

## INADUNATA

By R. C. MOORE, N. GARY LANE, H. L. STRIMPLE, JAMES SPRINKLE,  
and R. O. FAY

[University of Kansas; University of Indiana; University of Iowa; University of Texas; Oklahoma Geological Survey]

Subclass INADUNATA  
Wachsmuth & Springer, 1885

[*nom. transl.* MOORE & LAUDON, 1943a, p. 21 (*ex suborder* Inadunata WACHSMUTH & SPRINGER, 1885, p. 228)] [=order Pentacrinoidea JAEKEL, 1894, p. 114 (*partim*)] [Diagnosis by GEORGES UBAGHS]

Crinoidea with aboral cup composed of close-sutured plates; fixed brachials and interbrachials lacking (exception in few primitive forms); anal plates commonly present in aboral cup; mouth subtegmenal; arms pinnulate or nonpinnulate. *L.Ord.-U.Perm.*; *M.Trias.*

Order DISPARIDA  
Moore & Laudon, 1943

[*nom. correct.* MOORE, in MOORE, LALICKER, & FISCHER, 1952a, p. 613 (*pro* Disparata MOORE & LAUDON, 1943a, p. 24)] [=order Myelodactyloidea S. A. MILLER, 1883a; branch Larviformia WACHSMUTH & SPRINGER, 1885, p. 305; suborder Monocyclica BATHER, 1893a, p. 20; suborder Larvata JAEKEL, 1894, p. 116; order Monocyclica Inadunata BATHER, 1899b, p. 921; Turbata JAEKEL, 1918, p. 82]

By R. C. MOORE, N. GARY LANE,  
H. L. STRIMPLE, and JAMES SPRINKLE

Monocyclic inadunates with weak to very prominent bilateral symmetry developed in different planes (*E-BC* in Homocrinacea, Calceocrinacea, Pisocrinacea, Allageocrinacea; *D-AB* in Heterocrinacea; *C-EA* in Myelodactylacea, Anomalocrinacea; and *A-CD* in Belemnocrinacea, Hybocrinacea). *L.Ord.-U.Perm.*

Most disparids are small and characterized by simplicity in structure of the crown and cup; many are microcrinoids, with diameter and height of the theca less than 2 mm. Chief plates are radials, which are main components of the cup and orals of the tegmen. The arms are slender and uniserial, branched at several heights above the cup or unbranched; pinnules are lacking.

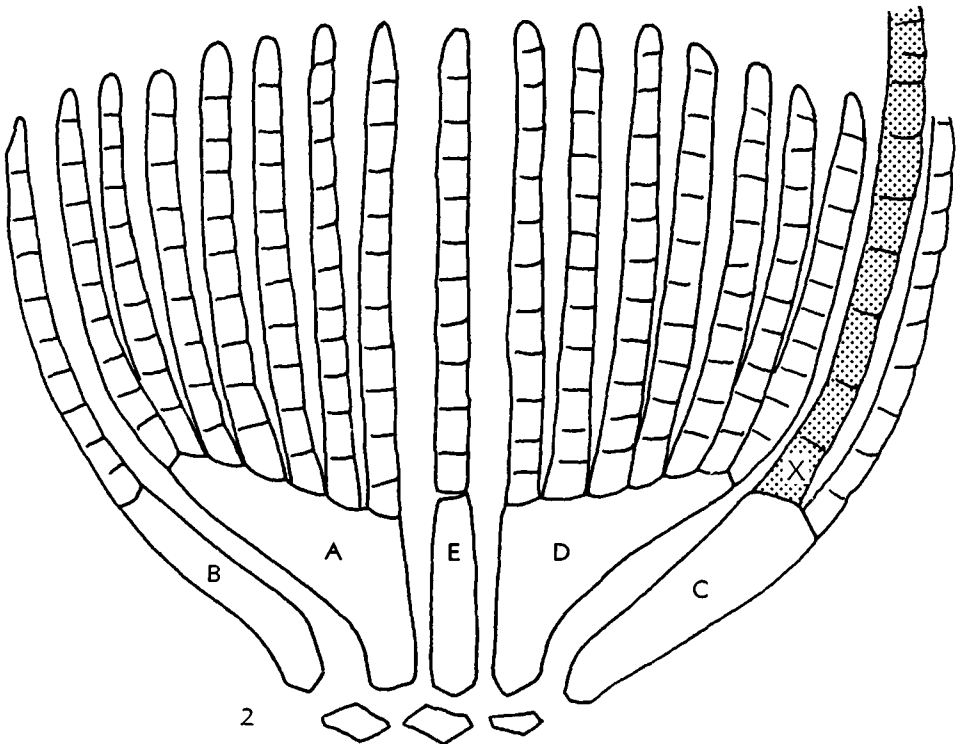
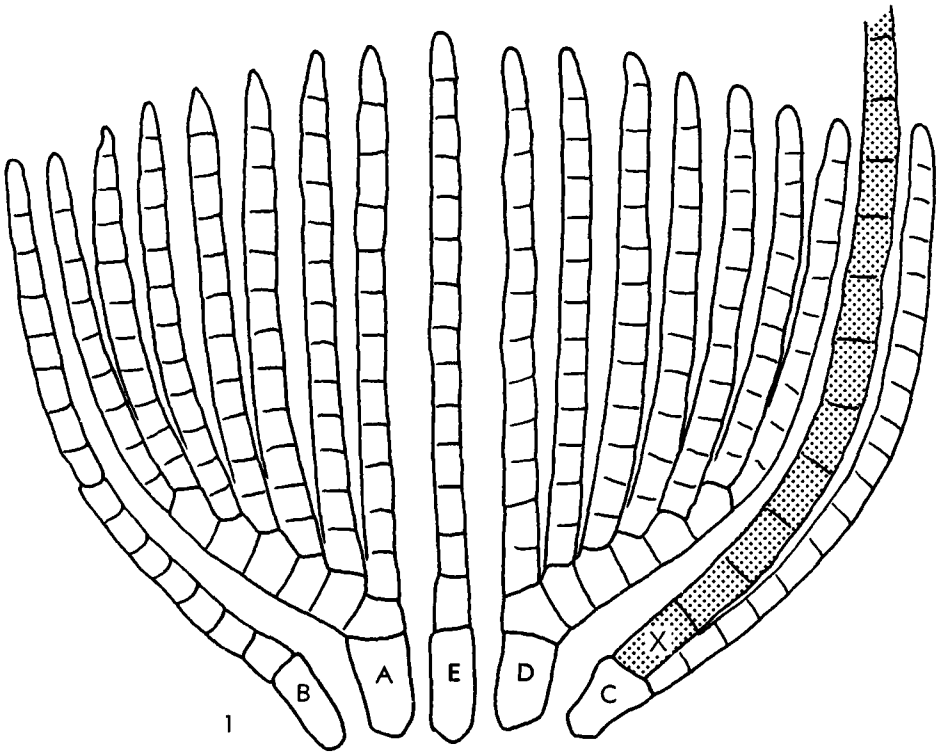
A well-marked tendency toward develop-

ment of bilateral symmetry is observed, oriented in different planes. These are respectively designated according to the ray and opposite interray in which they are placed, namely 1) homocrinoid (through the *E* ray), 2) heterocrinoid (through the *D* ray), 3) iocrinoid (through the *C* ray), and belemnocrinoid (through the *A* ray). The last is also called crinoid plane, since it is widely prevalent in cladid Inadunata, Flexibilia, Camerata, and Articulata. Genera having perfect pentamerous symmetry are bilaterally symmetrical with respect to planes passing through any ray and its opposite interray. Such symmetry is found in some crinoid groups, but not the Disparida.

A feature having general importance in the evolution, and hence classification of crinoids, is fusion of skeletal elements and another is change in structural relationships of morphological elements. Both of these result in simplicities derived from complexities. Among the disparid crinoids illustrations are offered by 1) reduction in number of basals from five to three to one, 2) lateral fusion of axillary brachials with each other and subjacent radials to produce the large multifaceted radials of Catilloocrinidae, Anamesocrinidae, and Calceocrinidae (Fig. 320), 3) fusion of infer- and superradials to yield simple undivided radials as in Haplocrininitidae and Pisocrinidae derived from Heterocrinacea and Iocrinidae of unknown ancestry, and 4) disappearance of proximal brachials fixed in the cup of Homocrinidae and Heterocrinidae, evidently by change of their status from fixed to free brachials. Cladid inadunates evolved similarly in the direction of reducing the number and complexity of thecal and arm components. For example, the Aethocrinidae, near-oldest (*L.Ord.*) of all known cri-

(See facing page.)

FIG. 320. Diagram showing large multifaceted radials produced by lateral fusion of axillary brachials and subjacent radials (Moore, n).—1. Hypothetical primitive calceocrinid with separate axillary brachials in the *A* and *D* rays.—2. Advanced calceocrinid with axillaries fused to *A* and *D* radials. Higher arm branches typical of calceocrinids omitted for clarity.



noids are followed soon (M.Ord.-U.Ord.) by much more simply organized genera.

Classification of the Disparida in the *Treatise* recognizes eight superfamilies defined mainly by shape of the cup and by the nature of bilateral symmetry. A large majority of genera have more or less steep-sided conical cup shapes; not very many are characterized by rounded bowl form and almost none are discoid. A basal concavity of the cup invariably is lacking.

### Superfamily HOMOCRINACEA Kirk, 1914

[*nom. correct.* MOORE & LANE, in MOORE & STRIMPLE, 1973, p. 16 (*pro* Homocrinaceae *nom. transl.* UBAGHS, 1953, p. 746, *ex* Homocrinidae KIRK, 1914, p. 479)] [Materials for this superfamily prepared by R. C. MOORE and N. GARY LANE]

Bilateral symmetry of crown and cup in *E-BC* plane; superradial and inferradial, present in *B*, *C*, and *E* rays, *A* and *D* rays with simple radials; radial articular facets as wide as radials, or composite and supporting several uniserial, atomous arms to a ray; anal *X* typically placed between *C* and *D* radials. Arms atomous, isotomously branched or with complex ramules. Anal sac tubular, with longitudinal row of enlarged plates posteriorly. *M.Ord.-U.Ord.*; *M.Sil.*

#### Family HOMOCRINIDAE Kirk, 1914

[Homocrinidae KIRK, 1914, p. 479]

Cup small, conical; *B*, *C*, and *E* radials compound; anal *X* incorporated in cup between *C* and *D* radials. *M.Ord.-U.Ord.*; *M.Sil.*

**Homocrinus** HALL, 1852, p. 185 [*\*H. parvus*; SD S. A. MILLER, 1889, p. 255 (*non* BATHER, 1893a)]. Cup small and cylindrical; basals elongate; *B*, *C*, and *E* rays with infer- and superradials; *A* and *D* rays with large, simple radials; anal *X* pentagonal, situated in notch between upper edges of *D* radial and *C* superradial. Anal sac not known. Arms long and slender, with first primibrach fixed in top of cup; atomous, or branching once on second primibrach, with widely spaced unbranched ramules on alternate sides of every third to sixth secundibrach. Column transversely round. [Species originally assigned to *Homocrinus* from the Lower Devonian of Maryland and from the Devonian of Germany are now placed in the Botryocrinidae.] *M.Sil.*(*Niagaran*), USA(N.Y.-Ind.-Ill.).—FIG. 321,3. *\*H. parvus*, N.Y.; 3a-d, *E*-ray, *CD*-interray, *BC*-interray, and *A*-ray views of theca,  $\times 8$ ; 3e, *A*-ray view of crown and stem,

$\times 5$  (Hall, 1852); 3f, plate diagram of theca (radials and superradials black, inferradials horizontally ruled, anal *X* stippled) (Moore, 1962b).

**Daedalocrinus** ULRICH, 1925, p. 97 [*\*D. kırki*; OD]. Cup low cone shaped; plates arranged as in *Homocrinus*; anal *X* large, pentagonal, supporting longitudinal row of anal sac plates which taper in width distally, sac large, inflated and balloon shaped, composed of numerous small, irregular plates. Proximal brachials not fixed in cup; primibrachs 3 axillary in all but *C* ray, which has axillary primibrach 4. Two stout rami to a ray, with long, robust, unbranched ramules on admedial side of every third or fourth secundibrach. Column transversely pentagonal proximally, becoming round distally. *M.Ord.*(*Trenton.*), Can. (Ont.).—FIG. 321,2. *\*D. kırki*; 2a-c, plate diagram of partial crown, side and transverse parts of column (Ulrich, 1925); 2d, plate diagram of partial crown (patterns as in Fig. 321,3f) (Moore, 1962b).

**Drymocrinus** ULRICH, 1925, p. 96 [*\*Heterocrinus geniculatus* ULRICH, 1879, p. 16; OD]. Cup small, plates arranged as in *Homocrinus*. Anal *X* large, supporting median row of posterior sac plates. Anal sac narrow, elongate, or with several longitudinal rows of thin, quadrate plates. Primibrachs 1 as wide as radials proximally, tapering in width distally; primibrach 2 axillary in all rays, supporting 2 main rami in each ray. Long, slender, unbranched ramules given off on alternate sides of every second or third secundibrach. Ramule-bearing brachials large and wedge shaped, producing zigzag appearance of each ramus. Column transversely round, with numerous long, slender cirri directed proximally; cirri near cup concealing lower part of crown. *U.Ord.*(*Cincinnati.*), USA (Ohio-Ky.)-Can.(Ont.).—FIG. 321,1. *\*D. geniculatus* (ULRICH), Ohio; 1a,b, plate diagram of partial crown and lat. view of stem,  $\times 1$  (Ulrich, 1925).

**Ectenocrinus** MILLER, 1889, p. 242 [*\*Heterocrinus simplex* HALL, 1847, p. 280; OD]. Cup cylindrical; basals short. Anal *X* small, pentagonal, barely in top of cup, supporting long, slender anal sac. Primibrachs normally free above radials, but first primibrachs may be fixed in cup; primibrach 2 axillary in all rays. Two stout rami to a ray, composed of wedge-shaped brachials that support long, slender ramules on alternate sides of every other, or every third or second, brachial. Stem transversely round, columnals composed of trimeres. *M.Ord.*(*Trenton.*)-*U.Ord.*(*Cincinnati.*), USA (Ky.-Mich.-Ohio-Iowa-Minn.-N.Y.)-Can. (Ont.).—FIG. 322,1a-e. *\*E. simplex* (HALL), U.Ord., Ohio; 1a,b, post. and ?*AB*-interray views of crown and stem,  $\times 2$  (Moore, n; Univ. Chicago 599A, 599B); 1c,d, plate diagram of partial crown and cross section of stem (Ulrich, 1925); 1e, *BC*-interray view of partial crown and stem,  $\times 2$  (Meek, 1873).—FIG. 322,1f,g. *E. grandis* (MEEK),

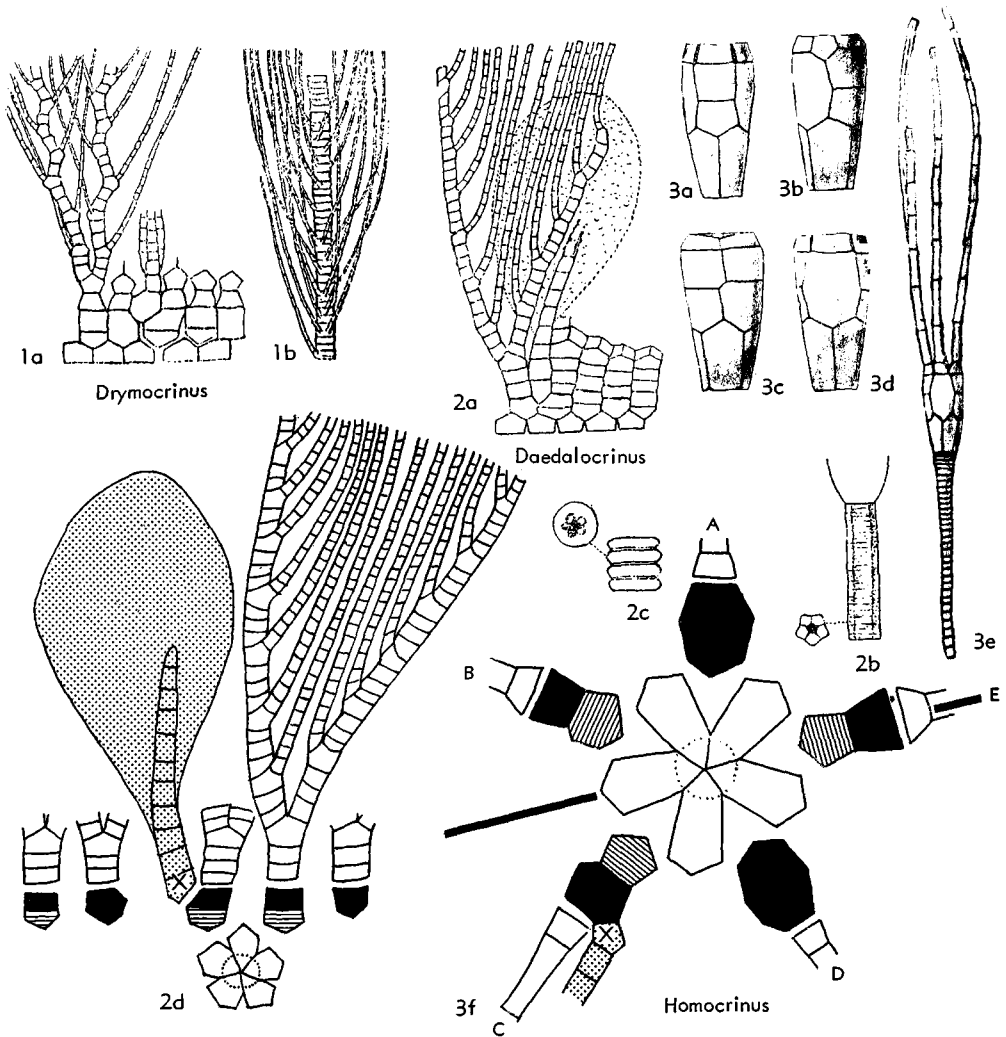


FIG. 321. Homocrinidae (p. T522).

U.Ord., Ohio; 1f,g, B-ray view of crown and stem and lat. view of part of arm and ramules,  $\times 1$ , enl. (Meek, 1873). [Also Fig. 324,1.]

**Ibexocrinus** LANE, 1970, p. 12 [\**I. lepton*; OD]. Crown slender and elongate; cup barely wider than proximal columnals. Compound radials in B, C, and E rays; D and A radials simple; C-ray superradial axillary, supporting anal sac plates on left side and arm on right; primibrach 2 axillary in 2 rays; each arm with 2 main rami; a long, stout, unbranched ramule given off on alternate sides of every sixth to eighth secundibrach. Columnals composed of pentameres and proximally confluent with base of cup. [*Ibexocrinus*, one of the oldest known genera of the Homocrinidae, is most similar to the slightly younger *Ectenocrinus*,

differing mainly in having pentameres rather than trimeres composing the columnals and in having more widely spaced ramules on the 2 branches of each arm.] M.Ord.(Trenton.), USA(Utah).—FIG. 323,1. \**I. lepton*; 1a, A-ray view of crown,  $\times 3.3$ ; 1b,c, CD-interray diagram of cup and A-ray diagram of crown (Lane, 1970a).

**Sygcaulocrinus** ULRICH, 1925, p. 98 [\**S. typus*; OD]. Cup steep sided, small, continuous below with much enlarged proximal columnals, which taper in width distally. Anal X minute, diamond shaped. Primibrachs 2 axillary. Two rami to a ray, with ramules on alternate sides of every third or sixth brachial. Column transversely round. U.Ord.(Cincinnat.), USA(Iowa).—FIG. 323,2. \**S. typus*; 2a,b, plate diagram and D-ray view of

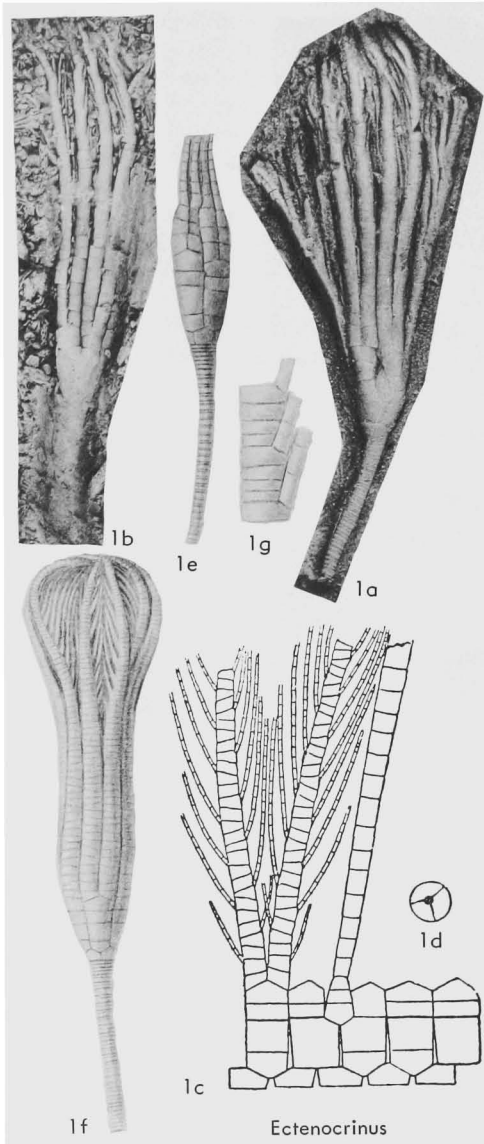


FIG. 322. Homocrinidae (p. T522-T523).

partial crown (patterns as in Fig. 321,3f) (Moore, 1962b).

### Superfamily CALCEOCCRINACEA Meek & Worthen, 1869

[*nom. transl.* MOORE & LANE, in MOORE & STRIMPLE, 1973, p. 16 (ex Calceocrinidae MEEK & WORTHEN, 1869a, p. 73)]  
[Materials for this superfamily prepared by R. C. MOORE and N. GARY LANE]

“Bent crown” monocyclic crinoids with

mostly almost perfect bilateral symmetry developed (like Homocrinidae) in the *E*-ray *BC*-interray plane. Cup commonly quadrangular in outline and flattened on the *A-D-E* side and moveably hinged with plates on opposite side to which the stem is attached. Main axils composed of joined proximal axillary plates of contiguous successive arms borne by the large undivided *A* and *D* radials are distinguishing morphological features, as are ramule-bearing axil arms joined to the main axil. Anal *X* associated with *C* ray supports tubular anal sac. Stem transversely round, sharply bent near attachment to cup. *M.Ord.-L.Miss.; L.Perm.*

### Family CALCEOCCRINIDAE Meek & Worthen, 1869

[Calceocrinidae MEEK & WORTHEN, 1869a, p. 73] [=Chirocrinidae ANGELIN, 1878, p. 22; Cheirocrinidae ZITTEL, 1879, p. 343; Cremacrinidae ULRICH, 1886, p. 105; Castocrinidae JAEKEL, 1918, p. 88; Calceocrinites JAEKEL, 1918, p. 86 (suborder) (*parim*)]

Crown pendent or recumbent on stem, with imperfect to perfect bilateral symmetry developed in the plane of the *E* ray and *BC* interray. Cup with basal circlet subtriangular in outline consisting of four, three, or one plates which bears all or part of stem impression at apex of triangle and is muscularly hinged along base of triangle with radial plates: median (*E*) radial compound, with inferradial forming middle part of all hinge contact with basals and superradial connected broadly to narrowly with inferradial or disconnected by intervention of adjoined edges of large lateral (*A, D*) radials; *B* and *C* radials compound, in some genera with infer- and superradial elements of each distinct, but in others with superradials fused together and in one genus (*Senariocrinus*) with inferradials fused in accompaniment with unfused superradials; lateral radials (*A, D*) large and undivided, oppositely placed with respect to the plane of bilateral symmetry. Median (*E* ray) arm unbranched or isotomously divided; lateral arms multiple, characterized by compound proximal axillary brachials that form main-axil series and more or less numerous axil-arms with heterotomously developed unbranched ramules produced alternately from abanal and adanal sides of the axil-arms (except in *Chiropinna*). Anal tube composed of stout,

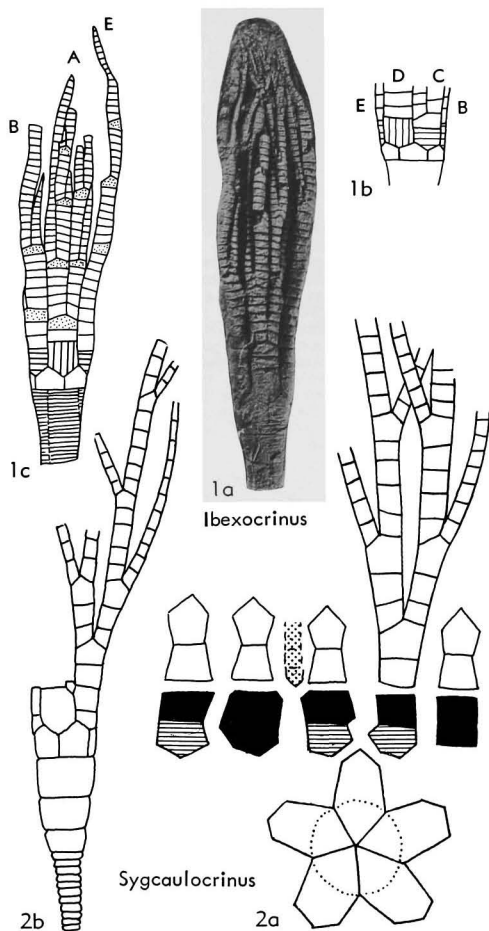


FIG. 323. Homocrinidae (p. T523-T524).

transversely crescentic plates arranged uniserially with inner (ventral) side covered by irregular, thin, small plates. Stem formed of moderately thin, discoidal columnals, which in some genera diminish in size distally. *M.Ord.-L.Miss.*; *L.Perm.*

This family comprises one of the most interesting groups of crinoids in peculiarities of their structure developed as adaptation to a particular mode of life. Most remarkable is their attainment of complete bilateral symmetry in a plane other than that coinciding with the anteroposterior axis of the theca (Fig. 324). Also, successive steps in evolution of the symmetry are clearly recognizable and its derivation from an ancestral homocrinid stock cannot be doubted (Fig. 321).

The heterotomous pattern of arm branching in the Calceocrinidae corresponds to that seen in various homocrinid genera (e.g., *Ectenocrinus*, *Drymocrinus*), but in most calceocrinids it is peculiarly accentuated in the *A* and *D* rays by development of so-called main-axils next above the radials and a series of axil-arms which give off unbranched ramules in a constant manner (Fig. 325) (MOORE, 1962a).

The structure of arms borne by the large lateral radials, mirror images of each other, is very remarkable and has importance in generic classification. First, is a linking together of the most proximal plates of the laterally successive arms to form so-called **main axils**. These are composed of axillary brachials at the base of all arms, with addition of a quadrangular nonaxillary plate at the base of arms next to the *E* ray. These plates are primibrachs and arms above them are termed **primaxil arms**. Arms next farther from the *E* arm begin with an axillary secundibrach and are called **secundibrach arms**. Following this plan farther from *E* we have **tertaxils** as main-axil components and **tertaxil arms**, **quartaxils**, and **quartaxil arms**, and so on.

Arms of each axil arm are divisible in **rami**, centrally placed main parts that are wider than bordering lateral parts, and possess successive axillary brachials separated by one or two nonaxillary brachials from preceding and following axils. Slender unbranched armlets are called **ramules**. These diverge from the rami first on the side nearest to the *E* ray and then on the opposite side. Successive axils and ramules in each axil arm are designated by Greek letters, alpha ( $\alpha$ ), beta ( $\beta$ ), gamma ( $\gamma$ ), delta ( $\delta$ ), and so on. The single ramule attached to the main axil farthest from *E* is known as omega ( $\omega$ ) ramule. The features are illustrated in Figure 325.

*Calceocrinus* HALL, 1852, p. 352 [\**Cheirocrinus chrysalis* HALL, 1860b, p. 123; SD WACHSMUTH & SPRINGER, 1886, p. 205(281)] [= *Cheirocrinus* HALL, 1860, p. 122 (type, *C. chrysalis*; SD BASSLER & MOODEY, 1943, p. 468) (obj.) (*non* EICHWALD, 1856, p. 123); *Euheirocrinus* MEEK & WORTHEN, 1869a, p. 73 (type, *C. chrysalis* HALL, 1860, p. 123; SD SPRINGER, 1926, p. 111) (obj.); *Proclivocrinus* RINGUEBERG, 1889, p. 396 (type, *Calceocrinus radiculis* RINGUEBERG, 1882, p. 120; OD) (= *C. chrysalis* HALL, 1860) (obj.);

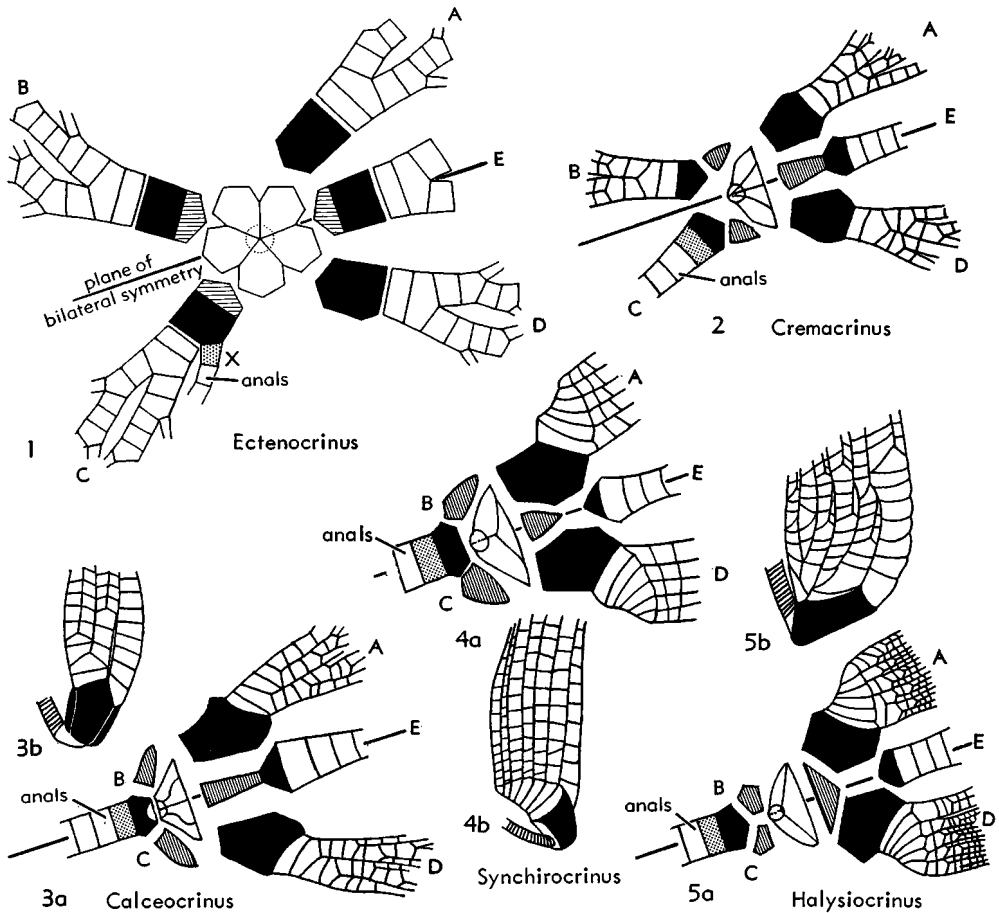


FIG. 324. Diagrams illustrating bilateral symmetry in the *E-BC* plane (homocrinid type) (mod. from Moore, 1962a).—1. *Ectenocrinus* (Ord.), typical homocrinid representative of inferred ancestral stock from which Calceocrinidae evolved, showing 5 subequal basals, 3 compound radials, and 2 undivided radials; anal series armlike succession of plates borne by *C* superradial.—2. *Cremacrinus* (Ord.-Sil.), bilateral symmetry well marked but imperfect; anal series not associated with remnant arm of *C* ray.—3. *Calceocrinus* (Ord.-Sil.), bilateral symmetry advanced by loss of arm in *B* ray.—4. *Synchirocrinus* (Sil.-Dev.), basals reduced to 3, main axils of *A* and *D* rays prominent.—5. *Halysiocrinus* (Dev.-Miss.), *B* and *C* superradials migrated to adjoin one another.

*Euchirocrinus* BATHER, 1893a, p. 65 (type, *C. chrysalis* HALL, 1860; OD) (obj.); non *Calceocrinus* AUCTT. (= *Chirocrinus* ANGELIN, 1878, p. 22)]. Crown with complete but not strikingly evident bilateral symmetry; median arm (*E* ray) generally branched isotomously but may be unbranched; 2 laterally placed arm systems (*A*, *D* rays) on opposite sides of crown composed of weakly developed main-axils, which commonly include nonaxillary plates alternating with successive axillaries that may have subequal distal facets, axil-arms and ramules few but developed in normal manner. Cup with four basals, each

of which forms part of stem impression, suture between 2 small median basals (*DE*, *EA*) tending to be obscure; oppositely placed large undivided radials of *A* and *D* rays, superradial of *E* ray mostly connected narrowly with inferradial, which widens proximally, inferradials of *B* and *C* rays small and spear shaped, well separated from each other by basals and fused superradial situated obliquely above them, this superradial forming subanal plate that supports anal *X* plate and anal tube adjoined by stem in median plane of bilateral symmetry (MOORE, 1962a). *M.Ord.-M.Sil.*, N.Am.-Eu.(Eng.-Sweden).—FIG. 326,5. \**C. chrysalis*

(HALL), M.Sil.(Niagaran), USA(N.Y.); *5a,b*, lower part of crown from *A*- and *E*-ray sides,  $\times 2$ ; *5c*, basal criclet showing 4 basals, stem impression above, hinge for articulation with radials below,  $\times 2$ ; *5d*, *A*-ray view of crown with part of attached stem (holotype of type species of *Proclivocrinus* RINGEBERG),  $\times 2$  (all Springer, 1926a). [Also Fig. 324,3.]

[HALL's original description and illustrations of *Calceocrinus* were unaccompanied by a specific name, and therefore when RINGEBERG (1889, p. 403) redescribed and figured a fragmentary fossil reported to be HALL's original specimen of *Calceocrinus*, naming it *C. halli*, various authors, including BASSLER (1938, p. 56), BASSLER & MOONEY (1943, p. 345), and RAMSBOTTOM (1952, p. 34), judged that the failure by HALL to publish a specific name for this single known representative of the genus has been rectified by RINGEBERG. Accordingly, they cited *C. halli* RINGEBERG as the type species of *Calceocrinus*. RINGEBERG, however, did not consider the very incomplete type specimen named *C. halli* adequate to serve for delineating characters of the genus and he therefore published description and illustrations of a crown which he named *C. typus*. RINGEBERG (1889, p. 402) explicitly designated *C. typus* as the type species of *Calceocrinus* and this action was accepted by BATHER (1893a, p. 65), SPRINGER (1926a, p. 115), and others as valid. ¶ Actually, neither *Calceocrinus halli* nor *C. typus* is eligible under the Rules to be the type species of the genus, for this must be either 1) the first species with valid "indication" assigned definitely to *Calceocrinus* by a subsequent author, if only one such species was so assigned, or 2) a species selected from a group of definitely referred species, if two or more were so referred at the same time, this selection being made either by the author who first assigned them to the genus or, if no selection then was made, by the first subsequent author who made a choice from the assigned group (all other species being excluded from consideration). Search of the literature shows no species were unequivocally placed in *Calceocrinus* until 1877 when S. A. MILLER (p. 72-73) listed 12 validly established species (including *Cheirocrinus chrysalis* HALL, 1860) as belonging to this genus. The type species must be one of this group, not some later-named form, but MILLER failed to make a choice. WACHSMUTH & SPRINGER (1886, p. 205 [281]) were first to do this when they explicitly designated *Cheirocrinus chrysalis* as the type species.]

**Anulocrinus** RAMSBOTTOM, 1961, p. 8 [*\*A. thraivensis*; OD]. Crown pendent, subparallel to stem, like *Cremacrinus* in having 4 basals and 4 arm-bearing rays, *E* arm unbranched or divided isotomously on about the sixth primibrach and fifth secundibrachs, lateral rays (*A*, *B*, *D*) with arms that branch isotomously or nearly so within main-axil series but heterotomously in all axil arms; ramules few to numerous, all arranged precisely in conformance with the normal calceocrinid pattern of heterotomy; *E* superradial wider than high, narrowly touching slender inferradial, which is slightly sinuous sided and appreciably taller than wide; large undivided lateral radials of *A* and *D* rays, forming most of opposite sides of cup; *B* superradial small, subquadrangular, *B* and *C* inferradials spear shaped, in type species *C* superradial (termed subanal) seemingly wide, low, nearly median plate at proximal extremity of anal tube, visible part of which consists of large, stout plates with height of each about equal to width. Stem moderately slender, composed of discoid to barrel-shaped columnals, circular transversely, thinnest in proximal region near cup and thickening distally until height may appreciably exceed diameter (MOORE, 1962a; RAMSBOTTOM, 1961).

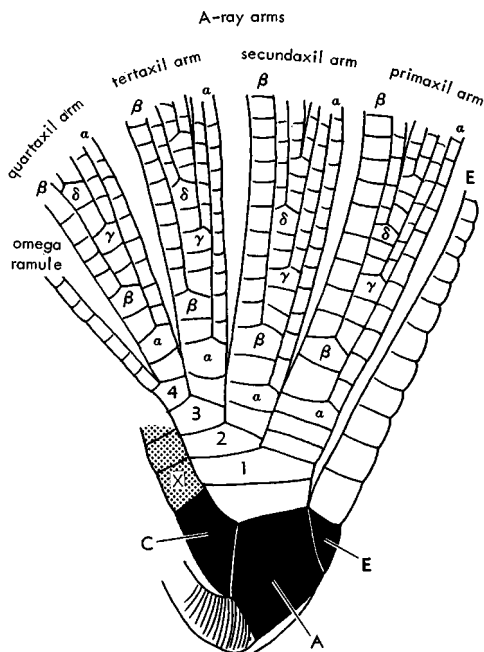


FIG. 325. Diagram of *A*-ray side of *Chirocrinus* illustrating differentiation of main-axil and axil-arms borne by it; abanal brachial and ramules shaded (mod. from Moore, 1962a).

*U.Ord.-U.Sil., Eu.-N.Am.*—FIG. 327,2a-d. *\*A. thraivensis*, U.Ord.(Ashgill), Scot.(Girvan); 2a, *E*-ray view of paratype,  $\times 2.8$ ; 2b, *A*-ray view of holotype, stout *E* arm at right,  $\times 3.5$ ; 2c,d, *D*-ray view of arms, and post. view of partial crown,  $\times 2.8$  (Ramsbottom, 1961).—FIG. 327,2e,f. *A. simplex* (SPRINGER), M.Sil.(Beech River), USA (Tenn.); 2e, view of holotype from *A*-ray side, *B* ray at left and *E* ray at right,  $\times 2.4$ ; 2f, same from opposite (*D* ray) side, *E* ray at left,  $\times 2.4$  (Springer, 1926a).

**Chirocrinus** ANGELIN, 1878, p. 22 [*\*C. gotlandicus*; M] [= *Calceocrinus* AUCTION. (non HALL, 1852) (non *Cheirocrinus* EICHWALD, 1856, nec HALL, 1852, nec SALTER, 1873)]. Crown with perfect bilateral symmetry; median (*E*) ray undivided, small inferradial generally separated from super-radial; lateral rays (*A*, *D*) with large radials succeeded by 2 primibrachs, primaxil with unequal distal facets, narrower one on abanal side supporting axil-arm and broader one bearing secund-axil of main-axil series, which, though definite, is not strongly distinguished or appreciably curved adanally; each axil-arm bearing moderately stout unbranched ramules that rise from axillaries separated by 1 or 2 quadrangular brachials, ramules of all series subequal in size. Cup showing mod-



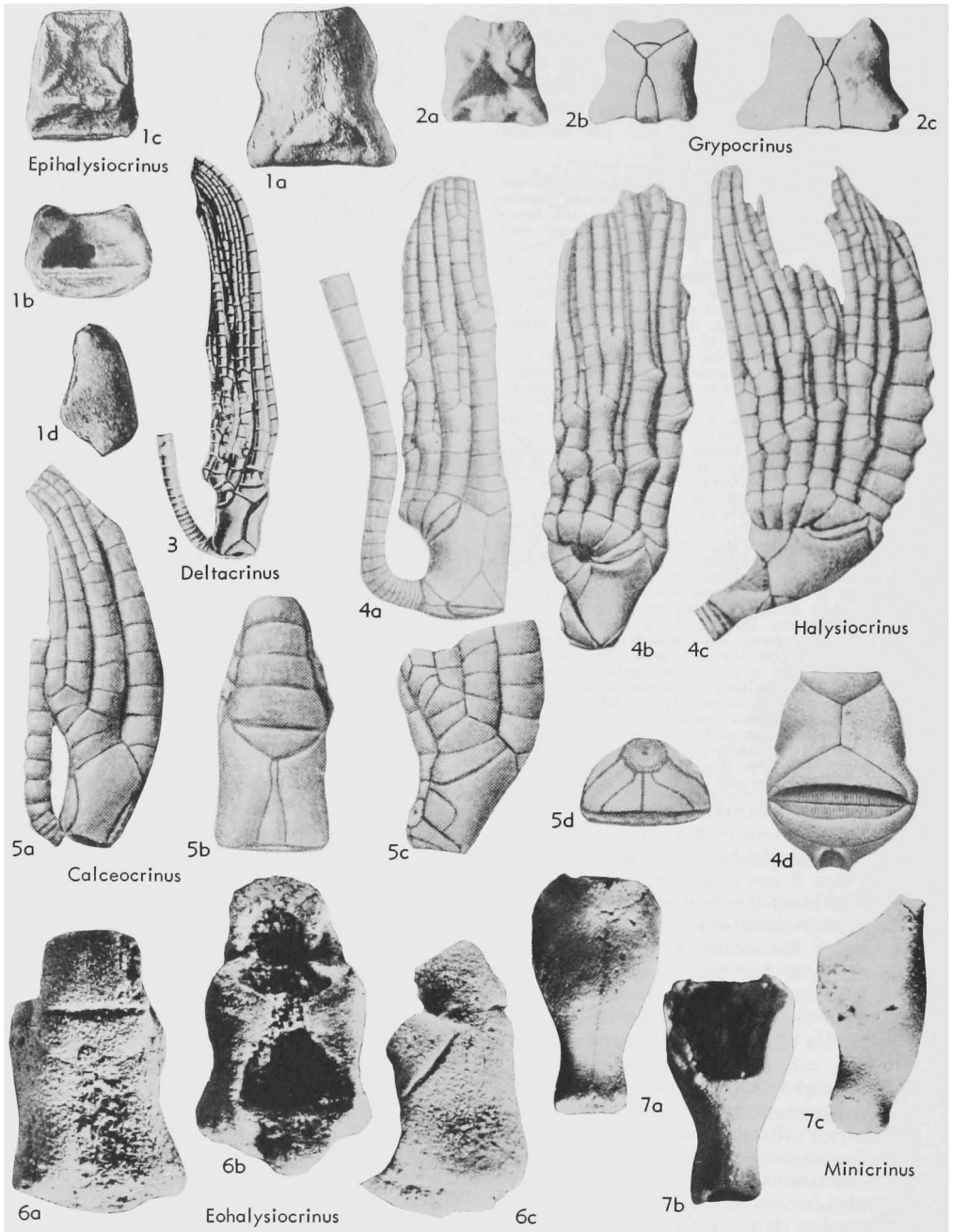


FIG. 326. Calceocrinidae (p. T525-T527, T530, T532).

erately large spear-shaped inferradials of *B* and *C* rays well separated by basals and fused super-radial beneath anal *X* plate; basals reduced to 3 by fusion of *DE* and *EA* plates, which form

low, triangular basal that generally does not extend into stem facet (MOORE, 1962a). *L.Sil.*, N.Am.; *M.Sil.*, Eu.—FIG. 327,4; 328. *C. fletcheri* (SALTER), *M.Sil.*(Wenlock.), Eng.(Dud-

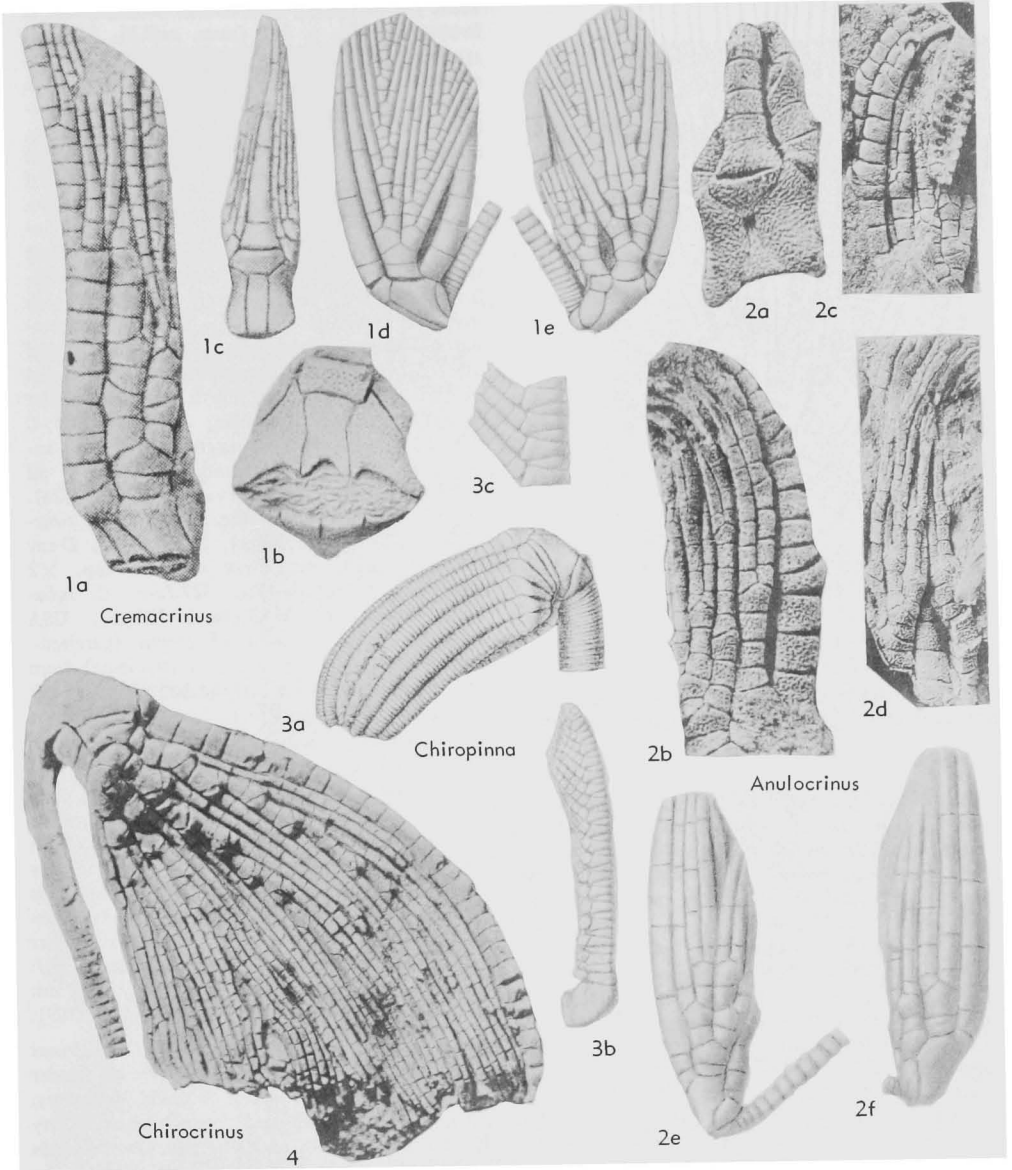


FIG. 327. Calceocrinidae (p. T527-T530).

ley); 327,4, *D*-ray view of nearly complete crown (holotype) with part of attached stem,  $\times 1$  (Ramsbottom, 1952); 328, drawing of same showing separate axil arms (Moore, n). [Also Fig. 325.] **Chiropinna** MOORE, 1962, p. 28 [\**Calceocrinus pinnulatus* BATHER, 1893a, p. 96; OD]. Crown compactly subcylindrical, cup of normal type, surmounted by pinnulate axil-arms in lateral rays and pinnulate dichotomous branches of median (*E*) ray, main-axils well developed (MOORE,

1962a). [This crinoid is not only a unique sort of calceocrinid but it stands alone among all disparid crinoids in having pinnulate arm structure (but interpretable also as extraordinarily numerous and regular ramules borne by brachials not distinguished as axils). Compared with all other calceocrinids, with which this genus unquestionably belongs, the unbranched offshoots of brachials on alternating sides are not different from ramules, except for the fact that every brachial plate of

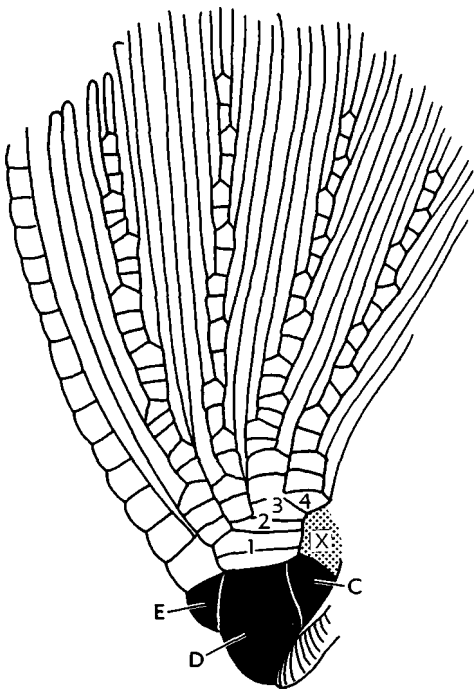


FIG. 328. Drawing of *Chirocrinus* showing separate axial arms 1-4 (anal plates stippled) (Moore, n).

each axil-arm is an axillary, giving off a branchlet (pinnule) to left or right. Thus the axil-arm structure of *Chiropinna* differs in no way from the pinnulate arms of such cladid inadunate genera as *Decadocrinus*, and numerous others. Whatever its significance may be, the brachials of *Chiropinna* give rise to first pinnules on the adanal side, rather than the abanal side of the E arm as characterizes the ramules in other genera of calceocrinids. The median (E) ray of *Chiropinna* is unique among calceocrinids in showing a dichotomous division into two arms that are unbranched (except for abundant pinnules) above the single axillary primibrach which bears them. The first pinnules of the median arms are given off from the adanal side of the second brachials above the axillary primibrach.] *U.Sil.* (Wenlock.), Sweden (Gotl.).—FIG. 327, 3. \**C. pinnulata* (BATHER); 3a, A-ray view of holotype showing unusually thick stem, well-developed main-axil and parallel axil-arms without visible pinnules, E arm at right edge of view,  $\times 1.3$ ; 3b, side view of single axil-arm of A ray showing pinnules borne by successive brachials,  $\times 2$ ; 3c, detail of axil-arm with pinnules,  $\times 4$  (Bather, 1893a).

*Cremacrinus* ULRICH, 1886, p. 107 [\**C. punctatus*;

OD] [= *Castocrinus* RINGUEBERG, 1889, p. 389 (type, *Calceocrinus furcillatus* W. R. BILLINGS, 1887, p. 51; OD); *Castocrinus* WACHSMUTH & SPRINGER, 1891, p. 387 (nom. null.)]. Bilateral symmetry of crown imperfectly developed, calyx asymmetrical, arm-bearing rays 4, stem not in plane of anal tube. Median (E) ray typically unbranched but in some species bifurcating distally, quadrilateral inferradial rather broadly in contact with superradial. Lateral arms 3, those of A and B rays on one side and of D ray alone on opposite side, each arm with ill-defined but definite main-axil series consisting of 2 primibrachs (axillary with subequal distal facets) and 1 or 2 secundi-brachs; axil-arms few, generally 2 borne by each main-axil, ramules numerous, strictly conforming to calceocrinid pattern of heterotomy. Anal tube supported by C superradial, B superradial supporting arm that generally is distinctly smaller than that borne by adjoining A ray; B and C inferradials spear shaped, separated from one another by basals and superradials. Basals 4, all partly covered by stem impression (MOORE, 1962a). *M.Ord.-U.Sil.*, N.Am.—FIG. 327, 1a,b. \**C. punctatus*, M.Ord. (Black River), Minn.; 1a,b, D-ray view of crown and E-ray view of cup,  $\times 2$  (Springer, 1926a).—FIG. 327, 1c-e. *C. tubuliferus* SPRINGER, M.Sil. (Beech River), USA (Tenn.); 1c, E-ray view of crown (paralectotype); 1d,e, lat. views of crown (lectotype) from D and AB sides, robust unbranched E arm at left and right margins, anal tube shown in 1d between D ray and stem; all  $\times 2$  (Springer, 1926a). [Also Fig. 324, 2.]

*Cunctocrinus* KESLING & SIGLER, 1969, p. 340 [\**C. fortunatus*; OD]. Basals 3; A and D radials laterally fused with B and C ray inferradials; E-ray infer- and superradials widely separated by admedial edge of A and D radials. Main axils 5 or 6, bearing heterotomously branched axil-arms with 2 to 4 alphabrachs, and at least two higher divisions. *M.Dev.*, USA (Ohio).—FIG. 329, 1. \**C. fortunatus*; 1a-d, post., A-ray, D-ray, and ant. views of crown,  $\times 5.2$  (Kesling & Sigler, 1969).

*Deltacrinus* ULRICH, 1886, p. 100 [\**Cheirocrinus clarus* HALL, 1862, p. 116; OD]. Crown slender and elongate, with perfect bilateral symmetry, median (E) ray undivided, lateral rays with very ill-defined main-axils and relatively few axil-arms which lack evident differentiation of alpha-, beta-, and gamma-ramules; inferradial of median ray triangular (delta-shaped) and widely separated from superradial by adjoining lateral radials; basals 3 closely resembling those of *Chirocrinus* (MOORE, 1962). [This genus is distinguished by relatively advanced characters of the cup combined with primitive features of the main-axils and slender axil-arms.] *L.Sil.-U.Sil.*, USA (Mo.-Ind.-N.Y.); *M.Dev.*, USA (N.Y.).—FIG. 326, 3. \**D. clarus* (HALL), *M.Dev.* (Hamilton), USA (N.Y.); holotype showing unbranched E ray toward right and

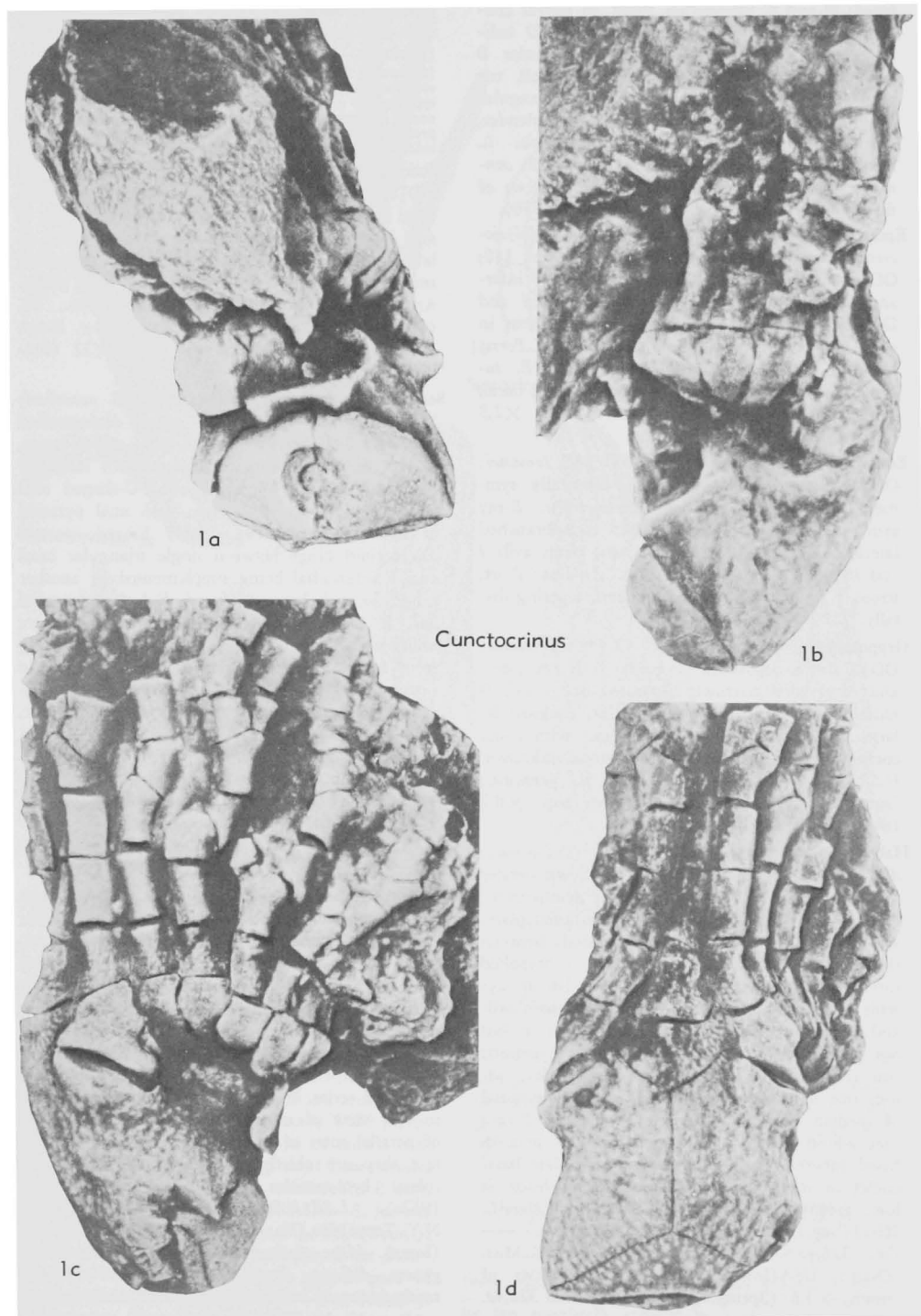


FIG. 329. Calceocrinidae (p. T530).

