

of cup, diagram of cup (Jaekel, 1918).

[While this volume was in press, YU. A. ARENDT (1976) proposed a new class of Crinoidea that included the above-mentioned taxa in the following classification:

- Class Hemistreptocrinoidea Arendt, 1976
 Order Hemistreptocrinida Arendt, 1976
 Family Hemistreptocrinidae Arendt, 1976
Hemistreptocrinus Arendt, 1976
 L.Ord., USSR (Leningrad area)
Nonparactocrinus Arendt, 1976
 L.Ord. or M.Ord., USSR (Leningrad area or Estonia)
Parorthocrinus Jaekel, 1918
 L.Ord., USSR (Leningrad area)
Tetractocrinus Jaekel, 1918
 L.Ord., USSR (Leningrad area)
 Family Paractocrinidae Jaekel, 1918
Paractocrinus Jaekel, 1918
 L.Ord. or M.Ord., USSR (Leningrad area or Estonia).—Eds.]

Family UNCERTAIN

Passalocrinus PECK, 1936, p. 292 [**P. triangularis*; OD]. Small, monocyclic, theca shaped like old-fashioned ice cream cone. Basals 3, elongated, equidimensional; radials 5, short, variable sizes and shapes with 3 largest bearing articular facets (*A*, *B*, and *D* rays); orals 5, *CD* oral the largest. No anal plates or anal opening known. Arms and column unknown. [Specimens described by CRONEIS & GEIS, 1940, purported to be immature representatives of the blastoids *Mesoblastus glaber* and *Pentremites princetonensis*, are remarkably similar to *Passalocrinus*. The ontogeny presented did not show a transition from a *Passalocrinus*-like stage to a recognizable blastoid stage and the matter has not been resolved to date.] *L.Miss.-M.Miss.*, USA (Mo.-Ky.-Okla.-N.Mexico).—FIG. 505,1. **P. triangularis*, *L.Miss.*, Mo.; 1a-f, views of theca from *A*, *E*, *D*, *C*, and *B* rays, and ventral, $\times 45$ (Peck, 1936). [STRIMPLE]

FLEXIBILIA¹

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GENERAL MORPHOLOGY

Crinoids included in the class Flexibilia display from beginning to end of their long existence (M.Ord.-U.Perm.) a remarkable unity of important morphological characters, which serves to set them well apart from other crinoid groups. Among the features that appear in almost every taxonomic category the foremost are the following:

1) An aboral cup composed of three infrabasal plates (uncommonly reduced to two plates or fused to a single one) combined with five basals and five radials.

2) The infrabasal cirlet typically is composed of a small plate (termed *azygous*, unyoked) and two larger ones each formed by fusion of a pair of antecedent small plates (hence termed *zygous*, yoked), uncommonly, all infrabasals are fused together.

3) In all but a few specimens of one genus (*Forbesiocrinus*) the *azygous* infrabasal is located in the *C* ray.

4) In simpler forms (e.g., lecanocrinids)

the basals and radials form the main part of the aboral cup with summits of the radials mostly forming an even horizontal boundary at the arm bases.

5) Relatively large or diminutive anal plates consisting of radianal and anal *X* plate, or of the latter alone, compose posterior parts of most aboral cups, in one group (Taxocrinidae) the linearly arranged anal plates comprise a tube not firmly joined to the posterior basal or either arm of the posterior rays.

6) Observed tegmens of flexible crinoids are mainly built of extremely numerous small plates that in life presumably were buried in a leathery integument that covered and protected the viscera; ambulacral and interambulacral tracts are differentiated, the former leading between medium-sized to large oral plates surrounding the mouth; the posterior oral, exceeding the others in size, is a porous plate that functioned as a madreporite.

7) Position of the tegmen is at the level of radial plate summits in small rotund forms but well above it in larger, many-plated crowns (e.g., *Sagenocrinites*,

¹In the chapter on Flexibilia the Wenlockian and Ludlovian of Sweden (God.) are bracketed as undifferentiated Upper Silurian, whereas in other parts of this volume the Wenlockian is identified as Middle Silurian.

Forbesiocrinus, *Onychocrinus*, and many others); wherever precisely known, it is at the height of the so-called Y-line of the crown situated at the boundary between laterally united arm plates (associated in many forms with interlocked interradian and interbrachial plates) at the lowermost limit of free arms.

8) Arms universally are uniserial and lacking pinnules, their brachials generally much wider than high, with mostly flattened exterior surfaces. A patelloid process is present on the midline of the brachials of many genera.

9) Arms of a few genera are unbranched but generally they divide one or more times isotomously; heterotomous branching (mostly of biendotomous type) characterizes several forms.

10) Strong incurving of arms at summit of the crown is general.

11) Interradial and interbrachial plates characterize many genera; they exhibit much variation in size and number, as well as in being loosely or very firmly joined to brachials of rays.

12) Except in a very few aberrant forms, the stem is transversely circular and relatively robust, never pentagonal; where moderate to considerable lengths of it are known, its diameter is substantially uniform, but distal tapering characterizes several forms, especially just below the calyx. A differentiated proxistele of wide, thin columnals is present in many genera.

FORM AND STRUCTURE OF CROWN

A large majority of flexible crinoids have a rotund crown, either 1) subspherical, with width and height subequal (most lecanocrinids, niptocrinids such as *Pycnosaccus* and *Hormocrinus*, dactylocrinids such as *Aexitrophocrinus*, *Paramphicrinus*, *Ainacrinus*, *Amphicrinus*, ichtyocrinids such as *Clidochirus* and *Metichthyocrinus*, and taxocrinids such as *Parichthyocrinus*, *Synerocrinus*, and *Euonychocrinus*); 2) elongate, with width modestly to very distinctly less than height (*Lecanocrinus* and *Miracrinus* among lecanocrinids, *Nipterocrinus* and *Cholocrinus* among nipterocrinids, most homalocrinids, dactylocrinids,

sagenocrinitids, ichtyocrinids, and taxocrinids); and 3) low rotund, with width greater than height (*Caldenocrinus*, *Zenocrinus*, and *Dieuryocrinus* among dactylocrinids). Illustrations and structural diagrams of all these forms are given with the systematic part of the text.

An examination of the structure of flexible crinoid crowns of all types reveals the anomalous nonflexible nature prevailing in their construction. Most plates of the calyx, including those of the more or less morphologically differentiated aboral cup and lower part of the arms, with associated interradian and interbrachial plates where present, are rigidly united together. Movement between them therefore is nil or at most insignificant. Only distal parts of arm appendages are capable of appreciable inward and outward movements, which can be defined as flexible. Thus, a comparative equivalence in the crown structure of all or nearly all crinoids clearly links the Flexibilia with Camerata, Inadunata, and Articulata. It is prevalence of interplate articulation by means of very short ligament fibers, accompanied by lack of structures providing for muscular articulations of any sort, which separate the flexible crinoids from others. In general, the Flexibilia comprise a readily recognizable assemblage of crinoids distinguished both by their crown structure and by all-but-constant morphological features of their aboral cup and arm construction.

ELEMENTS OF ABORAL CUP AND THEIR RELATIONSHIP TO OTHER PARTS OF WHOLE CRINOID

INFRABASALS

Morphologic features of the infrabasal plates at the base of aboral cups of flexible crinoids are described below according to the inclusion in six arbitrarily differentiated groups, in those numbered (3) and (4) entirely covered by the topmost columnal of the stem, but in others with a small or relatively large part of their distal extremities visible outside of the stem (Fig. 506). It is evident that the different groups lack taxonomic significance, for representatives

MEDIUM-SIZED TO LARGE TRIPARTITE CIRCLET

NOT ENTIRELY COVERED BY STEM



1
Mysticocrinus



2
3
4
5

- 2-Lecanocrinids
 a-Lecanocrinus
 b-Mespilocrinus
 c-Cibolocrinus
 d-Petrocrinus
 e-Syntomocrinus
 3-Nipterocrinids
 a-Cholocrinus
 b-Hormocrinus

- c-Pycnosaccus
 4-Homalocrinids
 a-Anisocrinus
 b-Asaphocrinus
 5-Dactylocrinids
 a-Lithocrinus
 b-Nevadacrinus
 c-Temnocrinus

- 6-Sagenocrinitid
 Sagenocrinites
 7-Ichthyocrinid
 Clidochirus
 8-Taxocrinids
 a-Taxocrinus
 b-Gnorimocrinus
 c-Meristocrinus
 d-Protaxocrinus

MEDIUM-SIZED TRIPARTITE CIRCLET ENTIRELY COVERED BY STEM



9-12

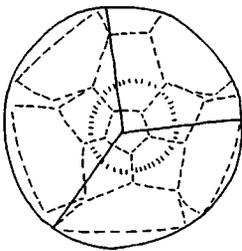
- 9-Dactylocrinids
 a-Aexitrophocrinus
 b-Caldenocrinus
 c-Wachsmuthicrinus
 d-Ainacrinus
 e-Artichthyocrinus
 f-Rumphocrinus
 10-Sagenocrinitid
 Trampidocrinus
 11-Ichthyocrinids
 a-Ichthyocrinus
 b-Metichthyocrinus
 c-Synaptocrinus
 12-Taxocrinids
 a-Parichthyocrinus
 b-Eutaxocrinus
 c-Synerocrinus
 d-Enascocrinus
 e-Euonychocrinus
 f-Onychocrinus

SMALL TRIPARTITE CIRCLET ENTIRELY COVERED BY STEM

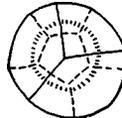


- 13 13-Dactylocrinids
 14 a-Dactylocrinus
 b-Euryocrinus
 c-Amphicrinus
 d-Dieuryocrinus
 14-Ichthyocrinid
 Cleistocrinus

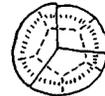
EXTERNALLY MUCH-ENLARGED BUT INTERNALLY
 CONSTRICTED TRIPARTITE CIRCLET



Dactylocrinid
 15-Calpiocrinus



Homalocrinid
 16-Homalocrinus



Sagenocrinitid
 17-Forbesiocrinus

LARGE FUSED CIRCLET NOT ENTIRELY COVERED BY STEM



18 19

- 18-Lecanocrinids
 a-Calycocrinus
 b-Proapsidocrinus
 c-Prophyllocrinus
 d-Ancistrocrinus
 19-Nipterocrinid
 Nipterocrinus

FIG. 506. Diagrams showing morphologic features of the infrabasal circlet of flexible crinoids (not to scale).

are distributed among different families.

1) Relatively large tripartite infrabasal circlet with most of plates visible beyond small stem impression. Such an arrangement characterizes *Mysticocrinus* (Lecanocrinidae) (Fig. 506, I), distinguishing it

from all other flexible crinoids.

2) Medium-sized tripartite infrabasal circlet not entirely covered by relatively large stem. Crinoids of this group resemble the first except that the stem covers most but not all of the plates, their distal extrem-

ities being clearly visible beyond the stem impression. Here belong lecanocrinids (Fig. 506,2a-e), nipterochrinids (Fig. 506,3a-c), homalocrinids (Fig. 506,4a,b), dactylochrinids (Fig. 506,5a-c), sagenocrinitid (Fig. 506,6), ichtyocrinid (Fig. 506,7), and taxocrinids (Fig. 506,8a-d). Orientation of the *azygous* plate is constantly in the *C* ray.

3) Medium-sized tripartite infrabasal circler entirely concealed by stem. The circler occupies most but not quite all of the stem impression. Here belong dactylochrinids (Fig. 506,9a-f), a sagenocrinitid (Fig. 506,10), ichtyocrinids (Fig. 506,11a-c), and taxocrinids (Fig. 506,12a-f).

4) Small tripartite infrabasal circler entirely concealed by stem which covers also proximal part of basals. These are mostly dactylochrinids (Fig. 506,13a-d). *Cleistocrinus* (Fig. 506,14) represents the ichtyocrinids.

5) Externally much enlarged but internally constricted tripartite infrabasal circler. This is an exceptional arrangement found in three flexible crinoids. The stem covers only proximal parts of exposed infrabasals in *Calpiocrinus* (Fig. 506,15) and *Homalocrinus* (Fig. 506,16) but most of these plates in *Forbesiocrinus* (Fig. 506,17). In *Calpiocrinus* the infrabasals are so enlarged that they cover not only basals but radial plates.

6) Large, fused infrabasal circler mostly but not entirely covered by stem. In this group are lecanocrinids (Fig. 506,18a-d) and *Nipterochrinus* (Fig. 506,19).

BASALS

Morphologically viewed, plates of the basal circler of flexible crinoids may be divided into two groups, based on relative importance as elements of the aboral cup.

1) Basals forming important, even major part of aboral cup, entirely outside and above area of stem impression. In numerous genera they form part of the base and the main part of the sides of the aboral cup. In others they are confined to the sides. Their size is relatively large, little if any smaller than the radials. Distally they invariably slope more or less steeply upward.

Basals of this group especially characterize lecanocrinids, as seen in *Mysticocrinus* (Fig. 507,1a), *Lecanocrinus* (Fig. 507,1b), *Mira-*

crinus (Fig. 507,1c), *Geroldicrinus* (Fig. 507,1d), *Mespilocrinus* (Fig. 507,1e), *Cibolocrinus* (Fig. 507,1f), and *Calyocrinus* (Fig. 507,1g). Among nipterochrinids typical representatives of the group are seen in *Cholocrinus* (Fig. 507,2a), *Pycnosaccus* (Fig. 507,2b), and *Hormocrinus* (Fig. 507,2c). Among homalocrinids these relatively large basals occur in *Anisocrinus* (Fig. 507,3a), and *Asaphocrinus* (Fig. 507,3b); in dactylochrinids they are well defined in *Lithocrinus* (Fig. 507,4a), *Nevadocrinus* (Fig. 507,4b), and *Temnocrinus* (Fig. 507,4c). The sagenocrinitids are represented by the single genus *Sagenocrinites* (Fig. 507,5) and ichtyocrinids by the single genus *Clidochirus* (Fig. 507,6). Among taxocrinids are four genera with large basals outside of the stem impression area, *Taxocrinus* (Fig. 507,7a), *Meristocrinus* (Fig. 507,7b), *Protaxocrinus* (Fig. 507,7c), and *Gnorimocrinus* (Fig. 507,7d).

2) Basals forming minor part of aboral cup, largely or entirely covered by stem except for distal extremity of the posterior basal. In this group the aboral cup is not a prominent part of the calyx, being differentiated only by morphologic distinctions.

Most dactylochrinids have basals belonging to this second group, *Amphicrinus* (Fig. 508,1a), *Dactylochrinus* (Fig. 508,1b), *Axi-trophocrinus* (Fig. 508,1c), *Ainacrinus* (Fig. 508,1d), *Euryocrinus* (Fig. 508,1e), *Dieuryocrinus* (Fig. 508,1f), *Artichthyocrinus* (Fig. 508,1g), *Rumphocrinus* (Fig. 508,1h), *Caldenocrinus* (Fig. 508,1i), and *Wach-smuthicrinus* (Fig. 508,1j). Sagenocrinitids are represented by *Forbesiocrinus* (Fig. 508,3a), and *Trampidocrinus* (Fig. 508,3b); ichtyocrinids by *Ichthyocrinus* (Fig. 508,2a), *Synaptocrinus* (Fig. 508,2b), and *Metichthyocrinus* (Fig. 508,2c). Five genera of taxocrinids have basals almost entirely covered by the stem; they are *Parichthyocrinus* (Fig. 508,4a), *Enascocrinus* (Fig. 508,4b), *Eutaxocrinus* (Fig. 508,4c), *Euonychocrinus* (Fig. 508,4d), *Synerocrinus* (Fig. 508,4e), and *Onychocrinus* (Fig. 508,4f).

ANALS

Anal plates of flexible crinoids range from a single one to many. They are more or less prominent elements of the posterior side of the aboral cup, also present only

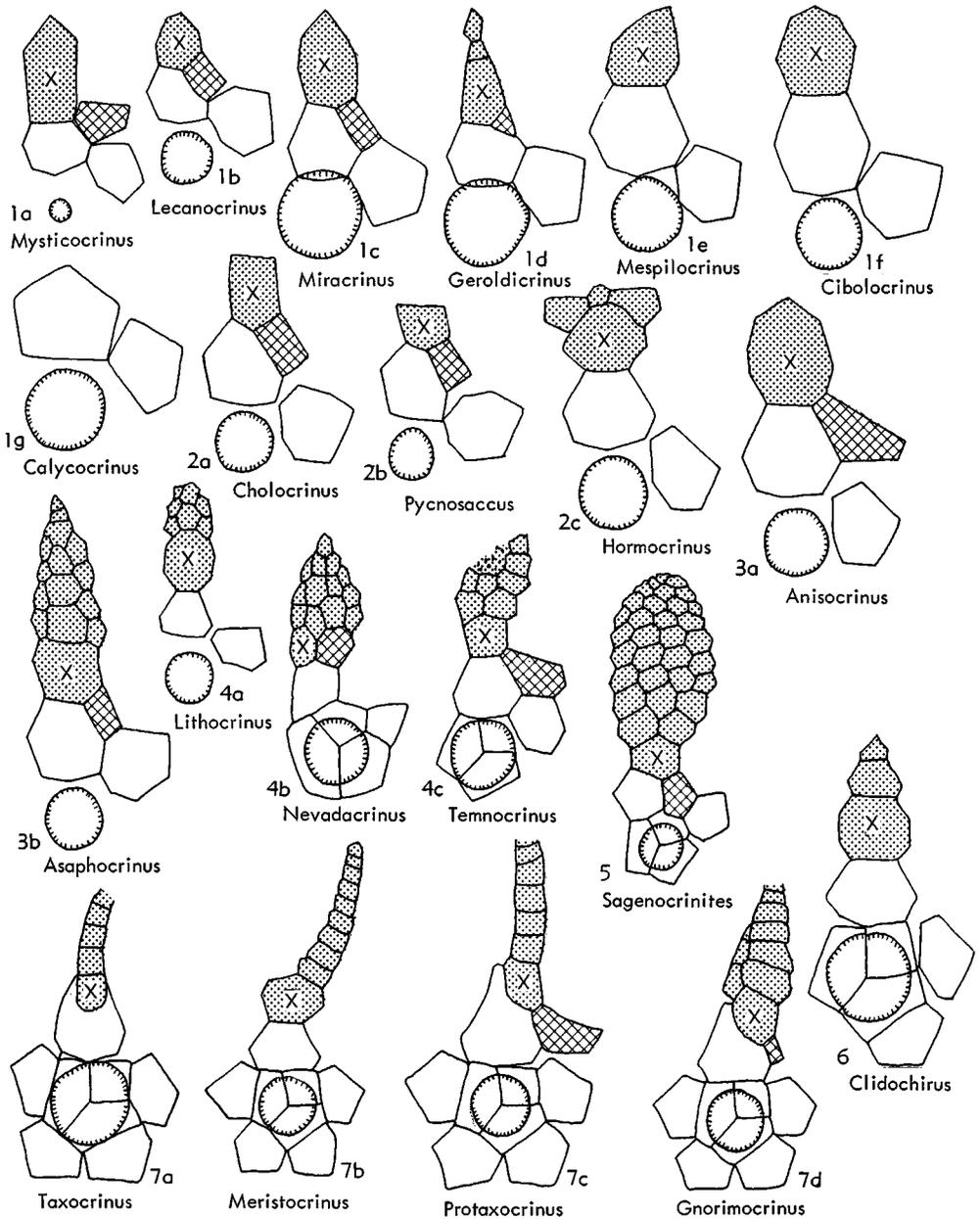


FIG. 507. Diagrams showing BC and CD basals or entire circlet in relation to stem impression, also anal-plate series (radial plate cross ruled, anal series stippled) (not to scale).

above the summit of the cup. They form a generally significant part of the calyx. The anals are distinguishable as a radial (absent in many forms); anal X plate and calyx or tube plates above the X.

Crinoids having a radial are divisible

into three groups differentiated as follows:

1) Radial primitive, occurring directly below the C radial. Here belong the lecanocrinid *Mysticocrinus* (Fig. 507,1a), the homalocrinid *Anisocrinus* (Fig. 507,3a), the dactylocrinid *Temnocrinus* (Fig. 507,4c),

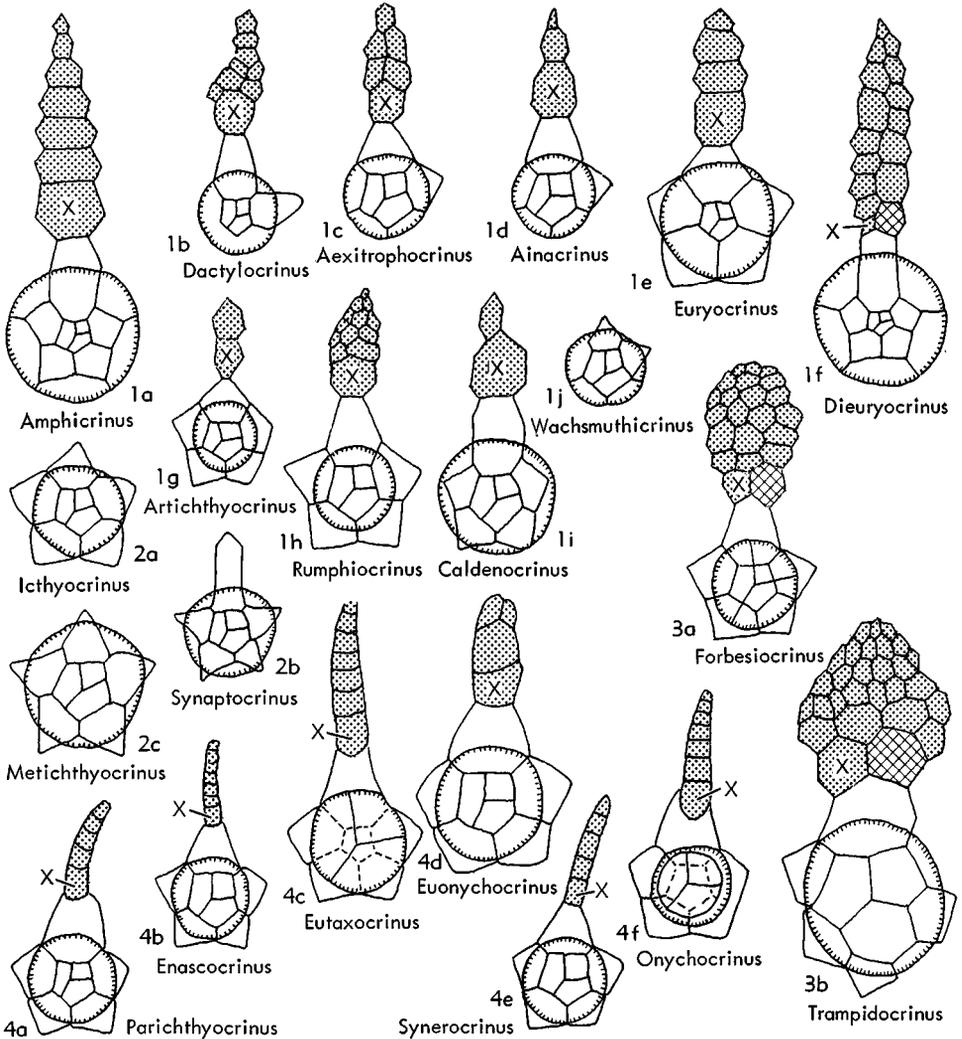


FIG. 508. Diagrams of same morphologic features given in Fig. 507 (patterns as in Fig. 507).

the sagenocrinitid *Sagenocrinites* (Fig. 507, 5), and the taxocrinid *Protaxocrinus* (Fig. 507,7c).

2) Radial rhombic (or modified to subtriangular, pentagonal, or hexagonal) obliquely at left below the C radial. In this group belong the lecanocrinids *Lecanocrinus* (Fig. 507,1b), *Miracrinus* (Fig. 507,1c), and *Geroldicrinus* (Fig. 507,1d); the nipterocrinids *Cholocrinus* (Fig. 507,2a), and *Pycnosaccus* (Fig. 507,2b); the homalocrinid *Asaphocrinus* (Fig. 507,3b); and the taxocrinid *Gnorimocrinus* (Fig. 507,7d).

3) Radial displaced upward to adjoin the anal X plate on right. Here four genera are recognized: among dactylocrinids, *Nevadacrinus* (Fig. 507,4b) and *Dieuryocrinus* (Fig. 508,1f); sagenocrinitids include *Forbesiocrinus* (Fig. 508,3a) and *Trampidocrinus* (Fig. 508,3b). A radial plate is lacking in all other flexibles.

Crinoids having no anal plates at all include the lecanocrinid *Calycocrinus* (Fig. 507,1g), the dactylocrinid *Wachsmuthicrinus* (Fig. 508,1j), and the ichthyocrinids *Ichthyocrinus* (Fig. 508,2a), *Synaptocrinus*

(Fig. 508,2b), and *Metichthyocrinus* (Fig. 508,2c). The orientation of cups and calyces belonging to these genera is determined by arrangement of plates in the infrabasal circlet.

RADIAL AND ARM PLATES

Radial plates of nearly all flexible crinoids have straight to very gently curved summits. In a few genera, however, the summit is moderately to strongly arcuate and asymmetrical. This latter group, all lecanocrinids, include *Mysticocrinus* (Fig. 509,1a), *Proapsidocrinus* (Fig. 509,1b), *Prophylocrinus*, and *Ancistrocrinus*.

Construction of the arms, combined with other morphological features, has considerable taxonomic significance. Three groups of arm types can be recognized among flexible crinoids, with several subgroups.

1) Arms unbranched. The lecanocrinids *Palaeoholopus* (see Fig. 525,1) and *Permo-brachypus* (see Fig. 525,4) lack arm bifurcations.

2) Flexible crinoids characterized by isotomous bifurcation of the arms comprise a second group, which is divisible into subgroups as follows:

2a) Single bifurcation in each ray. Only the lecanocrinids *Petrocrinus* (see Fig. 521,1) and *Mysticocrinus* (Fig. 509,1a), *Syntomocrinus* (see Fig. 521,2), *Gaulocrinus* (see Fig. 525,5), and *Ancistrocrinus* (see Fig. 528,4), appear to belong in this subgroup.

2b) Two even bifurcations in each ray. All structures of this type are seen in the lecanocrinids *Proapsidocrinus* (Fig. 509,1b), *Mespilocrinus* (Fig. 509,2c), and *Cibolocrinus* (Fig. 509,2d). Other flexibles of the subgroup include the niptero-crinids *Nipterocrinus* and *Cholocrinus*, the dactylocrinids *Artichthyocrinus* and *Nevadocrinus*, and the ichthyocrinid *Metichthyocrinus*.

2c) Three uneven bifurcations in all branches of each ray. Structures of this type are seen in the niptero-crinids *Hormocrinus* and *Pycnosaccus* (Fig. 509,3a,b), in the dactylocrinid *Temnocrinus* (Fig. 510,1a), in the sagenocrinitids *Trampidocrinus*, *Sagenocrinites*, and *Forbesiocrinus*, in the ichthyocrinids *Synaptocrinus* and *Clidochirus*, and in the

taxocrinids *Taxocrinus*, *Meristocrinus*, *Parichthyocrinus*, and *Eutaxocrinus* (Fig. 510,1b).

2d) Two or more even bifurcations in some but not all branches of each ray. Structures of this type are found in the lecanocrinids *Lecanocrinus* (Fig. 509,2a), *Miracrinus* (Fig. 509,2b), and *Geroldiocrinus*, in the dactylocrinids *Euryocrinus* (Fig. 510,2a), *Amphicrinus* (Fig. 510,2b), and *Caldenocrinus*, in the ichthyocrinid *Ichthyocrinus*, and in the taxocrinids *Gnorimocrinus* and *Protaxocrinus*.

3) Main arm branches bifurcating isotomously, then each branch dividing heterotomously. This readily differentiated assemblage is divisible into three subgroups.

3a) Uniendotomous (only two main branches). Here the main branches bear small ones facing each other on inner sides of the main ones, as in *Homalocrinus* (Fig. 509,4a).

3b) Biendotomous (four main branches). The two pairs of main branches bear small arms facing each other so as to form a double-combed pattern. This predominates in the dactylocrinids as illustrated by *Aexitrophocrinus* (Fig. 509,4b), *Wachsmuthicrinus* (Fig. 509,4c), *Dactylocrinus* (Fig. 509,4d), *Calpiocrinus* (Fig. 509,4e), *Paramphicrinus* (Fig. 510,3a), *Lithocrinus*, *Calpiocrinus*, and *Zenocrinus*. It is also seen in the taxocrinids *Synerocrinus* (Fig. 510,3b), *Enascocrinus*, *Euonychocrinus*, and *Onychocrinus*.

3c) Uniexoendotomous (two main branches with ramules on both sides of branches). This distinctive type of arm structure is found only in *Onychocrinus* of the Taxocrinidae.

