATE 23

1. *Cyclocharax modestus*, new, U.Sil., Ind. (p. 76).
2. *Ampholenium *apolegma*, new, L.Miss., Ky. (p. 75).
3. *Cyclostelechus *turritus*, new, L.Miss., Iowa (p. 76).
4. *Goniocion turgidus*, new, L.Miss., Iowa (p. 75).
5. *Cionerisma *exile*, new, U.Sil., Ind. (p. 76).
6. *Goniocion *gonimus*, new, L.Miss., Iowa (p. 75).
7-8. *Cyclocharax *fasciatus*, new, U.Sil., Ind. (p. 76).
9. *Exedrodiscus *excussus*, new, L.Miss., Ky. (p. 74).

PLATE 24

1-3. *Floricyclus granulosus*, new, U.Penn., Texas (p. 77).
4. *Floricyclus pulcher*, new, M.Penn., Kans. (p. 77).
5. *Floricyclus *hebes*, new, M.Penn., Texas (p. 77).
6-7. *Floricyclus angustimargo*, new, M.Penn., Colo. (p. 77).
8. *Floricyclus welleri*, new, L.Miss., Ky. (p. 77).
9. *Floricyclus kansasensis*, new, M.Penn., Kans. (p. 77).
10-14. *Plummeranteris *sansaba*, new, M.Penn., Texas (p. 78).
15-16. *Cyclocion *distinctus*, new, U.Miss., Ill. (p. 78).

PLATE 25

1-7. *Cyclocion *distinctus*, new, U.Miss., Ill. (p. 78).
8-9. *Leptocarphium regulare*, new, M.Penn., Texas (p. 79).
10. *Lamprosterigma *mirificum*, new, M.Penn., Kans. (p. 79).
11-12. *Leptocarphium *gracile*, new, M.Penn., Texas (p. 79).
13-14. *Cyclocrista *lineolata*, new, U.Penn., Texas (p. 80).
15. *Lamprosterigma erathense*, new, M.Penn., Texas (p. 79).

PLATE 26

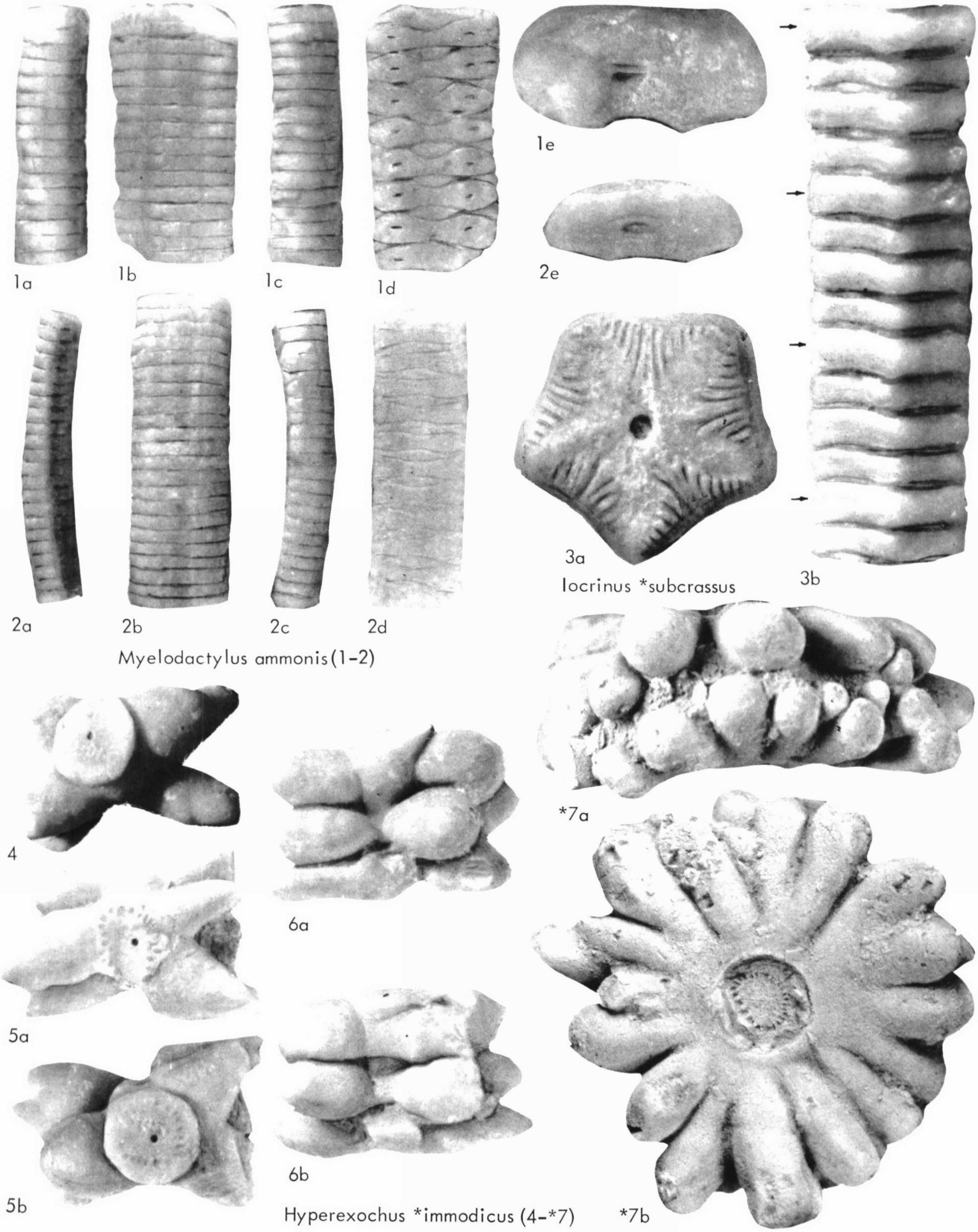
1-6. *Cyclocrista martini* MILLER, new, U.Penn., Texas (p. 80).
7-8. *Cyclocrista cheneyi*, new, L.Perm., Texas (p. 80).
9-16. *Floricyclus granulosus*, new, U.Penn., Texas (p. 77).

PLATE 27

1-9. *Preptopremnum *rugosum*, new, U.Penn., Texas (p. 81).
10. *Mooreanteris perforatus*, new, U.Penn., Texas (p. 67).
11. *Preptopremnum laeve*, new, M.Penn., Texas (p. 81).
12. *Cyclocaudiculus *regularis*, new, U.Penn., Texas (p. 83).
13. *Nothrosterigma *merum*, new, U.Penn., Texas (p. 84).
14. *Heterostaurus *belknapensis*, new, U.Penn., Texas (p. 83).
15. *Cycloscapus *laevis*, new, M.Penn., Texas (p. 83).
16. *Heterostelechus *texanus*, new, U.Penn.-L.Perm., Texas (p. 81).

PLATE 28

1. *Preptopremnum *rugosum*, new, U.Penn., Texas (p. 81).
2-6. *Heterostelechus jeffordsi* MILLER, new, U.Penn., Texas (p. 82).
7. *Heterostelechus *texanus*, new, U.Penn.-L.Perm., Texas (p. 81).
8-10. *Heterostelechus keithi* MILLER, new, U.Penn., Texas (p. 82).



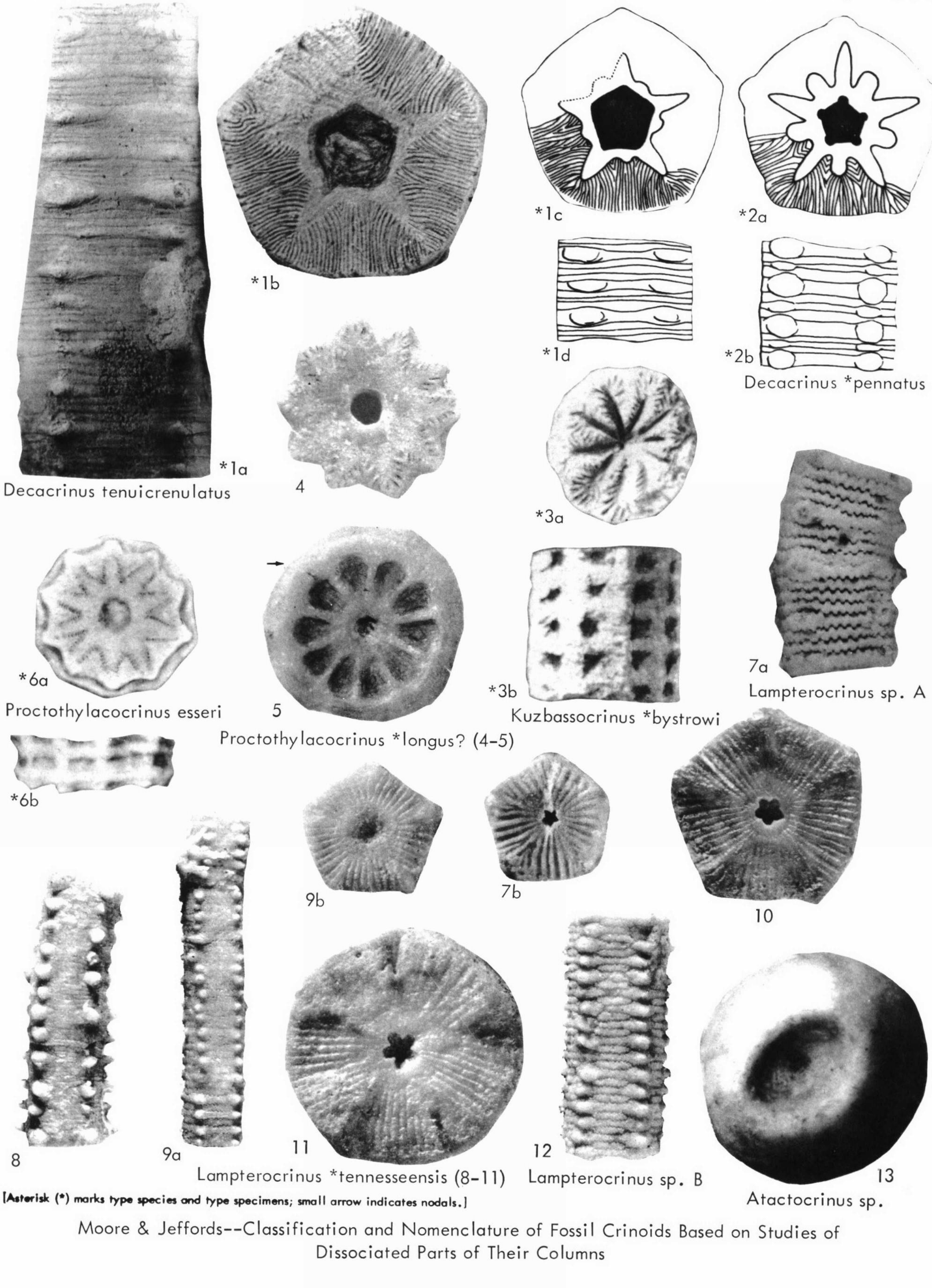
Myelodactylus ammonis (1-2)

Iocrinus *subcrassus

Hyperexochus *immodicus (4-*7)

[Asterisk (*) marks type species and type specimens; small arrow indicates nodals.]

Moore & Jeffords--Classification and Nomenclature of Fossil Crinoids Based on Studies of Dissociated Parts of Their Columns



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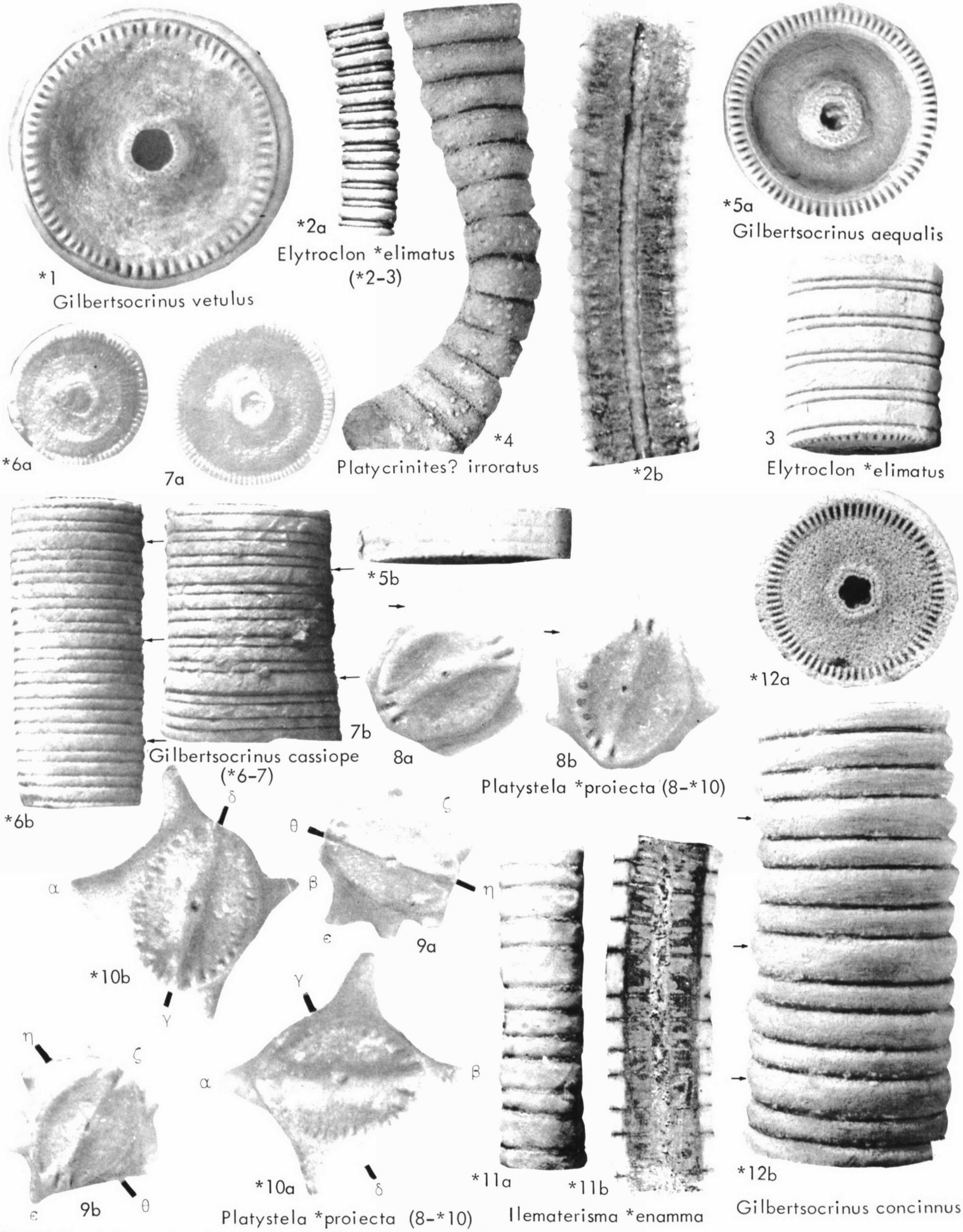