- axil-arms of *A* ray at left,  $\times 1.3$  (Goldring, 1923).
- Eohalsiocrinus** PROKOP, 1970, p. 97 [*\*E. convexus*; OD]. Cup small, elongate; basals 3, unfused; *B* and *C* inferradials small, in lateral contact, overlapped by large elongate *A* and *D* radials, bounded distally by fused, quadrangular *B* and *C* superradials; *E* ray inferradial small, triangular, widely separated from larger, triangular *E* superradial. Arms unknown. Stem slender, composed of minute, cylindrical columnals. *L.Dev.-M.Dev.*, Eu.(Boh.).—FIG. 326,6. *\*E. convexus*; 6a-c, *E*-ray, *BC*-interray, and lat. views of theca and first primibrach,  $\times 8$  (Prokop, 1970).
- Epihalysiocrinus** ARENDT, 1965, p. 90 [*\*Halysiocrinus? tuberculatus* YAKOVLEV, 1927b, p. 188; OD]. Basals fused into a single plate; *E*-ray infer- and superradial widely separated by the *A* and *D* radials; small *B* and *C* inferradials present in cup. Arms and anal tube unknown. *L.Perm.* (Artinsk.), Eu.(USSR).—FIG. 326,1. *\*E. tuberculatus* (YAKOVLEV); 1a, *E* ray,  $\times 2$ ; 1b, basal,  $\times 3$ ; 1c,d, int. and lat. views of cup,  $\times 2.3$  (Arendt, 1965).
- Espanocrinus** WEBSTER, 1976, p. 681 [*\*E. lemoinei*; OD]. Crown slender, elongate, bilaterally symmetrical. Cup like that of *Halysiocrinus*. *E*-ray arm unbranched, plates convex; 3 unbranched lateral axil arms in *A* and *D* rays, main axils *I* and *III* axillary in *A* and *D* rays. Anal sac short, strongly protuberant. Column round, tapering distally. *L.Dev.(Ems.)*, Eu.(Spain).
- Grypocrinus** STRIMPLE, 1963, p. 59 [*\*G. genuinus*; OD]. Basals unknown, probably 3; *E* ray infer- and superradial narrowly separated by *A* and *D* radials; superradial small, triangular, enclosed by large crescentic primibrach in contact with distal corners of *A* and *D* radials. Arms unknown. *U.Sil.*, USA (Okla.).—FIG. 326,2. *\*G. genuinus*; 2a-c, int. and ext. *E*-ray views of cup,  $\times 0.7$  (Strimple, 1963a).
- Halysiocrinus** ULRICH, 1886, p. 110 [*\*Cheirocrinus dactylus* HALL, 1860, p. 123; OD]. Crown slender to moderately full in girth, perfectly symmetrical, median (*E* ray) with infer- and superradial plates well separated by adjoined lateral radials between them and generally with dichotomously branched medial and distal parts of median ray, lateral rays with large radials that support curved main-axils and numerous axil-arms which bear large but not dominant beta-ramules, as in *Synchirocrinus*; cup composed of large lateral radials that adjoin one another between infer- and superradial of median radial, inferradials of *B*- and *C*-rays that adjoin above stem impression and beneath fused superradial of these rays, and 3-plate basal circlet in which median element along hinge is low, arcuate plate (MOORE, 1962a). *M.Dev.-L.Miss.(Osag.)*, N.Am.(Iowa-Ind.-Ky.-Tenn.).—FIG. 326,4a,b. *\*H. dactylus* (HALL), L.Miss.(Osag.), USA (Iowa); *A*- and *E*-ray views of crown,  $\times 1.6$  (Springer, 1926a).—FIG. 326,4c.
- H. nodosus* (HALL), L.Miss.(Osag.), USA (Ind.); *A*-ray view of crown,  $\times 1$  (Springer, 1926a).—FIG. 326,4d. *H. perplexus* (SHUMARD), L.Miss.(Osag.), USA (Ky.); exterior of cup showing radials and basals fully extended from hinge,  $\times 1.3$  (Springer, 1926a). [Also FIG. 324,5.]
- [BATHER'S (1893, p. 63) designation of *Calceocrinus ventricosus* (= *Cheirocrinus ventricosus* HALL, 1860) as type species of *Halysiocrinus* is invalid, whatever may be one's judgment as to the status of this species as a probable synonym of *Cheirocrinus dactylus* as generally held, or as an independent species.]
- Minicrinus** PROKOP, 1970, p. 109 [*\*M. inflatus*; OD]. Theca vase shaped, narrow and elongate in basal area, broad and inflated in radial area; *A* and *D* radials large, composing most of theca, in lateral contact with anal plate and separating small fused *B* and *C* inferradials from basal plates. Arms and stem unknown. *L.Dev.-M.Dev.*, Eu.(Boh.).—FIG. 326,7. *\*M. inflatus*; 7a-c, *E*-ray, *BC*-interray, and lat. views of theca,  $\times 12$  (Prokop, 1970).
- Senariocrinus** SCHMIDT, 1934, p. 16 [*\*S. maucheri*; M]. Bilaterally symmetrical crown distinguished by single dichotomous division of *A* and *D* arms, neither of which bears ramules, and by long unbranched *E* arm; stout series of U-shaped anal plates supports fine-plated sac with anal pyramid at its tip. Cup plates doubly hinged, normal calceocrinid hinge between single triangular basal and *E* inferradial being supplemented by another hinge located between fused *B* + *C* inferradial and *B* superradial, which with oblique suture underlies *C* superradial, with anal series rising from latter. Slender cylindrical stem attached to extremity of basal hinge, composed of thin columnals and tapering distally to point (SCHMIDT, 1934; MOORE, 1962a). [Inferred to have been free-swimming.] *L.Dev.(Ems.)*, Eu.(W.Ger.).—FIG. 330,1. *\*S. maucheri*, Hunsrück Sh., near Bundenbach; 1a, view of holotype from *D*-ray side, *E* arm at right and elongate anal sac left,  $\times 0.85$  (Schmidt, 1934); 1b,c, tip of anal sac, *D*-ray view of crown,  $\times 0.85$ , enl. (Moore, 1962a).
- Synchirocrinus** JAEKEL, 1918, p. 86 [*\*S. anglicus* (= *Calceocrinus nitidus* BATHER, 1893a, p. 91); OD] [= *Cheirocrinus* SALTER, in MURCHISON, 1859, p. 535 (*nom. nud.*); *Cheirocrinus* SALTER, 1873, p. 118 (type, *C. serialis*; SD MOORE, 1962a, p. 26 (*non* EICHWALD, 1856, *nec* HALL, 1860); *Pendulocrinus* SALTER, 1859, p. 535 (*nom. nud.*)]. Crown with perfect bilateral symmetry, resembling *Chirocrinus* except in having strongly marked main-axil series in lateral rays and axil-arms that in side view of most specimens seem to consist of parallel rows of subequal brachials, whereas in fact they are chiefly composed of exceptionally robust beta-ramules (see FIG. 12) (MOORE, 1962a). *L.Sil.-U.Sil.(Wenlock.)*, N.Am.(Ohio-N.Y.-Tenn.)-Eu.(Eng.-Sweden); *L.Dev.*, N.Am.(Iowa). [One of the most distinctive calceocrinid genera, differing from *Delacrinus* in its well-marked, curved main-axils and much more numer-

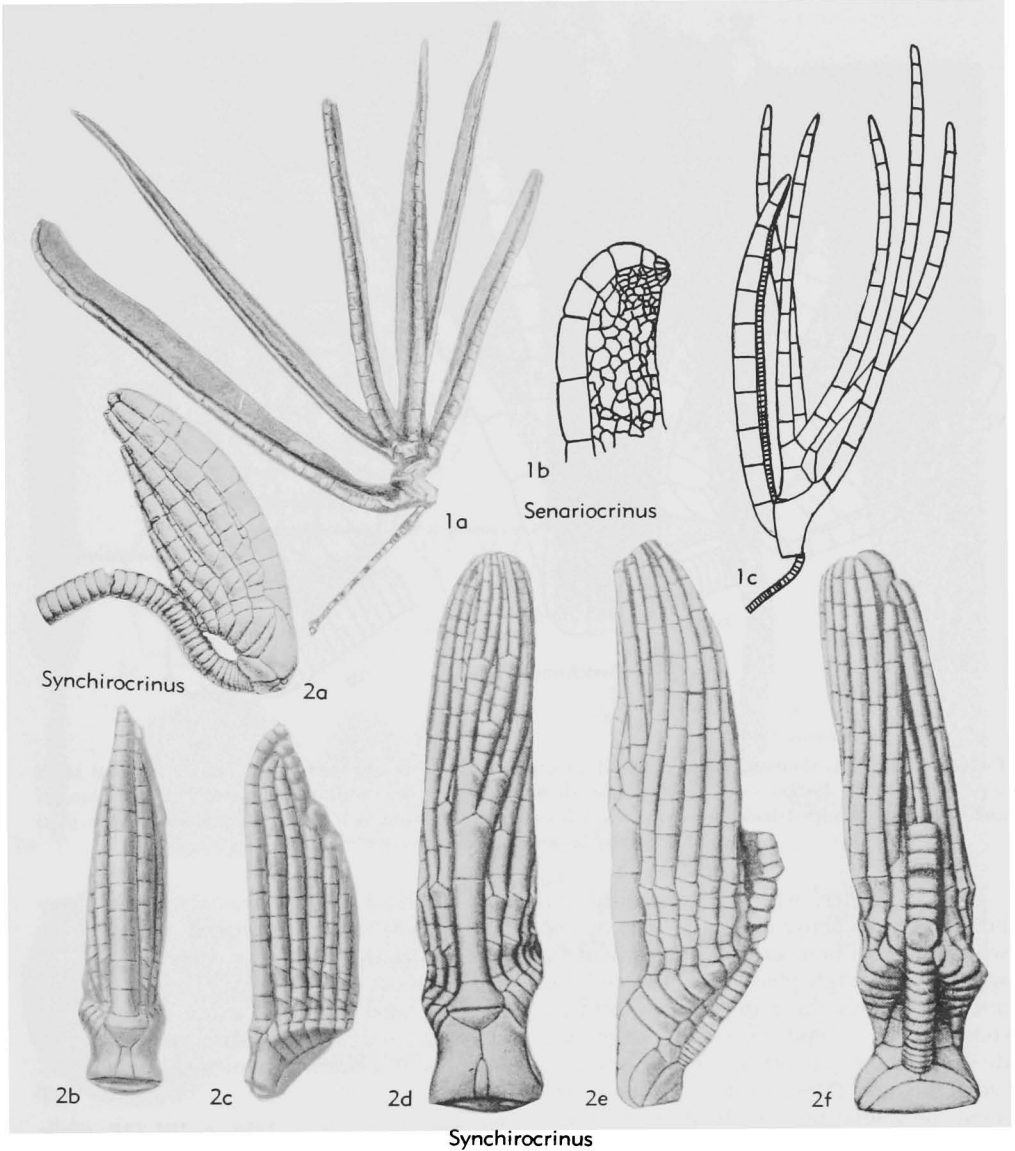


FIG. 330. Calceocrinidae (p. T532-T533).

ous axil-arms. It most closely resembles *Halysiocrinus*, but differs especially in its more robust beta-ramules and largely concealed axil-arms.]—FIG. 330,2a. *S. tucanus* (BATHER), U.Sil.(Wenlock.), Sweden(Gotl.); *D*-ray view of crown with part of attached stem, showing stout beta-ramules of this ray and, at right edge, unbranched *E* arm,  $\times 2$  (Bather, 1893a).—FIG. 330,2b,c. *S. foerstei* (SPRINGER), M.Sil.(Beech River F.), USA(Tenn.); 2b,c, *E*- and *D*-ray views of lectotype, latter showing only beta-ramules visible in upper part of crown,  $\times 1.3$  (Springer, 1926a).—FIG. 330,2d-f. *S. bifurcatus* (SPRINGER), M.Sil.(Beech River F.),

USA(Tenn.); 2d-f, holotype viewed from *E*, *D*, and posterior sides, showing well-developed main-axil and parallel robust beta-ramules which conceal axil-arms,  $\times 2$  (Springer, 1926a). [Also FIG. 324,4; 331,1.]

**Superfamily PISOCRINACEA**  
**Angelin, 1878**

[*nom. transl.* MOORE & LANE, in MOORE & STRIMPLE, 1973, p. 16 (ex Pisocrinidae ANGELIN, 1878, p. 20)] [Materials for this superfamily prepared by R. C. MOORE and N. GARY LANE]

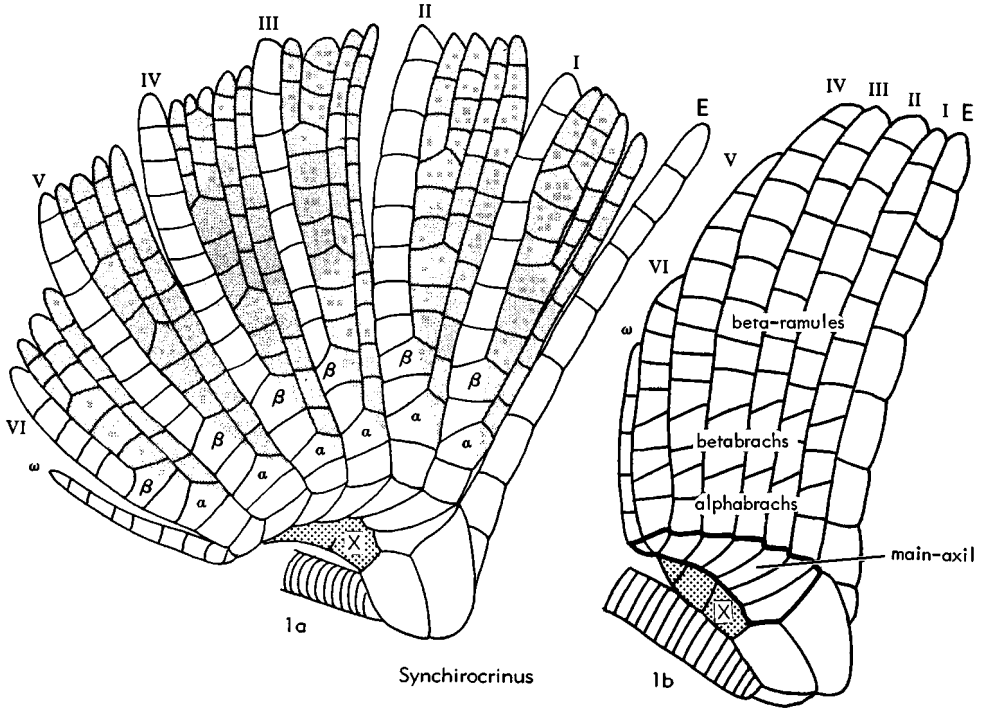


FIG. 331. Diagrams showing many-branched structure of *A* ray in *Synchirocrinus* (Sil.-Dev.) (anal series stippled) (Moore, 1962a).—*1a*. Axil-arms drawn in spread-out positions to reveal hidden parts of axil-arms and ramules (shaded).—*1b*. Arm branches above main-axil in normal position, visible parts being mostly betabrachs and beta-ramules.

Crown slender, with erect rounded unbranched arms above conical to globose cup which displays homocrinid type of bilateral symmetry through plane of *E* ray and *BC* interray. Basals three to five, low and inconspicuous; *A* and *D* radials large, undivided, those of other rays compound, radial articular facets narrow, leaving prominent interradial prongs. In Allagecrinidae, Catillocrinidae, and Anamesocrinidae some large multifaceted radials with threadlike unbranched arms. Small stem transversely round. *M.Sil.*(*Wenlock*., *Niagaran*)-*U.Dev.* (*Chemung*.).

#### Family PISOCRINIDAE Angelin, 1878

[Pisocrinidae ANGELIN, 1878, p. 20] [=Pisocrinidées DE LORIO, 1882-84, p. 46; Triacriniidae JAEKEL, 1918, p. 89; Cicerocrinidae JAEKEL, 1918, p. 89]

Small crinoids with globose or conical cup. Basals three or five; three small radials, which correspond to the *B*, *C*, and *E* compound radials of Homocrinidae, and

two large radials, inferradial of the *B* ray hypertrophied and displaced obliquely to right, forming with the large *A* and *D* radials most of the cup. Tegmen poorly known, anal opening above cup. Arms atomous and nonpinnulate or with two main ramule-bearing rami to a ray. *M.Sil.*-*U.Dev.*

*Pisocrinus* DE KONINCK, 1858, p. 104 [\**P. pilula*; M] [=Triacrinus RINGUEBERG, 1884, p. 144 (type, *T. pyriformis*), non MÜNSTER, 1839]. Cup small, globose or rarely conical with flat base or basal concavity; basals 5, unequal in size, *AE* and *BC* basals smaller than other 3 basals and with truncated rather than acute distal edge. Radials unequal in size, *C* and *E* radials small, triangular and not in contact with basals; *B* ray with small triangular superradial and large inferradial which is shifted obliquely to left and situated directly above *BC* basal; *D* and *A* radials are large, simple, in contact with basals, and together with the *B* inferradial comprise most of the theca. Anal *X* small, situated above cup and in contact with upper corners of *C* and

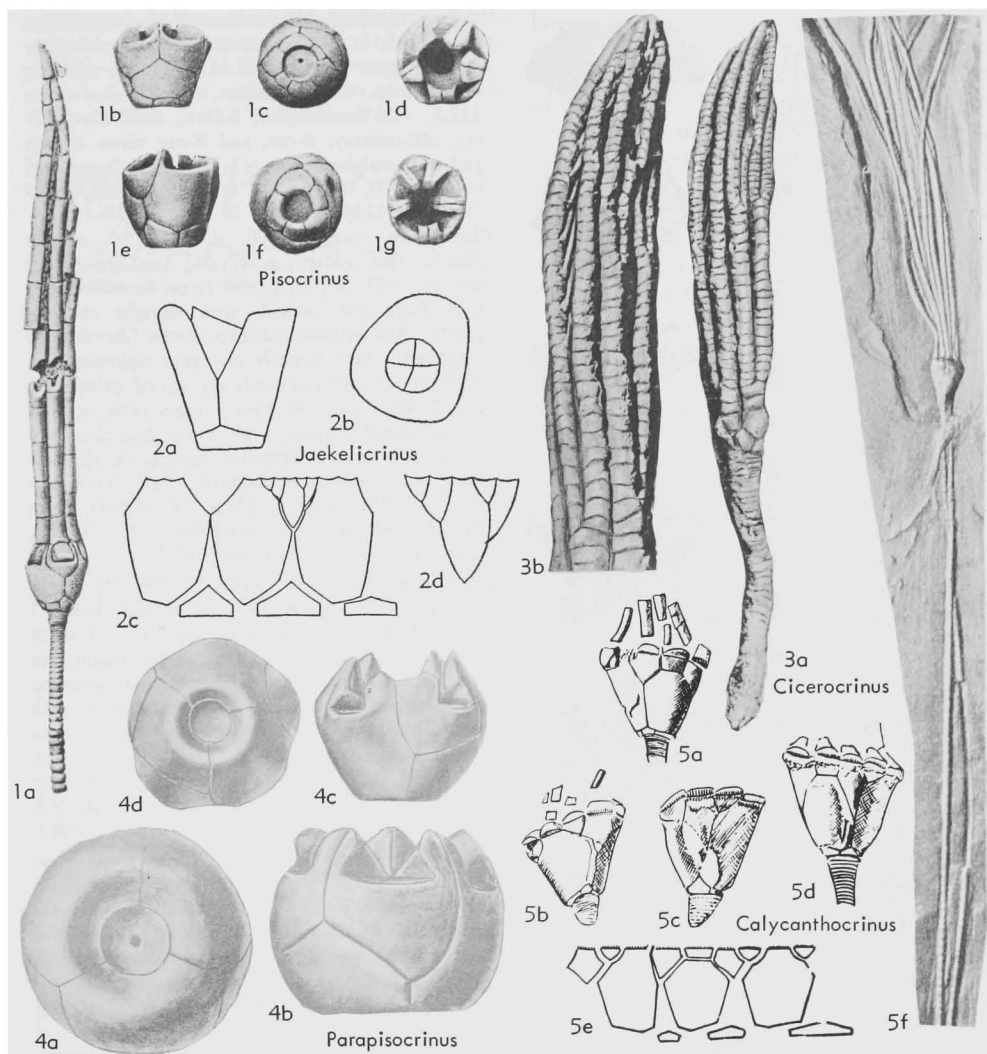


FIG. 332. Pisocrinidae (p. T534-T536).

*D* radials. Arm facets deeply notched into upper surfaces of radials; articular surfaces with fine radial ridges and grooves, or a transverse ridge; facets bounded laterally and internally by raised outer edges of the radials. First primibrach short, remainder of brachials slender and elongate; arms atomous and nonpinnulate. Anal sac narrow and elongate, closely resembling an arm, triangular or crescentic in cross section, supported directly by anal *X* and confined to posterior part of the tegmen. Tegmen arched by 5 oral plates which interlock medially and are in sutural contact with the radial processes. *M.Sil.* (*Niagaran*)-*L.Dev.*, Eu. (Gotl.-Boh.-Eng.-USSR)-USA (N.Y.-Tenn.-Ill.-Mo.-Ind.)-Australia.—FIG. 332, 1. \**P. pilula*; 1a-d,

*U.Sil.*, Gotl., lat, view of crown and stem, lat., dorsal, and ventral views of cup,  $\times 2$ ; 1e-g, *U.Sil.*, Eng.; lat., dorsal, and ventral views of cup,  $\times 2$  (Springer, 1926a).

**Calycanthocrinus** FOLLMAN, 1887, p. 115 [*\*C. decadactylus*; M]. Cup cone shaped; basals three, equal and triangular in shape. *A* and *D* radials large, each supporting a single atomous arm; *B* inferradial large, supporting small *C* radial and *B* superradial on upper left and right shoulders. Additional arm-supporting ray plates in the cup (pararadials) are present directly above the *B* inferradial, between *C* radial and *B* superradial, between the small *E* radial and large *D* radial, between the *E* radial and large *A* radial, and be-



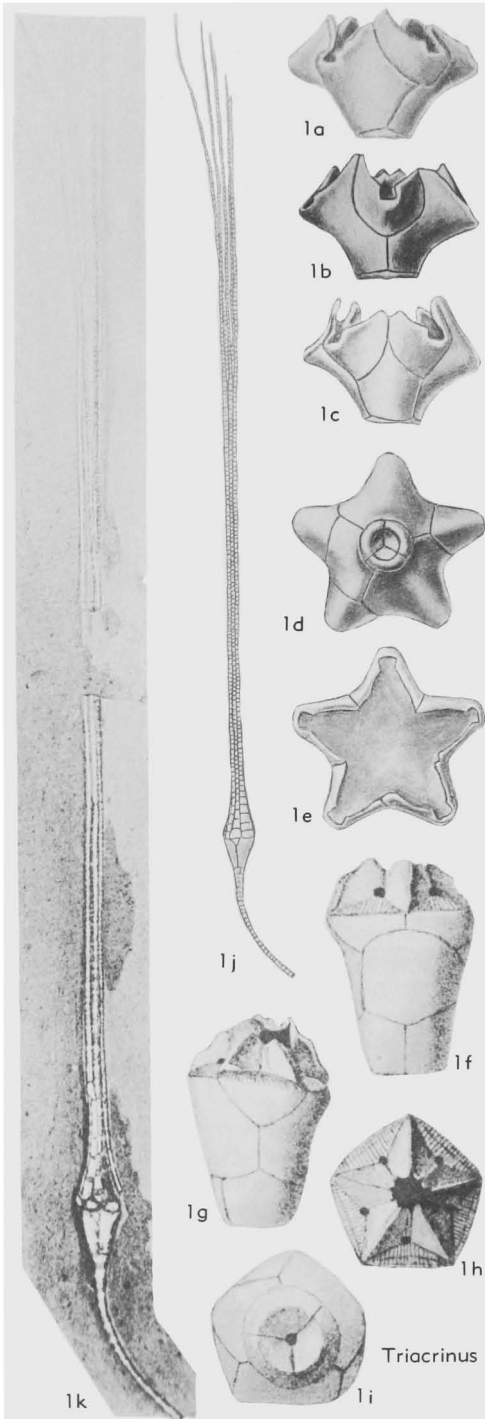


FIG. 333. Pisocrinidae (p. T536-T537).

tween the *B* superradial and *A* radial. Each of these 4 extra plates, as well as the 5 radials bears a long, slender, atomous arm so that nine arms are present in the crown. Anal *X* a small plate at the upper right corner of *D* radial; anal sac not known. *L.Dev.-M.Dev.*, Eu.(Ger.).—FIG. 332.5. \**C. decadactylus*, L.Dev., Ger.; 5*a-d*, *C*-ray, *AE*-interray, *B*-ray, and *E*-ray views of cup and proximal brachials,  $\times 1$ ; 5*e*, plate diagram of cup,  $\times 1$ ; 5*f*, lat. view of crown and stem,  $\times 0.5$  (Schmidt, 1934).

**Ciceroocrinus** SOLLAS, 1900, p. 267 [\**C. elegans* SOLLAS, 1900 (May), p. 27; M] [= *Lagarocrinus* JAEKEL, 1901 (Sept.), p. 480 (type, *L. osiliensis*)]. Cup high and conical, with upright elongate basals. Arrangement of cup plates like that of *Pisocrinus*. Anal *X* small, on upper right shoulder of *D* radial. Arms branch on second primibrach in all rays, each arm with 2 main rami or with an additional division high above cup. Secundi-brachs bear stout unbranched ramules on alternate sides of every second brachial. *U.Sil.*, Eu.(Eng.-Sweden-USSR).—FIG. 332.3. \**C. elegans*, Eng.; 3*a*, lat. view of crown and stem,  $\times 1.5$ ; 3*b*, lat. view of arms,  $\times 2$  (Sollas, 1900).

**Jaekelicrinus** YAKOVLEV, 1949, p. 435 [\**J. bashkiricus*; OD]. Cup small, cone shaped; basals 3 or 4; *A* and *D* radials large, each with 2 small arm facets; *B* inferradial large, with single arm facet; several small pararadials interposed between upper angles of *A* radial and *B* inferradial, each with single arm facet; 10 arm facets in all; arms and stem unknown. *U.Dev.*, Eu.(USSR).—FIG. 332.2. \**J. bashkiricus*; 2*a-d*, diagrams of lat. view of cup, basal view, plate diagram of cup,  $\times 2$ , and enlargement of pararadials (Yakovlev, 1949b).

**Parapisocrinus** MU, 1954, p. 331 [\**Pisocrinus ollula* ANGELIN, 1878, p. 21; OD] [= *Ollulocrinus* BOUŠKA, 1956, p. 28 (obj.)]. Like *Pisocrinus* except basal circlet small, circular in outline and confined to bottom of basal concavity. Basals 5, equal, and completely covered by proximal columnal. Recurved proximal edges of the *D* and *A* radials and *B* inferradial form lateral walls of basal concavity; interradial prongs prominent. *U.Sil.-L.Dev.*, Eu.(Gotl.-Czech.)-USA (Tenn.-Ill.-Mo.)-Australia.—FIG. 332.4*a,b*. \**P. ollula* (ANGELIN), *U.Sil.*, Boh.; basal and *B*-ray view of cup,  $\times 5$  (Bouška, 1956).—FIG. 332.4*c,d*. *P. quinquelobus* (BATHER), *U.Sil.*, Boh.; *CD*-interray and basal views of cup,  $\times 5$  (Bouška, 1956).

**Triacrinus** MÜNSTER, 1839, p. 3 [\**T. pyriformis*; SD WACHSMUTH & SPRINGER, 1886, p. 175] [= *Trichocrinus* MÜLLER, 1856, p. 354 (type, *T. altus*); non *Triacrinus* RINGUEBERG, 1884, p. 144 (= *Pisocrinus* DE KONINCK, 1858, p. 104)]. Like *Pisocrinus* except there are 3, rather than 5, basals in the cup. Cup commonly pentalobate in oral or aboral view. *U.Sil.-U.Dev.*, Eu.(Ger.-Gotl.-Boh.-USSR).—FIG. 333.1*a-e*. *T. regnelli* BOUŠKA, *U.Sil.*, Boh.; 1*a-e*, *CD*-interray, *E*-ray, *BC*-inter-

ray, basal, and ventral views of cup,  $\times 5.6$  (Bouška, 1956).—FIG. 333, *1f-i*. *T. altus* (MÜLLER), M.Dev., Ger.; *1f-i*, *BC*-interray, *E*-ray, ventral, and basal views of cup,  $\times 1.7$  (Schultze, 1867).—FIG. 333, *1j-k*. *T. elongatus* (FOLLMAN), L.Dev., Ger.; *1j-k*, lat. views of crown and stem,  $\times 0.75$ ,  $\times 1.12$  (Schmidt, 1934).

## Superfamily ALLAGECRINACEA Carpenter & Etheridge, 1881

[*nom. transl.* MOORE & STRIMPLE, 1973, p. 16 (*ex Allagecrinidae* CARPENTER & ETHERIDGE, 1881, p. 292)] [Materials for this superfamily prepared by R. C. MOORE and H. L. STRIMPLE]

Crown slender, moderately tall, mostly with many rope- or threadlike unbranched uniserial arms, rarely with fewer than five arms or armless as adults. Cup conical or bowl shaped; basals five or fused to one; radials upflaring, nearly equal or very unequal, with *A* and *D* much larger than others, large radials with multiple arm facets. Anal tube cylindrical, tall, composed of superposed brachial-like plates. Stem transversely circular. Bilateral symmetry in plane through *E* ray and *BC* interrayer remarkably developed in several genera. *Ord.*; ?*Sil.*; *Dev.-Perm.*

### Family ALLAGECRINIDAE Carpenter & Etheridge, 1881

[Allagecrinidae CARPENTER & ETHERIDGE, 1881, p. 292]  
[=Allagecrininae MOORE, 1940b, p. 111]

Microscopic to relatively small monocyclic crinoids with slender, tall crown having few to very many or closely appressed arms directed straight upward, rarely with fewer than five arms or armless as adults. Cup ranging from narrowly conical (among microcrinoids) to medium high or low bowl shaped, truncate at summit. Transverse outline normally circular to slightly elliptical but may be pentalobate or stelliform; horizontal base largely or entirely covered by proximal columnal; basals visible or invisible from side, consisting of five diminutive plates or fused to 3 or single moderately large solid one; radials five, sloping steeply upward, or longitudinally rounded to bulbous, planate radial articular facets gently hollow to rather deeply excavate, facets on different radials ranging from single ones to as many as 34, all relatively narrow and elongate in direction toward interior of cup, devoid of transverse ridge or distinct muscle areas. Dome-

shaped circlet of orals in microcrinoid adults, as well as in immature stages of larger forms and in diminutive adults. Anal *X* plate present in most genera but absent in some. Followed by linear series of medium-sized extraordinarily thick plates resembling brachials, all together forming tall, erect, anal tube which may extend well above distal extremities of arms. Unbranched cylindrical arms well rounded externally and grooved internally, lacking pinules. Elongate brachials with smooth truncate articular facets, oriented with planes normal to arm axis. Stem transversely circular or slightly elliptical, composed of homeomorphic or moderately heteromorphic columnals, stem tapering distally. *U. Dev.-U. Perm.*

The most distinctive morphological features of crinoids included in the Allagecrinidae are 1) occurrence of multiple unbranched arms on one or more radials of most genera (larviform adults in such genera as *Kallimorphocrinus*, *Desmacriocrinus*, and *Trophocrinus* excluded), and 2) distinct to strongly accentuated development of homocrinoid bilateral symmetry. Commonly, the *C* radial is developed as an aniradial but in some allagecrinine forms it is not.

Best development of multiple arms is seen in the Catillocrinidae, all genera of which show this feature. Maximum development of arms is found in the *A* and *D* rays (Tables 6, 7). In *Catillocrinus* as many as 34 arm facets are found on the *A* radial and 24 on the *D* radial, whereas the *B*, *C*, and *E* radials bear only single arm facets, thus indicating a total of 61 arms on the cup as a whole (see Table 6). The cup of *Eucatillocrinus* has up to 50 arms, with 22 on the *A* radial and 17 on the *D* radial (see Table 6). *Isocatillocrinus* is unique in that multiple arm facets occur on all radials.

Homocrinoid bilateral symmetry is recognized but weakly developed in most genera of the Allagecrinidae (lacking in *Desmacriocrinus*, *Kallimorphocrinus*, and *Trophocrinus*) (see Table 6). In the Catillocrinidae, on the other hand, homocrinoid bilateral symmetry is very distinct to strongly accentuated (Fig. 334).

*Allagecrinus* CARPENTER & ETHERIDGE, 1881, p. 282 [\**A. austinii*; OD] [= *Hybochlocrinus* J. M. WELLER, 1930a, p. 21 (type, *Allagecrinus ameri-*

TABLE 6. *Arms and Basal Plates of Allagecrinidae and Catilloocrinidae.*

[Explanation: A-E, CARPENTER designations of radials; BB, number of basals; Ref., reference; Total, total number of arms in adult; \*, type species.]

	D	E	A	B	C	Total	BB	Ref.
<b>ALLAGECRINIDAE</b>								
*Allagecrinus austinii	2	1	6	2	1	12	3	1, 14
Allagecrinus americanus	2	1	3	2	1	9	1	6a, b
*Desmacriocrinus weldenensis	?	1	?	1	1	3+	5	9
*Isoallagecrinus bassleri	5	1	4	3	1	14	3	8
Isoallagecrinus pecki	2	1	1	2	1	7	1	4
*Kallimorphocrinus astrus	1	1	1	1	1	5	1	13a
Kallimorphocrinus odiosus	0	0	0	0	0	0	1	13b
*Metallagecrinus quinquebrachiatus	1	1	1	1	1	5	1	11b
Metallagecrinus dux	2	1	5	3	1	12	1	12
Metallagecrinus multibrachiatus	3	1	3	4	1	12	1	16
*Stereobrachiocrinus pustulosus	?	?	?	?	?	?	?	3
*Thaminocrinus bplex	4	1	5	1	2-5	13-16+	3	15
*Trophocrinus tumidus	0	1	0	0	0	1	3	2
Trophocrinus corpulentus	1	1	0	0	1	3	1	7a
Trophocrinus exsertus	1	1	1	1	1	5	1	7b
*Wrightocrinus jakovlevi	4	1	3	1	1	10	1	11a
<b>CATILLOCRINIDAE</b>								
*Catillocrinus tennesseae	24	1	34	1	1	61	3	5
*Allocatillocrinus carpenteri	7	1	8	5	1	22	3	5
*Eucatillocrinus bradleyi	17	1	22	6	4	50	3	5
*Isocatillocrinus indicus	7	9	8	6	4	34	1	5
*Metacatillocrinus bulbosus	9	1	8	1	1	20	1	5
*Mycocrinus boletus	6	1	7	1	1	16	3	5
*Neocatillocrinus incisus	7	1	9	6	1	24	1	5
*Paracatillocrinus granulatus	8	1	10	1	1	21	3	5
*Xenocatillocrinus wrighti	8	1	10	5	4	28	?3	5

REFERENCES: 1, Carpenter & Etheridge, 1881, pl. 15, fig. 1b.—2, Kirk, 1930, p. 211.—3, Mather, 1915, p. 108.—4, Moore, 1940b, p. 125.—5, Moore, 1962b, p. 27.—6, Peck, 1935 (a, p. 766; b, p. 768).—7, Peck, 1936 (a, p. 285; b, p. 287).—8, Strimple, 1959, p. 116.—9, Strimple, 1966c, p. 109.—10, Strimple & Koenig, 1956, p. 1233.—11, Wanner, 1929b (a, p. 15; b, p. 24).—12, Wanner, 1930a, p. 23.—13, Weller, 1930a (a, p. 17; b, p. 28).—14, Wright, 1933, p. 203.—15, Wright, 1941, p. 294.—16, Yakovlev, 1927b, p. 191.

*canus* ROWLEY, 1895, p. 219; OD)]. Cup truncate bowl shaped or with straight sides flaring upward (greatest diameter in adults 1.5 to 6 mm.); basals 3 or fused to single plate; radials nearly equal to distinctly unequal in width, with largest ones in A and D rays, single arm facets on C and E radials, others multifaceted, with observed maximum of 6 on A radial; left shoulder on C radial with curved or straight bevel for reception of anal X plate (Fig. 334.3). Circling of orals forming dome above cup in immature stages but generally lost in adults. Subcylindrical arms nearly equal in diameter, moderate in height, composed of elongate brachials. Stem composed of circular low columnals narrowing distally. *U.Dev.-L.Miss.(Kinderhook.-Osag.)*, USA (Mo.-N. Mex.); *L.Carb.(Visean)*, Eu.(Scot.).—FIG. 335, 7a-d. \**A. austinii*, *L.Carb.(Visean)*, Scot.; 7a,b, E- and B-ray views of specimen with attached

proximal primibrachs and part of tapering stem,  $\times 10$ ; 7c,d, C-ray and dorsal views (A ray below) of cup,  $\times 10$  (all Wright, 1951-54).—FIG. 335,7e,f. *A. americanus* (ROWLEY), *U.Dev.(Louisiana Ls.)*, USA (Mo.); C-ray and ventral views of cup,  $\times 20$  (J. M. Weller, 1930).

*Desmacriocrinus* STRIMPLE, 1966, p. 109 [\**Kallimorphocrinus weldenensis* STRIMPLE & KOENIG, 1956, p. 1234; OD]. Similar to *Kallimorphocrinus* but distinguished by 5 small basals and prominent dome of oral plates, articular facets for arms known only on B, C, and E radials; no anal notch in posterior interray. *U.Dev.(Louisiana Ls.)*, USA (Mo.); *L.Miss.(Welden F.)*, USA (Okla.).—FIG. 335,1. \**D. weldenensis* (STRIMPLE & KOENIG), *L.Miss.(Welden F.)*, USA (Okla.); 1a-c, ventral, CD-interray, and A-ray views of holotype,  $\times 17$ ; 1d-f, ventral, CD-interray, and dorsal

views of paratype,  $\times 17$  (Strimple & Koenig, 1956).

**Isoallagecrinus** STRIMPLE, 1966, p. 105 [*\*Allagecrinus bassleri* STRIMPLE, 1938, p. 1; OD]. Similar to *Allagecrinus* but distinguished by its strongly depressed bowl-shaped cup and markedly convex radials, which may be distinctly tumid, in immature stages giving cups stelliform shape; basals 3, forming low, flat disc. Arms moderately tall, slender and threadlike, except for single robust ones borne by C and E radials, maximum observed number of arms 14 (see Table 6); where known, sequence in appearance of first arms is on radials C, E, B, D, and A (see Table 6). *M. Penn. (Atoġan)*-*L. Perm. (Wolfcamp.)*, USA (Texas-Okla.-Kans.-Mo.-Ill.).—FIG. 335,3. *\*I. bassleri* (STRIMPLE), U.Penn. (Missour., Wann F.), USA (Okla.); *3a*, D-ray view of crown, with smaller arms borne by this radial and robust ones in C (at right) and E (at left) radials,  $\times 4$ ; *3b,c*, ventral (A ray above) and dorsal (A ray below) views of typical cup,  $\times 4$ ; *3d*, dorsal view of small immature stage showing stelliform shape of cup,  $\times 4$  (all Strimple, 1938).

**Kallimorphocrinus** J. M. WELLER, 1930, p. 15 [*\*K. astrus typicus* (= *K. astrus astrus*), p. 17; OD] [= *Aidemocrinus* J. M. WELLER, 1930, p. 28 (type, *A. odiosus*; OD); *Callimorphocrinus* PECK, 1936, p. 287 (*nom. van.*) (*obj.*)]. Cup truncate conical, mostly taller than wide, pentamerously symmetrical with evenly expanded to nearly vertical sides; basals 3 or fused to solid disc; radials each with single crescentic arm facet (except *K. elongatus* WRIGHT, which may have total of 8 arm facets) or armless (*K. odiosus* (WELLER), Table 6), left shoulder of C radial not beveled for support of anal plate; summit with cirlet of moderately prominent orals, that of CD interray larger than others and bearing small hydropore (Fig. 334,1). Only primibrachs known as part of arms. Stem composed of low, circular columnals, tapering slightly in distal direction, generally not preserved. [Ontogenetic studies indicate that various allagecrinid and catillocrinid genera (e.g., *Allagecrinus*, *Allocatillocrinus*) have an initial larval stage which is similar to or identical with *Kallimorphocrinus* and on this basis the genus is interpreted as a primitive member of the family. Distinct asymmetry of the cup and development of multiple arm facets on some of the radials characterize ontogeny subsequent to the *Kallimorphocrinus* stage.] *L. Miss. (Kinderhook-Osag.)*, USA (Okla.-Mo.-N.Mex.-Nev.); *L. Carb. (Visean)*, Eu. (Scot.); *L. Penn. (Morrow.)*, USA (Ind.-Ill.-Mo.).—FIG. 335,4. *\*K. astrus*, *L. Penn.*, USA (Ind.); *4a,b*, lat. and dorsal views of holotype,  $\times 20$ ; *4c*, ventral view of another specimen,  $\times 20$  (all J. M. Weller, 1930).

**Metallagecrinus** STRIMPLE, 1966, p. 109 [*\*Allagecrinus quinquebrachiatus* WANNER, 1929b, p. 24; OD]. Cup evenly expanded upward, truncate

TABLE 7. Sequence of Appearance of First Arms During Ontogeny of Allagecrinid Species.

[Explanation: A-E, CARPENTER designations of radials; numbers 1-5 indicate sequence in appearance of arms.]

	D	E	A	B	C
<i>Allagecrinus austinii</i>	4	2	5	3	1
<i>Allagecrinus americanus</i>	4	2	5	3	1
<i>Isoallagecrinus pecki</i>	4	2	5	3	1
<i>Kallimorphocrinus angulatus</i>	3	2	5	4	1

conical; basals 3 or solidly fused, low to medium in height and visible from side; radials 5, subequal, each normally with single arm facet; cirlet of 5 orals moderately elevated, posterior oral separating BC and DE orals; like *Kallimorphocrinus* in lacking anal notch. *L. Perm. (Artinsk.)*-*U. Perm. (Basleo beds)*, Eu. (USSR)-Indon. (Timor).—FIG. 335,8. *\*M. quinquebrachiatus* (WANNER), *U. Perm.*, Timor (Basleo); *8a,b*, A-ray and dorsal views of holotype,  $\times 5$ ; *8c*, ventral view of holotype (A ray directed upward),  $\times 7.5$ ; *8d,e*, B-ray and ventral views of another specimen,  $\times 5$ ; *8f*, CD-interray views of another cup,  $\times 5$  (all Wanner, 1929b).

**?Stereobranchicrinus** MATHER, 1915, p. 108 [*\*S. pustulosus*; OD]. Cup unknown; genus based on dissociated solidly fused uniserial arms with nearly straight sides, well-rounded outer surface, and narrowly grooved ambulacrum on inner side. *L. Penn. (Morrow.)*, USA (Okla.-Ark.).—FIG. 335,6. *\*S. pustulosus*, Brentwood Ls. mbr., Bloyd Sh., NW. Ark. (Washington Co.); *6a,b*, side and outer surface of typical arm,  $\times 1.5$  (Moore & Plummer, 1938).

**Thaminocrinus** STRIMPLE & WATKINS, 1969, p. 217 [*\*Allagecrinus bplex* WRIGHT, 1933, p. 206; OD]. Similar to *Wrightocrinus* but much smaller, in having more numerous arms in A and C rays (see Table 6), anal series borne by left shoulder of C radial, and in lacking preserved oral cirlet in adults. *L. Carb. (Visean)*, Eu. (Scot.).—FIG. 336,1. *\*T. bplex* (WRIGHT); *1a-d*, C-ray, E-ray, ventral, and B-ray views of typical specimens,  $\times 12$  (Wright, 1941).

**Trophocrinus** KIRK, 1930, p. 210 [*\*T. tumidus*; OD]. Calyx tall conical to pyriform, morphologically similar to *Kallimorphocrinus* except for hypertrophic extensions of summit parts of some radials so as to form pouchlike structure or structures; basals 3, unequal, with azygous small plate in CD interray; radials 5, D and E largest, single arm facet on E radial in type species but additional facets (none multiple) on other radials in different species; oral cirlet evenly domelike, with posterior oral distinctly largest. [KIRK's inter-

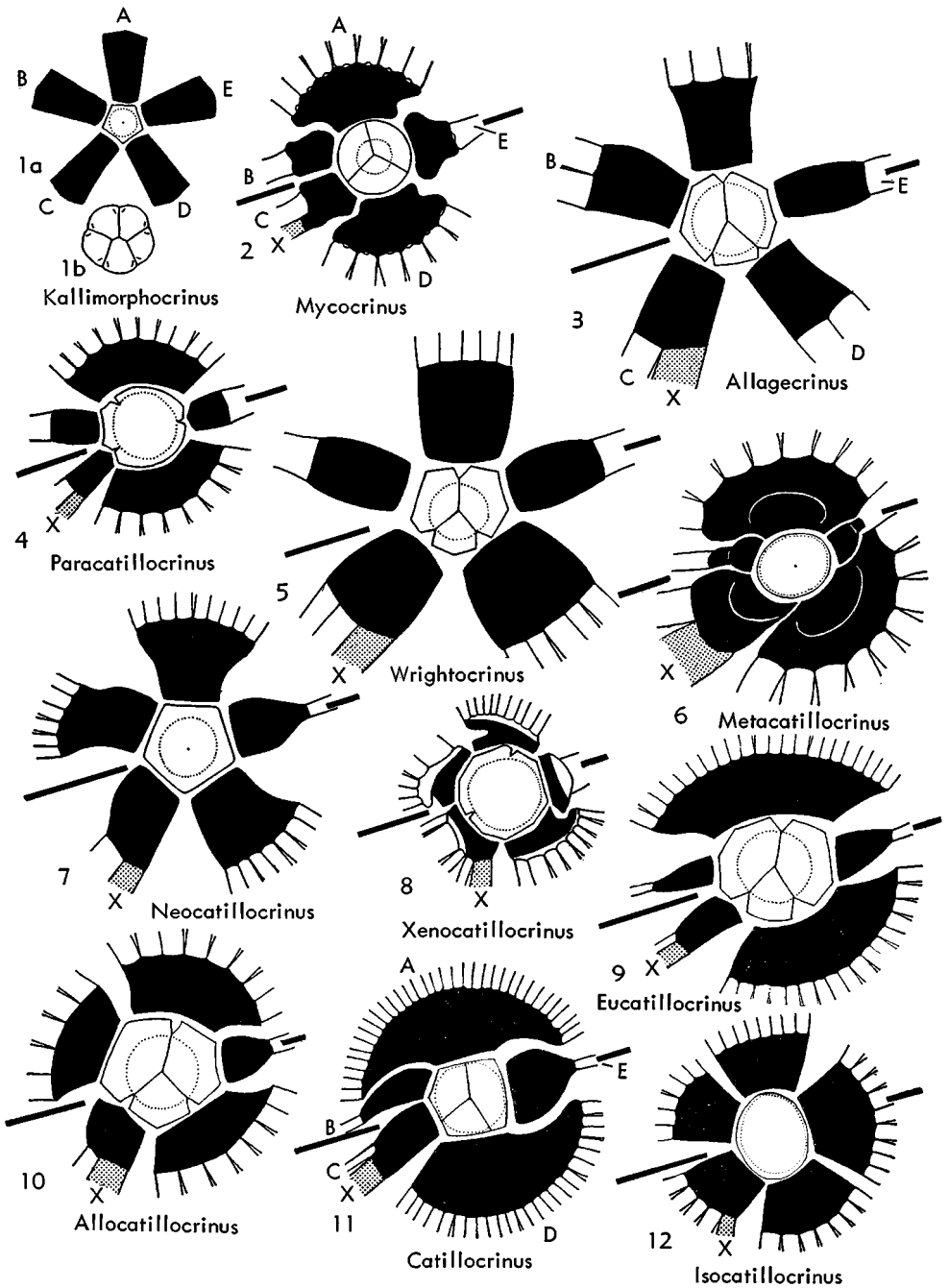


FIG. 334. Diagrammatic dorsal side views (not to scale) showing structure of allagegerinid cups with proximal parts of attached arms (radials black) and anitaxis (stippled) borne by C radius [A ray directed upward in all figures] (Moore, 1962a).

pretation of the marginal extensions borne by some radials as development of a type of brood

pouch is discounted, especially since 2 such pouches appear in *T. bicornis* (STRIMPLE &

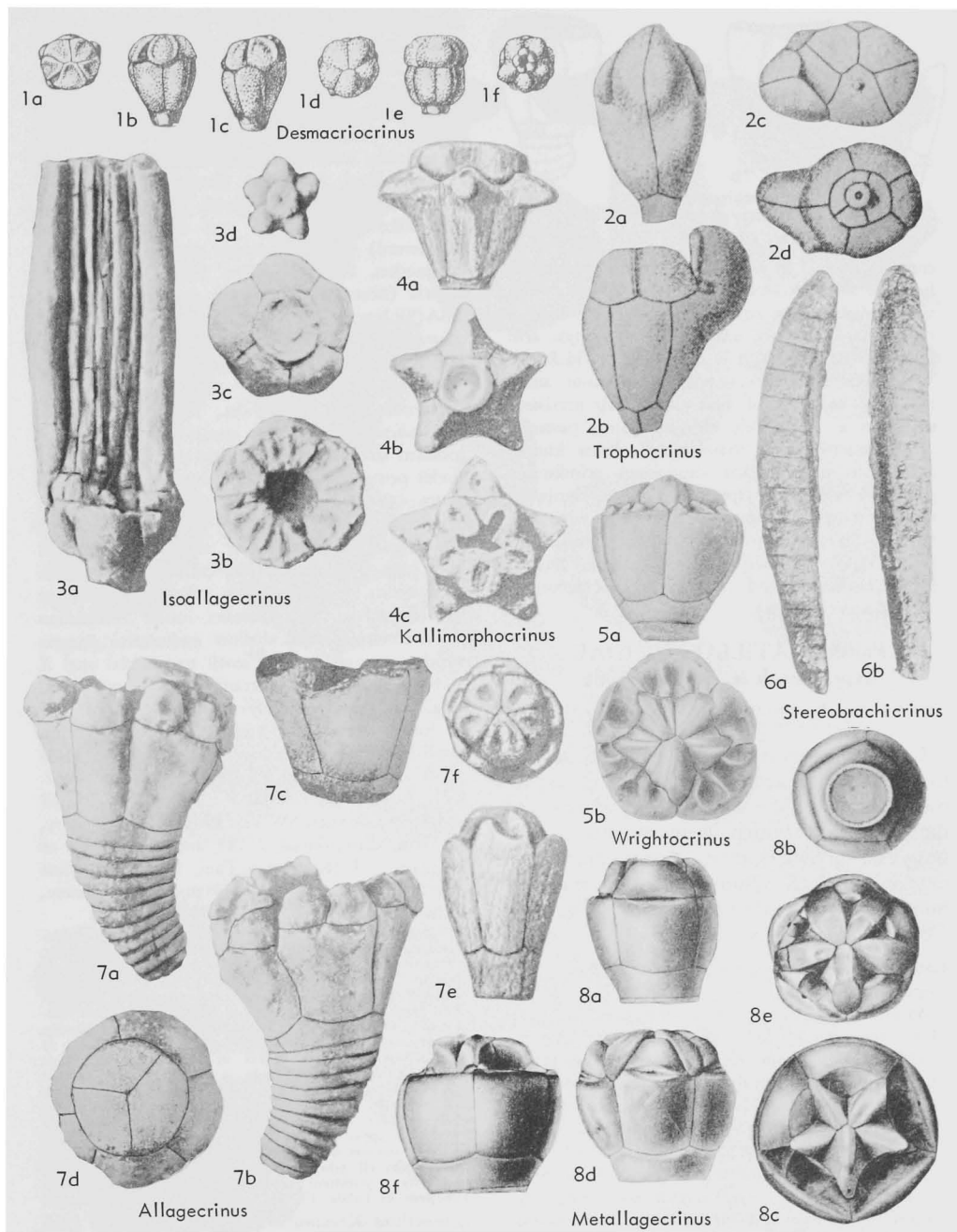


FIG. 335. Allagecrinidae (p. T537-T542).

KOENIG, 1956, p. 1238).] *L. Miss.* (*Kinderhook-Osag.*), USA (Okla.-Mo.).—FIG. 335, 2. \**T. tumidus*, Kinderhook (Sycamore Ls.), USA (S. Okla.); 2a, b, DE-interray and A-ray views of holotype,  $\times 25$ ; 2c, d, ventral (posterior oral down)

and dorsal (C radial down) views of holotype,  $\times 25$  (Kirk, 1930).

*Wrightocrinus* MOORE, 1940, p. 92 [\**Allagecrinus jakovlevi* WANNER, 1929b, p. 15; OD]. Calyx small (height 1.5 to 4.5 mm.), pyriform or low

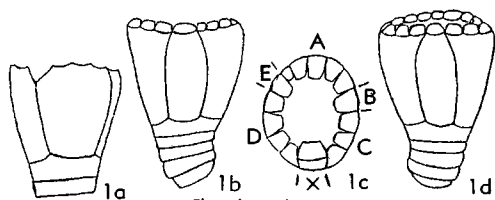


Fig. 336. *Thaminoocrinus*  
Allagecrinidae (p. T539).

conical; basals 3 in some specimens but commonly fused to solid moderately high circlet visible from side; radials nearly equal in width but *B* and *E* radials narrower than others and with single arm facet instead of multiple facets (Fig. 334,5; see Table 6); *CD* interray with or without small notch for reception of anal plate; orals persistent in adults as moderately elevated dome, posterior oral distinctly larger than others. Arms known only from quadrangular dissociated primibrachs preserved with some specimens. Stem composed of low, round columnals, tapering somewhat distally. *U.Perm.* (*Basleo beds*), Indon. (Timor).—FIG. 335,5. \**W. jakovlevi* (WANNER), *Basleo*; 5*a,b*, *CD*-interray and ventral views of holotype,  $\times 5$  (Wanner, 1929b).

#### Family CATILLOCRINIDAE Wachsmuth & Springer, 1886

[Catillocrinidae WACHSMUTH & SPRINGER, 1886, p. 118(194)]  
[=Catillocrininae MOORE, 1940b, p. 112]

Cup low truncate conical or bowl shaped to discoid, characterized by strong asymmetry produced by enlargement of two radials (*A*, *D*) which bear numerous unbranched slender arms, accompanied by marked bilateral symmetry with respect to homocrinoid plane (*E-BC*). *L.Ord.*; *M.Dev.*; *L.Miss.-M.Penn.*; *U.Perm.*

*Catilloocrinus* SHUMARD, 1865 (Oct.), p. 357 [catalogue publ. in parts (Aug., 1865, to Feb., 1866) and ultimately in complete volume issued in 1868] [\**C. tennesseae*; M] [= *Catillocrinites* TROOST, 1850*a*, p. 419 (*nom. van.*); *Nematocrinus* MEEK & WORTHEN, 1866*b* (July), p. 251 (type, *Synbathocrinus wachsmuthi* MEEK & WORTHEN, 1866*b*, p. 251; M); *Catillocrinus* S. A. MILLER, 1889, p. 231 (*nom. null.*)]. Crown relatively tall, subcylindrical, with multitudinous threadlike arms closely appressed to one another and rising vertically. Cup low truncate cone or bowl shaped, with flat discoid basal circlet normally composed of 3 plates not visible or only barely visible from side; radials exceptionally dissimilar in size, with many-armed *A* and *D* radials occupying at least 0.8 of summit periphery of cup, *B*, *C* and *E* radials with single arm facets (Fig. 334,11); *C* radial with raised process on left shoulder for support of large anal tube, which is composed

of much thickened, massive, armlike plates, crescentic in cross section, anal tube extended to distal extremities of arms or above. Transversely circular stem composed of wide low columnals next to cup, tapering distally. *L.Miss.* (*Osag.*), USA (Ky.-Tenn.-Ind.-Iowa).—FIG. 337,2*a-c*. \**C. tennesseae*, New Providence F., USA (Ky.); 2*a-c*, *C*-ray, ventral (*C* radial downward, *A* and *D* radials at left and right with extremely narrow groove-like arm facets), and dorsal (*E* radial downward) views of holotype cup, all  $\times 1$  (Moore & Laudon, 1943*a*).—FIG. 337,2*d,e*. *C. wachsmuthi* (MEEK & WORTHEN), up. Burlington Ls., USA (SE.Iowa); 2*d*, *B*-ray view of well-preserved crown,  $\times 1.5$  (Wachsmuth & Springer, 1886); 2*e*, *BC*-interray view of another crown,  $\times 1.5$  (Springer, 1923*a*).

*Acolocrinus* KESLING & PAUL, 1971, p. 228 [\**A. hydraulicus*; OD]. Cup truncate conical below rounded midheight and vertical sided above; basal circlet pentagonal in outline, composed of 2 large plates (*CDE*, *EAB*) and a small one (*BC*); 5 compound radials, consisting of subquadrangular inferradials and somewhat smaller superradials with pronglike upward projections on right sides of summits, several slender unbranched arms at left of prongs, their concave round articulation facets confluent with shallow ambulacral grooves which converge inward; small trapezoidal anal *X* between *C* and *D* superradials; outer surface of basals and radials deeply reticulate, that of anal *X* finely granulose. Stem transversely round, small, attached to cup in steep-sided basal concavity. *L.Ord.*, USA (Va.-Tenn.).—FIG. 338,2. \**A. hydraulicus*, Benbolt F., Ottosee Gr., Russell and Scott Counties, SW.Va., and Hawkins County, SE.Tenn.; 2*a-c*, dorsal, *D*-ray, and *E*-ray views of holotype,  $\times 4$  (Kesling & Paul, 1971); 2*d*, plate diagram showing proximal parts of arms (Moore, n, based on Kesling & Paul, 1971, fig. 3).

[*Acolocrinus* is like *Allagecrinus* and at least five catillocrinid genera (*Catilloocrinus*, *Wrightocrinus*, *Eucatilloocrinus*, *Allocatilloocrinus*, and *Paracatilloocrinus*) in having a tripartite basal circlet with 1 small and 2 large plates, although only in *Paracatilloocrinus* is the small basal located in the *BC* interray. This resemblance is not considered to be especially significant, however. Likewise, the presence of a small anal *X* supported by the *C* or *D* radial in the *CD* interray in *Acolocrinus* and these genera is not diagnostic. It is the numerous, simple, small, unbranched arms joined to summits of the radials that provides basis for placement of *Acolocrinus* in the Catillocrinidae, among which the division of radials into lower and upper parts by a transverse suture and prongs on right corners of superradial summits distinguishes this genus from all others. The biradial construction is undoubtedly a primitive trait. Segregation of the arms on left parts of radials links *Acolocrinus* with *Agostocrinus*.]

*Agostocrinus* KESLING & PAUL, 1971, p. 222 [\**A. xenus*; OD]. Cup rotund bowl shaped, truncate with 3 equal basals, 5 moderately tall radials with prominent leftward extensions at summit consisting of semifused arm main-axils similar to those found in several calceocrinid genera, separated on posterior side by large quadrangular anal *X* plate which rests on *CD* basal. Orals 5, large posterior one clearly or indistinctly divided longi-

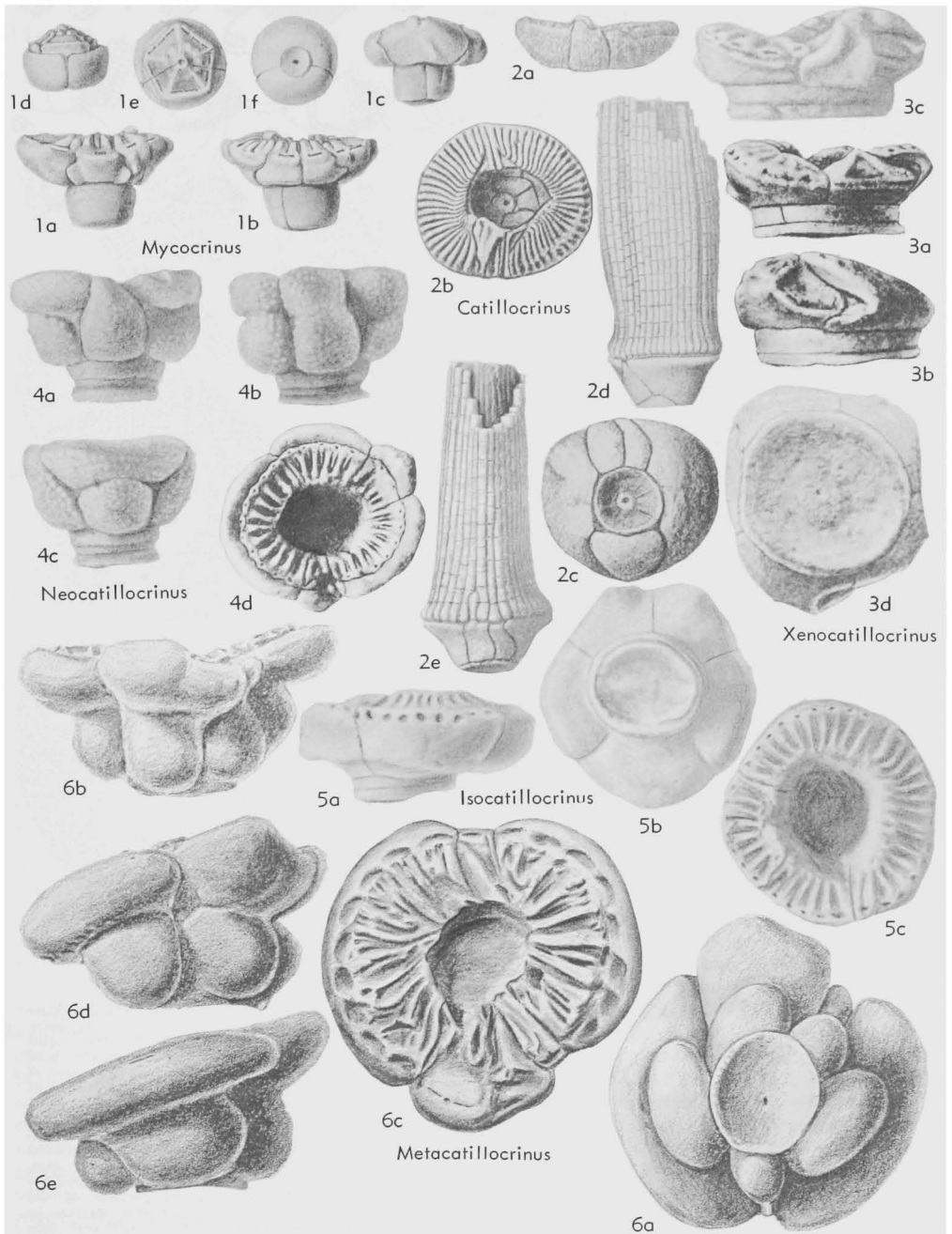


FIG. 337. Catilloocrinidae (p. T542, T545-T547).

itudinally into halves and containing large, round anal opening subequal in size to centrally located circular mouth and provided with cylindrical lining which reaches downward in cup halfway to

its base. Arms very slender, unbranched, 10 to 16 on each radial (50 to 72 in all), with somewhat elevated round facets on outer edges of radials formed by incorporated arm main-axil ele-



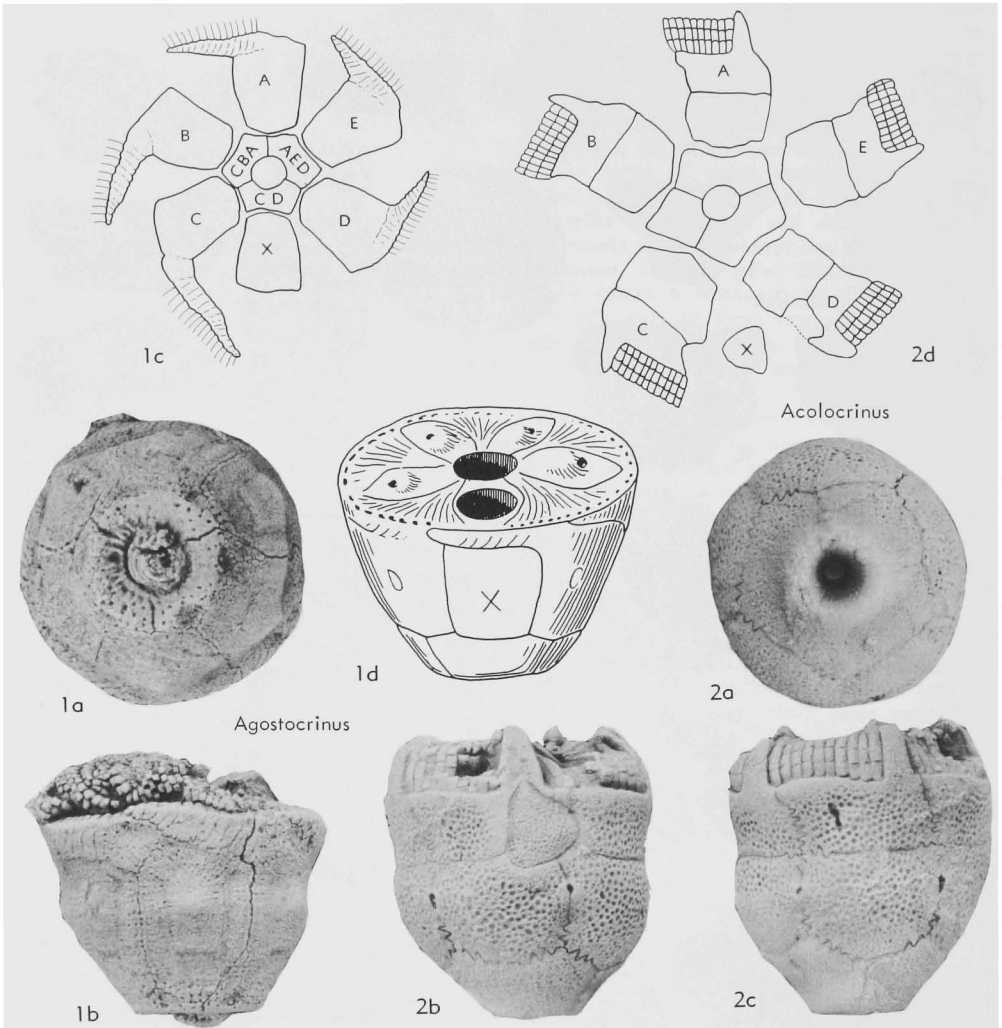


FIG. 338. Catillocrinidae (p. T542-T544).

ments, shallow ambulacral grooves converging toward mouth. Stem transversely circular. *L.Ord.*, USA (Va.).—FIG. 338, 1. \**A. xenus*, Benbolt F. (Ottosee Gr.), Russell and Scott Counties, SW. Va.; 1a, b, dorsal and C-ray views of holotype, X4 (Kesling & Paul, 1971); 1c, plate diagram showing leftward extensions of radials formed by fused to semifused arm main axils and attached tiny arms (Moore, n, based on Kesling & Paul, 1971, fig. 1); 1d, oblique post. diagramm. view of cup showing radials with leftward extensions and on summit mouth and anal apertures, arm facets and ambulacral grooves (Moore, n).

[This genus has exceptionally interesting morphological features that contribute to studies of disparid evolution. Relationship to calceocrinids is indicated by the presence of arm main-axils as components of summit parts of the radials in manner demonstrating the origin of catillocrinid

radials, solidly fused plates each of which support multiple slender unbranched arms—as many as 30 or more borne by the A and D radials of *Catillocrinus*. The three equal basals of *Agostocrinus* correspond exactly to the basal cirlet of *Mycocrinus*, a catillocrinid, although anal X of the latter genus is carried by the C radial instead of by the CD basal as in *Agostocrinus*. The plane of bilateral symmetry observed in *Agostocrinus* differs in orientation from that found in all catillocrinids and calceocrinids (E-BC, homocrinoidal plane), for it runs through midlines of the A ray and CD interray (crinoidal plane). Also, distinctive characters of *Agostocrinus* are the uniform leftward extensions of arm main-axil portions of the radials and nature of the large, round anal aperture in the posterior oral (or paired orals). A tall anal tube found in various catillocrinids is lacking in *Agostocrinus*, but in spite of this and other considerations the genus defined by KESLING & PAUL is assigned here to the Catillocrinidae.]

*Alloctillocrinus* WANNER, 1937, p. 109 [\**Allagecrinus carpenteri* WACHSMUTH, 1882, p. 40; OD]. Crown tall and slender. Cup generally similar to

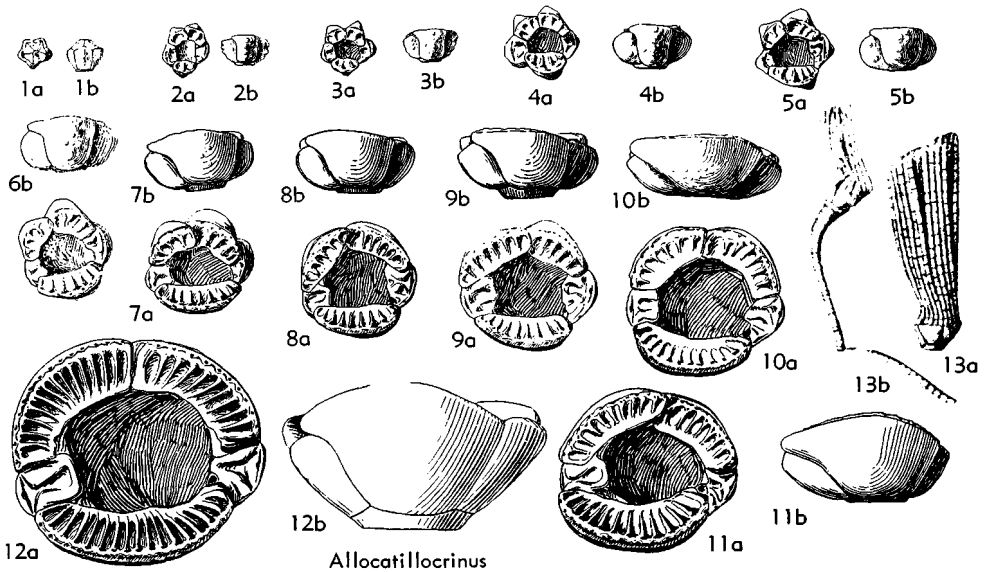


FIG. 339. Catilloocrinidae (p. T544-T545).