Subclass FLEXIBILIA Zittel, 1895

[*nom. transl.* MOORE & LAUDON, 1943a, p. 64 (ex order Flexibilia ZITTEL, 1895, p. 165)] [=Articulata ZITTEL, 1879, p. 345, non MILLER, 1821, p. 13; suborder Articulosa JAEKEL, 1894, p. 118; Articulata Impinnata WACHSMUTH & SPRINGER, 1885, p. 304(82) (*partim*); grade Impinnata BATHER, 1899b, p. 922; order Flexibilia PEARSE, 1947, p. 10] [Materials for this subclass prepared by R. C. MOORE, with additional contributions as noted in text]

Crown ovoid to globose, consisting mainly of closely abutting uniserial arms incurved distally, distinctly differentiated from cup or with proximal brachials and interarm plates merging uninterruptably with radials

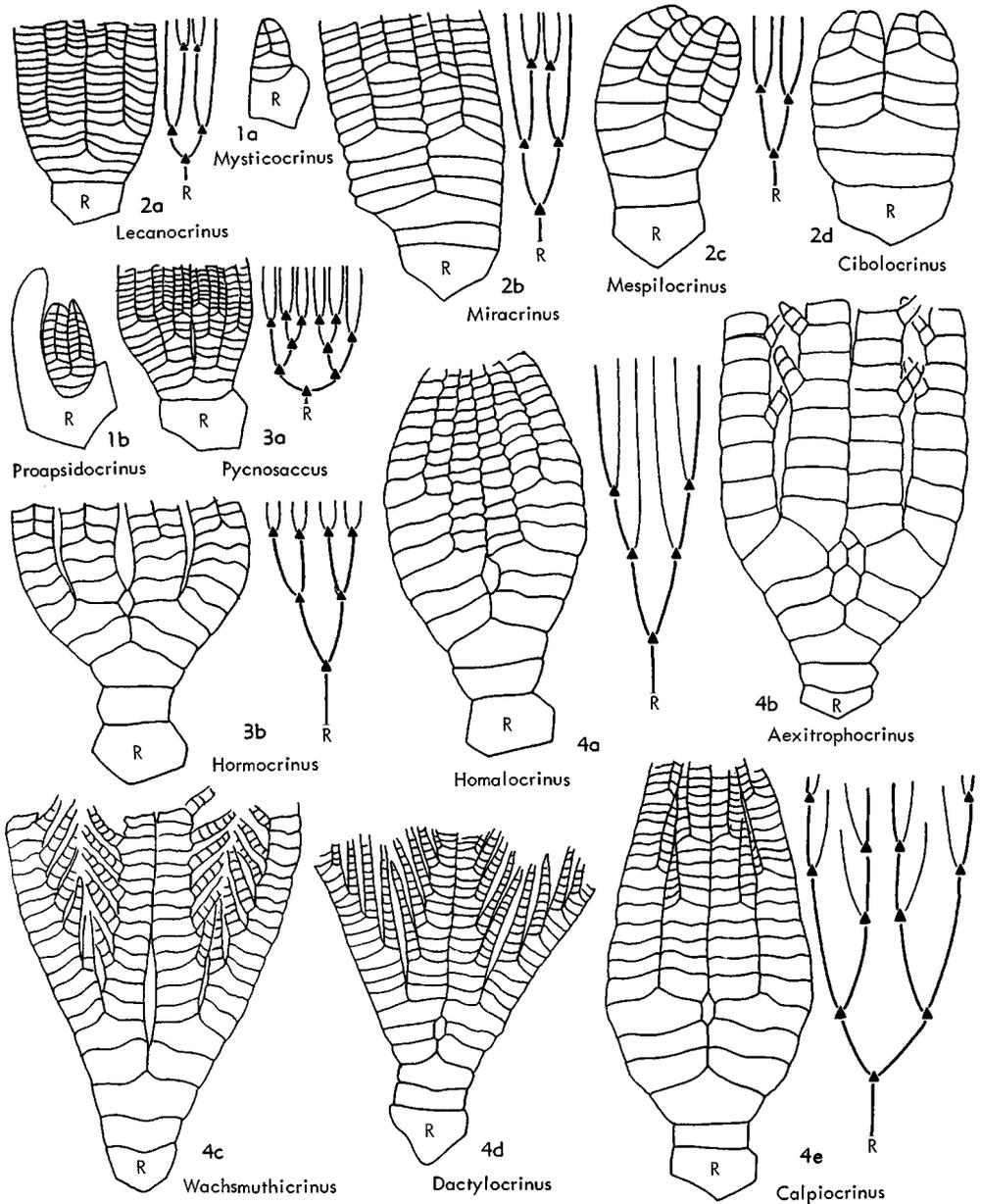


FIG. 509. Diagrams of radial (*R*) and arm structure of *C* ray observed in flexible crinoids, some accompanied by drawings designed to portray arm-branching pattern in simplified form (black triangles denote axillary brachials and heavier lines main arm branches; *R*, radial) (not to scale).

and two subjacent plate circlets, nearly all joined together by ligaments rather than by solid union. Infrabasals three, small azygous one in *C* ray and large ones in *AB* and *DE* rays, or rarely fused into single disc or

entirely resorbed. Five basals and five radials subequal in each circlet. Radial commonly present, either in primitive position directly below *C* radial or shifted obliquely left. Anal *X* plate inserted be-

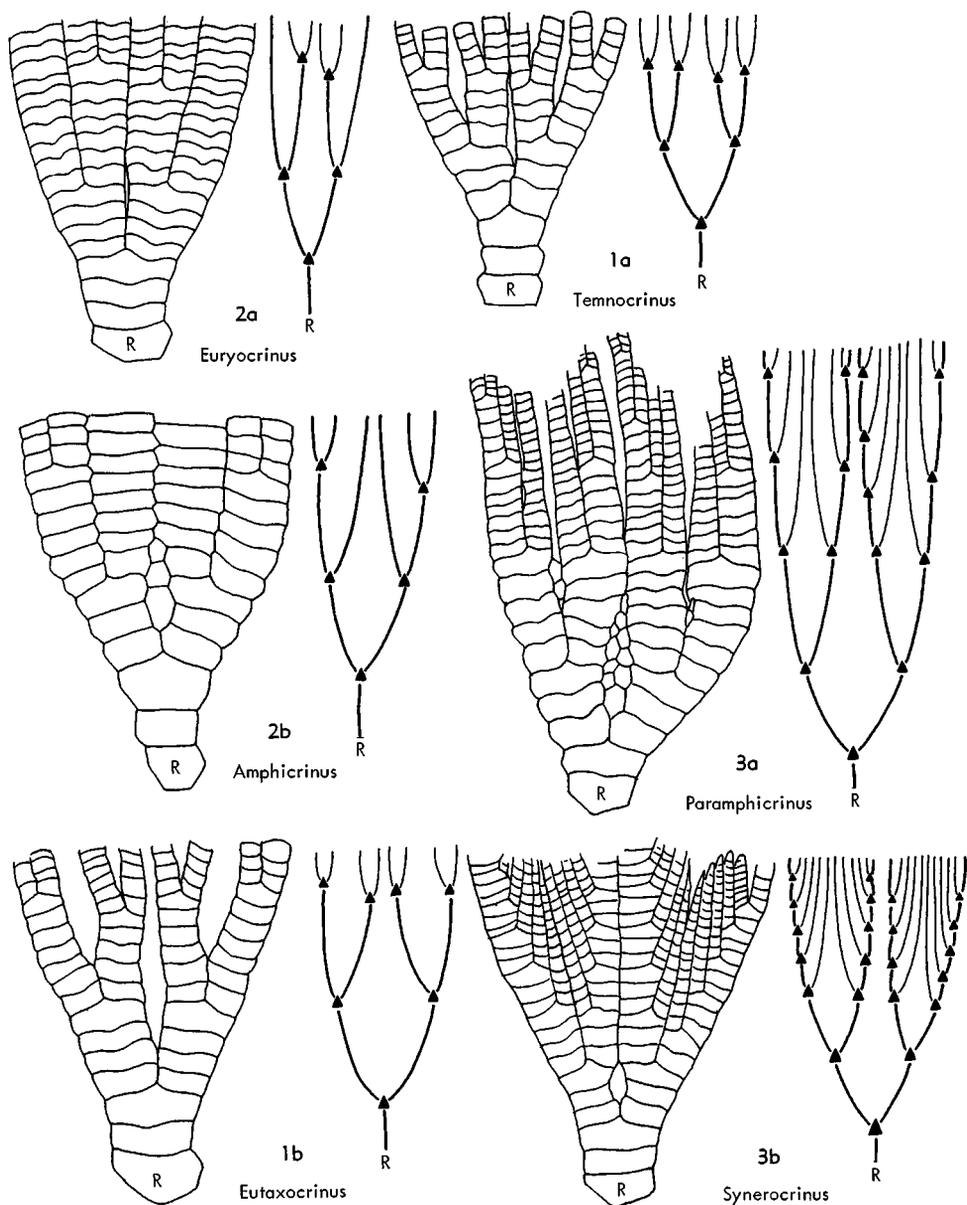


FIG. 510. Diagrams of same morphologic features given in Fig. 509.

tween posterior radials. Arms nonpinnulate generally branching isotomously or both isotomously and heterotomously, exceptionally atomous. Supplementary small, medium-sized or large polygonal plates may be developed interradially as well as between

arm branches (interbrachials). Tegmen flexible, lacking anal sac but in many genera containing five distinct orals (posterior one largest), rows of ambulacrals leading from arm bases to exposed mouth, and large areas of small interambulacral plates. Stem

transversely round, composed of thin columnals, or very rarely crescentic (*Ammonocrinus*); noncirriferous. *M.Ord.-U.Perm.*

Order TAXOCRINIDA Springer, 1913

[*nom. correct.* MOORE in MOORE, LALICKER, & FISCHER, 1952, p. 614 (*pro order* Taxocrinoidea SPRINGER, 1913, p. 205)] [= *Taxocrinites* JAEKEL, 1918, p. 78]

Crown elongate ovoid, with well-rounded arms not abutting next adjacent neighbors and relatively weak calyx lacking distinct cup, anal *X* and succeeding longitudinal row of anal plates separated from posterior radials and primibrachs by small-plated flexible perisome instead of joined to them and *CD* basal by close suture. *M.Ord.-U.Penn.*

Representatives of the Taxocrinida are the only Flexibilia known from pre-Silurian deposits anywhere in the world. These most ancient flexible crinoids resemble contemporaneous inadunates in having a steeply conical cup with strongly upflaring infra-basals, large radianal directly beneath the *C* radial, well-developed anal *X* and row of following anal plates, and slender round arms which are long and isotomously branched at various heights in the crown. Interbrachial plates generally are present but not abundant.

Silurian and youngest crinoids of the Taxocrinida are larger than oldest ones, have more gently upflared cups, display a leftward shift of the radianal or disappearance of this plate (e.g., *Eutaxocrinus*), and diminution of interbrachials without close juxtaposition of the arms. No evolutionary tendency toward greater simplicity of structure or decrease in size is observable.

Superfamily TAXOCRINACEA Angelin, 1878

[*nom transl.* MOORE & STRIMPLE, 1973 (*ex* Taxocrinidae ANGELIN, 1878, p. 8)] [incl. Onychocrinidae JAEKEL, 1918, p. 79]

Crown usually elongate, with rays above radials partly or wholly separated all around; posterior interray invariably differentiated by presence of anal plates in tubelike series not incorporated in calyx; branching of arms isotomous, heterotomous, or both. *M.Ord. (Trenton.)-U.Penn. (Missour.)*.

Family TAXOCRINIDAE Angelin, 1878

[Taxocrinidae ANGELIN, 1878, p. 8]

Branching of arms isotomous; radianal present or absent. *M.Ord. (Trenton.)-U. Miss. (Chester.)*.

Taxocrinus PHILLIPS in MORRIS, 1843, p. 59 [**Cyathocrinus? macrodactylus* PHILLIPS, 1841, p. 29 (= *Isocrinus macrodactylus* PHILLIPS, 1841, p. 30); SD WORTHEN in MEEK & WORTHEN, 1866a, p. 271] [= *Isocrinites* PHILLIPS, 1841, p. 30 (group) (*non* VON MEYER, 1836); *Isocrinus* PHILLIPS, 1841, p. 30 (obj.) (*non* VON MEYER, 1837); *Cladocrinites* AUSTIN & AUSTIN, 1843, p. 197 (type, *Poteriocrinites egertoni* PHILLIPS, 1836); *Cladocrinus* MORRIS, 1843, p. 59 (*nom. van. pro Cladocrinites*); *Euryalecrinus* AUSTIN & AUSTIN, 1846, p. 66 (*nom. nud.*); *Taxocrinites* STEININGER, 1853, p. 37 (*nom. van. pro Taxocrinus*); *Euryalocrinus* DELAGE & HÉROUARD, 1904, p. 477 (*nom. van. pro Euryalecrinus*)]. Crown elongate with rays not abutting above interray areas, arms divergent; infrabasals subhorizontal, mostly or entirely concealed by column; posterior basal elongate, with distal extremity hollowed for reception of anal *X* followed by anal tube; radianal only in upper oblique position when present; interprimibrachs variable, usually well defined between primibrach series of all rays except *CD* interray, distal margin of these plates crescentic, rising toward rays. Primibrachs 3, followed by arm branches which bifurcate additionally above axillary primibrach. Column usually enlarged proximally. *M.Dev.*, USA (Iowa-Wis.-N.Y.); *U.Dev.*, Eu. (Eng.); *L.Miss. (Kinderhook.-Osag.)*, USA (Iowa-Mo.-Ill.-Ind.-Ohio-Ky.); *U.Miss. (Chester.)*, USA (Mo.-Ill.-Ky.-Ala.-Okla.); *L.Carb. (Tournais.)*, Eu. (Belg.-Eng.-Eire-Ger.).—FIG. 511, *I*; 512, *5c*. **T. macrodactylus* (PHILLIPS), *L.Carb. (Pilton beds)*, Eng. (Devon.); 511, *I*, plate diagram of cup (radials black, *X* and higher anals stippled), part of *C*- and *D*-ray arms, anal-plate series, and interprimibrachs of *BC* and *DE* interrays (mod. from Springer, 1920); 512, *5c*, lat. view of holotype, rays unspecified, $\times 0.5$ (Springer, 1920).—FIG. 512, *4*. *T. colletti* WHITE, *L.Miss. (Osag.)*, USA (Ind.); partial plate diagram with edge views of thick brachials (Springer, 1920).—FIG. 512, *5a, b*. *T. intermedius* WACHSMUTH & SPRINGER, *L.Miss. (Kinderhook.)*, USA (Iowa); tegmental view of holotype showing ambulacral series reaching between large orals, and *D*-ray view of another specimen, $\times 1$ (Springer, 1920).—FIG. 512, *5d*. *T. ornatus* SPRINGER, *L.Miss. (Osag., Burlington Ls.)*, USA (Iowa); *EA*-interray view of holotype showing strongly incurved distal parts of arms, $\times 1$ (Springer, 1920). [= *Chladiocrinus* DELAGE & HÉROUARD, 1903 (*nom. null.*).]

Eutaxocrinus SPRINGER, 1906, p. 493 [**Taxocrinus affinis* MÜLLER, 1856, p. 353; SD SPRINGER, 1920,

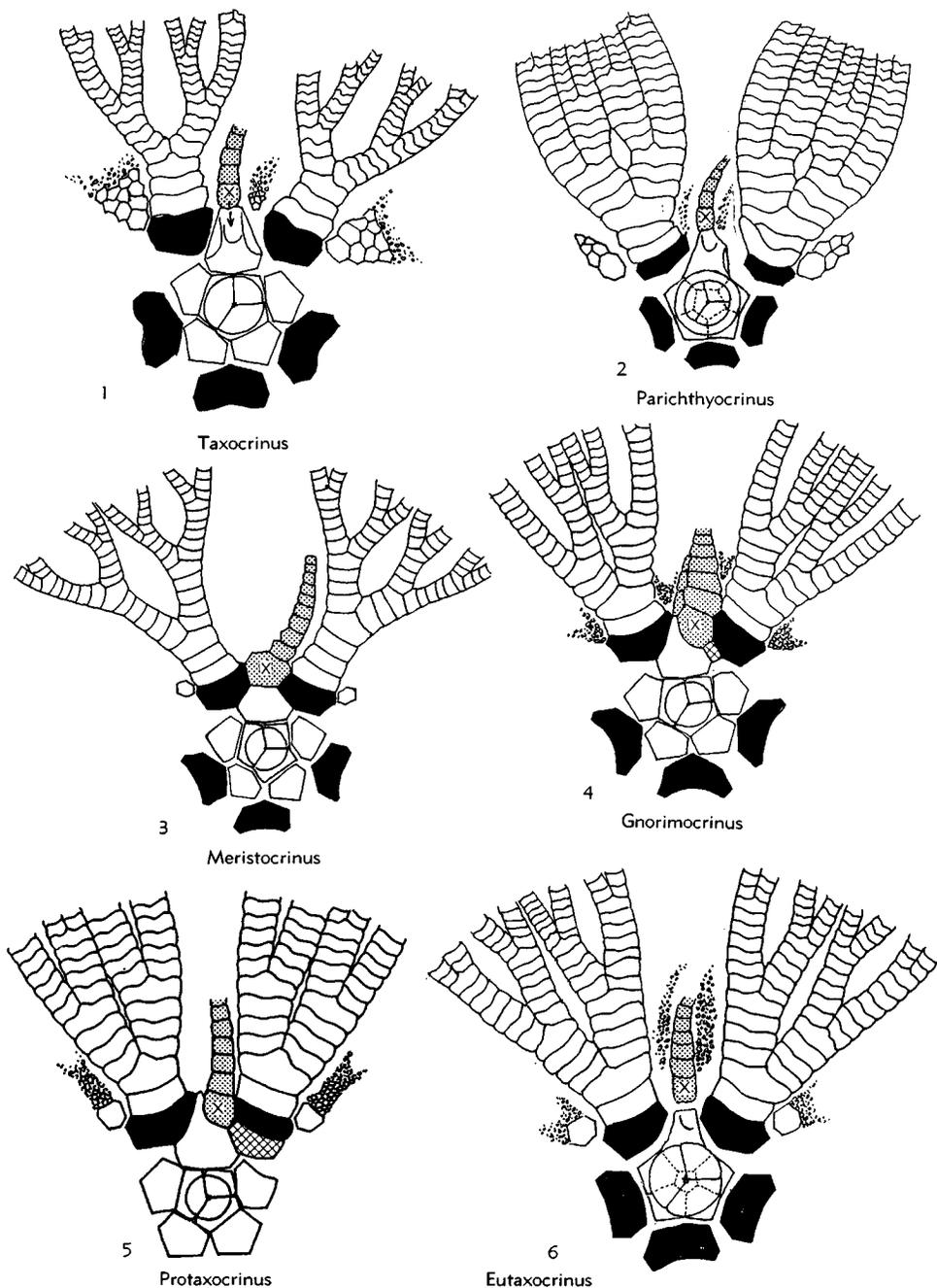


FIG. 511. Taxocrinidae (radials black, X and higher anals stippled; radianal cross ruled) (p. T768-T773).

p. 357] [*Taxocrinus oblongatus* ANGELIN, 1878, and *T. rigens* ANGELIN, 1878, only originally mentioned species, excluded from eligibility as type species because then considered incertae sedis

(Code, Art. 67h)]. Very similar to *Taxocrinus* but with only 2 primibrachs in each ray and with interprimibrachs very few or lacking. *U.Sil.*, Eu.(Sweden); *L.Dev.*, Eu.(Ger.); *M.Dev.*, Eu.

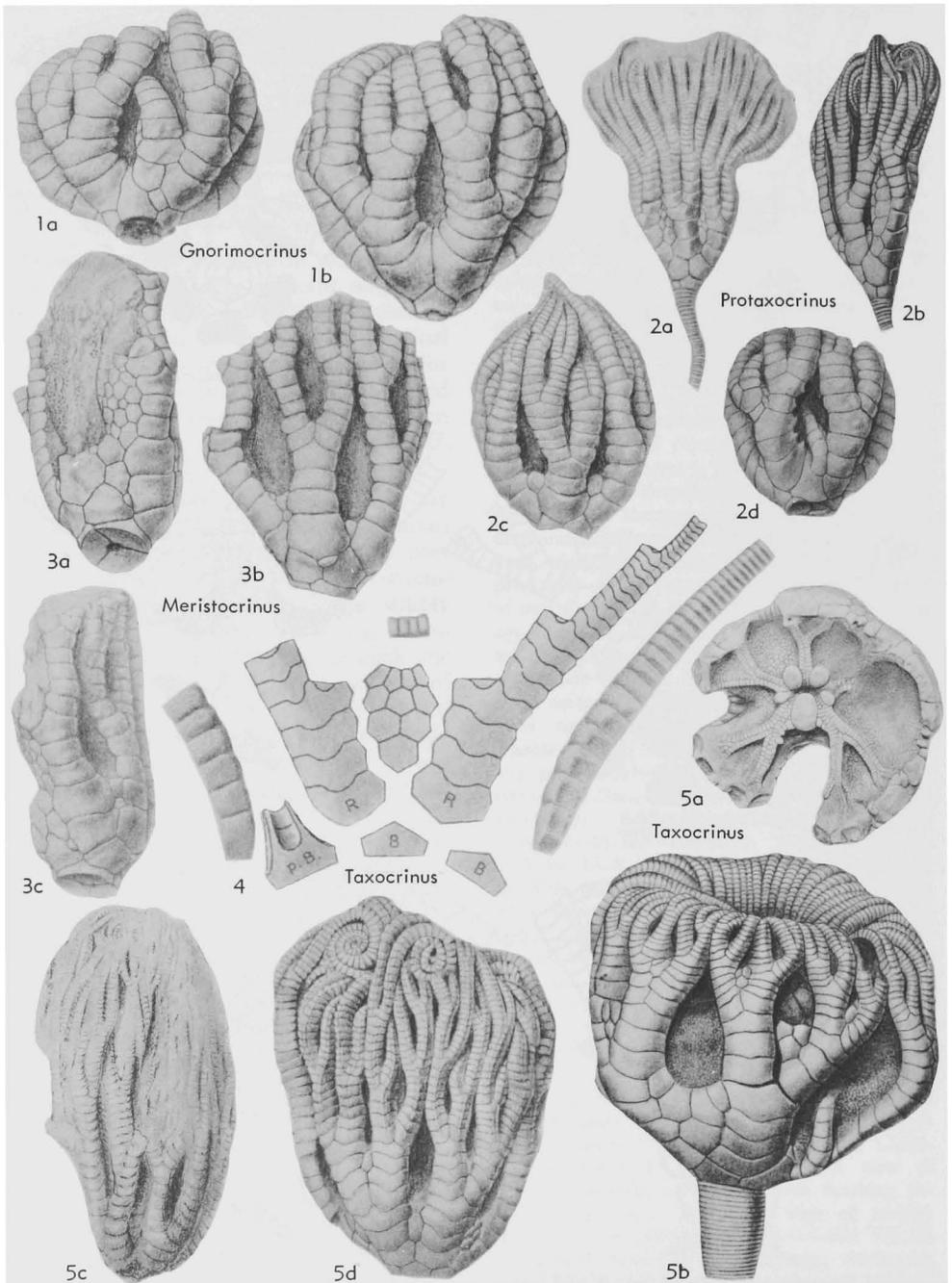


FIG. 512. Taxocrinidae (p. T768, T771-T773).

(Belg.-Ger.)-USA (Iowa-Ill.-N.Y.)-Can. (Ont.); *U. Dev.*, USA (N.Y.); *L. Miss.*, USA (Iowa-Mont.). —FIG. 511,6; 513,1a-c. **E. affinis* (MÜLLER),

M.Dev. (Couvain), Ger. (Eifel); 511,6, plate diagram of cup (radials black, X and higher anals stippled), arms of C and D rays, anal series, and

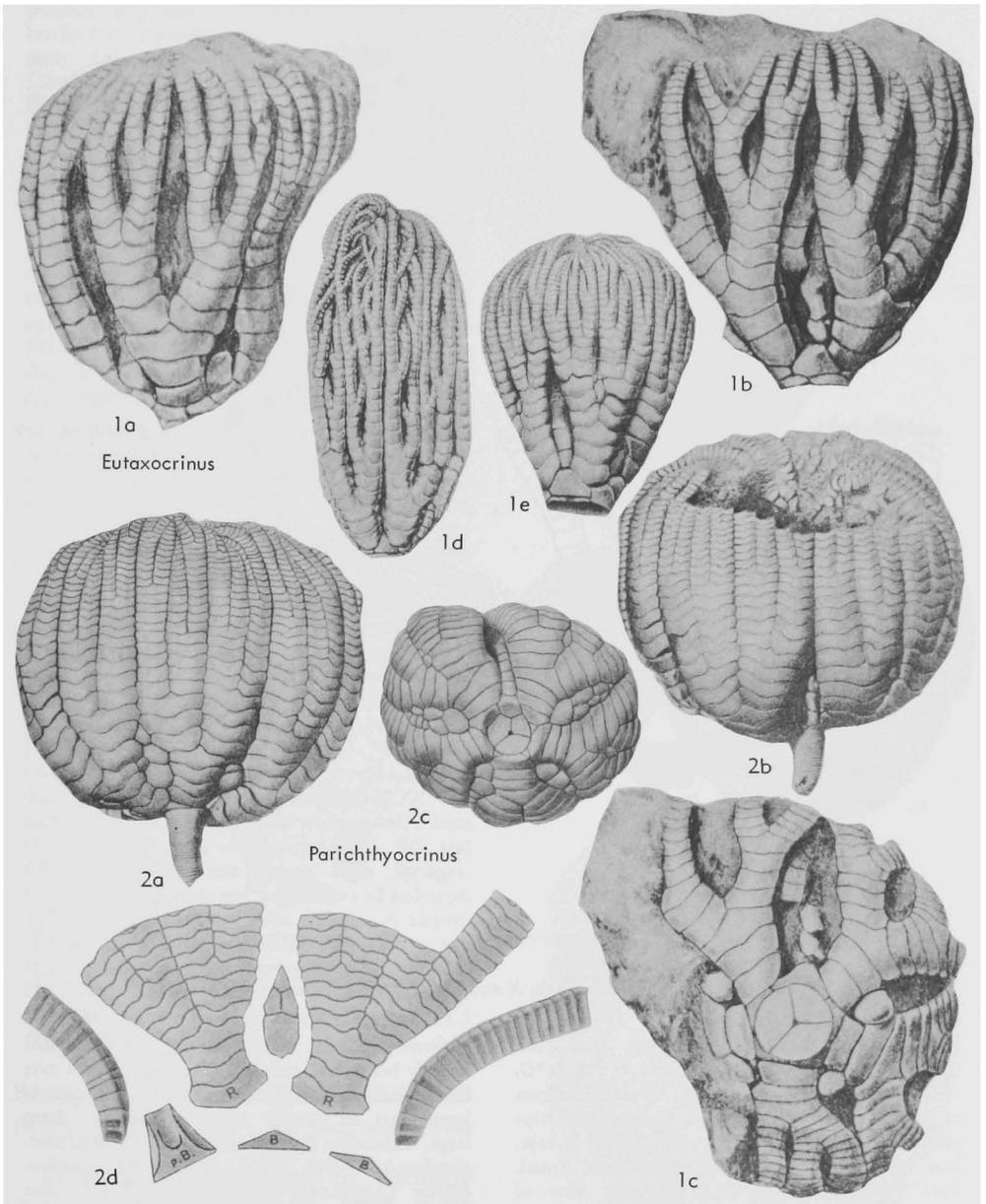


FIG. 513. Taxocrinidae (p. T768-T773).

BC and *DE* interrays (mod. from Springer, 1920); 513,1a-c, ant., post., and dorsal views, $\times 1.5$ (Springer, 1920).—FIG. 513,1d. *E. oblongatus* (ANGELIN), U.Sil.(Wenlock.), Sweden(Gotl.); *DE*-interradius view of holotype showing biheterotomous branching of arms, $\times 1$ (Springer, 1920).—FIG. 513,1e. *E. fletcheri* (WORTHEN), L.Miss. (Kinderhook.), USA(Iowa); C-ray view of crown, $\times 1$ (Springer, 1920).

Gnorimocrinus WACHSMUTH & SPRINGER, 1880, p. 273 [**Taxocrinus expansus* ANGELIN, 1878, p. 9; SD BATHER, 1899b, p. 923]. Crown low, rotund; infrabasals usually extending slightly beyond stem impression; rhombic radianal obliquely at left beneath *C* radial. Rays as in *Eutaxocrinus* with 2 primibrachs followed by divergent arm branches which bifurcate isotomously; interprimibrachs few or lacking. Stem short, not enlarging near calyx,

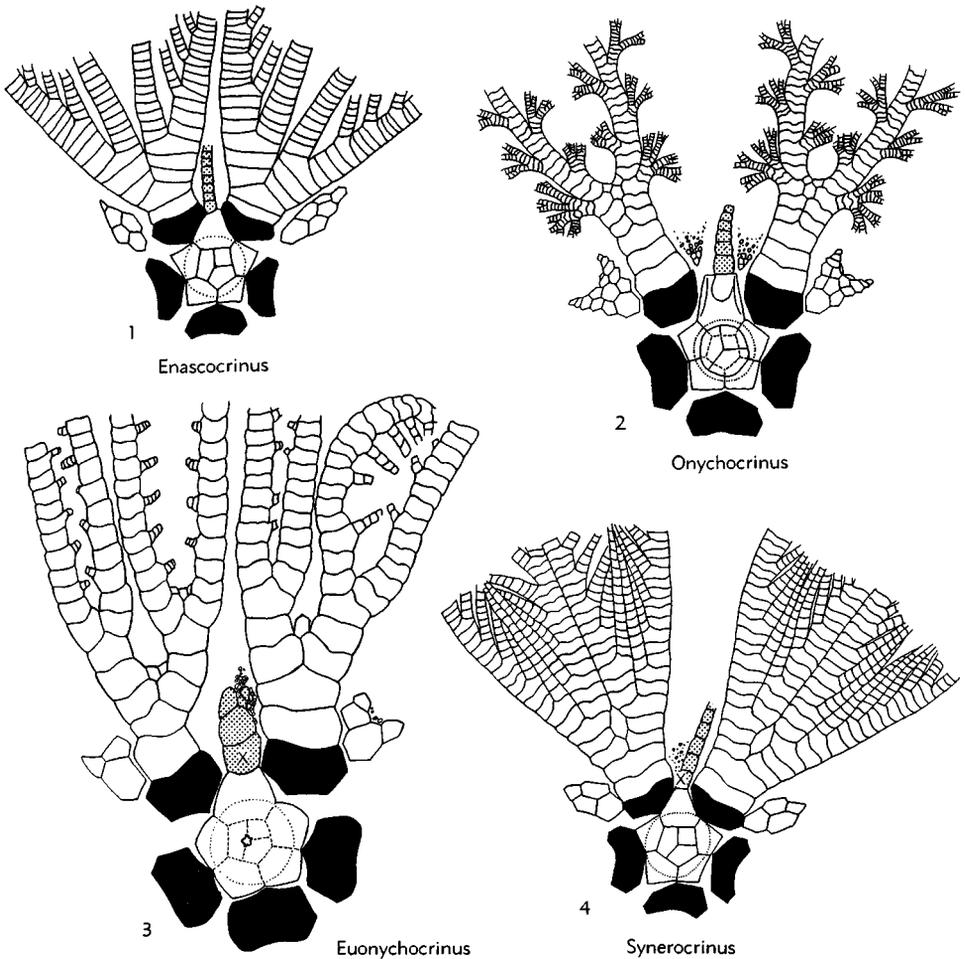


FIG. 514. Synerocrinidae (radials black, X and higher anals stippled) (p. T773-T775).

terminating distally in branched root. *U.Sil.*, Eu. (Sweden)-USA (Tenn.).—FIG. 511,4; 512,1. **G. expansus* (ANGELIN), Gotl.; 511,4, plate diagram of cup (radials black, X and higher anals stippled, radial cross ruled), arms of C and D rays, anal series, and minute interprimibrachs (mod. from Springer, 1920); 512,1a,b, post. view of holotype and EA-interray view of another specimen, $\times 3$ (Springer, 1920).

Meristocrinus SPRINGER, 1906, p. 515 [**Taxocrinus* (*Gnorimocrinus*) *loveni* WACHSMUTH & SPRINGER, 1880, p. 273 (= *Cyathocrinus interbrachiatus* ANGELIN, 1878, p. 23); OD]. Crown elongate, expanding above radials, with divergent isotomous arm branches; infrabasal slightly exposed beyond stem impression; posterior basal somewhat larger than others and truncated for contact with large anal X, which is followed by plates in anal tube bordered on left side by minute platelets of

perisome; radial usually in form of inferradial directly beneath C radial. Primibrachs 3 each ray; interprimibrachs very few and small, confined to lower part of interrays areas, or lacking. Stem large, expanding toward calyx. *U.Sil.*, Eu. (Sweden-Eng.).—FIG. 511,3; 512,3. **M. interbrachiatus* (ANGELIN), Sweden (Gotl.); 511,3, plate diagram of cup (radials black, X and higher anals stippled), arms of C and D rays, and anal series (mod. from Springer, 1920); 512,3a-c, post., B-ray, and C-ray views of holotype, $\times 1.5$ (Springer, 1920).

Parichthyocrinus SPRINGER, 1902, p. 94 [**Ichthyocrinus nobilis* WACHSMUTH & SPRINGER, 1879, p. 254; M]. Crown elongate ovoid, characterized by closely abutting nature of isotomous arms above radials; infrabasals prone, resembling columnal but not surrounded by ring of basals; posterior basal elongate; radial only in upper oblique

position if present. Primibrachs 3; interprimibrachs few and confined to lower part of interray areas. Column enlarging beneath calyx. *L.Miss.* (*Osag.*), USA (Iowa-Ill.-Ind.).—FIG. 511,2; 513, 2. **P. nobilis* (WACHSMUTH & SPRINGER), Burlington Ls., USA (Iowa); 511,2, plate diagram of cup (radials black, X and higher anals stippled), arms of C and D rays, anal series, and 2 interrays (mod. from Springer, 1920); 513,2a,b, ant. and post. views of nearly complete crown and small part of attached stem, $\times 1$ (Springer, 1920).—FIG. 513,2c. *P. meeki* (HALL), Keokuk Ls., USA (Ill.); dorsal view of complete crown with stem removed, $\times 0.7$ (Springer, 1920).—FIG. 513,2d. *P. subovatus* (MILLER & GURLEY), Borden Gr., USA (Ind.); partial plate diagram with edge view of thick brachials (Springer, 1920).

Protaxocrinus SPRINGER, 1906, p. 515 [**Taxocrinus ovalis* ANGELIN, 1878, p. 8; SD SPRINGER, 1920, p. 345]. Crown elongate, with isotomous arms usually not abutting laterally; infrabasals low, with tips exposed beyond stem impression; posterior basal elongate; radial in primitive position resembling inferradial directed beneath C radial; anal tube plates tending toward sutural connections with C brachials. Primibrachs 2; interprimibrachs very few, small or lacking. Stem enlarging next to calyx. *M.Ord.*, Can.(Ont.); *U.Ord.*, USA (Mo.-Ill.); *L.Sil.*, USA (Mo.); *M.Sil.-U.Sil.*, USA (Tenn.-Eu.(Sweden-Eng.))-Can.(Quebec); *L.Dev.*, USA (W.Va.).—FIG. 511,5; 512,2c,d. **P. ovalis* (ANGELIN), *M.Sil.*(Wenlock.), *God.*; 511,5, plate diagram of part of cup (radials black, X and higher anals stippled, radial cross ruled), arms of C and D rays, anal series, and BC and DE interbrachial areas (mod. from Springer, 1920); 512,2c,d, ant. and post. views of holotype, $\times 2$ (Springer, 1920).—FIG. 512,2a. *P. elegans* (BILLINGS), *M.Ord.*(Trenton.), Can.(Ont.); ant. view of holotype, $\times 1$ (Springer, 1920).—FIG. 512,2b. *P. laevis* (BILLINGS), *M.Ord.*(Trenton.), Can.(Ont.); post. view of complete crown, $\times 1.5$ (Springer, 1920).