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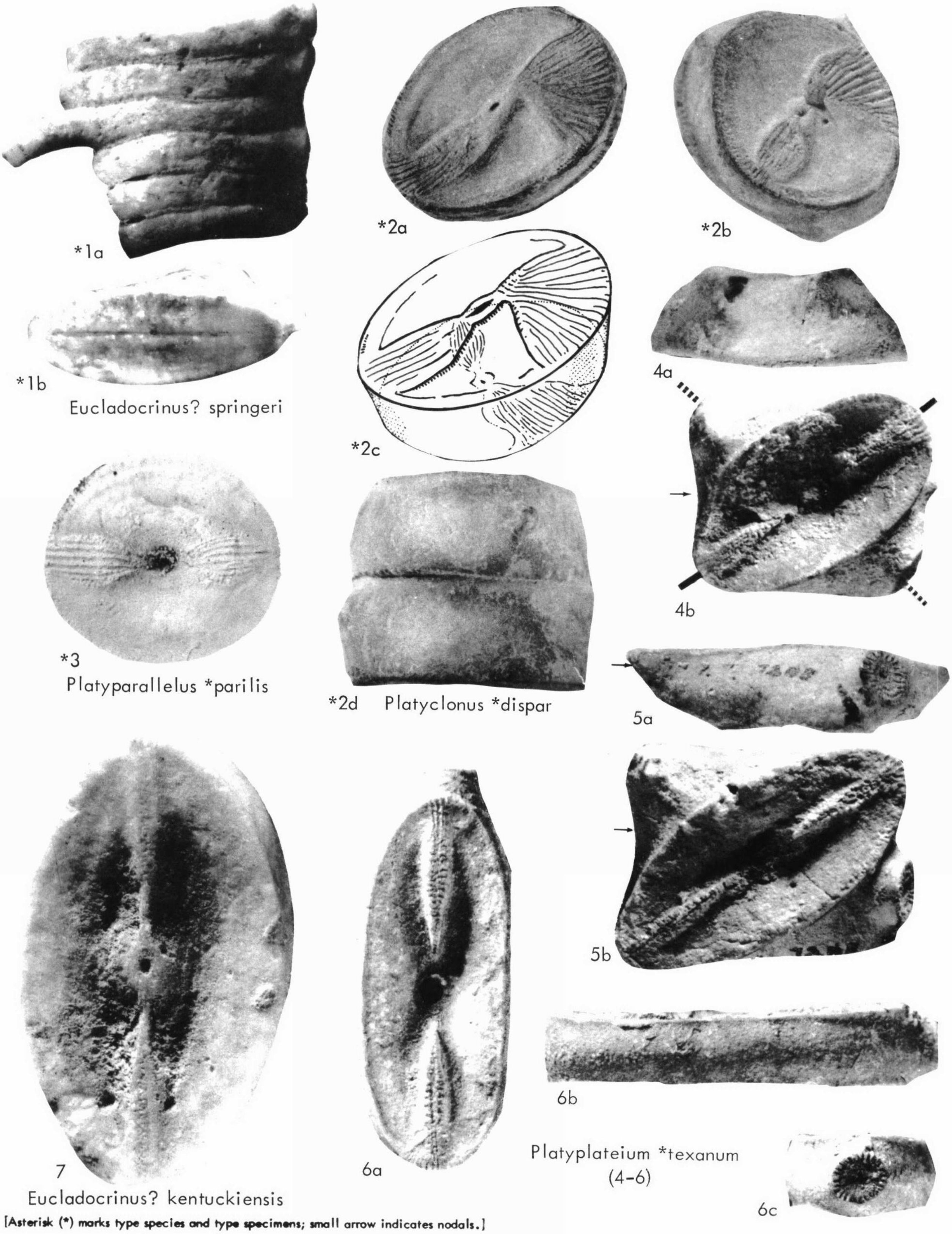

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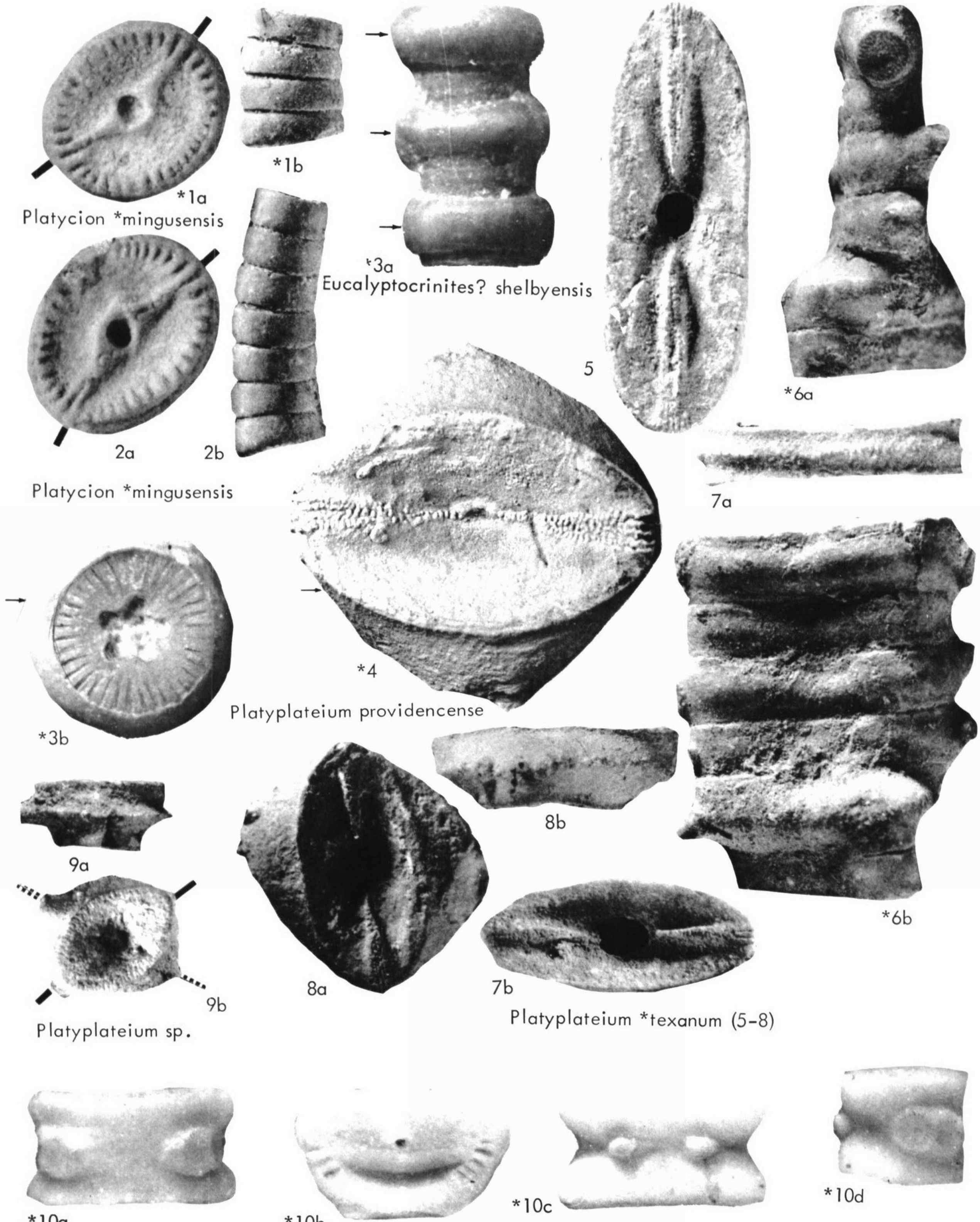

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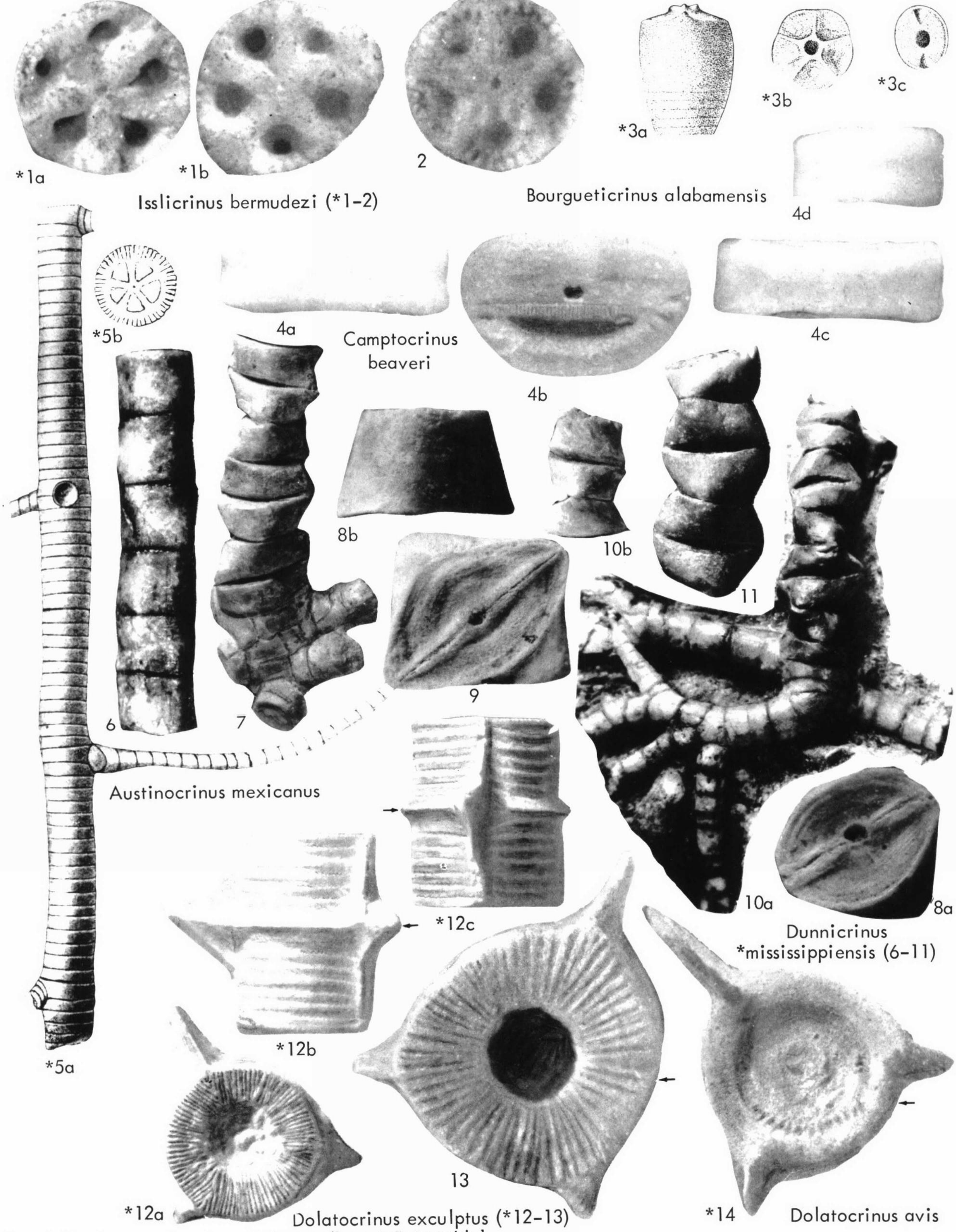
Moore & Jeffords--Classification and Nomenclature of Fossil Crinoids Based on Studies of Dissociated Parts of Their Columns