*Catillocrinus* except for presence of 3 large multifaceted radials (*A*, *B*, *D*) and beveled or even left shoulder of *C* radial for contact with anal *X* plate (Fig. 334,10); armlike anal tube with diameter 2 or 3 times that of arms, very elongate, commonly rising well above tips of arms. *U.Miss.* (*Chester.*), USA (Ill.-Ind.-Ala.-Tenn.); *L.Carb.* (*Visean*), Eu. (Scot.); *L.Penn.* (*Morrow.*), USA (Okla.).—FIG. 339,1-12. *A. rotundus* (MOORE), *L.Penn.* (*Morrow.*, Brentwood Ls.), USA (Okla.); 1-12, ventral and *D*-ray views of ontogenetic series of cups (1, *Kallimorphocrinus* stage; 2,3, *Allagecrinus* stage; 4-12, immature to fully grown adult *Allotatillocrinus* stage), all  $\times 3$  (Moore, 1940b).—FIG. 339,13. *\*A. carpenteri* (WACHSMUTH), *U.Miss.* (*Chester.*); 13a, *B*-ray view of crown from Monroe Co., Illinois,  $\times 1.5$  (Moore & Laudon, 1943a); 13b, *C*-ray view of crown with attached stem from Tennessee,  $\times 0.7$  (Wachsmuth & Springer, 1897).

*Eucatillocrinus* SPRINGER, 1923, p. 19 [*\*Catillocrinus bradleyi* MEEK & WORTHEN, 1868, p. 343; OD]. Crown tall and slender. Cup truncate conical, medium in height; basal cirlet composed of 3 plates or fused to solid piece with upflaring sides plainly visible in side view of cup; radials generally similar to *Catillocrinus*, with large, multifaceted *A* and *D* rays and others single armed (Fig. 334,9); *C* ray with even summit, its left part supporting first 2 plates of extremely long anal tube, which extends well above tips of threadlike arms. Long stem composed of low, round columnals, tapering distally near cup, but approximately uniform in diameter below this zone. *L. Miss.* (*Osag.*), USA (Ind.); *M. Penn.*

(*?Atoakan*), USA (Alaska).—FIG. 340,2. *\*E. bradleyi* (MEEK & WORTHEN), *Miss.* (Keokuk), Crawfordville, Ind.; *C*-ray view of incomplete crown with attached long stem and anal tube,  $\times 1$  (Springer, 1923a).

*Isocatillocrinus* WANNER, 1937, p. 109 [*\*I. indicus*; OD]. Cup very low, discoid, with greatest diameter about 14.5 mm.; basal disc solidly fused, barely visible from side; radials nearly equal in size and all multifaceted (Fig. 334,12); anal series unknown. *U.Perm.*, Indon. (Timor, Basleo).—FIG. 337,5. *\*I. indicus*; 5a-c, *B*-ray, dorsal (*E* ray below), and ventral (*E* ray above) views of holotype, all  $\times 2$  (Wanner, 1937).

*Metacatillocrinus* MOORE & STRIMPLE, 1942, p. 79 [*\*M. bulbosus*; OD]. Cup low, very asymmetrical, distinguished by strongly bulbous nature of radial-plate sides, all of which are divided by transverse constriction into upper flangelike part and laterally less extended subspherical or egg-shaped lower part; multifaceted *A* and *D* radials much enlarged, forming 0.8 of cup periphery, other radials single armed (Fig. 334,6), left part of distal surface of *C* radial flattened for attachment of anal tube; body cavity much restricted by lengthened and thickened radials; basals fused into single elliptical disc, which is very low and not visible or barely visible from side. Arms and stem unknown. *M.Penn.* (*Desmoines.*), USA (Okla.).—FIG. 337,6. *\*M. bulbosus*, Altamont Ls., Tulsa Co., Okla.; 6a-e, dorsal (*C* ray upward), *C*-ray, ventral (*E* ray upward), *CD*-interray, and *D*-ray views of holotype, distinct inclination of summit plane to base of cup illustrated in 6d and 6e, all  $\times 5$  (Moore & Strimple, 1942).

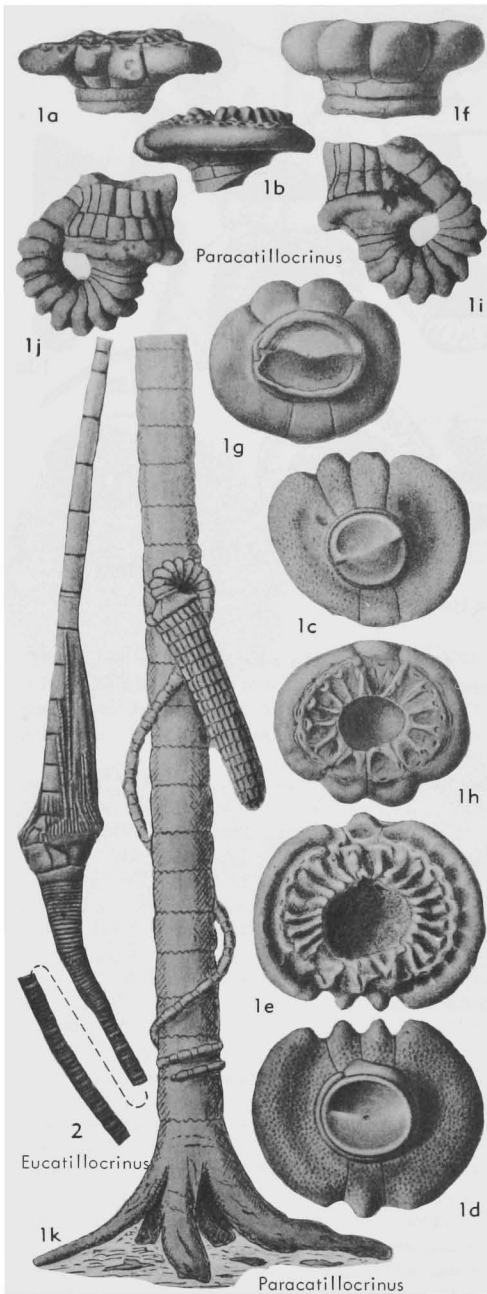


FIG. 340. Catilloocrinidae (p. T545-T546).

**Mycocrinus** SCHULTZE, 1867, p. 110 [*\*M. boletus*; M]. Cup with lower half consisting of massive, vertical-sided basal circling composed of 2 or 3 plates and upper half of broadly flaring radial circling similar to *Catilloocrinus* in having wide

multifaceted *A* and *D* radials, others bearing single arms (Fig. 334,2; see Table 6), left shoulder of *C* radial elevated for support of anal plate. Stem impression moderately small, circular. *M. Dev.*, Eu.(Ger.).—FIG. 337,1. *\*M. boletus*; 1a-c, complete cup from *E*-ray, *BC*-interray, *A*-ray sides,  $\times 2$ ; 1d-f, basal circling from *A*-ray, ventral, and dorsal sides,  $\times 2$  (all Schultze, 1867).

**Neocatilloocrinus** WANNER, 1937, p. 117 [*\*N. incissus*; OD]. Cup moderately small (greatest width about 9.5 mm.), bowl shaped, with low, fused, vertical-sided circling, visible from side, surmounted by strongly bulbous radials, in all except *E* ray divided into upper and lower halves by transverse constriction as in *Metacatilloocrinus*, lower parts rather evenly bulbous and upper parts flaring sideward; arm distribution on radials similar to that of *Allocatilloocrinus* (Fig. 334,7), left shoulder of *C* radial with attachment for anal plate. *U. Perm.*(*Basleo beds*), Indon.(Timor, Basleo).—FIG. 337,4. *\*N. incissus*; 4a-d, *E*-ray, *C*-ray, *A*-ray, and ventral (*E* ray downward) views of holotype,  $\times 3$  (Wanner, 1937).

**Paracatilloocrinus** WANNER, 1916, p. 6 [*\*P. granulatus*; OD]. Crown moderately tall, cylindrical, with slender, closely appressed vertical arms, articular facets of brachials transversely aligned. Cup turreted-discoid, with vertical-sided basal circling composed of 3 or 2 plates or single fused plate, visible from side; strongly convex radials flare outward, distribution of arms in pattern of *Catilloocrinus* (see Table 6) but facets wider and much fewer (Fig. 334,4). Stem transversely elliptical next to cup and joined to it somewhat obliquely, proximal part strongly curved and narrowing downward to merge with part of stem composed of moderately tall cylindrical columnals. *U. Perm.*(*Basleo beds*), Indon.(Timor, Basleo).—FIG. 340,1a-e, i-k. *\*P. granulatus*; 1a-c, *CD*-interray, *A*-ray, and dorsal (*CD* interrayer upward) views of holotype,  $\times 2$  (Wanner, 1916a); 1d-e, dorsal (*B* ray downward) and ventral (*B* ray upward) views of paratype,  $\times 2$  (Wanner, 1916a); 1i,j, complete crown with attached proximal part of stem from *A*- and *D*-ray sides,  $\times 2$  (Wanner, 1930a); 1k, complete specimen (reconstr.) showing presumed mode of attachment and pendent attitude of crown,  $\times 1$  (Wanner, 1930a).—FIG. 340,1f-h. *P. ellipticus* WANNER, *BC*-interray, dorsal (*BC* interrayer upward), and ventral (*BC* interrayer downward) views of cup with attached proximal columnal,  $\times 2$  (Wanner, 1924).

**Xenocatilloocrinus** WANNER, 1937, p. 119 [*\*X. wrighti*; OD]. Cup very low, turreted-discoid (greatest width about 10.5 mm.), with vertical-sided basal circling of 2 or 3 plates surmounted by very uneven, differently inclined radials, with all except *E* ray multifaceted (Fig. 334,8; Table 2), facet for attachment of anal plate on left shoulder of *C* radial. Stem facet elliptical, nearly featureless. *U. Perm.*(*Basleo beds*), Indon.(Timor,

Basleo).—FIG. 337,3. \**X. wrightii*; 3a-d, EA-, AB-, CD-interray views and dorsal side (A ray downward) of holotype cup,  $\times 3$  (Wanner, 1937).

### Family ANAMESOCRINIDAE Goldring, 1923

[Anamesocrinidae GOLDRING, 1923, p. 323]

Cup small, truncated below. Radials and superradials with multiple facets, each bearing slender unbranched arms. *M.Dev.*

**Anamesocrinus** GOLDRING, 1923, p. 323 [\**A. lutheri*; OD]. Cup small, conical; 5 low basals; large (A, D) radials and half as large superradials (B, C, E) each supporting 5 atomous arms; anal X small, triangular, wedged between upper angles of C superradial and D radial, supporting several small, quadrangular tube plates. Stem transversely round, tapering in width distally. *M.Dev.*, USA (N.Y.).—FIG. 341,3. \**A. lutheri*; 3a-c, E-ray, E-ray, and CD-interray views of 2 crowns and stem,  $\times 3$  (Goldring, 1923); 3d, plate diagram of cup and arm bases (radials and superradials black, inferradials horizontally ruled, anal X stippled),  $\times 7$  (Moore, 1962b).

### Family HAPLOCRINITIDAE Bassler, 1938

[*nom. correct.* BASSLER, 1938, p. 16 (pro Haplocrinidae ROEMER, 1855, p. 229)] [=Aplocrinidae d'ORBIGNY, 1852, p. 19]

Cup globose to conical, with five basals; B, C, and E radials compound; anal X lacking. Arms atomous. ?*Sil.*, *Dev.*, ?*L. Carb.*

**Haplocrinites** STEININGER, 1837, p. 232 [\**H. sphaeroideus* (=Eugeniocrinites mespiliformis GOLDFUSS, 1831, p. 213) (subj.); M] [=Asteroocrinus MÜNSTER, 1839, p. 4 (type, *A. murchisoni*); Asteroocrinites ROEMER, 1851, p. 390; Haplocrinus ROEMER, 1855, p. 63 (*nom. van.*); Aplocrinus d'ORBIGNY, 1852, p. 63 (*nom. van.*)]. Theca small, bipyramidal; basals 5, low; A and D radials simple, others compound, superradials larger than inferradials; no anal plates in cup. Tegmen composed of 5 large triangular oral plates, posterior one with median pore. Radial articular facets narrowly rounded, in deep notches at radial summits; grooves which housed proximal parts of arms extending from radial facets along lateral edges of orals to summit of theca. Arms atomous. Column unknown. ?*Sil.*, *Dev.*, ?*L. Carb.*, Eu. (Ger.-Eng.)-USA (Tenn.-N.Y.).—FIG. 341,2a,b. \**H. mespiliformis* (GOLDFUSS), *M.Dev.*, Ger.; lat. and ventral views of theca,  $\times 8$  (Wachsmuth & Springer, 1886).—FIG. 341,2c-f. *H. clio* (HALL), *M.Dev.*, N.Y.; dorsal, ventral, C-, and D-ray views of theca,  $\times 4$  (Goldring, 1923).

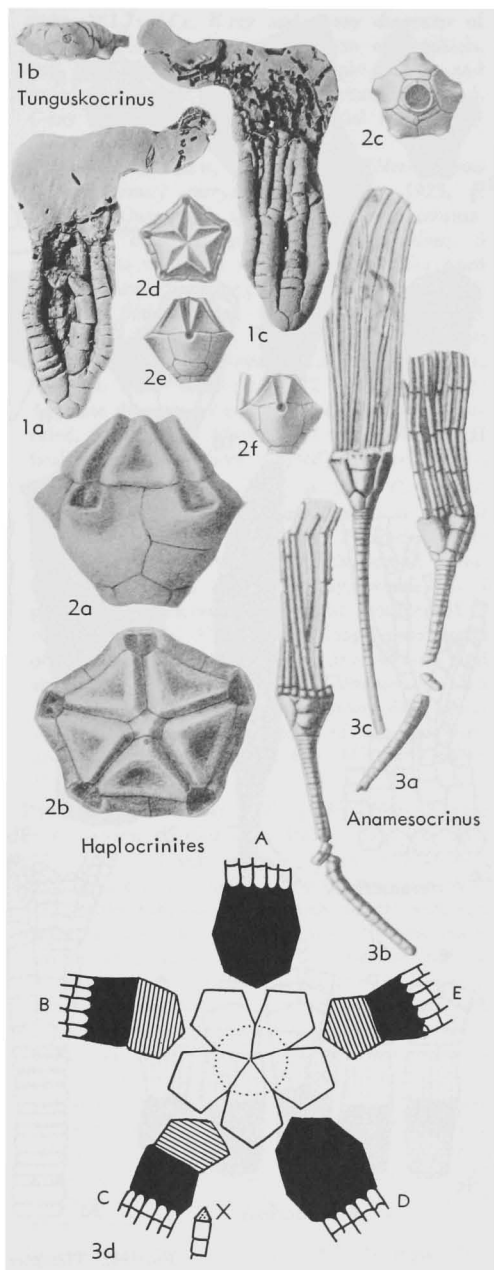


FIG. 341. Anamesocrinidae (3); Haplocrinitidae (2); Tunguskocrinidae (1) (p. T547-T548).

### Family TUNGUSKOCRINIDAE Arendt, 1963

[Tunguskocrinidae ARENDT, 1963, p. 132]

Cup with homocrinid (E-ray) bilateral symmetry. Arms branching once isoto-

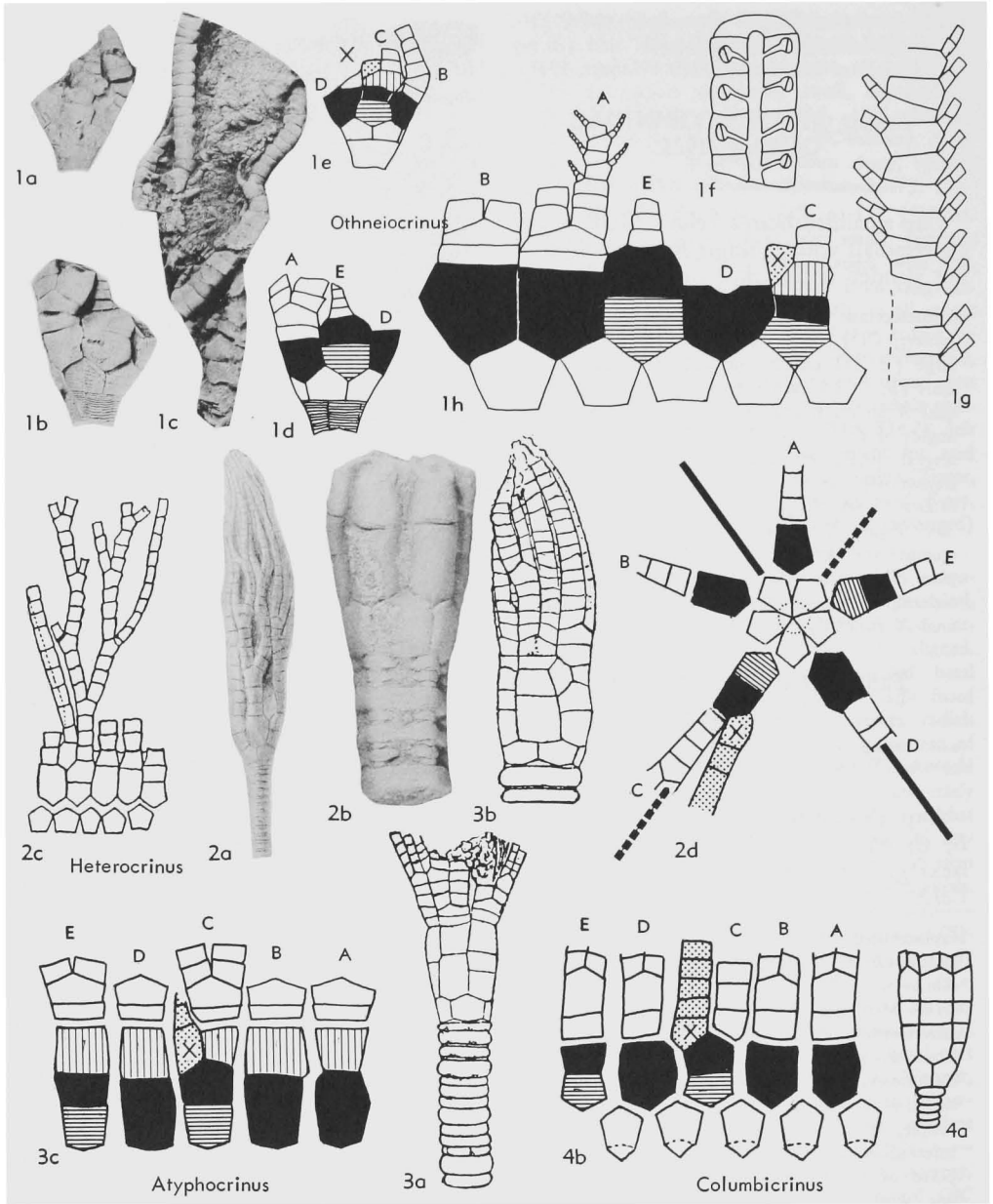


FIG. 342. Heterocrinidae (p. T549).

mously on primibrachs 7 or 8. Column minute, probably not functional. *Ord.*

**Tunguskocrinus** ARENDT, 1963, p. 132 [\**T. ivanovae*; OD]. Cup conical; basals spear shaped and upflaring; B, C, and E radials divided into infer- and superradials, radials of A and D rays simple; anal X large, on upper left shoulder of C super-radial, supporting longitudinal series of large tube

plates which taper in width distally. Arms stout, rounded, branching once isotomously on primibrachs 7 in all but E ray, which has 8 primibrachs. Stem facet on basals quite small and round. Column probably not functional for support of crown. *Ord.*, Eu.(USSR).—FIG. 341, I. \**T. ivanovae*; 1a-c, post., dorsal, and ant. views of crown,  $\times 1.3$  (Arendt, 1963).

## Superfamily HETEROCRINACEA Zittel, 1879

[*nom. correct.* MOORE & LANE, in MOORE & STRIMPLE, 1973, p. 17, *pro* Heterocrinacea UBAGHS, 1953, p. 747 (*nom. transl. ex* Heterocrinidae ZITTEL, 1879, p. 343)] [=Heterocrinites JAEKEL, 1918, p. 84 (suborder) (*partim*)] [Materials for this superfamily prepared by R. C. MOORE and N. GARY LANE]

Compound radials in *C* and *E* rays only, radials of other rays simple; anal *X* between *C* superradial and *D* radial. *M.Ord.* (*Mohawk.*)-*U.Ord.* (*Cincinnati.*).

## Family HETEROCRINIDAE Zittel, 1879

[Heterocrinidae ZITTEL, 1879, p. 343] [=Heterocrinidées DE LORIOI, 1882-84, p. 51]

Cup small, steeply conical; anal *X* supporting longitudinal row of enlarged tube plates. Anal tube elongate, may be spirally coiled. Proximal one to three primibrachs may be fixed in top part of cup, brachials occupying full width of radials. Arms uniserial, nonpinnulate, branching isotomously several times. *M.Ord.* (*Mohawk.*)-*U.Ord.* (*Cincinnati.*).

**Heterocrinus** HALL, 1847, p. 278 [*\*H. heterodactylus*; SD WACHSMUTH & SPRINGER, 1880, p. 70] [=*Stenocrinus* WACHSMUTH & SPRINGER, 1886, p. 13 (*obj.*)]. Cup small and slender; basals large and upright; *C* and *E* radials compound, others simple; anal *X* small, on upper left sloping shoulder of *C* superradial. Anal sac slender, armlike. Arms slender, rounded, branching on primibrachs 4 and with 2 or 3 higher equal divisions. Column transversely pentagonal. *M.Ord.* (*Mohawk.*)-*U.Ord.* (*Cincinnati.*), Can. (Ont.)-USA (Ohio-Ky.-N.Y.).—FIG. 342,2. *\*H. heterodactylus* HALL, *U.Ord.*, Ohio; 2*a*, *D*-ray view of crown,  $\times 2$  (Meek, 1873); 2*b*, *AB*-inter-ray view of cup,  $\times 4$  (Moore, n; Univ. Chicago 3136); 2*c,d*, plate diagrams of cup and parts of crown, 2*d* showing primary plane of bilateral symmetry—full heavy line through *D* ray—and secondary plane—broken line through *C* ray (Ulrich, 1925; Moore, 1962b).

**Othneocrinus** LANE, herein, *nom. subst. pro* *Atopocrinus* LANE, 1970, p. 14 (*non* CLARK, 1912) [*\*A. priscus*; OD]. Cup low conical; basals 5; infer- and superradials in *C* and *E* rays only. Primibrach 1 axillary in *C* ray, supporting anal *X* and row of sac plates on left and an arm on right. Anal sac unknown. Primibrachs 2 axillary in *A* and *B* rays, arms of *E* and *D* rays unknown. Each arm with 2 main rami, brachials with small unbranched ?ramules on one or both sides of each secundibrach. Columnals composed of pentameres. *M.Ord.* (*Mohawk.*), USA (Utah).—FIG. 342,1. *\*A. priscus*; 1*a,b*, *C*-ray and *E*-ray views of cup,  $\times 1.3$ ,  $\times 1.7$ ; 1*c*, *A*-ray view of

arms,  $\times 1.7$ ; 1*d,e*, *E*-ray and *C*-ray diagrams of cup; 1*f-h*, oral and aboral surfaces of brachials, and plate diagram of cup (simple radials and superradials black, inferradials horizontally ruled, *C*-ray primaxil vertically ruled, anal *X* stippled) (Lane, 1970a).

**Atyphocrinus** ULRICH, 1925, p. 85 [*\*Heterocrinus* (*Atyphocrinus*) *corryuillensis* ULRICH, 1925, p. 85; M]. Cup small, slightly wider than column. Plates of cup arranged as in *Heterocrinus*, 3 primibrachs to a ray, with first primibrachs fixed in cup. Arms branching heterotomously on every fourth or fifth brachial. *U.Ord.* (*Cincinnati.*), USA (Ohio).—FIG. 342,3. *\*A. corryuillensis* ULRICH; 3*a*, *D*-ray view of crown,  $\times 1.5$  (Ulrich, 1925); 3*b*, ant. view of crown,  $\times 2$  (Ulrich, 1925); 3*c*, plate diagram of cup (inferradials horizontally ruled, superradials black, fixed primibrachs vertically ruled, anal plates stippled) (Moore 1962b).

**Columbicrinus** ULRICH, 1925, p. 91 [*\*C. crassus*; M]. Cup conical; basals long hexagonal; *C* and *E* radials compound; proximal 2 brachials not fixed in cup and as wide as radials; second primibrachs axillary in all but *C* ray, which has 3 primibrachs preserved above right shoulder of *C* superradial; anal *X* supporting longitudinal series of 4 large anal plates. Distal parts of arms and anal sac not known. *M.Ord.* (*Mohawk.*), USA (Tenn.).—FIG. 342,4. *\*C. crassus*; 4*a,b*, *A*-ray view of cup and plate diagram of cup and proximal arms (symbols as in Fig. 342,3*c*) (Moore, 1962b).

**Dystactocrinus** ULRICH, 1925, p. 85 [*\*Heterocrinus* (*Homocrinus*) *constrictus* HALL, 1871, p. 210; M]. Plates of cup arranged as in *Heterocrinus*; anal *X* large, pentagonal, supporting elongate series of armlike anal sac plates. Anal sac elongate and tapering, composed of small, loosely united plates except for posterior anals. First primibrachs fixed in cup; second primibrachs axillary in all rays; brachials thin, rounded; arms heterotomous, with 2 main rami to each ray; large elongate armlets branching twice or more on alternate sides of every third or fourth secundibrach. *U.Ord.* (*Cincinnati.*), USA (Ohio).—FIG. 343,3. *D. crassus* ULRICH; 3*a*, plate diagram (symbols as in Fig. 342,3*c*) (Moore, 1962b, after Ulrich, 1925); 3*b-d*, cross sec. of cup, column, and anal sac,  $\times 1$  (Ulrich, 1925); 3*e,f*, post. and *B*-ray views of crown,  $\times 1.5$  (Ulrich, 1925).

**Isotomocrinus** ULRICH, 1925, p. 86 [*\*I. typus*; M]. Cup as in *Heterocrinus*. Anal sac elongate, with longitudinal series of posterior plates which are quadrangular proximally and become narrow and elongate distally; remainder of sac composed of small, loosely united plates. Proximal tip of anal *X* in contact with upper corner of *C* inferradial. Arms long and slender, free above radials, primibrachs 5 axillary, branching isotomously several times. *M.Ord.* (*Mohawk.*), Can. (Ont.).—FIG. 343,2. *\*I. typus*; 2*a,b*, plate diagrams of crown

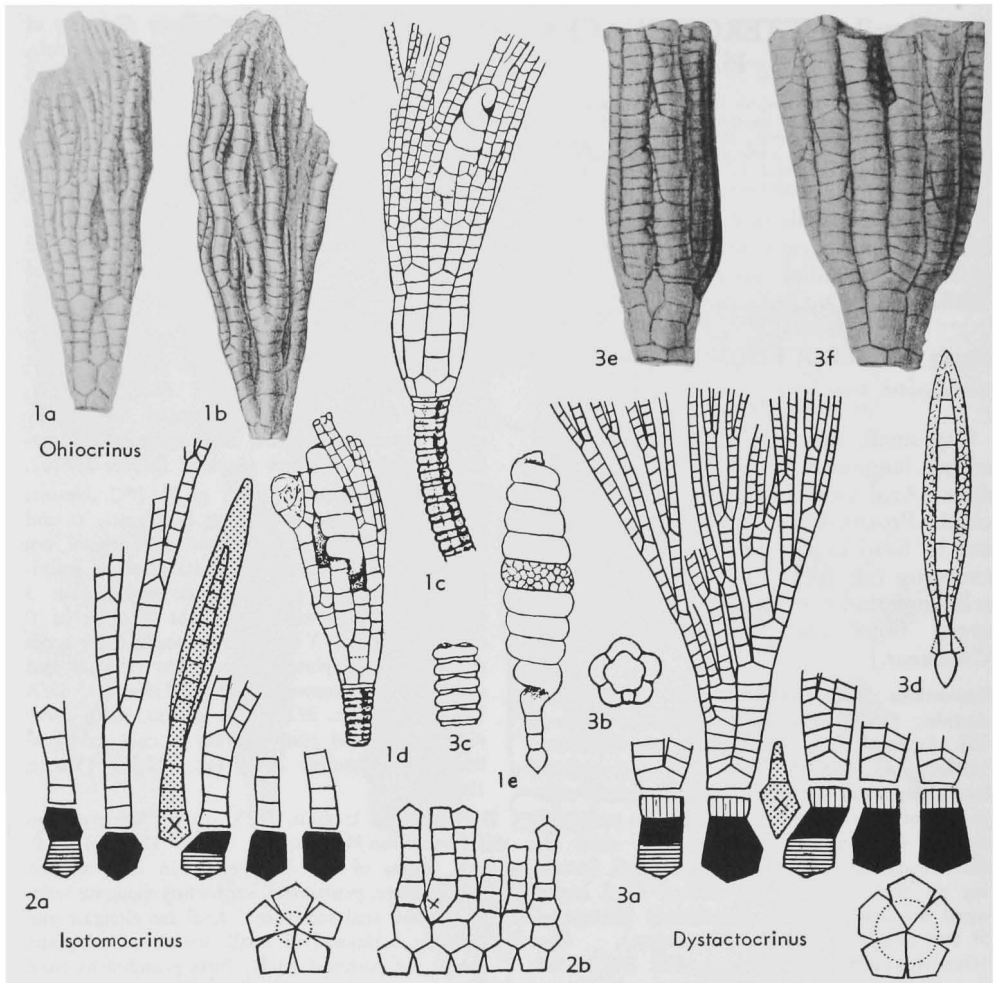


FIG. 343. Heterocrinidae (p. T549-T550).

and anal sac,  $\times 1$  (Symbols in 2a as in Fig. 342, 3c) (Moore, 1962b, Ulrich, 1925).

**Ohioocrinus** WACHSMUTH & SPRINGER, 1886, p. 208 (132) [*Heterocrinus laxus* HALL, 1871, p. 211; OD]. Cup as in *Heterocrinus*. First 2 primibrachs of each ray fixed in cup. Anal sac conspicuous, spirally coiled, composed of small rounded, imbricating plates. Arms heterotomous, branching first on primibrachs 4, with 2 main rami to each ray; slender unbranched ramules diverge from alternate sides of every fourth secundibrach. Stem transversely subpentagonal. *M.Ord.* (*Mohawk.*)-*U.Ord.* (*Cincinnati.*), USA (Ky.-Ind.-Ohio).—FIG. 343, 1a, b. \**O. laxus* (HALL), *U.Ord.*, Ohio; 1a, b, post. and AB-interray views of crown,  $\times 2$ ,  $\times 1.5$  (Meek, 1873).—FIG. 343, 1c-e. *O. brauni* UL-*rich*, *U.Ord.*, Ind.; 1c-e, E-ray and post. views of crown, and sketch of anal sac,  $\times 3.6$  (Ulrich, 1925).

**Superfamily**  
**MYELODACTYLACEA**  
**S. A. Miller, 1883**

[*nom. transl.* MOORE & LANE, in MOORE & STRIMPLE, 1973, p. 17 (ex Myelodactylidae S. A. MILLER, 1883a, p. 278)] [=superfamily Iocrinidae UBAGHS, 1953, p. 744 (*nom. transl.* ex Iocrinidae MOORE & LAUDON, 1943, p. 29)] [*non order Myelodactyloidea* S. A. MILLER, 1883a, p. 278] [Materials for this superfamily prepared by R. C. MOORE and N. GARY LANE]

Crown small and elongate, cup conical, monocyclic, with compound radials present in all five rays or in C ray only; anal X supported on left side of C superradial or directly above it. Bilateral symmetry developed in crown through C-AE plane. Arms uniserial, isotomous or heterotomous.

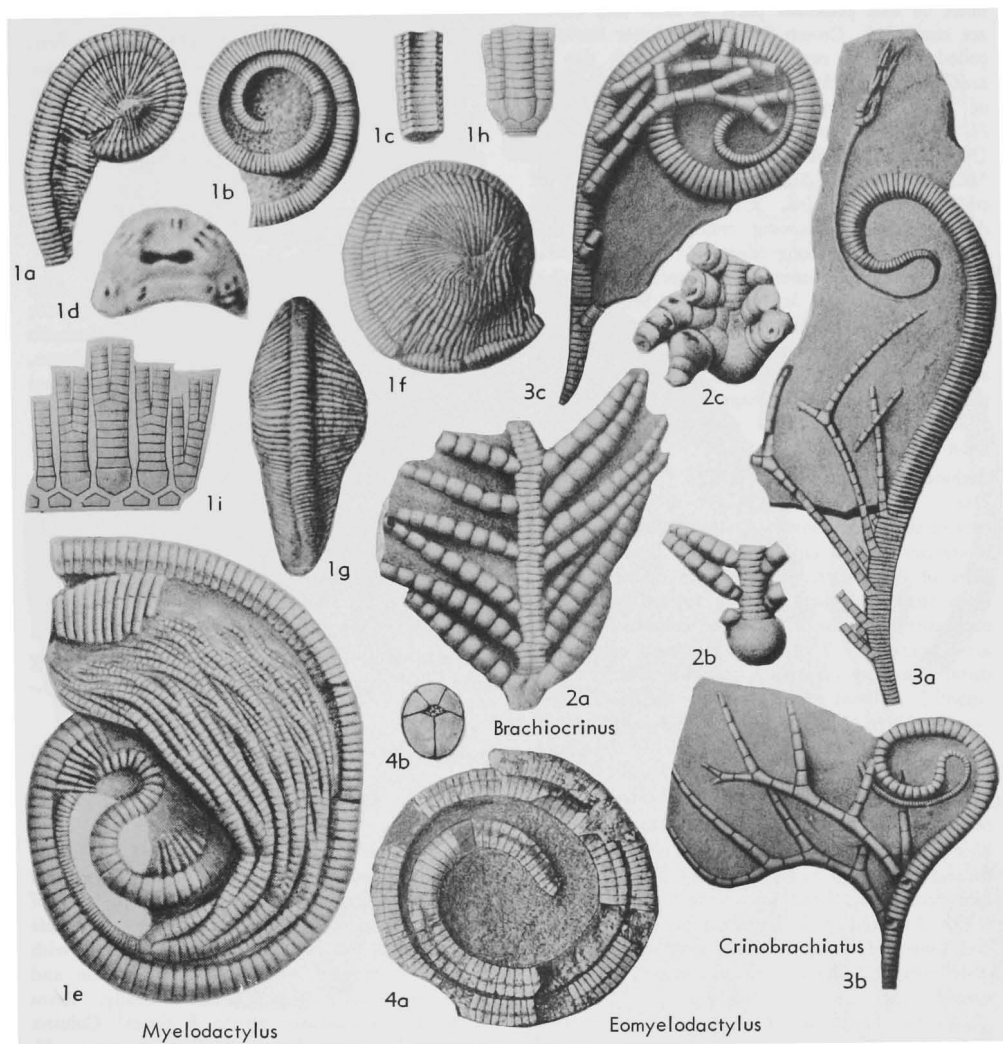


FIG. 344. Myelodactylidae (p. T551-T552).

Column transversely pentagonal, round, or bilaterally symmetrical subcrescentic and disposed in a doubly recurved coil. *L.Ord.-L.Dev.*, ?*U.Dev.*

**Family MYELODACTYLIDAE**  
S. A. Miller, 1883

[Myelodactylidae S. A. MILLER, 1883a, p. 278]

Stem composed of bilateral columnals arranged in a doubly recurved coil; cirri specialized for concealment of elongate slender crown; compound radial in *C* ray only, superradial bearing series of anal sac plates on left side and arm on right. Arms

slender, branching isotomously or heterotomously. *L.Sil.-L.Dev.*(Helderberg.), ?*U.Dev.*(Chemung.).

**Myelodactylus** HALL, 1852, p. 191 [\**M. convolutus*; SD SPRINGER, 1926b, p. 8]. Cup small, with 5 basals and compound radials in *C* ray only. Superradial of *C* ray in line with first primibrachs of other rays, bearing anal X on its left side and an arm on right. Arms slender, branching heterotomously. Proximal part of stem composed of thin circular columnals without cirri; distal part spirally coiled, composed of crescentic, bilaterally symmetrical columnals with paired cirri and shallow concavity between cirral sockets facing toward inner side of stem coil, long slender distal cirri



disposed on each side of coil parallel to one another so that proximal parts of stem and crown are concealed. Crown lies against inner curve of coiled stem in reversed position, with tips of arms pointed backward in direction of distal part of stem. *M.Sil.(Niagaran)*-*L.Dev.(Helderberg.)*, ?*U.Dev.(Chemung.)*; Eu.(Gotl.-Eng.-?Ger.)-USA (N.Y.-Tenn.-Ind.-W.Va.-Ill.).—FIG. 344,1a-d. \**M. convolutus*, U.Sil., N.Y.; 1a,b, lat. views of coiled stem and cirri,  $\times 1$ ; 1c, inward side of distal columnals showing concave inner surface and cirral sockets along edges,  $\times 1.5$ ; 1d, articular surface of distal columnal,  $\times 4$  (Springer, 1926b).—FIG. 344,1e-i. *M. keyserensis* SPRINGER, L. Dev., W.Va.; 1e, lat. view of stem and crown,  $\times 1.5$ ; 1f,g, views of stem and cirri from side and in plane of coil,  $\times 1$ ; 1h,j, E-ray view of partial crown and plate diagram,  $\times 1.5$  (Springer, 1926b). [= *Ophiocrinus* CHARLESWORTH, 1865 (non SALTER, 1856).]

**Brachiocrinus** HALL, 1858, p. 278 [\**B. nodosarius* HALL, 1859b, p. 118; M]. Crown and proximal part of stem not known. Column with very stout, moderately short cirri given off from opposite sides of stem; cirri thickening in diameter away from stem and then tapering toward outer end, each pair borne by 2 successive columnals, which are separated by 2 to 5 noncirriferous columnals; distal extremity of stem a rounded to spheroidal, smooth, bulbous enlargement. *L.Dev.(Helderberg.)*, USA (N.Y.).—FIG. 344,2. \**B. nodosarius*; 2a-c, stems with paired cirri and bulbous distal extremities,  $\times 1$  (Springer, 1926b).

**Crinobrachiatus** MOORE, 1962, p. 43 [\**Myelodactylus brachiatus* HALL, 1852, p. 232; OD]. Crown poorly known, apparently like *Iocrinus* in structure. Stem exceptionally large distally and thread-like proximally, bent into open S-shaped curve which does not enclose crown; cirri few, robust, and some very long, confined to part of stem on distal side of S-shaped coil and somewhat widely spaced, cirri composed of elongate cylindrical cirrals and branching in 2 or 3 places, directed obliquely upward; stem tapers to a point at distal extremity. *M.Sil.(Rochester)*, USA (N.Y.).—FIG. 344,3. \**C. brachiatus* (HALL); 3a, lat. view of stem and crown,  $\times 1.5$ ; 3b,c, lat. views of distal part of stem,  $\times 2$ ,  $\times 1.5$  (Springer, 1926b).

**Eomyelodactylus** FOERSTE, 1919 [\**Myelodactylus (Eomyelodactylus) rotundatus* FOERSTE, 1919, p. 19; OD]. Crown unknown. Stem closely coiled, without reverse curvature in proximal region, composed of moderately stout columnals circular to elliptical in outline, not concave on inner side, each columnal divided into pentameres of unequal size, those on inner side of stem being largest, relatively large lens-shaped lumen eccentrically placed slightly outward from center. *L.Sil.(Brassfield Ls.)*, USA (Ohio).—FIG. 344,4. \**E. rotundatus* FOERSTE; 4a,b, lat. view of column and articular surface of columnal showing pentameres

and lens-shaped lumen,  $\times 1.5$ ,  $\times 4$  (Foerste, 1919).

**Herpetocrinus** SALTER, 1873, p. 118 [\**H. fletcheri*; M]. Cup with 4 basals and 4 radials. Anal sac larger in diameter than arms, and very long. Arms 4, small, heterotomous, branching repeatedly; cirrals short, rounded and beadlike. *U.Sil.(Wenlock.)*, Eu.(Eng.-Sweden)-USA (Tenn.-Ind.).—FIG. 345,1. \**H. fletcheri*, Eng.; 1a,b, lat. views of crown and stem,  $\times 1$ ,  $\times 1.5$ ; 1c,d, C-ray and ?E-ray views of cup,  $\times 6$ ; 1e, plate diagram of cup and proximal brachials,  $\times 1$  (Springer, 1926b); 1f-k, same species from Gotland, 1f,g, anal tube plates from right and left sides,  $\times 6$ ; 1h,j, lat. and transv. views of distal columnals and cirri,  $\times 3$ ; 1j, lat. view of crown and column,  $\times 1.5$ ; 1k, lat. view of partial crown and proximal stem,  $\times 3$  (Bather, 1893a).

### Family IOCRINIDAE Moore & Laudon, 1943

[Iocrinidae MOORE & LAUDON, 1943a, p. 29]

Compound radial in C ray only; super-radial supports anal X on left side and free arm on right. Arms with many isotomous branches. Column transversely pentagonal to pentastellate, composed of alternating thick and thin columnals. ?*L.Ord.*, *M.Ord.*-*U.Ord.*

**Iocrinus** HALL, 1866, p. 5 [\**Heterocrinus (Iocrinus) polyxo* HALL, 1866, p. 5 (= *Heterocrinus subcrassus* MEEK & WORTHEN, 1865b, p. 148 [subj.], see MOORE, 1962b, p. 40); M]. Cup conical, basals 5; radials large, supporting several primibrachs in each ray. Infer- and superradial in C ray only; superradial axillary, at level of first primibrachs, supporting arm on right side and anal sac plates on left. Anal sac tall, with row of large anal plates on posterior side and thin, horizontally plicate plates laterally. Arms branching isotomously up to 8 times. Column transversely pentalobate. ?*L.Ord.(Arenig.)*, *M.Ord.(Llanvirn.)*-*U.Ord.*, Eu.(Wales-Eng.), USA (Ill.-Ohio-N.Y.)-Can.(Ont.).—FIG. 346,2a,b. \**I. subcrassus* (MEEK & WORTHEN), U.Ord., Ohio; lat. views of crown,  $\times 1$  (Hall, 1872).—FIG. 346,2c-f. *I. crassus* (MEEK & WORTHEN), U.Ord., Ohio; 2c,d, A- and D-ray views of cup,  $\times 1.5$  (Hall, 1872); 2e,f, A-ray and CD-interray views of crown,  $\times 1.5$  (Meek, 1873).

**Caleidocrinus** WAAGEN & JAHN, 1899, p. 106 [\**C. multiramus*; SD BASSLER, 1938, p. 56] [= *Caleidocrinus* WAAGEN & JAHN, 1892, p. 399 (nom. nud.); *Kaleidocrinus* JAEKEL, 1902, p. 1075 (obj.) (nom. van.)]. Cup small, low, plates arranged as in *Iocrinus*. Small, rounded interbrachial plates present between proximal parts of arms above radials. Arms isotomous, branching repeatedly. Stem transversely round. *M.Ord.(Llanvirn.)*, Eu.

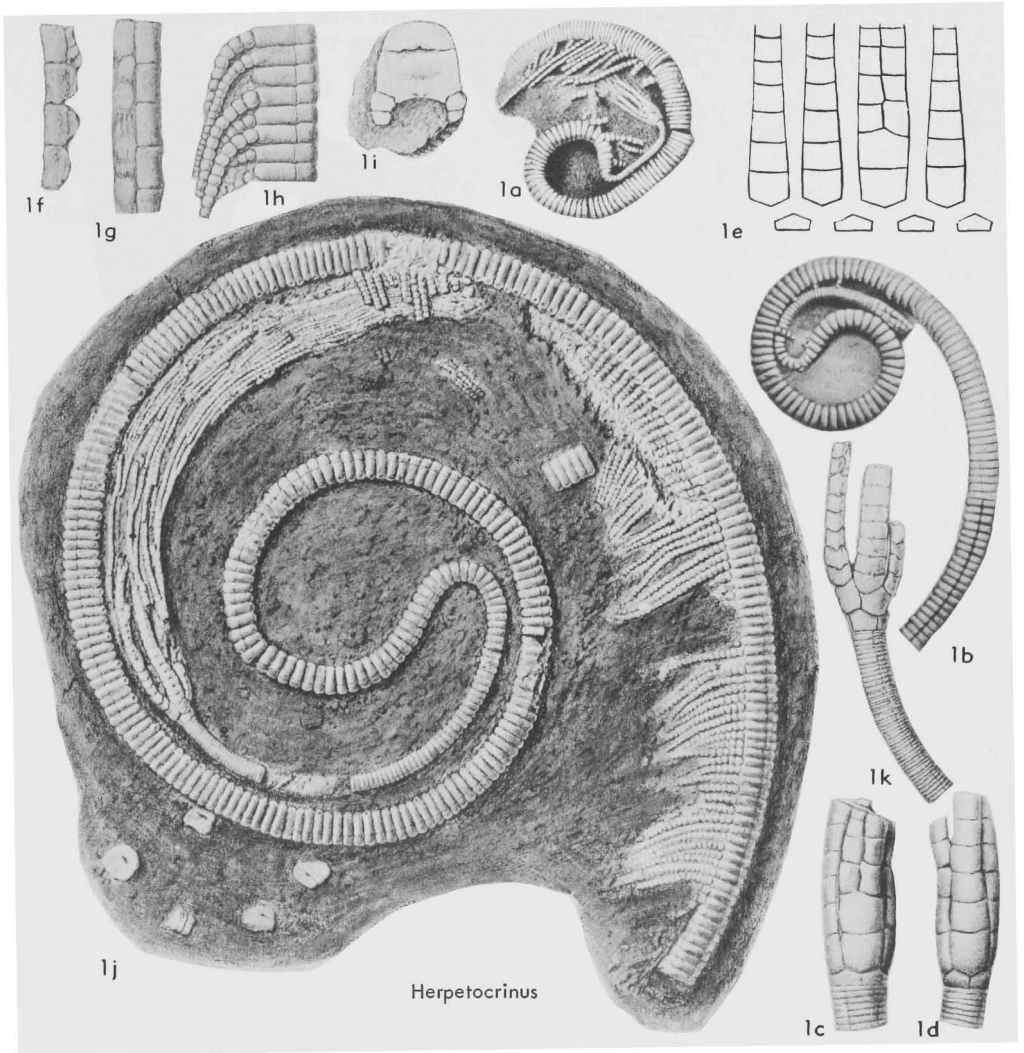


FIG. 345. Myelodactylidae (p. T552).

(Scot.-Boh.).—FIG. 346,1a,b. \**C. multiramus*, M.Ord., Boh.; lat. and *CD*-interray views of crown,  $\times 1$ ,  $\times 3$  (Springer, 1920).—FIG. 346,1c. *C. turquidulus* RAMSBOTTOM, M.Ord., Scot.; lat. view of crown,  $\times 2$  (Ramsbottom, 1961).

**Family EUSTENOCRINIDAE**  
Ulrich, 1925

[Eustenocrinidae ULRICH, 1925, p. 99]

Compound radials in all five rays. Anal *X* supported directly by *C*-ray superradial, or by left side of first fixed primibrach in *C* ray. *L.Ord.*-*M.Ord.*

*Eustenocrinus* ULRICH, 1925, p. 99 [\**E. springeri*;

OD]. Crown barely wider than stem; basals 5, infer- and superradials present in all 5 rays; *C* superradial supports anal *X* and row of anal sac plates directly above, without an arm. First primibrachs fixed in cup. Arms branching isotomously on sixth to tenth primibrach. *M.Ord.* (*Trenton.*), Can.(Ont.).—FIG. 347,1. \**E. springeri*; 1a, plate diagram of crown (superradials black, inferradials horizontally ruled, fixed brachials vertically ruled, anal plates stippled) (Moore, 1962b); 1b,c, *AE*-interray and *C*-ray views of crown,  $\times 5$  (Lane, n; Springer Coll., U.S. Natl. Museum).

*Peniculocrinus* MOORE, 1962, p. 33 [\**Heterocrinus? milleri* WETHERBY, 1880b, p. 153; OD]. Crown

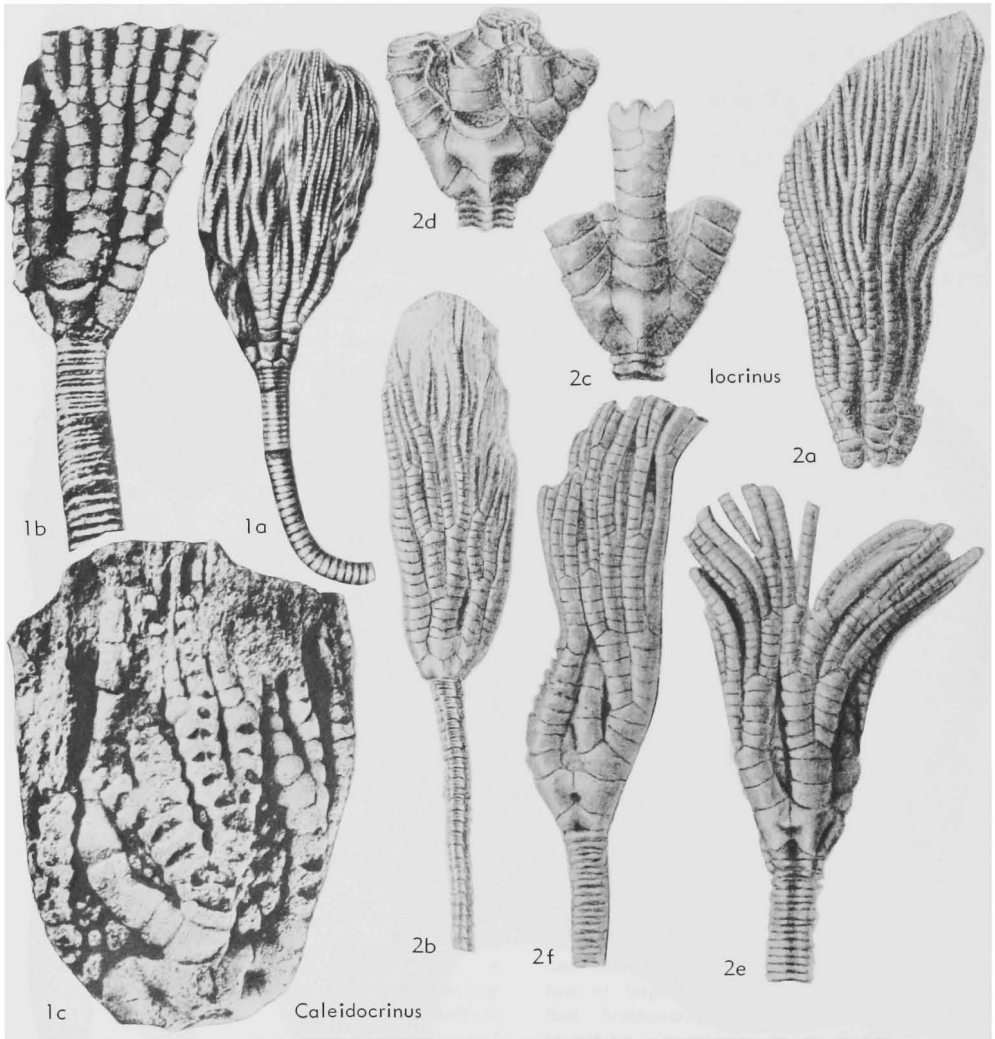


FIG. 346. Iocrinidae (p. T552-T553).

tall and very slender; basals 5; infer- and super-radials present in all rays; first fixed primibrach of *C* ray supporting anal *X* and series of anal sac plates on left side and arm on right. First 2 primibrachs fixed in top of cup in each ray. Arms rounded, branching on sixth or seventh primibrachs, and with at least 2 higher isotomous branches. Stem subpentagonal in section. *M.Ord.* (*Trenton.*), USA (Ky.).—FIG. 347,2. \**P. milleri* (WETHERBY); 2a, *AE*-interray view of crown,  $\times 2.25$  (Wetherby, 1880b); 2b, *AE*-interray view of crown,  $\times 3.75$ ; 2c,d, post. and ant. views of proximal part of crown and stem,  $\times 6$  (Moore, 1962b).

**Ramseyocrinus** BATES, 1968, p. 406 [\**Dendrocrinus cambriensis* Hicks, 1873, p. 50; OD]. Cup

composed of ?3 or ?4 basals; infer- and super-radials present in each ray. Those of *C* ray lower than in other rays and supporting series of anal plates directly above. Primibrachs 9 or more, proximal brachials not fixed in cup. Arms strongly rounded, branching isotomously 3 or more times. Stem transversely wide, quadrilobate, columnals irregular in height. *L.Ord.* (*Tremadoc.*), Eu. (Wales).—FIG. 348,2. \**R. cambriensis* (Hicks); 2a,b, ant. and post. views of crown and stem,  $\times 5$  (Bates, 1968).

**Ristnacrinus** ÖPIK, 1934, p. 3 [\**R. marinus*; OD]. Cup high conical, truncate below; basals fused with proximal columnal or absent, not visible; large quadrate inferradials present in each ray supporting smaller superradials above, that of *C*

ray next below small anal *X* and succeeding anal sac plates on left side and large primibrach on right. Primibrachs 1 axillary in *B*, *D*, and *E* rays, primibrachs 2 axillary in *A* and *C* rays; brachials not fixed in cup. Arms strongly rounded, branching at least twice isotomously. Stem transversely round, composed of thin and thick columnals, latter with bifascial articular surfaces. *M.Ord.* (*Caradoc.*), Eu.(Est.).—FIG. 348, *I*. \**R. marinus*; 1*a*, E-ray view of crown and stem,  $\times 2$ ; 1*b*, C-ray view of cup and proximal arms,  $\times 2.9$  (Öpik, 1934).

### Superfamily ANOMALOCRINACEA Wachsmuth & Springer, 1886

[*nom. transl.* MOORE & LANE, in MOORE & STRIMPLE, 1973, p. 17 (ex Anomalocrinidae WACHSMUTH & SPRINGER, 1886, p. 135[211])] [Materials for this superfamily prepared by R. C. MOORE and N. GARY LANE]

Cup globose, with convex base, upflared basals clearly visible from side; radial articular facets narrow, circular and small. Tegminal plates firmly united, with modified ambulacrals and interambulacrals. Arms heterotomous, with ramule developed on each brachial, arranged in series on one side of branch. *M.Ord.-U.Ord.*

### Family ANOMALOCRINIDAE Wachsmuth & Springer, 1886

[Anomalocrinidae WACHSMUTH & SPRINGER, 1886, p. 135 (211)]

Characters of superfamily. *M.Ord.-U.Ord.*

*Anomalocrinus* MEEK & WORTHEN, 1865, p. 148 [\**Heterocrinus?* (*Anomalocrinus*) *incurvus* MEEK & WORTHEN, 1865b, p. 148; M] [= *Ataxocrinus* LYON, 1869, p. 464 (type, *A. caponiformis*); *Ataxocrinus* BATHER in LANKESTER, 1900a, p. 146, *nom. van.*]. Cup large, globose; basals 5, small, subequal, pentagonal in outline; or with extra small quadrangular plate inserted in *D*-ray cirlet. Radials large, *A* and *B* radials simple, *C* and *E* rays with infer- and superradials; *D* radial divided into 2 equal plates by a vertical suture; radial articular facets deeply inserted in plates of *D* and *A* radials; others on central raised area of plates and facing adorally; large quadrangular anal plate (?anal *X*) situated between upper shoulders of *C* superradial and *D* radial; arms branching several times on second, third, or fourth primibrachs, branches above axillaries may be unequal in size; brachials large, rounded, slender unbranched ramules present at irregular intervals in distal parts of arms. *U.Ord.* (*Cincinnati.*), USA (Ohio).—FIG. 349, *I*. \**A. incurvus* (MEEK & WORTHEN); 1*a*, *b*, post. and ant. views

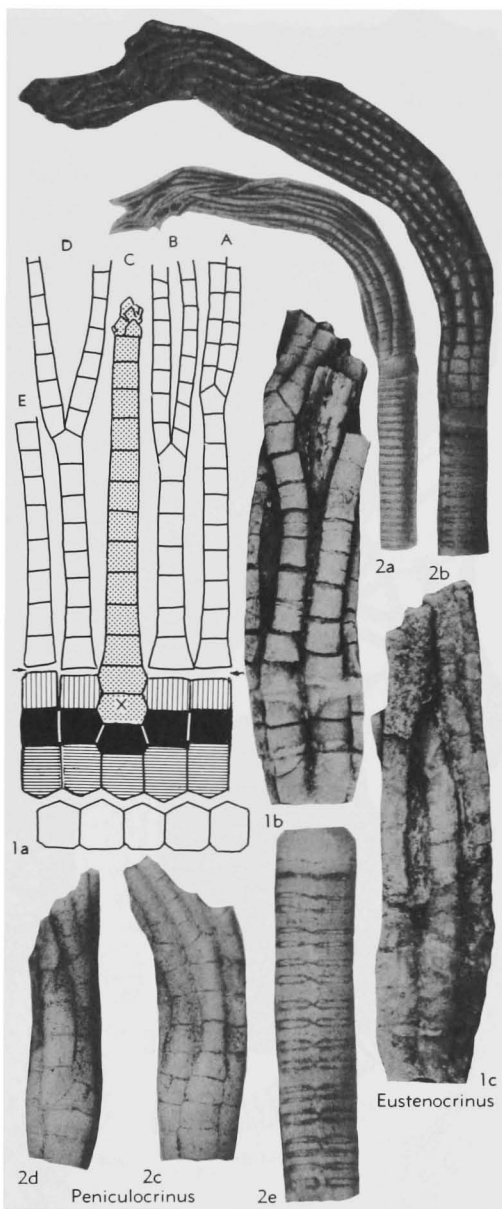


FIG. 347. Eustenocrinidae (p. T553-T554).

of crown,  $\times 1$ ; 1*c*, articular surface of columnal,  $\times 2$  (Meek, 1873).

*Geraocrinus* ULRICH, 1925, p. 92 [\**G. sculptus*; M]. Cup small, low; basals 5, subequal; *C* and *E* radials compound, others simple; large anal *X* on upper shoulders of posterior radials, supporting stout anal sac composed of 4 longitudinal rows of large convex plates. Arms long, stout, 2 to a ray, each brachial with simple, long ramule on

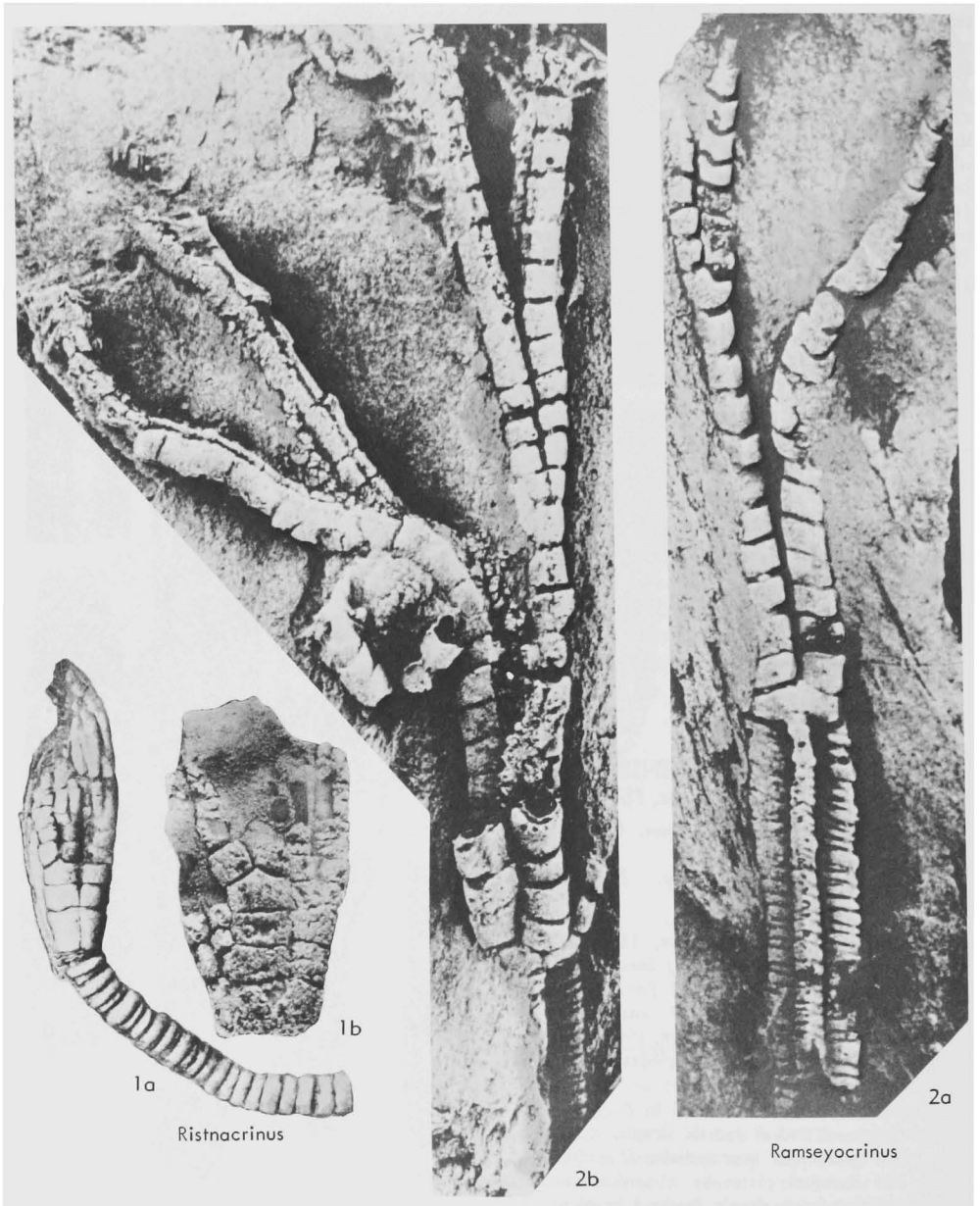


FIG. 348. Eustenocrinidae (p. T554-T555).

its admedial side; primibrachs nearly as wide as radials, 2 in all except anterior ray, which has only one primibrach. *M.Ord.(Trenton.)*, USA (Tenn.).—FIG. 349,2. \**G. sculptus*; 2a, post. view of partial crown,  $\times 1$ ; 2b,c, plate diagram and arms of one ray with ramules given off on inward sides,  $\times 2$ ; 2d,e, aboral surface of brachials and ramules and articular surface,  $\times 4$  (Ulrich, 1925).

**Glaucoerinus** PARKS & ALCOCK, 1912, p. 43 [\**G. falconeri*; M]. Cup globose, basals 5, equal and rather large; *D* and *B* rays with small infer- and superradials, commonly lacking articular facet and arm, other radials simple, large, with narrow rounded facets; anal *X* a small, triangular plate on upper left shoulder of *C* radial. Arms rounded, stout, dividing on first primibrach, and with 2 or 3 higher equal divisions. *M.Ord.(Trenton.)*,

N.Am.(Can., Ont.).—FIG. 349,3. \**G. falconeri*; post. view of crown,  $\times 1$  (Parks & Alcock, 1912).