Family SYNEROCRINIDAE Jaekel, 1918

[*Synerocrinidae* JAEKEL, 1918, p. 78]] [incl. *Onychocrinidae* JAEKEL, 1918, p. 79]

Taxocrinids distinguished by distinctly heterotomous branching of arms above isotomous division on primibrachs 2. *L.Miss.-U.Penn.*; *L.Carb.-U.Carb.*

Synerocrinus JAEKEL, 1898, p. 47 [**Forbesiocrinus incurvus* TRAUTSCHOLD, 1867, p. 31 (= *Talantocrinus jaekeli* MOORE & PLUMMER, 1940, p. 196); M] [*non Synerocrinus* MOORE & PLUMMER in MOORE, 1939c, p. 195; *nec* MOORE & PLUMMER, 1940, p. 90]. Crown elongate ovoid, expanding upward from radials; infrabasals and proximal part of basals covered by stem; posterior basal

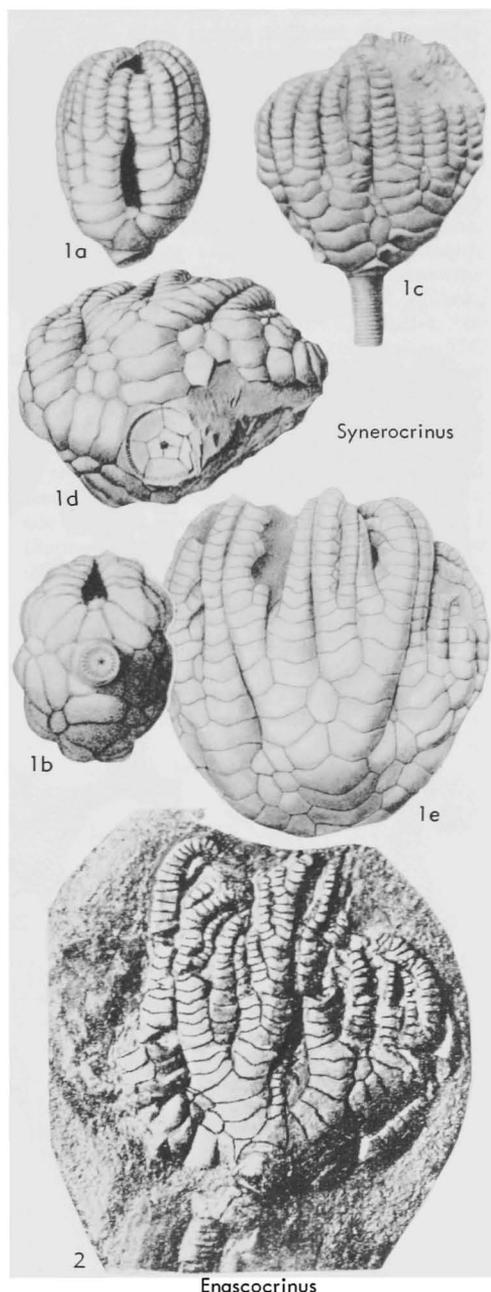


FIG. 515. Synerocrinidae (p. T773-T775).

larger than others and truncate distally for support of anal X which is followed by anal tube; no radial. Arms in each ray branching isotomously on primibrachs 2 and secundibrachs 3, thereafter with strongly heterotomous branching

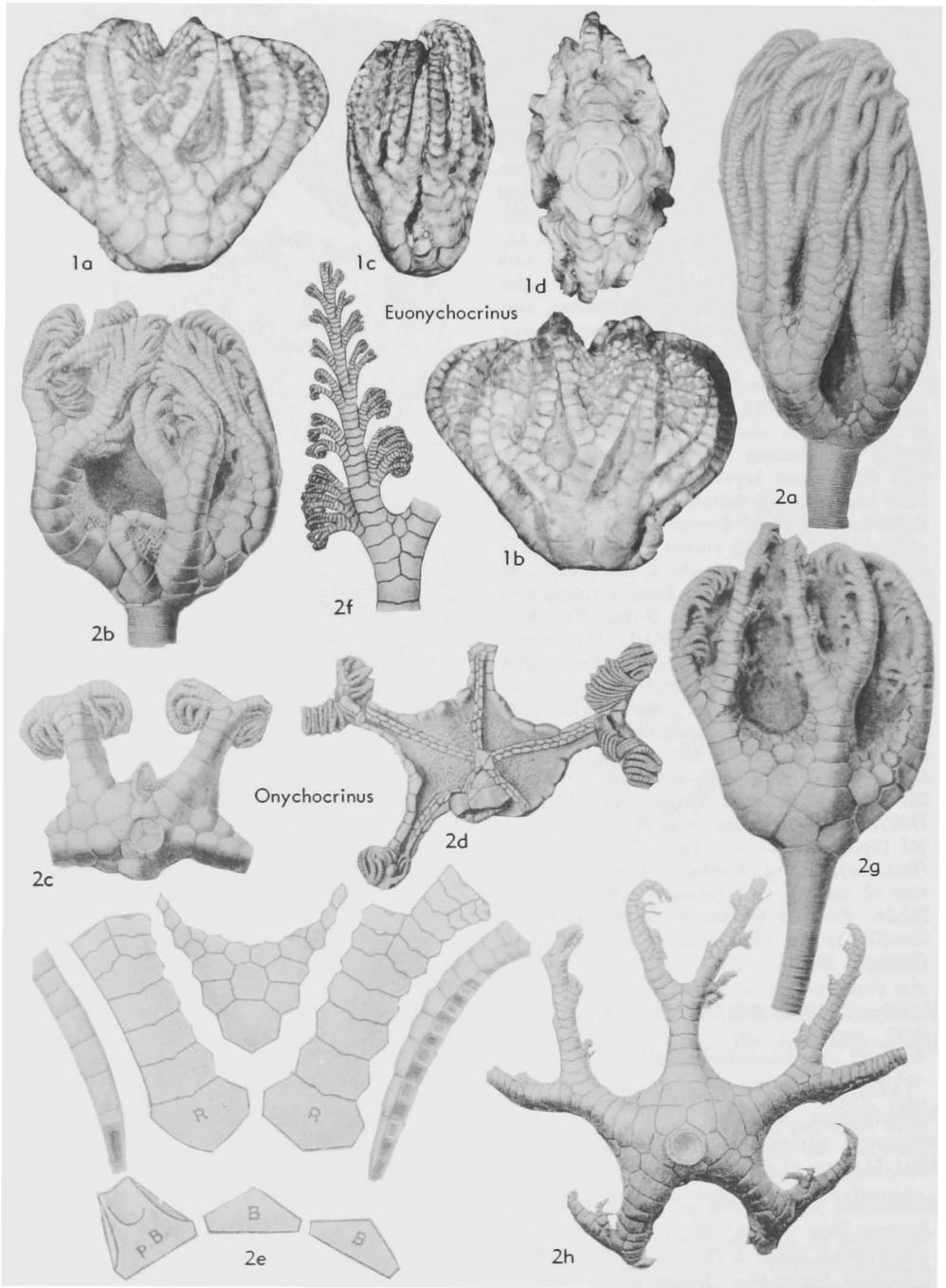


FIG. 516. Synerocrinidae (p. T775).

of bi-endotomous type, ramules unbranched, interprimibrachs few. Column large, expanding toward

calyx. *U. Carb.*, Eu.(USSR); *Penn.*, USA(Okla.).
 —FIG. 514,4; 515,1. **S. incurvus* (TRAUT-

SCHOLD), Moscov., Moscow basin; 514,4, plate diagram of cup (radials black, *X* and higher anals stippled), arms of *C* and *D* rays, anal series, and *BC* and *DE* interprimibrachs (mod. from Springer, 1920); 515,1*a,b*, post. and dorsal views of syntype, $\times 1$ (Springer, 1920); 515,1*c*, post. view of another syntype, $\times 1$ (Springer, 1920); 515,1*d,e*, dorsal view (*B* ray directed upward) and *B*-ray view of typical crown, $\times 1$ (Springer, 1920). [= *Forbesiocrinus* TRAUTSCHOLD, 1867 (non DE KONINCK & LEHON, 1854); *Forbsiocrinus* MEEK & WORTHEN, 1860 (nom. null.).]

Enascocrinus STRIMPLE & WATKINS, 1969, p. 231 [*Talantocrinus redesdalensis* WRIGHT, 1952c, p. 320; OD]. Very similar to *Synerocrinus* but crown smaller and heterotomous branching of arms in each ray of endotomous instead of bi-endotomous type. *L.Carb.*(Visean)-*U.Carb.*(Namur.), Eu.(Scot.-Eng.).—FIG. 514,1; 515,2. **E. redesdalensis* (WRIGHT), Visean, Scot.; 514,1, plate diagram of cup (radials black, *X* and higher anals stippled), arms of *C* and *D* rays, anal series, and *BC* and *DE* interbrachials (Moore, n); 515,2, *D*-ray view of crown, $\times 1$ (Wright, 1954).

Euonychocrinus STRIMPLE, 1940, p. 101 [**E. dubius*; OD]. Crown elongate ovoid with 20 well-separated, transversely rounded arms rising in forked manner from axillary secundibrachs, arm branching isotomous to this level, above which arm pairs give off short rounded unbranched ramules on sides facing each other, thus producing very simple sort of bi-endotomous heterotomy, each ramule-bearing tertibrach commonly separated by one without ramule; like *Synerocrinus* in having 2 primibrachs and 3 secundibrachs in each arm branch; each interray with small number (3-5) moderately large interprimibrachs; only tips of basals appearing beyond stem impression, posterior one longer than others and supporting anal *X* followed by transversely rounded anal tube not laterally united to brachials. *U.Penn.*(Missour.), USA(Kans.-Ill.).—FIG. 514,3; 516,1. *E. simplex* STRIMPLE & MOORE, LaSalle Ls., USA(Ill.); 514,3, plate diagram of cup (radials black, *X* and higher anals stippled), arms of *C* and *D* rays, anal series, and *BC* and *DE* interprimibrachs (Strimple & Moore, 1971a); 516,1*a-d*, *BC*-inter-ray, *DE*-inter-ray, post., and dorsal (anal series directed downward) views of holotype, $\times 1$ (Strimple & Moore, 1971a).

Onychocrinus LYON & CASSEDAY, 1860, p. 77 [**O. exculptus*; M] [= *Oligocrinus* SPRINGER, 1906, p. 519 (type, *Forbesiocrinus asteriaeformis* HALL, 1861a, p. 320; M); *Origocrinus* JAEKEL, 1918, p. 79 (nom. null.)]. Crown low with pentamerous outward extension of rays resembling starfish in shape, or round to elongate ovoid, especially distinguished by wide separation of rays above areas of small interprimibrachs adjacent to calyx; infrabasals low, with outward extremities com-

monly visible beyond stem; posterior basal elongate, with distal portion hollowed for reception of anal *X* which is followed by anal tube; radianal only in upper oblique position, if present. Each ray with 3 or more primibrachs, arms branching isotomously above axillary primibrach, thereafter with heterotomous branching, with ramules on both sides of 10 main arm trunks, these ramules commonly with 2 to several bifurcations, producing a unique, highly distinctive type of arm structure. Column enlarging next to calyx. *L.Miss.*(Osag.), USA(Iowa-Ill.-Ind.-Ky.-Can.); *U.Miss.*(Meramec-Chester.), USA(Ill.-Ind.-Ky.-Ala.-Okla.); *L.Carb.*, Eu.(Eire-Ger.-Scot.).—FIG. 514,2; 516,2*f-h*. **O. exculptus*, L.Miss.(Borden Gr.), USA(Ind.); 514, 2, plate diagram of cup (radials black, *X* and higher anals stippled), arms and ramules of *C* and *D* rays, anal series, and *BC* and *DE* interprimibrachs (mod. from Springer, 1920); 516,2*f-h*, diagram of arm with ramules, *A*-ray view of crown, and dorsal view of crown with spread-out arms (post. side directed downward), $\times 0.7$, $\times 0.7$, $\times 1$ (Springer, 1920).—FIG. 516,2*a*. *O. ramulosus* (LYON & CASSEDAY), L.Miss.(Borden Gr.), USA(Ind.); post. view of nearly perfect crown with attached part of stem, $\times 0.5$ (Springer, 1920).—FIG. 516,2*b-e*. *O. ulrichi* MILLER & GURLEY, L. Miss.(Borden Gr.), USA(Ind.); 516,2*b-d*, post., dorsal (post. side upward), and ventral (post. side downward) views of crown, $\times 0.7$ (Springer, 1920); 516,2*e*, partial plate diagram showing edges of thick brachials (Springer, 1920).

Order SAGENOCRINIDA Springer, 1913

[nom. correct. MOORE in MOORE, LALICKER, & FISCHER, 1952, p. 614 (pro order Sagenocrinoidea SPRINGER, 1913, p. 203)]

Crown globose to elongate ovoid with plates of calyx and commonly those of arms, interradianal and interbrachial areas united rather firmly together, anal plates of posterior interray (radianal, if present, anal *X*, and higher anal plates) joined firmly to adjoining basals, radials, and brachials instead of marked off by flexible perisome as in Taxocrinida. Cup low bowl shaped, mostly lacking well-defined separation from lower arm and interarm plates; infrabasals visible beyond stem or entirely concealed by it; basals and radials relatively large, upflaring gently or in distal part of radials moderately to steeply; radianal in primitive position directly below *C* radial shifted leftward and upward, or absent; anal *X* mostly large and reaching above radial summits but may be small or lacking entirely. Arms generally wide, externally

little rounded, composed of uniserially arranged short brachials, closely adjoining one another laterally or separated by interbrachials confluent with arm exterior surfaces; distal extremities of arms typically curved inward strongly. Stem transversely circular and tending to taper distally, very rarely columnals crescentic in outline. *L.Sil.-U. Perm.* (*Basleo beds*).

Comparatively numerous sagenocrininid genera which abruptly appear in Upper Silurian deposits of Europe and North America show such wide diversity of morphological characters that relationships to one another and to ancestors probably belonging among Taxocrinida are highly conjectural. For example, *Lecanocrinus* and *Mysticocrinus* (the latter misinterpreted at first by SPRINGER as an inadunate crinoid) possess few features of contemporary *Sagenocrinites*, *Ichthyocrinus*, *Calpiocrinus*, and *Lithocrinus*—not even in content and arrangement of cup anal plates—yet all are undoubtedly non-taxocrininid flexible crinoids. The tripartite pentagonal infrabasal circlet is horizontal. Branching of the arms is exclusively isotomous; although in some later sagenocrininids, like several taxocrininids, it is heterotomous. Interbrachial plates are found only in *Sagenocrinites*, among the Silurian genera mentioned. *Ichthyocrinus* has no cup anal plates, *Calpiocrinus* and *Lithocrinus* an *X* plate only, and the others both radial and anal *X*. These similarities and differences sufficiently characterize Sagenocrininida in general and indicate presence in the group of more than a single lineage.

Superfamily LECANOCRINACEA Springer, 1913

[*nom. transl.* MOORE & STRIMPLE, 1973, p. 15 (ex *Lecanocrinidae* SPRINGER, 1913, p. 203)]

Crown typically short, subglobular (exceptionally biconvex, e.g., *Ammonicrinus*), with stoutly built cup well delimited from arms, which are composed of very low and wide brachials and free above radials, arms unbranched or with one to three isotomous bifurcations, their distal extremities curved inward to conceal tegmen and with or without clockwise torsion. Interbrachials generally lacking, but present in Nipterocrinidae. Infrabasals sloping upward and

visible from side or forming flat base of cup with extension beyond stem impression, rarely in basal concavity, flat and down-sloping circlets not visible from side, normally with two large plates (*AB*, *DE*) and small one in *C* ray but solidly fused together in several genera. Basals relatively large, with surface area little smaller than large radials, which have straight or gently concave articular facets occupying entire width of plate or uncommonly only small part of it, facets short transversely, approximately equal to thickness of radials, and lacking well-defined ridge and ligament fossae. Radial obliquely left beneath *C* radial and moderately large anal *X* above squarely truncate distal edge of *CD* basal, or lacking radial. Arms composed of very wide short brachials, branching on primibrachs 2, secundibrachs 2 to 4, and higher in some genera. Stem mostly subcylindrical, composed of hetero- or homeomorphic low columnals with small axial canal, without cirri; stem may be distinctly xenomorphic and in forms with enrolled column moderately to strongly crescentic in transverse shape. *U.Sil.-U. Perm.*

Family LECANOCRINIDAE Springer, 1913

[*Lecanocrinidae* SPRINGER, 1913, p. 203 (incl. *Lecanocrininidae* BOWSER, 1953, p. 1)] [= *Cyrtidocrinidae* ANGELIN, 1878, p. 20]

Cup low bowl shaped with flaring sides and strongly defined even summit formed by straight facets of radials, which are subequal in size and adjoin one another except at *CD* interray where large anal *X* plate generally occurs; radial typically rhombic in outline obliquely at left beneath *C* radial; anal *X* may extend high enough above rim of cup to separate proximal secundibrachs. Infrabasals sloping upward or flat to slightly down-sloping in very shallow basal concavity. Arms formed by very low and wide brachials, primibrachs fully equal in width to radials; arms with two or three isotomous divisions, except in one genus (*Miracrinus*) with close sutures joining rays and branches laterally in proximal region to make rigid calyx, distal parts of arms free and strongly incurved over tegmen. Column transversely circular. *U.Sil.-M.Dev.*

Lecanocrinus HALL, 1852, p. 199 [**L. macropetalus*; SD WACHSMUTH & SPRINGER, 1880, p. 40] [= *Cyrtidocrinus* ANGELIN, 1878, p. 20 (type, *C. facietatus*; M)]. Infrabasals sloping slightly upward, visible in side view of cup, which has even summit defined by straight, wide articular facets of radials; medium-sized to large rhombic radianal obliquely beneath left margin of *C* radial; anal *X* large, may or may not extend above cup summit. Arms wide, free above radials, composed of very low brachials not united by synostiosal sutures, with 2 or 3 isotomous bifurcations in each ray, tips of arms curved inward so as to conceal tegmen. Column circular in section, formed of moderately low heteromorphic columnals with crenulate articularia and small circular axial canal. *U.Sil.-L.Dev.*, N.Am.-Eu.-Australia.

—FIG. 517,1. *Lecanocrinus* sp.; 1a, plate diagram of cup (radials black, radianal cross ruled, anal *X* stippled) and post. arms; 1b, long. sec. of cup showing nearly horizontal infrabasals (mod. from Springer, 1920).—FIG. 518,1a-c. **L. macropetalus*, *U.Sil.*(Rochester Sh.), USA(Lockport, N.Y.); 1a,b, side views of crown, $\times 1$; 1c, slightly oblique dorsal view of cup, $\times 1$ (all Springer, 1920).—FIG. 518,1d,e. *L. facietatus* (ANGELIN), *U.Sil.*(Wenlock.), Sweden(Gotl.); 1d,e, side views of cup and incomplete crown, $\times 2$ (Springer, 1920).

Geroldicrinus JAEKEL, 1918, p. 80 [**Lecanocrinus roemeri* SCHULTZE, 1867, p. 153; M]. Like *Lecanocrinus* but with evenly sloping sides of low truncate conical cup and with infrabasal circlet in shallow concavity entirely covered by stem; radianal variable in shape and size, subtriangular, rhombic, or pentagonal; anal *X* not reaching above summit of radials, followed by one or 2 small anal plates between primibrachs. Column circular, with finely crenulate articularia on columnal facets. *M.Dev.*, Eu.(Ger.).—FIG. 517,4; 518,2. **G. roemeri* (SCHULTZE), Eifel; 517,4a, plate diagram of cup (radials black, radianal cross ruled, *X* and higher anals stippled) and arms of *C* and *D* rays; 517,4b, vertical section of cup through *A* radial and anal *X* showing attitude of infrabasals; 517,4c,d, partial plate diagrams showing variations in shape of radianal (all Moore, n); 518,2a-c, side, oblique dorsal, and ventral views of typical crown, $\times 1$; 518,2d, dorsal view of cup showing rhombic radianal and infrabasals in steep-sided concavity, $\times 1$ (all Springer, 1920).

Miracrinus BOWSHER, 1953, p. 3 [**Lecanocrinus (Miracrinus) perdewi*; OD]. Resembles *Geroldicrinus* in having infrabasal circlet in concavity entirely covered by proximal part of column, but differs from this genus and *Lecanocrinus* in firmly sutured brachials in all rays to height of nearly twice that of cup, thus producing stout calyx above which free arms curve inward over tegmen; radianal subrhombic obliquely beneath *C* radial

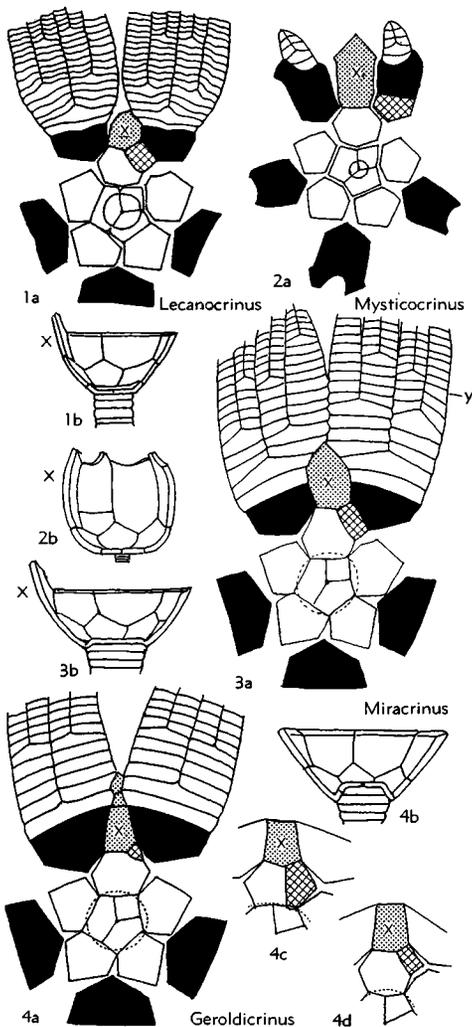


FIG. 517. Lecanocrinidae (radials black, *X* and higher anals stippled; radianal cross ruled) (p. T777-T779).

and large anal *X* which projects well above summit of cup enough to separate proximal secundibrachs of *C* and *D* rays. Stem transversely circular, articular facets of columnals with even short crenulae surrounding wide smooth areola, axial canal small, circular. *L.Dev.*(Helderberg.), USA (Md.).—FIG. 517,3; 518,4. **M. perdewi* (BOWSHER), New Scotland Ls., near Cumberland, Md.; 517,3a,b, plate diagram (radials black, radianal cross ruled, *X* and anals stippled) and vertical section through cup (Moore, n); 518,4a-c, ant., post., and summit views of crown (holotype) showing position of boundary between fixed and free brachials (*Y, Z, primibrach 1*), $\times 2$ (Bowsher, 1953).

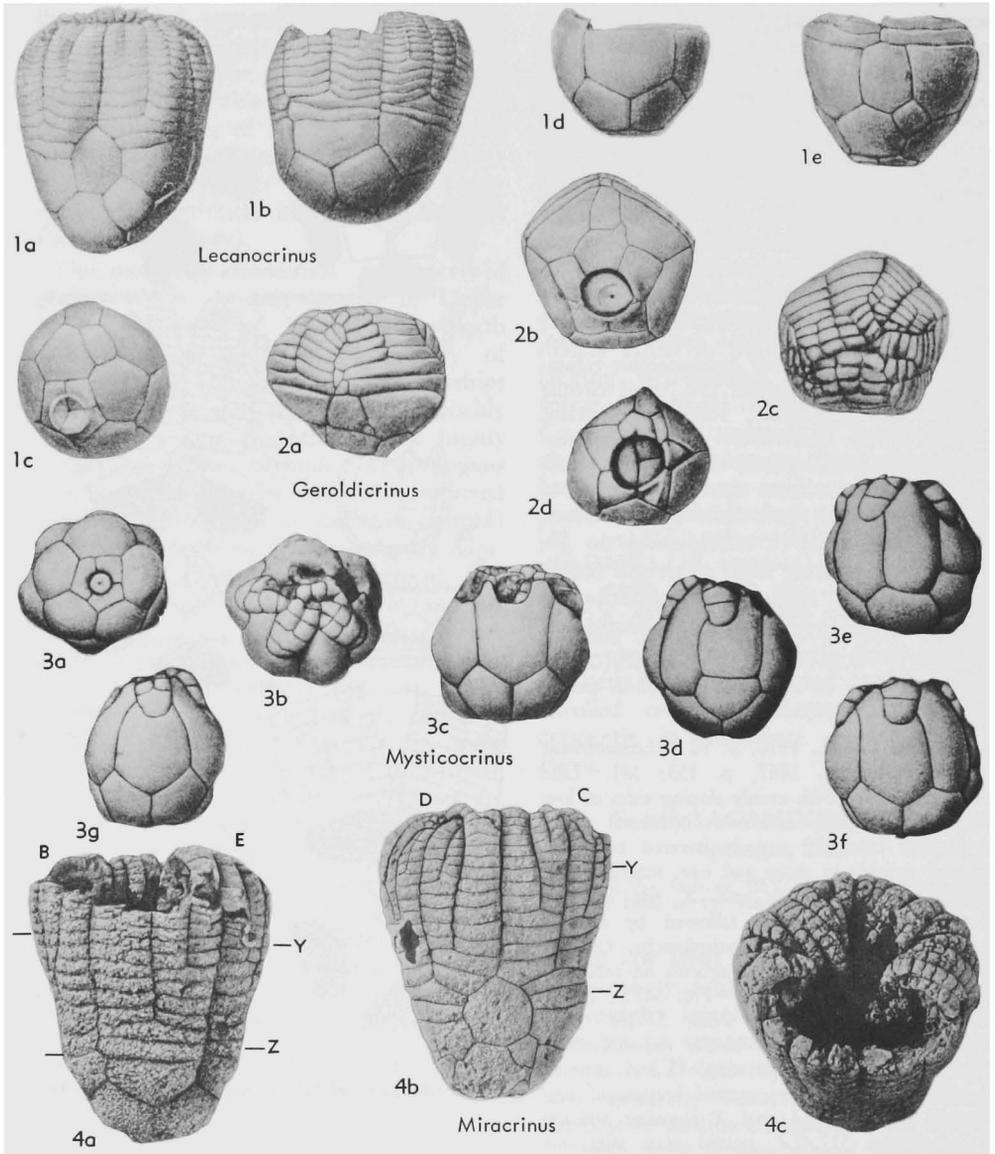


FIG. 518. Lecanocrinidae (p. T777-T779).

Mysticocrinus SPRINGER, 1918, p. 666 [**M. wilsoni*; OD]. Calyx globose, with rigidly united plates and cup with flat base and roundly curved sides; infrabasal cirlet subpentagonal, composed of 3 plates, small one in C ray; radials with height greater than width, curved articular facets occupying less than full width of plates, 1 or 2 shoulders of some projected upward in rounded elevation; radianal directly beneath C radial; relatively large and very tall anal X distally pointed and rising above summit of radials. Arms very short, bifurcating isotomously once on primibrach

2, each branch typically with 3 secundibrachs; brachials wide and short, with outer face distinctly curved. [This genus was considered by SPRINGER to be an inadunate, and, in spite of its dicyclic cup and tripartite infrabasal cirlet, most closely related to pisocrinids. Such interpretation is erroneous. In the nature of its radials and arms *Mysticocrinus* is most suggestive of undoubtedly flexible crinoids classified in the family Prophylocrinidae of the Lecanocrinacea but its possession of a radianal removes it from possible placement there. The genus differs from other members of

the Lecanocrinidae in shape and width of the radial articular facets, shorter and narrower arms, and primitive nature of the radianal, directly below the *C* radial.] *U.Sil.*, USA (Ind.).—FIG. 517,2; 518,3. **M. wilsoni*, Laurel Ls.; 517,2a,b, plate diagram (symbols as in Fig. 517,1a) and long. sec. of cup (anal *X* at left) (Moore, n); 518,3a-g, dorsal (*A* ray down), ventral (*A* ray up), *A*-ray, *C*-ray, *CD*-interray, *D*-ray, and *E*-ray views, $\times 4$ (Springer, 1926a).

Family NIPTEROCRINIDAE Jaekel, 1918

[Nipterocrinidae JAEKEL, 1918, p. 80]

Crown ovoid, moderately tall, characterized especially by prominence of line at summit of cup (except in *Hormocrinus*) marking division between radials and free arms; cup typically low bowl shaped or conical with evenly flaring sides, but in both types height may equal diameter; infrabasal circler sloping upward and visible from side or flat and not visible except in dorsal view, normally tripartite with small infrabasal in *C* ray, but fused to solid pentagonal plate in type genus; basals five, moderately large pentagonal plates forming important part of cup; radials also large, mostly with width exceeding height, gently curved articular facets mostly not extending to interradiar sutures, thus providing shoulders which meet interradiar plates; radianal and anal *X* plates present or absent. Arms composed of brachials which are wider than high, with isotomous bifurcations on primibrachs 1, 2, or 3, and above this isotomous to moderately heterotomous additional branching. Interradiar plates present between all rays mostly very diminutive and irregular; interbrachials also may be present but consist of numerous platelets only in type genus. Column medium sized, transversely circular, composed of homeomorphic to heteromorphic columnals and in some species exhibiting distinct xenomorphy. [The family name, determined by priority, is derived from genus modified by evolution and considered less representative of the assemblage than others.] *U.Sil.-L.Dev.*; *U.Dev.-L.Miss.*

Nipterocrinus WACHSMUTH in MEEK & WORTHEN, 1868, p. 341 [**N. wachsmuthi* MEEK & WORTHEN, 1868; M]. Crown relatively tall and marked by prominent differentiation of low bowl-shaped, large-plated cup from well-rounded moderately

slender branching arms separated by interradiar and interbrachial platelets; infrabasals fused into pentagonal plate partly visible from sides; basals slightly to distinctly smaller than large radials which have articular facets confined to middle portion of summit, forming scalloped indentation below prominent, subhorizontal shoulders; lack of any anal plates and undivided infrabasal circler make cup perfectly symmetrical radially preventing identification of CARPENTER-lettered rays. Well-rounded relatively slender arms formed by low brachials with straight to somewhat flexuous sutures; isotomous bifurcation on primibrachs 3 followed by isotomous branching at higher levels in each ray; extremely numerous irregular platelets in interrays areas denote lofty flexible tegmen. Robust stem of proximal region composed of very low circular columnals, those of intermediate and distal parts of stem somewhat narrower and distinctly taller. *L.Miss.(Osag.)*, USA (Iowa).—FIG. 519,2; 520,3b,c, **N. wachsmuthi* MEEK & WORTHEN, U.Burlington Ls.; 519,2, plate diagram (radials black), *CD* interrays upward (Springer, 1920, mod.); 520,3b, lat. view of distorted holotype crown, $\times 1$; 520,3c, same (reconstr.), $\times 1$ (both Springer, 1920).—FIG. 520,3a. *N. arboreus* WORTHEN, L.Burlington Ls.; lat. view of crown, $\times 2$ (Springer, 1920).

Cholocrinus SPRINGER, 1906, p. 517 [**Forbesiocrinus obesus* ANGELIN, 1878, p. 9; M]. Crown elevated ovoid with prominent line between the bowl-shaped cup and transversely rounded arms separated by wide areas of interradiar platelets and less prominent interbrachial ones; flat, fairly large infrabasal circler with 3 plates, small one in *C* ray, not visible from side; large basals and radials similar to those of *Nipterocrinus*; rhombic radianal obliquely beneath *C* radial at left, followed above by large anal *X*, its summit evenly confluent with shoulders of adjacent radials. Arms branching repeatedly, mostly in isotomous manner but partly heterotomously, initial bifurcation on primibrach 2. *U.Sil.*, Sweden (Gotl.).—FIG. 519,3; 520,4. **C. obesus* (ANGELIN); 519,3, plate diagram (radials black, radianal cross ruled, *X* and higher anals stippled), *CD* interrays upward (Springer, 1920, mod.); 520,4a,b, *A*- and *B*-ray views of holotype crown, $\times 1.5$ (Springer, 1920); 520,4c, part of same view as 4b showing diminutive platelets of *AB* and *BC* interrays, $\times 2$ (Springer, 1920).