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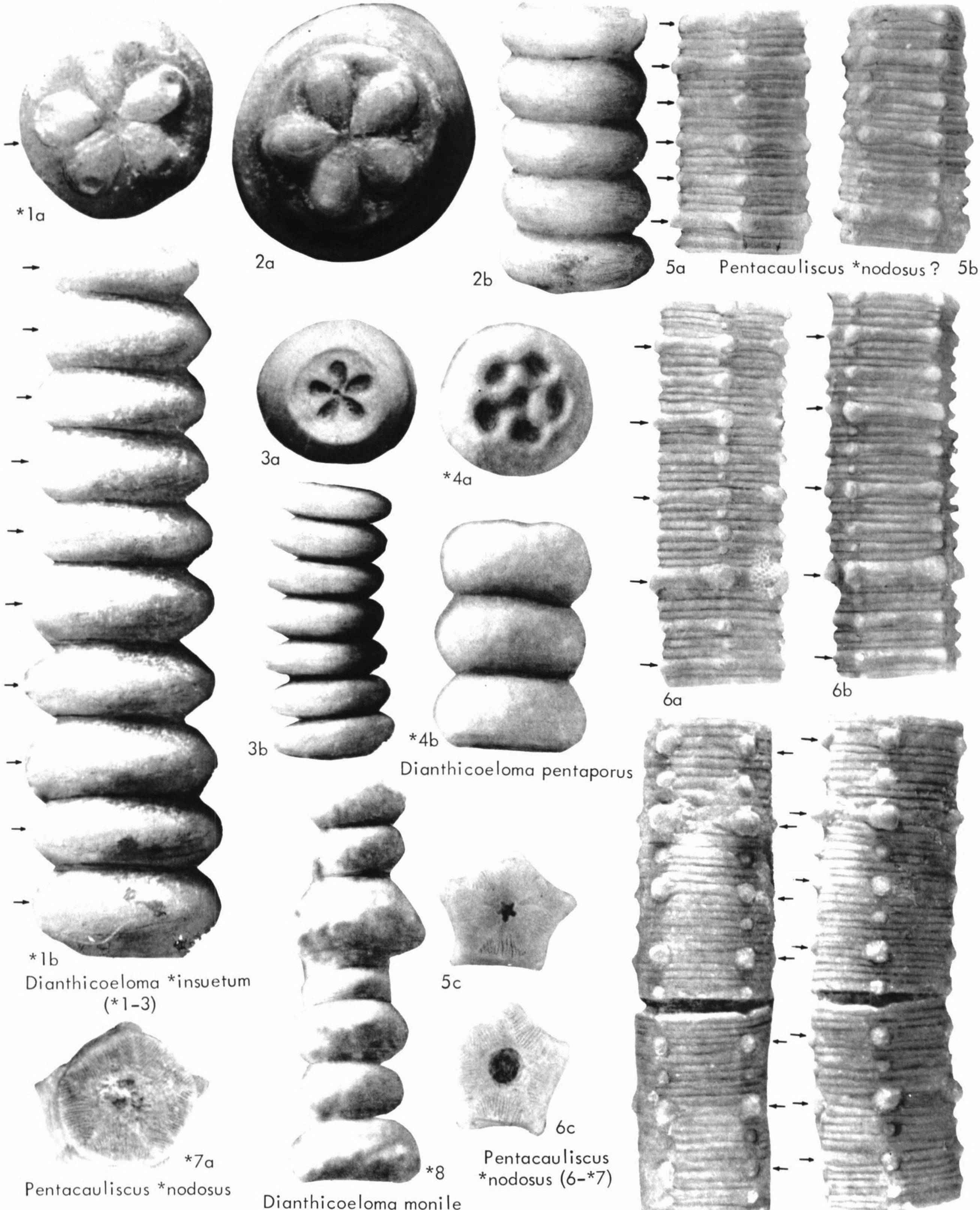
Moore & Jeffords--Classification and Nomenclature of Fossil Crinoids Based on Studies of Dissociated Parts of Their Columns



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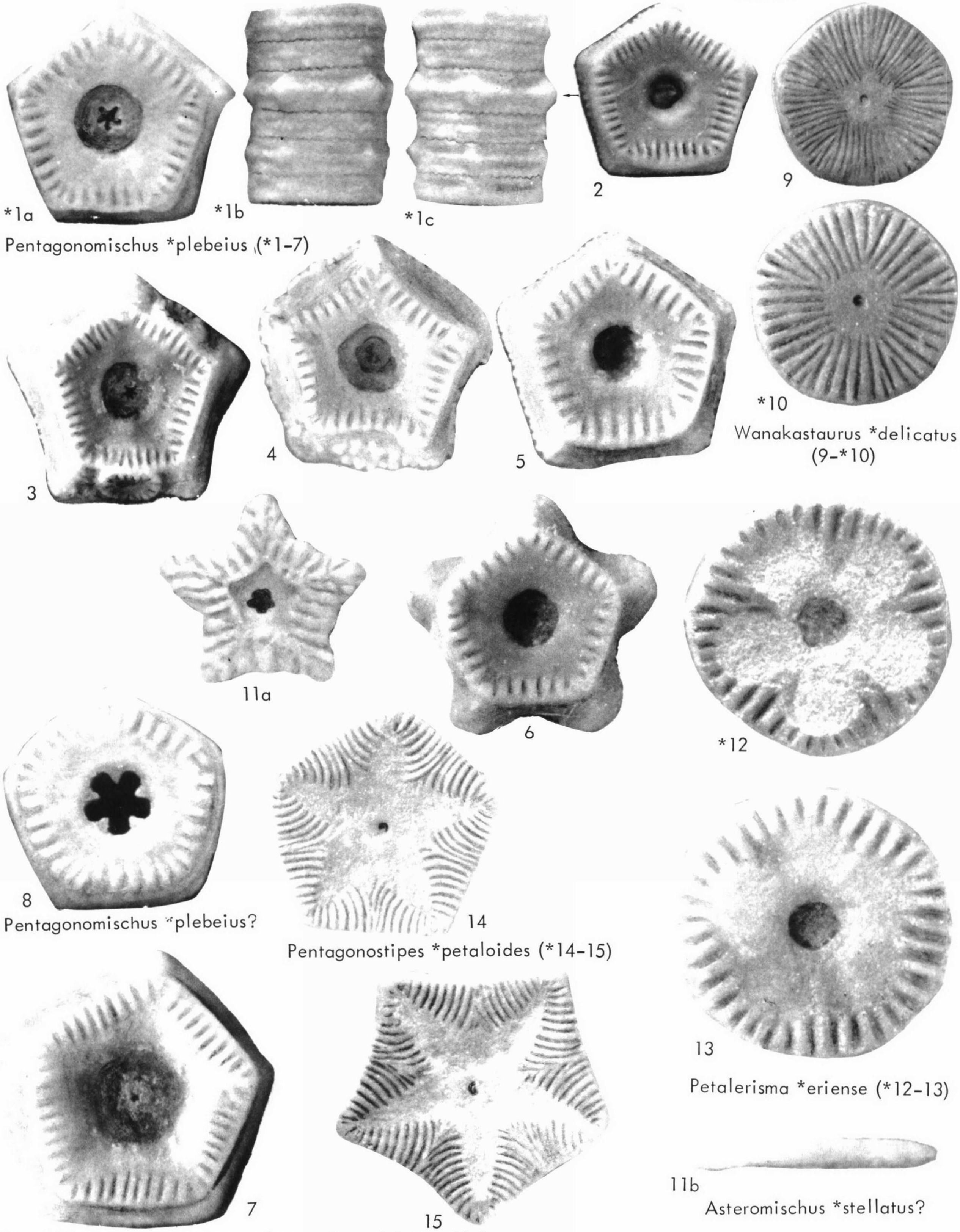
Moore & Jeffords--Classification and Nomenclature of Fossil Crinoids Based on Studies of Dissociated Parts of Their Columns



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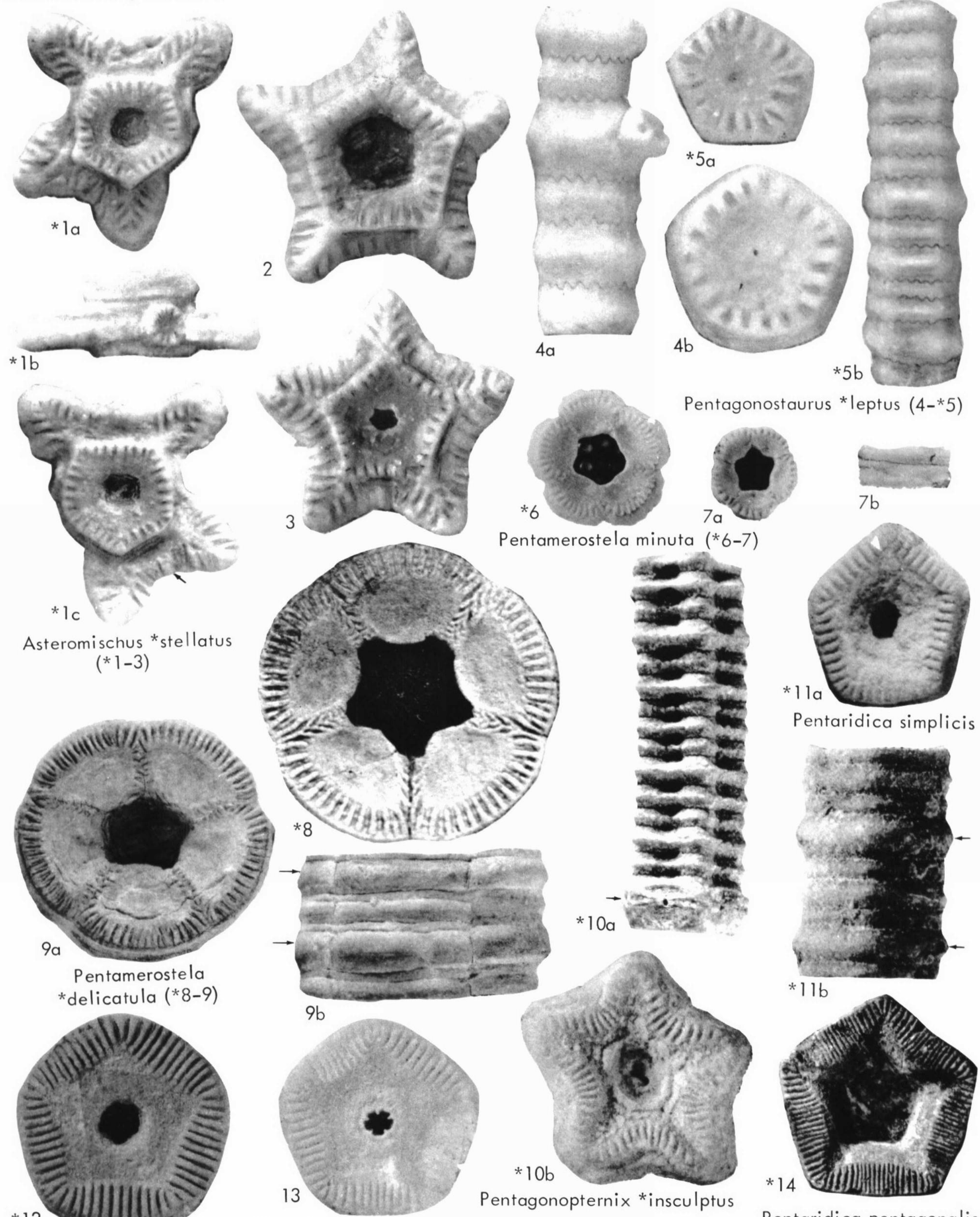


Asteromischus *stellatus (*1-3)

Pentagonostaurus *leptus (4-*5)

Pentamerostela minuta (*6-7)

Pentaridica simplicis

Pentamerostela *delicatula (*8-9)

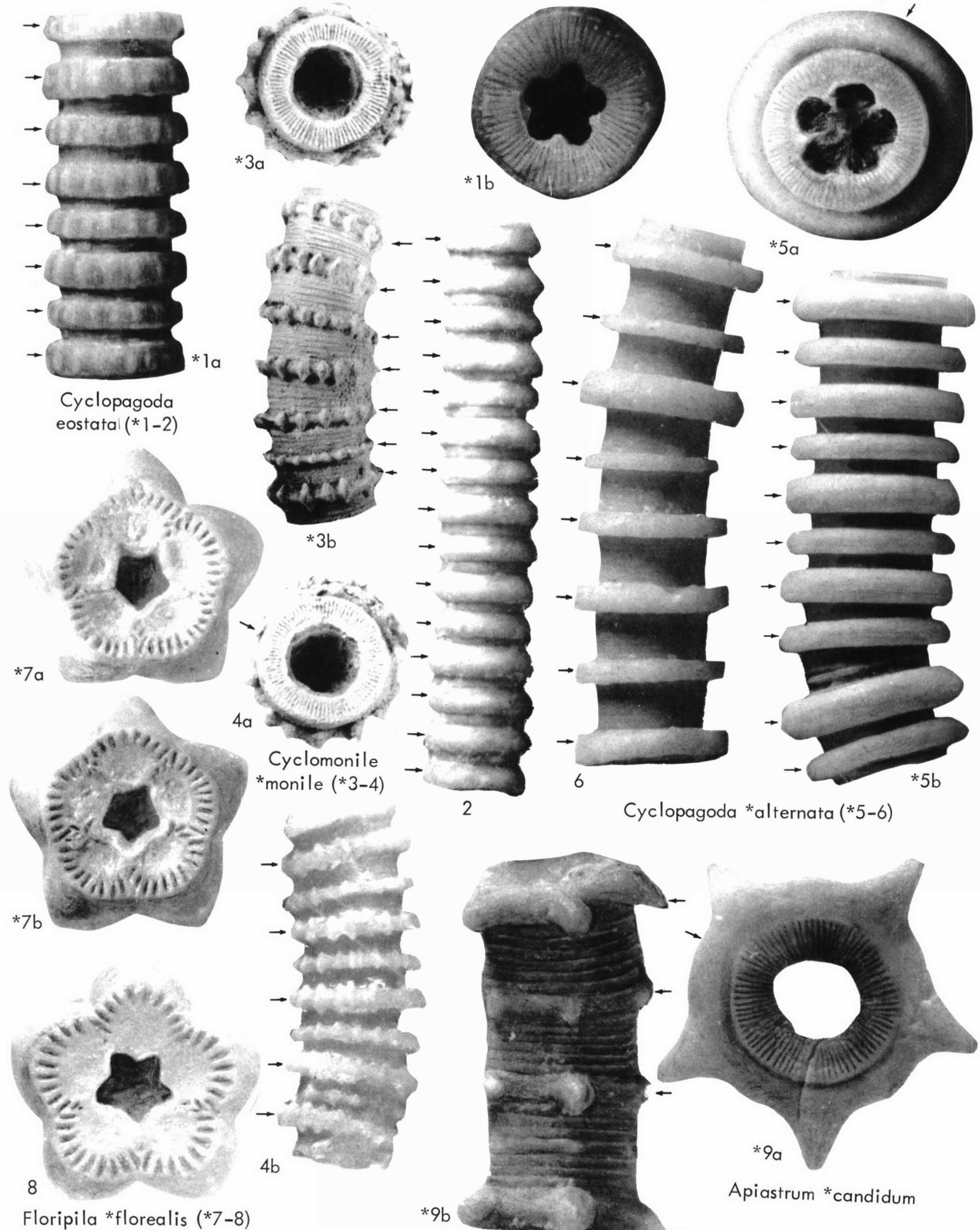
Pentagonopternix *insculptus

Pentaridica pentagonalis

Pentaridica *rothi (*12-13)

[Asterisk (*) marks type species and type specimens; small arrow indicates nodals.]