Superfamily  
BELEMNOCRINACEA  
S. A. Miller, 1883

[*nom. transl.* MOORE & LANE, in MOORE & STRIMPLE, 1973, p. 17 (ex Belemnocrinidae S. A. MILLER, 1883a, p. 276)]  
[Materials for this superfamily prepared by R. C. MOORE and N. GARY LANE]

Crown moderately tall, cylindrical. Cup with bilateral symmetry defined by plane through *A* ray and *CD* interray. Cup steep sided conical, five or three strongly upflared large basals; radials three to five, generally with narrow horseshoe-shaped articular facets sloping outward-downward or occupying full width of plate summit; single anal plate (*X* or radianal) in cup. Arms uniserial, branching isotomously on primibrachs 4 or unbranched. Stem transversely round. *M.Sil.-U.Carb.*; *U.Perm.*

Family BELEMNOCRINIDAE  
S. A. Miller, 1883

[Belemnocrinidae S. A. MILLER, 1883a, p. 276] [=Belemnocrinidae WACHSMUTH & SPRINGER, 1886, p. 193]

All five radials simple; basals highly elongate and rather large, making up most of cup. Anal sac large and with pores along plate sutures. Arms with two main branches, bearing branched or unbranched ramules. *L.Miss.(Osag.)*.

**Belemnocrinus** WHITE, 1862, p. 14 [\**B. typus*; M] [*non Belemnocrinus* MUNIER-CHALMAS, 1876, p. 105, =*Belocrinus* (blastoid)]. Cup small, narrow and tall; basals 5, elongate, conspicuously larger than radials, which are small and quadrangular. Radianal or anal *X* directly above *CD* basal in line with and equal in size to radials, supporting large anal sac composed of hexagonal plates with transverse slitlike pores across plate sutures. Arms long slender rounded, bifurcating once on fourth or fifth primibrachs, each arm with ramules on alternate sides of every second or third secundibrach. *L.Miss., USA(Iowa-Mo.)*.—FIG. 350,1. \**B. typus*, U.Burlington, Iowa; lat. view of crown and proximal part of column,  $\times 1$  (Wachsmuth & Springer, 1885).

**Whiteocrinus** JAEKEL, 1918, p. 58 [\**Belemnocrinus florifer* WACHSMUTH & SPRINGER, 1877, p. 256; M]. Like *Belemnocrinus* except basal-radial sutures strongly constricted and radials outflaring. Arms arranged as in *Belemnocrinus* but unbranched. Column strongly pentagonal in section

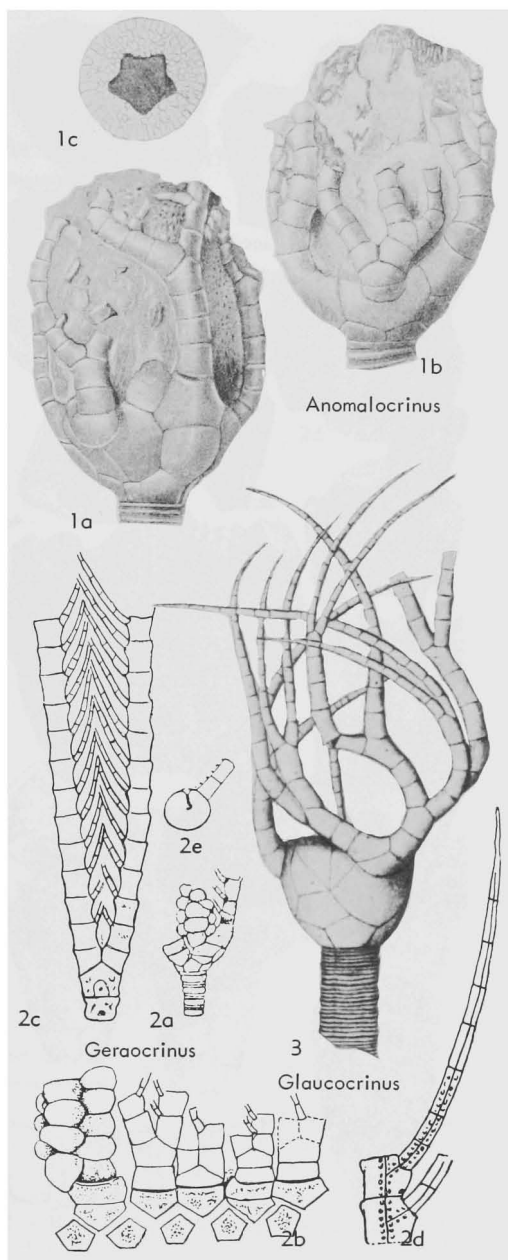


FIG. 349. Anomalocrinidae (p. T555-T557).

with cirriferous nodals. *L.Miss., USA(Iowa)*.—FIG. 350,3. \**W. florifer* (WACHSMUTH & SPRINGER); lat. view of crown,  $\times 1$  (Wachsmuth & Springer, 1885).

Family HOLYNOCRINIDAE  
Bouška, 1948

[Holynocrinidae BOUŠKA, 1948, p. 521]

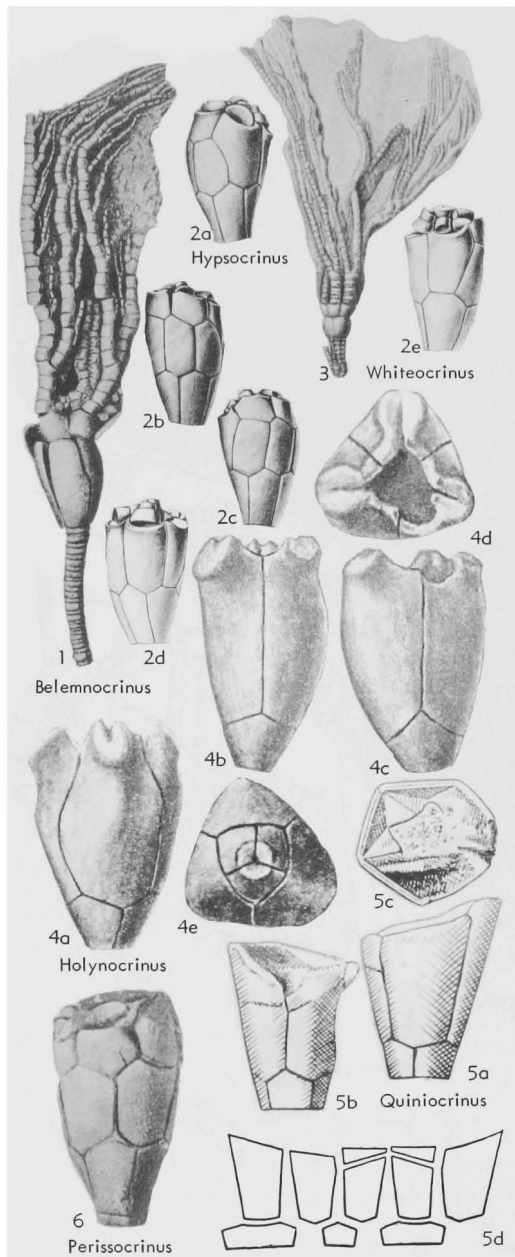


FIG. 350. Belemnocrinidae (1,3); Holynocrinidae (4); Perissocrinidae (2,5,6) (p. T557-T558).

Cup trimerous; *A*, *C*, and *D* radials only ones in cup. *M.Dev.*

**Holynocrinus** BOUŠKA, 1948, p. 521 [*\*H. moorei*; OD]. Cup small, trilobate in cross section; 3 equal basals; 3 large subequal radials (*A*, *C*, *D*) in cup; other radials, radial, and anal *X* plates lacking. Upper left shoulder of *C* radial notched

by proximal edge of anal opening. Arm facets small, narrowly rounded, horseshoe-shaped, with deep ambulacral notches. *M.Dev.*, Eu.(Boh.).—FIG. 350,4. *\*H. moorei*; 4a-e, *A*-ray, *AC*- and *CD*-interrays, ventral and dorsal views of theca,  $\times 20$  (Bouška, 1948).

### Family PERISSOCRINIDAE Strimple, 1963

[Perissocrinidae STRIMPLE, 1963a, p. 24]

Cup conical, with three or five basals, and two, three, or all five rays with infer- and superradials. Anal *X* either in cup or above it. *M.Dev.*

**Perissocrinus** GOLDRING, 1936, p. 20 [*\*P. papillatus*; OD]. Cup cylindrical, basals large and elongate; all rays with infer- and superradials; anal *X* large, pentagonal, separating *C* and *D* superradials and in contact below with *C* and *D* inferradials. Radial facets shallow, concave, filling most of distal surface of each radial. Three non-axillary primibrachs known in 2 rays, other arms unknown. *M.Dev.*, USA(N.Y.).—FIG. 350,6. *\*P. papillatus*; *CD*-interray view of theca,  $\times 2$  (Goldring, 1923).

**Hypsocrinus** SPRINGER & SLOCUM, 1906, p. 267 [*\*H. fieldi*; OD]. Cup narrow, conical; basals 5, large and elongate, one (?*DE*) basal larger than others, truncate distally and directly below *D* radial; anterior superradial large and expanded, so that *A* inferradial is shifted to left, partly below *B* superradial; *B* and *C* superradials bounded below by *A*, *B*, and *C* inferradials, *E* radial simple. Anal *X* not in cup. Two or 3 proximal brachials only known parts of arms. *M.Dev.*, USA(N.Y.).—FIG. 350,2. *\*H. fieldi*; 2a-e, *AE*-interray, *C*-, *B*-, *E*-, and *D*-ray views of theca,  $\times 1.5$  (Springer & Slocum, 1906).

**Quiniocrinus** SCHMIDT, 1942, p. 33 [*\*Q. erectus*; OD]. Cup small, conical; 3 unequal basals, small one in *CD* interray; *A*, *D*, and *E* rays with large simple radials; *B* and *C* rays with large inferradials and small, wedge-shaped superradials; radial articular facets as wide as radials. Arms and anal sac unknown. *M.Dev.*, Eu.(Ger.).—FIG. 350,5. *\*Q. erectus*; 5a-d, *A*-ray, *BC*-interray, and ventral views of theca,  $\times 2$ , and plate diagram of theca (Schmidt, 1942).

### Family PYGMAEOCRINIDAE Strimple, 1963

[Pygmaeocrinidae STRIMPLE, 1963a, p. 36]

Theca small, with perfect pentamerous symmetry, or with three unequal basals; no anal plates in cup. First primibrachs set in deep notch at top of each radial plate. *U.Sil.-M.Dev.*

**Pygmaeocrinus** BOUŠKA, 1947, p. 2 [*\*P. kettneri*;

OD]. Theca small, with perfect pentamer symmetry; bipyramidal in lateral view and pentastellate as seen from above or below; 5 small basals; 5 radials laterally protruding and keeled medially. Arms composed of only 2 primibrachs, first one small, quadrangular, and set into notch in radial, second primibrachs large, spear shaped, set into notches in top of cup and completely covering ventral surface of theca. *U.Sil.-M.Dev.*, Eu.(Boh.). FIG. 351,1. \**P. kettneri*, L.Dev.; 1a-c, lat., dorsal, and ventral views of crown (large keeled second primibrachs shown in 1a,c),  $\times 15$ ; 1d-f, ventral view of cup, int. and lat. views of arm,  $\times 10$  (Bouška, 1947).

**Storthingocrinus** SCHULTZE, 1867, p. 181 [\**Platyocrinus fritillus* MÜLLER, 1855, p. 80; OD]. Cup small; basals 3, unequal, small one in *DE* interray; radials 5, quadrangular, with deeply inset narrow articular facets. *L.Dev.-M.Dev.*, Eu.(Ger.-Eng.-Spain)-India.—FIG. 351,2. \**S. fritillus* (MÜLLER), M.Dev., Ger.; 2a-d, C-ray, D-ray, ventral, and dorsal views of cup,  $\times 2$  (Schultze, 1867).

#### Family SYNBATHOCRINIDAE S. A. Miller, 1889

[Synbathocrinidae S. A. MILLER, 1889, p. 215] [=Synbathocrinidae BATHER, 1899b, p. 921 (*nom. van.*); suborder Symbathocrinites JAEKEL, 1918, p. 89 (*partim*)]

Crown elongate and slender. Cup small, broadly truncate conical or bowl-shaped; basals three or five, small one in *AE* interray; radials simple and subequal, or with traces of transverse division into infer- and superradials in *B*, *C*, and *E* rays; radial articular facets wide, with transverse ridge and may extend inward almost to longitudinal axis of cup; lateral edges of facets may be produced distally into radial processes which abut sides of first primibrachs. Anal *X* either notching upper corners of *C* and *D* radials or out of cup. Anal sac slender, elongate, confined to posterior edge of tegmen, closely resembling an arm externally. Tegmen composed of five oral plates, *CD* oral slightly larger than others. Arms atomous, first primibrachs fully as wide as radials. *M.Sil.-U.Carb.*; *U.Perm.*

**Synbathocrinus** PHILLIPS, 1836, p. 206 [\**S. conicus*; M] [=Synbathocrinites AUSTIN & AUSTIN, 1842, p. 109 (*nom. van.*); *Donacirinites* TROOST, 1849, p. 420 (*nom. nud.*); *Symbathocrinus* D'ORBIGNY, 1852, p. 157 (*nom. van.*); *Donacirinus* BATHER in LANKESTER, 1900a, p. 202 (*nom. nud.*)]. Cup low conical or bowl shaped; basals low, 3, unequal, with small one in, *AE* interray; radials large, radial articular facets as wide as radials, with transverse ridge and ligament pit; anal *X* slender and elongate, with proximal part notching

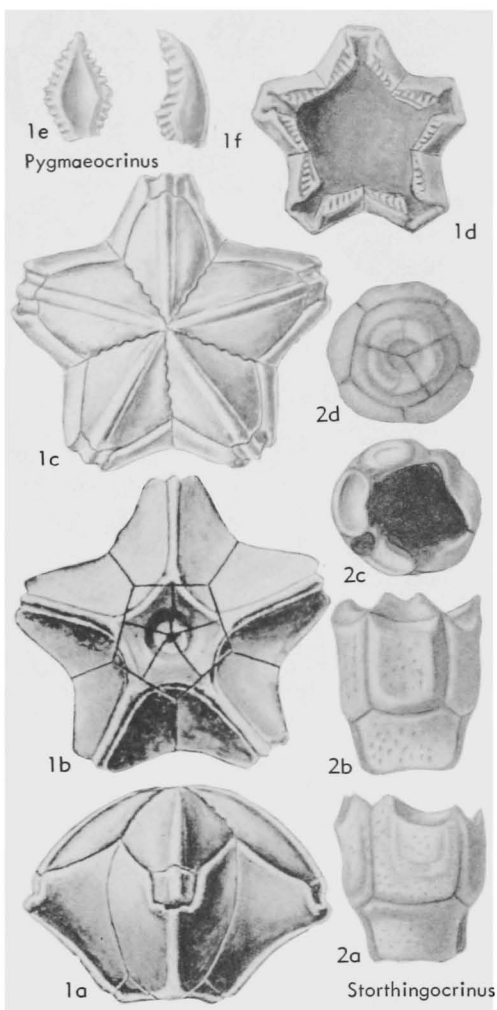


FIG. 351. Pygmaeocrinidae (p. T558-T559).

upper corners of *C* and *D* radials, extending distally to top of adjacent first primibrachs. Anal sac elongate and narrow, armlike, confined to posterior edge of tegmen. Tegmen composed of 5 large oral plates, *CD* oral slightly larger than others and interlocked at its apex with tips of *AB* and *AE* orals. Arms long and slender, atomous. *M.Dev.-U.Penn.*, cosmop.—FIG. 352,1a. \**S. conicus*, L.Carb., Eng.; lat. view of cup,  $\times 2$  (Wright, 1951-54).—FIG. 352,1b. *S. anglicus* WRIGHT, L.Carb., Eng.; lat. view of crown,  $\times 1$  (Wright, 1946).—FIG. 352,1c,d. *S. robustus* WACHSMUTH & SPRINGER, L.Miss.(Osag., Burlington Ls.), SE.Iowa; dorsal and ventral views of cup,  $\times 1$  (Moore & Laudon, 1943a).—FIG. 352,1e-p. *S. texasensis* MOORE & EWERS, L.Miss. (Osag., Chappel Ls.), Mason Co., Texas; 1e,f, *CD*-



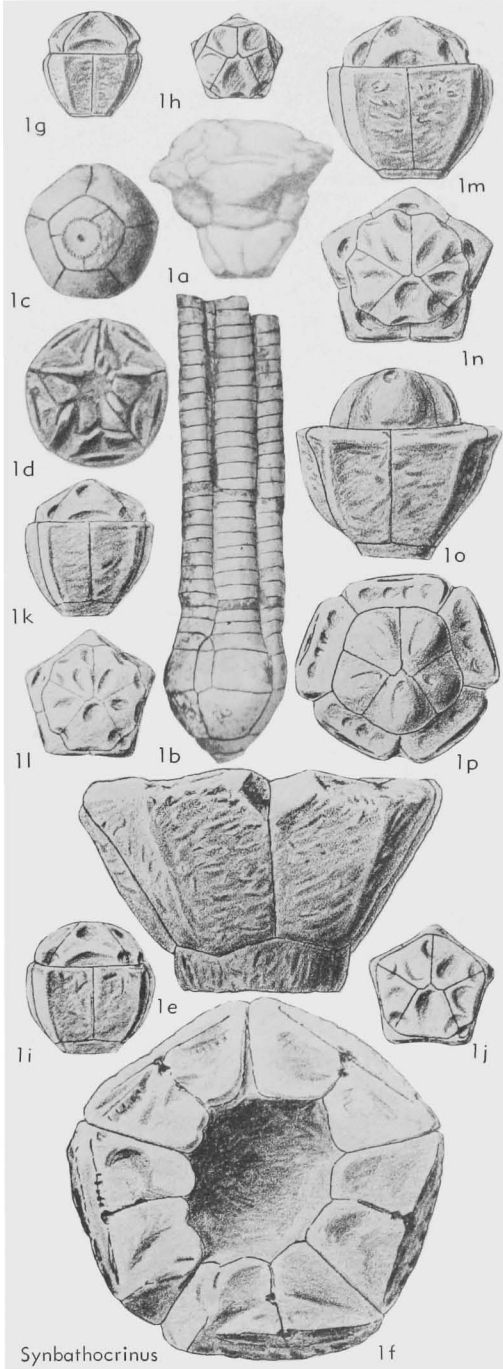


FIG. 352. Synbathocrinidae (p. T559-T560).

interray and ventral views of adult cup,  $\times 10$ ; 1g, h, 1i, j, 1k, l, 1m, n, 1o, p, CD-interray and ventral views of successively more mature juvenile

cup,  $\times 10$  (Moore & Ewers, 1942).

**Abyssocrinus** STRIMPLE, 1963, p. 29 [\**Synbathocrinus antiquus* STRIMPLE, 1952c, p. 76; OD]. Like *Theloreus* except transverse sutures separating infer- and superradials of B, C, and E rays not present consistently. Body cavity quite small and restricted ventrally by medially extended parts of radial articular facets. C and D radials notched by anal X. *M.Sil.* (Niagaran), USA (Okla.).—FIG. 353, 3. \**A. antiquus* (STRIMPLE); 3a-c, CD-interray, A-ray, and ventral views of theca,  $\times 2$  (Strimple, 1952c).

**Phimocrinus** SCHULTZE, 1866, p. 29 [\**P. laevis*; SD WACHSMUTH & SPRINGER, 1886, p. 170]. Cup high conical, truncate below; basals 5, simple; notch for anal X plate visible in side view of cup; posterior edges of C and D radial articular facets excavated at sides of anal tube, facets horizontal or inclined outward-upward, not visible in side view. *L.Dev.-M.Dev.*, Eu. (Ger.)-USA (Tenn.).—FIG. 353, 1. \**P. laevis*, *M.Dev.*, Ger.; 1a-c, lat., ventral, and dorsal views of theca,  $\times 2$  (Schultze, 1867); 1d, plate diagram of cup (radials black, A ray upward) (Moore, n).

**Ramacrinus** PROKOP, 1969, p. 375 [\**R. multiformis*; OD]. Basals 5, equal, high; A and D radials undivided, B, C, and E radials divided transversely by convex sutures into tall inferradials and short broad superradials. Arms unknown. Stem composed of low, cylindrical columnals. *L.Dev.-M.Dev.*, Eu. (Boh.).—FIG. 354, 1. \**R. multiformis*, *L.Dev.*, Boh.; 1a, b, post., and oral views of theca,  $\times 7.5$  (Prokop, 1970).

**Stylocrinus** SANDBERGER & SANDBERGER, 1856, p. 399 [\**S. scaber* (attributed to *Platycrinites scaber* GOLDFUSS [nom. nud.] by SANDBERGER & SANDBERGER); M]. Cup low; basals 5, or rarely 3, with small basal in DE interrady; posterior radials not notched by anal X; radial articular facets extending inward horizontally even with tops of radial plates, without distally directed radial processes. *U.Sil.-M.Dev.*, Eu. (Ger.)-USA (N.Y.-Okla.).—FIG. 353, 2. \**S. scaber*, *M.Dev.*, Ger.; 2a-c, lat. views of cup and crown and dorsal view,  $\times 3$ ,  $\times 6$ ,  $\times 12$  (Sandberger & Sandberger, 1856).

**Taidocrinus** TOLMACHEV, 1924, p. 289 [\**T. poljenowi*; M]. Like *Synbathocrinus* except that anal X is completely above cup and does not notch upper corner of either C or D radials. *U.Carb.*; *U.Perm.*, Eu. (USSR, Kuzbas)-Indon. (Timor).—FIG. 353, 5. *T. inflatus* (WANNER), *U.Perm.*, Timor (Noil Tonini); 5a-c, ant., dorsal, and ventral views of theca (CD interrady downward in 5b, c),  $\times 2$  (Wanner, 1916a).

**Theloreus** MOORE, 1962b, p. 44 [\**Phimocrinus jouberti* OEHLERT, 1882, p. 353; OD]. Cup tall and conical; basals 5, large, and distally upright; B, C, and E radials divided by transverse suture into large inferradial and short small superradial; upper corner of D radial and C superradial notched for reception of anal X. *M.Dev.*, Eu. (Ger.).—

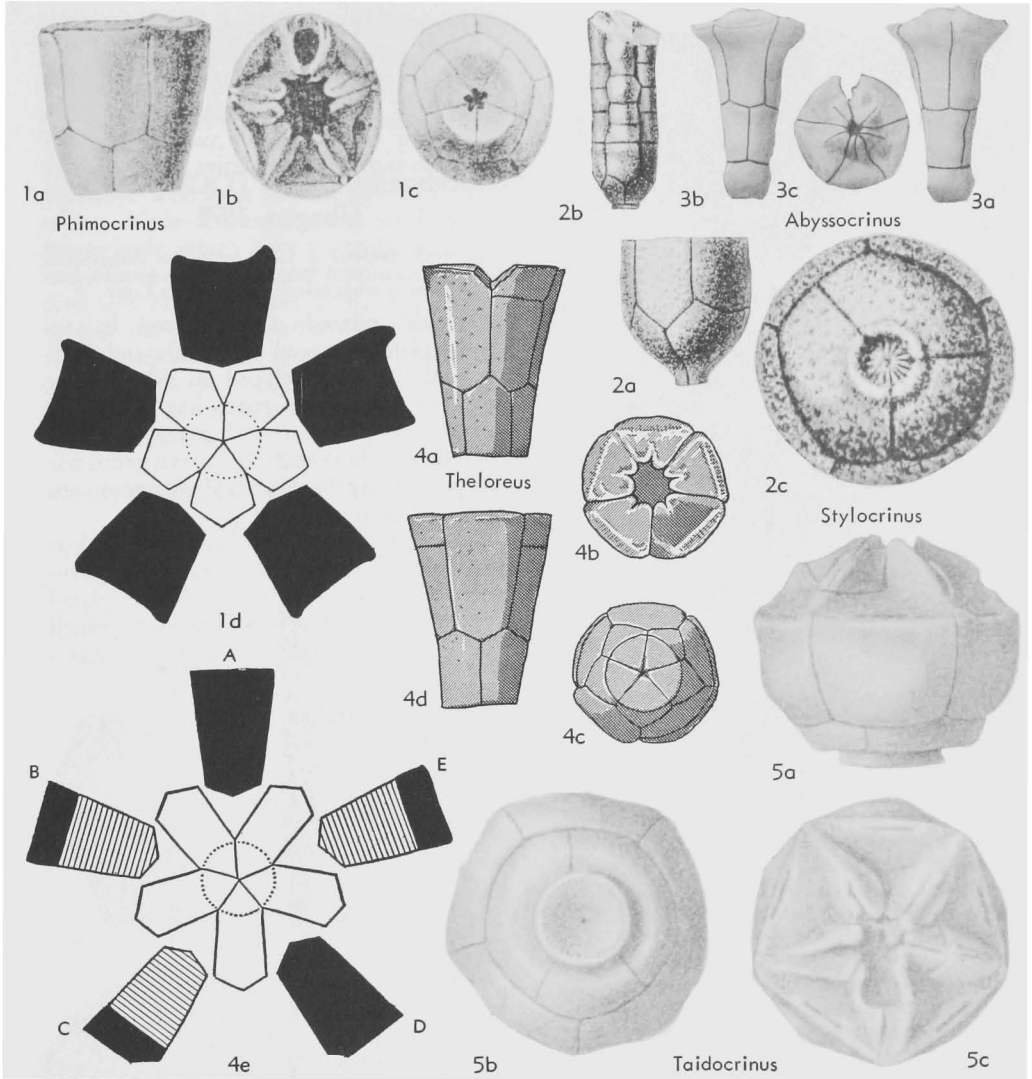


FIG. 353. Synbathocrinidae (p. T560-T561).

FIG. 353.A. \**T. jouberti* (OEHLERT); 4a-e, CD-interray, ventral, dorsal, and A-ray views of cup, plate diagram (radials and supraterials black, inferradials horizontally ruled),  $\times 2.5$  (Moore, 1962b).

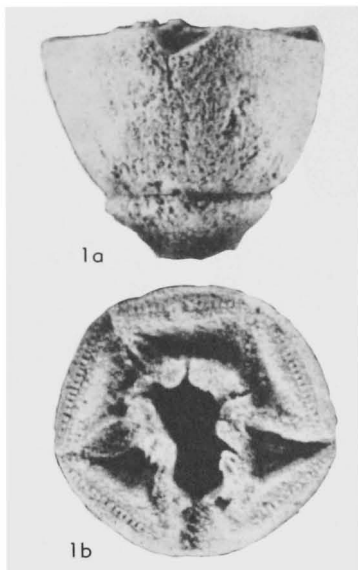
**Family ZOPHOCCRINIDAE**  
**S. A. Miller, 1892**

[Zophocrinidae S. A. MILLER, 1892b, p. 642] [=Tiaracrinidae BATHER in LANKESTER, 1900a, p. 57]

Cup small, globose; basals three or five; radials four or five; transverse epispiral canals may be present in radials; anal plates unknown; tegmen composed of five oral

plates. Arms much reduced or absent, brachials interposed between oral plates. *U. Sil.-M.Dev.*

**Zophocrinus** S. A. MILLER, 1891, p. 32 [\**Z. howardi*; M]. Cup small and high, pear shaped or obconical; basals 3, large, CD basal larger than others; radials 4, elongate, radial directly above CD basal larger than others and may represent laterally fused C and D radials. Anal plates unknown. Tegmen composed of 5 spear-shaped plates, CD oral slightly larger than others and interlocking with tips of AB and AE orals. Five groups of 3 small ?fixed brachial plates disposed around periphery of tegmen directly above each



Ramacrinus

FIG. 354. Synbathocrinidae (p. T560).

interloral suture and in contact with distal edges of radials. No ambulacral or other opening in theca known; center plates of each group bearing a small ?arm facet at its admedial end and bounded by curved ends of 2 lateral plates of each group. Arms and stem unknown. *U.Sil.*, USA (Ill.-Ind.-Okla.-Tenn.).—FIG. 355,1. \**Z. howardi*; 1a,b (Ind.), post. and ant. views of theca,  $\times 4$  (Springer, 1926b); 1c-e (Tenn.), dorsal, lat., and ventral views,  $\times 3$  (Miller, 1892b).

**Parazophocrinus** STRIMPLE, 1963, p. 61 [*\*P. callosus*; OD]. Like *Zophocrinus* except that 5 basal and 5 radial plates are present. *U.Sil.*, USA (Okla.).—FIG. 356,1. \**P. callosus*; 1a,b, ventral and dorsal views,  $\times 1.5$ ; 1c, dorsal view of another specimen,  $\times 1.5$  (Strimple, n).

**Tiaracrinus** SCHULTZE, 1867, p. 226 [*\*T. quadri-frons*; M] [= *Staurosoma* BARRANDE, 1887, p. 21 (obj.) (type, *S. rarum* BARRANDE, 1887, = *T. quadri-frons*)]. Cup small, globular, composed of 3 small, low basals which form basal concavity of cup; radials 4, large, with 4 sets of transverse epispiral ridges and intervening grooves; epispires increase in width distally, most proximal one just above basals having single opening above intraradial suture; epispiral canals extending under each ridge through skeletal material of radial from one external opening to another at extremities of each ridge; 8 to 25 canals present in each epispire. Tegmen composed of 5 large interlocking orals. ?Fixed brachials numerous, in 5 sets, and in contact with radials admedially, each set composed of 11 or 12 small thin plates and 1 or 2 small triangular plates admedially. Arm facets

obscure or absent. Arms and column unknown. *L.Dev.-M.Dev.*, Eu.(Ger.-France-Boh.).—FIG. 355,2. \**T. quadri-frons*; M.Dev., Ger.; 2a,b, CD-interray and dorsal views,  $\times 2$ ; 2c,d, dorsal and ventral views,  $\times 3$  (Springer, 1926b).

## Superfamily PERITTOCRINACEA Ubags, 1971

[*nom. transl.* SPRINKLE & LANE, herein (*ex* Perittocrinina UBAGHS, 1971a, p. 329)] [Material for this superfamily prepared by JAMES SPRINKLE and N. GARY LANE]

Disparid crinoids characterized by accessory plates between the basals and radials; anal X well developed on side of cup; only four basals; one genus has endotheal pore slits between cup and accessory plates, whereas the other presently known genus has enlarged proxistele composed of tetrameres. *Up.L.Ord.* or *low.M.Ord.*

Although classified by UBAGHS (1971a) as a suborder of the order Hybocrinida, perittocrinids do not seem to be closely related to hybocrinids. Both perittocrinid genera have numerous triangular accessory plates

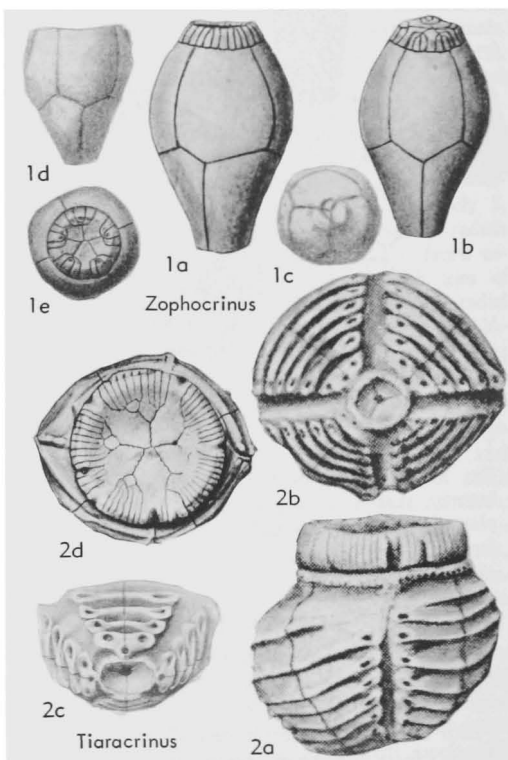


FIG. 355. Zophocrinidae (p. T561-T562).

between the larger basal and radial plates and only four basals; in addition, *Perittocrinus* has endothecal pore slits between most of the cup plates (not present in *Tetracionocrinus*, which has a proximally enlarged stem with primitive four-piece columnals). The stem is unknown in *Perittocrinus*. None of these features are found in hybocrinids, which have a standardized pattern of cup plates without accessory ones or pore slits and a slender stem composed of normal one-piece columnals. Perittocrinids are here classified as a separate superfamily of the Disparida because they do not seem to be closely related to any other Ordovician disparids.

### Family PERITTOCRINIDAE Abel, 1920

[Perittocrinidae ABEL, 1920, p. 264]

Cup globose, composed of four basals, five large radials, radianal, anal X, and numerous small to medium-sized accessory plates between primary cup plates; radial articular facets narrow and suboval; endothecal pore slits (respiratory folds) or hollow ridges crossing most cup plate sutures at right angles. *Up.L.Ord.* or *low.M.Ord.*

**Perittocrinus** JAEKEL, 1902, p. 1093 [*\*Porocrinus radiatus* BEYRICH, 1879, p. 61; SD BASSLER, 1938, p. 150]. Perittocrinids with endothecal pore slits crossing sutures between major cup plates and smaller triangular accessory ones. Stem, arms, and tegmen unknown. *Up.L.Ord.* or *low.M.Ord.*, Eu.(NW.USSR).—FIG. 357,2a-c. *\*P. radiatus* (BEYRICH); 2a, plate diagram; 2b,c, lat. post. and dorsal views of cup,  $\times 2$  (Ubaghs, 1971a).

**Tetracionocrinus** UBAGHS, 1971, p. 333 [*\*Perittocrinus transitor* JAEKEL, 1918, p. 49]. Perittocrinids with raised hollow ridges extending across sutures between all cup plates, including accessory plates. Enlarged proximal columnals composed of tetrameres. Arms and tegmen unknown. *Up.L.Ord.* or *low.M.Ord.*, Eu.(NW.USSR).—FIG. 357,1a-c. *\*T. transitor* (JAEKEL); 1a, plate diagram; 1b,c, ant. and post. views of cup,  $\times 5$  (Ubaghs, 1971a).

## Superfamily UNCERTAIN

### Family PARADOXOCRINIDAE Moore & Laudon, 1943

[Paradoxocrinidae MOORE & LAUDON, 1943a, p. 102] [Materials for this family prepared by N. GARY LANE]

Diagnosis same as for genus. *U.Perm.*

**Paradoxocrinus** WANNER, 1937, p. 205 [*\*P. patella*;

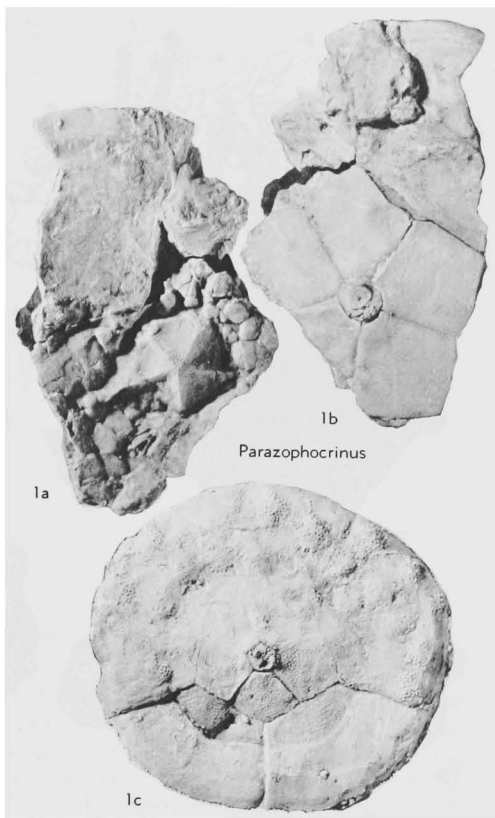


FIG. 356. Zophocrinidae (p. T562).

OD]. Cup bowl shaped, basally concave, constricted distally; basals 3, subequal in size; radials 5; basals and radials surrounded and mostly covered by 5 to 13 bulbous accessory plates; 5 triangular orals alternate with radials; anal vent opening below posterior oral and between C and D radials. Arms unknown. Stem round. *U.Perm.*, Indon.(Timor).—FIG. 358,1. *\*P. patella*, Basleo; 1a,b, lat. and ventral views of theca with orals in place,  $\times 1.5$  (Marez Oyens, 1940b); 1c-f, lat., dorsal, central, and dorsal views of cup,  $\times 2$  (Wanner, 1937).

### Family UNCERTAIN

**Vosekocrinus** JAEKEL, 1918, p. 56 [*\*V. granulatus*; M]. Cup low, bowl shaped; basals and radials large; radial facets rounded, somewhat narrower than radials; anal plates unknown. Arms isotomous, branching on second primibrachs and with at least two higher divisions. Stem pentagonal. [Poorly known, traditionally placed in the Dendrocrinidae of the cladid inadunates, but JAEKEL (1918) states clearly that infrabasal plates are lacking and he places the genus in the family Vosekocrinidae with *Caleidocrinus* WAAGEN &

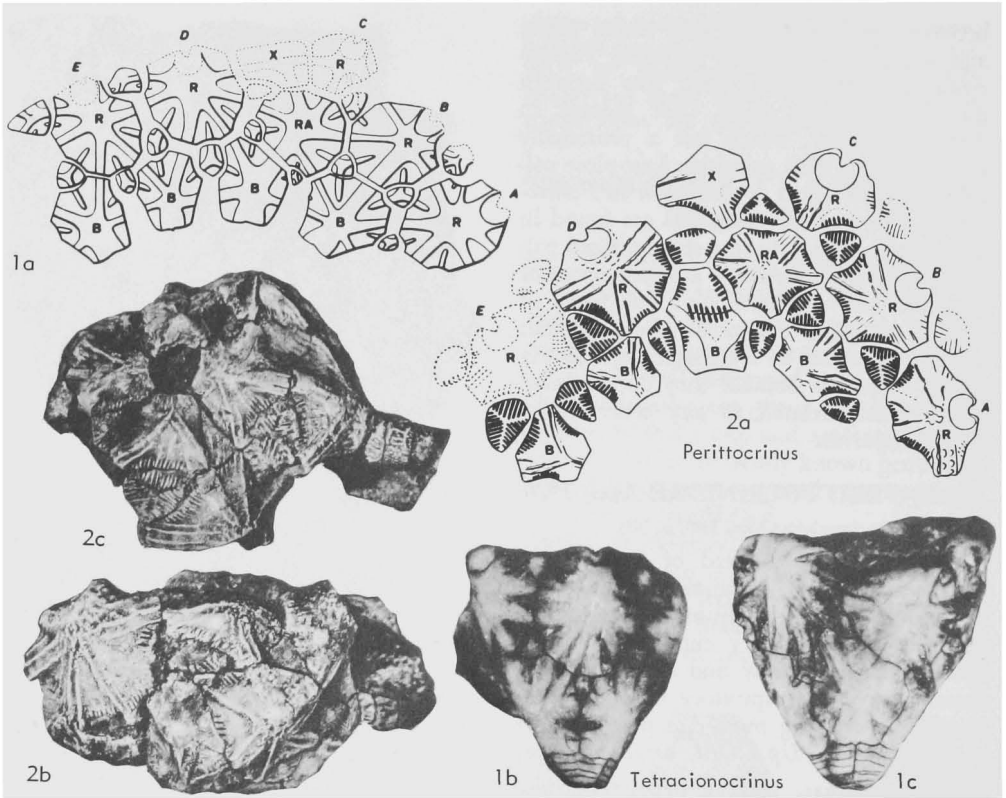


FIG. 357. Perittocrinidae (p. T563).

JAHN, a genus that has been accepted as a monocyclic disparid inadunate.] *L.Ord.*, Eu.(Boh.). —FIG. 359, I. \**V. granulatus*; diagram, lat. view of cup,  $\times 2$  (Jaekel, 1918). [LANE]

**HYBOCRINIDA**

By JAMES SPRINKLE and  
RAYMOND C. MOORE

**INTRODUCTION**

The Hybocrinida are a small group of early Paleozoic monocyclic inadunate crinoids that show a tendency toward reduction or loss of the arms and replacement by recumbent ambulacral grooves. Only seven genera and about 27 species are known, ranging from the Early to Late Ordovician. At present, these genera are grouped into four families in the order Hybocrinida, based on the number and type of appendages present. Although the food-gathering in appendages have been drastically mod-

ified in several advanced genera, the thecal plating and development of the water vascular system has remained very stable in nearly all hybocrinids, enabling them to be differentiated easily from other early echinoderm groups with similar morphology and recumbent ambulacra.

**THECA**

The theca of most hybocrinid genera consists of a large cup-shaped to globular cup with a reduced tegmen. No anal tube or sac is present in any of the known genera. The plating is monocyclic and only a single compound radial is present in the C ray. The lateral profile of the theca usually shows a slight to moderate asymmetry with a bulged CD interray, unequal-sized basals, and in some species a slightly offset stem facet.

All hybocrinids except *Cornucrinus* have standardized monocyclic arrangement of the cup plates with only slight variation from

genus to genus; five basals, five radials with the *C* radial generally much smaller than the others and supported by a large radial below, anal *X* and several accessory anals in the posterior interray, and five small orals around the mouth on the summit (Fig. 360). The specialized genus *Cornucrinus* has two of its basals fused, no anal *X*, the anal opening displaced down to the side of the cup, and either very small orals on the tegmen or none at all (see Fig. 366,1a).

The only plating feature to show any systematic variation is the size and position of the anal *X* with respect to the *C* radial and radial. In *Revalocrinus*, the most primitive hybocrinid, the anal *X* (missing) must have been quite small and confined to the tegmen obliquely above the *C* radial (see Fig. 364,3); it apparently did not reach the radial below. In slightly more advanced genera (*Baerocrinus*, *Hoplocrinus*), the anal *X*, still relatively small, is mostly confined to the domed tegmen but does reach the elongate radial (Fig. 364,2a). In relatively advanced genera such

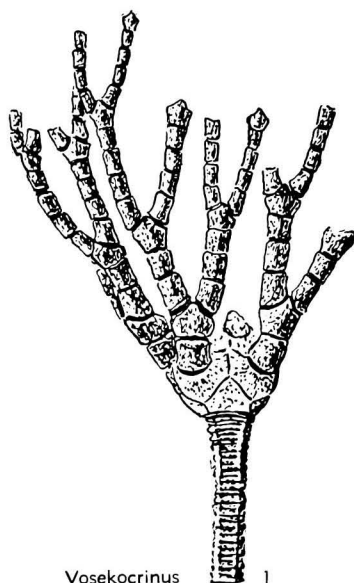


FIG. 359. Family Uncertain (p. T563-T564).

as *Hybocrinus*, *Hybocystites*, and *Tripato-*  
*crinus*, the anal *X* has moved down to become part of the cup above the radial and has increased to about the same size as the *C* radial, which is located directly beside it (Fig. 360).

Hybocrinids show two unequally-developed planes of bilateral symmetry in the organization of the theca, in addition to the basic pentamer symmetry. Because only one radial is compound (*C* radial plus radial in the *C* ray), hybocrinids should have an eustenocrinoidal plane (*C-AE*) of bilateral symmetry, but in most hybocrinid genera this is far outweighed by a crinoidal plane of bilateral symmetry passing through *A-CD* (Fig. 360). The sizes and shapes of all three circllets of cup plates, location of the hydropore and anal opening, comparison of the combined *C* radial plus radial with the larger *D* radial, and type of food-gathering appendage in each ray all correspond with this latter symmetry plane. The crinoidal plane is best developed in genera either with recumbent ambulacra or no food-gathering appendages in some rays, because the ray dominance in these structures conforms strongly to this bilateral symmetry plane.

Most hybocrinids have fine to relatively

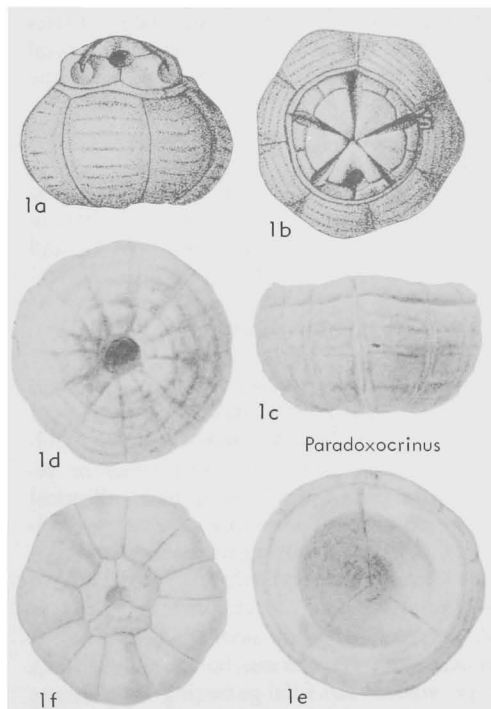


FIG. 358. Paradoxocrinidae (p. T563).

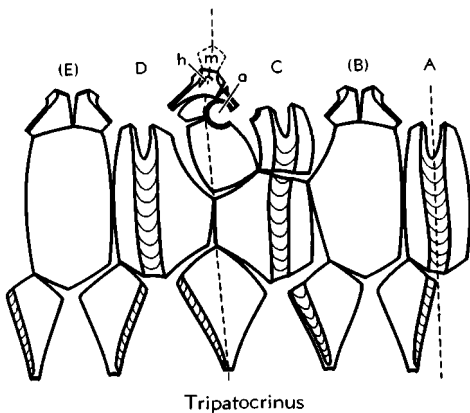


FIG. 360. Plate diagram of *Tripatocrinus* (Hybocrinacea, Cornucriinidae) (Sprinkle, 1973b, mod.). [Explanation: *a*, anus; *h*, hydropore; *m*, mouth.]

coarse pustulose or ridgelike ornament on the exterior of the cup plates. Concentric growth lines are also present on the interior of a few plates of *Tripatocrinus* (SPRINKLE, 1973b), implying that these plates have increased in size by overlaying primary plate growth, as is known to occur in several other fossil crinoids.

#### FOOD-GATHERING APPENDAGES

Hybocrinids show great variability in their type of food-gathering structures. These can be developed 1) as normal erect arms attached to the radial articular facets, 2) as modified and shortened arms with a recurved ambulacral groove, 3) as recumbent ambulacral grooves extending down over the surface of the cup plates, or 4) lack of any food-gathering structure at all in a ray. Normal arms, where present, are relatively short, uniserial, unbranched (atomous), and nonpinnulate. In the few complete specimens known, they range up to about three times the cup length (see Fig. 364, *lc*). An ambulacral furrow or food groove protected by a set of tiny ambulacral cover plates extends up the adoral side of each arm. These arms in hybocrinids seem to represent the simplest (and perhaps ancestral) type of arm found in all crinoids.

Modified arms are known only in the genus *Hybocystites* where they occur in the *A*, *C*, and *D* rays. These are very short, curved arms (less than the cup height) and

contain only two to six brachials. The ambulacral groove is recurved, running up the adoral side, over the rounded distal brachial, and down the aboral side, in some individuals even reaching the cup plates below (see Fig. 365, *ld*). These unusual arms in *Hybocystites* are thought to represent an intermediate stage in the change from an erect arm to a recumbent ambulacrum (Fig. 361).

Recumbent ambulacral grooves are found in three hybocrinid genera, but are practically unknown in other crinoids. In *Hybocystites* or *Tripatocrinus*, these U-shaped grooves extend from the central mouth down over the cup plates or along the sutures between them, in some specimens reaching the stem facet (Fig. 360). In *Cornucriinus*, these ambulacral grooves extend out over the humped or pronged radials and continue back along part of the dorsal side. No flooring (or side) plates occur in these recumbent grooves, probably because no other plated appendages were mounted on them. Like the food grooves on erect or modified arms, the recumbent ambulacral grooves were protected by one or two sets of minute cover plates. Plates of the cup beneath each of these ambulacral grooves are usually thickened to support the deeply embayed groove.

The *B* and *E* rays of three hybocrinid genera have no food-gathering structures at all. The radial and oral plates in these rays appear to be normally developed, but in contrast to the other three rays (*A*, *C*, and *D*) which bear either arms (*Baerocrinus*) or ambulacral grooves (*Tripatocrinus*, *Cornucriinus*), no appendages are present here. This apparently represents a terminal stage in the reduction of an erect arm or a continuation of the transition from an erect arm to a recumbent ambulacrum (Fig. 361).

Hybocrinids with modified arms or recumbent ambulacra have a large elliptical coelomic notch (SPRINKLE, 1973b) extending through the bottom of the ambulacrum into the cup interior at the oral-radial suture or radial articular facet. This opening is also present, although smaller, in hybocrinid genera with erect arms, but is absent from rays where no food-gathering appendage occurs. Extensions from the major coelomic cavities and from the water-vascular, hemal,

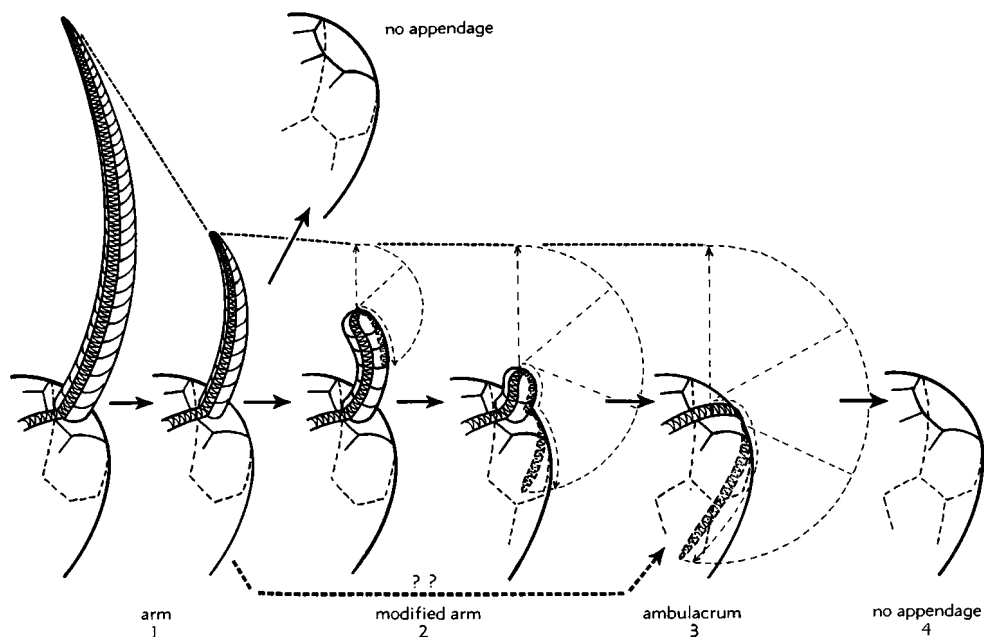


FIG. 361. Inferred modification of food-gathering appendages during hybocrinid evolution. Normal erect arms (state 1) are either directly lost (short side branch at top), or shortened to modified arms with recurved ambulacral grooves (state 2), then to recumbent ambulacral grooves (state 3), and finally lost (state 4, right) (Sprinkle, n).

perihemal, and nervous systems probably extended out through each coelomic notch to the ambulacral groove or arm, where feeding, respiration, sensory perception, and other important functions took place. The coelomic notches in *Tripatocrinus* show apparent allometric growth when compared to the size of the surrounding cup plates (SPRINKLE, 1973b), implying that their area served the internal volume of the cup. The presence of coelomic notches indicates that a water-vascular canal and tube feet were almost certainly present in the recumbent ambulacra of these hybocrinids, as would be expected in such crinoids. However, recumbent ambulacral areas in similar-appearing blastozoan echinoderms lack coelomic notches, implying a possible major difference in the development of the water-vascular system.

In hybocrinids retaining five arms, no ray dominance is seen because the arms are equally developed in all rays. However, in more specialized hybocrinids, which have developed modified arms, recumbent am-

bulacra, or no appendages in some rays, it is invariably the equally developed *A*, *C*, and *D* rays that have retained the more ancestral state, whereas rays *B* and *E* show an equal but greater change or reduction in food-gathering structures. Ray dominance in hybocrinids can therefore be indicated by the "equation":  $(A,C,D) \geq (B,E)$  where  $A=C=D$  and  $B=E$ .

Dominance of one or more rays over the others is observed in several other crinoid groups, such as Calceocrinidae where *A* and *D* are the dominant rays and retain the two sets of modified arms.

#### STEM

All hybocrinids have a normal stem of unknown length composed of dislike, one-piece, circular columnals. Near the cup the stem either has a small diameter (*Tripatocrinus*) or is slightly larger than its more distal portions (*Hoplocrinus*, *Hybocystites*). In most specimens of *Hybocystites*, the proxistele shows a strong curvature toward the bulged posterior (*CD*) side



of the cup (see Fig. 365, *1e*), perhaps implying that the theca may have been held either in a tilted position or upright just above the bottom with a distally recumbent stem. STRIMPLE (1975) has proposed that asymmetrical hybocrinids were bottom living and had a short trailing (or buried) stem. No terminal attachment structures have been found on hybocrinid stems.

### HYBOCRINID EVOLUTION

Hybocrinids apparently evolved from an ancestral inadunate crinoid with a relatively large cup, five short simple arms, reduced monocyclic arrangement of the cup plates with a divided radial in only one ray (*C*), and a normal columnal-bearing stem. No Late Cambrian or Early Ordovician crinoid ancestor with these features is known at present.

Once they had evolved, some hybocrinid genera (three out of seven) retained the primitive five-armed condition; these apparently represent the most conservative group of hybocrinids. However, four other genera have diverged from this arrangement either by losing two of the arms (*Baerocrinus*, see Fig. 365, *2a*) or by reducing and modifying all of the appendages to varying degrees (Fig. 361). *Hybocystites* (see Fig. 365, *1c,d*) has the most unusual arrangement with three modified arms and two ambulacral grooves. If we assume that *Hybocystites* represents an intermediate stage of arm reduction, we can construct a chart showing possible steps in this arm reduction and possible loss (Fig. 361).

These advanced genera apparently reduced the relatively short atomous arms found in conservative hybocrinids, but kept the food-gathering ambulacral groove nearly constant in total length by running it over the top of the rounded distal brachial and down the ventral side, in some crowns even reaching the cup plates (Fig. 361). From this stage, shown by the *A*-, *C*-, and *D*-ray arms of *Hybocystites*, it would have been only a short additional step to do away altogether with the reduced remnant of the arm and run about the same length of ambulacral groove down over the cup surface or out onto long radial prongs. The genera with no appendage at all in the *B* and *E* rays could have achieved this state either

by reducing an arm to zero with no modification (short side branch, Fig. 361), or by continuing the arm-to-ambulacrum reduction and finally eliminating the ambulacral groove also. The arm-reduction sequence appears to be pedomorphic in nature because growth of the arm by budding off new brachials at the distal tip stops at an earlier and earlier stage during this transition (Fig. 361).

Based on this inferred evolutionary sequence, an appendage-state "matrix" and evolutionary chart can be set up by plotting the appendage type in rays *A*, *C*, and *D* against the appendage type in rays *B* and *E* (1 = arm; 2 = modified arm; 3 = ambulacral groove; 4 = no appendage) and connecting by arrows all possible appendage reduction steps (Fig. 362, *A,B*). Conservative hybocrinids with five normal arms (*Revalocrinus*, *Hoplocrinus*, and *Hybocrinus*) fit into box [1, 1] of this appendage-state chart and matrix (Fig. 362, *B*). *Baerocrinus*, with 3 arms, belongs in box [1, 4]; *Hybocystites*, with 3 modified arms and 2 ambulacral grooves, fits into box [2, 3]; and *Tripatocrinus* and *Cornucrinus*, with 3 ambulacral grooves, belong in box [3, 4] (Fig. 362, *A,B*). Attention may be called to the fact that appendage states [2, 2], [3, 3], and [4, 4] are all unknown in fossil hybocrinids. This suggests that once arm reduction in the hybocrinids began, the *A*, *C*, and *D* rays became dominant over rays *B* and *E*, and these equal-reduction states may never have been reached. Therefore, a simplified evolutionary matrix and chart can be set up by eliminating these unlikely positions (Fig. 362, *C,D*). Three intermediates still remain unknown in this inferred phylogeny.

A normal hybocrinid ancestor with five equal arms could have given rise to *Baerocrinus* either by direct loss of the *B* and *E* arms or by reduction to modified arms, ambulacra, and then complete loss (Fig. 362, *D*). Also, *Hybocystites* could have evolved from the second of these unknown intermediates by reduction of the normal *A*, *C*, and *D* arms to modified arms. *Tripatocrinus* and *Cornucrinus* could have descended from either *Baerocrinus* (less likely) or *Hybocystites* (more likely) by means of an unknown intermediate with

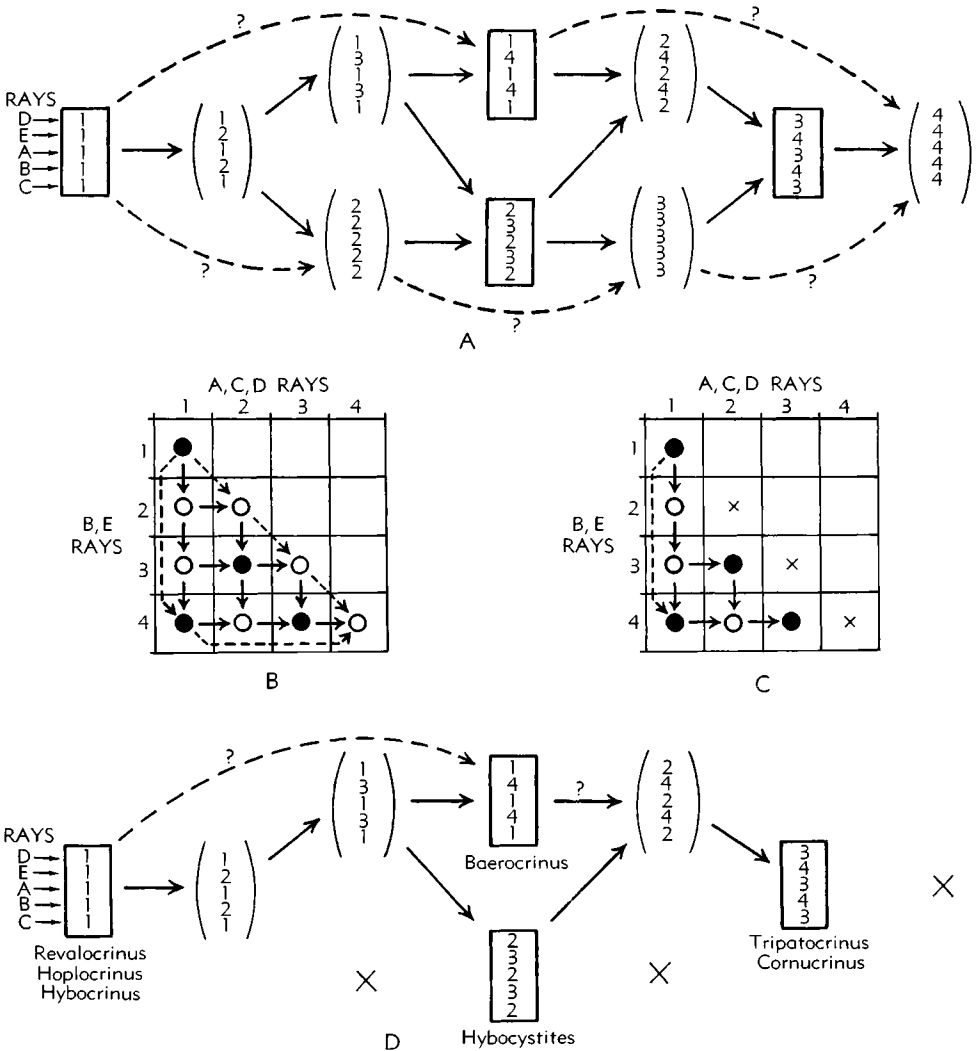


Fig. 362. Diagrams (A, D) and "matrices" (B, C) showing possible appendage states and pathways for hybocrinid evolution either with no assumptions (A-B) or assuming ray dominance [rays A, C, D > B, E for B, E > 1] (C-D). Note that even in the simplified phylogeny (C-D), three intermediates ([1, 2], [1, 3], and [2, 3]) are still missing from the fossil record of hybocrinids (Sprinkle, n). [Explanation of symbols: 1, arm; 2, modified arm; 3, ambulacrum; 4, no appendage; ● and □, morphology represented by genera in fossil record; ○ and ( ), morphology of unknown intermediates; X, improbably morphology because of appendage dominance.]

only three modified arms [2, 4] (Fig. 362,C,D). This sequence of appendage reductions apparently ended here because reduction to no appendages (box [4, 4]) was apparently impossible for crinoids as large as hybocrinids; however, some microcrinoids have apparently reached this final stage.

This modification and reduction of arms to ambulacral grooves in advanced hybocrinids such as *Tripatocrinus* and *Cornucrinus* has produced a plate arrangement in the cup very similar to that found in many blastozoan echinoderms (eocrinoids, rhombiferans, parablattoids, and blastoids)

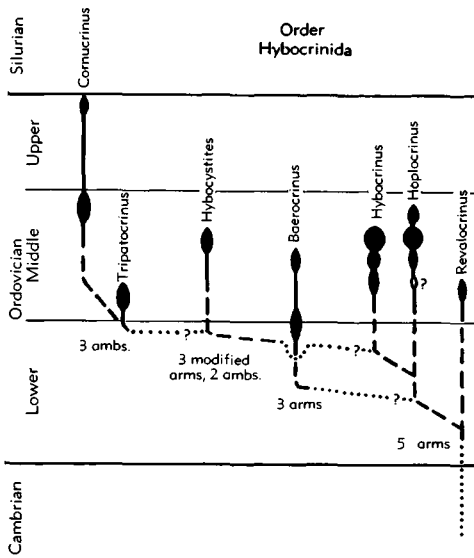


FIG. 363. Stratigraphic distribution of hybocrinids (Sprinkle, n).

(SPRINKLE, 1973a). These convergent hybocrinids have adopted a blastozoan "design" and perhaps way of life with a large globular theca, recumbent ambulacra, reduced cup plates, and strongly developed pentamer symmetry. However, they have made these changes while retaining a variety of features conclusively showing their crinoid affinities and ancestry—normal hybocrinid plating, unplated ambulacral grooves bearing a coelomic notch, overlaying plate growth, and inferred presence of ambulacral tube feet. The observed differences in ambulacral development in these two convergent groups may indicate several possible differences in soft part morphology (SPRINKLE, 1973b). Unlike blastozoans which have plated brachioles mounted on their recumbent ambulacra, hybocrinids apparently had only soft tube feet which were hydraulically controlled and needed no special supporting side or flooring plates. Flooring plates might also have interfered with the overlaying type of thecal growth found in these crinoids (SPRINKLE, 1973a).

Hybocrinids range from Early to Late Ordovician (Fig. 363), when they apparently became extinct without leaving any descendants.

## Order HYBOCRINIDA Jaekel, 1918

[*nom. transl. et correct.* MOORE in MOORE, LALICKER & FISCHER, 1952, p. 613 (*ex suborder Hybocrinites* JAEKEL, 1918, p. 90)]

Monocyclic crinoids having moderately large ovoid or trigonal to pentagonal conical theca with slight to well-defined asymmetry and dominance of bilateral symmetry in crinoidal plane (*A-CD*) over eustenocrinoidal plane (*C-EA*). Five relatively short, uniserial, atomous, and nonpinnulate arms which are erect in conservative genera, but recumbent or reduced to ambulacral grooves on cup plates in others and eliminated entirely from *B* and *E* rays in most specialized forms. Thecal plating simple (five basals and radials, one or more anals, five orals and small additional plates on tegmen); radials undivided except in *C* ray, no anal tube or sac, and tegmen considerably reduced. Small-diameter stem with circular columnals. *L.Ord.-U.Ord.*

### Family HYBOCRINIDAE Zittel, 1879

[Hybocrinidae ZITTEL, 1879, p. 350]

Hybocrinids having five relatively short uniserial arms, one in each ray. *M.Ord.*

**Hybocrinus** BILLINGS, 1857, p. 274 [*\*H. conicus*; SD WACHSMUTH & SPRINGER, 1880, p. 74] [= *Indianocrinus* MILLER & GURLEY, 1895b, p. 83 (type, *I. punctatus*)]. Cup moderately asymmetrical with normally arranged plates including medium-sized *C* radial and anal *X* on side of theca above radianal, several very small accessory anals present around multiplated periproct above anal *X*; posterior oral containing raised hydropore; radial articular facets relatively large and circular; arms relatively short; ambulacral cover plates in multiple series on peristome, one series aborally. Most species have fine granular ornament on cup plates. Stem slightly enlarged proximally. *M.Ord.*, Can. (Ont.-Que.), USA (N.Y.-Ky.-Va.-Tenn.-Okla.).