Hormocrinus SPRINGER, 1920, p. 166 [**Centrocrinus tennesseensis* WORTHEN, 1890, p. 95; OD]. Crown ovoid, with width typically greater than height, with prominent division between large-plated calyx and part of crown formed by rounded branching arms and small-plated interradiar areas, but actually this division is above *Z* line, being formed by summit of large interradiar plates and by division between fixed and free brachials, at distal edges of primibrachs 2 (therefore, this

T780

Echinodermata—Crinoidea

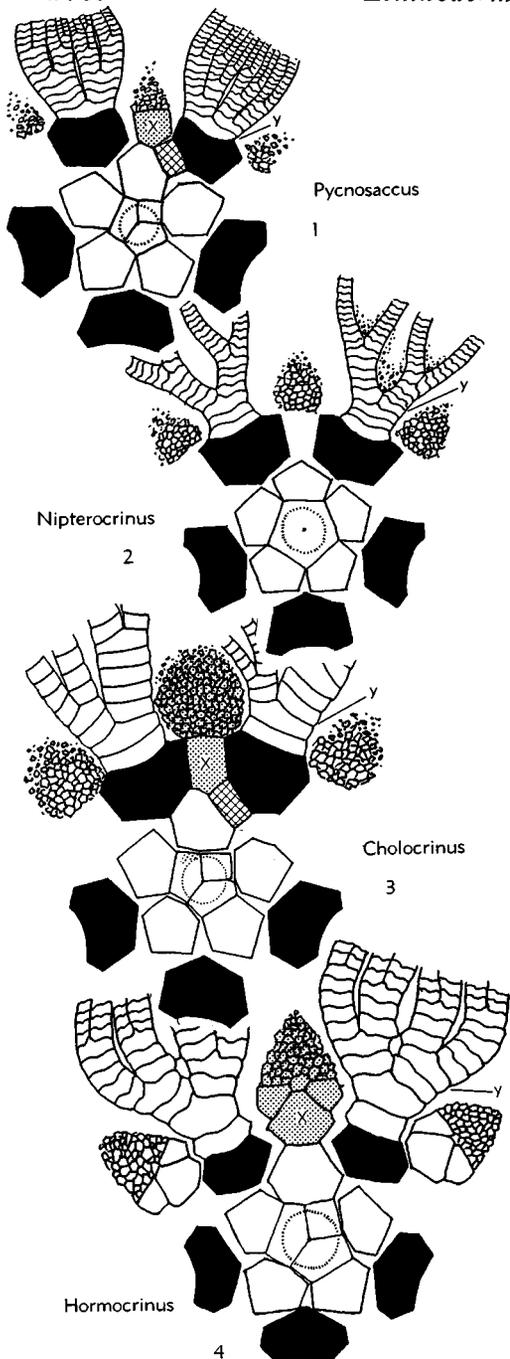


FIG. 519. Nipterocrinidae (radials black, X and higher anals stippled; radianal cross ruled) (p. T779-T780).

boundary denominated as Y line); posterior inter-ray with large anal X resting on truncated extremity of posterior basal, not accompanied by

radial. Arms branching isotomously at 2 or 3 levels. Column distinctly heteromorphic, nearly uniform in diameter in proximal and intermediate areas but narrowing distally, with noticeable increase in height of columnals. *U.Sil.*, Eu.(Eng.-Sweden)-USA(Tenn.).—FIG. 519,4; 520,2. **H. tennesseensis* (WORTHEN), Brownsport Ls., USA (Tenn.); 519,4, plate diagram (symbols as in Fig. 519,3), CD interray upward (Springer, 1920, mod.); 520,2a,b, oblique dorsal (E ray up) and E-ray views of 2 crowns, $\times 2$ (Springer, 1920); 520,2c, somewhat oblique EA-interray view of crown with attached long tapering heteromorphic stem, $\times 1$ (Springer, 1920).

Pycnosaccus ANGELIN, 1878, p. 13 [*Cyathocrinites scrobiculatus* HISINGER, 1840, p. 6; SD SPRINGER, 1920, p. 180] [= *Oncocrinus* BATHER, 1890b, p. 387 (type, *O. bucephalus*; M)]. Similar to *Cholocrinus* but cup more conical with upsloping infra-basals clearly visible from side, large basals and radials smooth or marked by ridges crossing plates normal to sutures between them; rhombic radial and anal X moderately large. Arms well-rounded laterally, typically slender, branching isotomously, with initial one on primibrachs 1; interradial areas filled by minute plates. Stem resembles that of *Hormocrinus* in heterotomous arrangement of columnals, thicker ones with well-rounded peripheries. *U.Sil.*, Eu.(Eng.-Sweden)-USA (Ill.-Ind.-Tenn.-N.Y.); *L.Dev.*, USA (W.Va.); *U.Dev.*, NW.Can.—FIG. 519,1; 520,1d-f. **P. scrobiculatus* (HISINGER), U.Sil., Sweden; 519,1, plate diagram (symbols as in Fig. 519,3), CD interray upward (Springer, 1920, mod.); 520,1d,e, E-ray and CD-interray views of holotype cup, $\times 1.5$ (Springer, 1920); 520,1f, facetal view of B radial (center) showing impressions of minute interradial plates on shoulders next to sutures, $\times 2$ (Springer, 1920).—FIG. 520,1a. *P. nodulosus* ANGELIN, U.Sil., Sweden(Gotl.); CD-interray view of crown with single primibrach in each ray, $\times 1.5$ (Springer, 1920).—FIG. 520,1b,c. *P. tenuibrachiatus* SPRINGER, L.Dev.(Keyser Ls.), USA(W.Va.); C- and E-ray views of crown, $\times 1.5$ (Springer, 1920).—FIG. 520,1g. *P. patei* SPRINGER, U.Sil.(Brownsport Ls.), USA(Tenn.); B-ray view of crown with stem, $\times 1$ (Springer, 1920).

Family MESPILOCRINIDAE Jaekel, 1918

[Mespilocrinidae JAEKEL, 1918, p. 80]

Generally similar to Lecanocrinidae, differing mainly in absence of radianal in cup, flat infrabasal circling extending beyond stem impression, commonly tripartite but may be solidly fused. Arms typically very short and crown rotund, with or without tendency toward clockwise torsion of rays. Stem transversely circular, medium sized to slen-

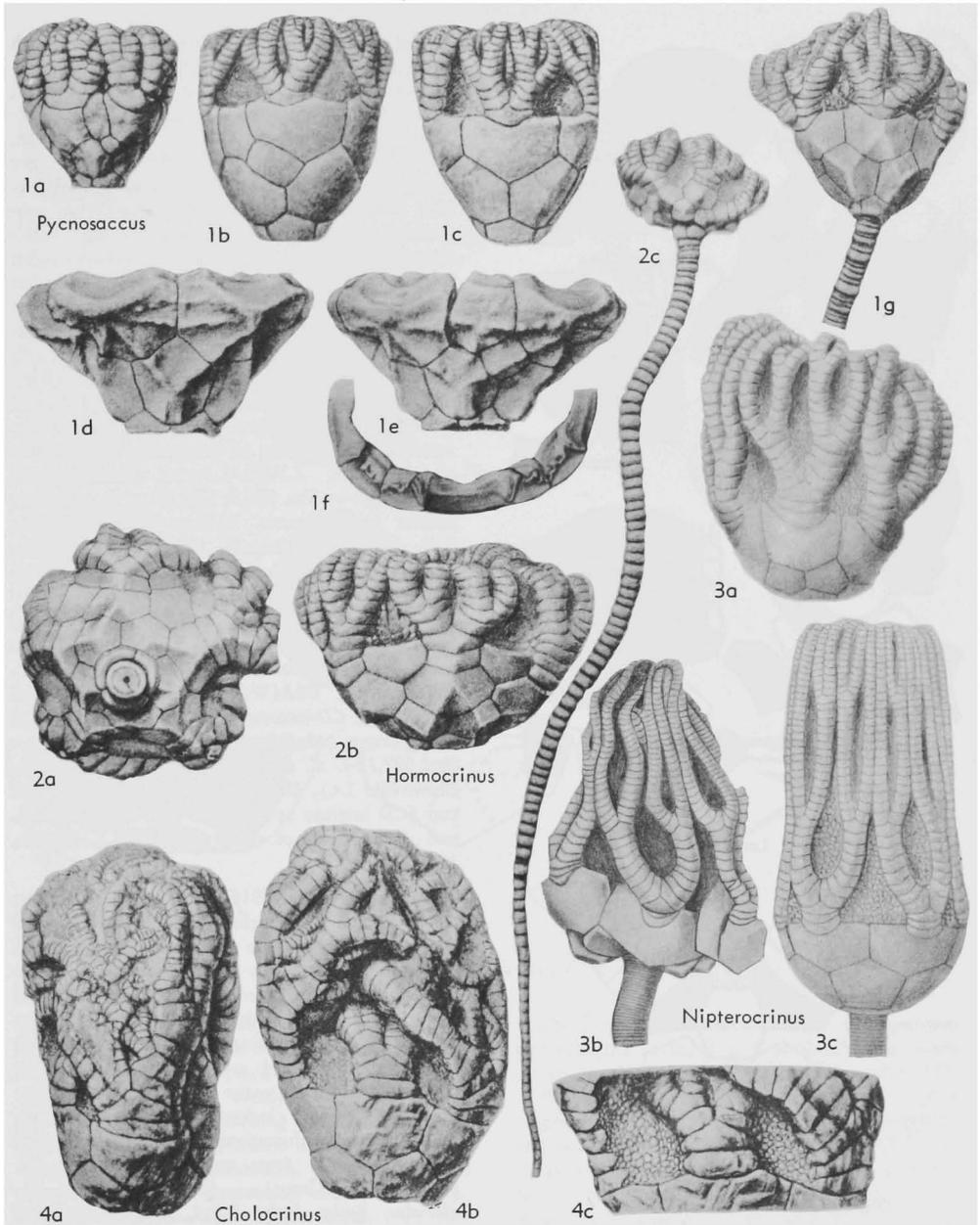


FIG. 520. Nipterocrinidae (p. T779-T780).

der, commonly heteromorphic and xenomorphic, cirri lacking. *L.Miss.*(*low.L.Carb.*)-*U.Perm.*

Mespilocrinus DE KONINCK & LE HON, 1854, p. 111 [**M. forbesianus*; SD S. A. MILLER, 1889, p. 262]. Small subglobular crown with short arms twisted spirally clockwise, isotomously bifurcating on primibrach 2 and secundibrachs 2

or 3, tips curved strongly inward; *CD* basal distinctly larger than others and followed by large anal *X* with distally pointed extremity reaching level of proximal secundibrachs; infrabasal cirlet with width 1.5 to 2 times that of circular stem impression. Stem nearly homeomorphic to distinctly heteromorphic and typically xenomorphic, with quite dissimilar proximal, intermediate, and distal portions. *L.Miss.*(*Osag.*), N.Am.; *L.Carb.*

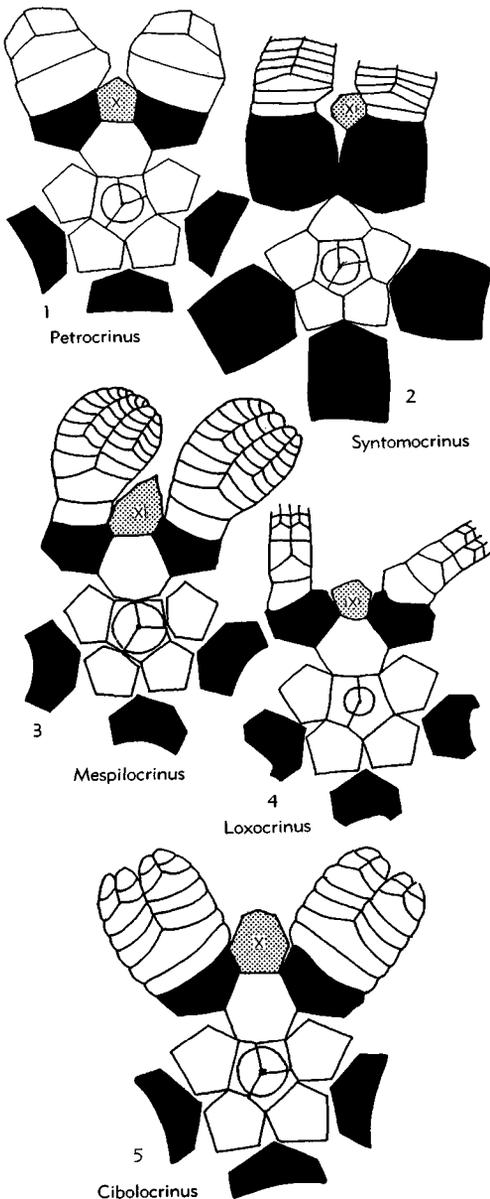


FIG. 521. Mespilocrinidae (radials black, anal X stippled) (p. T781-T783).

(*Tournais-Visean*), Eu.—FIG. 521,3; 522,2*c-f*. **M. forbesianus*, Belg.(Tournai); 521,3, plate diagram of cup (radials black, X stippled) and post. arms (Moore, n); 522,2*c-e*, D-ray, CD-interray, and dorsal (*A* ray down) views, $\times 1.5$ (Springer, 1920); 522,2*f*, lat. views of crown and stem, $\times 1.5$ (Springer, 1920).—FIG. 522, 2*a,b*. *M. konincki* HALL, Burlington Ls., USA

(Iowa); 2*a,b*, B- and D-ray views of crown with attached part of stem, $\times 2$ (Springer, 1920). **Cibolocrinus** WELLER, 1909, p. 630 [**C. typus*; OD] [*non Cibolocrinus* WELLER, 1909b, p. 632-633; *nec* WANNER, 1916a, p. 211; *nec* WANNER, 1924, p. 257; *nec* WANNER, 1934, p. 260; *nec* WANNER, 1937, p. 190; *nec* YAKOVLEV, 1930, p. 377; *nec* YAKOVLEV, 1934, p. 278]. Crown sub-globular, with shallow to moderately high bowl-shaped cup forming half or more of crown height; infrabasals 3, small one normally in *C* ray but found in *A* ray in type species; medium-sized to large anal *X* extending well above radial summits separating primibrachs and even proximal secundibrachs of *C* and *D* rays. Arms short, branching isotomously on primibrach 2 and secundibrachs 3 to 5, brachials very low and wide. Stem transversely circular, facets of columnals with narrow crenulate rim. *L.Penn.-L.Perm.*, N.Am.-?Sib.-S. Am.(Bol.).—FIG. 521,5; 522,1*d-g*. *C. punctatus* MOORE & PLUMMER, M.Penn.(Atokan, Marble Falls Ls.), USA(Texas); 521,5, plate diagram of cup (radials black, X stippled) and post. arms (Moore & Plummer, 1940); 522,1*d-g*, dorsal (*A* ray down), CD-interray, *A*-ray, and ventral (*E* ray up) views of crown, $\times 1.5$ (Moore & Plummer, 1940).—FIG. 522,1*a-c*. **C. typus*, L.Perm.(Wolfcamp.), USA(W.Texas); 1*a-c*, dorsal (*A* ray down), CD-interray, and ventral (*A* ray up) views of cup, $\times 1$ (Moore & Plummer, 1940).—FIG. 522,1*h-l*. *C. banioni* MOORE, U.Penn.(Virgil, Brownville Ls.), USA(Okla.); 1*h-l*, long. sec. of cup (CD interrays at left) and ext., int., proximal, and distal views of radial plate, $\times 1.5$ (Moore, 1939c).

Loxocrinus WANNER, 1916, p. 251 [**L. globulus*; OD]. Crown small, globular, with bowl-shaped cup forming more than half its height, plates of cup massive; infrabasals 2 in type species but may be 3 in others or fused entirely; posterior basal larger than others, with distal curved truncation for reception of medium-sized anal *X*; radials with slightly inclined articular facets occupying almost but not quite entire width of plate, bearing short arms twisted clockwise as in *Mespilocrinus*, with isotomous bifurcations on primibrachs 2 and secundibrachs 2. Stem transversely circular. *U. Perm.*, Indon.(Timor).—FIG. 521,4; 523,1. **L. globulus*, Basleo beds; 521,4, plate diagram of cup (radials black, anal X stippled) and post. arms (Wanner, 1916a, mod.); 523,1*a-d*, CD-interray, *A*-ray, ventral (*A* ray up), and dorsal (*A* ray down) views of crown, $\times 2$ (Wanner, 1916a); 523,1*e-g*, CD-interray, ventral (*A* ray up), and dorsal (*A* ray down) views of cup, $\times 2$ (Wanner, 1916a).

Petrocrinus WANNER, 1924, p. 92 [**P. beyrichi*; OD]. Crown relatively large, ovoid; cup conical to bowl shaped, fused infrabasal circling flaring upward peripherally and visible from side; radials

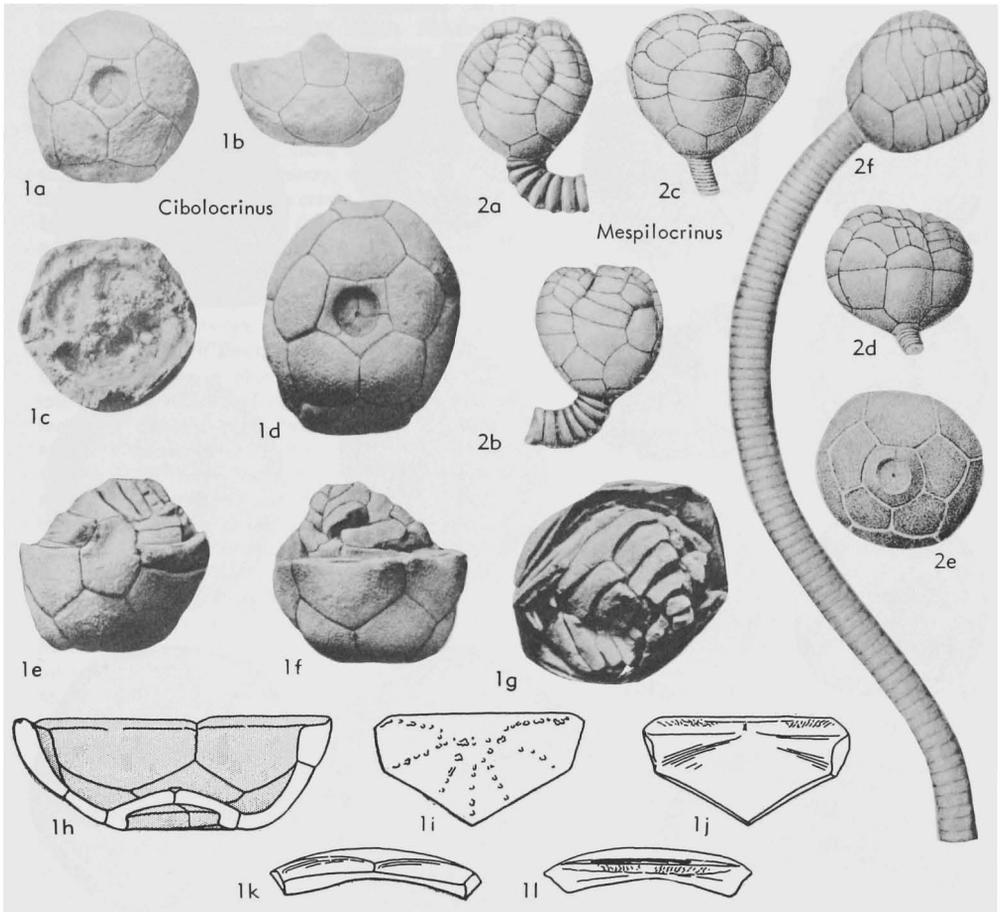


FIG. 522. Mespilocrinidae (p. T781-T782).

with wide straight articular facets forming very even summit of cup; anal *X* barely rising above radials. Arms short, composed of wide and unusually tall brachials, sloping evenly upward to pointed tip of crown, arms branching isotomously in each ray on primibrachs 2, which is followed by only single pairs of secundibrachs, so that total in crown is 10. Stem transversely circular. *U. Perm.*, Indon. (Timor).—FIG. 521, 1; 523, 2. **P. beyrichi*, Basleo beds; 521, 1, plate diagram of cup (radials black, anal *X* stippled) and post. arms (Wanner, 1924, mod.); 523, 2, *CD*-interray view of holotype, $\times 1$ (Wanner, 1924).

Syntomocrinus WANNER, 1916, p. 256 [**S. sundaicus*; OD]. Crown pear shaped, narrowing upward from very even summit of cup, which is nearly straight sided and gently concave at base, only distal tips of basals visible from side, if at all, small pentagonal infrabasal cirlet largely covered by circular stem. Arms composed of wide, short brachials, branching isotomously on primi-

brachs 2 or 3, secundibrachs 3 or 4, uppermost arm branches having 3 or 4 tertibrachs, but rarely preserved. *U. Perm.*, Indon. (Timor).—FIG. 521, 2; 523, 3. **S. sundaicus*, Basleo beds; 521, 2, plate diagram of cup (radials black, anal *X* stippled) and post. arms (Wanner, 1916a, mod.); 523, 3a, b, *A*-ray and dorsal (*A* ray down) views of crown, $\times 1.5$ (Wanner, 1916a); 523, 3c, d, dorsal (*A* ray down) and ventral (*A* ray up) views of cup, $\times 1.5$ (Wanner, 1916a); 523, 3e, part of specimen figured in 3c, d, showing *A*-ray facet, $\times 2$ (Wanner, 1916a).

Family CALYCOCRINIDAE Moore & Strimple, 1973

[Calycocrinidae MOORE & STRIMPLE, 1973, p. 34]

Lecanocrinids chiefly characterized by development of bilateral symmetry in plane bisecting *CD* interrays and on anterior side

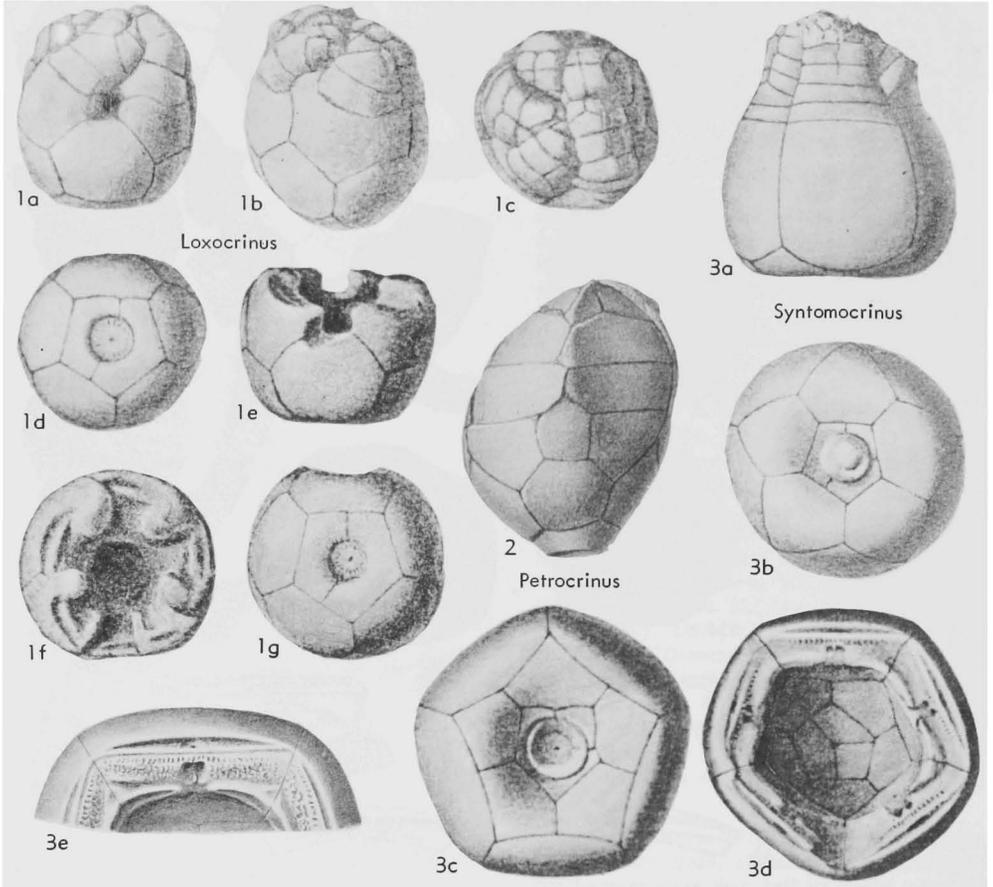


FIG. 523. Mespilocrinidae (p. T782-T783).

of crown either bisecting *A* ray or *AE* inter-ray, this bisymmetry best developed in forms with crown distinctly bent on stem or stem coiled around crown; cup low to tall conical or bowl shaped, with shortest and tallest sides in plane of symmetry; infrabasal circler reduced to two plates or fused into single plate largely or entirely covered by proximal columnal of stem; basals with distinct tendency for *CD* basal to be larger than others or reduced to three (*AE* and *AB* basals lacking) or with *CD* basal standing alone, radials subequal in shape and size or distinctly unequal, with margin or articular facets straight or strongly curved; radianal and anal *X* present or absent. Arms formed by wide short brachials, branching isotomously once or

more in each ray. Stem transversely circular in section or unevenly elliptical. *M.Dev.*; *L.Penn.*; *U.Perm.*

Calyccocrinus WANNER, 1916, p. 260 [**C. curvatus*; OD]. Crown low to moderately tall, subconical to bowl shaped with rounded summit formed by incurved arms; cup with similar sides all around or with posterior and anterior sides quite dissimilar in height and curvature, with posterior side longitudinally convex and anterior side concave; infrabasals solidly fused into pentagonal plate largely covered by stem impression; basals 5, pentagonal in outline and equal in size or with anterior one smaller than *CD* basal; radials 5 with nearly straight margin of articular facet; without radianal and anal *X* (Fig. 524). Arms short, formed by wide short brachials, branching isotomously, normally on primibrach 3, and with additional bifurcation in some branches. Stem transversely circular, columnal articular with short peripheral

crenulatae. *L.Penn.*(Morrow.), USA(Okla.); *U. Perm.*, Indon.(Timor).—FIG. 525,2; 526,3c-f. **C. curvatus curvatus* (= *C. curvatus typus* WANNER, 1924, p. 96), *U. Perm.*, near Basleo; 525,2, plate diagram of cup (radials black) and post. arms showing bilateral symmetry through *A* ray and *CD* interray (Wanner, 1924, mod.); 526,3c-f, *CD*-inter-ray, *A*-ray, *DE*-inter-ray, and ventral (*A* ray down) views of holotype crown, $\times 2$ (Wanner, 1916a).—FIG. 526,3a,b. *C. curvatus subtrubinnatus* WANNER, *U. Perm.*, Basleo; 3a,b, *DE*-inter-ray and ventral (*A* ray down) views of crown, $\times 1$ (Wanner, 1924).

Ammonicrinus SPRINGER, 1926, p. 22 [**A. wanneri*; OD]. Crown short, rounded asymmetrically, incurved strongly in plane bisecting *AE* and *CD* interrays; infrabasals reduced to 2 subequal, symmetrically disposed plates which are larger than any of 3 basals adjoining them on posterior side (*AB* and *EA* basals lacking); *A* and *E* radials symmetrically disposed and distinctly larger than others, with margins of articular facets rather strongly curved; rhombic radianal obliquely at left below *C* radial (apparently doubled in some specimens); large anal *X* above *CD* basal and followed by several smaller anal plates. Arms formed by wide, short and straight or laterally somewhat curved brachials, branching isotomously on primibrachs 6 to 8 with up to 10 secundibrachs in some branches, followed by at least some terti-brachs. Stem coiled almost completely around crown, with distinct impressions of columnals on cup; columnals throughout midlength of stem strongly arched, with crescentic cross section; articular facets with transverse ridge and otherwise with nearly smooth surface, indicating synostosomal articulation; distal part of stem narrowing to point without holdfast or prolonged in elongate cylindrical columnals; axial canal very diminutive, circular. [SPRINGER was uncertain whether *Ammonicrinus* belonged to the Inadunata or Camerata, but judged that it most probably was a hexacrinid camerata. A painstaking study by UBAGHS (1953) that included dissection of a well-preserved specimen of the type species has served to demonstrate beyond doubt that this crinoid is a lecanocrinacean flexible.] *M.Dev.*, Eu.(Ger.).—FIG. 525,3; 526,5. **A. wanneri*, Eifel; 525,3, plate diagram (radials black, radianals cross ruled, *X* and higher anals stippled), *CD* interray upward (Ubaghs, 1952); 526,5a-c, opposite sides and edge of enrolled column, distal extremity pointed upward, $\times 1.5$ (Springer, 1926b); 526,5d,e, edge and side views of larger specimen, $\times 1.5$ (Springer, 1926b).

Plagiocrinus WANNER, 1924, p. 110 [**P. torynocrinoides*; OD]. Crown asymmetrically pear shaped, with nearly straight anterior side, rounded summit, and longitudinally strongly convex posterior side; cup obliquely inclined from stem or bent almost at right angles to it; infrabasal circlet

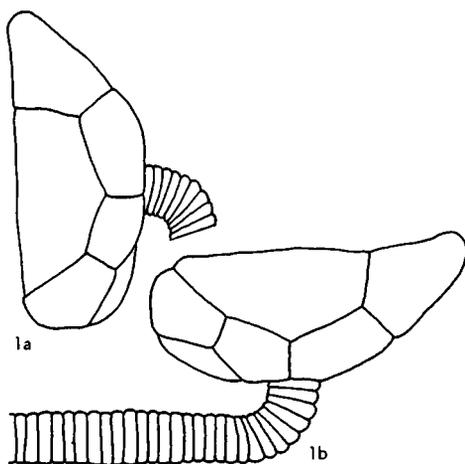


FIG. 524. Interpretations of orientation of cup and stem of *Calyptocrinus* during life; 1a, erect attitude like that of an air ventilator, postulated by YAKOVLEV; 1b, prone attitude on sea bottom, suggested by MOORE & STRIMPLE (Moore & Strimple, 1973).

reduced to small subrescentic fused plate on posterior side of stem impression, followed on this side by single *CD* basal (no others in cup); radials 5, quadrangular to pentagonal in outline, with straight margin of articular facet, *A* and *E* radials in contact with infrabasal circlet beneath proximal columnal. Arms varying in width, composed of low, wide brachials, branching isotomously on primibrach 2, and with 1 or 2 additional bifurcations in different branches. Stem unknown but impression at base of cup unevenly elliptical. [*Plagiocrinus* resembles *Ammonicrinus* in disposition of its plane of near-bilateral symmetry. It differs from strongly oblique species of *Calyptocrinus* mainly in having only a single basal plate.] *U. Perm.*, Indon.(Timor, Basleo).—FIG. 526,6; 526,4d. **P. torynocrinoides*, Basleo; 525,6, plate diagram (radials black), *CD* interray upward (Wanner, 1924, mod.); 526,4d, *E*-ray view of holotype crown, $\times 2$ (Wanner, 1924).—FIG. 526,4a-c. *P. jaekeli* WANNER, Basleo; 4a-c, *DE*-inter-ray, *CD*-inter-ray, and ventral (*A* ray down) views of holotype cup, $\times 1.5$ (Wanner, 1924).