Plate 10



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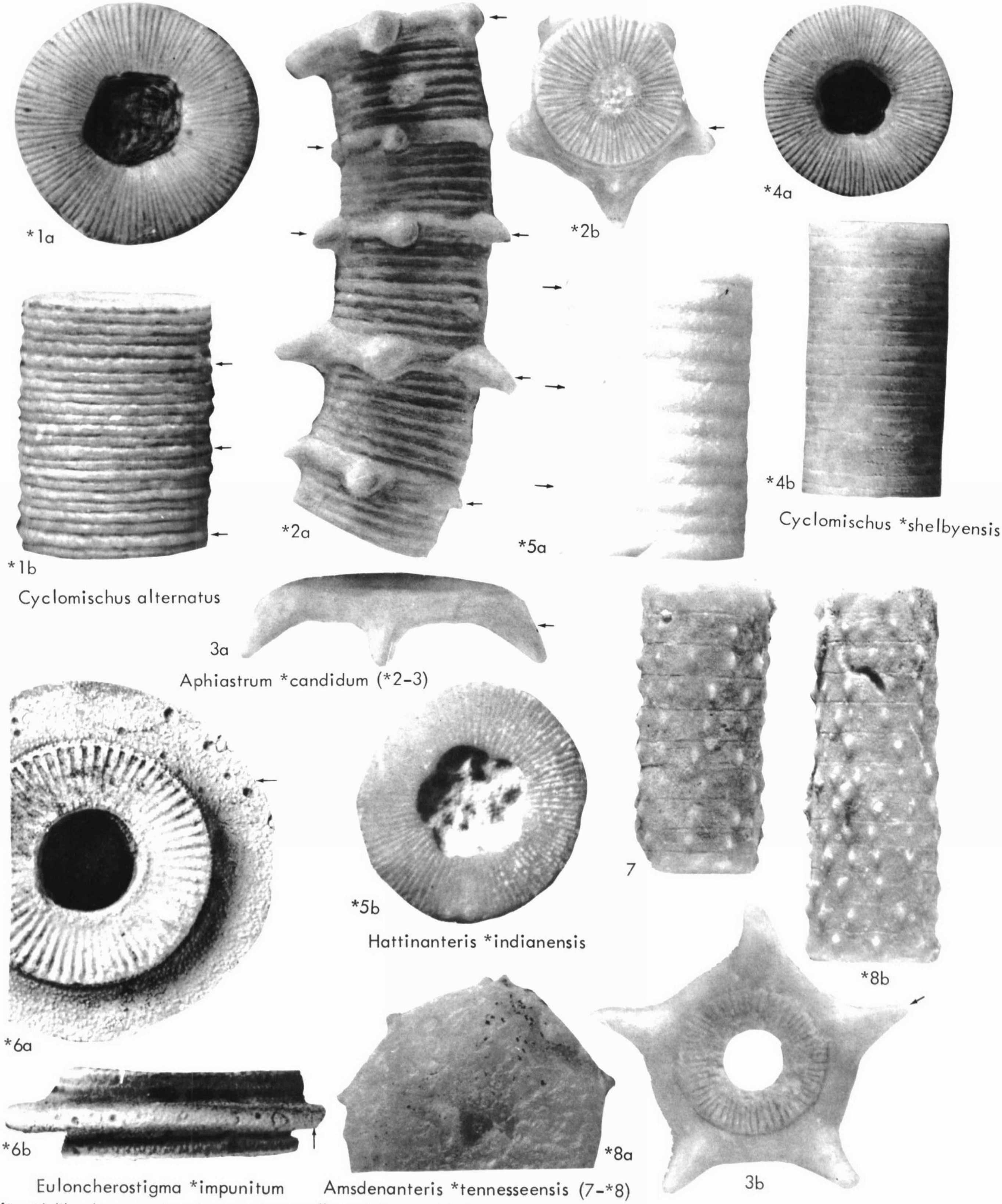
Moore & Jeffords--Classification and Nomenclature of Fossil Crinoids Based on Studies of Dissociated Parts of Their Columns



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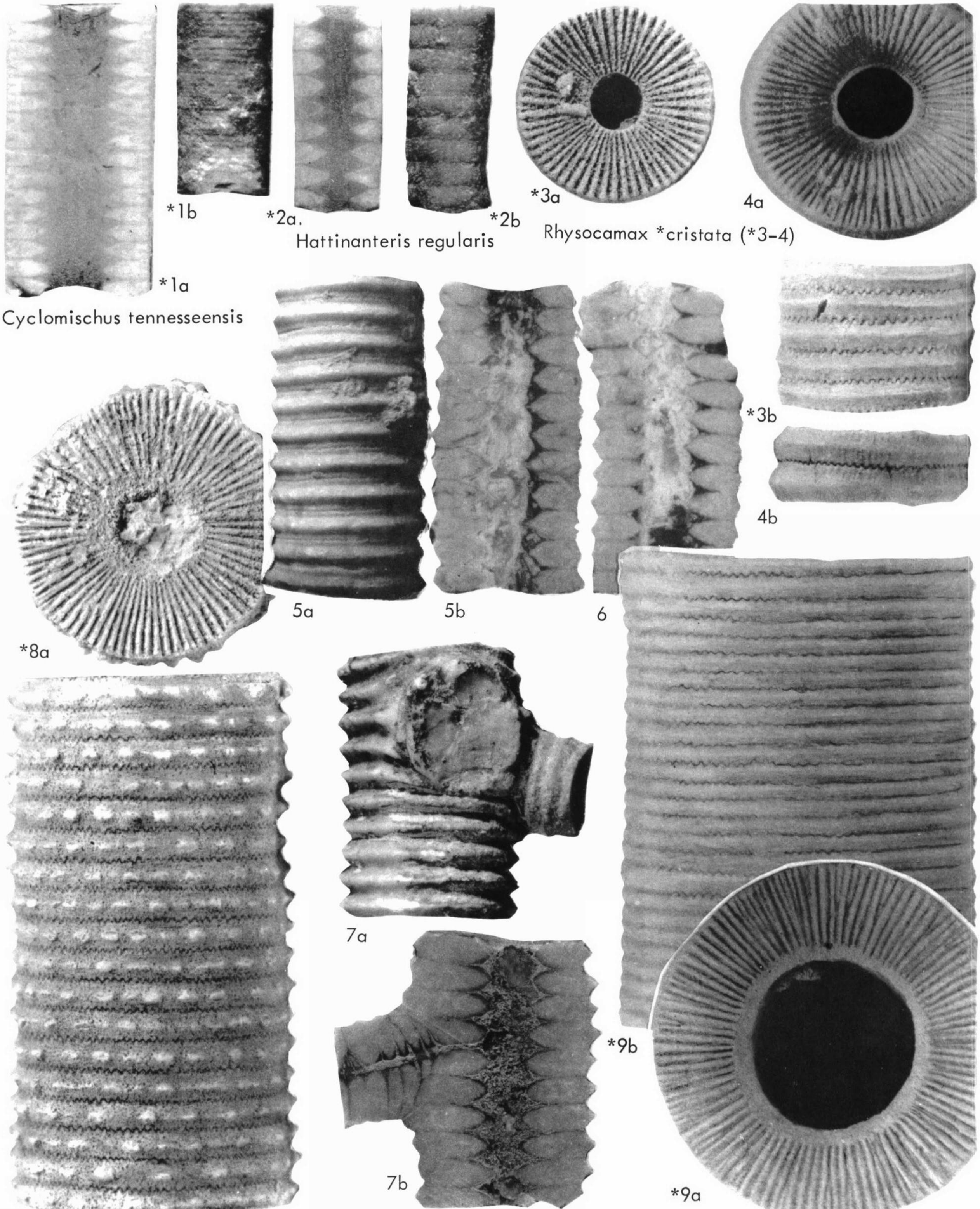


Cyclomischus tennesseensis (*1a, *1b)

Hattinanteris regularis (*2a, *2b)

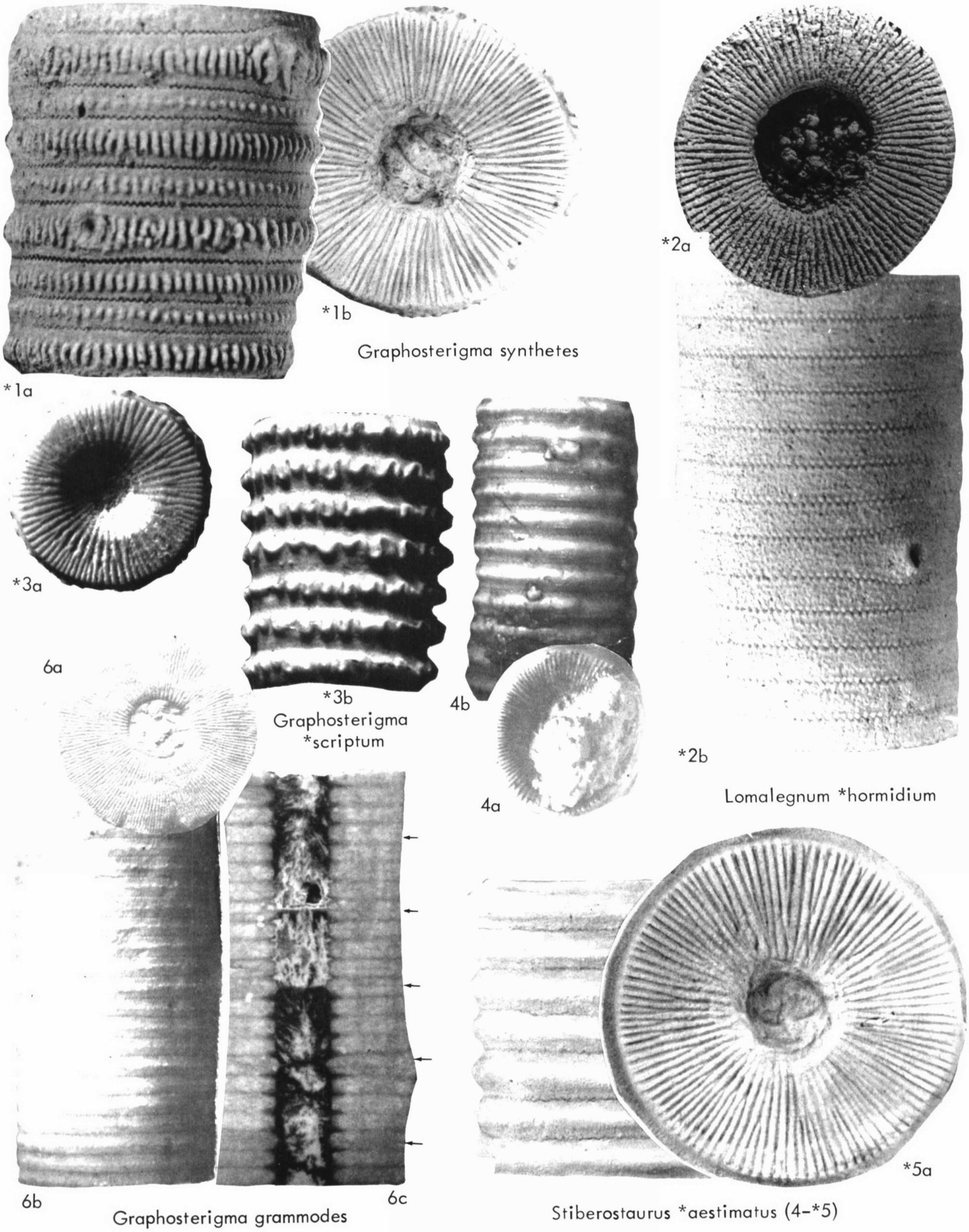
Rhysocamax *cristata (*3-4)

Rhysocamax tuberculata (*8a, *8b)

Stiberostaurus *aestimatus (5-7)

Rhysocamax grandis (*9a, *9b)

[Asterisk (*) marks type species and type specimens.]