—FIG. 364, *1a-f*. *\*H. conicus*, Ont.; *1a,b*, plate diagram and reconstruction of specimen with appendages restored (*h*, hydropore; *m*, mouth) (Sprinkle, n); *1c,d*, side views of 2 nearly complete specimens, showing relatively short uniserial arms,  $\times 1$  (Billings, 1859); *1e,f*, side and oral views of well-preserved theca showing multiplated anal pyramid, hydropore, and ambulacral cover plates,  $\times 1$  (Springer, 1911b).

**Hoplocrinus** GREWINGK, 1867, p. 7 [*\*Apiocrinus dipentus* LEUCHTENBERG, 1843, p. 17; M]. Cup slightly asymmetrical; radianal reaching level of radial summits, obliquely supporting medium-sized *C* radial and smaller anal *X* which is confined to rim of cup; plates with fine-coarse pus-

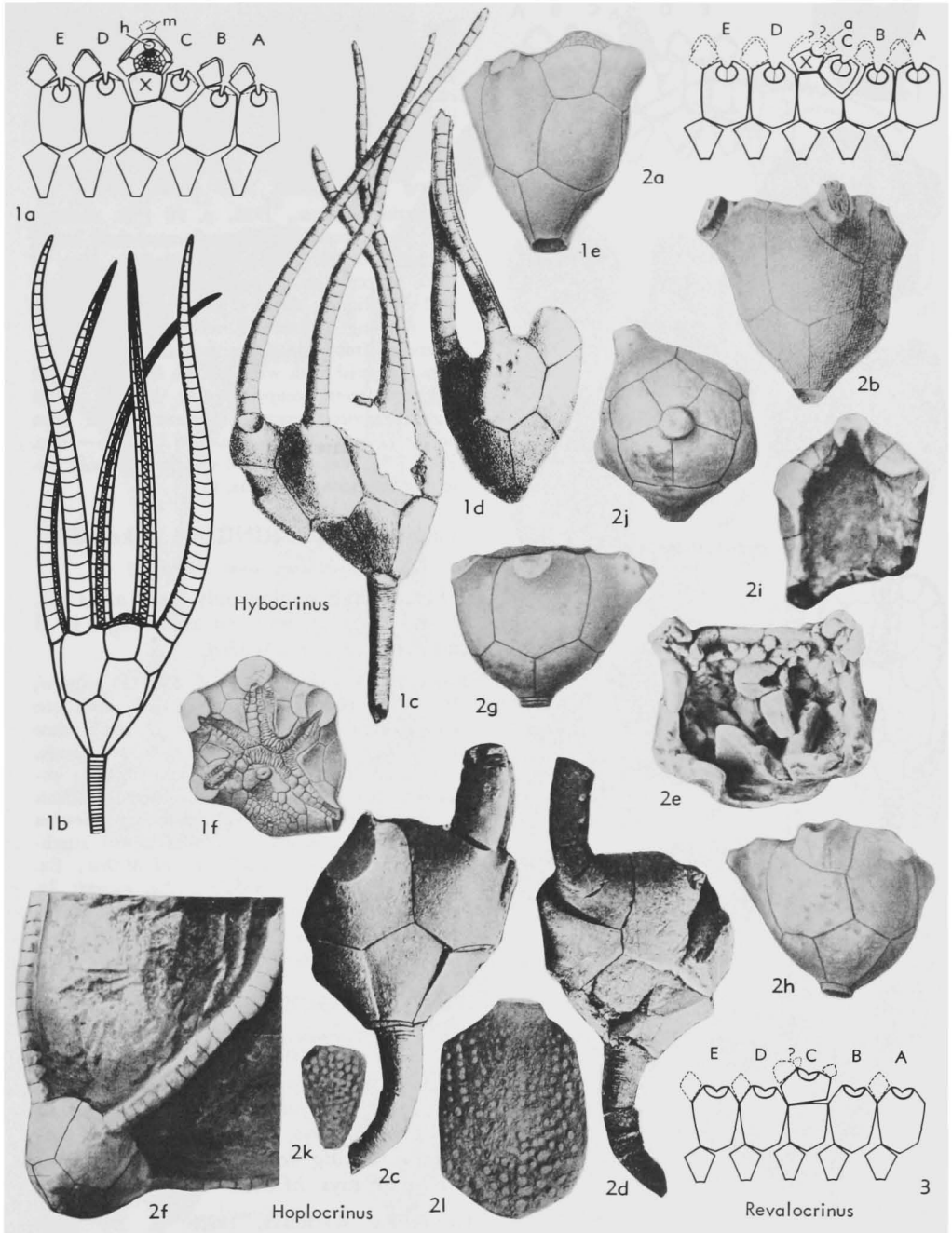


FIG. 364. Hybocrinidae (p. T570-T572).

tulose ornament; tegminal features poorly known. Arms relatively short, brachials U-shaped, with relatively large facets occupying about one-half of radial width. Stem slightly enlarged proximally. *M.Ord.*, Eu. (NW. USSR-Sweden)-USA (Utah).

—FIG. 364,2a,b. \**H. dipentus* (LEUCHTENBERG), USSR; 2a, plate diagram (a, anus) (Sprinkle, n); 2b, complete specimen showing thecal shape, ? $\times$ 1 (Grewingk, 1867).—FIG. 364,2c,d. *H. laevis* MYANNIL, USSR (Est.); side

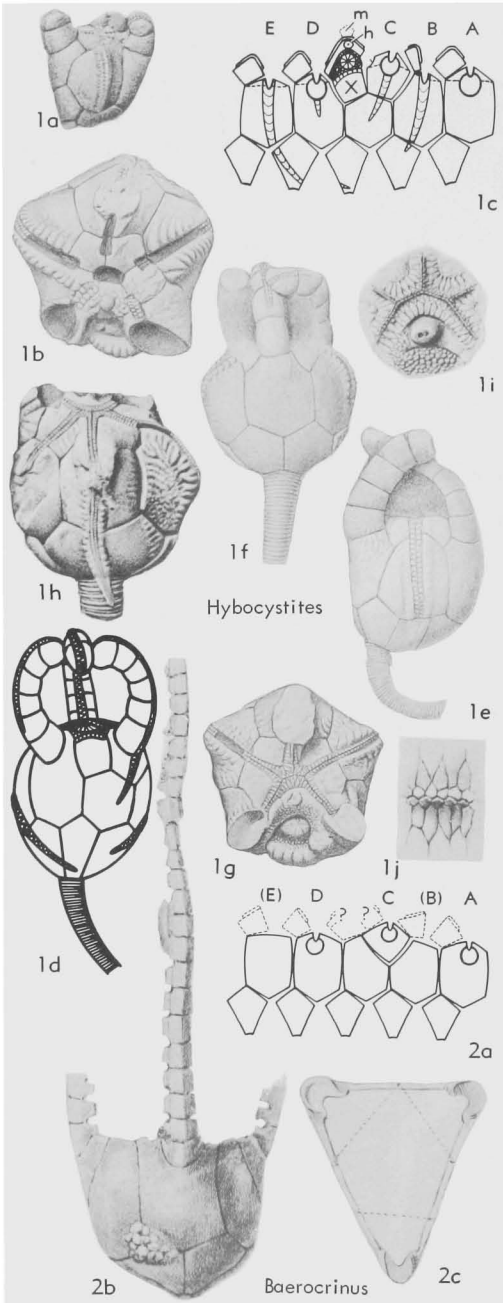


FIG. 365. Baerocrinidae (2); Hybocystitidae (1) (p. T572-T574).

views of specimen with slightly enlarged proximal stem and attached arm,  $\times 1.1$  (Myannil, 1959).—FIG. 364.2e. *H. estonus* ÖPIK, USSR(Est.); specimen showing details of crushed summit, incl. anal X, U-shaped brachials, and scattered ambulacral cover plates,  $\times 1.2$  (Öpik, 1935).—

FIG. 364.2f. *H. tallinnensis* ÖPIK, USSR(Est.); specimen showing relatively short incomplete arms,  $\times 1$  (Öpik, 1935).—FIG. 364.2g-j. *H. dalecarlicus* REGNÉL, Sweden; lat., lat., ventral, dorsal views of well-preserved cup,  $\times 2$  (Regnéll, 1948a).—FIG. 364.2k,l. ?*H.* sp. LANE, USA(Utah); 2k,l, isolated basal and radial plates which may belong to this genus,  $\times 1.3$  (Lane, 1970a).

**Revalocrinus** JAEKEL, 1918, p. 90 [*\*R. costatus*; M]. Cup composed of 5 small equal-sized basals, 5 large elongate radials with relatively large C radial directly above pentagonal radianal, small anal X obliquely above C radial on summit and not reaching radianal, 5 relatively large ?orals extending from side of cup to summit of tegmen. Arms uniserial with wide massive brachials, radial articular facets occupying over half of radial width; tegmen structures, ornament, and stem poorly known. *M.Ord.*, Eu.(NW.USSR).—FIG. 364.3. *\*R. costatus*, plate diagram of only described specimen, (Sprinkle, n).

### Family BAEROCRINIDAE Jaekel, 1918

[Baerocrinidae JAEKEL, 1918, p. 90]

Hybocrinids having only three arms (A, C, and D rays), with no appendages in B and E rays. *L.Ord.-M.Ord.*

**Baerocrinus** VOLBORTH, 1864, p. 65 [*\*B. ungeri*; M]. Cup triangular in ventral view, with one arm at each corner (A, C, and D rays); plate arrangement normal, radianal and C radial large, anal X small and confined to summit, orals unknown. Arms 3, composed of uniserial brachials quadrangular in side view, with large notches ventrally for insertion of muscles. Stem attachment scar relatively small. *L.Ord.-M.Ord.*, Eu. (NW.USSR).—FIG. 365.2a-c. *\*B. ungeri*; 2a, plate diagram (Sprinkle, n); 2b,c, lat. and ventral views showing shape of cup and development of arms,  $\times 2$  (Grewingk, 1867).

### Family HYBOCYSTITIDAE Jaekel, 1918

[*nom. correct.* REGNÉL, 1948a, p. 2 (*pro* Hybocystidae JAEKEL, 1918, p. 90)]

Hybocrinids having three short arms with long recurved ambulacral grooves in A, C, and D rays, in addition to long ambulacra running downward to base of cup in B and E rays. *M.Ord.*

**Hybocystites** WETHERBY, 1880b, p. 150 [*\*H. problematicus*; M] [= *Hybocystis* BATHER, 1890a, p. 324 (*nom. van.*)]. Hybocrinids having normally arranged plates showing slight to moderate asymmetry; C radial and anal X on side of theca above radianal; basals asymmetrical, with stem attachment slightly shifted forward; anal X distal, edges of radials, and areas alongside ambulacral grooves ornamented by raised ridges. Three short,

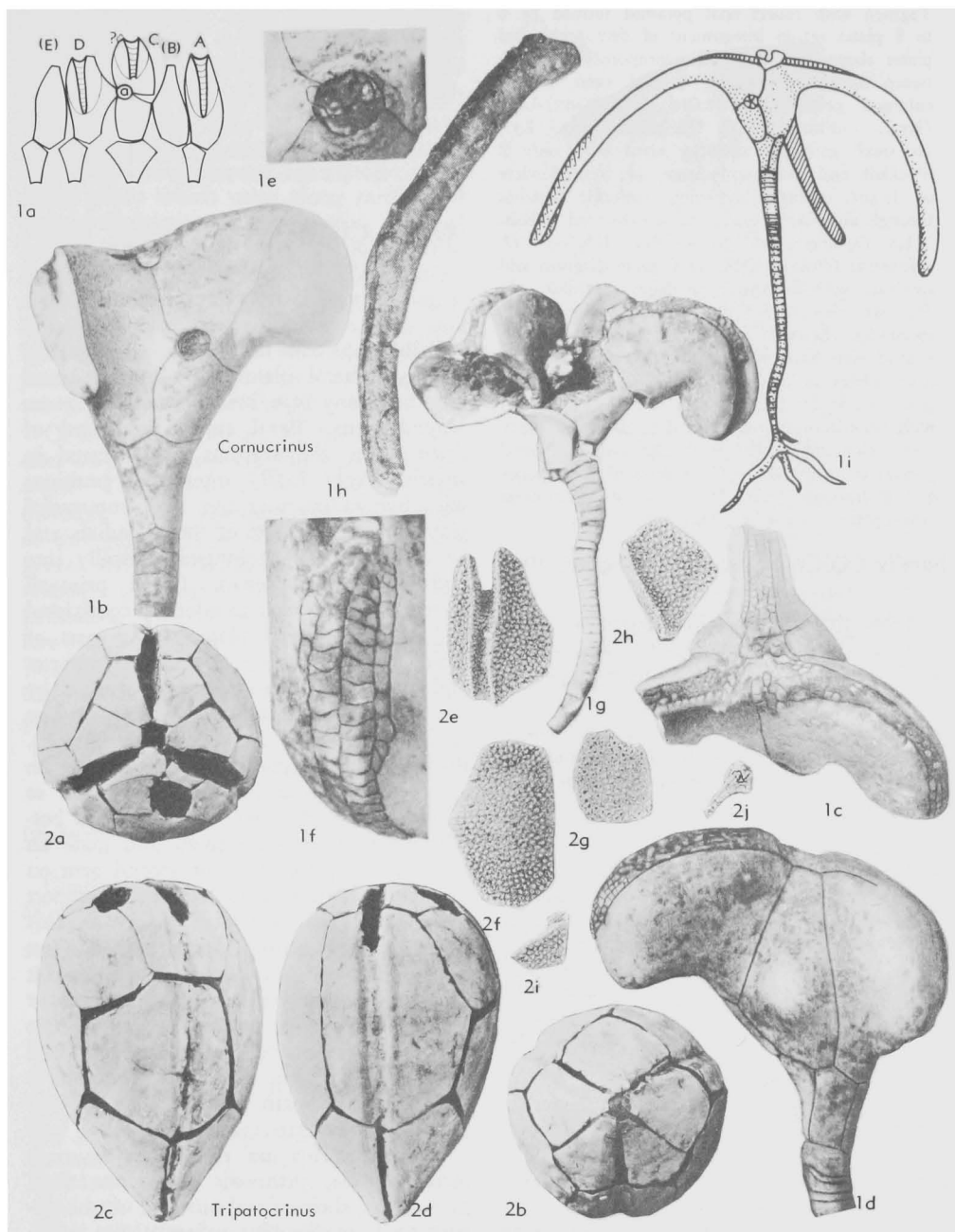


FIG. 366. Cornucrinidae (p. T574).

modified arms present in *A*, *C*, and *D* rays, each containing 2 to 6 uniserial brachials and rounded at distal tip, ventral side bears covered ambulacral groove which extends over tip and down dorsal side, in some cases reaching radial plates or even basals; similar grooves in armless *B* and *E* rays

located on radials and commonly extended diagonally across basals; all ambulacral grooves apparently provided with elongate coelomic notches between radials and orals near central mouth; 3 sets of ambulacral cover plates on peristome, but seemingly only single set present aborally.

Tegmen with round anal pyramid formed by 6 to 9 plates set in integument of tiny periproctal plates above anal *X*; small hydropore located between anus and mouth. Curved stem slightly enlarged proximally. *M.Ord.*, Can.(Ont.)-USA (Ky.).—FIG. 365, *1a,b*. \**H. problematicus*, Ky.; *1a*, small specimen showing arms with only 2 brachials and short ambulacra; *1b*, ventral view of larger specimen showing coelomic notches through ambulacra, orals, and ornamented radials,  $\times 1.3$  (Springer, 1911b).—FIG. 365, *1c-j*. *H. eldonensis* (PARKS), Ont.; *1c,d*, plate diagram and specimen with restored appendages (Sprinkle, n); *1e,f*, lat. views (*E* and *A* rays) of 2 complete specimens showing arms and stems,  $\times 2$ ; *1g*, ventral view showing peristomial and ambulacral cover plates in place, anal pyramid, and hydropore,  $\times 1.5$ ; *1h*, ant. view of abnormal specimen with ambulacrum from aborted or damaged *A*-ray arm extending down over cup onto proximal portion of stem,  $\times 1.3$ ; *1i*, peristomial cover plates and hydropore,  $\times 2.3$ ; *1j*, 3 rows of peristomial cover plates,  $\times 8$  (*1e-j*, Springer, 1911b).

### Family CORNUCRINIDAE Regnéll, 1948

[Cornucrinidae REGNÉLL, 1948a, p. 8]

Hybocrinids having three recumbent ambulacra running down over thecal plates in *A*, *C*, and *D* rays, with no appendages in *B* and *E* rays. *M.Ord.*-*U.Ord.*

**Cornucrinus** REGNÉLL, 1948, p. 11 [\**C. mirus*; M]. Cup with 3 widely flared recumbent ambulacra running down over strongly humped or elongated radials in *A*, *C*, and *D* rays; only 4 basals (*CD* and *BC* fused); no anal *X*; anal opening displaced down side of theca and bounded by *C* and *D* radials and radianal; orals absent or covered with wide adoral ambulacra. *M.Ord.*-*U.Ord.*, Eu.(Sweden).—FIG. 366, *1a-g*. \**C. mirus*, *M.Ord.*; *1a*, plate diagram (Sprinkle, n); *1b-d*, post., ventral, and right lat. view of complete specimen,  $\times 1.5$ ; *1e,f*, periproct and ambulacral cover plates,  $\times 2.5$ ,  $\times 4$ ; *1g*, post. view of another specimen with long stem segment attached,  $\times 1.3$  (*1b-g*, Regnéll, 1948a).—FIG. 366, *1h,j*. *C. longicornis* REGNÉLL, *U.Ord.*; *1h*, separate radial,  $\times 1$ ; *1i*, (reconstr.) complete specimen in life position,  $\times 1$  (both Regnéll, 1972).

**Tripatocrinus** SPRINKLE, 1973b, p. 872 [\**T. pustulatus*; M]. Cup. ovoid and slightly asymmetrical, with 3 long ambulacra running down over thecal plates in *A*, *C*, and *D* rays; plate arrangement normal, *C* radial and anal *X* equally developed above radianal on side of theca; 2 small accessory anals above anal *X*; elongate coelomic notch present through bottom of each ambulacrum between radial and orals; slitlike hydropore opening through posterior oral; small-diameter stem attached to basals. Known only

from disarticulated plates. *M.Ord.*, USA (Nev.-Calif.).—FIG. 360; 366, 2. \**T. pustulatus*, Nev.; 360, plate diagram; 366, *2a-d*, ventral, dorsal, *C*-, and *D*-ray views of cup (reconstr. model),  $\times 1$ ; 366, *2e-j*, ext. views of separate plates (*D* radial, *B* radial, anal *X*, *DC* basal, *EA* oral, *CD* oral), showing pustulose ornament and diagnostic plate shapes,  $\times 1$  (all Sprinkle, 1973b).

### Order CORONATA Jaekel, 1918<sup>1</sup>

[Coronata JAEKEL, 1918, p. 109]

By R. O. FAY

Crinozoans with three circlets of regularly arranged thecal plates, without pores and infolds of any type, with five biserially arranged arms. Basal circlet composed of three plates, the azygous basal located in anterior right (*AB*) interradial position; with five radials and five large interradial plates on ventral part of theca; radials and interradial plates prolonged ventrally into high coronal processes. Small primaxil plate attached rigidly to adorally constricted end of each radial plate, adoral part of which rests internally on adjacent interradial plates. Each primaxil surmounted by two plates, and these by two more, and so on for at least nine sets of plates (Fig. 367). Bottom pair of plates each appearing to give rise to a biserial arm, second pair so arranged that plate on left supports a bottom plate of second armlet, and plate on right supports top plate of second arm on that side, bottom plate receiving support from first plate below. Thus, from this point upward, armlets are arranged alternately and are not paired. Each armlet coiled planispirally adorally, with three or four revolutions to each armlet and single food groove on adoral surface. Food grooves on left side lead to a food groove on left side of main plates of arm on that side, and food grooves on right side lead to a food groove on right side of main plates. Thus, primaxils have two food grooves on their adoral surface. Arms appear to have flexible sutures above primaxils. Food grooves extend adorally along margins of interradial plates, meeting along suture between interradial plates about one-

<sup>1</sup> The author, R. O. FAY, would prefer to raise the order Coronata to the level of subclass because of incorporation of the lower brachial circlet into the top of the cup, the presence of a coronal process, the unique sausage-shaped cover plates, and the rare biserial arrangement of the arms.

third of distance from mouth, forming single food groove in each ambulacrum that leads to mouth. Two large, sausage-shaped cover plates above food grooves on each ambulacrum abutting against primaxil and slightly overlapping adoral portion of primaxil. Ambulacra floored by adjacent interradial plates which meet along midline of each ambulacrum. Oral opening covered by five large oral plates which are interrational in position, each abutting against interradial and adjacent cover plates. Single large anal opening on aboral side of anal interrational plate at its junction with adjacent radial limbs, with four subtriangular cover plates. *M.Ord.-U.Ord.*; *M.Sil.-U.Sil.*

Of five genera referred to this order, only one, *Stephanocrinus*, is fairly well understood. The characters of the order are therefore taken mainly from descriptions of this genus. It is obvious that the five genera assigned to the Coronata are closely related, and that they belong to the Crinoidea. It is difficult to place them, however, within known groups of the class. The genera are distinguished mainly by their external form and stratigraphic and geographic occurrence.

### Family STEPHANOCRINIDAE Wachsmuth & Springer, 1886

[Stephanocrinidae WACHSMUTH & SPRINGER, 1886, p. 282  
[=Stephanoblastidae JAEKEL, 1918, p. 110]

Characters of order. *M.Ord.-U.Ord.*; *M.Sil.-U.Sil.*

*Stephanocrinus* CONRAD, 1842, p. 278 [\**S. angulatus*; M]. Conical theca with angular ridges on dorsal side, and high-pointed coronal processes, with sharp adoral surfaces and ridged lateral surfaces; ornamentation consists of fine ridges, in the form of pore-rhombs. [Small rounded forms referred to this genus may belong to another genus.] *M.Sil.*, N.Am., ?*M.Sil.*, Eu.(Eng.).—FIG. 367; 368,1. \**S. angulatus*, USA(N.Y.); 367, *A* ambulacrum,  $\times 31$ ; 368,1a, oral view,  $\times 5$ ; 368,1b, *D*-ray view,  $\times 4$ ; 368,1c, anal view,  $\times 15$ ; 368,1d, oral view with *A*-ray arms in place,  $\times 4.9$ ; 368,1e, side view of *A* amb., showing aboral face of arms,  $\times 20$  (Fay, 1962a).—FIG. 369,1a-d. *S. gemmiformis* HALL, Waldron Sh., Tenn.; 1a, oral view showing "pores" in weathered coronal processes, anal opening toward bottom,  $\times 14$  (Fay, 1960); 1b-d, side view,  $\times 8$ ; right ant. (*AB*) interambulacrum showing deeply weathered coronal process with divided coelomic cavity appearing like 2 pores,  $\times 24$ ; "*C*" ambulacrum

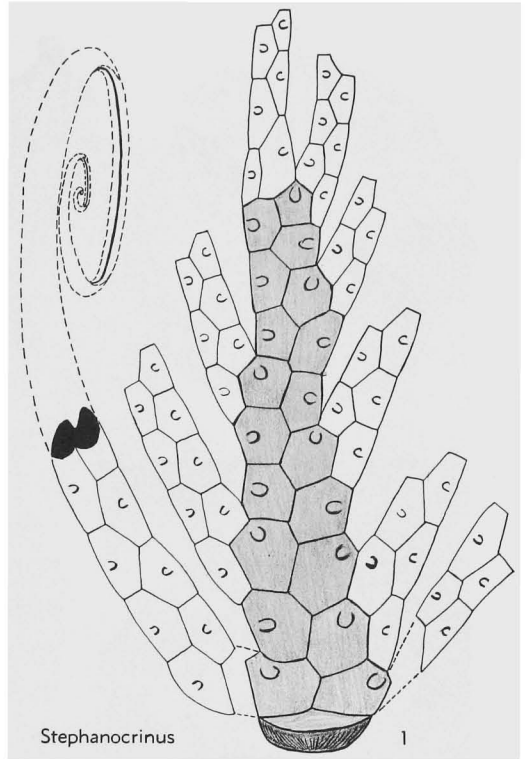


FIG. 367. *Stephanocrinus angulatus*, schematic diagram of aboral side of the anterior (*A*) arm,  $\times 31$  (Fay, 1962a).

showing cover plates and primaxil in place,  $\times 18$  (Fay, n; Illinois Dept. Geology).—FIG. 369,1e. *S. osgoodensis* S. A. MILLER, Niagaran, Ind.; *A* ambulacrum showing sutures between interambulacral plates and radial plate,  $\times 22$  (Fay, n). *Mespilocystites* BARRANDE, 1887, p. 162 [\**M. bohemicus*; M] [= *Mespilocystis* BATHER, 1889c, p. 269 (obj.)]. Theca cup shaped, almost as wide as high, with coronal processes as long as theca, and apparently with interrational plates visible in side view, with strong ornamentation of thecal plates similar to pore-rhombs. *M.Ord.*(*D<sub>2</sub>-D<sub>4</sub>*) (*Llandeil.-Caradoc.*), Eu.(Czech.).—FIG. 370,1. \**M. bohemicus*; 1a-c, oral, side, and aboral views, all  $\times 10$  (Fay, 1962b); 1d, plate layout of *B* and *C* radials,  $\times 10$  (Fay, n; Univ. Oklahoma Dept. Geology 2380A, 2380B, 2380C). *Paracystis* SJÖBERG, 1915, p. 173 [\**P. ostrogothica*; M]. Cup-shaped theca with low rounded coronal processes and large, wide basal plates. Base concave adjacent to stem. Ornamentation consists of strongly developed ridges similar to pore-rhombs. *M.Ord.*, Eu.(Sweden).—FIG. 368,2. \**P. ostrogothicus*, Chasmops Ls., Östergötland; 2a-e, *A*, *B-C*, *E*, aboral, and oral views, all  $\times 5$  (Regnéll, 1945).



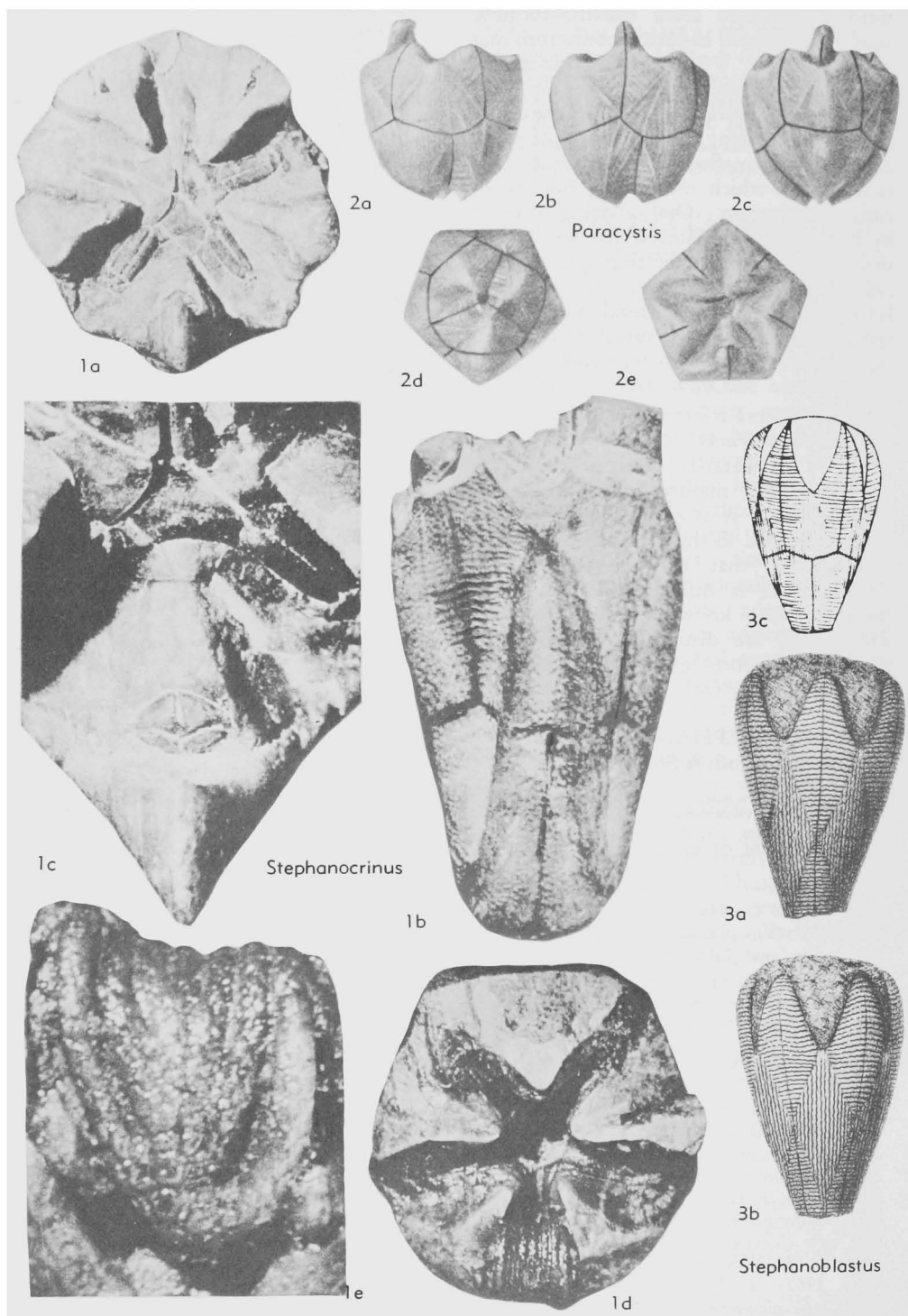


FIG. 368. Stephanocrinidae (p. T575, T577).

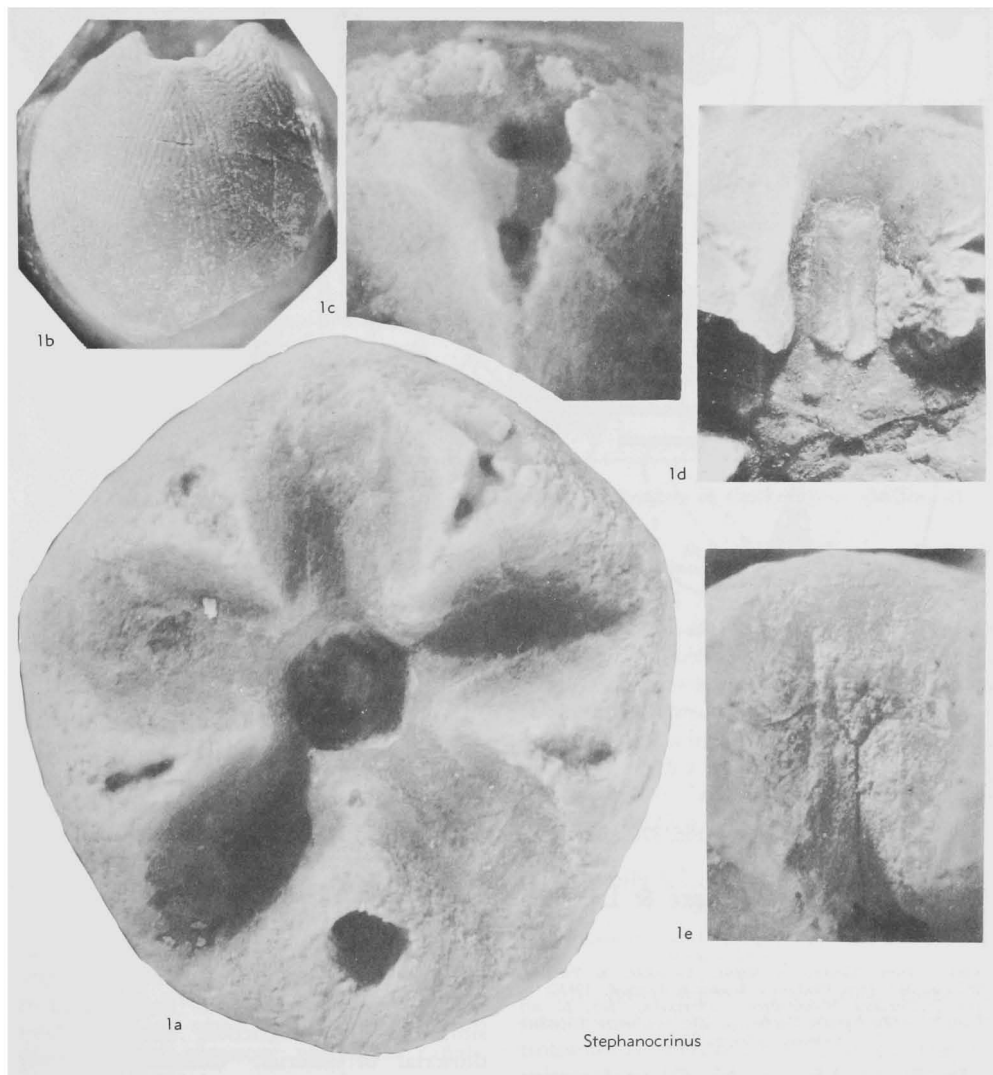


FIG. 369. Stephanocrinidae (p. T575).

**Stephanoblastus** JAEKEL, 1918, p. 110 [*\*Rhom-bijera? mira* BARRANDE, 1887, p. 80; M]. Club-shaped theca with rounded top and conical sides, and broadly triangular base; coronal processes are high and wide, with sharply rounded ventral terminations; ornamentation consists of strongly developed ridges resembling pore-rhombs. *U.Sil.* (*E<sub>2</sub>*) (*Ludlov.*), Eu.(Czech.).—FIG. 368,3. *\*S. mirus* (BARRANDE), near Loděnice; 3*a,b*, side views,  $\times 5$  (Barrande, 1887); 3*c*, side view,  $\times 3.2$  (Fay, n, after Jaekel, 1918).

**Tormoblastus** JAEKEL, 1927, p. 1 [*\*T. bodae*; M]. Cup-shaped theca with high, rounded coronal processes as long or longer than theca, which is as wide as high, with strongly developed ridges on basals and radial bodies; a few short indented grooves occur on the radial limbs; interradial plates not visible in side view. *U.Ord.*, Eu.(Sweden).—FIG. 370,2. *\*T. bodae*, Leptaena Ls., Boda, Dalarne; 2*a-e*, oral, (*A-B*), aboral, anal, and side coronal process views, all  $\times 10$  (Jaekel, 1927a).

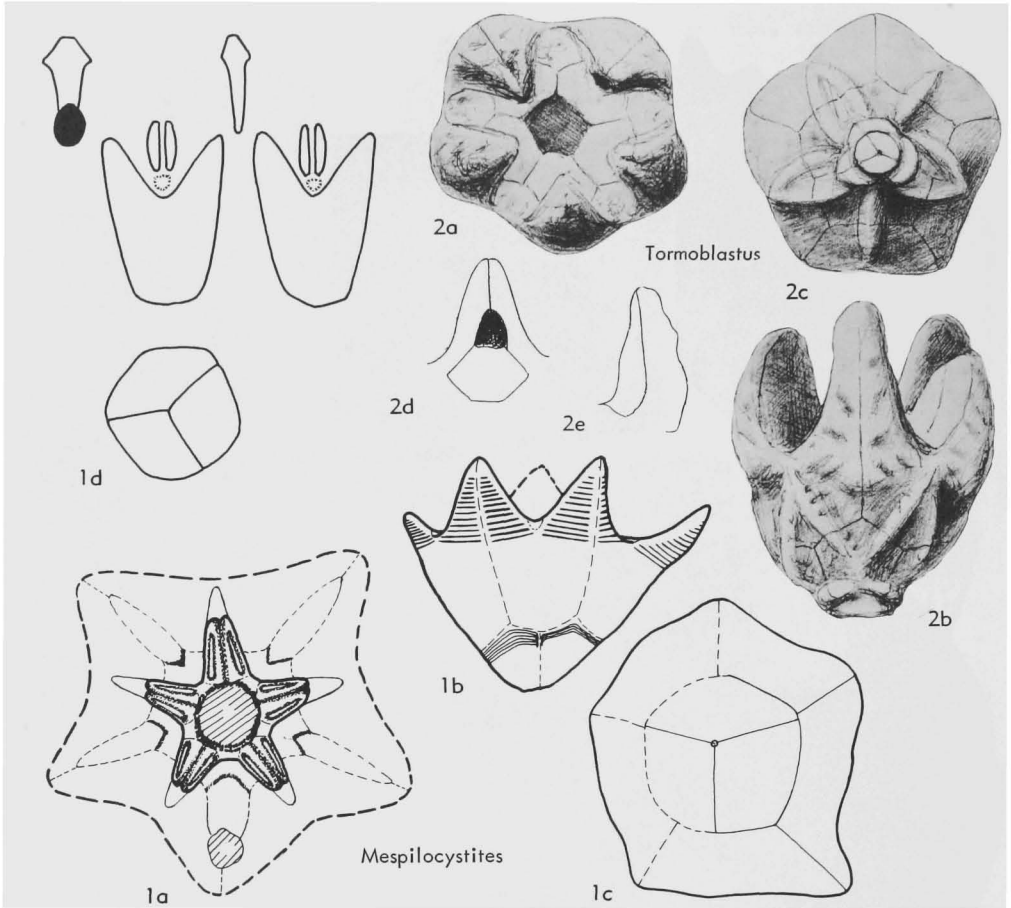


FIG. 370. Stephanocrinidae (p. T575, T577).

**Order CLADIDA Moore & Laudon, 1943**

[*nom. correct.* MOORE, in MOORE, LALICKER, & FISCHER, 1952, p. 613 (*pro* Cladoidea MOORE & LAUDON, 1943a, p. 32)] [=Fistulata WACHSMUTH & SPRINGER, 1885, p. 305 (83); Dicyclica BATHER, 1893a, p. 100; Inadunata Dicyclica BATHER, 1899b, p. 921]

By R. C. MOORE, N. GARY LANE,  
and H. L. STRIMPLE

Dicyclic inadunate crinoids having two circlets of plates below radials, mostly three, two, or one anal plates in cup but a few lacking any. Anal sac generally prominent. Arms branched or unbranched. Stem mostly circular in section. *L.Ord.*(*Tremadoc.*)-*U.Perm.*; *M.Trias.*

[KNAPP (1969, p. 351) split off from the Inadunata a new order Declinida having

the following characteristics: Dicyclic cup bowl shaped with flat or concave base, infrabasals downflaring to horizontal, basals large or small, anal plate and radialian present but may decrease in number, arms simple or multibranching, brachial plates uniserial or biserial. Considered mainly significant is structure of lower plates of cup, with evolution toward strongly downflared infrabasals and proximal parts of basals. *U. Miss.-L. Perm.* This order is here judged unacceptable as a natural taxonomic division of inadunate crinoids.—R. C. MOORE.]

**Suborder CYATHOCRININA  
Bather, 1899**

[*nom. correct.* MOORE, in MOORE, LALICKER, & FISCHER, 1952,

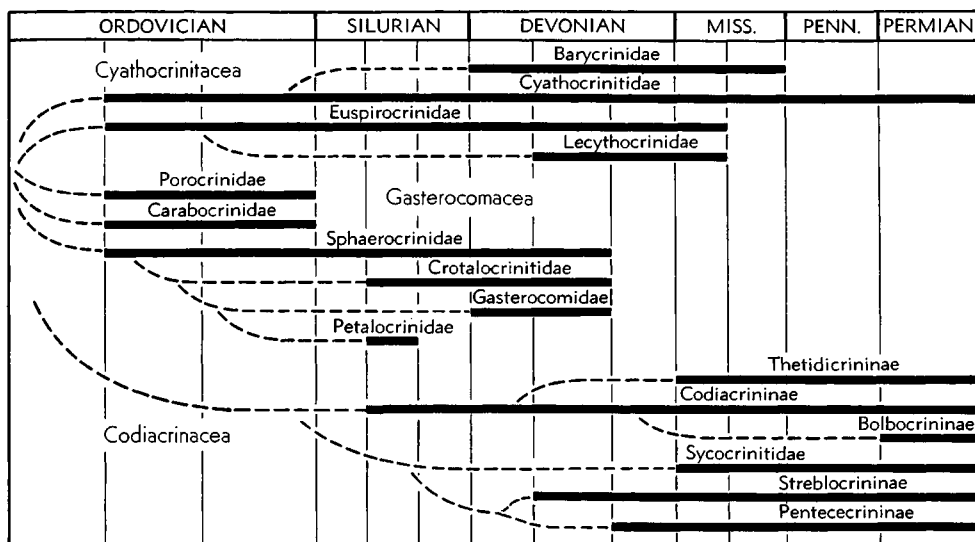


FIG. 371. Stratigraphic distribution and inferred phylogeny of families of Cyathocrinina (Moore, n).

p. 613 (pro suborder Cyathocrinoidea BATHER, 1899b, p. 922) [Materials for this suborder prepared by N. GARY LANE and R. C. MOORE]

Dicyclic inadunates with bowl- to globe-shaped theca; anal plates in cup five to none, commonly anal X only present; radial facets narrower than width of radials, smooth or rarely with obscure transverse ridge, axial canal commonly present. Tegmen low or with short, generally nonporous, anal sac; anal opening flush with tegmen or at distal end of sac. Orals prominent, posterior one imperforate, a madreporite or with hydropore. Arms narrowly rounded, uniserial, nonpinnulate; atomous or branching isotomously or rarely heterotomously, commonly with stout ambulacral covering plates. Stem transversely round, with large axial canal or small and associated with three or four accessory peripheral canals. *M.Ord.-U.Perm.*

At least 65 genera considered to be valid here and distributed among three superfamilies are assigned to the Cyathocrinina. Stratigraphic distribution and inferred phylogeny of the family divisions are shown graphically in Figure 371.

**Superfamily  
CYATHOCRINITACEA  
Bassler, 1938**

[*nom. transl.* LANE, 1967b, p. 9 (ex family Cyathocrinitidae

BASSLER, 1938, p. 20; *nom. correct. pro* Cyathocrinidae ROEMER, 1854, p. 227)]

Theca bowl to cone shaped; anal X large, radianal small or absent or with one to three additional anal plates in cup (Fig. 372,1). Tegmen produced into a short, stout or slender, elongate anal sac that is generally imperforate and has terminal anal opening. Arms typically isotomous with few to many branches, or rarely heterotomous. *M.Ord.-U.Miss.; U.Perm.*

**Family CYATHOCRINITIDAE  
Bassler, 1938**

[*nom. correct.* BASSLER, 1938, p. 20 (pro Cyathocrinidae ROEMER, 1854, p. 227)]

Cup bowl shaped, infrabasals three or five; single anal plate in cup. Arms branch isotomously several times, first on axillary primibrachs 1 to 7. Anal sac short, slender to massive, imperforate, confined to posterior area of tegmen. Posterior oral may be a madreporite. ?*M.Ord.; M.Sil.-L.Miss.; U.Perm.*

Cyathocrinites MILLER, 1821, p. 85 [\**C. planus*; SD WACHSMUTH & SPRINGER, 1880, p. 81 (non *C. tuberculatus* MILLER, 1821; SD ROEMER, 1851, p. 365, type of *Temnocrinus* SPRINGER, 1902); ICZN pend.] [= *Cyathocrinus* AGASSIZ, 1836, p. 197 (*nom. van.*); *Saccosomopsis* MEEK & WORTHEN, 1870, p. 25]. Cup low bowl shaped to globose, with flat or gently convex base; radials

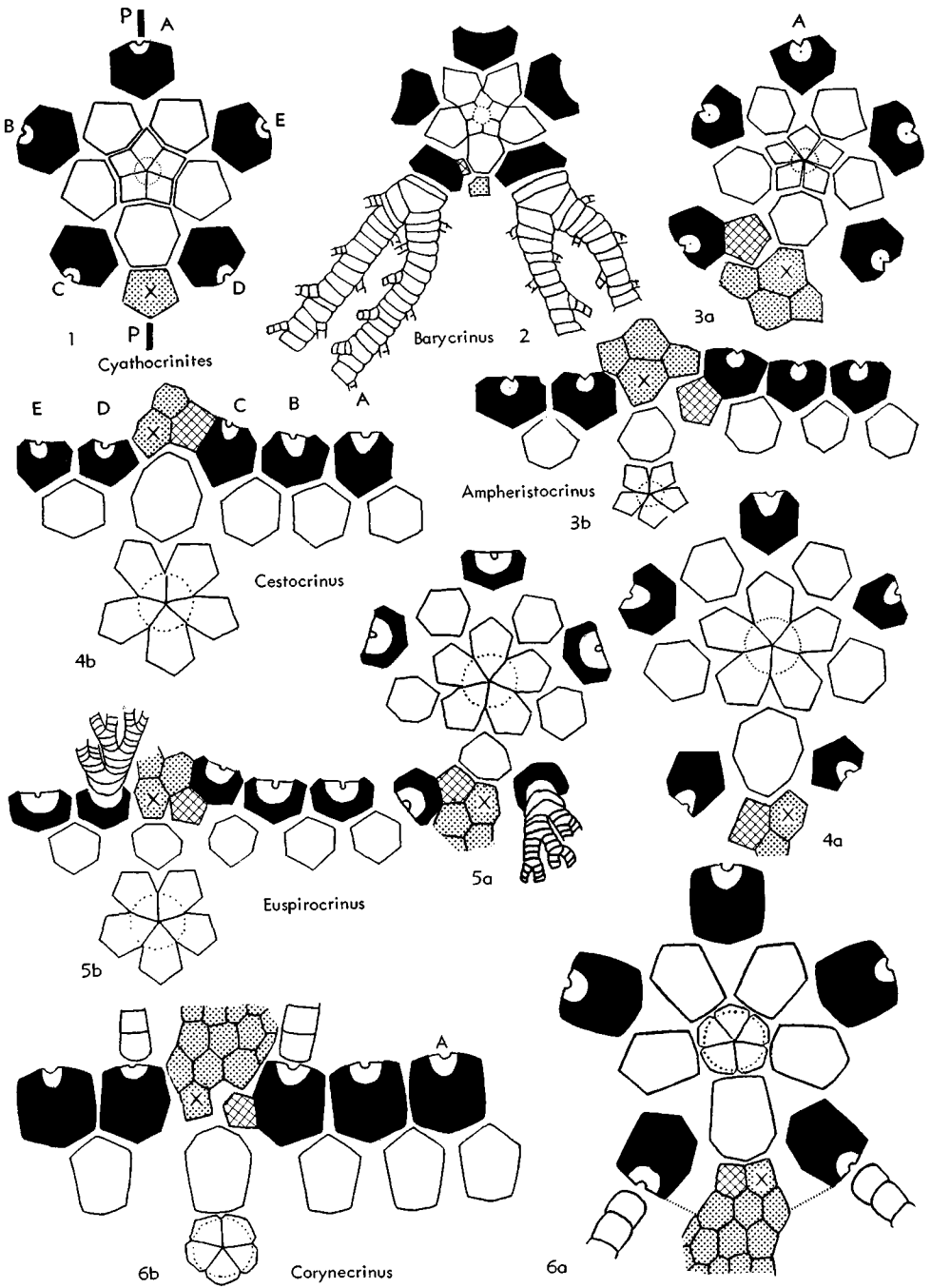


FIG. 372. Morphological features of representative Cyathocrinitea (plate diagrams, not to scale). [A-E, ray designations in CARPENTER system; X, proximal anal sac plate; solid black, outer surface of radials (excluding articular facets); cross ruled, radianal plate; stippled, plates of anal series; heavy black line, plane of bilateral symmetry.]

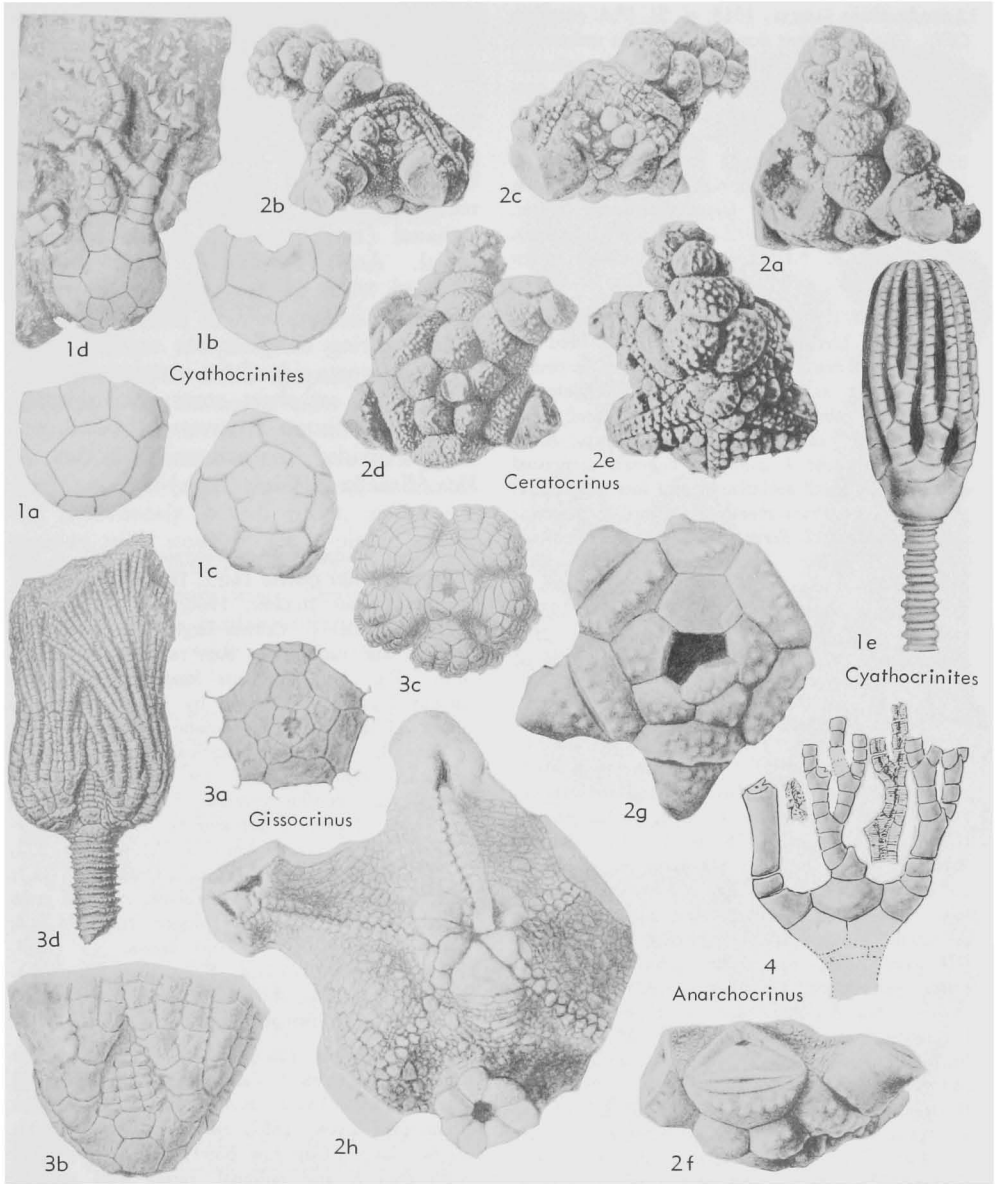


FIG. 373. Cyathocrinitidae (p. T579, T581-T582).

quadrangular, with narrow, horseshoe-shaped articular facets; large anal X alone in cup, directly above CD basal (Fig. 372,1). Tegmen stout, with 5 large orals, posterior one a madreporite; anal sac narrow, cylindrical, confined to posterior area of tegmen. Arms narrow, branching isotomously twice or more, first on axillary primibrachs 1 to 7; ambulacral covering plates large, stout, commonly preserved. Stem round or pentagonal in section. *M.Sil.* (Wenlock.)-*L.Miss.* (Osag.), ?*U.Perm.*, cosmop.—FIG. 372,1; 373,1a-d. \**C. planus*, L.

Carb. (Tournais.), Eu. (Eng.); 372,1, plate diagram of cup (radials black, anal X stippled) (Moore, 1962b); 373,1a-c, post., ant., and dorsal views of cup,  $\times 1$ ; 373,1d, post. view of crown,  $\times 1$  (Wright, 1951-54).—FIG. 373,1e. *C. milleri* (M'Coy), L. Carb. (Tournais.), Eu. (Ir.); lat. view of crown,  $\times 2$  (M'Coy, 1862). [Revision of M'COY's species of Irish crinoids by G. SEVASTOPULO has resulted in transfer of *Atocrinus* M'COY in GRIFFITH, 1844, from *Cyathocrinites* to *Platycrinites* (G. SEVASTOPULO, pers. comm.)]

?*Anarchocrinus* JAEKEL, 1918, p. 51 [*\*A. rossicus*; OD]. Cup wide, low bowl shaped, base unknown; cup plates smooth; radials large, with articular facets narrowly rounded and directed gently outward-downward. Uniserial arms branching on primibrachs 1, 2, or 3; primaxils short to extremely high; arms branch isotomously again on secundibrach 3 and tertibrach 3 in only known ray. Anal tube with large sculptured plates. [Poorly known.] *M.Ord.(Caradoc.)*, Eu.(Est.).—FIG. 373,4. *\*A. rossicus*; lat. view of crown (part. reconstr.,  $\times 0.7$ ) (Jaekel, 1918).

*Ceratocrinus* WANNER, 1937, p. 177 [*\*C. exornatus*; OD]. Cup low, infrabasals mostly covered by stem, cup plates highly nodose; radial articular facets almost as wide as radials, declivate or vertically directed, with proximal parts of arms subhorizontal; single anal plate in cup. Arms stout, primibrachs 1 axillary. Tegmen composed of numerous small ambulacral and interambulacral plates; anal sac short, massive, confined to posterior side of tegmen. *U.Perm.*, Indon.(Timor, Basleo).—FIG. 373,2a-e. *\*C. exornatus*; 2a-e, post., BC- and DE-interray, dorsal and ventral views of theca and proximal arms,  $\times 1$  (Wanner, 1937).—FIG. 373,2f-h. *C. gracilis* WANNER; 2f,g, B-ray and dorsal views,  $\times 2$ ; 2h, ventral view of theca,  $\times 3$  (Wanner, 1937).

*Gissocrinus* ANGELIN, 1878, p. 10 [*\*G. typus* BATHER, 1893a, p. 155 (*nom. subst. pro G. arthriticus* ANGELIN, 1878, *non* PHILLIPS in MURCHISON, 1839, p. 674, = *Actinocrinites? arthriticus*) (= *G. punctuosus* ANGELIN, 1878, p. 10, *partim*; *G. nudus* ANGELIN, 1878, p. 10; *G. tubulatus* ANGELIN, 1878, p. 11); SD BATHER, 1893a, p. 155]. Cup bowl shaped, 3 or 5 infrabasals; radials low, wide, with articular facets almost as wide as radials. Single anal plate in cup, directly above CD basal. Arms branching isotomously several times, primibrach 1 axillary; brachials narrow, spindle shaped. Anal sac stout, composed of longitudinal rows of heavy plates. *M.Sil.-L.Dev.*, Eu.(Boh.-Ger.-Eng.-Sweden-USSR), USA (Tenn.-Ind.-Ky.-Mo.-Okla.).—FIG. 373,3a,b. *\*G. typus* BATHER, U.Sil., Gotland; 3a,b, dorsal view of cup and post. view of crown,  $\times 2$  (Bather, 1893a).—FIG. 373,3c,d. *G. campanula* BATHER, U.Sil., Gotland; 3c,d, dorsal and post. views of crown,  $\times 1.5$  (Bather, 1893a).

[The problem of defining the type species of *Gissocrinus* is an involved one, as reviewed at length by BATHER (1893a), who properly introduced a substitute name for *G. arthriticus* ANGELIN, although incorrect in stating that this was ANGELIN's choice as type species of the genus. ANGELIN simply placed this species first, without indicating it or any other described form as the type. BASSLER's (1938, p. 103) subsequent designation of *G. arthriticus* ANGELIN as type species was erroneous and moreover was superseded by the action of BATHER (1893a).]

### Family BARYCRINIDAE Jaekel, 1918

[Barycrinidae JAEKEL, 1918, p. 58]

Crown large, cup broad bowl shaped;

radials with relatively wide articular facets which are semicircular in outline, concave, and strongly declivate, with weak median cross-ridges extending laterally from deep V-shaped notch on inner side of facet, thus providing trifascial articulation with primibrachs 1. Anal X large, quadrangular, directly above CD basal; small quadrangular radianal (rarely absent) at left below C radial. Arms 10 to 16, long, strongly rounded, with narrow ambulacral groove, branching isotomously on primibrachs 2 or 3 and bearing nonpinnulate ramules given off on alternate sides from every second brachial. Anal sac short, stout; anal opening terminal. Column transversely round, columnals divided into pentameres or not. *L.Dev.(Ems.)*; *L.Miss.(Osag.)*-*U.Miss.(Meramec.)*.

*Barycrinus* WACHSMUTH & WORTHEN, 1868c, p. 338 [*\*Cyathocrinus spurius* HALL, 1858b, p. 625; OD] [= *Pottocrinus* JILLSON, 1960, p. 37 (type, *P. quinstilus*; OD)]. Crown large; commonly with anal X and radianal in cup, rarely with anal X only (Fig. 372,2). Arms long, robust, primibrachs 2 axillary, followed by isotomous or unbranched half-rays. Every second brachial generally a subaxil, supporting branched armlets or unbranched ramules. Anal sac low, with large plates, anal opening terminal. Circular columnals composed of discrete pentameres. *L.Miss.(Osag.)*-*U.Miss.(Meramec.)*, N.Am.(CUSA).—FIG. 372, 2; 374,1a,b. *\*B. spurius* (HALL), Osag., USA(Ia.); 372,2, plate diagram (radials black, radianal cross ruled, anal X stippled) (Moore, n); 374,1a,b, post. and dorsal (C ray up) views,  $\times 1$  (Hall, 1858b).—FIG. 374,1c,d. *B. sp.*, Osag.(Keokuk), Iowa; 1c,d, radials, showing large, rounded articular facets,  $\times 1$  (Springer, 1911c).

*Pellecrinus* KIRK, 1929, p. 15 [*\*Cyathocrinites hexadactylus* LYON & CASSEDAY, 1860, p. 74; M] [= *Vasocrinus* LYON *auct.* prior to 1929 (*non Vasocrinus* LYON, 1857, *emend.* KIRK, 1929a)]. Crown large. Cup low bowl shaped, commonly with anal X and radianal, rarely with anal X only. Arms long, slender, dividing isotomously on primibrachs 3, regularly heterotomous, with armlets alternately on opposite sides of each second brachial, which is subaxil; armlets similarly bearing ramules alternately on opposite sides of each second brachial. Anal sac conical, with longitudinal series of large plates above anal X. Columnals not divided into pentameres. *L.Miss.(Osag.)*, N.Am.(CUSA).—FIG. 374,3. *\*P. hexadactylus* (LYON & CASSEDAY), USA(Ind.); 3a,b, D-ray view of crown and part of arm with armlets and ramules on one side,  $\times 1$  (Hall, 1872). *Situlacrinus* BREIMER, 1962, p. 153 [*\*S. costatus*;

OD]. Cup high conical; primibrachs joined to tegmen by small, interradial plates; posterior oral madreporitic. *L.Dev.(low. Ems.)*, Spain.—FIG. 374,2. \**S. costatus*, LaVid Sh., León Prov.; 2a,c, post., ventral, and dorsal views of cup,  $\times 4$  (Breimer, 1962).

## Family EUPIROCRINIDAE Bather, 1890

[Euspirocinidae BATHER, May, 1890b, p. 346 [=Ampheristocrinidae S. A. MILLER, 1889, p. 346 (Dec., 1890); Vasocrinidae JAEKEL, 1918, p. 61; Parisocrinidae JAEKEL, 1918, p. 51]

Cup cone or bowl shaped; infrabasals three to five, visible in side view; radial articular facets vertically or subhorizontally directed, with axial canal; three anal plates in cup, anal X large. Arms slender, branching isotomously several times, ambulacral grooves with stout covering plates; primibrachs 2 to 4 axillary. Anal sac present or not, porous or nonporous. Orals five, large, posterior one a madreporite. Stem transversely round, wide. *M.Ord.(Mohawk.)-L.Carb.(Tournais.)*.

**Euspirocrinus** ANGELIN, 1878, p. 24 [*E. spiralis*; M]. Cup low, wide bowl shaped; 5 infrabasals; radianal and anal X in cup. Anal sac short, slender, composed of few large plates. Tegmen of 5 large orals and numerous small interambulacral and ambulacral. Arms branching isotomously and curved spirally inward; primibrachs 2 axillary. Stem wide. *M.Ord.(Mohawk.)-U.Sil., Can. (Ont.)-Eu. (Sweden)-USA (Ohio)*.—FIG. 372,5; 375,3. \**E. spiralis*, U.Sil., Gotland; 372, 5a,b, plate diagrams of cup and D-ray arms (radials black, radianal cross ruled, anal X and other anals stippled) (Moore, n; 1962b); 375,3a, lat. view of crown and stem,  $\times 1.5$ ; 375,3b,c, post. view of crown and ant. view of theca,  $\times 1.5$ ; 375,3d, ventral view of tegmen,  $\times 1.5$  (Bather, 1893a).

**Ampheristocrinus** HALL, 1879, p. 11 [*A. typus*; OD]. Cup cone shaped, plates with strong ridges; infrabasals 3 or 5, visible in side view, C infrabasal smaller than others. Anal X large, supporting 3 tube plates above, radianal pentagonal, below and left of C radial. Arms slender, primibrachs 3 axillary, branching isotomously 3 or more times. Anal sac long, slender, projecting above arms. Stem transversely round, stout, composed of short, alternating nodals and internodals. *M.Sil. (Niag.)*, USA (Tenn.-Ind.-Ill.).—FIG. 372,3; 375,6. \**A. typus*, USA (Ind.); 372,3a,b, plate diagrams of cup (radials black, radianal cross ruled, anal X and other anals stippled) (Moore, n; 1962b); 375,6, lat. view of crown,  $\times 1$  (Springer, 1926a).

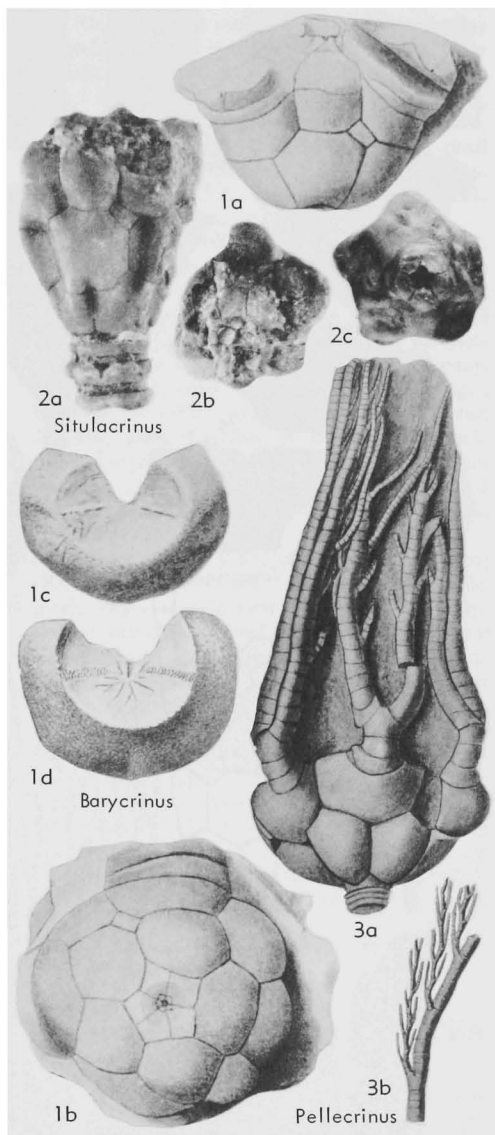


FIG. 374. Barycrinidae (p. T582-T583).