Family GAULOCRINIDAE Moore & Strimple, 1973

[Gaulocrinidae MOORE & STRIMPLE, 1973, p. 15]

Cup low bowl shaped, with flat to slightly concave base and longitudinally convex sides, becoming subvertical in upper part and curving inward slightly at margins of

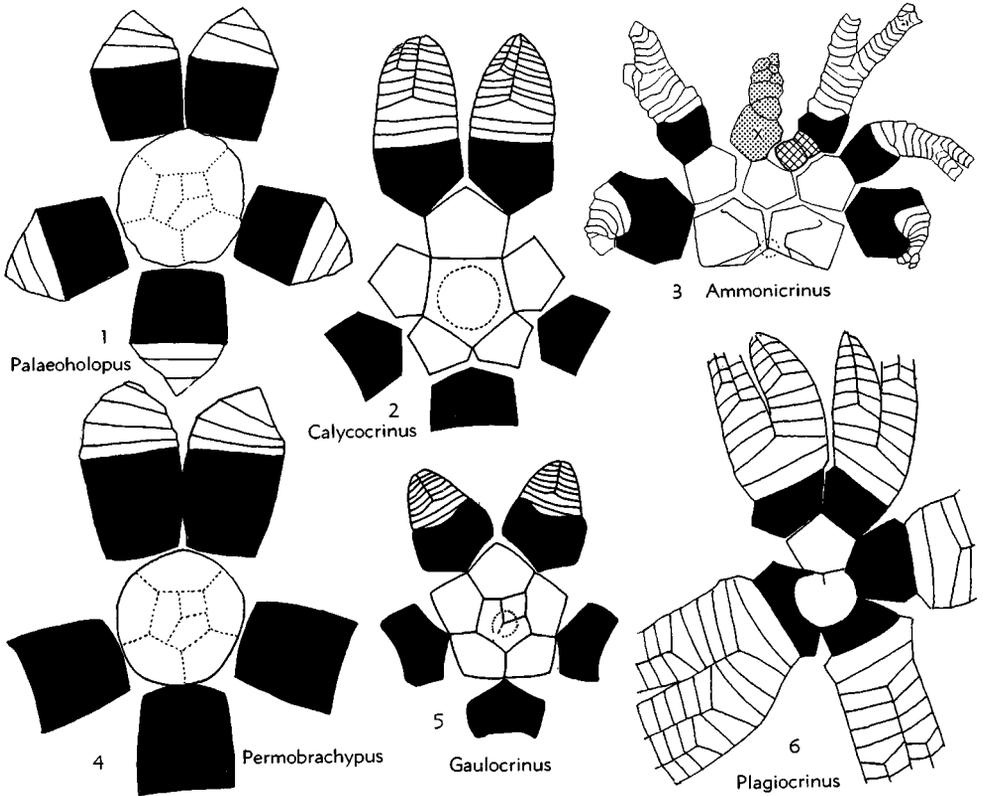


FIG. 525. Calyocrinidae (2,3,6); Gaulocrinidae (5), Palaeoholopodidae (1,4) (radials black, anal series stippled, radianals cross ruled) (p. T784-T786, T789).

radials; infrabasal circlet angularly pentagonal, with small infrabasal in *C* ray or possibly all plates fused, approximately half of its diameter occupied by shallowly concave stem impression; basals large and very thick, strongly convex both longitudinally and transversely, all pentagonal in outline; radials wider than high, also exceptionally thick, with broad, nearly featureless facets with faint transverse ridge not quite reaching interradial sutures. Arms composed of very wide short brachials, branching isotomously on primibrachs 2, succeeded in each branch by five or more secundibrachs, terti-brachs unknown; arms slope inward with gentle convexity to meet at center of crown. No radianal or anal *X* in cup. Column transversely circular but otherwise unknown. *L.Miss.*

Gaulocrinus KIRK, 1945, p. 180 [**Stemmatocrinus trautscholdi* WACHSMUTH & SPRINGER, 1885, p. 180; OD]. Characters of family. *L.Miss.(Osag.)*, USA (Ind.-Tenn.-?Ky.).—FIG. 525,5; 527,1. *G.

trautscholdi (WACHSMUTH & SPRINGER), New Providence F., White's Creek Springs, Tenn.; 525,5, plate diagram (radials black), *CD* interray upward (Moore, n); 527,1a,b, ventral (presumed *A* ray up) view showing very thick radials and nature of facets, and part of dorsal view (presumed *BC* interray down), $\times 1.5$ (Moore, n; U.S. Natl. Museum); 527,1c-g, *A* to *E* radials from exterior showing near identity in appearance and broadly scalloped profile of articular facets, $\times 1.5$ (Moore, n; U.S. Natl. Museum); 527,1h, side view of incomplete crown (rays unidentified) showing typical sort of flexible arm structure, $\times 1.5$ (Moore, n; U.S. Natl. Museum).

Family PROPHYLLOCRINIDAE Moore & Strimple, 1973

[Prophylocrinidae MOORE & STRIMPLE, 1973, p. 15]

Crown moderately small, globose; cup with flat or somewhat concave base formed by pentagonal completely fused infrabasal circlet, surrounded by five equal pentagonal basals, strongly curved longitudinally as well as transversely; radials with articu-

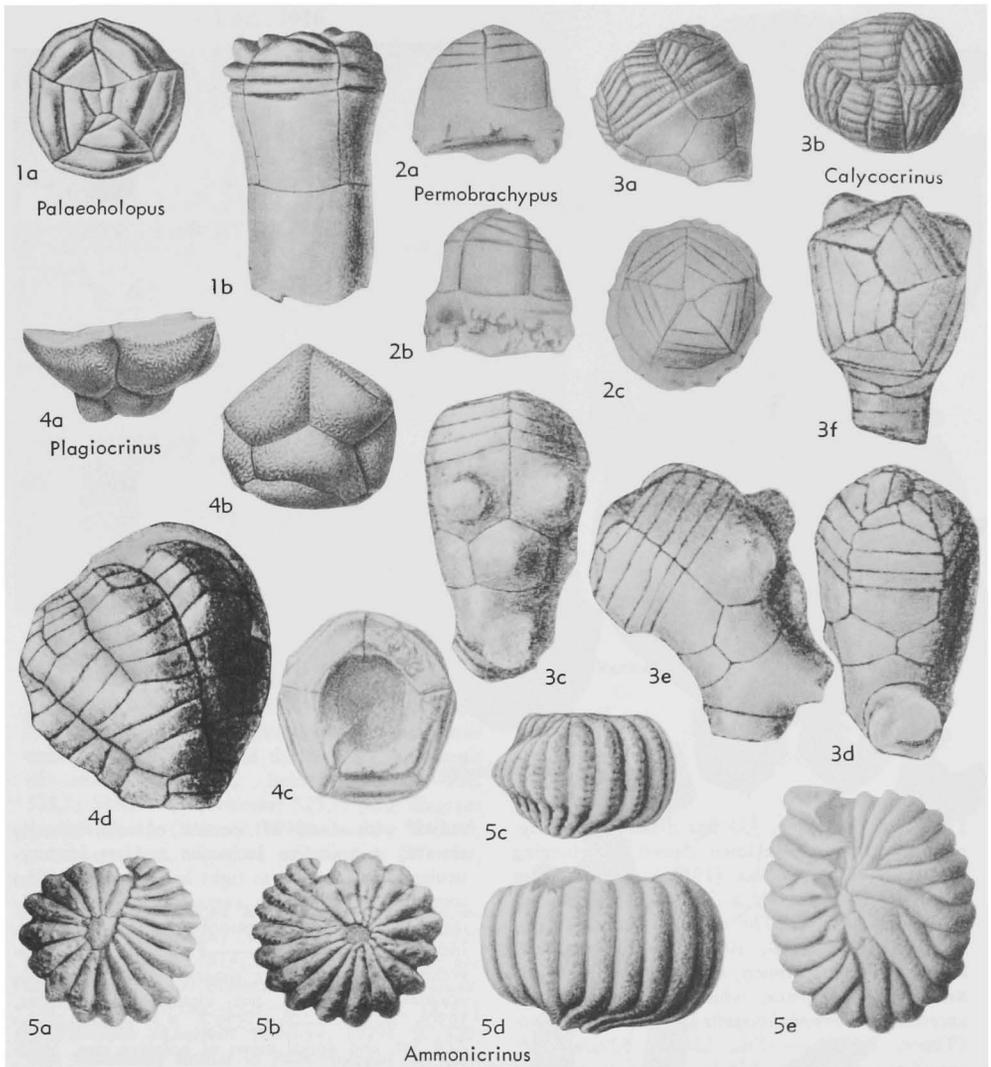


FIG. 526. Calyptocrinidae (3-5), Palaeoholopodidae (1,2) (p. T784-T785, T789).

lar arm facets much narrower than width of plates, bordered on one or both sides by pronglike projections, which may be symmetrical or decidedly asymmetrical, with projection on left side of facet most extended; quadrangular radial X on distally truncate *CD* basal or both of these plates lacking. Arms short, narrow, bifurcating isotomously once or twice. *U.Perm.*

Prophylocrinus WANNER, 1916, p. 273 [**P. dentatus*; OD]. Cup subglobular, with flattened or

concave base, formed of massive plates; pentagonal infrabasal circlet entirely fused; radials with symmetrical or nearly symmetrical upward projections on either side of medially placed articular facet approximately 0.3 width of radial. Arms formed of wide, low brachials with transversely curved faces, branching isotomously on primibrachs 2 or 3 (rarely 4) followed by 2 to 6 secundibrachs in each branch and 0 to 8 tertibrachs; arms bent strongly inward concealing tegmen. Stem transversely circular, diameter 0.4 to 0.8 width of infrabasal circlet, facets with peripheral girdle of short, fine crenulae, axial canal very small, circular.

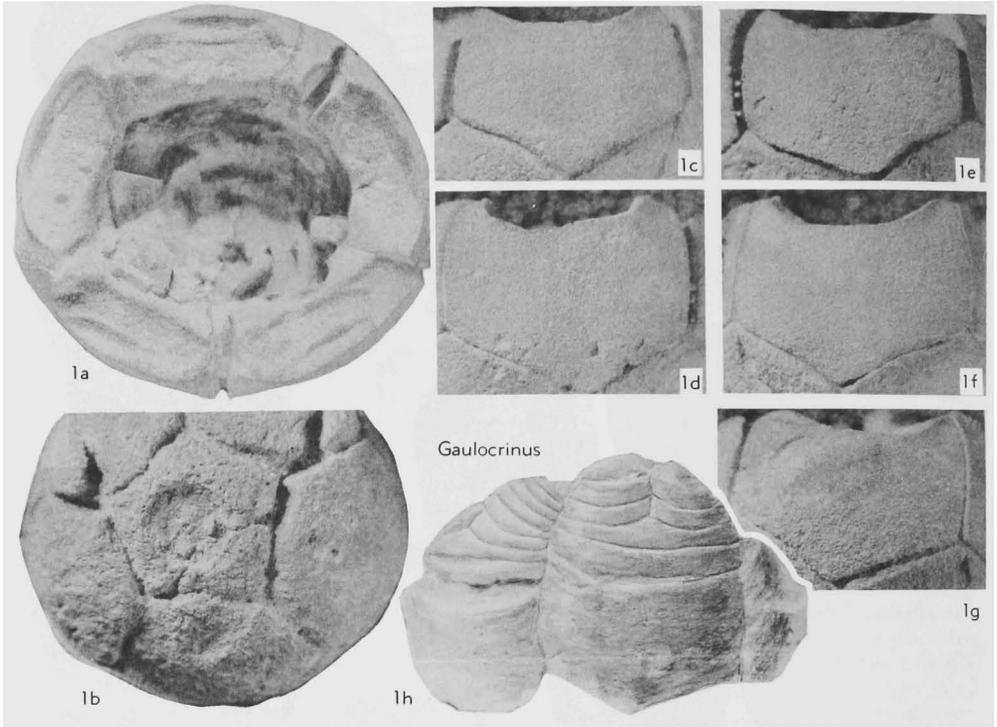


FIG. 527. Gaulocrinidae (p. T786).

[WANNER (1930b, p. 43) has described and figured an abnormal specimen classed as belonging to *P. cuspidatus* WANNER (1916a) differing from others in having both a rhombic radianal and pentagonal anal X. The radianal occurs directly beneath the C radial, as in *Mysticocrinus*, and accordingly the specimen was compared by WANNER with this genus, which he interpreted as ancestral to *Prophyllocrinus*.] *U.Perm.*, Indon. (Timor, Basleo).—FIG. 528,2a; 529,3a,b. *P. cuspidatus* WANNER; 528,2a, plate diagram of specimen classed as abnormal by WANNER because of presence of small plates seemingly representing radianal and anal X (radials black, radianal cross ruled, X stippled) (Wanner, 1930b, mod.); 529, 3a,b, lat. and dorsal views of cup, $\times 1.5$ (Wanner, 1916a).—FIG. 528,2b; 529,3c-e. **P. dentatus*; 528,2b, plate diagram (radials black), ray orientation not identifiable (Wanner, 1916a, mod.); 529, 3c-e, ventral, dorsal, and lat. views of holotype crown, $\times 2$ (Wanner, 1916a).

Ancistrocrinus WANNER, 1924, p. 119 [**A. vermistriatus*; M]. Generally very similar to *Prophyllocrinus*, but cup plates more massive and externally bulbous, infrabasal cirlet in distinct concavity, mostly concealed by proximal columnals, and chiefly distinguished by very asymmetrical

radials with distal left portion of each strongly elevated as spikelike projection and rounded articular facet confined to right half of plate. Arms composed of taller than average brachials, branching isotomously on primibrachs 2. *U.Perm.*, Indon. (Timor, Basleo).—FIG. 528,3. *A. depressus* WANNER; plate diagram (radials black), orientation of rays not identifiable (Wanner, 1930b, mod.).—FIG. 529,2. **A. vermistriatus*; 2a,b, lat. and dorsal views of holotype cup, $\times 1.5$ (Wanner, 1924).

Proapsidocrinus WANNER, 1924, p. 116 [**P. permicus*; OD]. Like *Ancistrocrinus*, but narrowly rounded articular facets of radials submedial, bordered on right by moderate upward projection and on left by very strong one arched inward to meet those of other radials at summit of cup, thus forming deep niches for reception of arms, which branch isotomously on primibrachs 2 and secundibrachs 2, latter supporting 7 or more terti-brachs on either side. *U.Perm.*, Indon. (Timor, Basleo).—FIG. 528,1; 529,1. **P. permicus*; 528,1, plate diagram (radials black), orientation of rays not identifiable (Moore, n); 529,1a-c, lat., dorsal, and ventral views of holotype incomplete crown, $\times 1$ (Wanner, 1924).

Family PALAEOHOLOPODIDAE

Wanner, 1916

[*nom. correct.* MOORE, herein (*pro* Palaeoholopidae WANNER, 1916a, p. 279)]

Crown gumdrop shaped, with subvertical, longitudinally nearly straight sides and evenly rounded, very low summit formed by wide and extremely short arms curved inward to meet centrally. Cup consisting of five quadrangular radials surrounding tall cylindrical base presumably formed by fused basal and infrabasal circlets, cup attached to featureless low or moderately tall peduncle, no true stem. Arms unbranched, composed of three to five brachials which tend to be inclined clockwise. *U. Perm.*

Palaeoholopus WANNER, 1916, p. 279 [**P. pretiosus*; M]. Crown with nearly vertical sides and flatly rounded summit, 0.7 of height formed by 5 quadrangular radials of cup, which has very even summit formed by wide straight articular facets of radials, base of cup consisting of flat circular disc thought to be formed by fused basal and infrabasal circlets; cup attached to stemlike peduncle, which is cylindrical sutureless tube with diameter equal to that of cup and sides confluent with cup. Arms formed by very wide short brachials which are longitudinally convex, arms unbranched, with pointed tips meeting at summit of crown. *U. Perm.*, Indon. (Timor).—FIG. 525, 1; 526, 1. **P. pretiosus*; 525, 1, plate diagram (radials black) (Wanner, 1930b, mod.); 526, 1a, b, ventral and lat. views of crown, $\times 1$ (Wanner, 1916a).

Permobrachypus MOORE & STRIMPLE, 1973 [*nom. subst. pro* *Brachypus* WANNER, 1929a, p. 320 (*non* VON MEYER, 1814; *nec* SWAINSON, 1824; *nec* MEIGEN, 1824; *nec* SCHOENHERR, 1825; *nec* GRAY, 1825; *nec* FITZINGER, 1826; *nec* GULDING, 1828)] [**Brachypus adhaerens* WANNER, 1929a, p. 320; M]. Essentially similar to *Palaeoholopus* but radials proportionally wider and shorter and arms forming relatively higher more evenly rounded summit of crown. Peduncle very short and with sides tending to flare outward from base of cup. Arms composed of only 3 brachials which progressively decrease in width upward. *U. Perm.*, Indon. (Timor).—FIG. 525, 4; 526, 2. **P. adhaerens* (WANNER); 525, 4, plate diagram (radials black) (Wanner, 1930b, mod.); 526, 2a-c, 2 lat. and ventral views of holotype crown, $\times 2$ (Wanner, 1930b).

Superfamily ICTHYOCRINACEA

Angelin, 1878

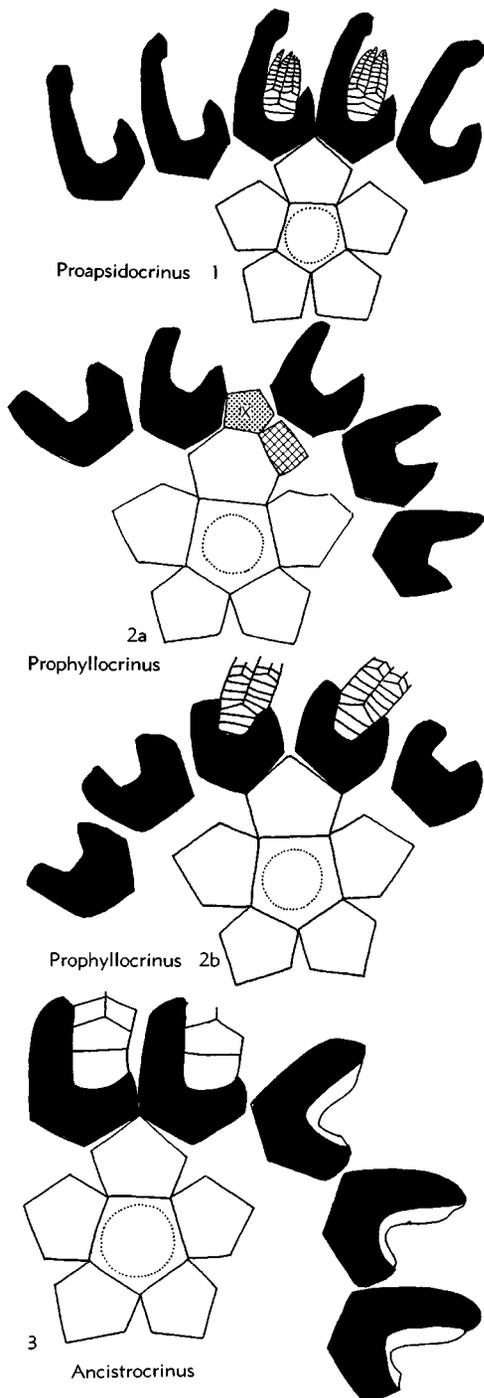
[*nom. transl.* MOORE & STRIMPLE, 1973 (*ex* Icthyocrinidae

FIG. 528. Prophyllocrinidae (radials black, anal \times stippled, radianal cross ruled) (p. T787-T788).

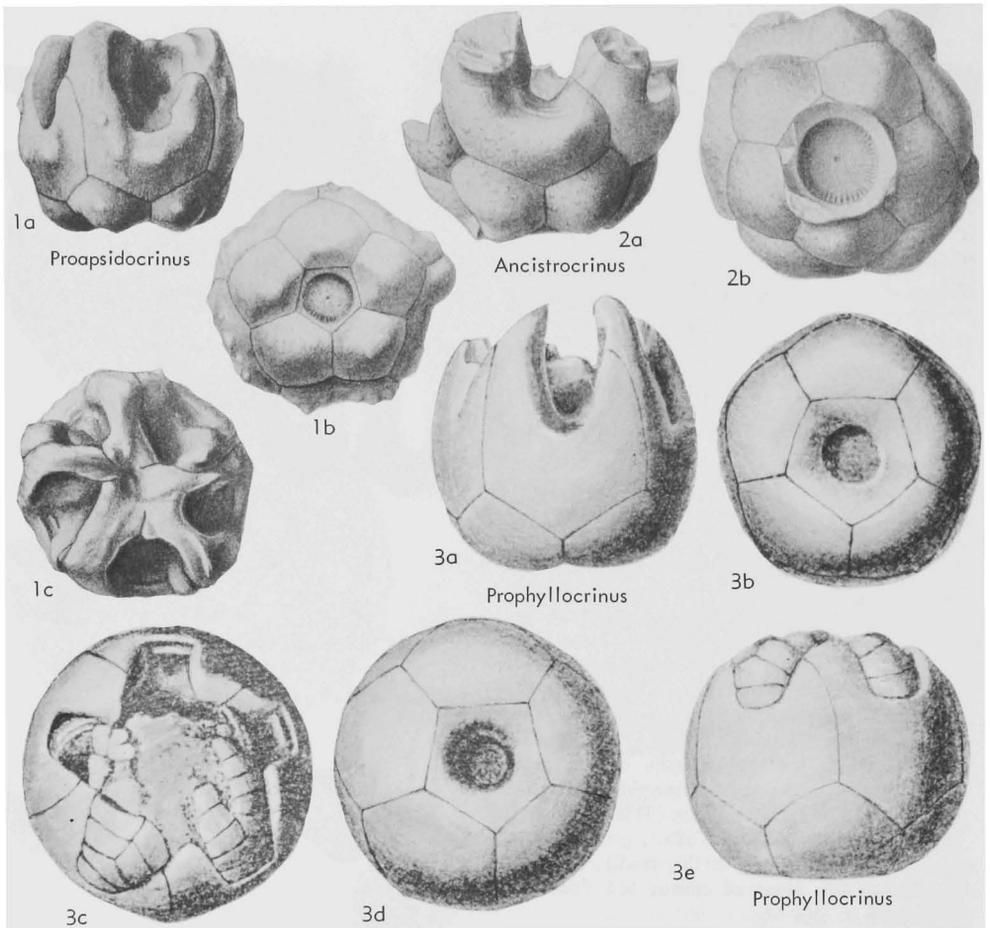


FIG. 529. Prophyllocrinidae (p. T787-T788).

ANGELIN, 1878, p. 13; *nom. correct.* MOORE & STRIMPLE, 1973, *pro* Ichthyocrinidae ANGELIN, 1878, p. 13] [The ICZN Code, 1964 (art. 11e), requires that "a family-group name must, when first published, be based on the name then considered to be valid for a contained genus . . ." *Ichthyocrinus* HALL, 1852 (erroneously attributed to CONRAD, 1842) for erection of Ichthyocrinidae by ANGELIN (1878) is not such a valid name and consequently the family name given by ANGELIN must be rejected. The fact that CONRAD transliterated *ichthys* from the Greek as *ichthy-* does not prevent *Ichthyocrinus* as published by him (1842, p. 279) from being construed as a "correct original spelling" (Code, art. 32,a,ii) and therefore *Ichthyocrinus* cannot legally replace *Ichthyocrinus*]

Crown globose to elongate ovoid, many-armed, with cup not separated from fixed proximal brachials which form much or most of calyx, arms joined together closely, without associated interbrachials, cup anal plates lacking or restricted to radial or anal X. Arms branching isotomously. Stem transversely circular. *L.Sil.-L.Miss.* or *low. L.Carb.*

Family ICTHYOCRINIDAE Angelin, 1878

[*nom. correct.* MOORE & STRIMPLE, 1973 (*pro* Ichthyocrinidae ANGELIN, 1878, p. 13)] [See nomenclatural note under Ichthyocrinacea]

Characters of superfamily. [The unimportant, even rudimentary nature of the infrabasal circllet was considered by SPRINGER to be a diagnostic feature of this assemblage, but the dominance of fixed ray plates unassociated with interprimibrachs in forming a stoutly built calyx seems more significant.] *L.Sil.(Medinan)-L.Miss.(Osag.)*.

Ichthyocrinus CONRAD, 1842, p. 279 [**I. laevis*; M] [= *Ichthyocrinus* HALL, 1852, p. 195 (*nom. van.*) (obj.)]. Crown ovoid to pear shaped, expanding upward from base of calyx which is formed by small radials and subjacent cup plates; greatly larger part of calyx composed of interlocking, firmly sutured ray plates; small infrabasal circllet

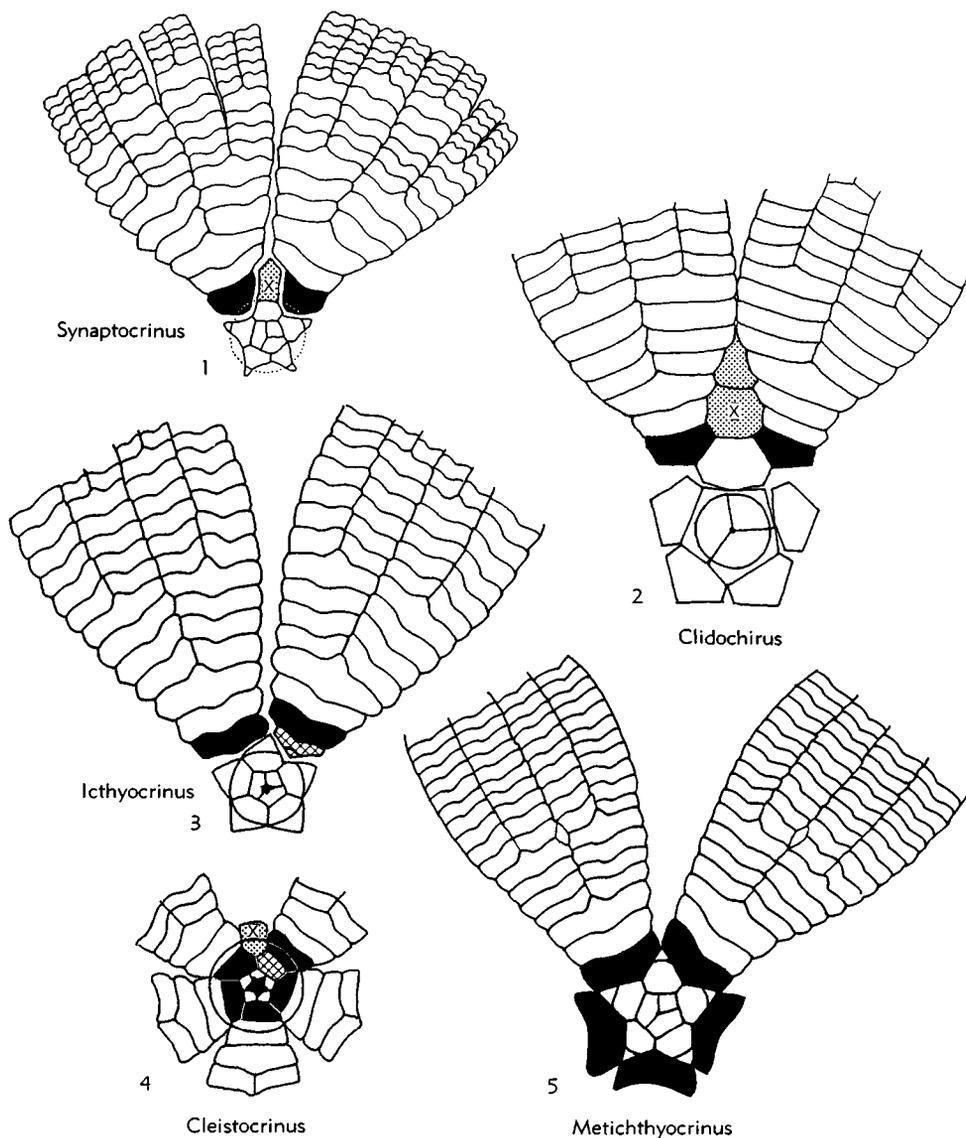


FIG. 530. Icthyocrinidae (radials black, anals stippled, radialian cross ruled) (p. T790-T794).

entirely concealed by stem or resorbed; posterior basal not differentiated, orientation of crown being determined by position of small infrabasal in *C* ray and occurrence of primitive radialian in this ray directly below radial; no anal *X* or interradial plates. Arms in calyx and above it branching isotomously on primibrachs 2, secundibrachs 3 or more commonly 4. Stem composed of thin, circular columnals tapering abruptly beneath cup or gradually reduced in width, axial canal small, circular or bluntly pentagonal. *M.Sil.*(*Niagaran*),

USA (N.Y.-Ind.-Ill.)-Eu. (Sweden-Eng.); *L.Dev.* USA (Tenn.)-Eu. (Czech.).—FIG. 530,3; 531, 3*a-c*. **I. laevis*, Lockport Ls., USA (N.Y.)-Can. (Ont.); 530,3, plate diagram of part of calyx (radials black, radialian cross ruled) and arms of *C* and *D* rays (mod. from Springer, 1920); 531, 3*a,b*, dorsal view of crown (*CD* interray directed upward) and *B*-ray view of same, specimen from Lockport, N.Y., $\times 2$ (Springer, 1920); 531,3*c*, *AB*-interray view of crown from Grimsby, Ont., $\times 2$ (Springer, 1920).—FIG. 531,3*d*. *I. pyri-*

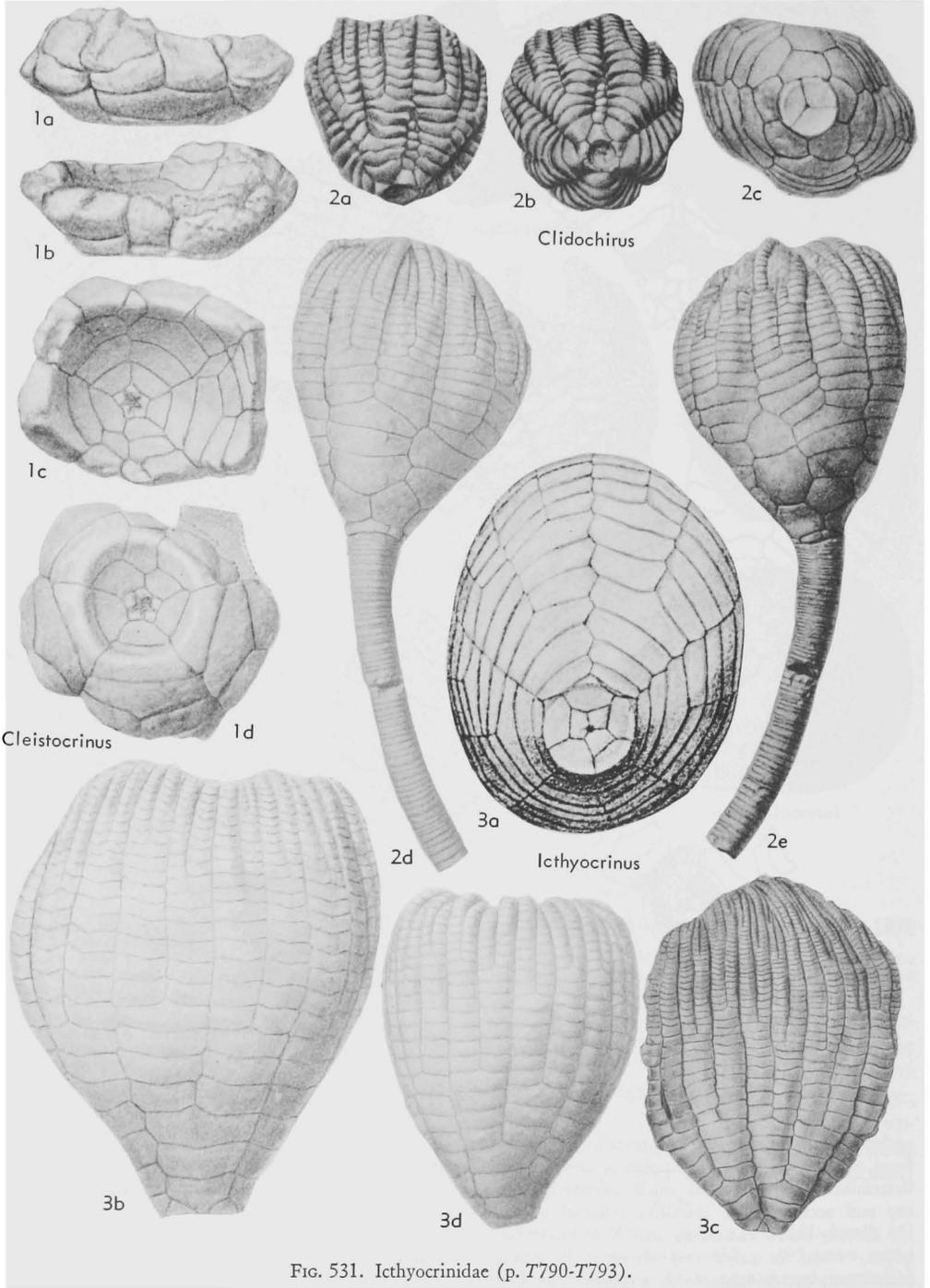


FIG. 531. Ichthyocrinidae (p. T790-T793).

formis (PHILLIPS), Visby F., Sweden (Gotl.); D-ray view of undistorted crown, $\times 2$ (Springer, 1920).