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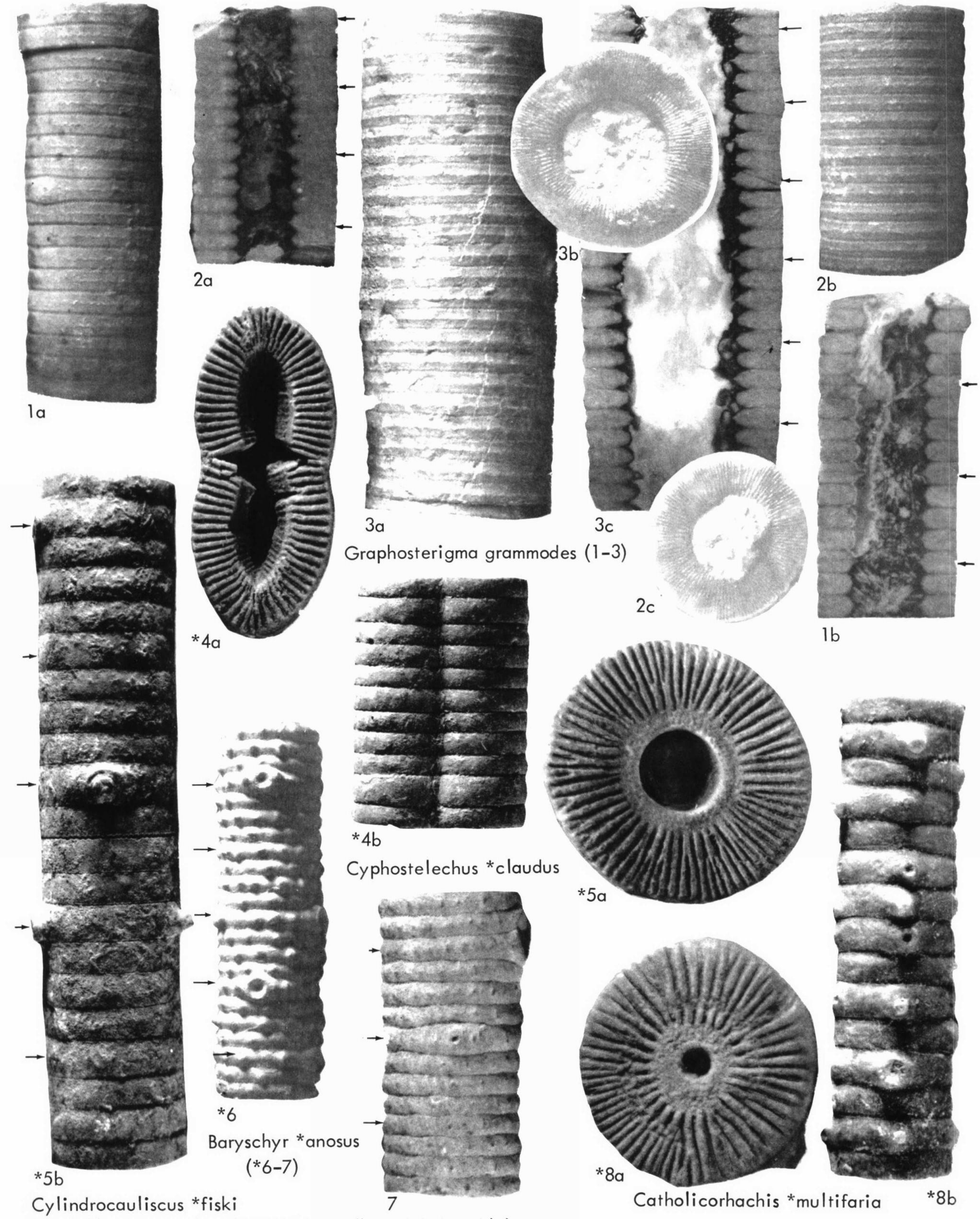
Moore & Jeffords--Classification and Nomenclature of Fossil Crinoids Based on Studies of Dissociated Parts of Their Columns



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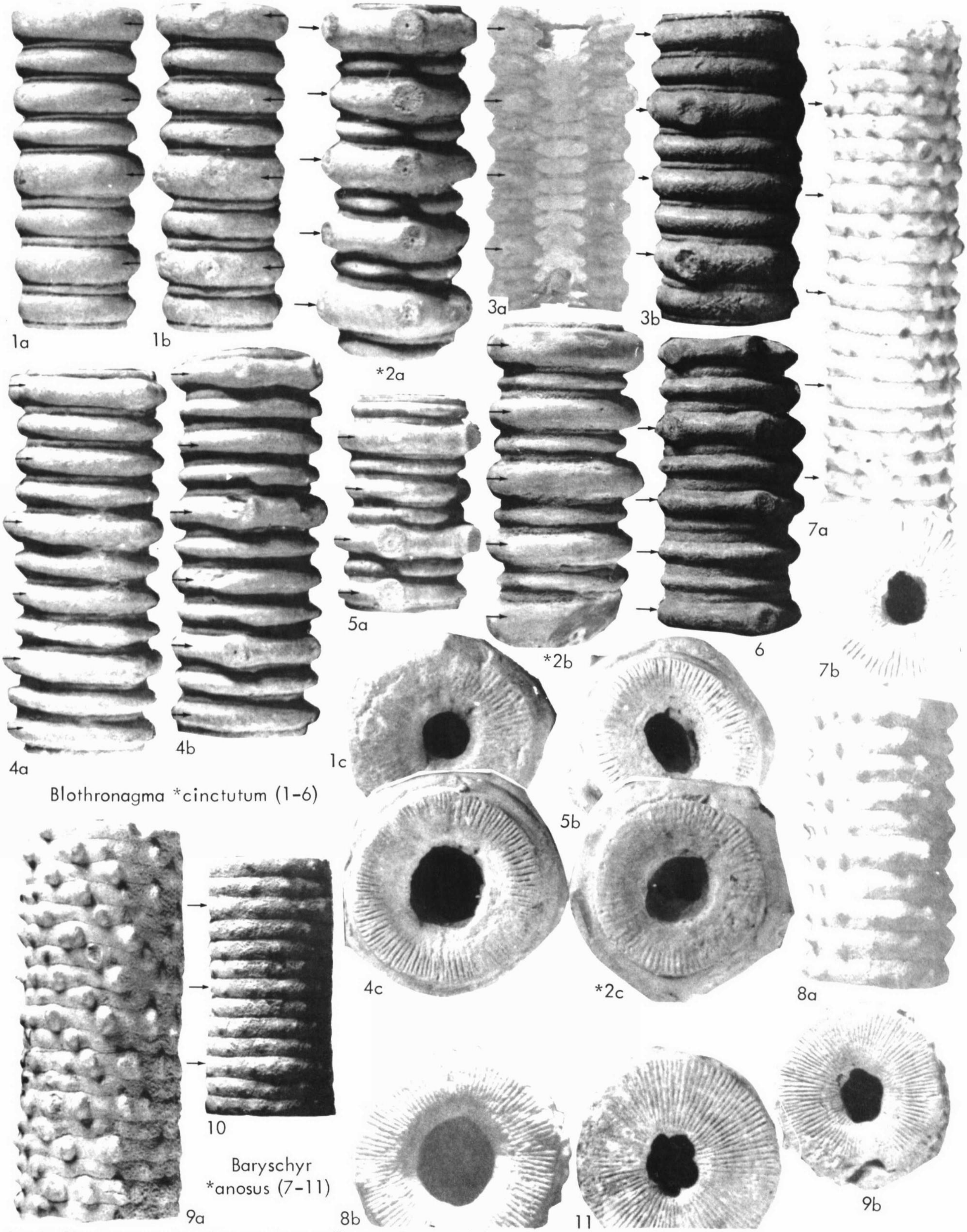

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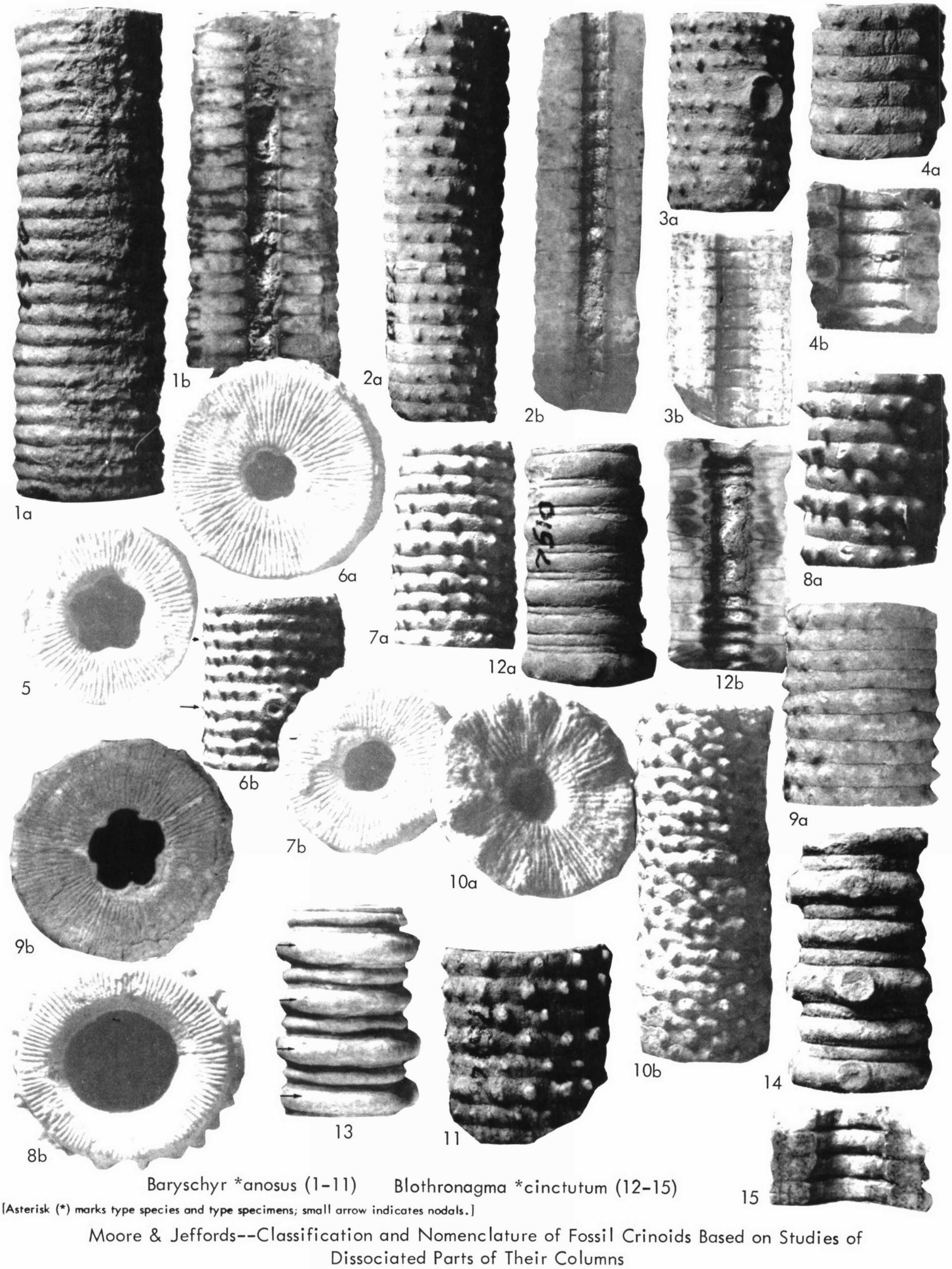
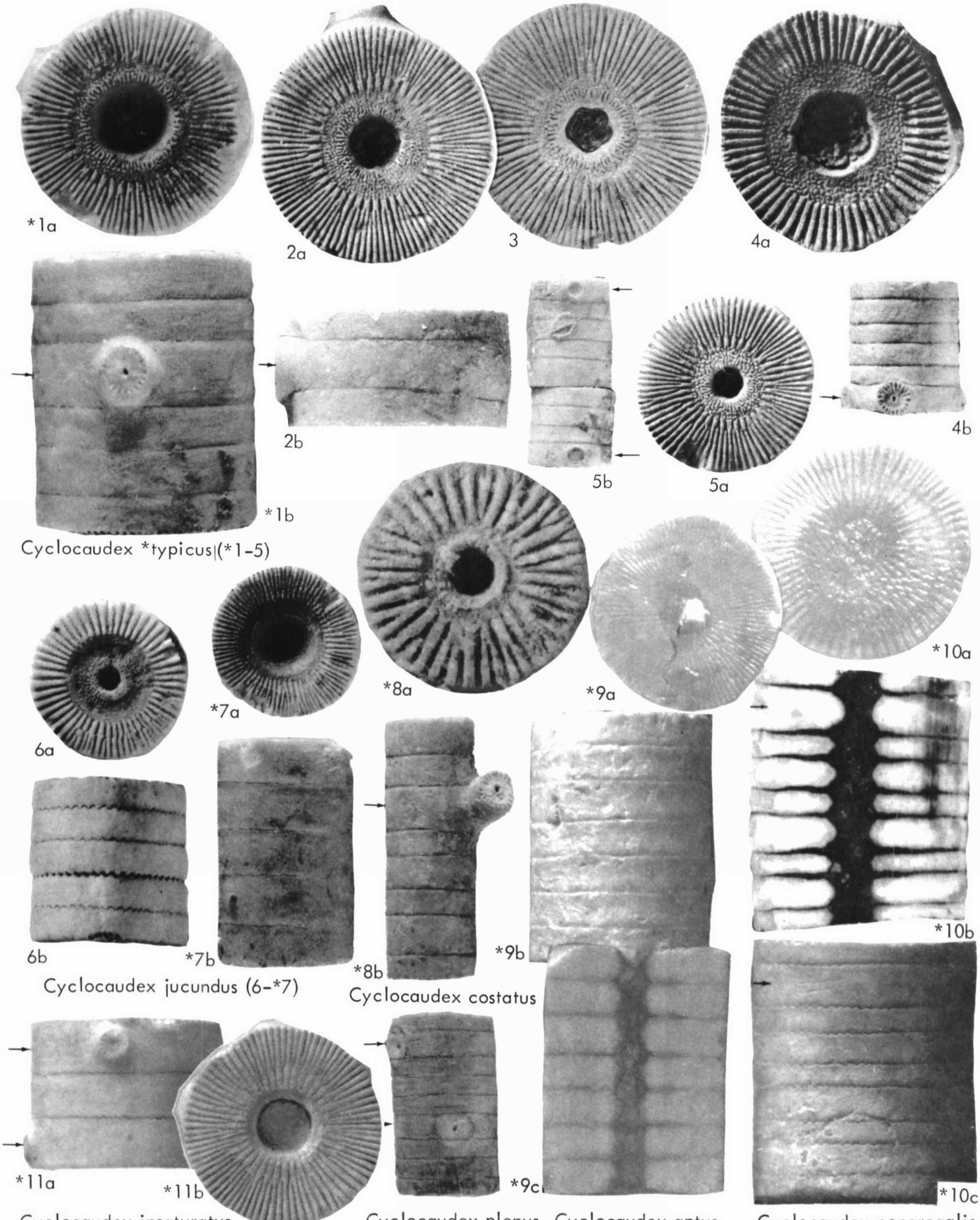


Baryschyr *anosus (1–11) Blothronagma *cinctutum (12–15)

[Asterisk (*) marks type species and type specimens; small arrow indicates nodals.]