**Caelocrinus** Xu, 1962, p. 46 [*C. stellifer*; OD]. Cup low, bowl shaped, with moderate basal concavity, basals and radials ornamented with strong ridges that radiate from the center of each of the 5 basals. Infrabasals 3, the small one in the C-ray position. Basals large, pentagonal; radials wider than high, and apparently with wide radial facets. Radianal narrow, quadrangular, between C radial and CD basal. Anal X large, separating 2 posterior radials. Stem, arms and tegmen unknown. *L.Sil.*, China (Szechwan Prov.).  
? **Closterocrinus** HALL, 1852, p. 179 [*C. elongatus*;



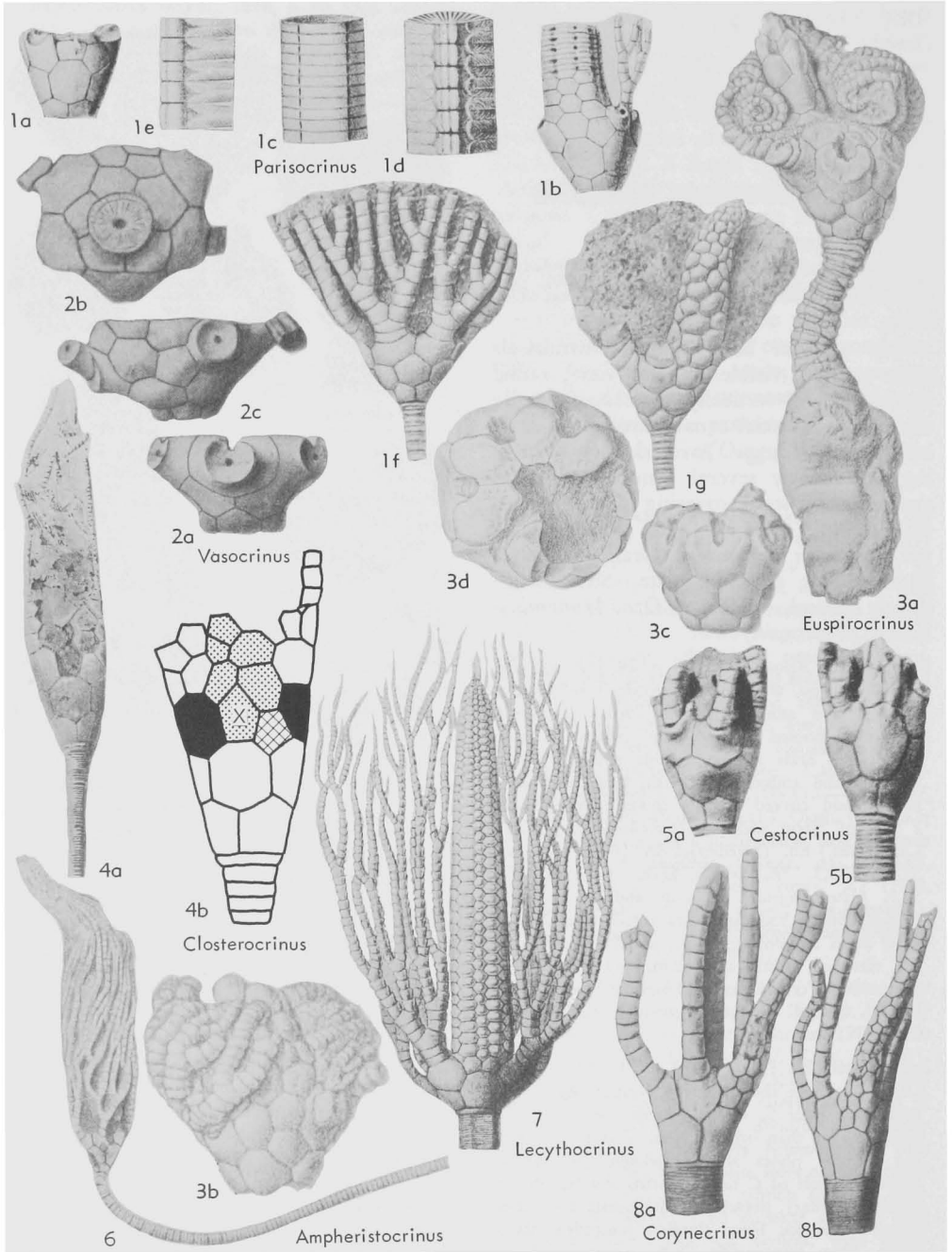


FIG. 375. Euspirocrinidae (1-4,6); Lecythocrinidae (5,7,8) (p. T583-T585).

OD]. Cup narrow, high, steeply conical, with wide flat base; infrabasals 3 or 5, high, visible in side view; radials ?5, with subhorizontal articular facets. Anal X, radial, and right tube plate in

cup. Arms branching on primibrachs ?3. Anal sac apparently present. Stem transversely round, stout, expanded proximally just below cup. *M.Sil.* (Niagaran), USA (N.Y.).—FIG. 375,4. \**C. elon-*

*gatus*; 4a, post. view of crown,  $\times 1$  (Hall, 1852); 4b, plate analysis of post. side of cup (radials black, radianal cross ruled, anal X and other anals stippled) (Hall, 1852, mod.).

**Parisocrinus** WACHSMUTH & SPRINGER, 1880, p. 109 [*\*Poteriocrinites perplexus* MEEK & WORTHEN, 1869c, p. 138; OD]. Cup bowl to cone shaped, as wide as high; infrabasals large, visible in side view; radials pentagonal, with narrow horseshoe-shaped articular facets; anal X, radianal, and right tube plate in cup. Arms narrowly rounded, branching isotomously several times, primibrachs 3 or 4 axillary. Anal sac large and porous or short and without pores, anal opening terminal. Madreporite present on anterior side of tegmen at base of anal sac. [Devonian species have separate axial canal in radials.] *M.Sil.(Niagaran)-L. Carb.(Tournais.)*, Eu.(Ger.-Eng.-Belg.-Ire.-USSR)-USA(Ind.-N.Y.-Ill.-Iowa).—FIG. 375,1a,b. *P. siluricus* SPRINGER, U.Sil., USA(Ind.); 1f,g, ant. and D-ray views of crown,  $\times 1.5$  (Springer, 1926a).—FIG. 375,1c-g. *P. curtus* (MÜLLER), M.Dev.(Givet.), Ger.; 1a,b, post. views of cup and partial crown,  $\times 1$ ; 1c-e, lat. view and transv. sections of stem, 1c,d,  $\times 2$ ; 1e,  $\times 3$  (Schultze, 1867).

**Vasocrinus** LYON, 1857, p. 485 [*\*V. valens*; OD] [*non Vasocrinus* LYON, pre-1929 auctt. (= *Pellecrinus* KIRK, 1929a, p. 82)]. Cup low cone shaped, plates thin and smooth or with sharp ridges radiating from basals and crossing adjacent radials; base wide, 5 low infrabasals visible in side view; radials wide, low, with large vertical horseshoe-shaped articular facets with large axial canal and obscure transverse ridge at either side; 3 anal plates in cup. Arms massive, directed horizontally or declivate at low angle; ambulacral grooves covered by stout, high cover plates, 3 to a brachial; primibrachs 1 and 2 (all known) not axillary. Tegmen low, convex, composed of numerous small plates and 5 large orals, posterior one a madreporite. *Up.L.Dev.-M.Dev.*, Eu.(Ger.-Spain)-USA(Ky.).—FIG. 375,2. *\*V. valens*, M.Dev., USA(Ky.); 2a-c, lat., basal, and post. views of cup,  $\times 1$  (Kirk, 1929a).

?**Zygotocrinus** KIRK, 1943 [*\*Z. fragilis*; OD]. *L. Miss.(Osag., Burlington Ls.)*, USA(Iowa).

## Family LECYTHOCRINIDAE Kirk, 1934

[Lecythocrinidae KIRK, 1934, p. 4]

Cup small, bowl or cone shaped; two anal plates directly above CD basal, none to three additional anal plates in cup. Anal sac narrow and tall, with well-marked vertical rows of polygonal plates. Arms branching isotomously three times or more, many slender arms in upper part of crown. Stem large, transversely round, with large central axial canal and four peripheral canals. *M.Dev.(Givet.)*; *L.Miss.(Osag.)*.

**Lecythocrinus** MÜLLER, 1858, p. 196 [*\*L. eifelianus*; M]. Cup low bowl shaped; infrabasals small, may be undivided; CD basal large, followed above by 2 small, equal anal plates. Primibrachs 3 axillary, with 5 higher isotomous divisions. Anal tube long, with strong plates in longitudinal rows. Stem transversely subquadrangular, with large axial canal and 4 peripheral canals. *M.Dev.(Givet.)*, Eu.(Ger.)—FIG. 375,7. *L. briareus* (SCHULTZE); post. view of crown,  $\times 1$  (Schultze, 1867).

**Cestocrinus** KIRK, 1940, p. 221 [*\*C. striatus*; OD]. Cup cone shaped; large infrabasals visible in side view; CD basal projecting upward between C and D radials, supporting 2 large anal plates (radianal at right, anal X at left). Arms slender, subcylindrical, 3, 4, or more than 6 primibrachs to a ray, remainder of arms unknown. *L.Miss.(Osag.)*, USA(Ind.).—FIG. 372,4; 375,5. *\*C. striatus*; 372,4a,b, plate diagrams of cup (radials black, radianal cross ruled, anal X and higher anal plates stippled) (Moore, n; 1962b); 375,5a,b, ant. and post. views of incomplete crown,  $\times 1$  (Kirk, 1940a).

**Corynecrinus** KIRK, 1934, p. 1 [*\*C. romingeri*; OD]. Cup cone shaped; infrabasals low, wide, barely visible in side view; CD basal large, supporting subequal radianal at right and anal X at left, followed by additional anal plates in cup. Arms slender, brachials with stout covering plates and axial canal; primibrachs 9 or 10 axillary. Anal tube composed of 5 longitudinal series of plates. Stem large, composed of thin, round columnals with large obscurely quadripartite axial canal. *M.Dev.*, USA(Ind.).—FIG. 372,6; 375,8. *\*C. romingeri*; 372,6a,b, plate diagrams of cup (radials black, radianal cross ruled, anal X and higher anal plates stippled) (Moore, n; 1962b); 375,8a,b, D-ray and post. views of incomp. crown,  $\times 1.15$  (Kirk, 1934).

**Tetrapleurocrinus** WANNER, 1942 [*\*T. eifelsenis*; OD]. *M.Dev.*, Eu.(Ger.).

## Superfamily GASTEROCOMACEA Roemer, 1854

[*nom. transl.* MOORE & LANE in MOORE & STRIMPLE, 1973, p. 18 (ex Gasterocomidae ROEMER, 1854, p. 299)] [=superfamily Palaeocrinacea BATHER, 1899b (*nom. transl.* LANE, 1967b, p. 9, ex Palaeocrinidae BATHER, 1899b, p. 922); superfamily Hypocrinacea WANNER, 1916a (*nom. transl.* ARENDT, 1970, p. 94, ex Hypocrinidae WANNER, 1916a, p. 88) (*partim*)]

Theca bowl shaped; radianal and anal X present, or one or both may be absent; infer- and superradianal present primitively. Tegmen low, anal opening through tegmen or side of cup; posterior oral with hydro-pore or developed as madreporite. Arms atomous or isotomous; brachials fused in each ray or laterally united in specialized families. *M.Ord.(Black River.)-U.Ord.*; *M.Sil.-M.Dev.(Givet.)*.

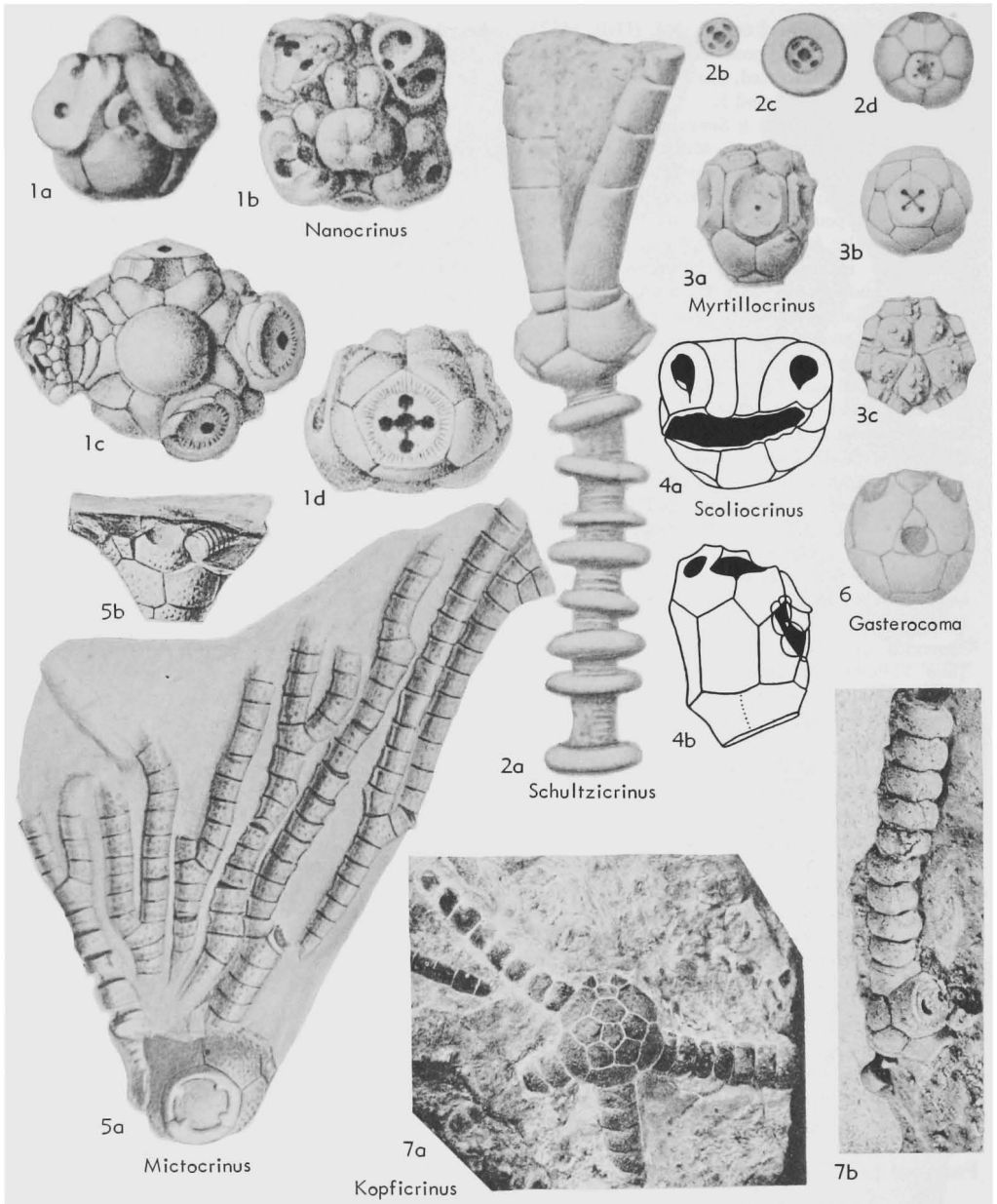


FIG. 376. Gasterocomidae (p. T587-T588).

**Family GASTEROCOMIDAE**  
**Roemer, 1854**

[Gasterocomidae ROEMER, 1854, p. 299] [=Gastrocomidae JAEKEL, 1895, p. 73; Schultzicrinidae JAEKEL, 1918, p. 82]

Theca conical bowl shaped to globose; infrabasals five, three, or one; radial articular facets narrow horseshoe shaped; with

axial canal; radialian lacking, anal X present or absent, anal opening generally through side of cup below posterior radials. No anal sac. Moderately thick uniserial arms spread sideward, branching isotomously. Transversely round to quadrangular stem with axial and three or four peripheral canals. *L.Dev.-M.Dev.*

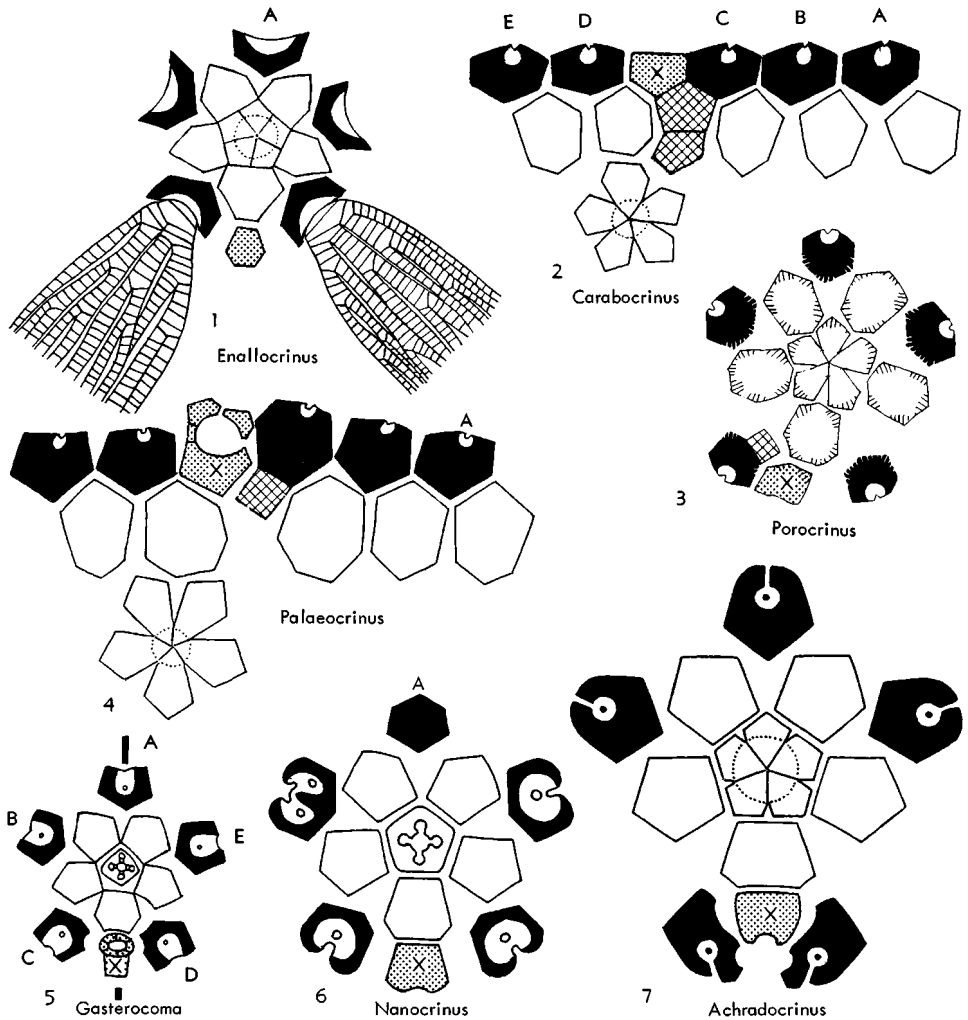


FIG. 377. Morphological features of representative Gasterocrinacea (plate diagrams, not to scale). [Letters and patterns as in Fig. 372.]

**Gasterocoma** GOLDFUSS, 1839, p. 350 [*G. antiqua*; M] [= *Ceramocrinus* MÜLLER, 1855, p. 83; *Epactocrinus* MÜLLER, 1855, p. 84; *Gastrocoma* BEYRICH, 1871, p. 50 (*nom. van.*)]. Theca globular; infrabasals low, fused, barely visible in side view; arm facets horseshoe shaped, very steeply declivate, with large axial canal; quadrangular anal X directly above anal opening and between C and D radials, or irregular in disposition. Arms, tegmen, and column unknown. *M.Dev.*(*Givet.*), Eu.(Ger.). —FIG. 376,6; 377,5. \**G. antiqua*; 376,6, CD interray view of cup,  $\times 2$  (Springer, 1911c); 377,5, plate diagram of cup (radials black, anal X stippled) (Moore, 1962b).

**Kopfcrinus** GOLDRING, 1954, p. 11 [*K. pustuliferus*; OD]. Cup low, bowl shaped, flaring slightly ventrally; three unequal infrabasals, small one anterior; basals large; radials with flat, steeply inclined, horseshoe-shaped facets; one anal plate above enlarged posterior basal, followed by three small anal plates; tegmen unknown; arms heavy rounded, consisting of at least 13 primibrachs; stem round, small. *L.Dev.*, USA(N.Y.). —FIG. 376,7. \**K. pustuliferus*; 7a,b, basal view of cup and partial arms; lat. B-ray view of cup and arms,  $\times 1.3$  (Goldring, 1954).

**Mictocrinus** GOLDRING, 1923, p. 362 [*M. robustus*; OD]. Cup low cone shaped, plates with coarse

nodes; infrabasals 3, low, visible in side view; *CD* basal supporting small, quadrangular anal *X*; anal opening above anal *X* and between *C* and *D* radials. Arms robust, strongly rounded, branching isotomously on primibrachs 5 or 6, and with 2 higher bifurcations. Column transversely round, large, with large axial canal and 4 peripheral canals. *M.Dev.*, USA (N.Y.).—FIG. 376,5. \**M. robustus*; 5*a,b*, dorsal view of crown and *C*-ray view of cup,  $\times 1$  (Goldring, 1923).

**Myrtillocrinus** SANDBERGER & SANDBERGER, 1856, p. 388 [\**M. elongatus*; M] [= *Tripleurocrinus* WOOD, 1904, p. 56 (type, *T. levis*)]. Cup higher than wide, infrabasals fused, anal plate absent; arm facets large, horseshoe shaped, vertically directed and occupying most of outer surface of radials, with large axial canal; tegmen low, composed of 5 large orals; anal opening through tegmen. Column with 4 small peripheral canals joined to small central axial canal. *M.Dev.*, Eu.(Ger.)-USA (N.Y.).—FIG. 376,3. *M. americanus* HALL, N.Y.; 3*a,b*, lat. and dorsal views of theca,  $\times 2$  (Springer, 1911c); 3*c*, ventral view of theca,  $\times 1$  (Springer, 1926a).

**Nanocrinus** MÜLLER, 1856, p. 355 [\**N. paradoxus*; M]. Theca small, low, infrabasals fused; basals 5; faceted radials 4, facet not developed on *A*, radial articular facets large, steeply declivate, with large axial canal; anal *X* directly above *CD* basal, anal opening above anal *X*, laterally directed; tegmen composed of several small plates and large, central bulbous *CD* oral. *M.Dev.*(*Givet.*), Eu.(Ger.).—FIG. 376,1; 377,6. \**N. paradoxus*; 376,1*a-d*, *CD*-interray, ventral views of 2 specimens, and dorsal view of cup,  $\times 3$  (Schultze, 1867); 377,6, plate diagram of cup (radials black, anal *X* stippled) (Moore, n).

**Schultzicrinus** SPRINGER, 1911, p. 132 [\**S. typus*; OD]. Cup like *Arachnocrinus*. Arms unbranched, primibrachs 1 short, subsequent primibrachs high; brachials and radials with axial canal. Stem with 4 peripheral canals and thin nodals about twice as wide as internodals. *M.Dev.*, USA (N.Y.).—FIG. 376,2. \**S. typus*; 2*a*, lat. view of crown and stem,  $\times 2$ ; 2*b,c*, articular surfaces of nodal and internodal,  $\times 1.3$ ,  $\times 2$ ; 2*d*, dorsal view of cup,  $\times 1.3$  (Springer, 1911a).

**Scoliocrinus** JAEKEL, 1895, p. 76 [\**S. eremita*; OD]. Cup asymmetrical, high cone shaped; infrabasals fused, basals 5, unequal in size, *AE* basal largest; radials unequal, large *A* and *E* radials with arm facets, other radials small, without facets; arm facets large, horizontally directed, with large axial canal; anal *X* small, quadrangular, directly below large anal opening and in line with basals; anal opening laterally directed, in side of cup, bounded above by small *B*, *C*, and *D* radials; tegmen unknown, space at top of cup lozenge shaped. *M.Dev.*(*Givet.*), Eu.(Ger.).—FIG. 376,4. \**S. eremita*; 2*a,b*, ventral and *DE*-interray views of cup,  $\times 1$  (Jaekel, 1895).

## Family SPHAEROCRINIDAE Jaekel, 1895

[Sphaerocrinidae JAEKEL, 1895, p. 64] [=Palaeocrinidae BATHER, 1899b, p. 922]

Theca globose or conical; angles of cup plates with radially directed pore slits in one Ordovician genus (*Palaeocrinus*); infrabasals five, high; radials five, with narrow articular facets; large anal *X* and radial present; anal opening in side of cup or through low, flat tegmen; posterior oral larger than others and a madreporite where known; arms branching isotomously or unbranched in one genus (*Palaeocrinus*) where known. *M.Ord.*; *M.Sil.*; *M.Dev.*

**Sphaerocrinus** ROEMER, 1851, p. 369 [\**Cyathocrinites geometricus* GOLDFUSS, 1831, p. 189; OD] [= *Sphaerocrinites* STEININGER, 1853, p. 38 (*nom. van.*)]. Theca globose; infrabasals 5 or rarely 3; radials pentagonal, articular facets semicircular, with large axial canals; radial and anal *X* large, in normal position; anal opening large, on side of cup below summit of radials, surrounded by anal *X* below and 3 to 5 small accessory anal plates. Tegmen low, flat, composed of 4 small orals and large madreporitic posterior oral; central tegmental area composed of numerous small irregular plates. Arms and stem unknown. *M.Dev.*(*Givet.*), Eu.(Ger.).—FIG. 378,1*a-c*. *S. paucisculptus* WANNER; *A*-ray, *CD*-interray, and ventral views of theca,  $\times 1.15$  (Wanner, 1942a).—FIG. 378,1*d-f*. \**S. geometricus* (GOLDFUSS); 1*d*, *AB*-interray view of typical specimen from Kerpen; 1*e,f*, dorsal and ventral views of smooth-surfaced theca, from same locality, all  $\times 1$  (Schultze, 1867).

**Palaeocrinus** BILLINGS, 1859, p. 24 [\**P. striatus*; SD MILLER, 1889, p. 267]. Theca small, cone shaped, with prominent hollow ridges radiating from center of each basal to adjacent infrabasals and radials; infrabasals 5, high, visible in side view; basals large; radials low, wider than high with narrow, rounded, subhorizontal articular facets; radial large, quadrangular, below and left of *C* radial; anal *X* large, pentagonal, with concave upper surface forming proximal edge of anal opening. Tegmen composed of 10 plates, 4 orals above interradial sutures, 3 plates bordering anal opening, and large central madreporitic *CD* oral. [Other species assigned to this genus have an anal sac and probably do not belong in this family.] *M.Ord.*(*Chazy-Mohawk*), USA (Minn.-Ky.)-Can.—FIG. 377,4; 378,2. \**P. striatus*, Chazy, Que.; 377,4, plate diagram of cup (radials black, radial cross ruled, anal *X* and higher anals stippled) (Moore, 1962); 378,2*a,b*, *AB*-interray and ventral views of theca,  $\times 2$  (Lane, n; Springer Coll., U.S. Natl. Museum).

**Thalamocrinus** MILLER & GURLEY, 1895b, p. 82 [\**T. ovatus*; OD]. Cup small, cylindrical; infra-

basals large, making up one-third to one-half of cup side; basals higher than wide, pentagonal; radials small, decreasing in width distally, incurved at top, each with narrow rounded subhorizontal articular facet; radianal small, rectangular, anal *X* smaller than radials, directly above *CD* basal. *M.Sil.* (*Niagaran*), USA (Tenn.).—FIG. 378,3*a-c*. \**T. ovatus*; *CD*-interray, ventral, and dorsal views of cup,  $\times 1$  (Springer, 1926a).—FIG. 378,3*d*. *T. cylindricus* MILLER & GURLEY; *CD*-interray view of cup,  $\times 1$  (Springer, 1926a).

### Family POROCRINIDAE Miller & Gurley, 1894

[Porocrinidae MILLER & GURLEY, 1894b, p. 24]

Theca globose or conical, anal *X* and radianal present; cup plates with one or more folds and ridges at plate corners. *M.Ord.* (*Mohawk.*)-*U.Ord.* (*Richmond.*).

**Porocrinus** BILLINGS, 1857, p. 279 [\**P. conicus*; M]. Theca small, steeply conical, base narrow, truncate; infrabasals 5, high; basals hexagonal; radials higher than wide, small circular articular facets declivate; radianal small, rectangular, anal *X* almost as large as radials, directly above *CD* basal and between posterior radials; cup-plate angles bear goniospire areas, with slits directed toward points where 3 plates come together, slit areas rounded triangular in outline, present between all infrabasals and basals, basals and radials, radianal, and at upper corners of adjacent radials, but lacking from upper juncture of anal *X* and adjacent radials. Arms slender, rounded, unbranched to height of primibrach 14. *M.Ord.* (*Mohawk.*)-*U.Ord.* (*Richmond.*), USA (Ky.-Ill.-Iowa-Minn.-Wis.)-Can. (Ont.-Baffin Island)-Eu. (Scot.).—FIG. 377,3; 379,2. \**P. conicus*, Mohawk., Ont.; 377,3, plate diagram of cup (radials black, radianal cross ruled, anal *X* stippled) (Moore, n); 379,2*a*, lat. view of crown,  $\times 3.3$  (Lane, n; Springer Coll., U.S. Natl. Museum); 379,2*b,c*, post. and ventral views of cup,  $\times 7$  (Lane, n); 379,2*d,e*, E-ray view of crown,  $\times 2.7$ , and plate diagram (Kesling & Paul, 1968).

**Triboloporus** KESLING & PAUL, 1968, p. 13 [\**T. cryptoplicatus*; OD]. Like *Porocrinus* except goniospires single, consisting of median ridge with deep trough on each side of plate corner. *M.Ord.* (*Mohawk.*), USA (Pa.-Va.).—FIG. 379,1. \**T. cryptoplicatus*, Va.; 1*a-d*, ventral, oblique *CD*-interray, *C*-ray, and *A*-ray views,  $\times 2.7$ ; 1*e*, thecal diagram; 1*f*, *CD*-interray view,  $\times 5.3$  (Kesling & Paul, 1968).

### Family CARABOCRINIDAE Bather, 1899

[Carabocrinidae BATHER, 1899b, p. 922]

Theca egg shaped; infer- and superradial-anal and anal *X* present in cup. *M.Ord.*-*U.Ord.*

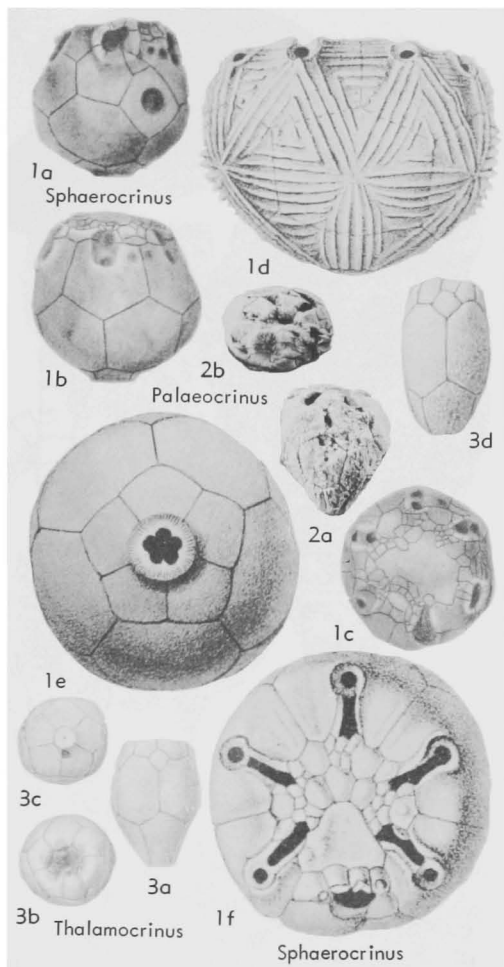


FIG. 378. Sphaerocrinidae (p. T588-T589).

**Carabocrinus** BILLINGS, 1857, p. 276 [\**C. radiatus*; M] [= *Strophocrinus* SARDESON, 1899, p. 264 (type, *S. dicyclicus*)]. Cup egg shaped, base wide, sides gently convex; infrabasals large, visible in side view; radials wider than high, inclined inward distally toward narrow tegminal area; arm facets small, round, vertically inclined; infer- and superradial in cup, inferradial in contact with 2 infrabasals, *CD* and *BC* basals, superradial above inferradial, below and left of *C* radial; anal *X* large, above and right of *CD* basal, between *C* and *D* radials; arms narrowly rounded, short, branching on primibrachs 2 or 3. *M.Ord.* (*Chazy.*)-*U.Ord.* (*Richmond.*), USA (Minn.-Iowa-Ky.-N.Y.-Okla.-Wis.)-Can. (Ont.)-Eu. (Est.).—FIG. 377,2. *Carabocrinus* BILLINGS; plate diagram of cup (radials black, infer- and superradial cross ruled, anal *X* stippled) (Moore, 1962b). [Restudy of SARDESON's type specimens by J.

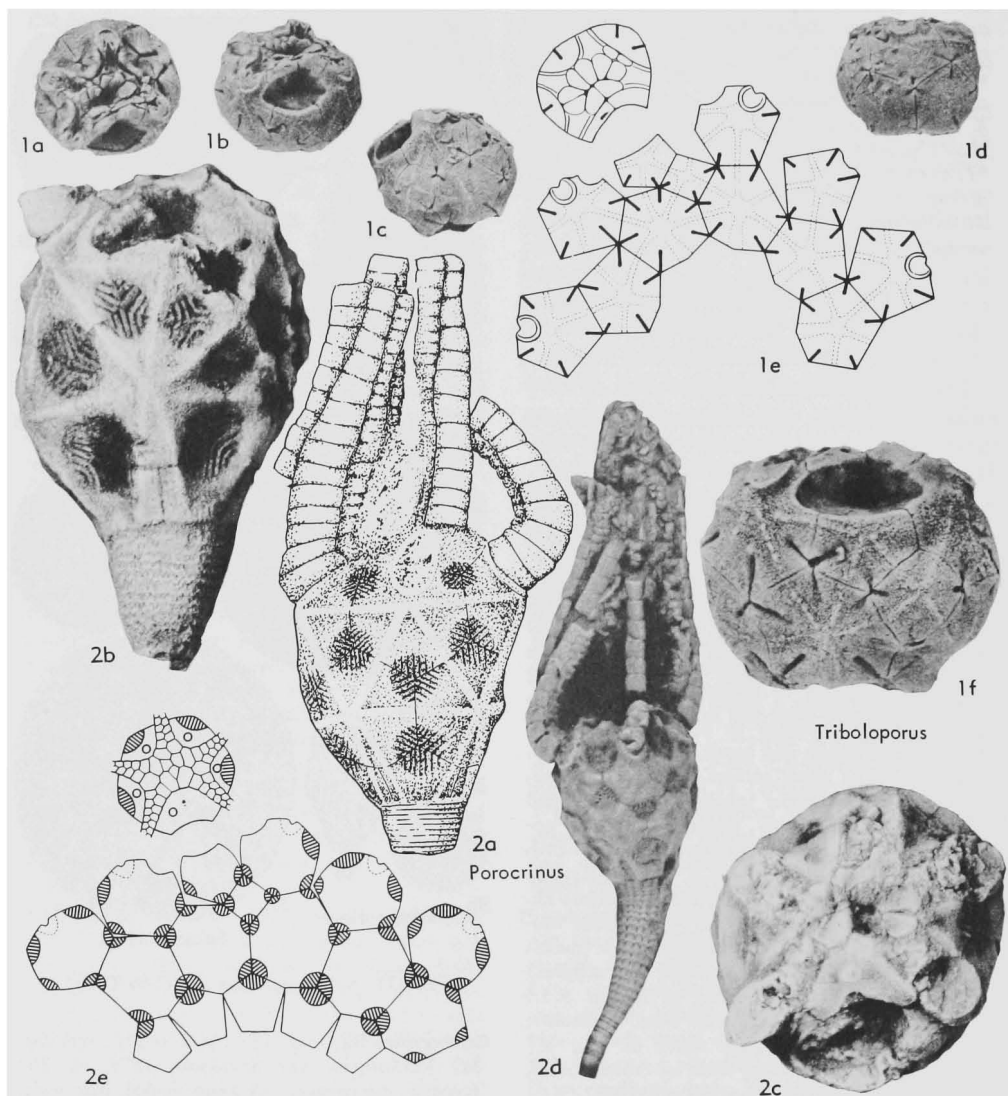


FIG. 379. Porocrinidae (p. T589).

BROWER, results as yet unpublished, reveals that *Strophocrinus* is a junior subjective synonym of *Carabocrinus*.—J. BROWER (pers. comm., Aug., 1968).]

#### Family CROTALOCRINITIDAE Bassler, 1938

[*nom. correct.* BASSLER, 1938, p. 18 (*pro* Crotalocrinidae ANGELIN, 1878, p. 26)] [=Enallocrinidae ANGELIN, 1878, p. 25]

Cup low, with wide flat base; anal X in cup or absent; radials support narrow primaxil, secundaxil 1, and in some genera,

tertaxil 1; axial canal in radials and brachials; tegmen low, flat, composed of numerous plates; madreporitic posterior oral and other orals recognized in one genus; anal opening directly through tegmen. Arms composed of numerous, exceptionally thick brachials laterally joined together proximally or completely joined within a ray, or both within and between rays, forming large, laterally directly fanlike appendages; ventral side of arms with stout ambulacral covering plates; arms enrolled

orally at lateral edges. Stem transversely circular, wide, with large, circular lumen; stout and short, with radicular cirri in some genera. *M.Sil.-M.Dev.(Givet.)*.

**Crotalocrinites** AUSTIN & AUSTIN, 1843, p. 198 [*\*Cyathocrinites rugosus* MILLER, 1821, p. 89; OD] [= *Crotalocrinites* AUSTIN & AUSTIN, 1842, p. 109 (*nom. nud.*); *Crotalocrinus* MORRIS, 1843, p. 50 (*nom. van.*); *Anthocrinus* MÜLLER, 1854, p. 192 (type, *A. loveni*)]. Cup low bowl shaped, base wide and flat; plates strongly ornamented with radiating ridges or rows of nodes; infrabasals 5, visible in side view; *CD* basal truncate above, in contact with anal *X* situated between *C* and *D* radials; radials pentagonal, incurved and narrow distally, upper surface occupied by multiple articular facets; axial canal present in radials and brachials; radianal absent. Arms with minute axillary primibrachs *1*, confined to center of radial; secundibrachs *1* and tertibrachs *1* in contact with radial; arms composed of numerous, isotomously branching brachials laterally united by articular processes at sides of each brachial, which in each ray are united into large flexible fan-shaped appendage or completely joined crown with edges enrolled adorally; individual brachials elongate, slender, smooth and rounded dorsally, with deep ambulacral groove and alternating covering plates ventrally. Tegmen composed of numerous small plates, 5 orals, posterior one a madreporite; anal opening above anal *X* flush with tegmen surface or at end of short anal tube. *U.Sil.*, Eu.(Boh.-Eng.-Sweden-USSR)-USA(Wis.-Iowa-Ill.).—FIG. 380,1a-c. *\*C. rugosus* (MILLER), Eng.; 1a-c, *CD*-interray view of theca, radial and proximal brachials, and ventral side of brachials,  $\times 2$  (Springer, 1926a).—FIG. 380,1d. *C. pulcher* (HSINGER), Gotl.; lat. view of crown,  $\times 0.7$  (Springer, 1926a).—FIG. 380,1e. *C. sp.*, Gotl.; ventral view of theca,  $\times 1$  (Wachsmuth & Springer, 1889b).

**Achradocrinus** SCHULTZE, 1867, p. 213 [*\*A. ventrosus*; M]. Cup bowl shaped; infrabasals 5, visible in side view; anal *X* quadrangular, directly above truncate *CD* basal; *C* and *D* radials concave on posterior sides, surrounding anal opening directly above anal *X*; radial articular facets narrow, vertically directed, with axial canals. Arms unknown. Stem transversely circular, with circular lumen, no peripheral canals. *M.Sil.*, USA(Ill.), *M.Dev.*, Eu.(Ger.).—FIG. 377,7; 380,2. *\*A. ventrosus*, M.Dev., Ger.; 377,7, plate diagram of cup (radials black, anal *X* stippled) (Moore, n); 380,2a-c, *CD*-interray, ventral, and dorsal views of cup,  $\times 1.5$  (Schultze, 1867).

**Arachnocrinus** MEEK & WORTHEN, 1866, p. 177 [*\*Cyathocrinus bulbosus* HALL, 1862, p. 123; OD]. Cup small, globose; infrabasals fused; anal opening directly above *CD* basal, bounded above by lower edges of *C* and *D* radials; anal *X* absent. Arms robust, branching isotomously on

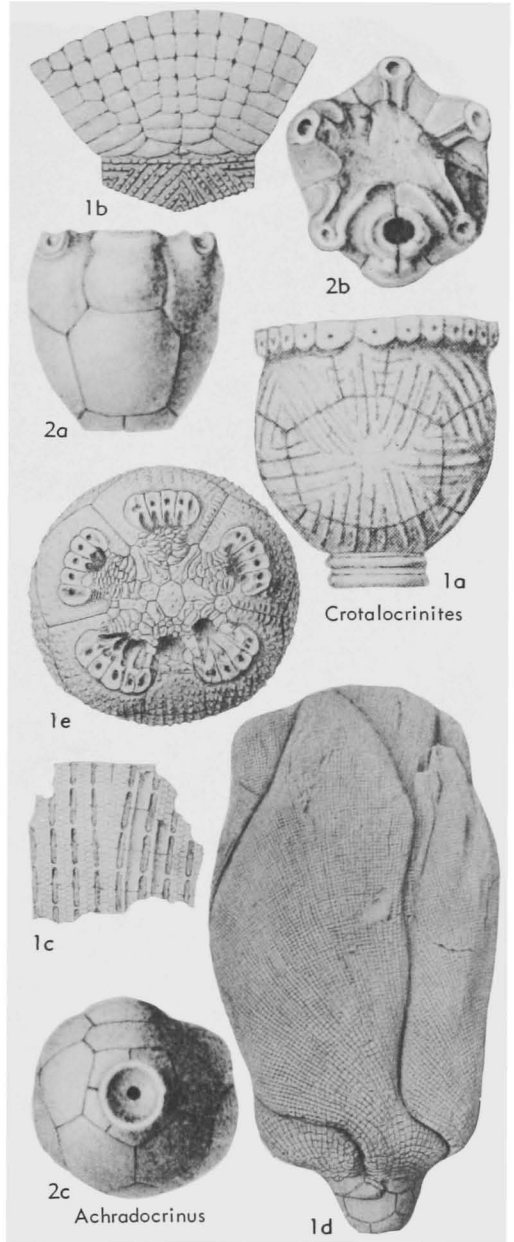


FIG. 380. Crotalocritidae (p. T591).

primibrachs 3 to 12, and with 4 or 5 higher bifurcations; brachials strongly rounded, axillaries large and bulbous; axial canal in brachials and radials. Stem round or subquadrate in section, with 4 peripheral canals. *M.Dev.*, USA(N.Y.-Ky.)-Can.(Ont.).—FIG. 381,2a-d. *\*A. bulbosus* (HALL), N.Y.; 2a,b, lat. and ventral views of crown,  $\times 2$ ; 2c,d, *CD*-interray and dorsal views



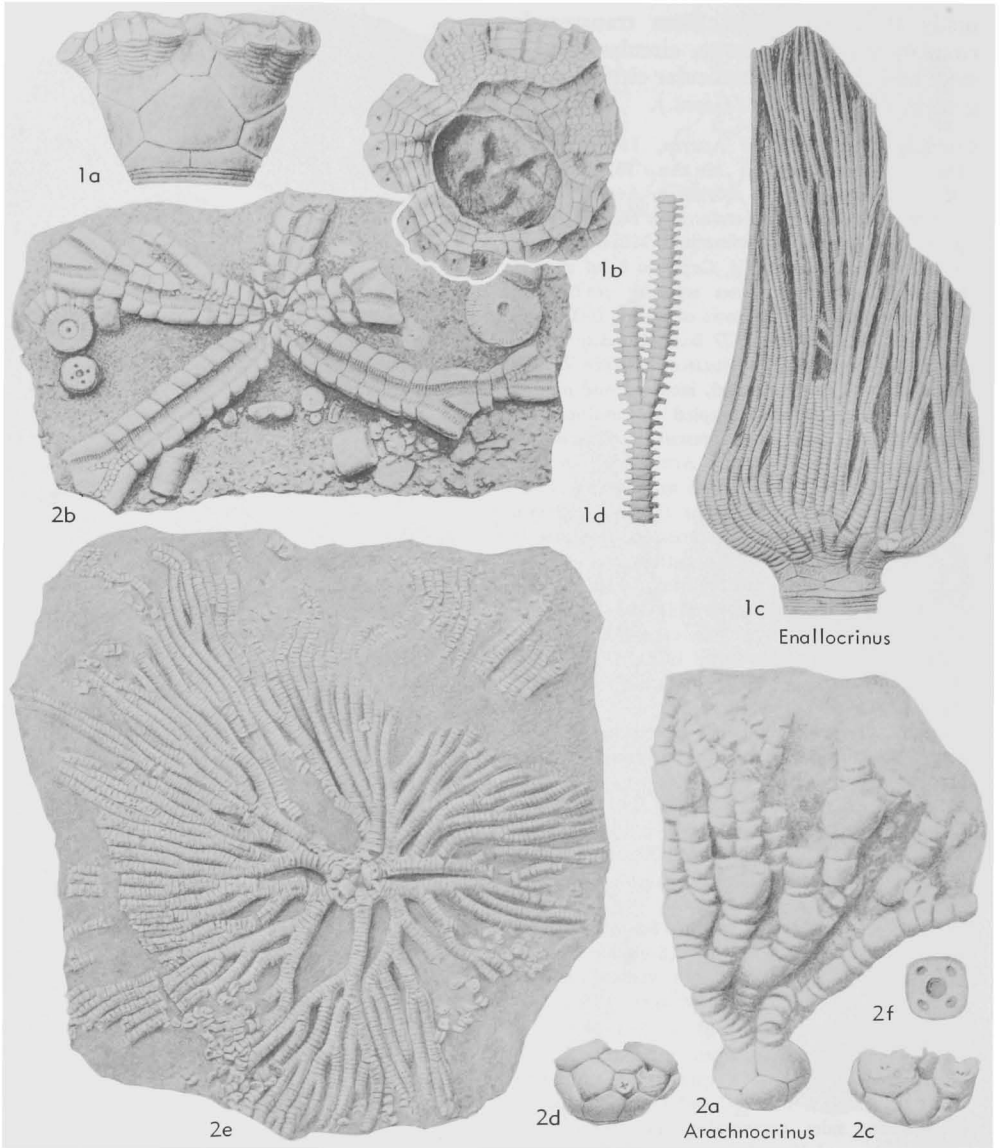


FIG. 381. Crotalocrinitidae (p. T591-T592).

of cup,  $\times 2$  (Springer, 1911c).—FIG. 381,2e,f. *A. extensus* WACHSMUTH & SPRINGER; 2e, dorsal view of crown,  $\times 0.5$ ; 2f, articular surface of columnal,  $\times 2$  (Springer, 1911c).

**Enallocrinus** D'ORBIGNY, 1850, p. 46 [*\*Apicrinites scriptus* HISINGER, 1828, p. 217; M]. Like *Crotalocrinites* except brachials laterally joined only in proximal parts of each arm. *U.Sil.*, Eu. (Eng.-Sweden).—FIG. 377,1; 381,1. *\*E. scriptus* (HISINGER), Wenlock., Gotland; 377,1, plate diagram of cup and arms of C and D rays (radials black, anal X stippled) (Moore, n);

381,1a,b, CD interray and ventral views of theca and proximal brachials,  $\times 1$ ; 381,1c, lat. view of crown,  $\times 0.7$ ; 381,1d, dorsal view of brachials,  $\times 1.5$  (Wachsmuth & Springer, 1889b).

**Parapernerocrinus** YAKOVLEV, 1949, p. 17 [*\*P. sibiricus*; M]. Cup composed of numerous, small, irregularly arranged plates; brachials thick, closely appressed and laterally joined together, with axial canal and angular ambulacral groove. Arms branching isotomously several times, on primibrachs 5 or 6, and on about secundibrach 12. Stem large, composed of thin, wide, circular col-

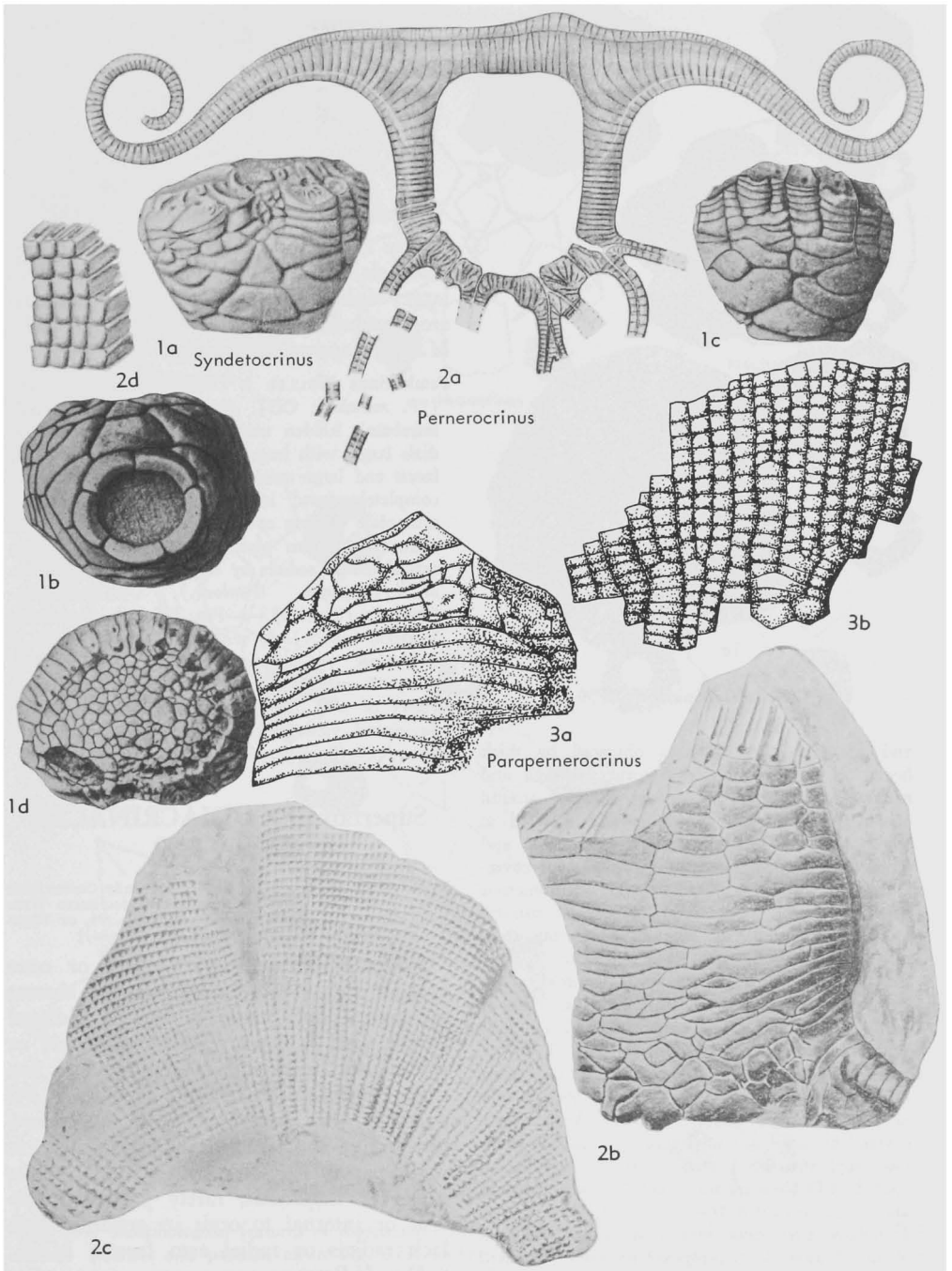


FIG. 382. Crotalocrinitidae (p. T592-T594).

uminals with wide circular lumen about four-fifths width of stem. *L.Dev.*, USSR(C.Urals).—  
 FIG. 382,3. \**P. sibiricus*; 3a,b, lat. view of fragmentary proximal columnals and cup, and dorsal

view of arm fragment,  $\times 1.3$  (Lane, n; mod. from Arendt & Gekker in Orlov, 1965).  
**Pernerocrinus** BOUŠKA, 1946, p. 18 [*P. paradoxus*; OD]. Crown large, mushroom shaped; stem, cup,

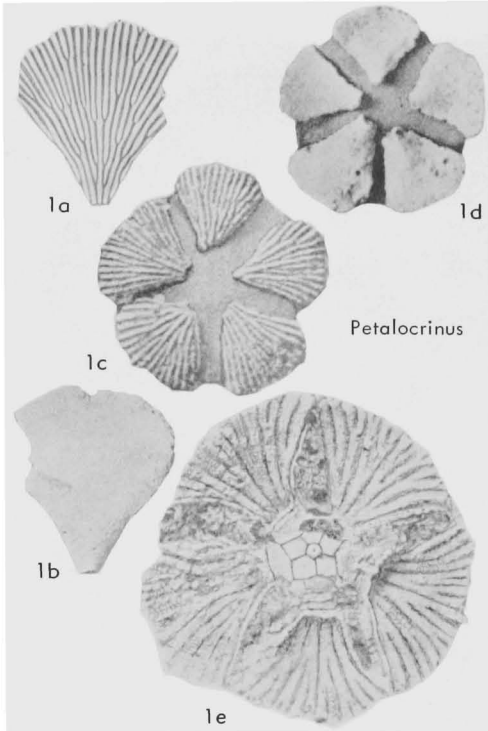


FIG. 383. Petalocrinidae (p. T594).

and proximal part of arms obscured by thick layers of stereom; brachials numerous, high and narrow, completely in contact laterally around crown, forming wide expanse orally enrolled at edges; brachials with prominent axial canal and ambulacral groove concealed by imbricated covering plates. Tegmen flat, composed of numerous small polygonal plates; anal opening at summit of low protuberance of tegmen. Numerous stout radicular cirri penetrate stereom distally. *L.Dev.*, Eu.(Boh.).—FIG. 382,2. \**P. paradoxus*; 2a, vert. sec. through crown,  $\times 0.3$ ; 2b,d, lat. view of partial crown and oblique view of brachials,  $\times 1$ ; 2c, dorsal side of arms,  $\times 0.5$  (Bouška, 1946).

**Syndetocrinus** KIRK, 1933, p. 345 [\**S. dartae*; OD]. Cup low, with wide flat base and straight or gently convex sides; infrabasals low, mostly covered by wide proximal columnal; radials wide, low, separated on posterior side by pentagonal anal *X*; CD basal truncate above for contact with anal *X* or separated from it by edges of *C* and *D* radials; axial canal present in radials and brachials. Tegmen low, composed of numerous small irregular plates; orals not certainly identified. Arms with axillary primibrachs *1* occupying one-half to full width of radial; where primaxil is narrow, secundibrach *1* in contact with lateral edge of radial; secundibrachs *2* and tertibrachs *1* and tertibrachs *2* or *4* axillary; arms laterally in

contact and firmly joined together at sides. Circular columnals wide, low, with large circular lumen. *U.Sil.*, Can.(Que.)-Eu.(Boh.-USSR).—FIG. 382,1. \**S. dartae*, Que.; 1a-d, CD-interray, dorsal, BC-interray, and ventral views of partial crown,  $\times 1$  (Kirk, 1933).

### Family PETALOCRINIDAE Weller & Davidson, 1896

[Petalocrinidae WELLER & DAVIDSON, 1896, p. 167]

Cup small, radianal and anal *X* lacking; brachials of each ray laterally fused into large, rigid, fan-shaped plates bearing covered ambulacral grooves on ventral side. *M.Sil.*(Niagaran, *Wenlock.*).

**Petalocrinus** WELLER & DAVIDSON, 1896, p. 167 [\**P. mirabilis*; OD]. Cup small, bowl shaped; infrabasals hidden under proximal columnal; radials large, with large, vertically directed articular facets and large axial canal; brachials of each ray completely fused into single, large, fan-shaped arm plate bearing covered ambulacral grooves on ventral side; arm plates smooth on dorsal side, articulated to radials by single, short, primibrach. *M.Sil.*(Niagaran, *Wenlock.*), USA (Iowa-Ind.-Ohio)-Eu.(Sweden).—FIG. 383,1a,b. *P. inferior* BATHER, Iowa; 1a,b, ventral and dorsal views of arm plate,  $\times 1$  (Springer, 1926a).—FIG. 383, 1c-e. \**P. mirabilis*, Iowa; 1c,d, ventral and dorsal views of arm plates, artificially mounted,  $\times 1$ ; 1e, dorsal view of crown with arm-fans broken away,  $\times 2$  (Springer, 1926a).

### Superfamily CODIACRINACEA Bather, 1890

[*nom. transl.* LANE, 1967, p. 10 (ex subfamily Codiocrinites BATHER, 1890b, p. 385) [=superfam. Hypocrinacea WANNER, 1916a (*nom. transl.* ARENDT, 1970a, p. 94, ex Hypocrinidae WANNER, 1916a, p. 88) (*partim*)]

Theca small, typically globose or cone shaped; radials five, three, one, or absent; infrabasals five, three or fused; radianal absent, anal *X* present only primitively or secondarily; tegmen low, composed of five orals; posterior oral large, separating *BC* and *DE* orals, commonly with hydropore, or rarely and secondarily developed as madreporite (Fig. 384; see Fig. 388). Arms uniserial, isotomous, rarely preserved; absent or internal to orals in genera which lack radials or radial arm facets. *M.Sil.*; *L.Dev.*-*U.Perm.*

### Family CODIACRINIDAE Bather, 1890

[*nom. transl. et correct.* JAEKEL, 1895, p. 63 (ex subfamily Codiocrinites BATHER, 1890b, p. 385)] [=Embryocrinidae WANNER, 1916a, p. 130; Hypocrinidae WANNER, 1916a, p. 88]

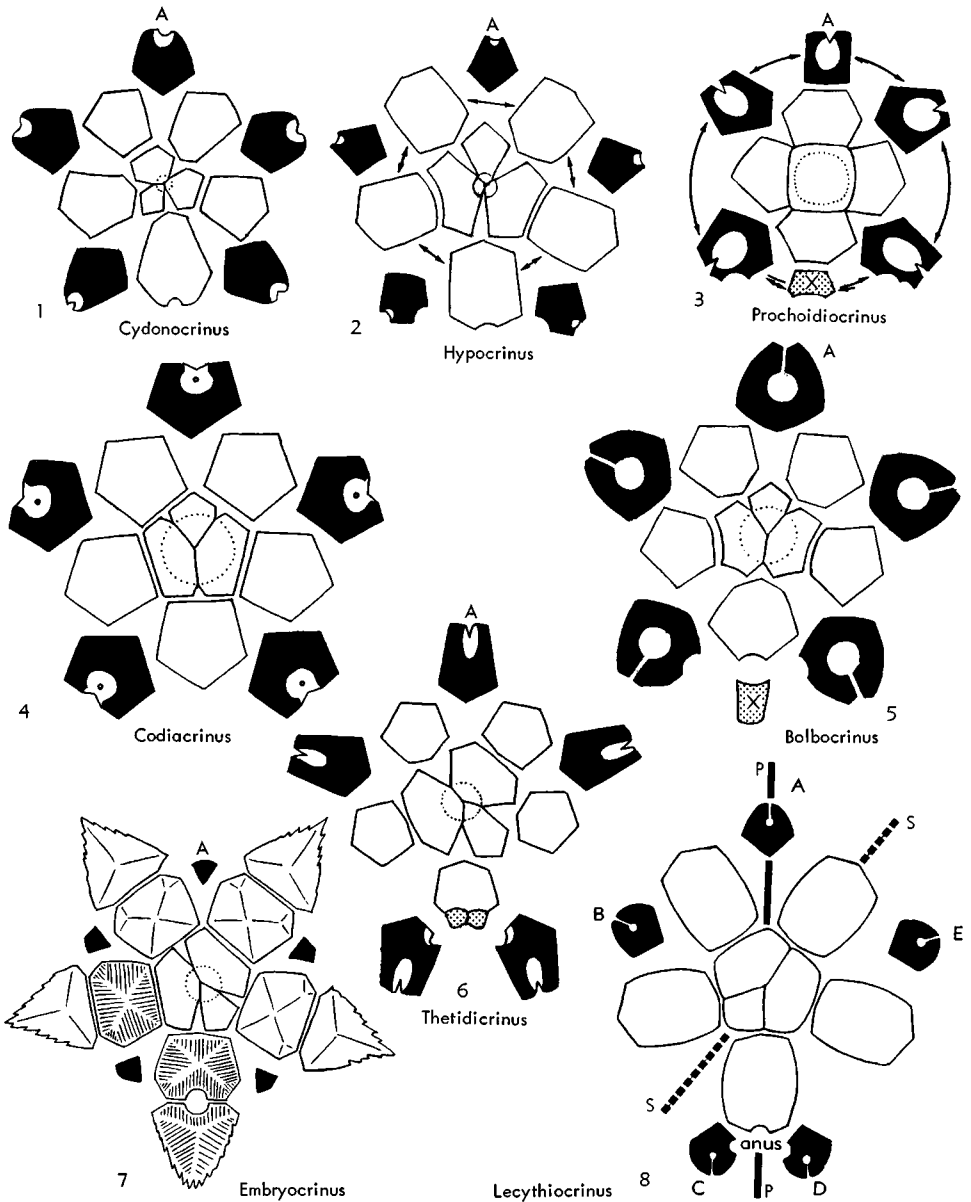


FIG. 384. Morphological features of representative Codiocrinacea (Codiocrinidae) (plate diagrams, not to scale). [Letters and patterns as in Fig. 372; broken heavy black line in Fig. 384,8 marks secondary plane of bilateral symmetry.]

Theca with five facet-bearing radials, or rarely with five secondarily reduced, non-facet-bearing radials of equal size; anal X absent, or secondarily developed above or below opening in advanced genera; anal

opening between radials and basals, or radials and orals, posterior oral a madreporite or with hydropore. *M.Sil.*; *L.Dev.-M.Dev.*; *L.Miss.-U.Perm.*

## Subfamily CODIACRININAE Bather, 1890

[*nom. correct.* LANE, 1967, p. 11 (*pro* subfamily Codiocrininae BATHER, 1890b, p. 385)] [=Hypocrinininae WANNER, 1929b, p. 38; section Hypocrinites WANNER, 1929b, p. 38] [incl. Cranocrininae ARENDT, 1970a, p. 140; Infrasalidocrininae ARENDT, 1970a, p. 192]

Theca without anal plate; posterior oral not a madreporite. *M.Sil.*; *L.Dev.-M.Dev.*; *L.Miss.-U.Perm.*

**Codiocrinus** SCHULTZE, 1867, p. 143 [*\*C. granulatus*; OD]. Cup high, conical; 3 or 75 infrabasals visible in side view; 5 large basals and 5 large radials with small articular facets; no anal plate in cup. Arms branching dichotomously on primibrachs 3, with at least 2 higher divisions. Stem round. *L.Dev.-M.Dev.*, Eu.(Ger.-Spain).—FIG. 384,4; 385,7. *\*C. granulatus*, M.Dev., Ger.; 384,4, plate diagram of cup (radials black) (Moore, n); 385, 7a-c, lat., dorsal, and ventral views of cup,  $\times 2$  (Schultze, 1867).