Cleistocrinus SPRINGER, 1920, p. 292 [**Calpiocrinus humilis* ANGELIN, 1878, p. 12; OD]. Lower part of calyx strongly built, shallow bowl shaped, with

gently sloping sides; infrabasal circllet very diminutive or lacking; basals very small, entirely covered by stem, which likewise conceals all radials except in *C* ray where lower half of radial and radial plate directly beneath it are included in stem impression; proximal part of primibrachs concealed by stem except in *C* ray; ray branching isotomously on primibrachs 2, parts of calyx above secundibrachs 2 and free arms unknown; pentagonal anal *X* in *CD* interray rests on beveled edges of the *D* radial and radialian. Stem large, transversely circular, shown by impression on calyx to have facets with long fine crenulae; axial canal quinquestellate. *U.Sil.*, Eu. (Sweden).—FIG. 530,4; 531,1. **C. humilis* (ANGELIN), Wenlock Ls., Gotl.; 530,4, plate diagram of calyx (radials black, radialian cross ruled, anal *X* stippled) and proximal parts of arms (mod. from Springer, 1920); 531,1a-d, ant., post., ventral, and dorsal views of syntype, *CD* interray directed upward in 1d and downward in 1c, $\times 2$ (Springer, 1920).

Clidochirus ANGELIN, 1878, p. 12 [**C. pyrum*; M] [= *Clidocrinus* WANNER, 1916a, p. 251 (*nom. null.*) (obj.)]. Crown elongate ovoid to pear shaped, generally resembling *Ichthyocrinus* in appearance, but distinguished by larger plates in lower part of calyx, infrabasals sloping upward and visible from side (but concealed in one species); *CD* basal larger than others and broadly truncate distally for support of large anal *X*, which is followed by additional anal. Arms laterally interlocked, divided isotomously on primibrachs 2, secundibrachs 4 and at higher levels. Stem very little tapered next below calyx and subequal in diameter throughout its observed length, formed of low columnals in proximal region but taller ones distally, articular facets distinctly crenulate. *L.Sil.*, USA (Ohio); *U.Sil.*, Eu. (Sweden); *L.Dev.*, USA (W.Va.-N.Y.); *U.Dev.*, USA (Iowa); *L.Miss.*, USA (Ky.).—FIG. 530,2; 531,2c-e. **C. pyrum*, U.Sil. (Wenlock), Gotl.; 530,2, plate diagram of lower part of calyx (radials black, anals stippled), with proximal part of *C* and *D* rays separated by anal plates (mod. from Springer, 1920); 531,2c, dorsal view of crown, *CD* interray upward, $\times 1$ (Springer, 1920); 531,2d,e, ant. and post. views of complete crown with attached stem, $\times 1$ (Springer, 1920).—FIG. 531,2a,b. *C. keyserensis* SPRINGER, L.Dev. (Helderberg.), USA (W.Va.); 2a,b, post. and dorsal views of complete crown, 2b with *CD* interray upward, $\times 1$ (Springer, 1920).

Metichthyocrinus SPRINGER, 1906, p. 517 [**Ichthyocrinus burlingtonensis* HALL, 1858b, p. 557; M]. Crown subglobular, with smoothly sloping sides of calyx and free arms well inturned at summit; stem concealing subhorizontal infrabasals and basal circllet except for their distal extremities. Arms expanding upward, closely abutting with brachials interlocking. Stem tapering somewhat

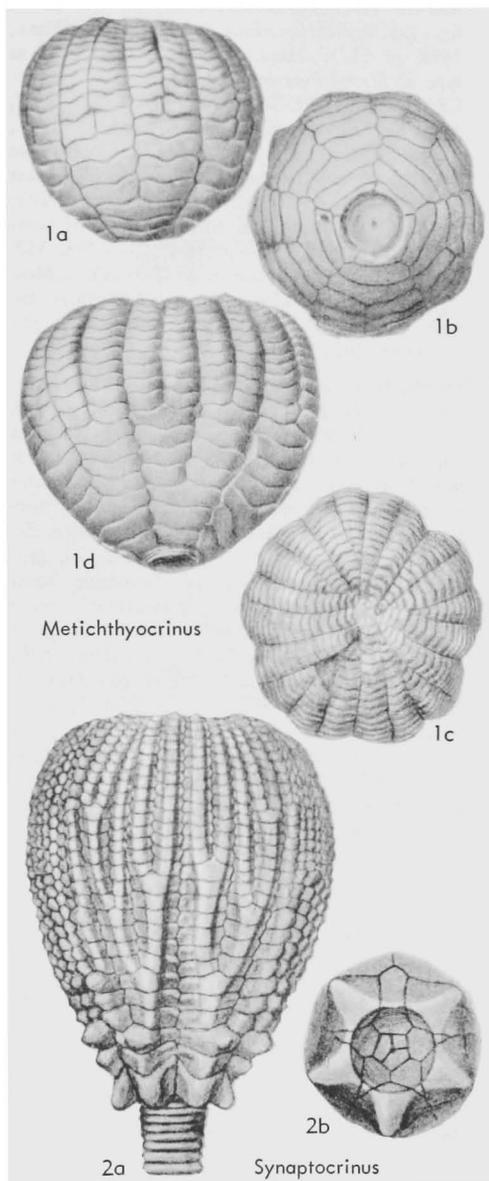


FIG. 532. Icthyocrinidae (p. T793-T794).

next below calyx but thereafter nearly uniform in diameter, columnals very thin proximally but much thicker distally with tendency in some species toward heteromorphy. [The type species of this genus is not the form recorded by SPRINGER (1920, p. 320), given as *Cyathocrinites tiaraeformis* TROOST (*nom. nud.*) (= *Ichthyocrinus tiaraeformis* TROOST in HALL, 1858b, p. 558). This is because in his original publication SPRINGER cited a single species as *M. burling-*

tonensis HALL (SPRINGER, 1906, p. 522, pl. 6, fig. 15) (= *Ichthyocrinus burlingtonensis* HALL, 1858, p. 557). HALL's species is thus fixed as type of *Metichthyocrinus* by monotypy.] *L.Miss.*, USA (Iowa-Ind.-Ky.-Tenn.).—FIG. 530,5; 532, 1a-c. *M. tiaraeformis* (TROOST), *L.Miss.* (Osag., New Providence F.), USA (Tenn.); 530,5, plate diagram of cup (radials black) and major part of *C* and *D* ray (mod. from Springer, 1920); 531, 1a-c, lat., basal, and summit views of complete crown, $\times 1$ (Springer, 1920).—FIG. 532, 1d. *M. clarkensis* (MILLER & GURLEY), *L.Miss.* (Osag., New Providence F.), USA (Tenn.); lat. view of crown, identity of rays unspecified, $\times 1$ (Springer, 1920).

Synaptocrinus SPRINGER, 1920, p. 301 [**Forbesiocrinus nuntius* HALL, 1862, p. 124; OD]. Crown pear shaped, widest near summit; calyx includes cup plates largely concealed by stem, *CD* basal notably elongate and pointed distally; ray plates bifurcating isotomously, brachials strongly interlocked; type species distinguished by rounded elevation of the median part of each brachial, producing appearance of raised branching arms entirely foreign to typical ichtyocrinids. Stem heteromorphic, not appreciably reduced in diameter distally. *M.Dev.*, USA (N.Y.); *U.Dev.*, NW. Can.—FIG. 530,1; 532,2. **S. nuntius* (HALL), Hamilton Gr., USA (N.Y.); 530,1, plate diagram of part of cup (radials black, anal *X* stippled) and arms of *C* and *D* rays (mod. from Springer, 1920); 532,2a,b, post. view of crown (reconstr.) and diagrammatic view of base with *CD* interray directed upward, $\times 2$ (Springer, 1920).

Superfamily SAGENOCRINITACEA Roemer, 1854

[*nom. transl.* MOORE & STRIMPLE, 1973 (*ex* Sagenocrinitidae BASSLER, 1938, p. 23; *nom. subst. pro* Sagenocrinitidae ROEMER in BRONN, 1854, p. 228)]

Crown globose to elongate ovoid, with many laterally abutting arms and joined together also by interradian and interbrachial plates, arms curved inward at top of crown above tegmen, which therefore generally cannot be seen. Stoutly built calyx comprising lower one-half or more of crown includes one or several anal plates in posterior interray or uncommonly lacks them entirely. Stem mostly large, transversely circular. *U.Sil.*-*U.Perm.*

Family HOMALOCRINIDAE Angelin, 1878

[Homalocrinidae ANGELIN, 1878, p. 11]

Crown small, rotund, with cup (defined

as including plates below summit of radials) not distinctly separated from higher part of crown, in this respect clearly differentiated from Lecanocrinidae and Nipterocrinidae; infrabasals extending beyond stem impression; radianal in primitive position directly beneath *C* radial, anal *X* extending above articular facets of adjoining radials. Arms gently to somewhat strongly rounded transversely, composed mostly of brachials wider than high, with only few of them in each ray joined together by firm sutures to form fixed brachials, branching of arms isotomous up to *Y* level at upper limit of fixed brachials and heterotomous above *Y* line; one or two large interprimibrachs between contiguous rays or with larger number of small, irregularly arranged and shaped interprimibrachs; interbrachials very few or lacking. Stem transversely circular, composed of low columnals or in intermediate and distal regions of columnals with height nearly equal to diameter; axial canal circular, very tiny. [Endotomous branching of arms in upper part of crown is a most diagnostic attribute of the family.] *U.Sil.*

Homalocrinus ANGELIN, 1878, p. 11 [**H. parabasalis* (= *Taxocrinus nanus* SALTER, 1873, p. 126, *nom. nud.*; *H. dudleyensis* SPRINGER, 1906, p. 482); M] [= *Leiocrinus* SPRINGER, 1902, p. 95 (type, *Calpiocrinus ovatus* ANGELIN, 1878; OD) (*non* D'ORBIGNY, 1850, p. 180)]. Large anal *X* resting on truncated distal margin of posterior basal and extending upward so as to separate primibrachs of *C* and *D* rays; other characters as for family. *U.Sil.*, Eu. (Sweden-Eng.).—FIG. 533,3; 534,2a-h. **H. parabasalis*; 533,3, plate diagram (radials black, radianal cross ruled, *X* and higher anals stippled), *CD* interray upward (Springer, 1920, mod.); 534,2a-c,h, *E*-ray, *CD*-interray, *C*-ray oblique from below, and dorsal (*CD* interray up) views of specimen from Gotland figured by ANGELIN, $\times 1.5$ (Springer, 1920); 534,2d-f, *A*-ray, dorsal (*A* ray down), and *D*-ray views of specimens from Dudley, Eng., $\times 2$ (Springer, 1920); 534,2g, *CD*-interray view of juvenile crown from Gotland, $\times 2$ (Springer, 1920).—FIG. 534,2i-k. *H. liljevalli* SPRINGER, Sweden (Gotl.); 2i,j, dorsal (*CD* interray up) and *B*-ray views of holotype crown, $\times 2$; 2k, under side of finely plated tegmen of another specimen showing 5 centrally placed orals and ambulacra passing between them to arms, $\times 2$ (all Springer, 1920).

Anisocrinus ANGELIN, 1878, p. 13 [**A. interradialis*; M]. Radianal directly or somewhat obliquely at left below *C* radial; interrays with very

large plates resting on shoulders of radials and arched over by fixed brachials, anal *X* largest of these, distinguished by its position on truncated distal margin of posterior basal and by its contact with radialial; large proximal plates of interrays may be followed by 1 or 2 smaller ones above; *Y* line at summit of axillary secundibrachs 4 or 5. *U.Sil.*, Eu. (Sweden)—N.Am. (Ill.-Ind.-Ky.-Tenn.).—FIG. 533,1; 534,1a-c. **A. interradians*, Sweden (Gotl.); 533,1, plate diagram (radials black, radialial cross ruled, anal *X* stippled; *y*, upper line of fixed brachials), *CD* interray upward (Springer, 1920, mod.); 534,1a, *A*-ray view of essentially perfect crown showing upflared infrabasal circllet and truncate summit formed by in-folded arms, $\times 2$; 534,1b,c, *CD*-interray and dorsal (*CD* interray up) views of incomplete crown, $\times 2$ (all Springer, 1920).

Asaphocrinus SPRINGER, 1920, p. 174 [**A. bassleri*; OD]. Crown expanding upward, with transversely well-rounded arms not abutting laterally; interray areas with numerous irregularly shaped and arranged plates; infrabasals visible from side, *CD* basal larger than others and firmly joined to rhombic radialial and large anal *X*, latter supporting numerous smaller anals in form of sac or tube interlocking laterally with contiguous brachials. Each ray with several isotomous bifurcations of arms at different levels. *U.Sil.*, USA (N.Y.-Ind.-Tenn.).—FIG. 533,2; 534,3a-c. **A. bassleri*, Brownsport Ls., Tenn.; 533,2, plate diagram (radials black, radialial cross ruled, *X* and higher anals stippled), *CD* interray upward (Springer, 1920, mod.); 534,3a-c, *D*-ray, *A*-ray, and *DE*-interray views of three crowns, $\times 1$ (Springer, 1920).—FIG. 534,3d. *A. ornatus* (HALL), Rochester Sh., N.Y.; *CD*-interray view of crown showing tubelike appearance of anal plate series, $\times 1.5$ (Springer, 1920).

Family SAGENOCRINITIDAE Roemer, 1854

[*nom. correct.* BASSLER, 1938, p. 23 (*pro* Sagenocrinidae ROEMER in BRONN, 1854, p. 228)] [incl. Forbesiocrinidae JAEKEL, 1918, p. 78]

Crown ovoid to pear shaped, elongate cup (radials, anals, and lower plate circllets) not at all set off from bulk of large stout calyx composed of numerous fixed brachials in all rays and prominent many-plated interradial and interbrachial areas; free arms mostly well differentiated from calyx, transversely rounded, separated from one another and bifurcating several times isotomously, distal extremities of arms curved strongly inward at top of crown; infrabasal circllet subhorizontal, largely, or entirely concealed by column; basals and radials commonly not larger than fixed brachials

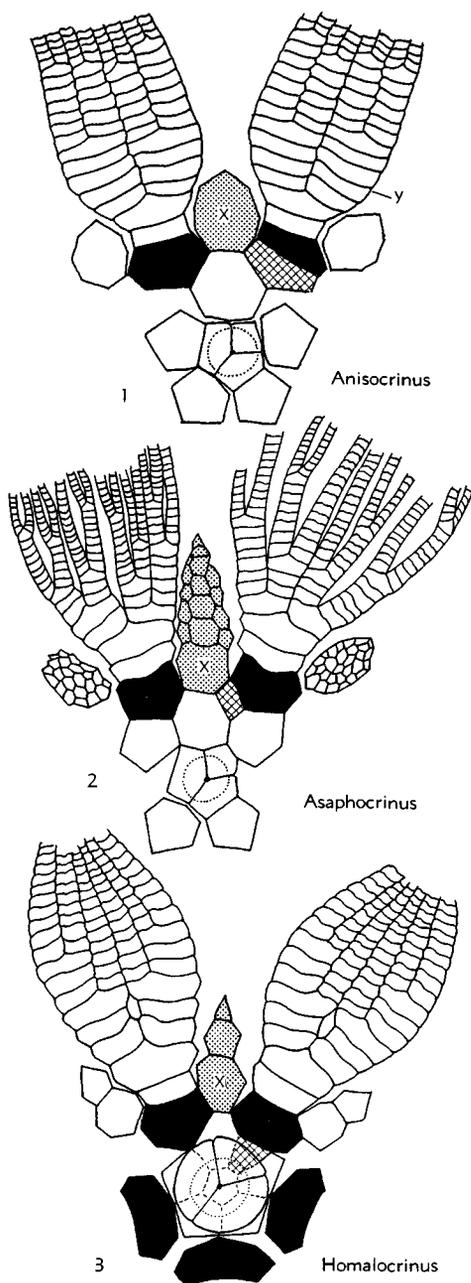


FIG. 533. Homalocrinidae (radials black, anals stippled, radialial cross ruled) (p. T794-T795).

and interbrachials, all massive thick plates firmly joined together; radialial and anal *X* present in all genera. Stem homeomorphic or distinctly heteromorphic, composed of

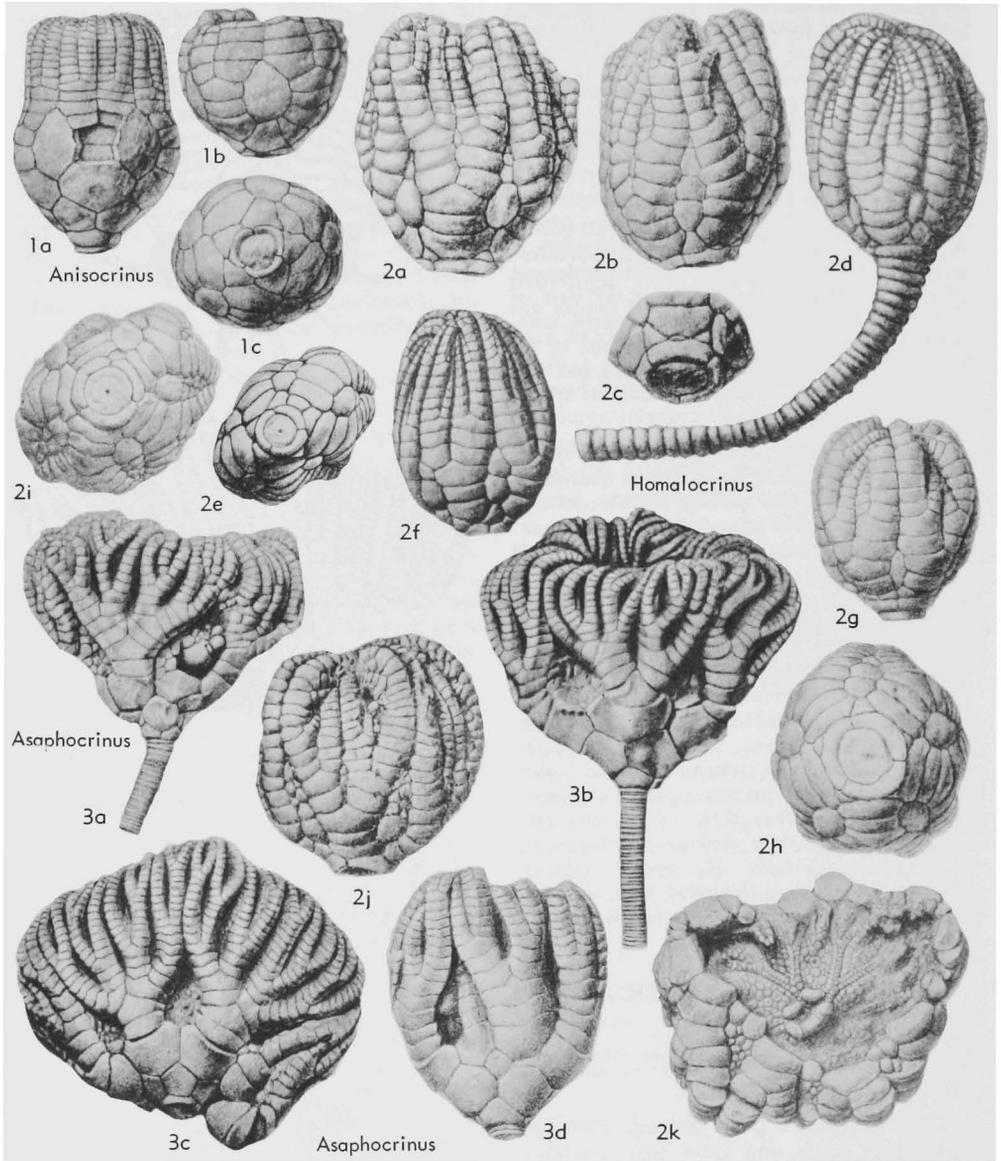


FIG. 534. Homalocrinidae (p. T794-T795).

relatively low columnals which commonly are perforated by quinquestellate axial canal. *U.Sil.*; *Miss.*; *L.Perm.*

Sagenocrinites AUSTIN & AUSTIN, 1842, p. 110 [**Actinocrinites? expansus* PHILLIPS in MURCHISON, 1839, p. 674; M] [= *Sagenocrinus* MORRIS, 1843, p. 58 (*nom. van.*) (obj.); *Periechocrinites* AUSTIN & AUSTIN, 1843, p. 203 (type, *P. articulatus*; = *Actinocrinites? expansus*, obj.; OD) (*non* BASSLER, 1938, p. 149); *Sageniocrinus* ZITTEL,

1895, p. 130 (*nom. null.*)]. Crown ovoid to biturbinate, small to moderately large; infrabasals somewhat recumbent, not entirely covered by stem impression; basal circler commonly interrupted in C-ray position by radial which occurs in primitive position directly beneath C and touches small infrabasal; CD basal not larger than others or truncated distally; anal, interradial and interbranchial areas filled by numerous polygonal solid plates in more than one series and characterized by appreciable breadth of these areas; fixed and

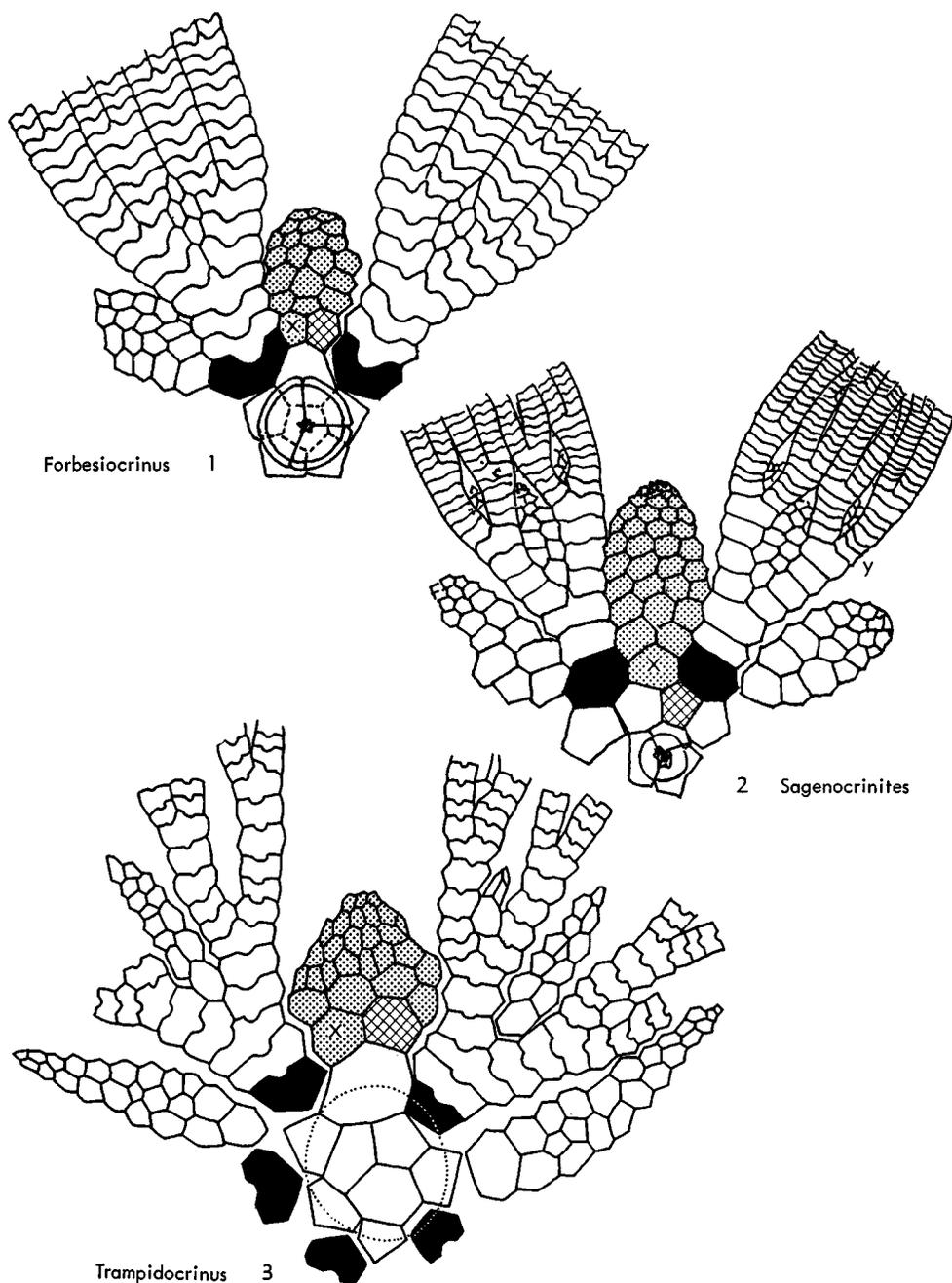


FIG. 535. Sagenocrinitidae (p. T796-T800).

free brachials in isotomously branching successions, narrowing upward and with straight to distinctly sinuous interbrachial sutures; each ray or arm branch with 2 primibrachs, 3 or 4 secundibrachs, 5 to 8 tertibrachs, and indefinite number

of plates in higher brachitaxes. Stem transversely circular, heteromorphic, not expanding at calyx; columnals penetrated by quinquestellate axial canal. *U.Sil.*, Eu. (Eng.-Sweden)-USA (Ind.-Tenn.).—FIG. 535,2; 536,1a,b. **S. expansus* (PHILLIPS),

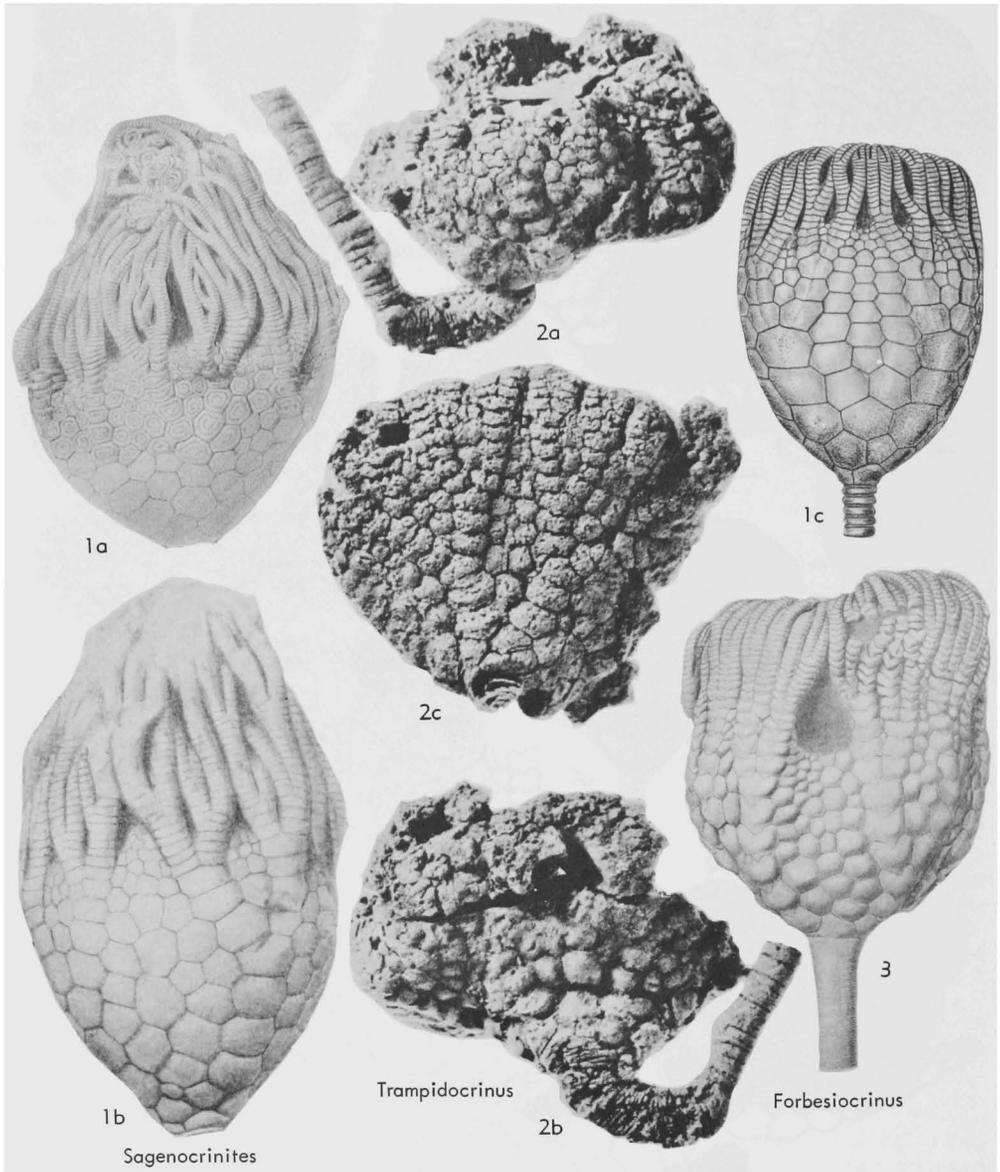


FIG. 536. Sagenocrinitidae (radials black, anals stippled) (p. T796-T800).

Wenlock Ls., Eng.; 535,2, plate diagram of calyx (radials black, radianal cross ruled, X and higher anal plates stippled; y, upper line of fixed brachials) and post. rays with adjoining interrays (mod. from Springer, 1920); 536,1a,b, side view of incomplete crown (rays not specified) and post. view of nearly complete specimen, both from Dudley, Eng., $\times 0.7$, $\times 1.5$ (Springer, 1920). —FIG. 536,1c. *S. clarki* SPRINGER, Brownsport F., USA(Tenn.); post. side of crown, $\times 0.7$

(Springer, 1920).
Forbesiocrinus DE KONINCK & LE HON, 1854, p. 118 [**F. nobilis*; M] [=Proguettardicrinus STEINMANN, 1908, p. 153 (type, *Forbesiocrinus greenii* MILLER & GURLEY, 1896b, p. 57; OD)]. Crown globular to elongate ovoid, medium sized to unusually large, with stout calyx formed by firmly sutured thick cup and ray plates joined laterally with large areas of interradianal and interbrachial plates; transversely rounded free arms in upper

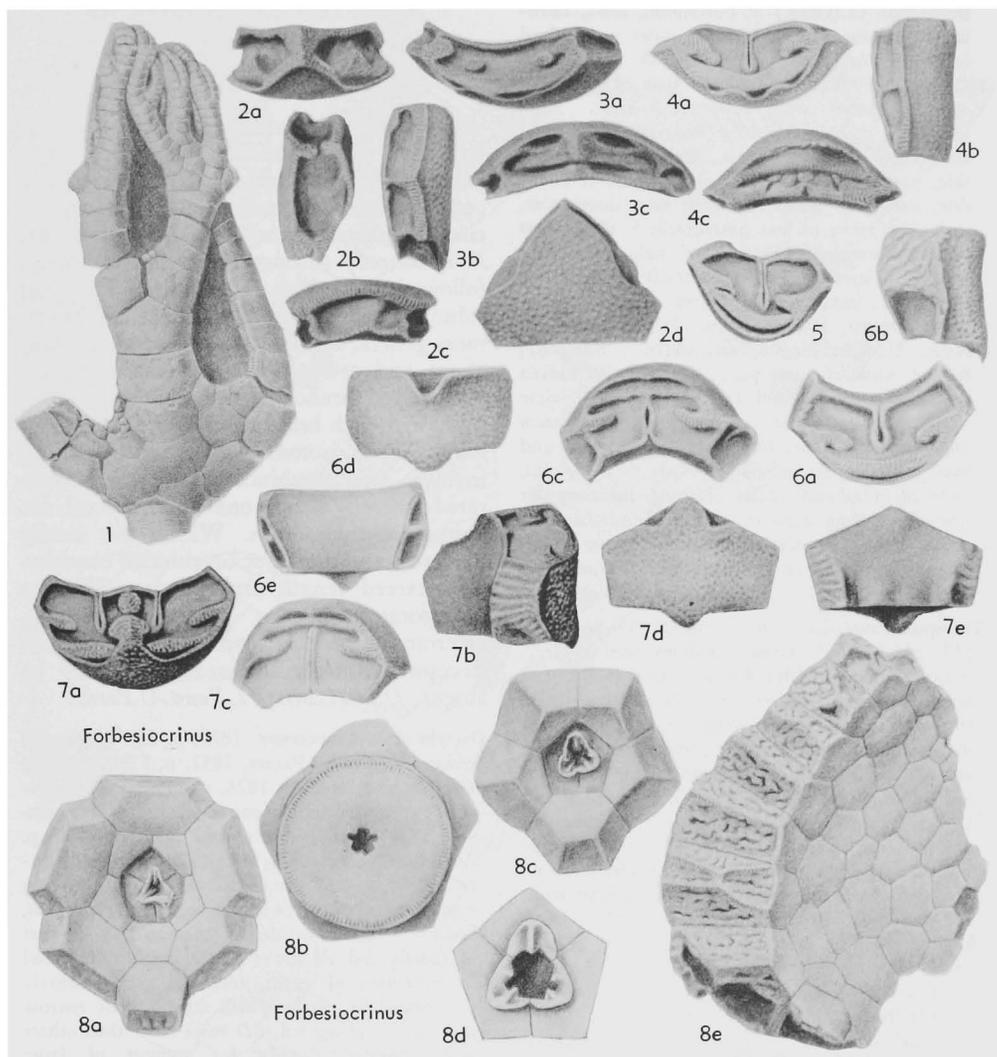


FIG. 537. Sagenocrinitidae (p. T798-T800).

part of crown branching isotomously and separated, incurved distally; infrabasal cirlet barely visible beyond large stem impression externally, very thick, and narrowing internally to small pentagon; only distal extremities of basals exposed, *CD* largest, with distal margin beveled for contact with anal *X* at left and upwardly displaced radially at right, these plates followed by numerous other medium-sized polygonal anals in posterior interray; radials approximately equal in size and shape to proximal primibrachs, laterally united with one another except where separated by anals. Both fixed and free arms branching evenly isotomously, composed of brachials with strongly sinuous sutures produced by prominent

patelloid processes and sockets on outer parts of their articular facets. Large stem composed of low circular columnals which decrease gradually in diameter for short or considerable distance beneath calyx but after initial taper maintain fairly constant diameter, with or without distinct increase in height of columnals; stem penetrated by quinquestellate axial canal. *L. Carb. (Tournais.)*, Eu. (Belg.-Eng.); *L. Miss. (Osag.)-U. Miss. (Merrimac.)*, USA (Iowa-Mo.-Ill.-Ind.-Ky.-Tenn.-Ohio). —FIG. 535, 1; 536, 3; 537, 1-7. **F. nobilis*, Tournais., Belg.; 535, 1, plate diagram of calyx (symbols as in Fig. 535, 2), *C* and *D* lower part of arms, and adjoining interrays (mod. from Springer, 1920); 536, 3, post. view of crown from

Burlington Ls.(Osag.) at Burlington, Iowa, showing very numerous anal plates, outer ones joined firmly to brachials of *C* and *D* rays, $\times 0.5$ (Springer, 1920); 537,1, C-ray view of somewhat crushed crown from Tournais., Belg., $\times 0.7$ (Springer, 1920); 537,2-7, dissociated calyx and arm plates from Tournais., Belg.; 2*a-d*, distal, side, prox., and ext. views of basal; 3*a-c*, distal, side, and prox. views of radial; 4*a-c*, distal, side, and prox. views of first primibrach; 5, distal view of 2nd secundibrach; 6*a-e*, distal, side, prox., ext., and int. views of 2nd primibrach; 7*a-e*, distal, side, prox., ext., and int. views of primaxil; all $\times 2$ (Springer, 1920).—FIG. 537,8. *F. saffordi* HALL, U.Miss.(Meramec.), USA(Ind., Spergen); 8*a*, int. view of basal part of calyx with radials (*A* radial upward) and anal, $\times 2$; 8*b*, ext. view of basal circllet (post. basal upward) and stem impression, $\times 2$; 8*c*, int. view of infrabasal and basal circllets (post. side downward), $\times 2$; 8*d*, int. view of infrabasal circllet showing subtriangular rim surrounding axial canal (small infrabasal in *A* ray), $\times 4$; 8*e*, part of interior showing corrugated edges of thick brachials for attachment to interbrachials, $\times 1.5$ (all Springer, 1920).