Moore & Jeffords--Classification and Nomenclature of Fossil Crinoids Based on Studies of Dissociated Parts of Their Columns



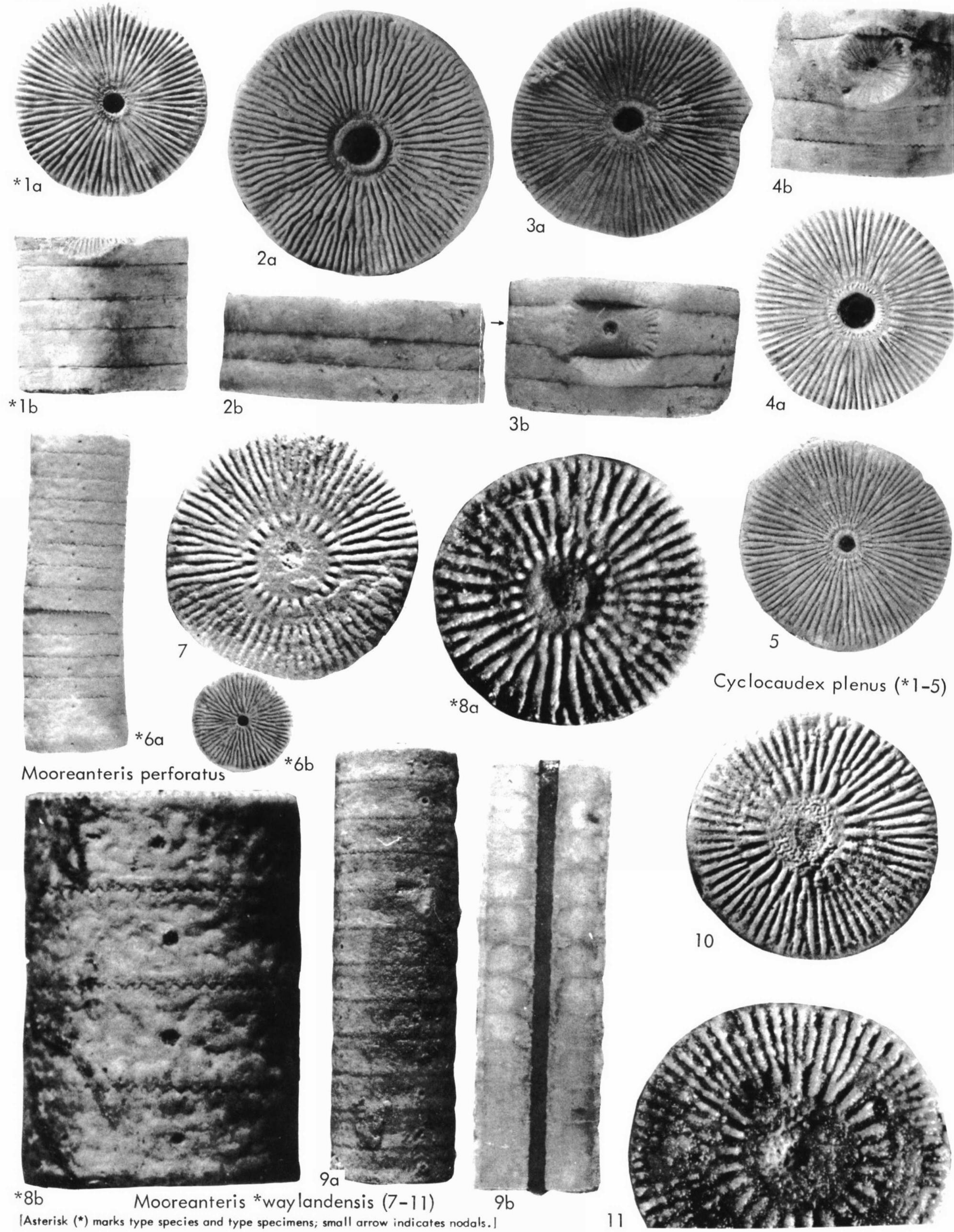
Cyclocaudex *typicus (*1-5)

Cyclocaudex jucundus (6-*7)

Cyclocaudex costatus

Cyclocaudex insaturatus Cyclocaudex plenus Cyclocaudex aptus Cyclocaudex congregalis

[Asterisk (*) marks type species and type specimens; small arrow indicates nodals.]

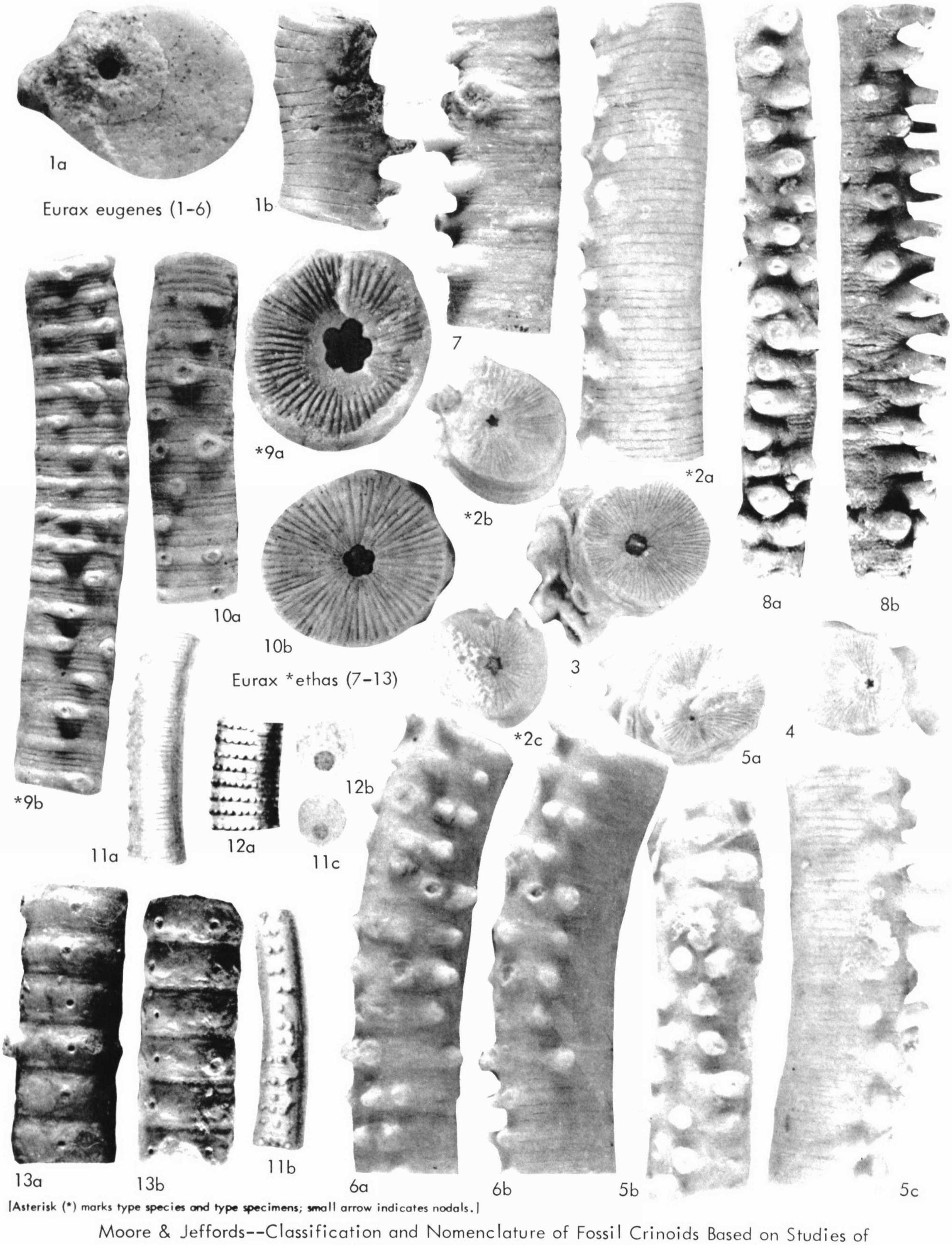


Cyclocaudex plenus (*1-5)

Mooreanteris perforatus

Mooreanteris *waylandensis (7-11)

[Asterisk (*) marks type species and type specimens; small arrow indicates nodals.]



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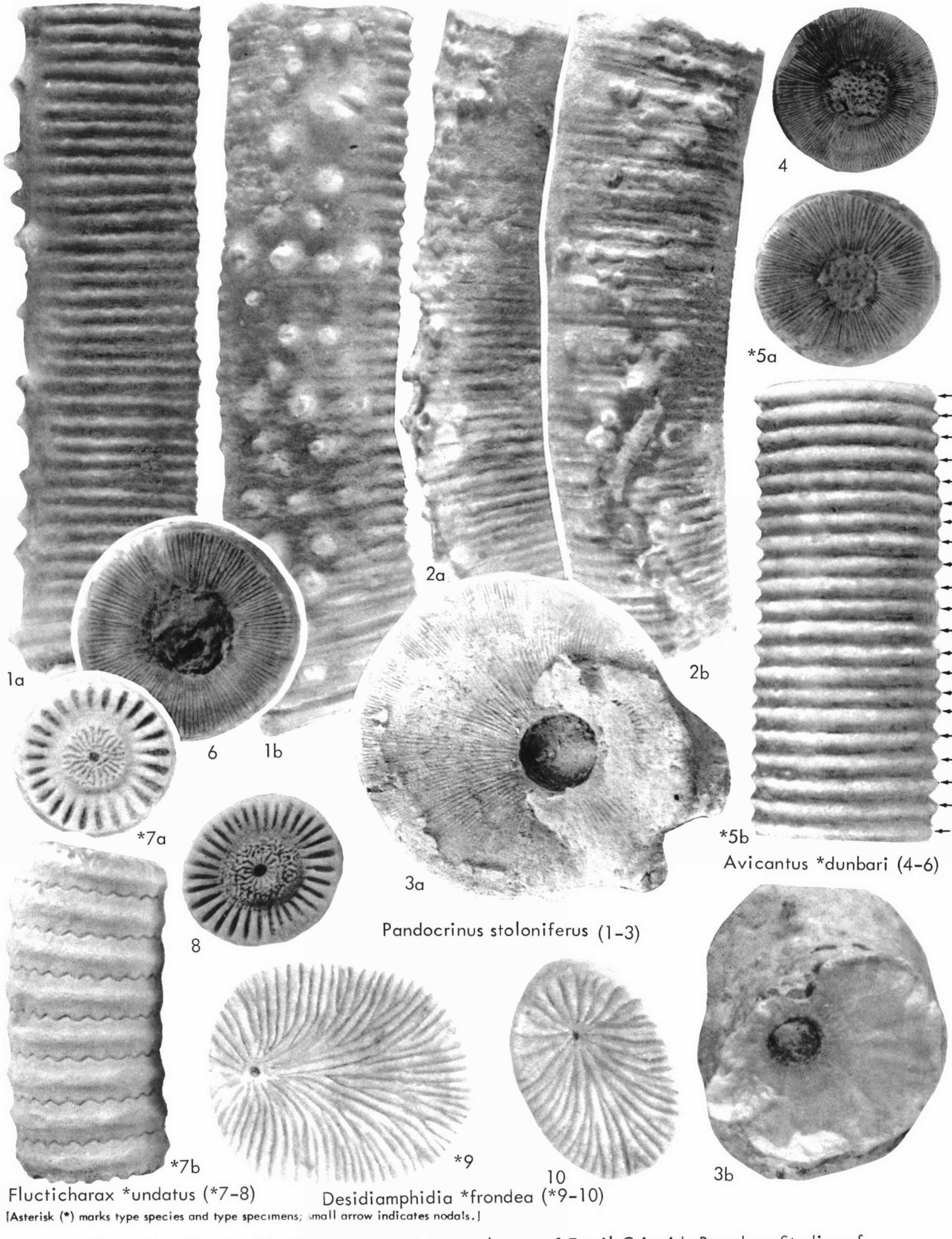

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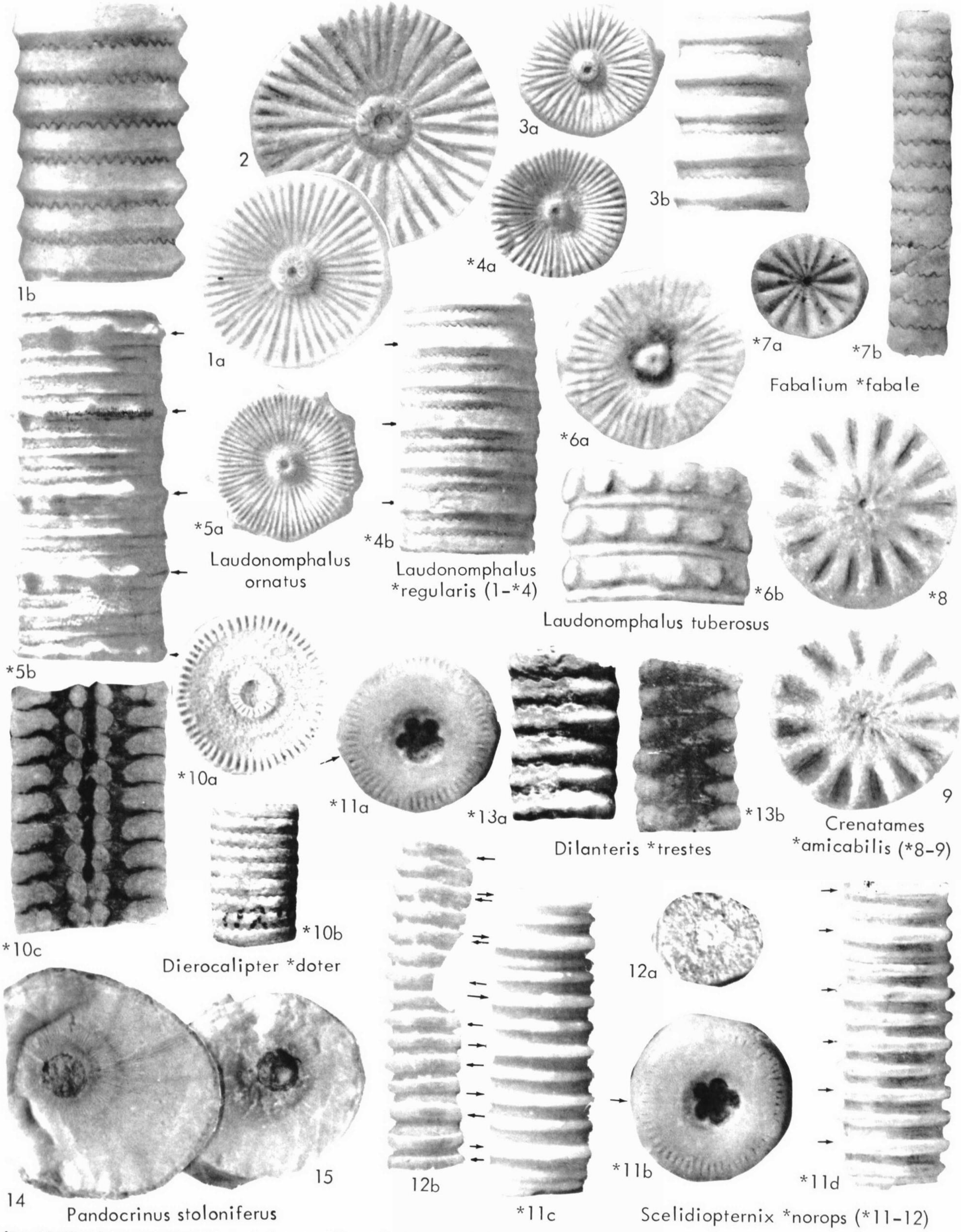