**Abrachiocrinus** WANNER, 1920, p. 29 [*\*Sycocrinites clausus* AUSTIN & AUSTIN, 1843, p. 206; OD]. Theca pear shaped; composed of 4 circlets (3 infrabasals, and 5 basals, radials, and orals); radial articular facets and anal plate lacking; anal opening in side of cup, bounded by *CD* basal and *C* and *D* radials; orals alternating with radials, forming swollen vault over radial circlet. Stem round. *L.Carb.(Tournais.)*, Eu.(Eng.), *U.Perm.*, Indon.(Timor, Basleo).—FIG. 385,1. *\*A. clausus* (AUSTIN & AUSTIN), *L.Carb.*, Eng.; 1a-e, ant., *CD* interray, *B*-ray, ventral, and dorsal views of theca,  $\times 3$ ; 1f,g, diminutive juvenile theca and columnar articular views,  $\times 3$  (all Bather, 1914a).

**Amphipsalidocrinus** J. M. WELLER, 1930, p. 33 [*\*A. scissurus*; OD]. Theca small, mushroom shaped; cup low cone shaped; infrabasals absent, atrophied or hidden; basals 3, equal, supporting 5 small radials with large articular facets; anal opening small, bordered below by projecting lip, bounded by *CD* basal, *C* and *D* radials, and *CD* oral, situated closer to *C* than to *D* radial facet; orals large, protruding, each with conspicuous elongate depression above radial facet that may have partly enclosed short, atomous arm. *L.Miss.-L.Perm.*, USA (Mo.-Ind.).—FIG. 385,3. *\*A. scissurus*, L.Penn., Ind.; 3a,b, *CD*-interray and dorsal views of theca,  $\times 30$  (Peck & Connelly, 1951).

**Asymmetrocrinus** WANNER, 1937, p. 130 [*\*A. poteriocrinoides*; OD]. Cup cone shaped, asymmetrical, composed of 3 circlets of 5 plates each; infrabasals visible in side view; *CD* basal separates *C* and *D* radials; *E* radial and radial facet twice as large as *B* and *C* radials and facets, and projecting ventrally; facets semicircular, obliquely inclined. Stem round. *U.Perm.*, Indon.(Timor, Basleo).—FIG. 385,8; 386,4. *\*A. poteriocrinoides*; 385,8a-d, *CD*-interray, ventral, *B*-ray, and *A*-ray views of cup,  $\times 3$  (Wanner, 1937); 386,4a-c, dorsal, post., and ventral views of holotype (radials black),  $\times 3$  (Arendt, 1970a).

**Cranocrinus** WANNER, 1929, p. 41 [*\*C. timoricus*; OD]. Theca composed of 4 circlets; infrabasals fused into single plate visible in side view; basals and radials more or less asymmetrical; *CD* basal elongate, 6-sided; *C* and *D* radials separated by anal opening, all others in lateral contact; radial articular facets projecting, horseshoe shaped, narrow, steeply declivate, unequal in size; anal opening in side of cup, bounded by *CD* basal, *C* and *D* radials, and *CD* oral; orals 5, in normal interradial position, forming helmet-shaped vault over cup, hydropore on *CD* oral, each oral centrally concave. *L.Perm.(Artinsk.)*, USSR (NC.Sib.); *U.Perm.(Basleo beds)*, Indon.(Timor).—FIG. 385,5. *\*C. timoricus*, *U.Perm.*, Timor (Basleo); 5a-c, *CD*-interray, ventral, and dorsal views of theca,  $\times 6$  (Wanner, 1929b).—FIG. 386,3. *C. praestans* ARENDT, *L.Perm.*, Kolva R., NC.Sib.; 3a-e, *EA*-, *DE*-, *CD*-, *BC*-, and *AB* interray views (radials black, anus oblique ruled) of theca showing size variation of radial articular facets and hydropore on *CD* oral,  $\times 10$  (Arendt, 1970a).

**Cydonocrinus** BATHER, 1913, p. 391 [*\*C. parvulus*; OD]. Cup small, globular; 3 infrabasals visible in side view, small infrabasal in *C* ray; basals large, *CD* basal truncate above for anal opening between *C* and *D* radials; posterior side of cup bulging and distal edge of *CD* basal inflated around ventrally directed anal opening; radials 5, smaller than basals, incurved distally; arm facets semicircular, raised above level of surrounding radial, horizontally directed. *L.Carb.(Visean)*; *U.Perm.*, Eu.(Eng.)-Indon.(Timor, Basleo).—FIG. 384,1; 385,4. *\*C. parvulus*, *L.Carb.*, Eng.; 384,1, plate diagram of cup (radials black) (Moore, n); 385,4a-d, *CD*-interray, ventral, dorsal, and *B*-ray (with hypothetical reconstruction of anal sac and arms) views of cup,  $\times 3$  (Bather, 1913d).

**Embryocrinus** WANNER, 1916, p. 130 [*\*E. hanieli*; OD] [*non Embryocrinus* HUDSON, 1918, p. 162 (= ?*Dendrocrinus* HALL, 1852, p. 193)]. Theca small, pear shaped; 4 circlets of massive plates forming closed capsule with anal opening between *CD* basal and oral; 3 infrabasals, small one in *D* ray; radials small, trigonal, not forming continuous circlet around cup, isolated between projecting distal edges of basals; orals forming dome-shaped arch with broad base resting on basals and radials. *U.Perm.*, Indon.(Timor, Basleo).—FIG. 384,7; 385,6. *\*E. hanieli*; 384,7, plate diagram of theca (radials black) (Moore, n); 385,6a-c, post., dorsal, and ventral views of theca,  $\times 3$  (Wanner, 1916a).

**Hydroporocrinus** ARENDT, 1970, p. 146 [*\*H. obliquus*; OD]. Theca low, transversely pentagonal in outline, cup conical and moderately elevated oral dome quinquestellate owing to strong median depressions and raised lateral margins of orals; infrabasals solidly fused together and similarly joined to *DE* basal; 5 basals, *CD* and *DE* larger than others and asymmetrical; radials with side-

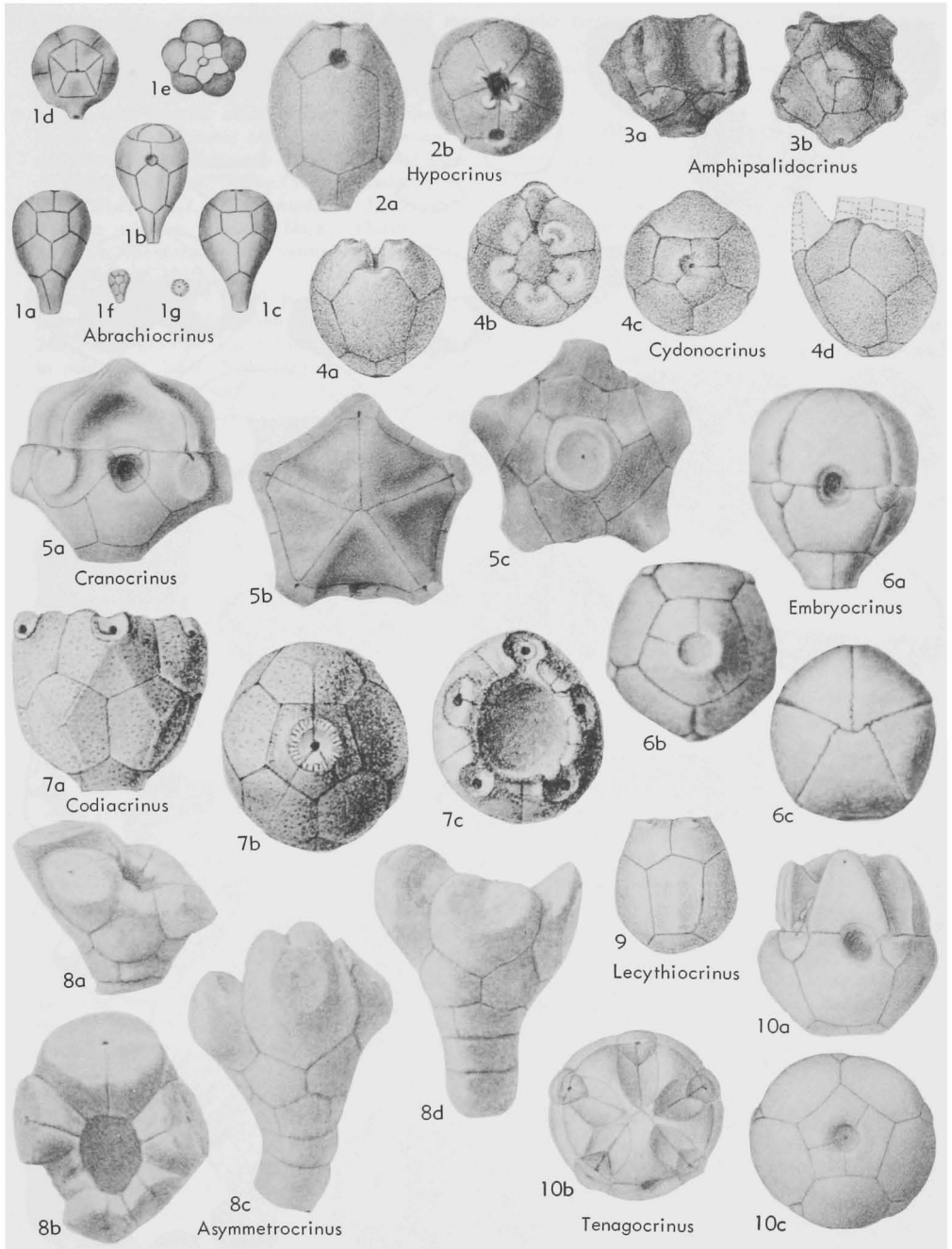


FIG. 385. Codiocrinidae (Codiocrininae) (p. T596, T598-T599).

ward projections which bear subvertical circular articular facets slightly notched at upper margins. CD oral distinctly wider than others and bearing large hydropore on prominent tubercle; smaller hydropores and tubercles on other orals, except

DE which lacks them. *L.Perm.(up.Artinsk.)*, USSR (Kolva River, NC.Sib.).—FIG. 386.2. \**H. obliquus*; 2a-d, dorsal, post., DE interray, and ventral views of holotype,  $\times 5.3$ ; 2e-i, diagram. views of theca from EA-, DE-, CD-, BC-, and

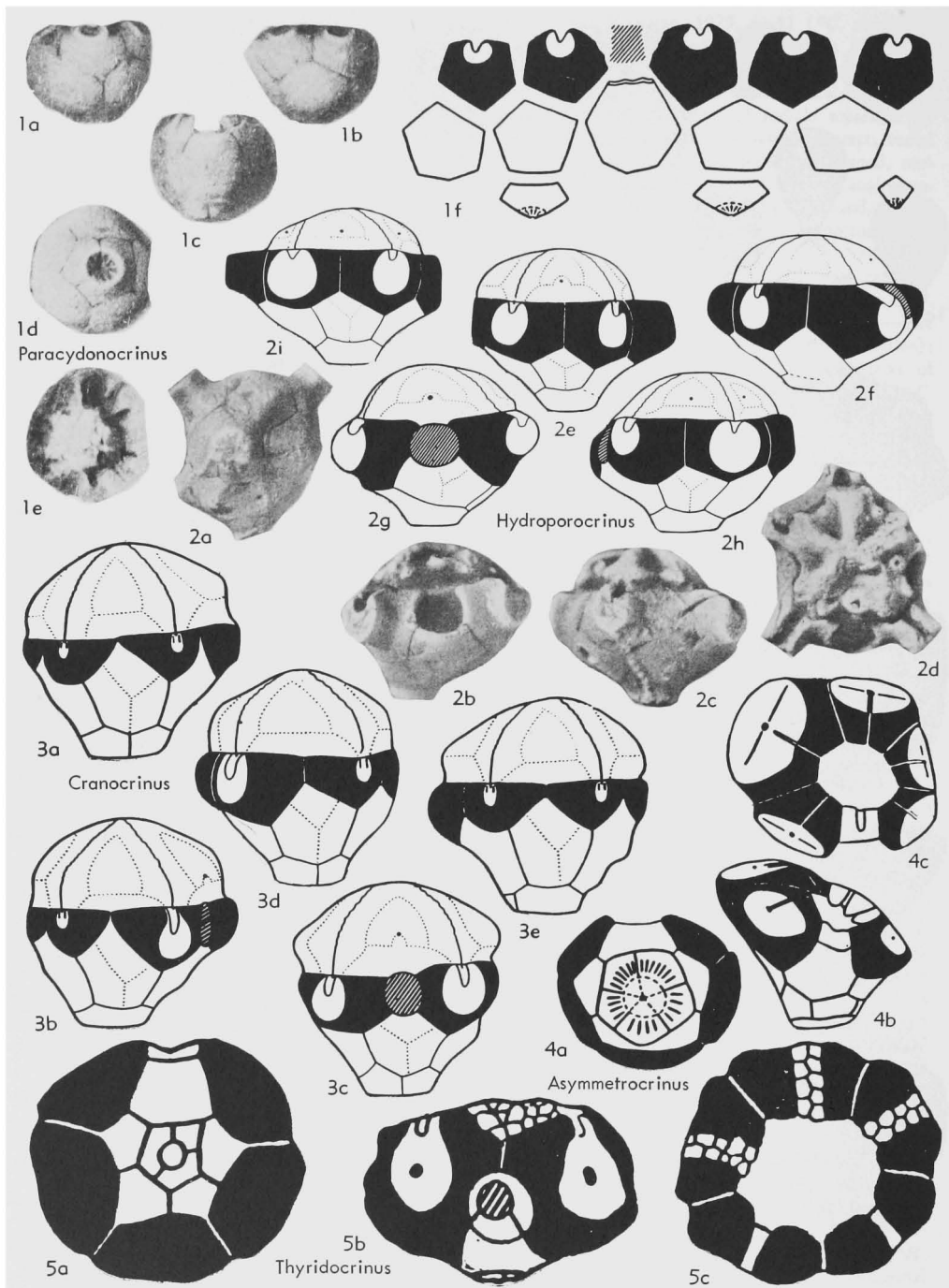


FIG. 386. Codiocrinidae (Codiocrininae) (p. T596-T599).

AB-interray sides (radials black, anus oblique ruled),  $\times 6$  (Arendt, 1970a).

**Hypocrinus** BEYRICH, 1862, p. 537 [*H. schneideri*;

M]. Cup small, globose; infrabasals high, 3, small one in anterior position, restricted in width proximally just above small stem facet; basals high,

convex, circler forming widest part of theca; radials small, shield shaped, distally restricted, inclined into center of distal cup border, in contact around cup; arm facets small, horizontally directed, with narrow ambulacral groove; opening at top of cup narrow; anal opening between *C* and *D* radials, notching top of *CD* basal and sides of radials. *U.Perm.*, Indon.(Timor, Basleo).—FIG. 384,2; 385,2. \**H. schneideri*; 384,2, plate diagram of cup (radials black) (Moore, n); 385,2a,b, *CD*-interray, and ventral views of cup,  $\times 2$  (Wanner, 1916a).

**Lecythiocrinus** WHITE, 1880, p. 256 [\**L. olliculaeformis*; OD] [= *Menocrinus* MILLER, 1889, p. 262]. Cup globose; 3 or 5 low infrabasals, visible in side view; basals high, bulging distally below radials, which are small, low, distally restricted and inclined toward center of cup; articular facets small, horizontally directed; anal opening large, bounded above and at sides by *C* and *D* radials, and proximally by bulging upper edge of *CD* basal. *L.Penn.-U.Penn.*, USA (Ind.-Ill.-Okla.-Kans.).—FIG. 384,8; 385,9. \**L. olliculaeformis*, U. Penn., Kans.; 384,8, plate diagram of cup (radials black, *P-P* primary and *S-S* secondary planes of bilateral symmetry) (Moore, 1962); 385,9, lat. view of cup,  $\times 2$  (White, 1880b).

**Paracydonocrinus** ARENDT, 1970, p. 106 [\**P. diviensis*; OD]. Cup very diminutive, globose; small infrabasal in *A* ray, rather than *C* ray as in *Cydonocrinus*, *CD* basal distally truncate, distinctly larger than others; anus between posterior radials. Stem small, transversely circular. *L.Perm.* (*up.Artinsk.*), USSR (Sib., Krasnoufmsk).—FIG. 386,1. \**P. diviensis*; 1a-e, *A*-ray, *AB*- and *CD*-interray, dorsal, and ventral (*A* ray downward) views of holotype cup,  $\times 2$ ; 1f, plate diagram of cup (radials black),  $\times 2.5$  (all Arendt, 1970a).

**Tenagocrinus** WANNER, 1929, p. 48 [\**Embryocrinus sulcatus* WANNER, 1916a, p. 141; OD]. Theca small; 3 infrabasals, small one in *A*-ray, barely visible in side view; basals large, in lateral contact; radials 5, small, 3-sided, not in contact, with stunted articular facets for arms; orals large, in normal interradial position, forming high vault, with deep, recessed furrow above each arm facet for reception of small unbranched arm; large anal opening in side of theca, shifted to right of *CD* midline, bounded by *CD* basal and oral, and *C* radial. *U.Perm.*, Indon.(Timor).—FIG. 385,10. \**T. sulcatus* (WANNER); 10a-c, *CD*-interray, ventral, and dorsal views of theca,  $\times 5$  (Wanner, 1929b).

**Thyridocrinus** KIRK, 1944, p. 388 [\**Lecythiocrinus? problematicus* SPRINGER, 1926a, p. 133; OD] [= *Prolecythiocrinus* ARENDT, 1970a, p. 117 (obj.)]. Differs from *Lecythiocrinus* in low spheroidal form of theca instead of tall pear shape, as well as in proportionally much smaller basals and larger radials which extend from summit almost to basal plane; large subvertical radial ar-

ticular facets horseshoe shaped, with central round canal opening; *A*, *B*, and *E* rays with biserially arranged cover plates traversing ambulacra on distal part of radials leading to tegmen. *M.Sil.* (*Niagaragan*), USA.—FIG. 386,5. \**T. problematicus* (SPRINGER), Laurel Ls., USA (Ind.); 5a-c, dorsal, post., and ventral views of theca (radials black),  $\times 4$  (Arendt, 1970a).

#### Subfamily BOLBOCRININAE Wanner, 1930

[*nom. transl.* LANE, 1967, p. 11 (*ex section* Bolbocrinites WANNER, 1930a, p. 4)]

Anal opening in side of cup, bounded above or below by secondarily developed anal plate; without madreporite. *L.Perm.-U.Perm.*

**Bolbocrinus** WANNER, 1916, p. 115 [\**B. hieroglyphicus*; OD]. Cup bowl shaped; 3 infrabasals low but visible in side view, with wide stem facet; small pentagonal infrabasal in *A* or *C* ray; basals large, regularly pentagonal; radials almost as large as basals, sharply constricted distally; *C* and *D* radials not in lateral contact, separated by anal opening and quadrangular anal plate which does not project above radial circler; articular facets large, horseshoe shaped, with long deep ambulacral canals; anal opening large, rounded, bounded by *CD* basal, *C* and *D* radials, and anal plate. *L.Perm.-U.Perm.*, Indon.(Timor, Basleo)-USSR.—FIG. 384,5; 387,3a-c. \**B. hieroglyphicus*, *U.Perm.*, Timor; 384,5, plate diagram of cup (radials black, anal *X* stippled) (Moore, n); 387,3a-c, *CD*-interray, dorsal, and ventral views of cup,  $\times 1.5$  (Wanner, 1916a).—FIG. 387,3d,e. *B. rex* WANNER, *U.Perm.*, Timor; 3d,e, *CD*-interray and ventral views of cup,  $\times 0.7$  (Wanner, 1916a).

**Nereocrinus** WANNER, 1924, p. 127 [\**N. antiquus*; OD] [= *Oceanocrinus* WANNER, 1924, p. 131 (type, *O. granulatus*)]. Like *Bolbocrinus* except anal plate directly above *CD* basal and anal opening not in cup. *L.Perm.-U.Perm.*, Indon.(Timor, Basleo)-USSR (Krasnoufmsk).—FIG. 387,4. \**N. antiquus*; 4a,b, post. and ventral views of cup,  $\times 2$  (Wanner, 1924).

#### Subfamily THETIDICRININAE Wanner, 1930

[*nom. transl. et correct.* LANE, 1967, p. 11 (*ex section* Thetidicrinites WANNER, 1930a, p. 3)]

Codiocrinidae with one or two anal plates in cup and madreporitic posterior oral. *L.Carb.* (*Tournais.*); *U.Perm.*

**Thetidicrinus** WANNER, 1916, p. 111 [\**T. piriiformis*; OD]. Theca high, cone shaped; 3 infrabasals in funnel-shaped circler; small plate in *D* ray; *CD* basal protruding distally, with concave upper border supporting 2 equal anal plates; radials large, constricted distally, in lateral contact; articular facets large, elongate, horseshoe shaped,



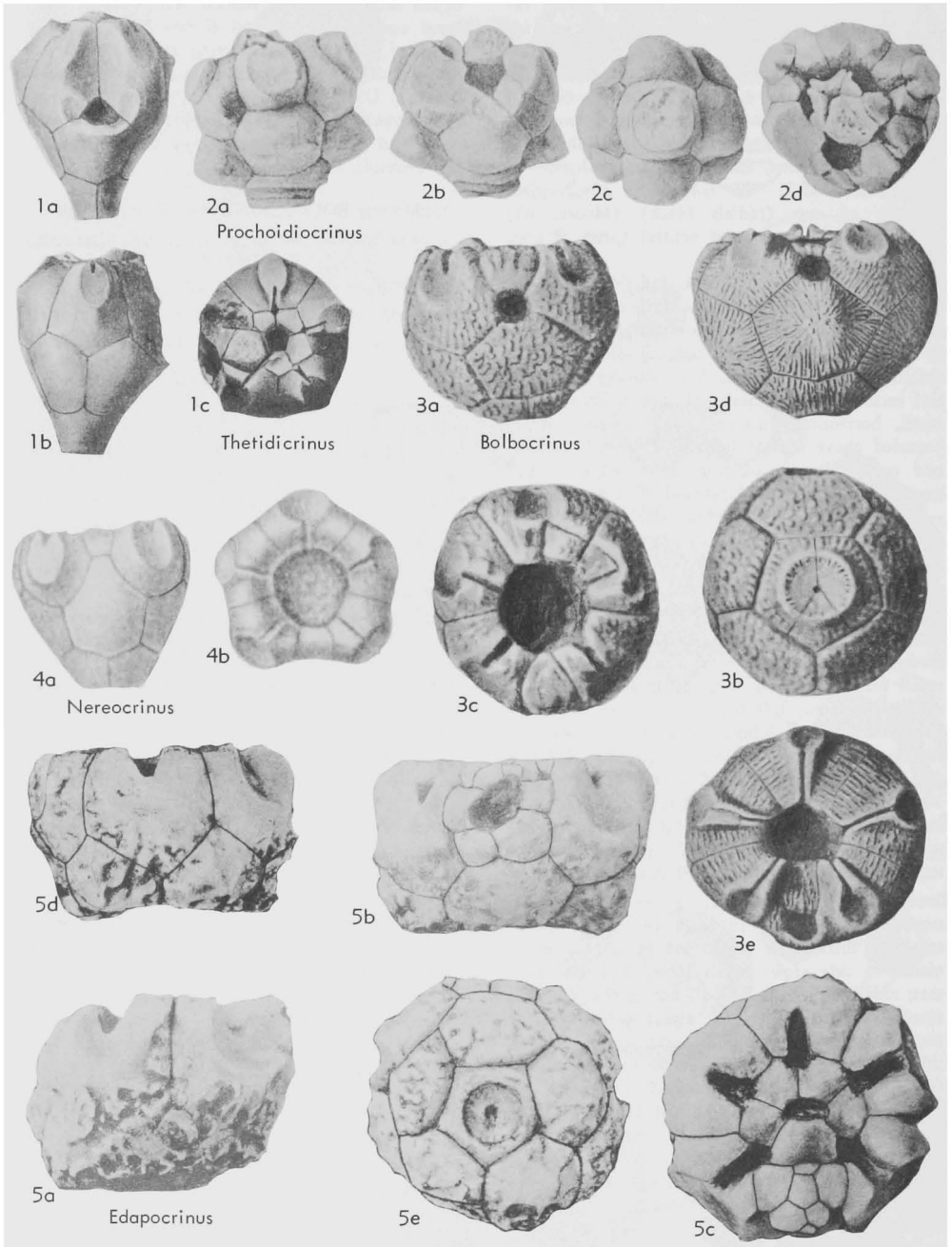


FIG. 387. Codiocrinidae (Bolbocrininae) (3A), (Thetidocrininae) (1,2,5) (p. T599-T601).

inclined outward, with deeply incised ambulacral canals; anal opening directed obliquely upward, bounded by *C* and *D* radials above, and externally by 2 equal anal plates; small pentagonal orals in lateral contact; *CD* oral larger and madreporite.

*U. Perm.*, Indon. (Timor, Basleo).—FIG. 384,6; 387,1. \**T. piriformis*; 384,6, plate diagram of cup (radials black, anals stippled) (Moore, n); 387, 1a-c, *CD*-interray, *E*-ray, and ventral views of theca,  $\times 1.5$  (Wanner, 1916a).

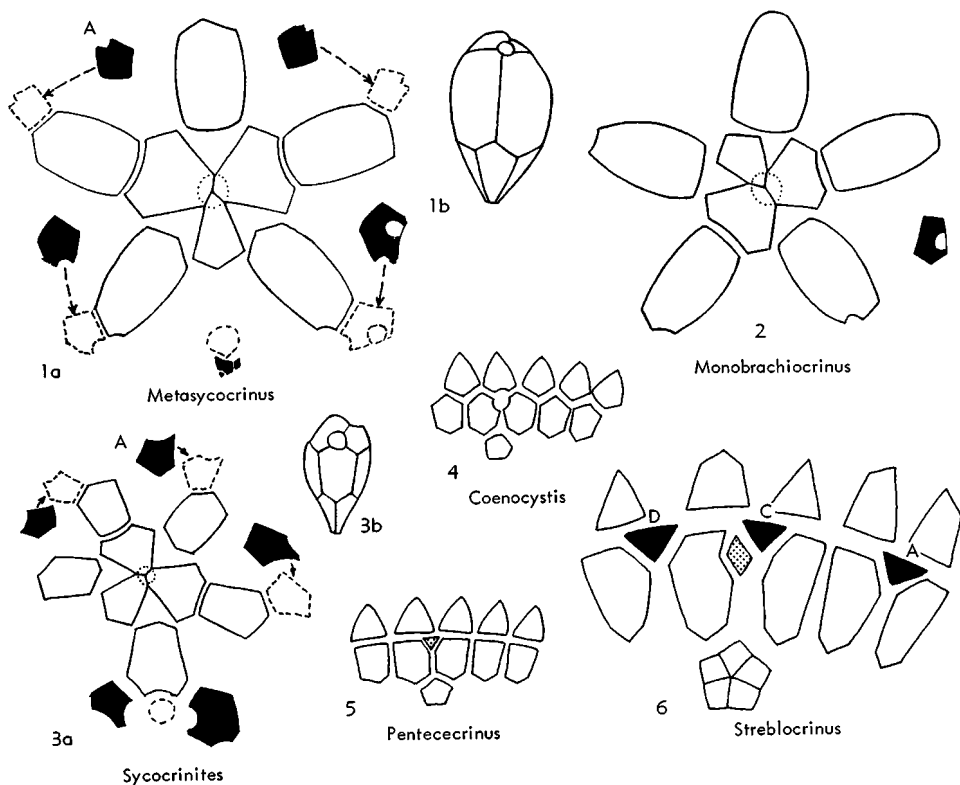


FIG. 388. Morphological features of representative Codiocrinacea (Sycocrinitidae, Streblocrinidae) (plate diagrams, not to scale). [Letters and patterns as in Fig. 372.]

**Edapocrinus** WRIGHT, 1935, p. 195 [*\*E. rugosus*; OD] [= *Edaphocrinus* WANNER, 1937 (*nom. van.*)]. Cup bowl shaped, base wide, flat; infrabasals fused, not visible in side view; radials 5, with large, horseshoe shaped, vertically directed facets and deep ambulacral notches; anal opening in side of cup between *C* and *D* radials, directly above truncate *CD* basal, surrounded by 7 small accessory anal plates; anal *X* and radianal not definitely identified; tegmen narrow, flat, with 5 orals, posterior one larger and a madreporite, tegmen with central, oval opening. *L.Carb.* (*Tournais.*), Eu. (Eng.).—FIG. 387.5. *\*E. rugosus*; 5*a-e*, *AB*-interray, *CD*-interray, ventral, *A*-ray, and dorsal views of theca,  $\times 1.5$  (Wright, 1951-54).

**Prochoidiocrinus** WANNER, 1937, p. 127 [*\*P. nodosus*; OD]. Theca bowl shaped, infrabasals fused, barely visible in side view; 4 nodose basals, *AB* and *AE* basals fused below *A* radial, radials 5, with large, vertically directed articular facets occupying most of outer plate surfaces; anal opening in side of cup, between *C* and *D* radials, bounded below by small quadrangular anal *X* directly above *CD* basal; orals 5, small except for large posterior oral developed as madreporite and

bounding ventral edge of anal opening. *U.Perm.*, Indon. (Timor, Basleo).—FIG. 384.3; 387.2. *\*P. nodosus*; 384.3, plate diagram of cup (radials black, anal *X* stippled) (Moore, n); 387.2*a-d*, *A*-ray, *CD*-interray, dorsal, and ventral views of theca,  $\times 1.5$  (Wanner, 1937).

### Family SYCOCRINITIDAE Lane, 1967

[Sycocrinitidae LANE, 1967, p. 12]

Theca with one arm-bearing radial; other radials present or absent, commonly unequal and reduced in size; infrabasals three; anal *X* plate absent; anal opening bounded by basals and radials, or by radials. Orals small, commonly not preserved. *L.Carb.* (*Tournais.*); *L.Perm.*-*U.Perm.*

**Sycocrinites** AUSTIN & AUSTIN, 1842, p. 111 [*\*S. anapeptamenus*; SD BATHER, 1914a, p. 253] [= *Sycocrinus* MORRIS, 1843, p. 54 (*nom. van.*)]. Cup high globular with narrow base; infrabasals 3, high, small plate in *C* ray; 5 radials, *D* radial

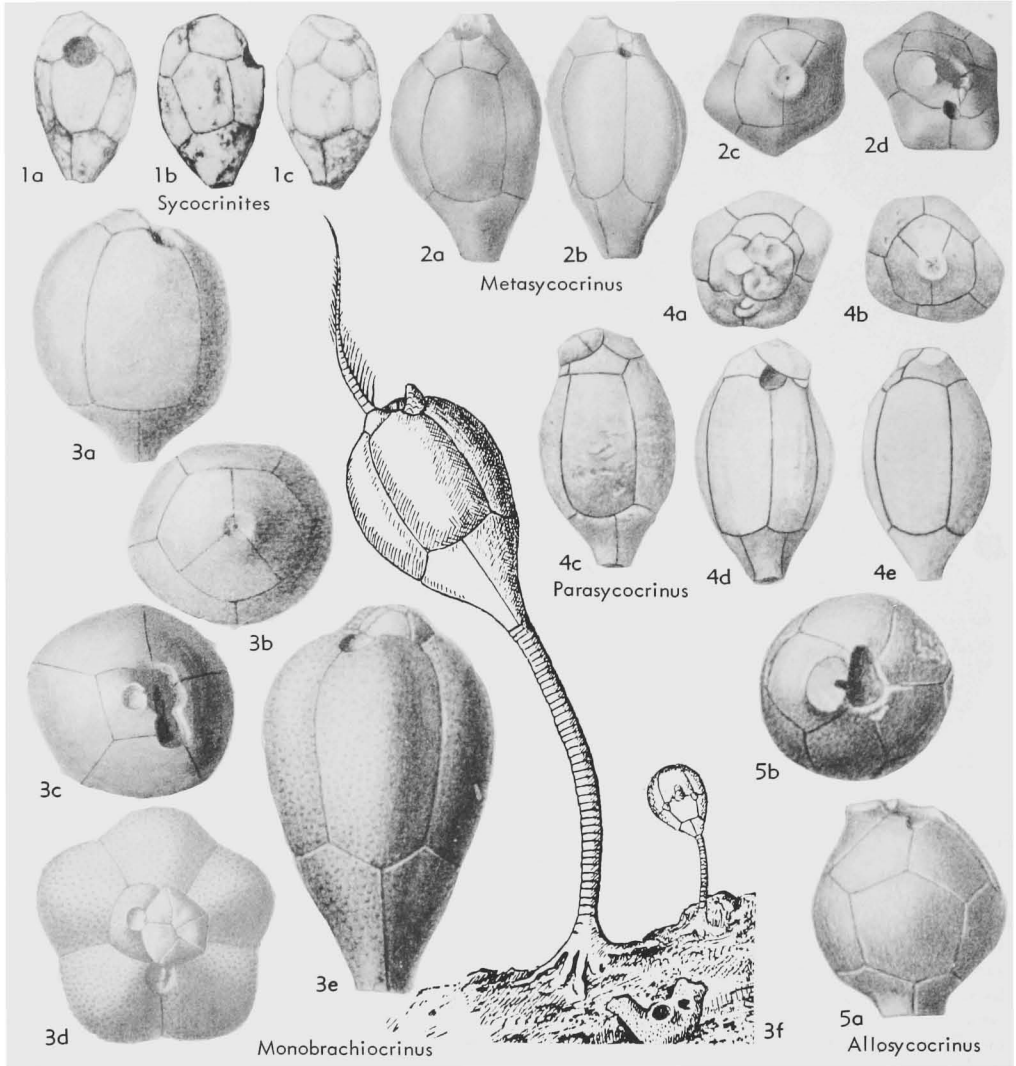


FIG. 389. Sycocrinidae (p. T601-T603).

large, higher than others and with large horse-shoe-shaped articular facet; other radials small, without facets; anal opening large, bounded by concave edges of *CD* basal and *C* and *D* radials. *L.Carb.* (*Tournais.*), Eu. (Eng.).—FIG. 388,3; 389,1. \**S. anapeptamenus*; 388,3a,b, plate diagram of cup (radials black) and post. view of theca (Moore, n); 389,1a-c, *CD*-interarray, *E*-ray, and *A*-ray views of cup,  $\times 2$  (Wright, 1951-54).

**Allosyocrinus** WANNER, 1924, p. 141 [*\*A. pusillus*; OD]. Like *Sycocrinites* except anal opening forms notch in distal edge of one of nonarm-bearing radials, and is strongly variable in position; tegmen a vault of 5 small oral plates. *U.Perm.*, Indon. (Timor, Basleo).—FIG. 389,5. \**A. pusillus*; 5a,b, *CD*-interarray, and ventral views

of cup,  $\times 3$  (Wanner, 1924).

**Metasyocrinus** WANNER, 1920, p. 25 [*\*Hypocrinus pyriformis* ROTHPLETZ, 1892, p. 75; OD]. Cup globular, base attenuate; 3 high narrow infrabasals, small one in *C* ray; basals large, inflated; *D* radial largest and highest in circlet; radials inclined inward toward axis of cup, arm facet on *D* radial only; anal opening on upper right shoulder of *CD* basal, bounded by *CD* and *BC* basals, *B* and *D* radials and by minute plate above that may be *C* radial. *U.Perm.*, Indon. (Timor, Basleo).—FIG. 388,1; 389,2. \**M. pyriformis* (ROTHPLETZ); 388,1a,b, plate diagram of cup (radials black) and post. outline of cup (Moore, n); 389,2a-d, *AE*- and *CD*-interarray, dorsal, and ventral views of cup,  $\times 0.7$  (Wanner, 1916a).

**Monobrachiocrinus** WANNER, 1916, p. 103 [\**M. ficiformis*; OD]. Cup inverted pear shaped; infrabasals 3, forming conspicuous part of cup, small infrabasal in *A* ray; basals 5, higher than wide; *D* radial enlarged, rounding off top of *DE* basal and limited laterally by *CD* and *AE* basals, other radials absent; anal opening bounded by *CD* and *BC* basals, *D* radial, and 2 orals; orals 5, small, *CD* one largest. *L.Perm.-U.Perm.*, Indon.(Timor, Basleo), Eu.(USSR, Krasnoufinsk-Sicily).—FIG. 388,2; 389,3*c-e*. \**M. ficiformis*, Basleo beds, Timor; 388,2, plate diagram of cup (*D* radial black) (Moore, n); 389,3*c-e*, dorsal, ventral, and *CD*-interray views of cup,  $\times 1.5$  (Wanner, 1916a).—FIG. 389,3*a,b,f*. *M. granulatus* WANNER, Basleo beds, Timor; 3*a,b*, *BC*-interray and dorsal views of theca,  $\times 1.5$  (Wanner, 1924); 3*f*, reconstr. (with *Embryocrinus hanieli*),  $\times 1$  (Wanner, 1920).

**Parasyocrinus** MAREZ OYENS, 1940, p. 321 [\**P. fastigate-pileatus*; OD]. Cup high, cone shaped; infrabasals 3, unequal, small one in *C* ray; basals large, high; radials 4, *C* radial absent, *A* and *B* radials reduced, *D* radial only with arm facet; anal opening large, circular, bounded by *CD* and *BC* basals below and *D* radial above. *L.Perm.*, Indon.(Timor, Tae Wei).—FIG. 389,4. \**P. fastigate-pileatus*; 4*a-e*, ventral, dorsal, *E*-ray, post., and *D*-ray views of cup,  $\times 2$  (Marez Oyens, 1940b).

## Family STREBLOCRINIDAE Lane, 1967

[Streblocrinidae LANE, 1967, p. 12]

Theca typically composed of infrabasals, basals, and orals; abrachiate; radials and anal plate absent in all but most primitive genera; posterior oral commonly with hydropore and separating *BC* and *DE* orals; orals primitively above basals in interrarial position, and anal opening on lower right side of posterior oral and upper right shoulder of *CD* basal. *M.Dev.-U.Perm.*

### Subfamily STREBLOCRININAE Lane, 1967

[Streblocrininae LANE, 1967, p. 12] [incl. Piliidiocrininae ARENDT, 1970a, p. 184]

Anal opening shifted to left of *A-CD* axis and orals uniformly rotated clockwise to radial position, alternating with basals. *M.Dev.-L.Penn.*; *Perm.*

**Streblocrinus** KOENIG & MEYER, 1965, p. 393 [\**S. brachiatus*; OD]. Theca small, composed of 4 circlets of plates; infrabasals 5, low; basals large, elongate; 3 small spoutlike radials in *A*, *C*, and *D* rays, other radials absent; single anal plate may have been present in cup (only known specimen is damaged in *CD* area); orals 5, large, directly above basals in interrarial position; *CD* oral with hydropore. *M.Dev.*, USA(N.Y.).—FIG. 388,6; 390,5. \**S. brachiatus*; 388,6, plate diagram of

cup (radials black, anal plate stippled) (Moore, n); 390,5*a-g*, ventral, *CD*-interray, *BC*-interray, *AB*-interray, dorsal, *AE*-interray, and *DE*-interray views of theca,  $\times 50$  (Koenig & Meyer, 1965).

**Atremacrinus** WANNER, 1929, p. 82 [\**A. calyculus*; OD]. Theca small, bud shaped; infrabasals and basals apparently fused, radials and anal opening absent; tegmen dome-shaped vault of 5 orals; stem thick, round. *U.Perm.*, Indon.(Timor, Basleo).—FIG. 390,6. \**A. calyculus*; 6*a,b*, lat. and ventral views of theca,  $\times 3$  (Wanner, 1929b). **Coenocystis** GIRTY, 1908, p. 109 [\**C. richardsoni*; OD] [= *Coenocystis* PECK, 1936 (*nom. null.*)]. Theca small, pear shaped, composed of infrabasals, basals, and orals; infrabasals visible in side view, completely fused on most specimens; basals 5, in lateral contact, radials lacking; anal opening in midline of *CD* oral, bounded by oral and 2 basals; orals 5, forming cap-shaped vault, radial in position, alternating with basals; *CD* oral with hydropore. *L.Miss.(Osag.)*, USA(Mo.); *L.Perm.-U.Perm.*, USA(Texas)-Indon.(Timor, Basleo).—FIG. 388,4; 390,2. \**C. richardsoni*, *U.Perm.*(Guadalup.), Texas; 388,4, plate diagram of theca (Moore, n); 390,2*a-d*, ventral and lat. views of large cup, *CD*-interray views of 2 small thecae,  $\times 4$  (Girty, 1908).

**Dichostreblocrinus** J. M. WELLER, 1930, p. 36 [\**D. scrobiculus*; OD]. Cup cone shaped, longitudinally twisted slightly in counter-clockwise direction; infrabasals low, fused; basals elongate, supporting 5 large orals, radials absent; anal opening bordered below by upper right edge of *CD* basal and on right by *BC* basal; orals shifted about 9° to left of normal interrarial position; *CD* oral larger than others, with minute, central hydropore. *L.Miss.(Osag.)*, USA(N.Mex.-Mo.); *L.Penn.*, USA (Ind.); *U.Perm.*, Indon.(Timor, Basleo).—FIG. 390,4. \**D. scrobiculus*, *L.Penn.*, Ind.; 4*a-c*, *CD*-interray, *E*-ray, and ventral views of theca,  $\times 1.5$  (Weller, 1930a).

**Hemistrectacron** YAKOVLEV, 1926, p. 52 [\**H. abrachiatum*; M]. Theca small, composed of infrabasals, basals, and orals; infrabasals 3 or fused, visible in side view; basals large, in lateral contact; radials lacking; orals 5, forming cap-shaped vault above cup, shifted to left 12° from interrarial position; anal opening large, between *CD* oral and basal, not in midline of these plates, shifted somewhat to left side of basal and to right side of oral; *CD* oral with hydropore. *L.Perm.*, Eu.(USSR, Krasnoufinsk)-*U.Perm.* Indon.(Timor, Basleo).—FIG. 390,1. \**H. abrachiatum*, *L.Perm.*, USSR; 1*a-d*, post., ant., dorsal, and ventral views of theca,  $\times 5$  (Yakovlev & Ivanov, 1956).

**Piliidiocrinus** WANNER, 1937, p. 138 [\**P. permicus*; OD]. Theca adnate on other echinoderms, without column; infrabasals lacking or fused with 5 basals which are proximally adherent to substrate; orals 5 equal plates alternating with basals.

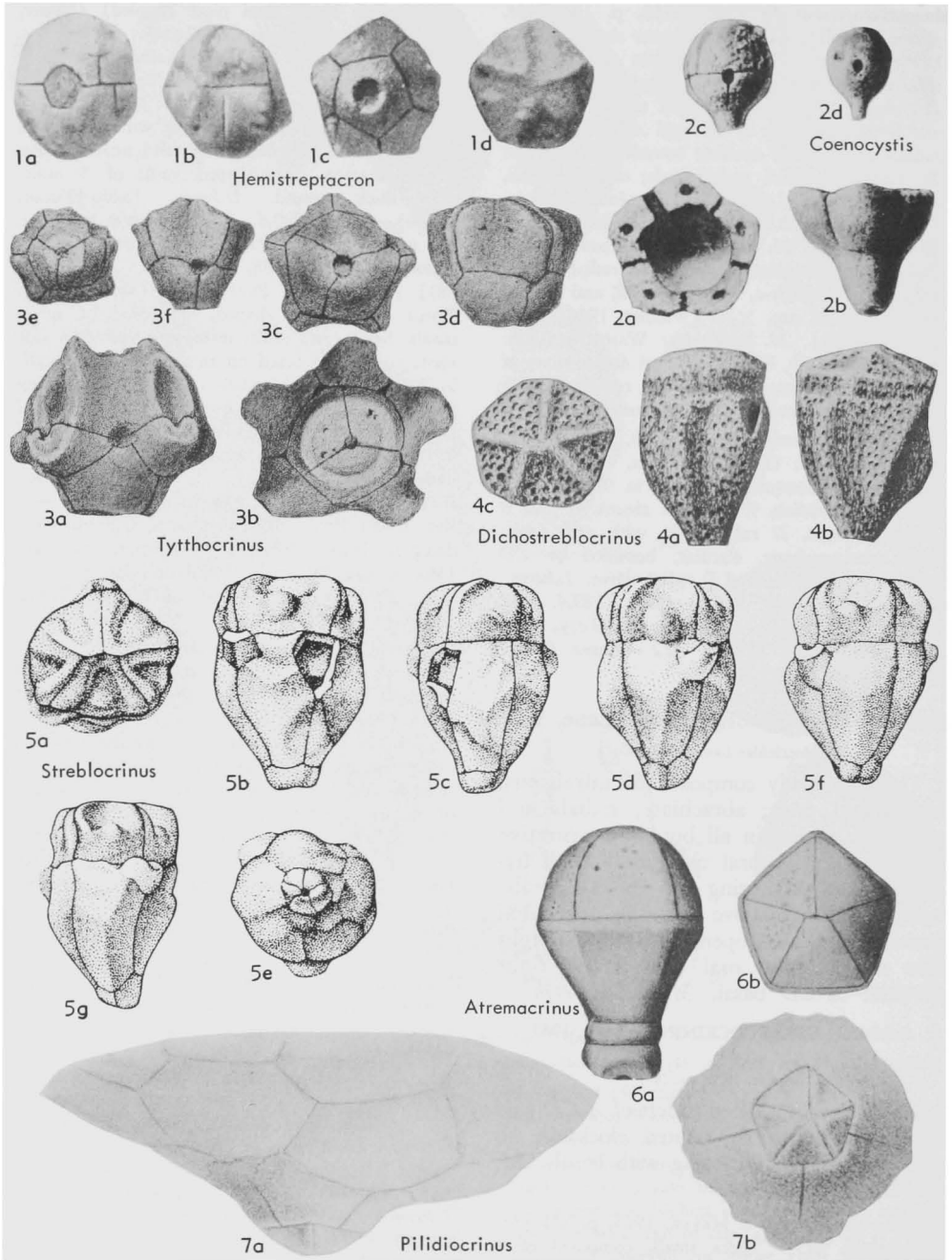


FIG. 390. Streblocrinidae (Streblocrininae) (p. T603-T605).

*U. Perm.*, Indon. (Timor, Basleo).—FIG. 390, I.  
 \**P. permicus*; 7a, b, lat. and ventral views of theca,  
 ×4 (Wanner, 1937).

*Tythocrinus* J. M. WELLER, 1930, p. 35 [\**T.*  
*comptus*; OD] [= *Octocrinus* PECK, 1936, p. 291

(type, *O. inconsuetus*)]. Theca cone shaped; small  
 specimens with 3 infrabasals and basals, and 5  
 orals; large specimens with 3 basals and 5 orals,  
 infrabasals fused or atrophied; orals large, centrally  
 depressed, CD oral larger than others; anal open-

ing marked by notch at distal end of interbasal suture just below right side of *CD* oral. *M.Dev.-L. Penn.*, USA (Ind.-Mo.-N.Mex.-N.Y.).—FIG. 390,3a-d. *T. inconsuetus* (PECK), L.Miss., Mo.; 3a,b, post., and dorsal views of large individual; 3c,d, dorsal and post. views of small individual,  $\times 30$  (Peck & Connelly, 1951).—FIG. 390,3e,f. *\*T. comptus*, L.Miss., Mo.; 3e,f, dorsal and post. views of theca,  $\times 30$  (Peck & Connelly, 1951).

#### Subfamily PENTECECRININAE Lane, 1967

[Pentececrininae LANE, 1967, p. 13] [Incl. Acariaiocrininae ARENDR, 1970a, p. 169; Lageniocrininae ARENDR, 1970a, p. 158]

Anal opening shifted secondarily to *A-CD* axis, and orals rotated to radial position by left-lateral extension of *CD* oral. ?*U. Dev.*, *L.Miss.-L.Penn.*; *L.Perm.-U.Perm.*

**Pentececrinus** KOENIG & NIEWOEHNER, 1959, p. 464 [*\*P. parvus*; OD]. Theca small, globe shaped; 5 infrabasals, basals, and orals; radials lacking; single anal plate in notch on upper right shoulder of *CD* basal and below lower right edge of *CD* oral; orals large, in interradial position directly above basals, each with single vertical protuberance. ?*U.Dev.* or ?*L.Miss.*, USA (Mo.).—FIG. 388,5; 391,1. *\*P. parvus*, Louisiana F.; 388,5, plate diagram of theca, anal plate stippled (Moore, n); 391,1a-g, *CD*-interray, *C-*, *B-*, *E-*, *D*-ray, ventral, and dorsal views of theca,  $\times 22$  (Koenig & Niewoehner, 1959).

**Acariaiocrinus** WANNER, 1924, p. 141 [*\*A. clavulus*; OD] [= *Streptostomocrinus* YAKOVLEV, 1927, p. 186 (type, *S. caryophylloides*)]. Theca small, flask or club shaped; infrabasals 3, visible in side view; basals 5; radials lacking; orals 5, large, in radial position, alternating with basals; anal opening in notch between *CD* basal below and *C*- and *D*-ray orals above. *L.Perm.*, Eu. (USSR, Krasnoufimsk)-*U.Perm.*, Indon. (Timor, Basleo).—FIG. 391,5. *\*A. clavulus*, *U.Perm.*, Timor; 5a-c, *A*-ray, *CD*-interray, and ventral views of theca,  $\times 8.7$  (Wanner, 1924).

**Clistocrinus** KIRK, 1937, p. 106 [*\*C. pyriformis*; OD] [= *Clisthocrinus* KIRK, 1937b (*nom. van.*); *non Clistocrinus* SPRINGER, 1920]. Theca small, globe shaped; infrabasals 3, unequal, small one in *A* ray; basals 5, large; anal opening large, situated between upper right shoulder of *CD* basal and upper left shoulder of *BC* basal, bounded above by lower left edge of *C* oral; orals shifted to radial position by enlargement of left side of originally *CD* oral, which occupies a *D*-ray position; *D*-ray oral with central hydropore. *L.Penn.*, USA (Alaska).—FIG. 391,2. *\*C. pyriformis*; 2a-d, *CD*-interray, *A*-ray, ventral, and dorsal views of theca,  $\times 4.5$  (Kirk, 1937a).

**Lageniocrinus** DEKONINCK, in DEKONINCK & LEHON, 1854, p. 187 [*\*L. seminulum*; M]. Theca small; cup cone shaped; infrabasals 3, small one in *A*

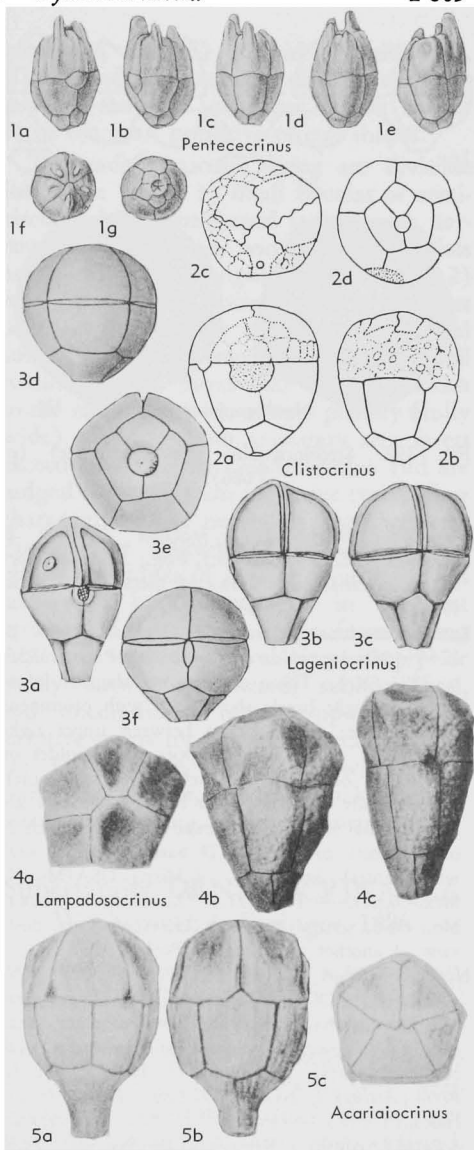


FIG. 391. Streblocrinidae (Pentececrininae) (p. T605-T606).

ray; basals 5, anal opening between upper right and upper left corners of *CD* and *BC* basals; orals 5, large, each plate with raised borders next to interoral sutures, in interradial position directly above basals; *CD* oral with hydropore. [One Permian species referred to this genus by WANNER (1920) was judged by KIRK (1940e) to be an immature *Embryocrinus*.] *L.Carb.* (*Tournais.*, ?*Visean*), Eu. (Belg.-Eng.); *L.Penn.*, USA (Ind.).—FIG. 391,3a-c. *\*L. seminulum*, *L.Carb.* (*Visean*), Belg.; 3a-c, *CD*-interray, *BC*-interray, and *AB*-interray views of theca,  $\times 2.6$  (Kirk, 1940e).

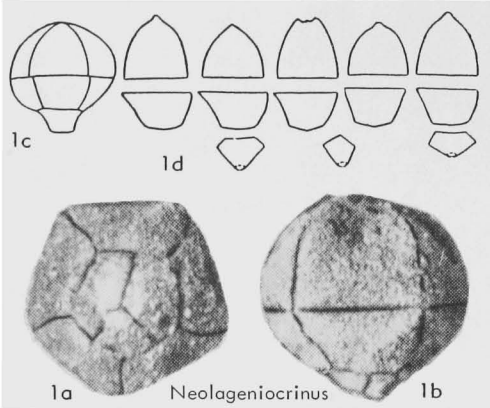


FIG. 392. Streblocrinidae (Pentecocrininae) (p. T606).

—FIG. 391, 3d-f. *L. jacksoni* (AUSTIN & AUSTIN), L.Carb. (Tournais.), Eng.; 3d-f, lat., dorsal, and CD-interray views of theca,  $\times 5$  (Kirk, 1940e).

**Lampadosocrinus** STRIMPLE & KOENIG, 1956, p. 1244 [*Dichostreblocrinus minutus* PECK, 1936, p. 289; OD]. Theca small, cone shaped; infrabasals 5, high; basals short, each with prominent central node; anal opening between upper right shoulder of CD basal and upper left shoulder of BC basal; orals high, flattened ventrally, each oral centrally depressed with raised borders; orals nearly radial in position except CD oral, which is only slightly to left of CD basal; posterior oral with central hydropore. *L. Miss.*, USA (Mo.-N. Mex.-Okla.).—FIG. 391, 4. \**L. minutus* (PECK), Mo.; 4a-c, ventral and post. views of theca, post. view of another theca,  $\times 30$  (Peck, 1936).

**Neolageniocrinus** ARENDT, 1970a, p. 162 [*N. shichanensis*; OD]. Closely similar to *Lageniocrinus* but infrabasals may be fused together, anal opening in theca is absent, and posterior oral commonly lacks hydropore. *L. Penn.*, USA; *L. Perm.* (Artinsk.), NC.Sib.; *U. Perm.* (Basleo beds), Indon. (Timor).—FIG. 392, 1. \**N. shichanensis*, L. Perm. (Artinsk.), Krasnoufmsk, NC.Sib.; 1a, b, dorsal and post. views of holotype,  $\times 5$ ; 1c, d, BC side of paratype,  $\times 6.5$ , and plate diagram of holotype,  $\times 3$  (Arendt, 1970a).

### Superfamily and Family UNCERTAIN

**Ellicrinus** PROKOP, 1973, p. 221 [*E. procerus*; OD]. Cup high, conical; infrabasals 3, 2 large and one small; 5 high basals and radials; no anal plate in cup; radial facet narrow, rounded, horseshoe shaped, with distinct fulcral ridge. Tegmen, arms, and stem unknown. *L. Dev.* (Prag.), Eu. (Boh.).—FIG. 393, 2. \**E. procerus*; 2a, b, lat. views of cup,  $\times 71$  (Prokop, 1973).

**Parastephanocrinus** SPRINGER, 1926, p. 139 [*\*P. typus*; OD]. Dicyclic small cup with basal concavity. Five small infrabasals form bottom of basal invagination; 5 large basals form sides of concavity and most of cup height, posterior basal elongated and extending to the anal opening; radials small in exterior but extending inward toward a small oral center, ambulacral grooves prominent and bounded by projecting processes, articular facets small, directed outward. *M. Sil.* (Niagaran), USA (Tenn.).—FIG. 393, 1. \**P. typus*; 1a-c, cup from post., summit, and base,  $\times 3$ ; 1d, detail of radials and food grooves,  $\times 3$  (Springer, 1926a).

### Suborder DENDROCRININA Bather, 1899

[*nom. correct.* MOORE, in MOORE, LALICKER, & FISCHER, 1952, p. 613 (*pro* suborder Dendrocrinoidea BATHER, 1899b, p. 178)] [=suborder Dendrocrinites JAEKEL, 1918, p. 52] [Materials for this suborder prepared by R. C. MOORE, N. GARY LANE, and H. L. STRIMPLE]

Crown small to moderately large, mostly tall, cylindrical to ovoid or pear shaped, uncommonly explanate, with widely separated horizontal or pendent arms. Cup prevailing conical but bowl shaped or discoid in many genera, base convex, flat, or concave; infrabasals five, uncommonly three or fused as a single solid circler, mostly visible from side but not visible in flat- and concave-based forms; radials with narrowly rounded articular facets occupying small part of radial summits or wide, with gently curved external margins, plane of facets sloping outward-downward, essentially horizontal, or exceptionally inclined outward-upward, in terms of inner to outer facet margins; anal plates in cup three, two, one, or none visible from side of cup, anal sac tall, cylindrical, inflated, or not evident, many with prominent plicate plates. Arms atomous, branched isotomously or heterotomously, few or very many, brachials arranged uniserially or biserially, pinnulate or lacking pinnules. Stem pentagonal or mostly circular. *L. Ord.*-*L. Miss.*

The suborder Dendrocrinina includes lower and middle Paleozoic crinoids that gave rise on one hand to the Flexibilia in the Ordovician and to the more advanced cladid inadunates, the Poteriocrinina in the Devonian, on the other. Although dendrocrinines are present in the Ordovician and Silurian, they are neither abundant nor diverse. The few genera that have been

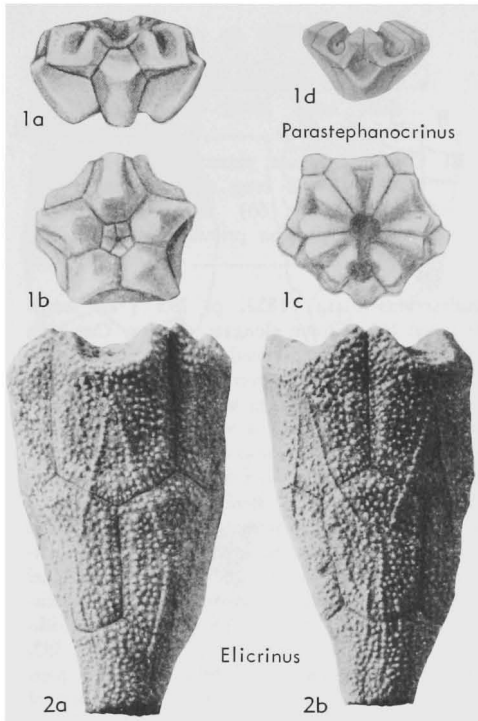


FIG. 393. Cyathocrinina Superfamily and Family Uncertain (p. T606).

described, however, are quite important to knowledge of the main evolutionary pathways that developed within this group. During the Devonian the Dendrocrinina diversified rapidly and many genera are recognized currently, most of them placed in the families Dendrocrinidae and Botryocrinidae. Crinoids in both of these families exhibit a tendency to evolve from types that have isotomously branched arms to ones with strongly heterotomous arms. These latter reached the verge of pinnulation in the Dendrocrinidae and true pinnules developed in Late Devonian members of the Poteriocrinina.

Shape of the cup observed in crinoids of the Inadunata include 1) cylindroconical, 2) moderately steep-sided conical with narrowly to broadly truncate base equal to or wider than the stem impression, 3) deep to shallow bowl shaped with longitudinally curved sides and gently convex, flat, or slightly concave base, all classed as crateriform, 4) basally invaginated, with wide to narrow and moderate to very deep central

concavity, and 5) discoid (patelliform). The Dendrocrinina are distinguished by cups of the first two types, which appear to be the most primitive of cup shapes.

The radial articular facets are divisible into three types: 1) small circular or semi-circular, horseshoe-shaped facets much narrower than summit width of the radials and hence called **angustary** (narrow), 2) broad outwardly shallow crescentic facets occupying much but not all of the radial summits, called **penepenary** (almost full width), and 3) facets fully equal in width to the radial summits, termed **plenary** (fully wide). Crinoids with angustary arm facets exceed others in the Dendrocrinina and are judged to be the most primitive type. They characterize all or nearly all Cyathocrinina. Finally, the attitude of articular facet planes on radials of inadunate crinoids has taxonomic importance, for in different genera it is found to range from facing outward vertically to sloping steeply or gently outward-downward, subhorizontal, and uncommonly outward-upward. Descriptive terms for types of facet attitudes are 1) **declivate**, sloping outward-downward; 2) **planate**, subhorizontal, and 3) **sursumate**, sloping outward-upward.

### Superfamily DENDROCRINACEA Wachsmuth & Springer, 1886

[*nom. transl.* MOORE & LANE in MOORE & STRIMPLE, 1973, p. 19 (ex Dendrocrinidae WACHSMUTH & SPRINGER, 1886)]  
[Materials for this superfamily prepared by R. C. MOORE and N. GARY LANE]

Crown tall, mostly somewhat narrowly cylindrical. Cup conical, with very steep to moderately sloped, longitudinally straight sides; infrabasals five, distal parts upflared, readily visible in side views of cup; radial articular facets narrow, with strongly rounded to horseshoe-shaped outer margins, interradial notches commonly prominent, surface of facets curved or plane, sloping outward-downward; two or three anal plates in cup, anal sac mostly cylindrical, very tall, and formed partly of plicate plates. Arms well rounded externally, slender, branching isotomously and heterotomously, mostly numerous, brachials uniserial, in some genera laterally bearing ramules. Stem transversely circular or less commonly pentagonal. *M.Ord.-U.Dev.*



**Family DENDROCRINIDAE**  
**Wachsmuth & Springer, 1886**

[*nom. transl.* BATHER, 1890b (May), p. 383 (*ex section* Dendrocrinites WACHSMUTH & SPRINGER, 1886, p. 115 (191))] [=Dendrocrinidae S. A. MILLER, 1890 (Dec.), see MOORE, 1962b, p. 37; Bactrocrinidae JAEKEL, 1918, p. 55; Esthonorcinidae JAEKEL, 1918, p. 53]

Cup steeply conical; infrabasals strongly upflared, visible from side; radialian directly below or obliquely left below *C* radial, anal *X* in line with radials and above *CD* basal. Radial arm facets narrow, horseshoe shaped, smooth or with fine radial culmina. Arms rounded, slender, branching repeatedly, with strong tendency toward heterotomy. *M.Ord.-U.Dev.*

Chief primitive features of the Dendrocrinidae are the steeply conical form of the cup, structure of its posterior side, and the smooth, outwardly directed radial facets. The rounded facets are horseshoe shaped and narrow. The arms are strongly rounded and branch isotomously several times, representing an advanced evolution of non-pinnulate ray structure. An archaic feature of *Dendrocrinus* is the occurrence of a radialian directly below the *C* radial (Fig. 394,5). The very tall anal sac, formed of a number of vertical rows of thin plicate plates, is a distinctive attribute of the family that is very unlike the sacs of merocrinids and cupulocrinids but closely similar to those of botryocrinid genera and others, which are inferred to belong in the same genetic line as the Dendrocrinidae.