Trampidocrinus LANE & WEBSTER, 1966, p. 17 [**T. phiala*; OD]. Crown medium sized to large, compact, sides of calyx flaring rather evenly outward from stem with free arms above calyx curved strongly inward; notably similar to *Forbesiocrinus* in general features, including arrangement of large anal *X* and radianal plates above large *CD* basal but differing radically in broad contact of *B* and *C* radials with infrabasals. Isotomous branching of fixed and free arms well defined, as is strongly sinuous interbrachial sutures produced by patelloid processes. Stem very unlike that of *Forbesiocrinus* and corresponding closely to *Nevadacrinus* (dactylocrinid flexible crinoid) in having a curved, gently tapered basillarid region composed of 25 to 40 very low columnals with strongly crenulate articula ending distally at a bulbous wedge-shaped columnal (cuneus) with facetal planes disposed at angle of 45° to 55° to each other; beyond cuneus stem is distinctly heteromorphic, composed of moderately tall columnals with longitudinally convex profile alternating with much thinner, straight-sided columnals; curvature and abrupt flexure of stem is in direction of *CD* interray, thus differing from *Nevadacrinus* in which curvature and flexure appear to be toward *AB* interray. *L.Perm.*, USA(Nev.).—FIG. 535,3; 536,2*a-c*. **T. phiala*; 535,3, plate diagram of calyx (symbols as in Fig. 535,2), lower part of *C* and *D* arms, and adjoining interrays (mod. from Lane & Webster, 1966); 536,2*a,b*, views of crown with part of attached stem from *B*-ray side (distal arms of *A* ray at right) and from *DE*-interray side (*CD* interray at right), $\times 1$ (Lane & Webster, 1966); 536,2*c*, *DE*-interray view of holotype (*D* ray at right), $\times 1$ (Lane & Webster, 1966).

Family DACTYLOCRINIDAE Bather, 1899

[Dactylocrinidae BATHER, 1899b, p. 923] [incl. Calpiocrinidae JAEKEL, 1918, p. 79]

Crown ovoid, moderately elevated, with virtually no distinction between fixed brachials forming upper part of calyx and cup composed of radials and lower plate circllets; radianal normally lacking but anal *X* commonly distinct and relatively large, followed by other anal plates. Proximal columnal concealing infrabasal circllet in most genera, as well as much or all of basal plates and even portions of radials. First and second branching of arms confined to calyx in which brachitaxes and lower plates are fixed, is isotomous; higher branching involves free brachitaxes, which are separated laterally from one another and are strongly heterotomous. Within this family free arms and their free brachitaxes considerably exceed length and number of arms incorporated in the calyx; accordingly, heterotomy prevails over isotomy in arm structure. Interbrachials few or may be absent. *U.Sil.-L.Miss.*; *L.Penn.-U.Perm.*

Dactylocrinus QUENSTEDT, 1876, p. 520 [**Dimero-crinites oligoptilus* PACTH, 1852, p. 339; M] [*non Dactylocrinus* SLADEN, 1878, p. 245] [= *Dimero-crinites* PACTH, 1852 (*non* PHILLIPS in MURCHISON, 1839) (obj.); *Aristocrinus* ROWLEY, 1895, p. 218 (type, *A. concavus*; M); *Callawaycrinus* ROWLEY, 1895, p. 219 (= *Aristocrinus*, obj.)]. Crown rotund to elongate, widening upward; base flat, broadly concave, or deeply excavated, with part of radials and all lower plates involved in bowl for reception of stem; infrabasal circllet entirely surrounded by basals, which are relatively narrow and notably elongated, *CD* basal more than others and truncated distally for support of large polygonal anal *X*; radials with large articular facets and beveled shoulders for sutural contact with large interradianal plate and with anal *X* in posterior interray; no radianal, *X* followed by several anal plates which are suturally joined laterally to brachials. Arms branching isotomously in each ray on primibrachs 2 and secundibrachs 3 to 5, in more distal portions characterized by strong heterotomy of bi-endotomous type, with main arm trunks subequal or with inner ones somewhat smaller than outer. Column enlarging proximally. [Name derived from fingerlike appearance of ramules.] *M.Dev.-L.Miss.*, Eu.(Belg.-Ger.-W.USSR)-USA (Ohio-Mich.-Mo.-Iowa).—FIG. 538,3*a,b*; 539,1*a,b*. **D. oligoptilus* (PACTH), U.Dev., USSR; 538,3*a,b*, plate diagram (radials black, *X* and other anals stippled), *CD* interray

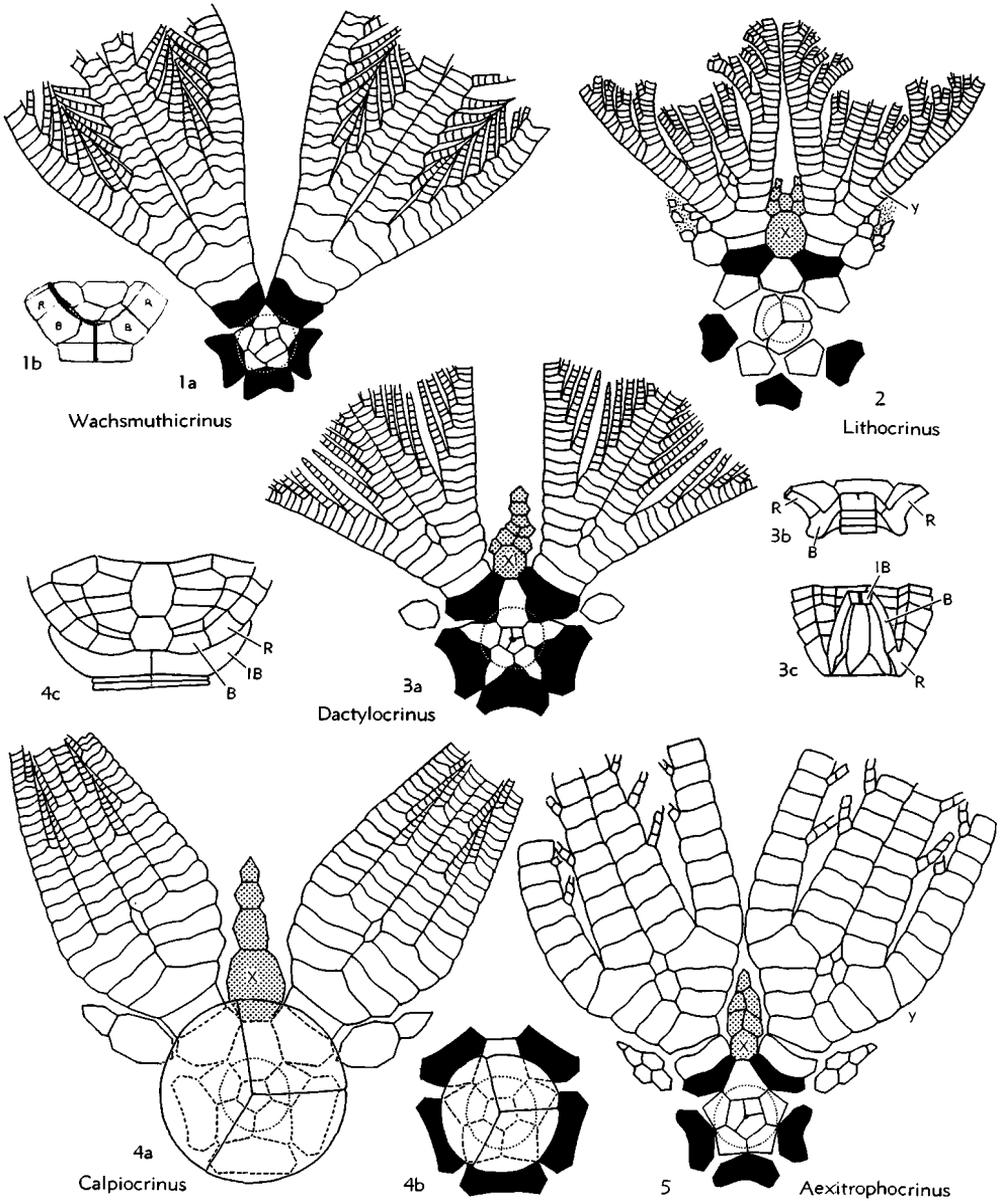


FIG. 538. Dactylocrinidae (p. T800-T804, T806).

upward, and section of basal part of cup (Springer, 1920, mod.); 539,1a, post. side of crown showing isotomous divisions of main branches of C and D rays with ramules on facing sides (bi-endotomous), also arrangement of anal plates, $\times 1$ (Springer, 1920); 539,1b, dorsal side of cup showing basal concavity, basals entirely concealing infrabasals, $\times 1$ (B, basal; R, radial) (Springer, 1920).—FIG. 538,3c. *D. excavatus* (SCHULTZ), M.Dev., Ger.; vert. sec. of lower part of calyx

(B, basal; IB, infrabasal; R, radial) (Springer, 1920).—FIG. 539,1c-e. *D. concavus* (ROWLEY), M.Dev.(Hamilton), USA(Mo.); D-ray, CD-inter-ray, and dorsal views, $\times 1.5$ (Springer, 1920). *Aexitrophocrinus* STRIMPLE & WATKINS, 1969, p. 229 [**Synerocrinus formosus* MOORE & PLUMMER, 1940, p. 94; OD] [= *Trautscholdicrinus* MOORE & PLUMMER in MOORE, 1939c, p. 195 (non YAKOVLEV & IVANOV, 1939, p. 66) (type, *T. jaekeli*; OD); *Synerocrinus* MOORE & PLUMMER in MOORE,

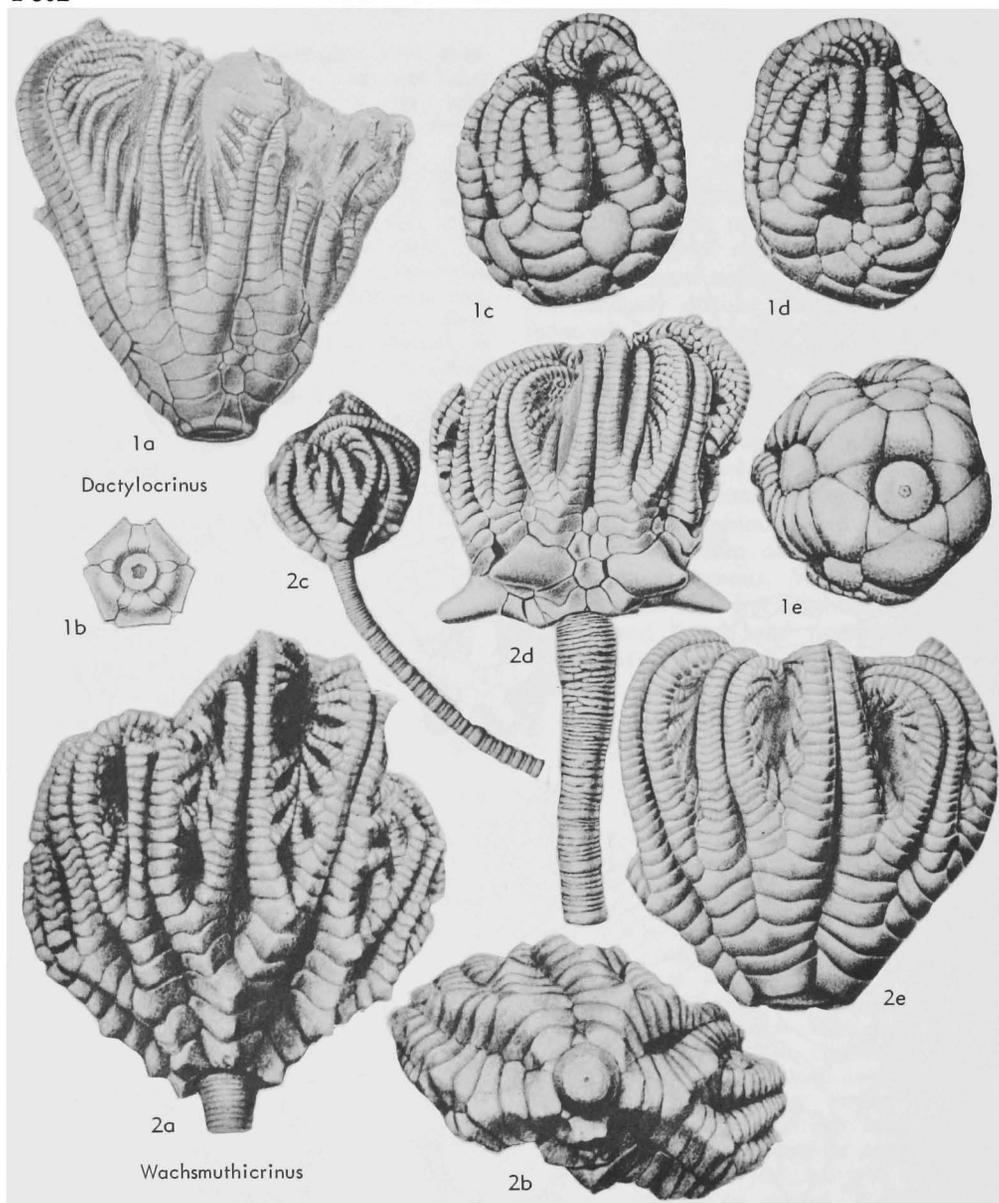


FIG. 539. Dactylocrinidae (p. T800-T801, T806).

1939c, p. 195 (*non* JAEKEL, 1898a); *Talanterocrinus* MOORE & PLUMMER, 1940, p. 96 (type, *T. jaekeli*, = *Trautscholdicrinus jaekeli*, = *Forbesiocrinus incurvus* TRAUTSCHOLD, 1867, = *Synrocricinus incurvus* JAEKEL, 1898a; OD)]. Differs from *Dactylocrinus* chiefly in much smaller number and diminutive size of short ramules, presence of 4 or more interradial plates between each contiguous pair of rays, and 2 primibrachs, 3 secundi-brachs, and 9 or more tertibrachs in each brachi-

taxis; large anal X with oblique distal facets supporting double series of additional anal plates which are suturally joined to C- and D-ray brachials. Stem medium sized to large, narrowing somewhat beneath proximal region. [In appearance this genus corresponds rather closely to *Synrocricinus* but differs in having anal plates suturally interlocked with adjacent brachials. *Synrocricinus* has a tubular anal series not so connected. MOORE & PLUMMER (1940, p. 90)

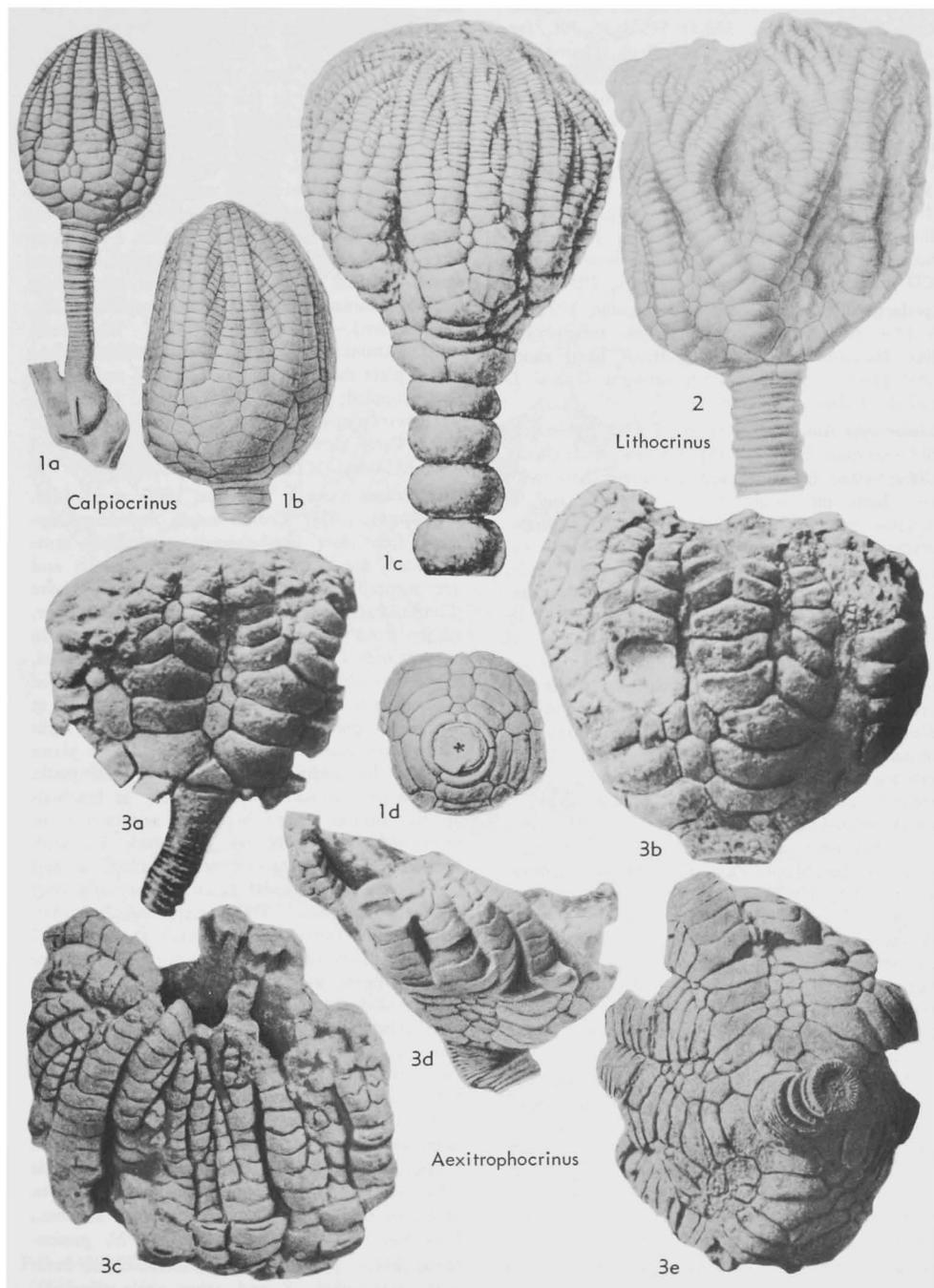


FIG. 540. Dactylocrinidae (p. T801-T804).

overlooked this distinction and failed to recognize the heterotomous nature of distal parts of the arm branches. They also misconstrued the nature of the type species of *Synerocrinus* and needlessly

introduced a new generic name called *Trautscholdicrinus*, later changed without explanation to *Talantierocrinus*.] *M.Penn.-U.Penn.*, USA (Okla.-Colo.-Texas).—FIG. 538,5; 540,3a,b. **A. formosus* (MOORE & PLUMMER), *M.Penn.* (Des Moines, Millsap Lake F.), USA (Texas, Parker Co.); 538,5, plate diagram (radials black, X and higher anals stippled; y, upper line of fixed brachials), CD interray upward (Moore, n); 540, 3a,b, C-ray view of paratype and D-ray view of holotype, $\times 1$ (Moore & Plummer, 1940).—FIG. 540, 3c-e. *A. mcguirei* (MOORE), *U.Penn.* (Virgil, Brownsville Ls.), USA (Okla., Osage Co.); 3c-e, holotype from above, side, and below (with CD interray upward), $\times 1.5$ (Moore, 1939c).

Apodactylocrinus STRIMPLE & LEVORSON, 1971, p. 9 [**A. keithi*; OD]. Crown small, subglobular, like *Dactylocrinus*, except posterior basal short, anal plate in shallow notch between C and D radials. *U.Dev.*, USA (Iowa).

Calpiocrinus ANGELIN, 1878, p. 12 [**C. fimbriatus*; SD SPRINGER, 1920, p. 145]. Crown ovoid; chiefly characterized by its highly specialized base with very large infrabasals enveloping basals and to variable extent even radials and part of primibrachs; large anal X resting on truncated extremity of CD basal and followed by other anals; interbrachials consisting of single large plate between adjacent rays or by such plate followed by smaller ones in series. Free arms heterotomous of bi-endotomous type, with small ramules confined to distal region. Column large, short, tapering gradually to encrusting root. [Corresponds to *Homalocrinus* in enlargement of infrabasals externally, but in *Homalocrinus* this is much less extreme. Also, heterotomy of latter genus is endotomous with much larger ramules.] *U.Sil.*, Eu. (Sweden-Eng.-Czech.).—FIG. 538,4b; 540, 1c,d. **C. fimbriatus*, Wenlock Ls.; 538,4b, plate diagram (radials black), CD interray upward (Moore, n); 540,1c, B-ray view of syntype from Gotland (Fara), $\times 1.5$ (Springer, 1920); 540,1d, dorsal view of specimen from Eng. (Wisby), CD interray upward, showing stellate axial canal of stem, $\times 1.5$ (Springer, 1920).—FIG. 540,1a. *C. intermedius* SPRINGER, Wenlock Ls., Eng. (Dudley); CD-interray view of complete crown with attached stem, $\times 1.5$ (Springer, 1920).—FIG. 540,1b. *C. ovatus* (ANGELIN), Wenlock Ls., Sweden (Gotl.); C-ray view of holotype, $\times 1.5$ (Springer, 1920).—FIG. 538,4a,c. *C. rotundatus* SPRINGER, Wenlock Ls., Sweden (Gotl.); plate diagram (radials and basal outlines dashed, X and higher anals stippled), CD interray upward, and vert. sec. lower part of calyx (B, basal; 1B, infrabasal; R, radial) (mod. from Springer, 1920).

Lithocrinus WACHSMUTH & SPRINGER, 1880, p. 275 [**Forbesiocrinus divaricatus* ANGELIN, 1878, p. 9; SD BATHER, 1899b, p. 923]. Crown elongate, expanding upward; infrabasals somewhat recum-

bent, with parts exposed beyond stem impression; moderately large basals and radials subequal in size, without well-marked distinction from upper part of calyx formed by fixed brachials and interbrachials; large anal X followed by 3 anals and additional higher ones, border anals suturally joined to brachials at left and right, small plate on upper right shoulder of anal X and interpreted by SPRINGER as radianal in upper oblique position, but this is doubtful. Arms branching isotomously in calyx on primibrachs 2 and secundibrachs 3, with similar bifurcations of free arms at 2 or more levels in different arm branches, heterotomy in distal part of crown very irregular, without clearly marked pattern. Stem large, transversely circular columnals distinctly heteromorphic. *U.Sil.*, Eu. (Sweden).—FIG. 538,2; 540,2. **C. divaricatus* (ANGELIN), Wenlock Ls., Sweden (Gotl.); 538,2, plate diagram (radials black, X and higher anals stippled; y, upper line of fixed brachials), CD interray upward (mod. from Springer, 1920); 540,2, D-ray view of holotype showing crown and attached stem, $\times 1.5$ (Springer, 1920).

Nevadacrinus LANE & WEBSTER, 1966, p. 15 [**N. geniculatus*; OD]. Crown small, expanding upward from low bowl-shaped calyx, free arms separated, not touching one another laterally and not suturally united with interbrachials above primibrachs; infrabasal circlet relatively large, visible from side, with small plate directly in contact with C radial, as well as large CD basal, which has oblique distal margins for support of 2 anal plates interpreted by authors as anal X at left and upwardly displaced radianal at right (latter here considered very doubtful), these plates followed by additional ones above; anal plates and interprimibrachs joined laterally to brachials by firm sutures. Arms branching isotomously on primibrachs 4 (rarely on primibrach 5), with additional bifurcations on secundibrachs 2 and possibly higher; articular facets of brachials with patelloid processes. Transversely circular stem composed in proximal (basillarid) region by 14 to 16 very low columnals with strongly crenulate articular facets, moderately curved in A-ray direction, joined distally to very prominent bulbous thick columnal (cuneus) with angularly divergent facets, followed distally by columnals thicker than those in the basillarid region and moderately heteromorphic. [LANE & WEBSTER's assignment of this genus to the Taxocrinoidea is not accepted here, for the rather wide group of anal plates, firmly sutured laterally to radials and brachials is far removed from the linear anal series in form of a tube found in typical Taxocrinida.] *L.Perm.*, USA (Nev.).—FIG. 541,4; 542,1. **N. geniculatus*; 541,4, plate diagram (radials black, radianal cross ruled, X and other anals stippled), with part of C and D rays and adjoining interrays (Moore, n); 542,1a,b, AB-interray and D-ray

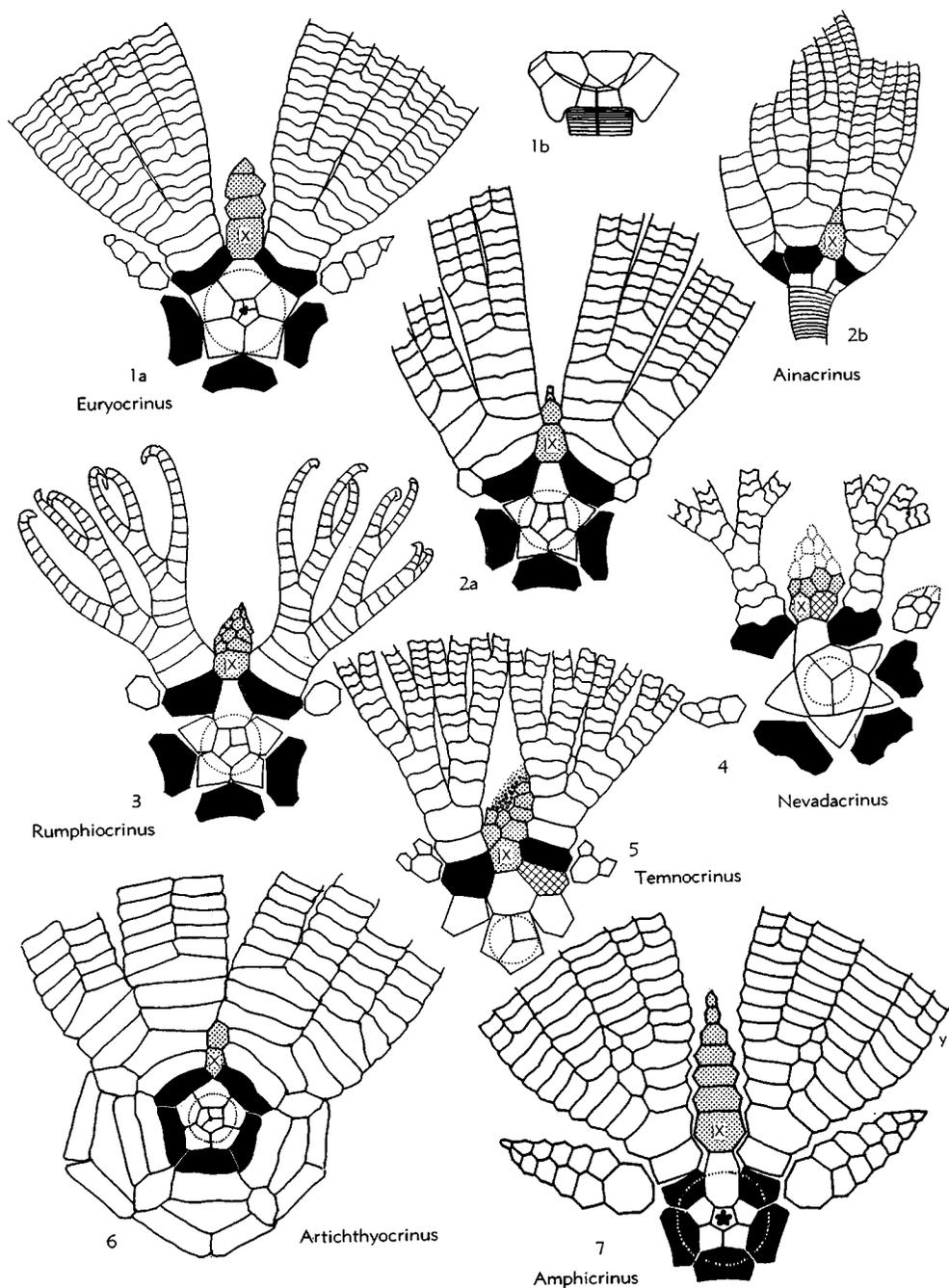


FIG. 541. Dactylocrinidae (3-5), Euryocrinidae (1,2,6,7) (radials black, anals stippled, radianal cross ruled) (p. T804-T806, T808-T811).

views of holotype, $\times 1.5$ (Lane & Webster, 1966); 542, *1c,d*, side view of stem adjacent to crown showing much-enlarged wedge-shaped columnal

(cuneus) separating proximal thin columnals of basillarid region from more distal heteromorphic columnals, and *D*-ray view of paratype, $\times 1.5$

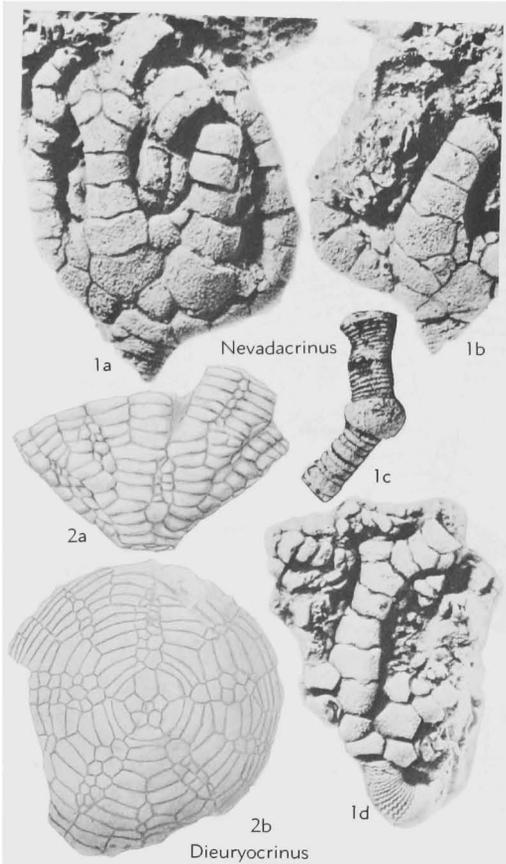


FIG. 542. Dactylocrinidae (1), Euryocrinidae (2) (p. T804-T805, T811).