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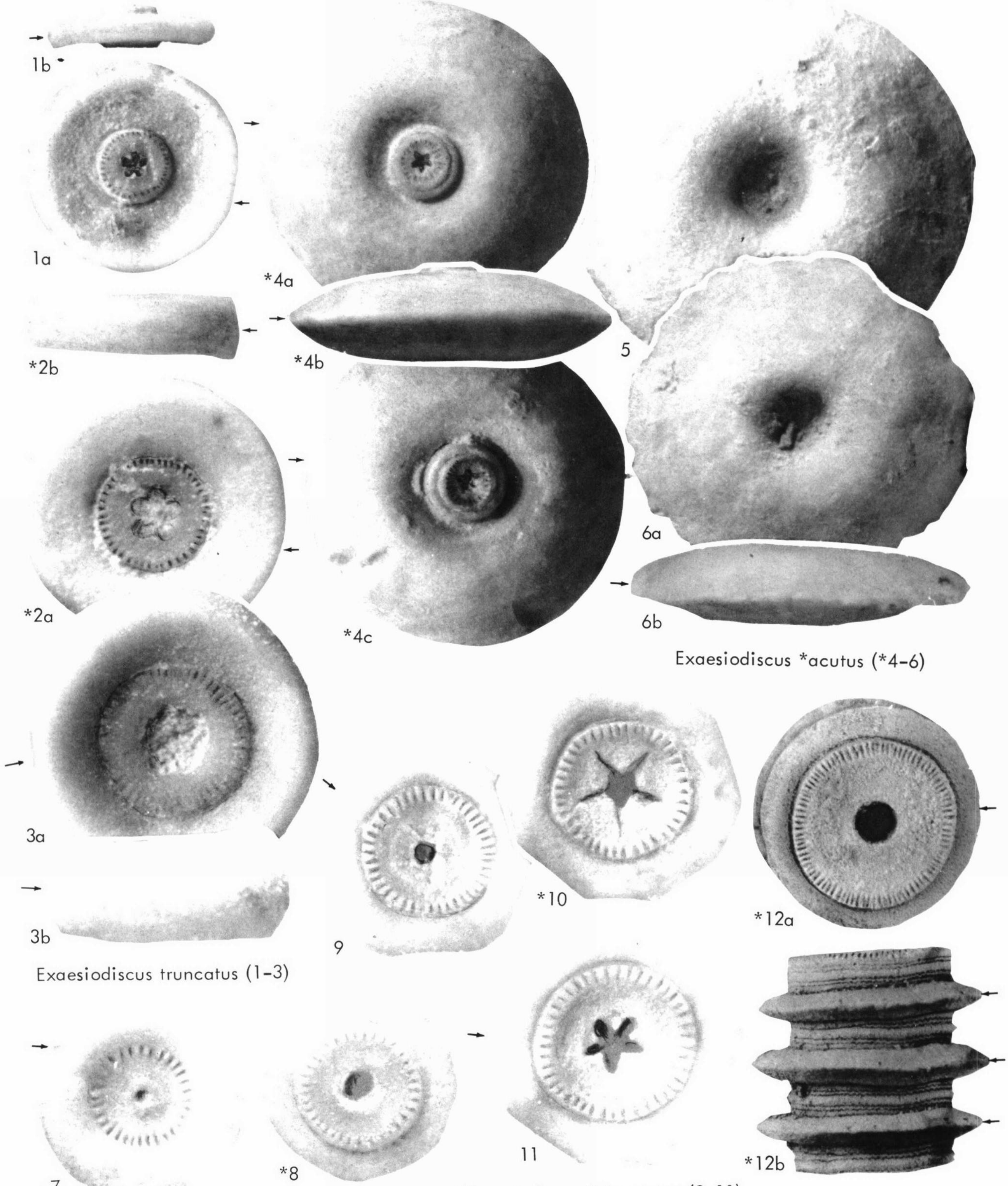


Exaesiodiscus truncatus (1-3)

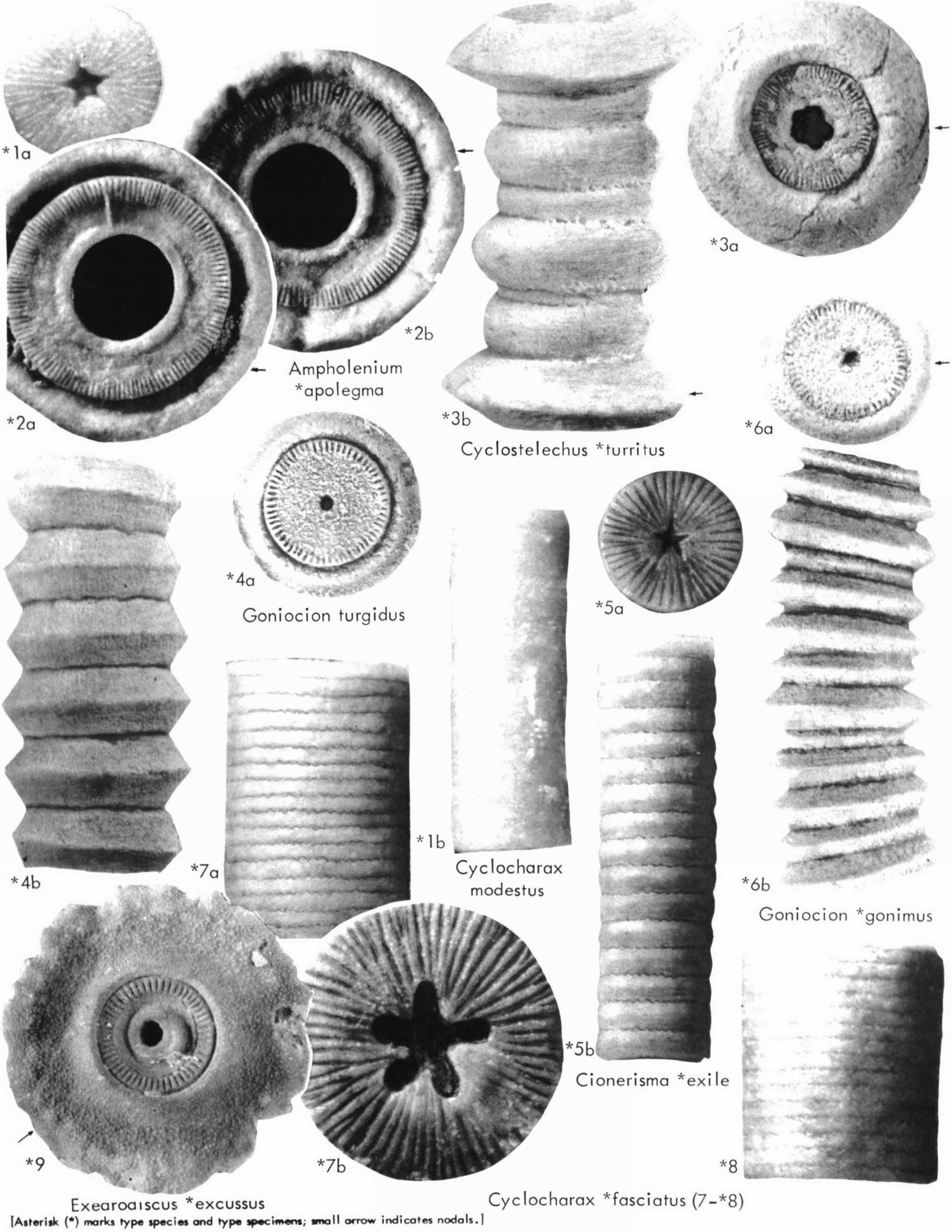
Exaesiodiscus *acutus (*4-6)

Exaesiodiscus minutus (7-*8)

Clematodiscus *denotatus (9-11)

Goniostathmus *annexus

[Asterisk (*) marks type species and type specimens; small arrow indicates nodals.]



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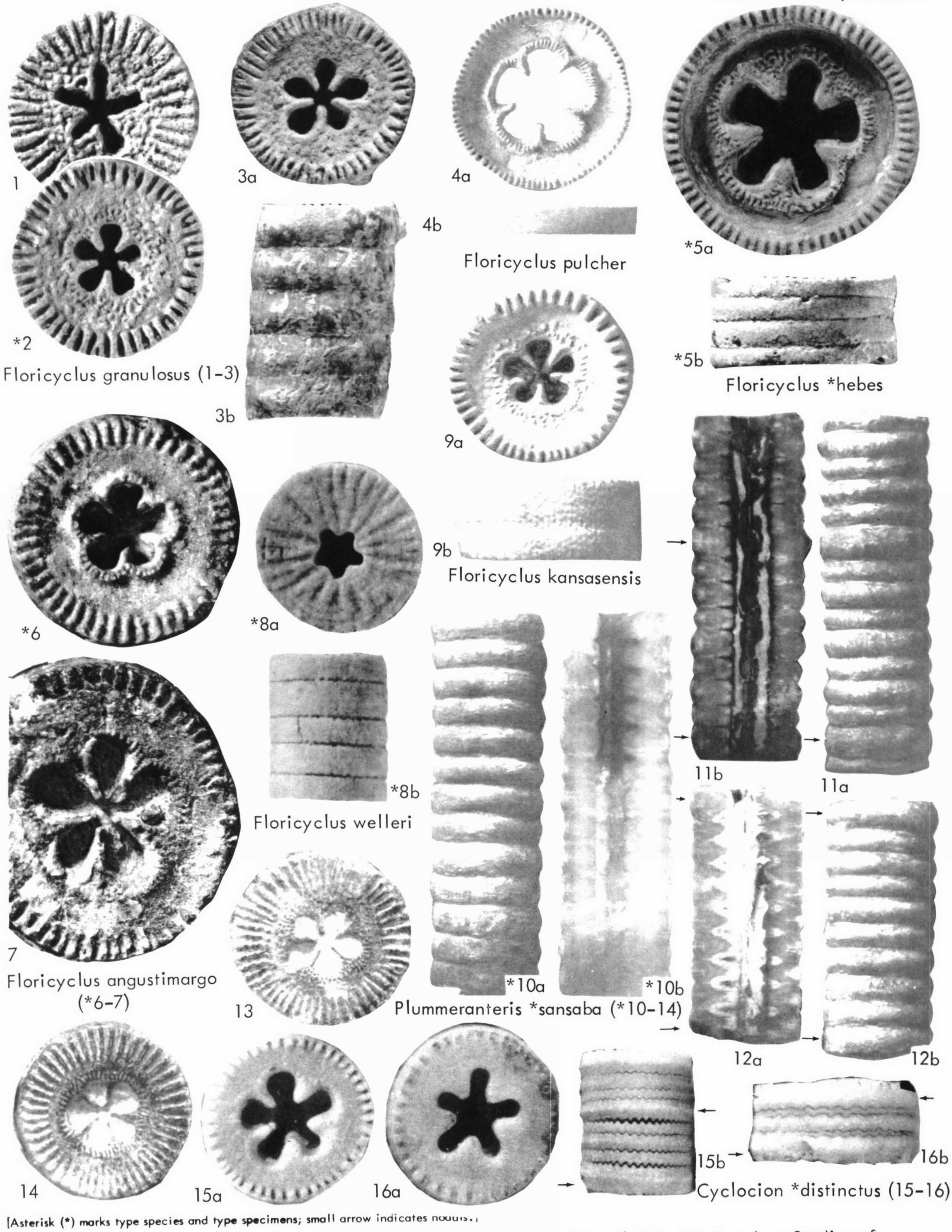

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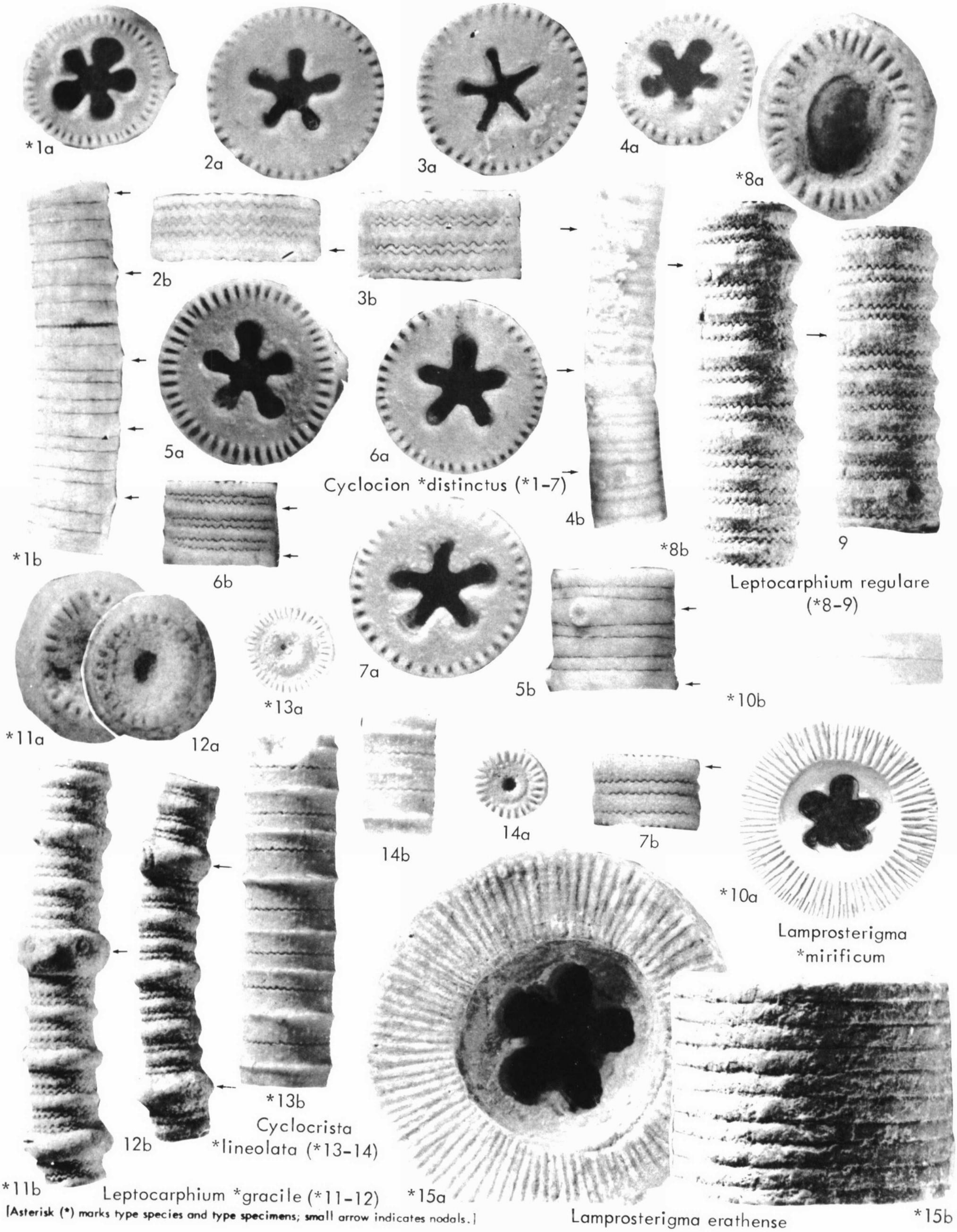

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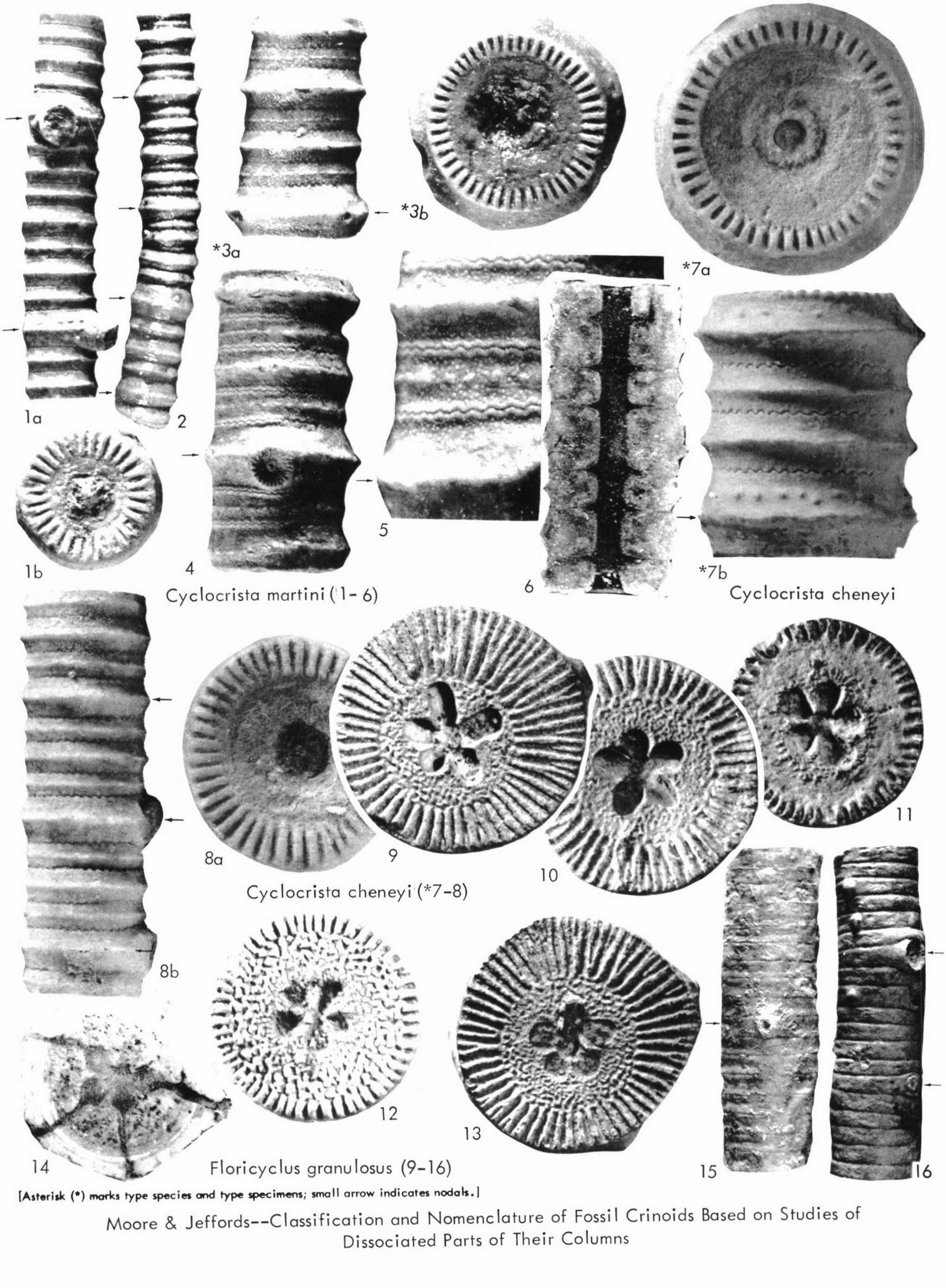


Cyclocrista martini (1- 6)

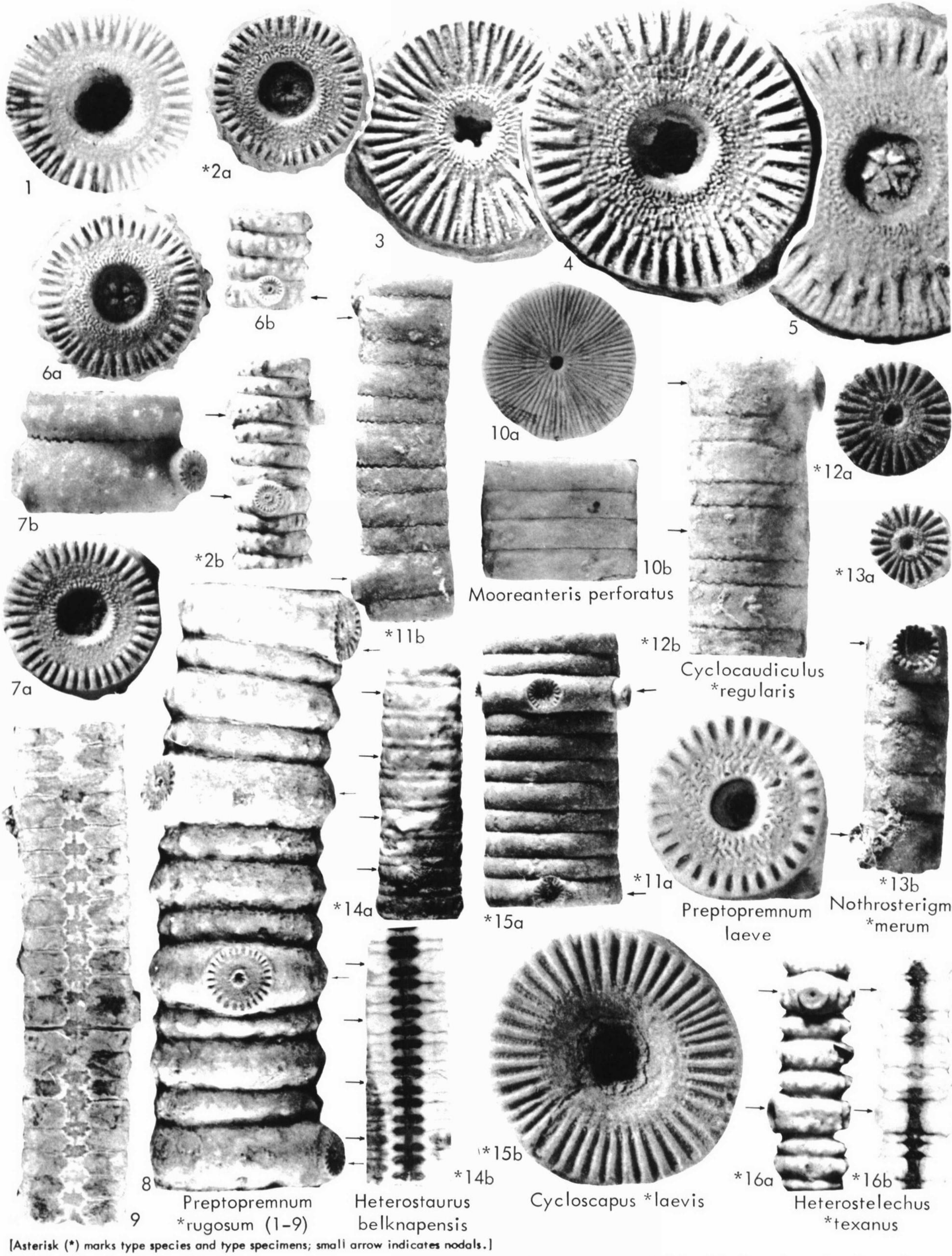
Cyclocrista cheneyi

Cyclocrista cheneyi (*7-8)

Floricyclus granulosus (9-16)

[Asterisk (*) marks type species and type specimens; small arrow indicates nodals.]

Moore & Jeffords--Classification and Nomenclature of Fossil Crinoids Based on Studies of Dissociated Parts of Their Columns



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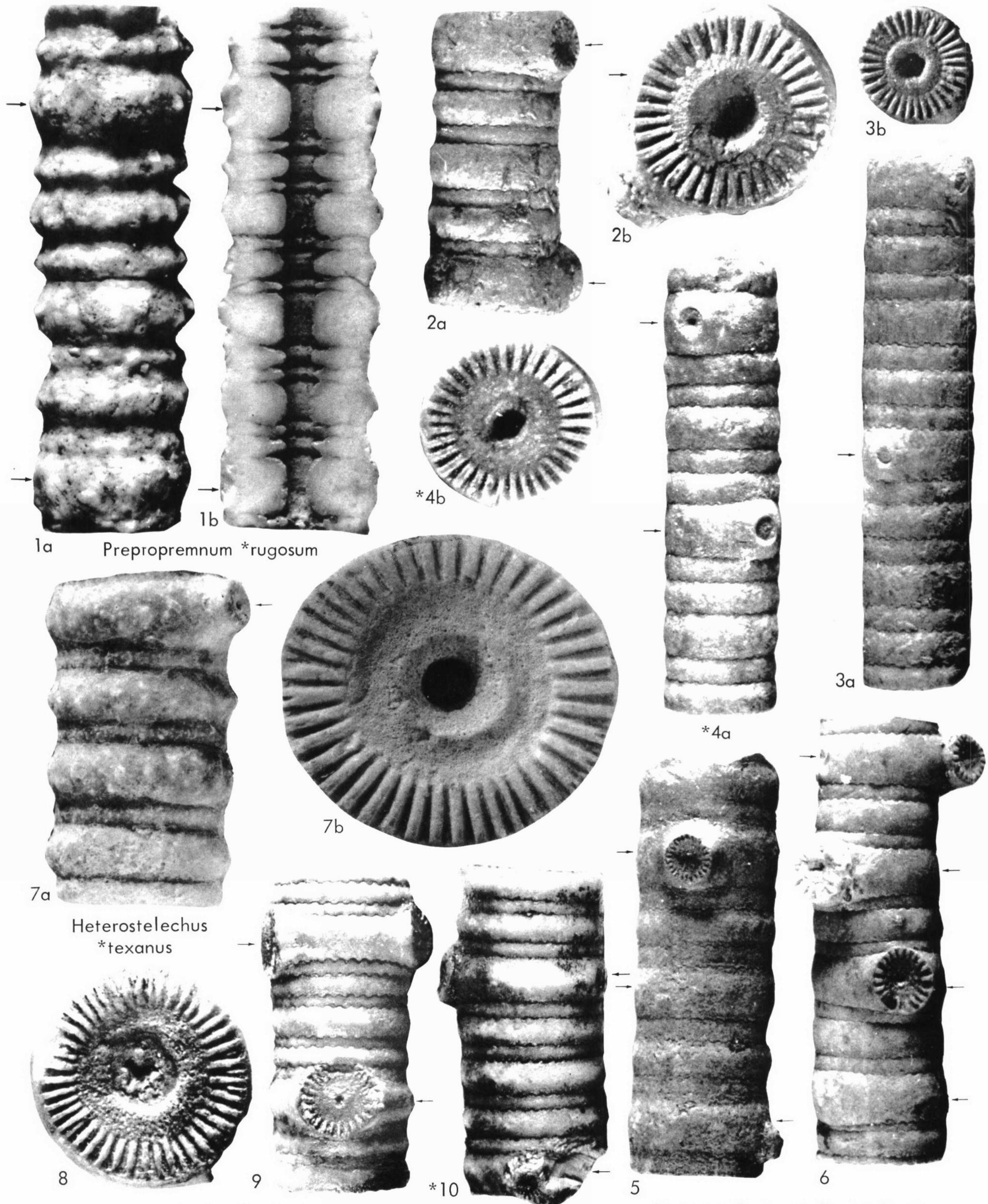

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