(Lane & Webster, 1966).

Rumphiocrinus WANNER, 1924, p. 122 [**R. singularis*; OD]. Crown ovoid with height slightly greater than width, transversely well-rounded arms incurved at summit; infrabasal circler and proximal parts of basals covered by stem, *CD* basal distally truncate for support of large anal *X*, which is followed by several additional irregularly arranged anals laterally joined by firm sutures to brachials; calyx formed by radials and lower plate circlers combined with fixed brachials consisting of 3 or 4 primibrachs and 2 or 3 secundibrachs in each ray, large interprimibrach followed by 1 or 2 small ones in each interray, including previously mentioned anals. Arms branching in calyx isotomously, separated above first secundibrach, in most arm branches with additional bifurcation above axillary secundibrachs. Stem formed by moderately tall strongly crenulate columnals with gradual reduction in diameter distally and showing moderate curvature toward *CD* interray. [Relatively large plate above right distal margin of anal *X* corresponding to similarly

placed plates in *Nevadacrinus*, *Dactylocrinus*, *Aexitrophocrinus*, and *Lithocrinus*, doubtfully interpreted as radialian displaced upward.] *U.Perm.*, Indon.(Timor).—FIG. 541,3; 543,3a,b. **R. singularis*, Basleo; 541,3, plate diagram of calyx (radials black, *X* and other anals stippled), *C* and *D* rays, and adjacent interrays (mod. from Wanner, 1924); 543,3a,b, post. and ant. views of holotype, $\times 1.5$ (Wanner, 1924).

Temnocrinus SPRINGER, 1902, p. 94 [**Cyathocrinites tuberculatus* MILLER, 1821, p. 88; M]. Crown elongate, expanding upward; infrabasals slightly recumbent, almost entirely covered by stem impression, *CD* basal larger than others and truncate distally for support of large anal *X*, which is followed by 2 or 3 rows of polygonal plates which interlock suturally with brachials at sides; proximal plate of *C* ray identified as lower element of compound radial and defined as radialian in primitive position; all radials followed by fixed brachials which include 2 primibrachs, 3 secundibrachs, and 2 to 5 tertibrachs for each arm branch, sutures between brachials sinuous; interprimibrachs few, followed by perisome passing into tegmen. Proximal part of stem composed of low circular columnals which decrease in diameter downward along with gradual increase in height. *U.Sil.*, Eu.(Eng.).—FIG. 541,5; 543,6a-c. **T. tuberculatus* (MILLER), Wenlock Ls., Dudley; 541,5, plate diagram part of calyx (radials black, radialian cross ruled, *X* and higher anals stippled), *C* and *D* rays, and adjacent interrays (mod. from Springer, 1920); 543,6a-c, post. views of two crowns and *D*-ray view of third, $\times 1$, $\times 1$, $\times 1.5$ (Springer, 1920).

Wachsmuthicrinus SPRINGER, 1902, p. 95 [**Forbesiocrinus thiemei* HALL, 1861a, p. 317; M]. Crown elongate, expanding upward from radials; infrabasals in central part of stem impression surrounded by basals of subequal size and shape, *CD* basal identified only by its relation to azygous small infrabasal in *C* ray, neither radialian nor anal *X* present. Arms branching isotomously in calyx, on primibrachs 2 and secundibrachs 3, above which strongly marked heterotomy of bi-endotomous type closely resembles that of *Dactylocrinus*; interprimibrachs none to 4 or more and interbrachials none to 1 or 2; outer edges of brachials and main arms may interlock laterally even in distal parts of crown as well as in calyx formed by fixed brachials and lower plates. Stem large, expanding proximally. *Dev.*, USSR; *L.Miss.* (Osag.), USA (Ky.-Ind.-Mo.-Iowa-N.Mex.); *low. L.Carb.*, Eu.(Scot.).—FIG. 538,1; 539,2a-c. **W. thiemei* (HALL), *L.Miss.* (Osag., Burlington Ls.), USA (Iowa); 538,1a,b, plate diagram (radials black) with *D* and *C* rays at left and right above, and vert. sec. of cup (mod. from Springer, 1920); 539,2a,b, side and dorsal views of holotype, rays not identified, $\times 1.5$ (Springer, 1920); 539,2c, side view of specimen with part of attached stem,

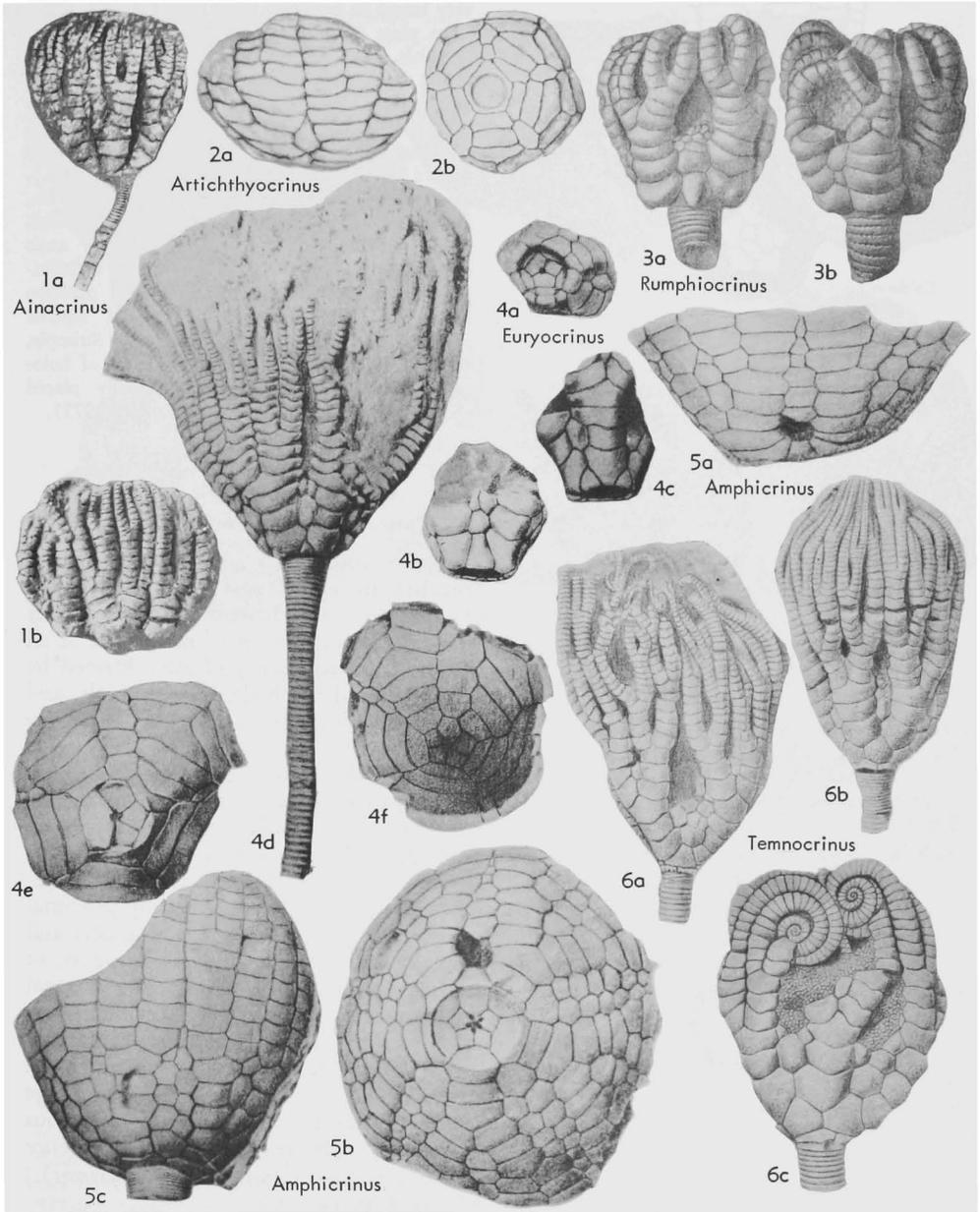


FIG. 543. Dactylocrinidae (3,6), Euryocrinidae (1,2,4,5) (p. T806, T808-T811).

×1 (Springer, 1920).—FIG. 539,2d. *W. spinifer* (HALL), L.Miss.(Osag., Burlington Ls.), USA (Iowa); side view of crown with part of attached stem, ×1 (Springer, 1920).—FIG. 539,2e. *W. spinulosus* (MILLER & GURLEY), L.Miss.(Osag., New Providence Sh.), USA (Ky., Lincoln Co.); side view of crown showing brachials interlocked to height of 2nd arm bifurcations, ×1 (Springer,

1920).

Zenocrinus MOORE & STRIMPLE, 1973, p. 36 [*Z. zeus; OD]. Small, low crown with wide shallow calyx rounded steeply upward at sides in fixed brachials of proximal parts of arms which branch isotomously on primibrachs 2 and secundibrachs 2 (or exceptionally 3), arms abutting but free above axillary secundibrachs, with strongly heterotomous

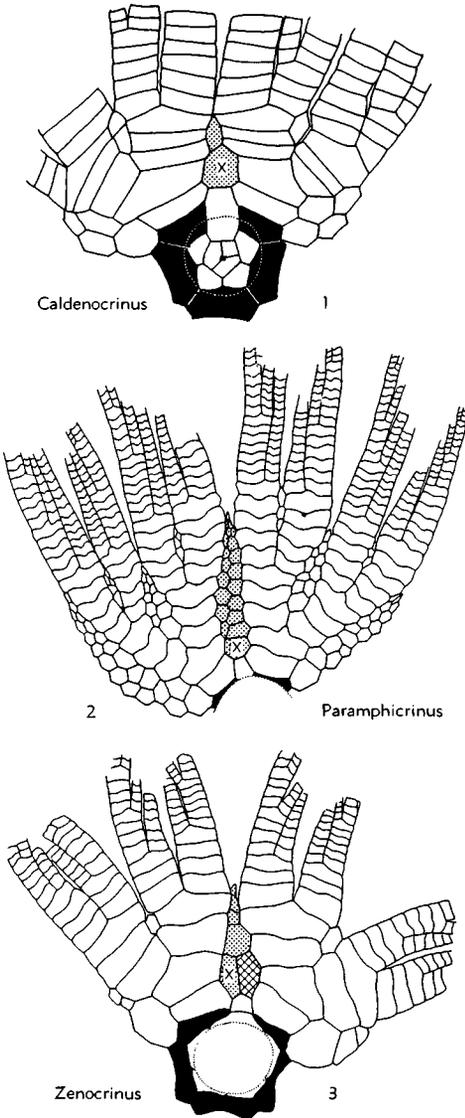


FIG. 544. Dactylocrinidae (3), Euryocrinidae (1,2) (radials black, anals stippled, radialian cross ruled) (p. T807-T808, T811-T812).

branching of bi-endotomous type in upper part of crown, each complete ray with 16 slender arm tips bent inward (indicating 80 or more arm tips in perfect crown); infrabasals and most of basal circlet concealed by large proximal columnals; radials exposed all around, laterally abutting except where separated by *CD* basal or (?abnormally) arching over this plate to allow *C* and *D* radials to meet; *CD* interray variable, with anal *X* followed by 6 additional anals in holotype of type species but with only 2 plates (lower one

very large) in paratype; other interrays with single large plate touching radials and separating fixed brachials, with or without 1 to 3 small plates above them; single intersecundibrach in each ray. Stem circular in section, composed of very low columnals with peripherally finely crenulate facets, tapering away from calyx and curved strongly toward *A* ray. *L.Penn.*(*Morrow.*), USA(Okla.). —FIG. 544,3; 545,2. **Z. zeus*, Wapanucka Ls., Pontotoc Co., Okla.; 544,3, plate diagram (radials black, radialian cross ruled, *X* and higher anals stippled), *CD* interray at midline (Moore & Strimple, n); 545,2*a*, oblique dorsal view of paratype from post. side showing curved and tapered proximal part of stem, $\times 1.5$ (Moore & Strimple, 1973); 545,2*b,c*, *D*-ray and dorsal views of holotype, latter with *CD* interray centrally placed above stem, $\times 1.5$ (Moore & Strimple, 1973).

Family EURYOCRINIDAE Moore & Strimple, 1973

[Euryocrinidae MOORE & STRIMPLE, 1973, p. 16]

Crown rotund to elongate with arm branches in upper part closely appressed or separated; cup, defined to include plates below *Z* line at summit of radials not at all distinct from remainder of calyx formed by firmly sutured brachials, interbrachials, and anals; chief distinctive feature of the family is prominence of the stoutly built calyx which may have thick plates and considerably exceed upper part of crown formed by relatively short, stubby free arms which tend to branch isotomously rather than heterotomously. Infrabasal circlet surrounded by basals entirely concealed by proximal columnal; *CD* basal larger than others and typically truncate distally for support of anal *X*, which may be followed by additional anal plates. Arms in calyx branching isotomously on primibrachs 2, less commonly on 3. Stem transversely circular. [Main distinguishing features of this assemblage are stout nature of the calyx, isotomous branching of the arms, and general absence of interbrachials (exception, *Amphicrinus*).] *M.Dev.-U.Penn.*

Euryocrinus PHILLIPS, 1836, p. 205 [**E. concavus*; M] [=Euryocrinites AUSTIN & AUSTIN, 1842, p. 109 (*nom. van.*) (obj.)]. Crown expanding upward from radials, its lower part comprising stout bowl-shaped calyx formed of anals, and fixed brachials and interprimibrachs in addition to cup plates; infrabasal circlet diminutive or resorbed, surrounding basals moderately large with *CD* basal truncate distally for support of large anal

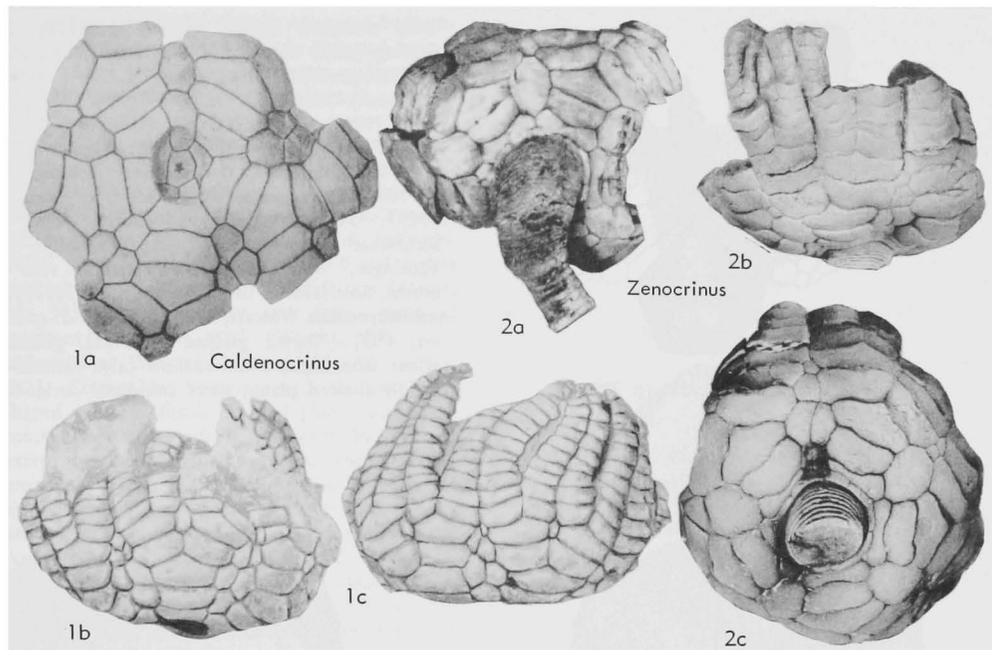


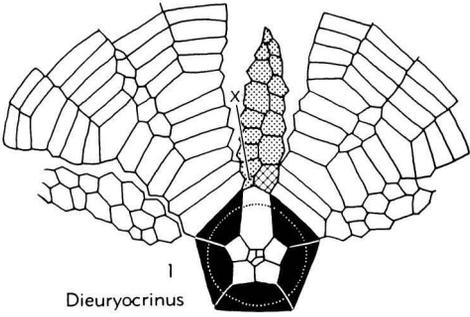
FIG. 545. Dactylocrinidae (2), Euryocrinidae (1) (p. T807-T808, T811).

X, which is followed by others mostly in single series filling *CD* interray and firmly interlocked laterally with brachials. Arms branching isotomously on primibrach 3 and thereafter at higher levels, with branches laterally abutting and tending to be joined firmly; interprimibrachs few, usually limited to single series; interbrachials uncommon but may be present. Column large, expanding toward calyx. *M.Dev.*, USA (Iowa); *U.Dev.*, USA (Ohio-Mich.); *L.Miss.*, USA (Ky.-Ind.-Tenn.); *L.Carb. (Visean)*, Eu. (Eng.).—FIG. 543, 4a-d. *E. barrisi* SPRINGER, *M.Dev.* (Hamilton), USA (Mich.-Iowa); 4a-c, dorsal, post., and B-ray views of specimens from Michigan, $\times 1$ (Springer, 1920); 4d, B-ray side of crown with attached stem, from Iowa, $\times 1$ (Springer, 1920).—FIG. 541, 1; 543, 4e, f. **E. concaus*, *L.Carb.*, Eng.; 541, 1a, b, plate diagram (radials black, X and higher anals stippled), with *CD* interray centrally placed above, and vert. sec. of cup (mod. from Springer, 1920); 543, 4e, f, dorsal and ventral views of lower part of calyx, *CD* interray directed upward in each, $\times 1$ (Springer, 1920).

Ainacrinus WRIGHT, 1939, p. 56 [**Synerocrinus? smithi* WRIGHT, 1934, p. 253; OD]. Crown subglobose to ovoid, with arms infolded at summit; infrabasal circlet moderately large but entirely covered by proximal columnal; *CD* basal broadly truncate for support of anal X, followed by one or more other anals in series, laterally joined firmly to brachials. Arms branching isotomously on primibrachs 2, followed by 2 or more addi-

tional bifurcations at different levels in various arm branches; interprimibrachs few, normally only 1 or 2 in each interray but may be as many as 4. Stem composed of low circular columnals which expand toward base of calyx. *L.Carb. (Visean)*, Eu. (Scot.).—FIG. 541, 2; 543, 1. **A. smithi* (WRIGHT), Ayrshire; 541, 2a, diagram of plate arrangement in cup (radials black, X and higher anals stippled) and C and D rays; 541, 2b, D-ray view of crown showing anal X (stippled) at right; 543, 1a, b, side views of crown with attached stem and another crown, $\times 1$ (Wright, 1950).

Amphicrinus SPRINGER, 1906, p. 518 [**A. scoticus* SPRINGER in WRIGHT, 1914, p. 161; SM]. Crown subglobose, consisting mostly of strongly built calyx, small free arms in upper part of crown laterally abutting but not joined together; stem impression covering diminutive tripartite (or ?fused) infrabasals, basals (except distal extremity of *CD* basal) and most of radials; *CD* interray identified by single plate defined as anal X resting on truncated posterior basal, proximal plates of other interrays not touching basals but resting on oblique shoulders of radials; radianal lacking. Rays with 2 primibrachs in calyx followed by isotomously branching arms with 3 to 4 or more bifurcations, with tendency toward heterotomy observed in summit portion of crown; sutures between brachials sinuous and above primibrachs commonly with patelloid processes. Stem large, next to crown composed of very low columnals

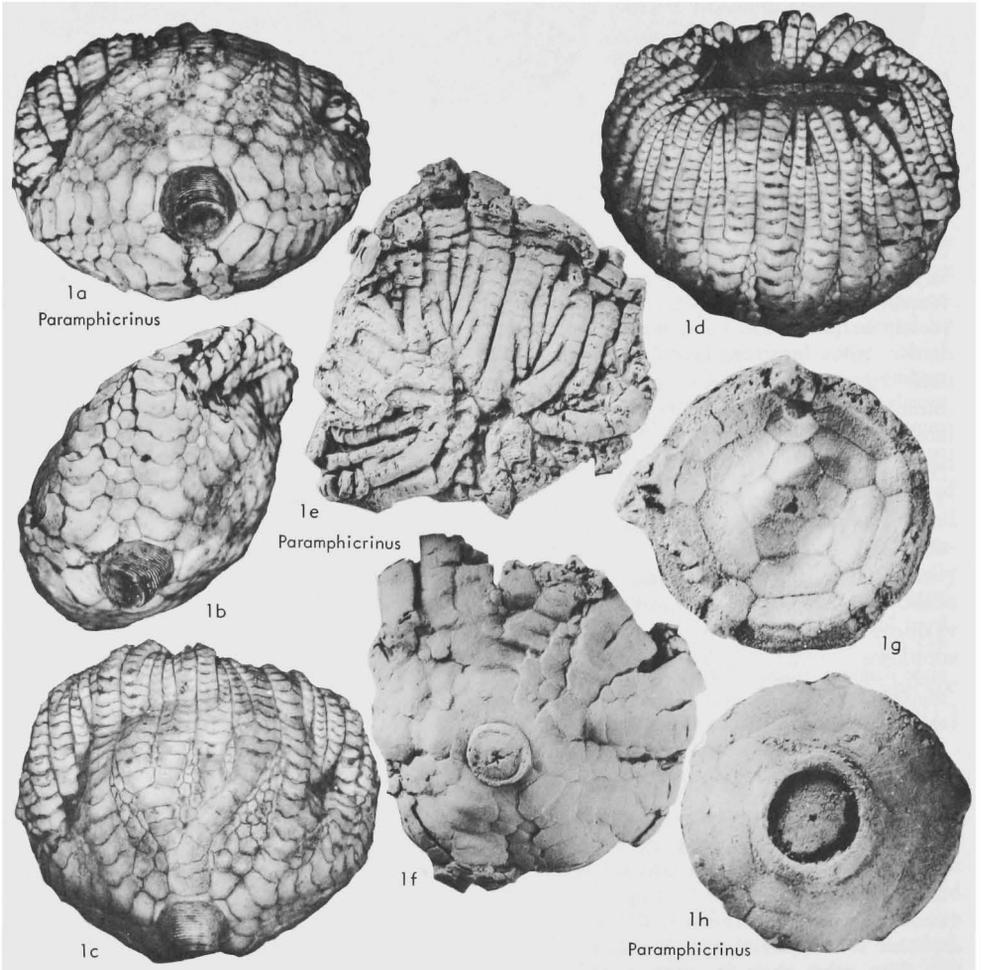


Dieuryocrinus

FIG. 546. Euryocrinidae (p. T811).

with crenulate facets, tapering gradually and curving gently away from cup; columnals pierced by quinquestellate axial canal. *L. Carb. (Viséan), Eu. (Scot.)-USSR-USA (Okla.)*.—FIG. 541,7; 543, 5a-c. **A. scoticus*; 541,7, plate diagram (radials black, X and higher anals stippled; y, upper line of fixed brachials), with C and D rays accompanied by adjoining interbrachials (mod. from Springer, 1920); 543,5a,b, post. and dorsal views of somewhat flattened calyx, Eng.(Roscobie), ×1 (Springer, 1920); 543,5c, AB-interray view of crown, Scot.(Hurlet Ls.), ×1 (Springer, 1920).

Artichthyocrinus WRIGHT, 1923, p. 481 [**A. springeri*; OD]. Crown globose to ovoid, generally wider than high; broad shallow calyx formed by rigidly sutured plates; small infrabasal circler sur-



1a
Paramphicrinus

1d

1e
Paramphicrinus

1g

1c

1f

1h
Paramphicrinus

FIG. 547. Euryocrinidae (p. T811-T812).

rounded by basals and entirely concealed by proximal columnal, present in sharply indented faceted calyx. Arms with nearly flat outer surfaces with brachials fitted smoothly together laterally or interlocked, articular facets somewhat arcuate; interradials commonly 1 in each interray; small anal X followed by additional plate in posterior interray, orientation of calyx mainly determinable from C-position of small infrabasal. *L.Carb.(Visean)*, Eu.(Scot.).—FIG. 541,6; 543,2. **A. springeri*; 541,6, plate diagram (radials black, X and higher anal stippled), with part of C and D rays (Moore, n); 543,2a,b, AB-interray and dorsal views of specimen from Fife, $\times 1.5$ (Wright, 1950).

Caldenocrinus WRIGHT, 1946, p. 33 [**C. curtus*; OD]. Crown low, rounded, with shallow bowl-shaped calyx of firmly sutured plates; infrabasals concealed by stem, which also covers basal circler except distal part of CD basal and encroaches on proximal tips of radials; large anal X followed by one or more additional anals; 4 or 5 moderately large interprimibrachs in other interrays. Arms branching heterotomously above axillary primibrachs 2 but not strongly so. *L.Carb.(Visean)*, Eu.(Scot.).—FIG. 544,1; 545,1a-c. **C. curtus*; 544,1, plate diagram (radials black, X and higher anals stippled), CD-interray upward (Moore, n); 545,1a, paratype from Roscobie, Fife, dorsal view with CD interray upward, $\times 1$ (Wright, 1954); 545,1b,c, holotype from Seafield Tower Ls., near Kirkcaldy, Fife, B-ray and DE-interray views, $\times 1$ (Wright, 1954).

Dicuryocrinus WRIGHT, 1954, p. 165 [**Euryocrinus duplex* WRIGHT, 1942, p. 280; OD]. Lower part of broadly flaring calyx formed by stout sutured plates, rather closely resembling *Euryocrinus* and *Amphicrinus*, but with double series of anal plates in CD interray, in which proximal small plate at left is interpreted as anal X and that at right as upwardly displaced radianal. Primibrachs 3, as in *Euryocrinus*, rather than 2 as in *Amphicrinus*; free arms of upper crown unknown. Stem impression not indented. *L.Carb.(Visean)*, Eu.(Eng.).—FIG. 542,2; 546,1. **D. duplex* (WRIGHT); 542,2a,b, AB-interray and dorsal views of large calyx, CD interray directed upward in 2b, $\times 0.75$ (Wright, 1954); 546,1, plate diagram (radials black, radianal cross ruled, X and higher anals stippled), with part of C and D rays and adjoining interrays (Moore, n).

Paramphicrinus STRIMPLE & MOORE, 1971, p. 40 [**Amphicrinus oklahomensis* STRIMPLE, 1939a, p. 4 (364); OD]. Crown rotund, medium-sized, with stoutly built bowl-shaped calyx forming lower half of crown and closely parallel free arms upper half, curving inward at summit so that arm tips nearly meet; infrabasal circler and all except posterior plate of basal circler covered by stem, subhorizontal in attitude; only distal edges of radials exposed, those of C and D rays slightly smaller than others and visible parts asymmetrical; no

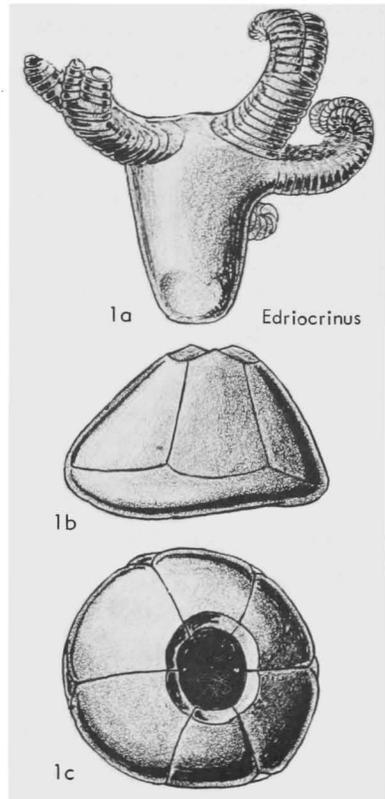


FIG. 548. Edriocrinidae (p. T812) (from *Index Fossils of North America*, H. W. Shimer and R. R. Shrock (eds.), John Wiley & Sons, 1944, by permission of MIT Press, Cambridge, Mass.).

radial but moderately large anal X on truncate extremity of CD basal, followed by 16 to 20 higher anals in double series, interlocking side-ward with fixed brachials from primibrach to tertibrach series. Arms broad in proximal portion, branching isotomously in calyx on primibrachs 2 and secundibrachs 3 in each ray, thereafter displaying well-marked heterotomy of bi-endotomous type, distal parts of all arms narrowing upward, with 80 to 100 arm tips at crown summit, each complete half-ray with 20 arms, interbrachial sutures mostly sinuous; interradial polygonal plates 16 to 20 beginning between first primibrachs with large plate, much smaller distal ones suturally joined to tertibrachs; interbrachials beginning between proximal secundibrachs and extending upward nearly to distal tertibrachs; 2 small areas of 3 to 5 intertertibrachs in each ray. Stem large, composed of very low crenulate columnals, with quinquelobate axial canal, proximal part tapering gradually and strongly curved toward DE interray or A ray. *L.Penn.(Morrow.)-U.Penn.(Missour.)*,

USA (Okla.-Ark.-Ill.-Kans.).—FIG. 544,2; 547,1. **P. oklahomaensis* (STRIMPLE), U.Penn.(Missour.), USA (Okla.-Ill.); 544,2, plate diagram of post. side of crown (radials black, X and higher anals stippled), showing anal plates of CD interray (center) flanked by C and D rays on right and left, based on specimen from LaSalle Ls., Ill.; 547,1a-d, views of crown from Missouri (LaSalle Ls.), Ill., from below (B ray upward), post. side, B-ray side, and obliquely from above (DE interray located centrally), all $\times 0.9$ (Strimple & Moore, 1971); 547,1e,f, holotype from Missouri (Stanton Ls.), near Bartlesville, Okla., viewed from above (C and D rays centrally placed at left and right of midline above) and dorsal view (A ray directed upward) showing proximal columnal with stellate axial canal, $\times 0.9$ (Strimple, 1939a).—FIG. 547,1g,h. *P. poundi* (STRIMPLE), Missouri (Stanton Ls.), USA (Kans., Montgomery Co.); ventral and dorsal views of holotype, CD interray directed upward, $\times 3.5$ (Strimple, 1939a).

Order UNCERTAIN

Family EDRIOCRINIDAE

S. A. Miller, 1889

[Edriocrinidae S. A. MILLER, 1889, p. 214] [Materials for this family prepared by H. L. STRIMPLE]

Stalkless crinoids attached by base of cup,

at least during youthful stages. Basals four, commonly fused, anal X in line with radials; arms broad, incurving distally, formed of very short brachials. *L.Dev.-M.Dev.*

Edriocrinus HALL, 1858, p. 278 [**E. pocilliformis* HALL, 1859, p. 121; SD MILLER, 1889, p. 242]. Cup thought to be pseudomonocyclic, i.e., infra-basals probably present in ontogeny but fused or resolved in process of producing base for attachment to foreign objects. Arms strikingly similar to those of flexible crinoids. [Some evidence indicates that some individuals, or even species, became free in full maturity and used the rigid arms for limited locomotion. Some species (e.g., *E. sacculus*) developed a long fused basal cone that could have been buried in a soft marl of the substrate, and yet others (e.g., *E. dispansus*, Fig. 548,1b) have a broad flat base suitable for resting on soft substrate without becoming mired.] *L.Dev.* (Helderberg.), USA (N.Y.-Md.-Va.-W.Va.-Tenn.-Mo.-Okla.); *L.Dev.-M.Dev.*, Eu. (Boh.); *M.Dev.*, Afr. (Alg.).—FIG. 548,1a. *E. sacculus* HALL, *L.Dev.* (Oriskany), Md.; adult showing attachment scar, $\times 1.3$ (Moore & Laudon, 1944).—FIG. 548,1b,c. *E. dispansus* KIRK, *L.Dev.* (Linden), Tenn.; 1b,c, lat. and ventral view of cup, $\times 1.3$ (Moore & Laudon, 1944).