*Key to Genera of Dendrocrinidae*

- A. Cup tall and narrow cylindroconical .....
- I. Infrabasals very tall; radial articular facets narrow, horseshoe shaped; round slender arms branching on primibrachs 4-5; stem transversely round .. *Bactrocrinites*
  - II. Infrabasals moderately tall; radial articular facets wider than horseshoe shaped; arms branching on primibrachs 3 or 4; stem transversely pentagonal .. *Atractocrinus*
- B. Cup moderately wide conical .....
- I. Infrabasals 3; anals in cup 2 .. *?Alsopocrinus*
  - II. Infrabasals 5; anals in cup 3 or 4.
    - a. Radialian directly below *C* radial, anal sac very tall cylindrical with plicate plates; arms branching first on primibrachs 5-7 .. *Dendrocrinus*
    - b. Radialian obliquely left below *C* radial; arms many (60 or more),

branching first on primibrachs 3

- ..... *Grenprisia*  
 c. Radialian obliquely left below *C* radial; arms ?few, branching on primibrachs 3 .. *Esthonorcrinus*

- III. Cup very minute, plates ill-known, extremely slender long arms, numerous (approximately 60) well separated, branching first on primibrachs 6-9 ....

..... *Parisangulocrinus*

**Dendrocrinus** HALL, 1852, p. 193 [*\*D. longidactylus*; M]. Crown elongate, slender. Cup high conical, with large radialian directly below *C* radial; anal *X* large, between posterior radials and supporting series of large anal plates at posterior base of anal sac, which is very elongate, tapering to a point distally, composed of several longitudinal rows of thin, plicate, laterally interlocking plates. Arms rounded, slender, branching several times isotomously; primibrachs 5 to 7 axillary. Radial articular facets narrow, rounded, with outward-downward slope and wide interradian notches. Stem circular transversely, tapering distally. *M.Ord.-U.Sil.*, N.Am.(Ont.-N.Y.-Ky.-Ill.-Ind.-Ohio-Wis.-Iowa)-Eu.(Eng.).—FIG. 395, 1a-d. *\*D. longidactylus*, U.Sil., N.Y.; 1a, post. view of cup, tall anal sac, and proximal parts of arms and stem,  $\times 1$ ; 1b, fragment of anal sac,  $\times 2$ ; 1c, post. view of theca and slender uniserial arms,  $\times 1$  (Hall, 1852); 1d, plate diagram (radials black, radialian cross ruled, anal plates stippled) (Moore, n).—FIG. 395, 1e,f. *D. caduceus* (HALL, 1866), U.Ord., Ohio; 1e,f, ?ant. and lat. views of crown,  $\times 2$  (Moore, n; Univ. Chicago 2302A, 2302B).

**?Alsopocrinus** TANSEY, 1924, p. 181 [*\*A. anna*; M]. Cup small, truncated below; infrabasals 3, small azygous one in *C* ray, barely visible in side view, with wide concavity for proximal columnal; basals large and hexagonal; radials with straight articular facets that bear transverse ridge; radialian below and to left of *C* radial, anal *X* in line with radials. Tegmen, arms and column unknown. [Poorly known and possibly not a dendrocrinid.] *L.Dev.*, USA (Mo.).—FIG. 395, 2. *\*A. anna*; 2a-c, lat., post., and dorsal views of cup, with attached pleurotomariid gastropod,  $\times 2$  (Tansey, 1924).

**Atractocrinus** KIRK, 1948, p. 701 [*\*A. concinnus*; OD]. Cup narrow, elongate; infrabasals nearly equal in size to large basals, both elongate; radials small, *A* radial smaller than others and with reduced articular facet, other articular facets larger, rounded, sloping outward-downward; radialian, anal *X* and additional anal plate in cup. Arms stout, branching first on third or fourth primibrach. Stem pentagonal. *M.Dev.-U.Dev.*, USA (Mich.-Iowa), Can.(Ont.).—FIG. 396, 1. *\*A. concinnus*; M.Dev., Ont.; 1a-d, ant., post., ventral and dorsal views of cup,  $\times 1.5$  (Kirk, 1948).

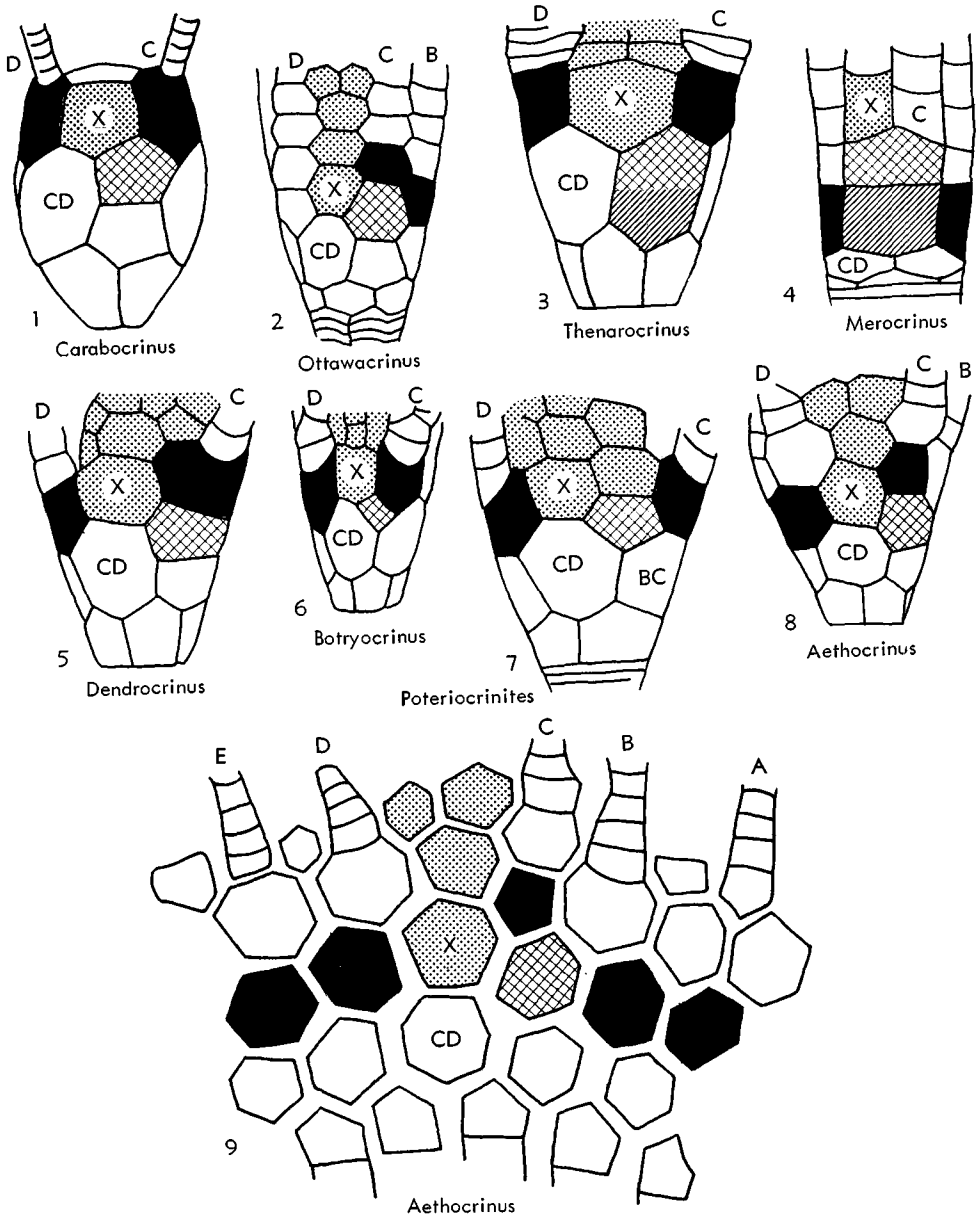


FIG. 394. Posterior side of a cyathocrinid (1, *Carabocrinus*), dendrocrinines (2, *Ottawacrinus*; 3, *Thenarocrinus*; 4, *Merocrinus*; 5, *Dendrocrinus*; 6, *Botryocrinus*; 8, *Aethocrinus*), and poteriocrinine (7, *Poteriocrinites*) showing anal plates in relation especially to C ray (Moore, n); 9, plate diagram of *Aethocrinus*, identification of anal plates and C radial (modified from Ubaghs, 1969). [A-E, ray designations in CARPENTER system; radials black, anal X and anal plates stippled, radianals cross ruled, infradianals oblique ruled.]

*Bactrocrinites* SCHNUR, 1849, p. 22 [\**Poteriocrinus jusiformis* ROEMER, 1844, p. 61; M] [=

*Bactrocrinites* QUENSTEDT, 1875, p. 533 (*nom. van.*)]. Theca narrow and very tall; infrabasals and basals

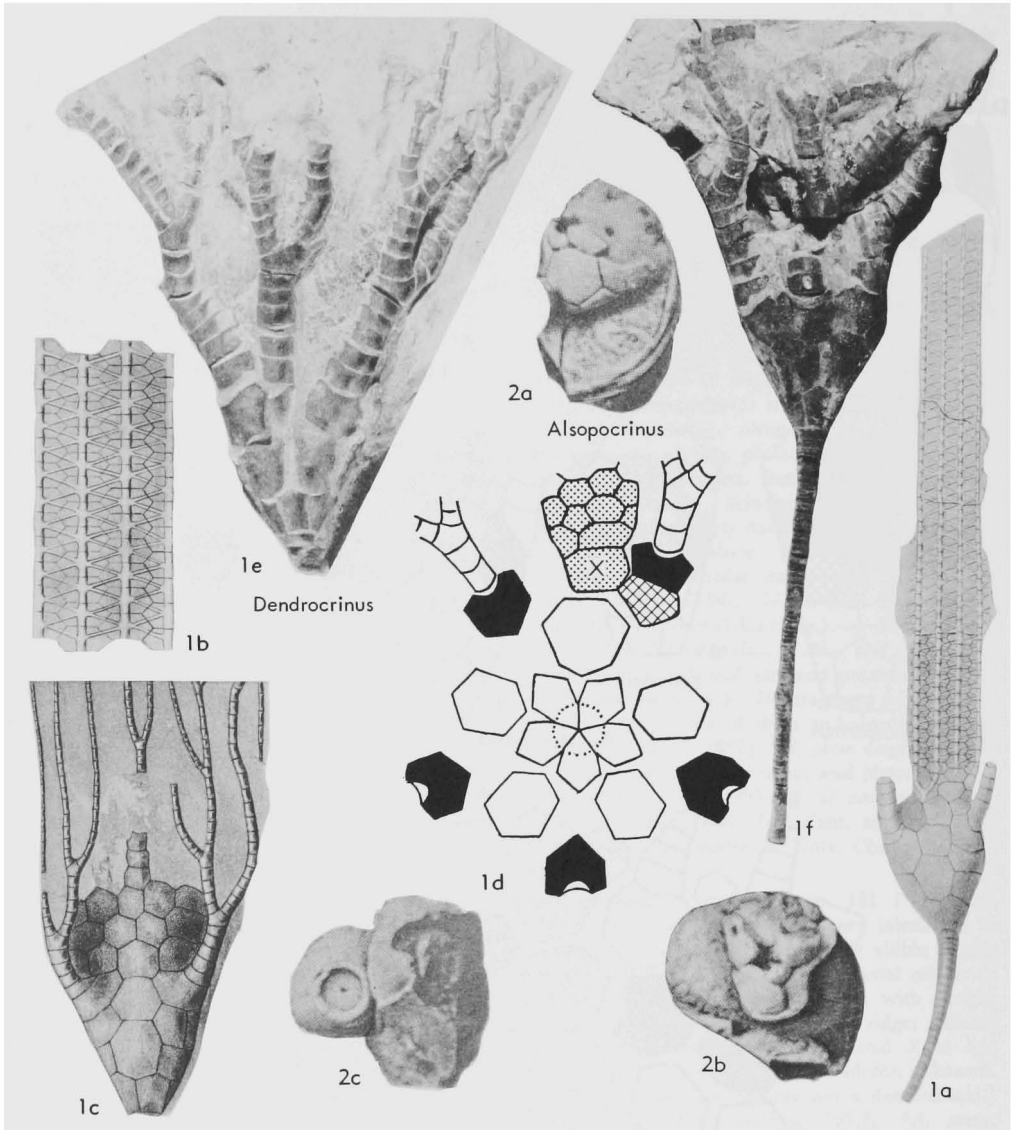


FIG. 395. Dendrocrinidae (p. T608).

large and elongate; radials small, quadrangular, radial articular facets sloping obliquely outward-downward; small radianal and anal X in cup; tegmen with 4 large interambulacral plates. Anal sac narrow and elongate, base confined to posterior part of tegmen. Arms long, slender, branching 3 or 4 times isotomously, first on primibrachs 4 or 5. *U.Sil.-M.Dev.*, Eu.(Ger.)-Asia(India)-USA (Iowa-N.Y.-Okla.).—FIG. 396,2a,b. *B. oklahomaensis* STRIMPLE, *U.Sil.*, Okla.; 2a,b, BC and post. views of theca,  $\times 1$  (Stimple, 1952c).—FIG. 396,2c,d. *B. reimanni* GOLDRING, *M.Dev.*, N.Y.; ant. and post. views of theca,  $\times 2$  (Goldring,

1954).—FIG. 396,2e,f. *\*B. fusiformis* (ROEMER), *M.Dev.*, Ger.; post. and ventral views of theca,  $\times 2$  (Schultze, 1867).

**Esthocrinus** JAEKEL, 1918, p. 53 [*\*E. laevior*; OD]. Theca large, relatively broad, with depressions at each cup plate angle; infrabasals upright, basals slightly larger than radials; articular facets rounded and narrow, interradial notches prominent, radianal large, below and to left of C radial; anal X above radianal and almost out of cup. Base of anal sac composed of longitudinal row of large posterior anal plates and small lateral plates. Arms narrow, rounded, branching on

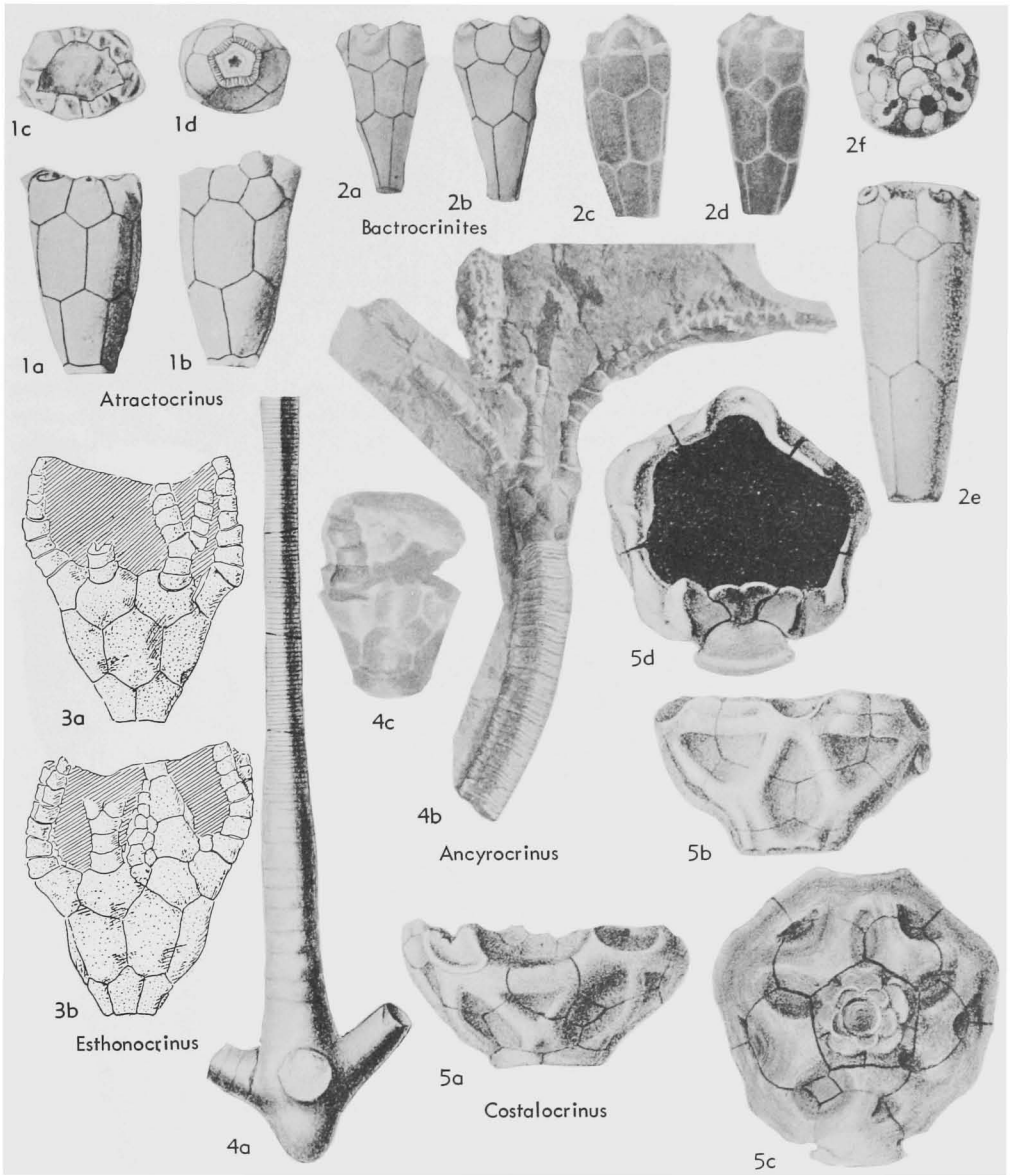


FIG. 396. Dendrocrinidae (1-3); Botryocrinidae (4,5) (p. T608-T611, T614-T615).

primibrachs 3. [Poorly known.] *M.Ord.*, Eu. (Est.).—FIG. 396,3. \**E. laevior*; 3a,b, AB- and CD-interray views of cup and proximal parts of arms,  $\times 0.7$  (Jaekel, 1918).

**Grenprisia** MOORE, 1962, p. 38 [*Ottawacrinus billingsi* SPRINGER, 1911b, p. 40; OD] [= *Ottawacrinus* SPRINGER, 1911b (non W. R. BILLINGS, 1887) (obj.)]. Cup high; infrabasals and basals large, radials equal to or smaller than basals; large radial in line with basals, supporting anal

X and an anal sac plate above; small interbrachial plates above interradiar notches between proximal brachs. Anal sac very large, cylindrical, composed of numerous small stellate plates. Arms uniserial, strongly heterotomous, branching first on primibrachs 3, ramules that have 1 or 2 branches given off on alternate sides of main rami. Stem transversely subpentagonal. *M.Ord.*, Can.(Ont.).—FIG. 397,2a-g. \**G. billingsi* (SPRINGER); 2a,b, A- and D-ray views of crown,

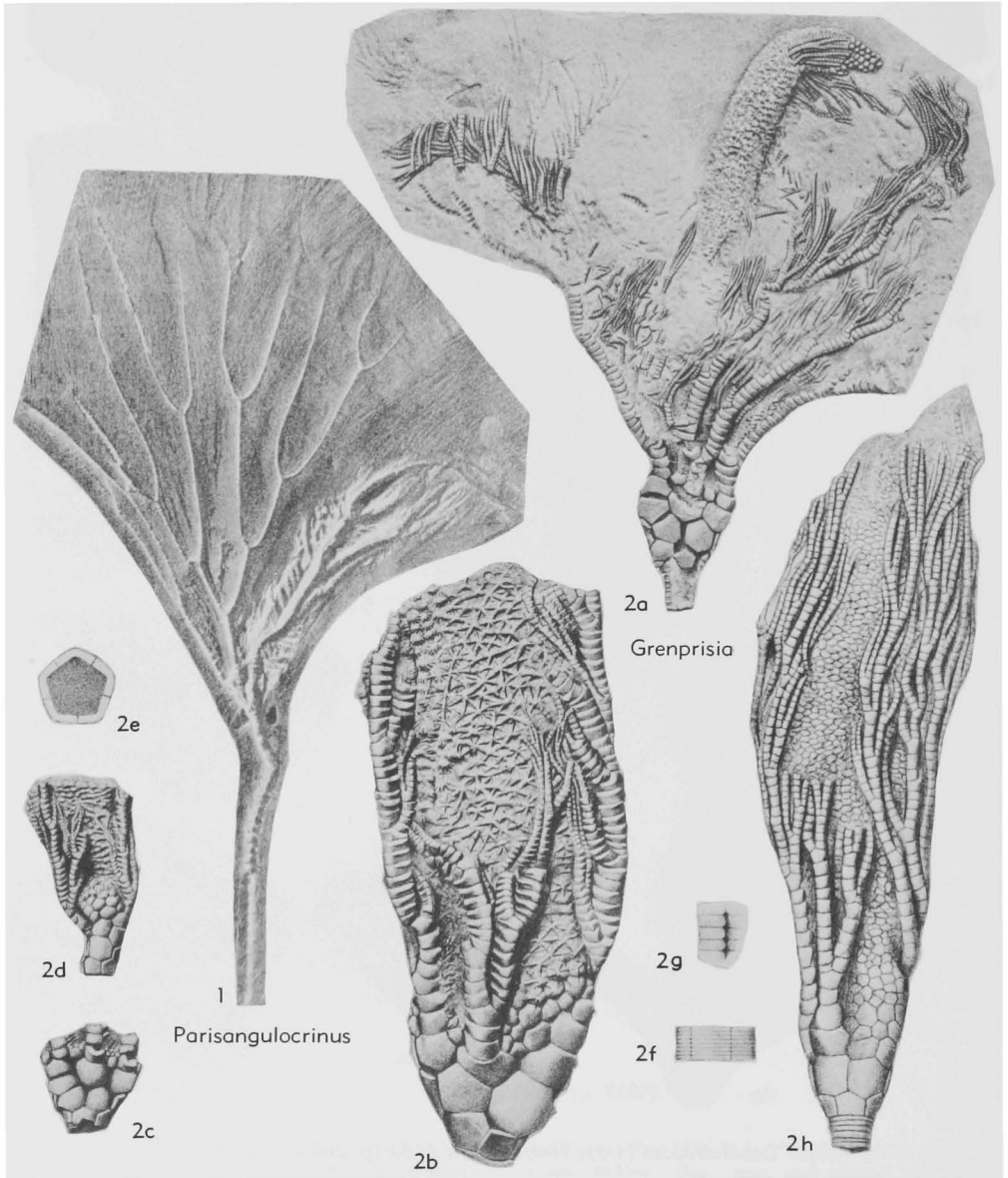


FIG. 397. Dendrocrinidae (p. T611-T612).

×0.7, ×1.3; 2c-f, B-ray view of theca and proximal brachs, post. view of crown, transv. and long. views of columnals, ×0.7; 2g, view of suture between columnal pentameres, ×2.7 (Springer, 1911b).—FIG. 397,2h. *G. springeri* MOORE; post. view of crown, ×2 (Springer, 1911b).  
**Parisangulocrinus** SCHMIDT, 1934, p. 59 [*Poteriocrinus zeaeformis* SCHULTZE, 1866, p. 43; OD].

Crown explanate. Cup small, low, cone shaped; 3 anal plates in cup; radial articular facets narrow and rounded. Anal sac large, elongate, composed of several rows of thin, plicate plates. Arms slender, rounded, branching isotomously several times. Stem transversely round. *L.Dev.*, Eu. (Ger.).—FIG. 397,1. *P. furcaxialis* SCHMIDT; lat. view of crown and stem, ×1 (Schmidt, 1934).

### Family BOTRYOCRINIDAE Wachsmuth & Springer, 1886

[*nom. transl.* BATHER, 1899b, p. 921 (*ex section* Botryocrinites WACHSMUTH & SPRINGER, 1886, p. 191)] [=Gothocrinidae JAEKEL, 1918, p. 59; Pandoracrinidae JAEKEL, 1918, p. 56; Rhadinocrinidae JAEKEL, 1918, p. 58]

Radial articular facets typically much narrower than radials, sloping outward-downward (declivate); anal plates in cup generally three but may be only two, radial-anal small and quadrangular, or large, pentagonal, or absent; anal *X* situated between posterior radials. Anal sac large, with plicate plates, distally recurved, with anal opening directed anteriorly in some genera. Arms uniserial, typically heterotomous, with two main rami, but may be isotomous with numerous branches, or with single ramus; armllets on alternate sides of brachials, branched or unbranched; ramules developed in advanced forms. Stem mostly round transversely and noncirriferous, but may be pentagonal and cirriferous. ?*M.Ord.*; *M.Sil.-Ü.Dev.*

[WACHSMUTH & SPRINGER (1886, p. 191) clearly used the name Botryocrinites to discriminate a suprageneric assemblage of crinoids and not as synonymous with *Botryocrinus* ANGELIN (1878, p. 24)].

Members of this family are progressive early and middle Paleozoic Dendrocrinina, which are interpreted as close relatives of the Dendrocrinidae but not derived from them. The botryocrinid arm facets resemble those of the Cyathocrinina, but the nature of the tegmen and thin-walled plicate anal sac are characters of the Dendrocrinina. In *Botryocrinus* and several other members of the family a quadrangular radial-anal occurs obliquely below the *C* radial at left (Fig. 394,6). Also, the arms divide heterotomously, as well as isotomously. Some crinoids placed in the family show a tendency toward disappearance of the radial-anal plate, which is an evolutionary specialization.

#### *Key to Genera of Botryocrinidae*

- A. Cup steep-sided conical, radial articular facets narrow horseshoe shaped; 2 anal plates in cup (small radial-anal, large anal *X*) .....
- I. Arms 20 or more, branching first on primibrachs 4; anal sac tall composed of small, polygonal plates; stem transversely quadrangular, terminating distally in massive grapnel-shaped hold-fast .....

*Ancyrocrinus*

- II. Arms 10 or more, branching first on primibrachs 4-5; anal sac tall, stem transversely round .....
- B. Cup wide conical; radial-anal small or lacking, anal sac slender, tall .....
- I. Cup very diminutive, partly ill known; infrabasals 5, except *Parabotryocrinus*; 1-4 anal plates in cup, anal sac tall; arms 10-40 or more, branching first on primibrachs 2-8, commonly bearing ramules .....
- a. Infrabasals 3; anal plates in cup 2; arms ?10 .....
- Parabotryocrinus*
- b. Large anal *X*; arms 10, branching on primibrachs 2, ramules abundant .....
- Imitatorcrinus*
- c. Anal plates in cup 3, anal sac extremely slender and tall; arms ?10, branching on primibrachs ?2-3 .....
- Schmidtocrinus*
- d. Anal plates in cup 3, anal sac cylindrical and very tall; arms 10, branching on primibrachs 4, widely spaced armllets branched .....
- Rhadinocrinus*
- e. Anal plates in cup 4, anal sac large, cylindrical; arms 30-40, branching first on primibrachs 8 or higher; stem transversely pentagonal, bearing cirri .....
- Gastrocrinus*
- II. Cup medium sized; anal plates in cup 1-4, anal sac slender, cylindrical; arms 5-40 or more .....
- a. Radial-anal small, quadrangular, anal *X* large; arms 10-40 or more.
1. Two anal plates in cup above anal *X*, anal sac tall, cylindrical, with plicate plates; arms 30-40 or more, branching first on primibrachs 2 .....
- Botryocrinus*
2. No anal plates in cup above anal *X*; anal sac unknown; arms 10 or more, branching on primibrachs 3-4 .....
- Jahnocrinus*
3. No anal plates in cup above small anal *X*; anal sac and arms unknown; cup plates strongly fluted .....
- Costalocrinus*
- b. Radial-anal absent, anal *X* small; arms 5 .....
- Sigambrocrinus*
- c. Cup anal-anal unknown, anal sac cylindrical, composed of short and wide hexagonal plates; arms 10 or more, first branching on primibrachs 2-4 .....
- Pandoracrinus*

**Botryocrinus** ANGELIN, 1878, p. 24 [\**B. ramosissimus*; SM BATHER, 1893a, p. 117] [= *Sicyocrinus* ANGELIN, 1878, p. 23 (type, *S. cucurbitaceus*)]. Cup conical, plates smooth or ornamented with radial ridges, spines or longitudinal folds; infrabasals 5, upflared; radial-anal small, quadrangular;

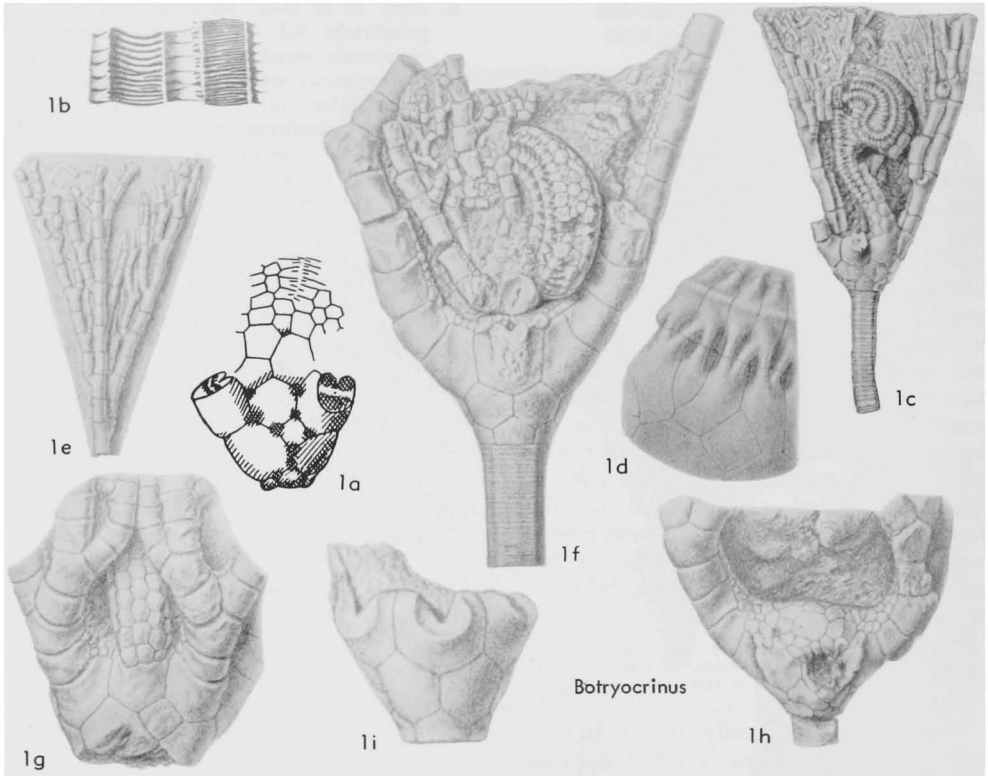


FIG. 398. Botryocrinidae (p. T613-T614).

anal *X* large, situated between *BC* and *CD* basals and supporting 2 or 3 small sac plates. Anal sac large, composed of numerous rows of small hexagonal plates, with anal opening at distal tip or recurved with anal opening directed anteriorly and lateral sac plates sharply plicate. Arms stout, with 2 or 4 main branches, primibrachs 2 commonly axillary; stout covering plates preserved over ambulacral grooves; ramules on alternate sides of main branches. Stem transversely round or subpentagonal, pentameres commonly developed. *M.Sil.-M.Dev.*, Eu. (Sweden-Ger.-Eng.), USA (N.Y.-Tenn.-Mich.-Iowa-Ill.-Ind.), Can. (Ont.).—FIG. 398, *1a, b*. *B. schultzei* HAARMANN, *L.Dev.*, Ger.; *1a*, diagram of post. part of cup,  $\times 1$ ; *1b*, view of anal sac plates,  $\times 2$  (Schmidt, 1942).—FIG. 398, *1c-e*. *B. cucurbitaceus* (ANGELIN), *M.Sil.*, Gotl.; *1c*, *D*-ray view of crown showing recurved slender anal sac, and proximal part of stem,  $\times 1.5$ ; *1d*, part of anal sac,  $\times 10$ ; *1e*, arm,  $\times 1.5$  (Bather, 1893a).—FIG. 398, *1f-i*. \**B. ramosissimus*, *U. Sil.*, Gotl.; *1f, g*, *A*-ray view of crown and stem, post. view of theca and proximal parts of arms and anal sac,  $\times 1.5$ ; *1h*, lat. view of cup with arm removed, showing tegmen,  $\times 3$ ; *1i*, *A*-ray view of cup,  $\times 1.5$  (Bather, 1893a). **Ancyrocrinus** HALL, 1862, p. 118 [\**A. bulbosus*;

SD S. A. MILLER, 1889, p. 223]. Cup cone shaped, broadly truncate below; radial small, quadrangular; anal *X* large, between posterior radials; median parts of radial plates protruding, radial articular facets directed obliquely outward-downward, narrow and rounded. Anal tube large, elongate, composed of numerous small plates. Arms branching on primibrachs 4, with 2 main rami, and ramules on opposite sides of alternate secundibrachs. Stem massive, quadrangular in cross section proximally; columnals thin proximally becoming fused distally and merging into a large, grapple-like terminal holdfast bluntly rounded distally, with 4 or 5 blunt or sharply pointed projections directed obliquely back toward crown; lumen quadrilobate or rarely pentalobate; articular facets quadrangular in outline. *L.Dev.-M.Dev.*, N.Am. (N.Y.-Penn.-Ont.-Ind.-Ohio)-Eu. (France).—FIG. 396, *4*. \**A. bulbosus*, *M.Dev.*, N.Y.; *4a*, lat. view of distal part of stem and holdfast,  $\times 1$ ; *4b*, *B*-ray view of crown and stem,  $\times 1$ ; *4c*, post. view of cup and proximal brachs,  $\times 2$  (Goldring, 1923, 1942).

**Costalocrinus** JAEKEL, 1918, p. 60 [\**Poteriocrinus dilatatus* SCHULTZE, 1867, p. 161; M]. Cup low bowl shaped; plates thin, ornamented with strong ridges radiating from center of each radial and

- basal; radialian small, quadrangular, situated in depression between ridges; anal *X* large, bearing part of prominent transverse ridge between posterior radials; radial articular facets about one-half as wide as radials, thin and arcuate; posterior facets obliquely inclined toward anterior side of cup by large, medially projecting edges of primanal and posterolateral edges of radials, which together form large concave surface projecting ad-medially and presumably providing support for an anal sac. Arms, anal sac, and stem not known. *M.Dev.*, Eu.(Ger.).—FIG. 396,5a-d. \**C. dilatatus* (SCHULTZE); post., ant., dorsal, and ventral views of cup (*CD* interray directed downward),  $\times 1.5$  (Schultze, 1867).
- Gastrocrinus** JAEKEL, 1895, p. 60 [\**Poteriocrinus patulus* MÜLLER, 1859, p. 192; M]. Cup small, low, poorly known; plates stellate. Anal sac very large, cylindrical, composed of several vertical rows of convex interlocking hexagonal plates which bear transverse median ridges and small folds perpendicular to sutures between plates of adjacent rows; anal opening terminal. Arms slender, short, branching first high above cup, with 2 or 3 additional branches and widely spaced branching armlets in distal parts of arms. Stem transversely pentagonal, with cirriferous nodals at intervals along its entire length; cirri long, slender, and directly obliquely back toward cup. *L.Dev.*, Eu.(Ger.-France).—FIG. 399,1. *G. giganteus* SCHMIDT, Ger.; lat. view of crown and stem,  $\times 0.5$  (Schmidt, 1934).
- Gothocrinus** BATHER, 1893, p. 114 [\**G. gracilis*; OD]. Cup steeply conical; plates smooth; basals 5; small pentagonal radialian below and to left of *C* radial; arm facets well rounded externally, much narrower than radials; anal *X* large, situated between posterior radials, supporting 2 large anal plates which are succeeded by several rows of smaller hexagonal plates of anal sac. Arms uniserial, composed of large, quadrangular brachials; primibrachs 4 or 5 axillary; each ray with 2 main rami; long, slender, unbranched ramules given off on alternate sides of each arm. *M.Sil.*, Eu.(Sweden).—FIG. 399,2. \**G. gracilis*, Gotl.; 2a, crown with attached stem,  $\times 1.5$ ; 2b, theca and proximal brachials,  $\times 3$  (Bather, 1893a).
- Imitocrinus** SCHMIDT, 1934, p. 104 [\**Cyathocrinus gracilior* ROEMER, 1863, p. 149; OD]. Cup small, low conical, with smooth plates; radialian apparently not developed, anal *X* directly above *CD* basal; radial articular facets about two-thirds as wide as radials. Anal sac not known. Arms uniserial, long, slender, with 2 main rami in each ray, primibrachs 2 axillary; long slender ramules present on secundibrachs. Stem transversely round, slender. *L.Dev.*, Eu.(Ger.).—FIG. 399,4. \**I. gracilior* (ROEMER); lat. view of crown and stem,  $\times 1$  (Schmidt, 1934).
- Jahnocrinus** JAEKEL, 1918, p. 54 [\**J. minutus*; M]. Cup low bowl shaped; infrabasals small, low; basals with prominent longitudinal median folds; radial articular facets one-half as wide as radials; radialian small, quadrangular. Anal sac unknown. Arms slender, first primibrachs short, succeeding 2 to 3 primibrachs elongate, primibrachs 3 or 4 axillary; distal parts of arms not known. Stem transversely pentagonal (poorly known). *M.Dev.*, Eu.(Boh.).—FIG. 399,3. \**J. minutus*; 3a-c, *A*- and *D*-ray views of partial crown and stem, plate diagram of cup,  $\times 4$  (Jaekel, 1918).
- ?**Pandocrinus** JAEKEL, 1918, p. 57 [\**P. pinnulatus*; OD]. Cup low, broad, with smooth plates; infrabasals low or possibly entirely covered by stem; radial articular facets small and narrow; radialian and anal *X* unknown. Anal sac apparently large, composed of wide, low, hexagonal plates. Arms branching at least twice isotomously; primibrachs 2 to 4 axillary; brachials with ?2 ramules on each side possibly joined ?laterally. Stem transversely round. *M.Ord.*, Eu.(Boh.-Eng.).—FIG. 400,4. \**P. pinnulatus*, Boh.; lat. view of incomplete crown and proximal part of stem,  $\times 2$  (Jaekel, 1918).
- [The type species of this genus is poorly known and the holotype of \**P. pinnulatus* may be a monocyelic inadunate referable to the Disparida. JAEKEL (1918) placed together within his suborder Meroocrinites five genera, two of which are now accepted as monocyelic inadunates (*Iocrinus*, *Caleidocrinus*), one clearly has infrabasals (*Meroocrinus*), and two others (*Pandocrinus*, *Vosekocrinus*), all of which JAEKEL illustrated as lacking infrabasals, but nevertheless assigned by him to the dicyclic Botryocrinidae. JAEKEL believed that these apparently monocyelic crinoids had secondarily lost their infrabasals plates, and therefore should be classified as dicyclic inadunates. This interpretation is unacceptable. Until the type specimens of these forms or duplicates of them are re-studied their systematic position must remain in doubt.]
- Parabotryocrinus** YAKOVLEV, 1941, p. 327 [\**P. tschudovensis*; OD]. Cup low, bowl shaped; infrabasals small, 3, barely visible in side view; radials larger than basals; radialian and anal *X* present in cup. Arms with slender ramules, mode of branching unknown. Stem round in section. *U.Dev.*, Eu.(USSR).—FIG. 400,3. \**P. tschudovensis*; 3a, lat. view of cup,  $\times 1$ ; 3b, brachials and ramules,  $\times 3$  (Yakovlev, 1941b).
- Rhadinocrinus** JAEKEL, 1895, p. 87 [\**R. rhenanus*; OD]. Cup small, cone shaped, plates smooth; infrabasals upflared; radial articular facets strongly curved at outer margins, two-thirds as wide as radials; 3 anal plates in cup, radialian small, quadrangular, separated from anal *X* by right tube plate in line with posterior radials. Anal sac very long and slender, composed of few rows of small hexagonal plates, or distally recurved and with plicate plates. Arms long, slender, branching on primibrachs 4, with 2 main rami bearing short and slender armlets, densely branched and widely spaced, or quite long, slender and unbranched, or with single branch and more closely spaced. *L.Dev.-M.Dev.*, Eu.(Ger.).—FIG. 400,1a. *R. nanus* (ROEMER), *L.Dev.*; lat. view of crown and stem,  $\times 0.7$  (Schmidt, 1934).—FIG. 400,1b. \**R. rhenanus*, *L.Dev.*; post. view of crown and prox-



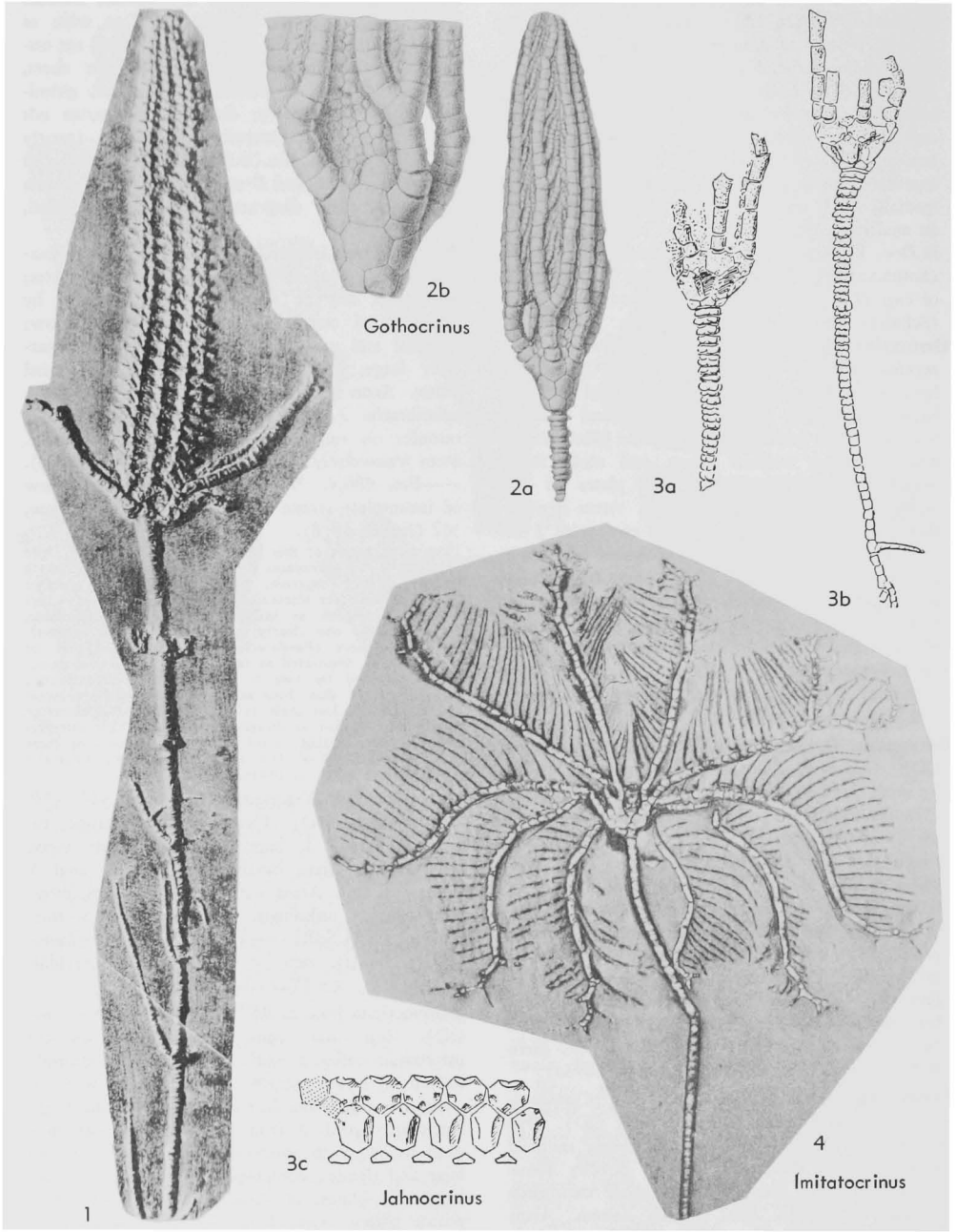


FIG. 399. Botryocrinidae (p. T615).

imal stem,  $\times 1$  (Jaekel, 1895).  
**Schmidocrinus** HAARMANN, 1921, p. 41 [*\*Rhenocrinus winterfeldi* SCHMIDT, 1906, p. 544; M].  
 Cup small, conical, arrangement of plates not

known. Anal sac extremely slender and tall. Arms long and delicate, branching once just above cup and again in distal region; brachials elongate, arranged in zigzag pattern, with long slender

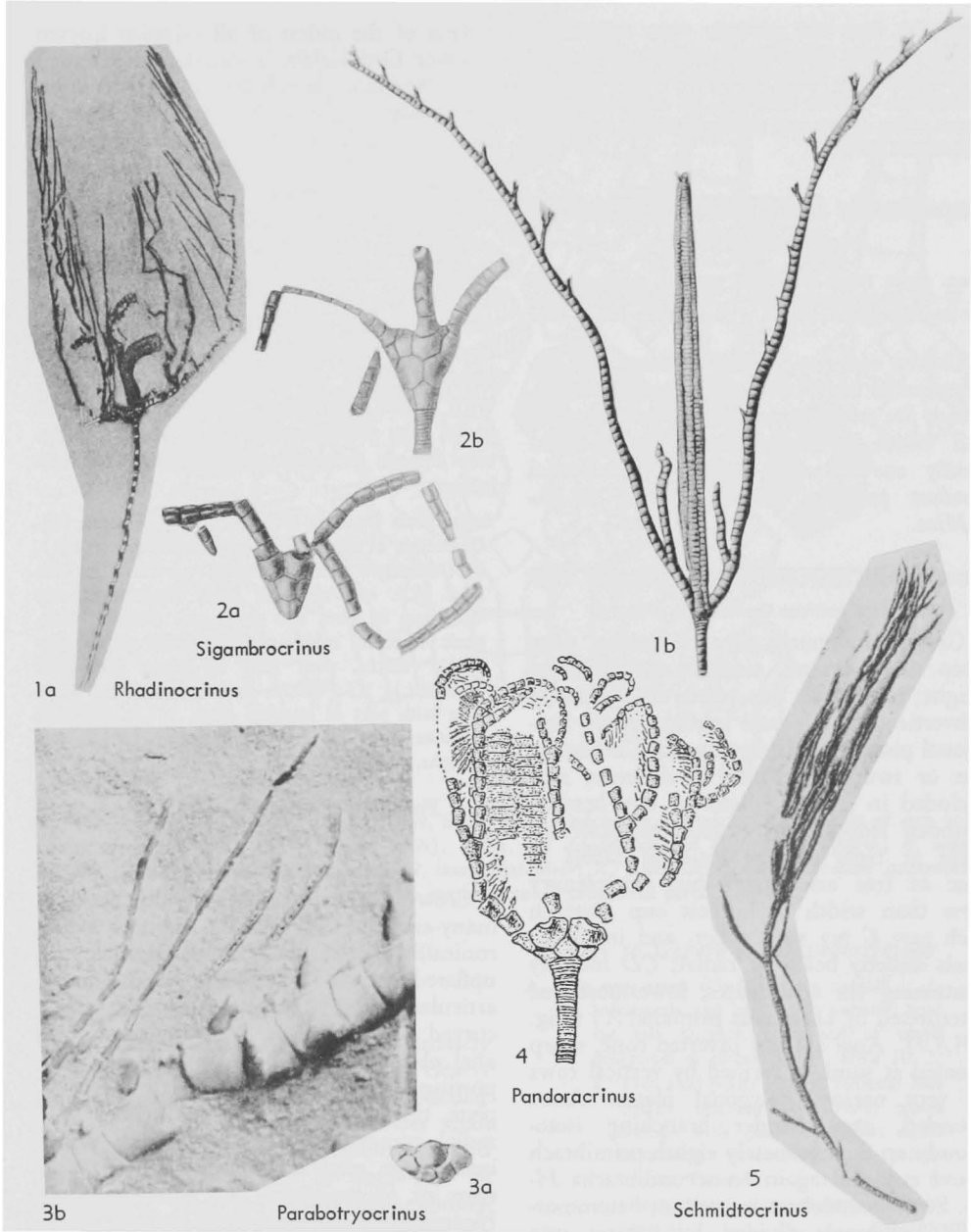


FIG. 400. Botryocrinidae (p. T615-T618).

ramules on opposite sides of every second brachial. Stem pentagonal in section, with widely spaced cirri directed obliquely up toward crown. *M.Dev.*, Eu.(Ger.).—FIG. 400,5. \**S. winterfeldi* (SCHMIDT); lat. view of crown and stem,  $\times 2$  (Haarmann, 1921).

[Although the type species of this genus has been credited to JAEKEL by SCHMIDT (1906), HAARMANN (1921) pointed out that SCHMIDT did not ascribe authorship of this species

to JAEKEL, although he did cite JAEKEL as the author of *Rhenocrinus* and of *R. ramosissimus* on the same page where *R. winterfeldi* is described. HAARMANN recorded SCHMIDT as the author of *R. winterfeldi*, and his view is accepted here.]

**Sigambrocrinus** SCHMIDT, 1942, p. 178 [\**S. laevis*; M]. Cup high, cone shaped, plates smooth; radial absent from cup, anal X small, situated between posterior radials. Anal sac unknown. Arms

uniserial, long and relatively stout, unbranched, with ramules; ambulacral grooves with small covering plates. Stem transversely round. *L.Dev.*, Eu.(Ger.).—FIG. 400,2a,b. \**S. laevis*; ant. and post. views of cup and proximal part of arms,  $\times 1$  (Schmidt, 1942).

## Superfamily MASTIGOCRINACEA Jaekel, 1918

[*nom. transl.* MOORE & LANE in MOORE & STRIMPLE, 1973, p. 19 (ex Mastigocrinidae JAEKEL, 1918, p. 55)] [Materials for this superfamily prepared by R. C. MOORE and N. GARY LANE]

Crown and cup similar to those of Dendrocrinacea except for articular radial facets, which are wide (peneplenary) but less than full width of radials, and mostly have gently curved outer margins, interradial notches present. *L.Ord.-M.Ord.*; *M.Sil.-L.Miss.*

### Family AETHOCRINIDAE Ubaghs, 1969

[Aethocrinidae UBAGHS, 1969, p. 2]

Crown moderately tall and slender. Cup steep sided conical, summit width 0.7 of height; infrabasals five, with distal portion subvertical; basals and radials large hexagonal plates (except heptagonal *CD* basal); one or two primibrachs of different rays included in cup; all plates of cup bearing rounded ridges which cross interplate sutures at right angles; articular facets at base of free arms wide but peneplenary (less than width of highest cup plate in each ray; *C* ray with super- and inferradials directly below *C* radial; *CD* interray containing six anal plates, lowermost one interpreted by UBAGHS as primanal *X*) (Fig. 394,8,9). Anal sac low inverted cone, sharp pointed at summit, formed by vertical rows of very narrow polygonal plates. Arms rounded, very slender branching isotomously on approximately eighth primibrach above cup and again on secundibrachs 13-16. Stem pentalobate in section, heteromorphic, columnals divided by sutures into pentameres with lobate expansions radial in position aligned with infrabasals. *L.Ord.* (*Tremadoc.-Arenig.*).

The Aethocrinidae are assigned to the Mastigocrinacea because the comparatively wide proximal facets of fixed primibrachs 2 and succeeding free primibrachs are distinctly narrower than fixed primibrachs 1 and radial plates.

One of the oldest of all crinoids known (Lower Ordovician, Tremadoc or Arenig) is *Aethocrinus*, which has a steep straight-sided conical cup, and it must be close to the root stock of other cladid inadunates and possibly disparids also. Five anal plates and lowermost primibrachs are fixed in the cup (Fig. 394,8,9) and articular facets for attachment of the free arms are on fixed brachials rather than summit edges of radials. The free arms are uniserial, transversely round, and branched isotomously first on free primibrachs 8. The relatively large stem is transversely quinquelobate, with wide axial canal, and columnals divided into pentameres. All of these characters denote primitiveness in stage of evolution.

*Aethocrinus* UBAGHS, 1969, p. 2 [\**A. moorei*; M]. Characters of family. *L.Ord.* (*Tremadoc.-Arenig.*), Eu. (Montagne Noire, S. France).—FIG. 401; 402, 1a-d. \**A. moorei*; 401, plate diagram of cup with part of arms and stem, enl. (radials black, anals vertically ruled, and interradial plates stippled); 402, 1a, post. view of crown and stem (reconstr.),  $\times 1$ ; 402, 1b, view of uncrushed paratype with part of attached stem,  $\times 1.7$ ; 402, 1c,d, opposite sides of crushed holotype,  $\times 1.7$  (all Ubaghs, 1969).

### Family THENAROCRINIDAE Jaekel, 1918

[Thenarocrinidae JAEKEL, 1918, p. 55]

Crown tall, expanding in width upward, many-armed. Cup steeply straight sided, conical, truncate at base; infrabasals strongly upflared outside of stem impression; radial articular facets peneplenary, with gently curved outer margins, declivate; large radial-anal obliquely at left below *C* radial, supporting on its left shoulder large anal *X* plate, third anal barely extending below *C* radial summit (Fig. 394,3). Very prominent large anal sac composed of vertical rows of plicate plates, sac pointed at top. Nonpinnulate uniserial arms branching several times, first on primibrachs 1. Stem wide, formed of thin circular columnals, noncirriferous. *M.Sil.*

*Thenarocrinus* BATHER, 1890, p. 334 [\**T. callipygus*; OD]. Characters of family. *M.Sil.*, Gotl.-Eu. (Eng.).—FIG. 403, 1a-c. \**T. callipygus*, Gotl.; 1a,b, ant. and post. views of crown,  $\times 0.7$  (Bather, 1891a); 1c, plate diagram of cup (radials black, radial cross ruled, anal *X* and higher anal plates stippled) (Moore, n).

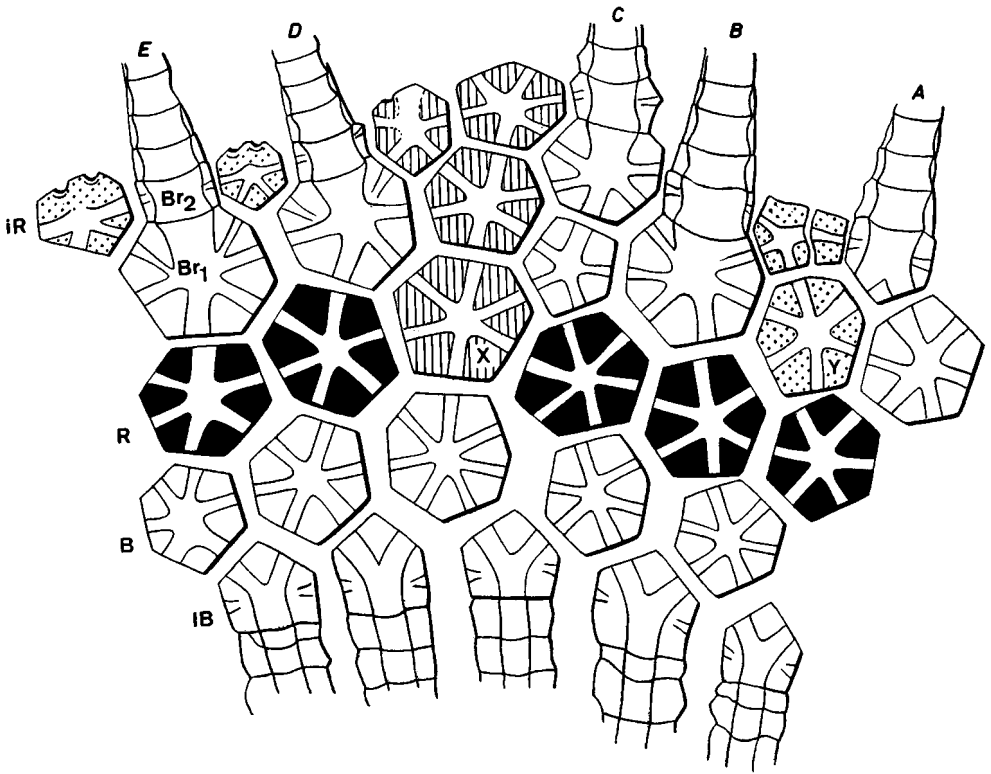


FIG. 401. *Aethocrinus moorei* UBAGHS, 1969, from Lower Ordovician, France; plate diagram of cup with part of arms and stem, enl. (Ubaghs, 1969). [A-E, ray designations in CARPENTER system; B, basal; Br<sub>1</sub>, Br<sub>2</sub>, primibrachs 1,2; IB, infrabasal; iR, interradial plate; X, primanal; Y, supplementary interradial; radials black, anal plates vertically ruled, interradial plates stippled.]

### Family MASTIGOCRINIDAE Jaekel, 1918

[Mastigocrinidae JAEKEL, 1918, p. 55]

Cup conical with height approximately equal to width; infrabasals upflared, clearly visible in side view of cup; radial articular facets wide but somewhat narrower than radial summits, sloping outward-downward (declivate); anal plates in cup, one or mostly two. Anal sac mostly tall; cylindrical. Arms uniserial, slender, branching isotomously on primaxils and isotomously or heterotomously higher in crown. Stem circular or pentagonal in section. *M.Ord.*; *M.Sil.-L.Miss.*

The Mastigocrinidae are mostly diminutive crinoids with few upflared, uniserial, slender arms and conical cups. Probably they constitute an offshoot from the pterocrinids or botryocrinids.

### Key to Genera of Mastigocrinidae

- A. Cup very steep sided, narrow conical .....
- I. Infrabasals and basals tall, narrow; anal sac tall, slender, composed of small polygonal or plicate plates, arms 10 ....
    - a. Two anal plates in cup, radianal like basals, touching infrabasals; plates fluted, with pits at angles; arms branching isotomously on primibrachs 4 or 5; anal sac tall, with plicate plates, stem transversely pentagonal ..... *Atelestocrinus*
    - b. Three anal plates in cup; arms 10, branching isotomously on primibrachs 4 or 5; stem transversely pentagonal ..... *Quantoxocrinus*
    - c. Four anal plates in cup; arms branching isotomously on primibrachs 4 and secundibrachs 4; stem transversely round ..... *Antihomocrinus*
    - d. Three anal plates in cup; arms 10; extra plates between radials and

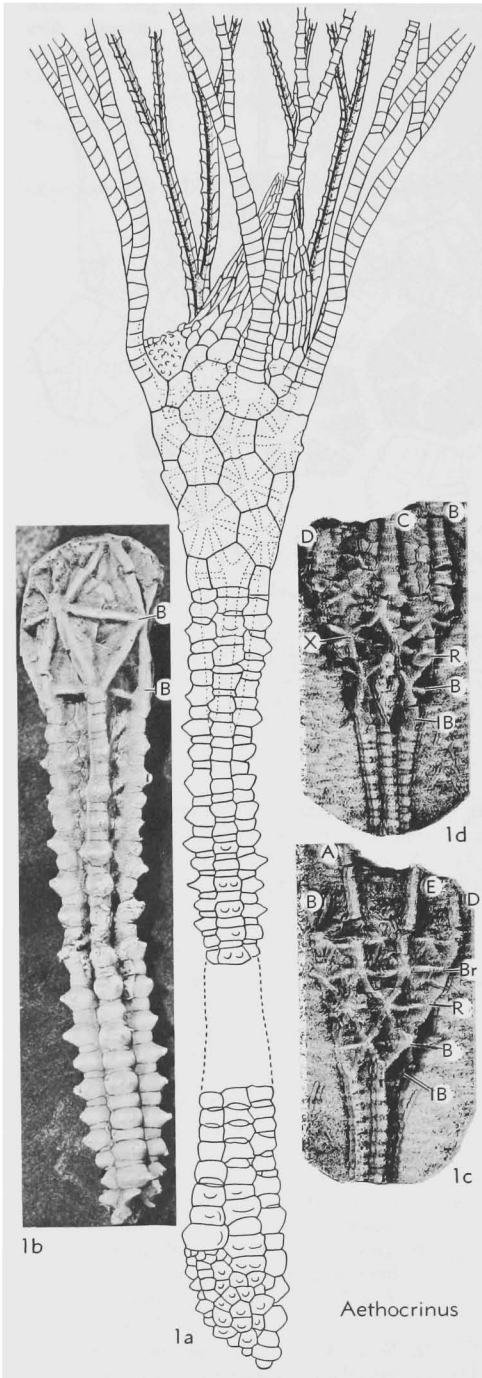


FIG. 402. Aethocrinidae (p. T618).

basals ..... *Belanskiocrinus*  
 II. Infrabasals low; 2 anal plates in cup

(small quadrangular radianal, large anal X); stem transversely pentagonal ..  
 a. Anal sac tall, with plicate plates; arms 10, branching isotomously on primibrachs 3-5 ..... *Dictenocrinus*  
 b. Anal sac tall, composed of small polygonal plates; arms 60 or more, branching first isotomously on primibrachs 4 and heterotomously higher in crown ..... *Lasiocrinus*  
 c. Basals tall and slender, radials small, pits at plate angles; arms many, branching first isotomously on primibrachs 3 or 4 and heterotomously higher in crown .... *Cradeocrinus*  
 III. Infrabasals low; only anal X plate in cup; stem transversely pentagonal ..  
 ..... *Kalpidocrinus*

- B. Cup conical, with height subequal to width .....
- I. Cup with fluted plates, pits at their angles; 2 anal plates in cup (small quadrangular radianal, large anal X) ..  
 a. Arms approximately 90, branching first isotomously on primibrachs 3 and heterotomously higher in crown; anal sac tall and slender .... *Goniocrinus*  
 b. Arms at least 10, branching isotomously on primibrachs 6-8; anal sac short, distally pointed, composed of polygonal plates ..... *Nassoviocrinus*
- II. Cup smooth plated; anals in cup 1 or 2 .....
- a. Arms numerous, branching isotomously on primibrachs 4 and heterotomously higher; anal plates in cup 2, anal sac with laterally directed summit spines ..... *Bathericrinus*  
 b. Arms numerous, branching isotomously first on primibrachs 10-12 and 5 or 6 times higher in crown; anal plate in cup 1 (radianal absent, anal X large), tall anal sac composed of small polygonal plates with posterior "backbone" of large convex plates ..... *Mastigocrinus*  
 c. Arms branching first isotomously on primibrachs 2 or 3 and heterotomously higher in crown; anal plates in cup 2 ..... *Iteacrinus*  
 d. Arms 20-40, branching isotomously first on primibrachs 4 or 5 and higher in crown; anal sac low spheroidal, composed of stellate polygonal plates ..... *Follicrinus*  
 e. Main arms unbranched, bearing very numerous short slender ramules on opposite sides; anal sac tall, slender; stem tapering distally to prehensile point ..... *Eifelocrinus*  
 f. Arms 40 or more, first branching

isotomously on primibrachs 4 or 5;  
single anal plate in cup; anal sac  
composed of small polygonal plates

..... *Polycrinus*

- C. Cup medium sized; anal plates in cup 1-4,  
anal sac slender, cylindrical; arms 5-40 or  
more. Radial lacking, anal X large;  
slender anal sac spirally coiled; arms 10 or  
more, branching on primibrachs 1-4 .....

..... *Streptocrinus*

**Mastigocrinus** BATHER, 1892, p. 194 [*\*M. loreus*;  
OD]. Cup conical; infrabasals large, upflaring;  
radial articular facets peneplenary, slightly nar-  
rower than radials; radianal absent, anal X large,  
situated between posterior radials; anal sac large,  
elongate, composed of wide, low plates, each with  
transverse ridge that bifurcates at lateral edges of  
sac plates, in confluence with bifurcate ridges of  
sac plates of adjacent rows. Arms uniserial, slender,  
long, bifurcating on primibrachs 10 to 12,  
with 5 or 6 higher, isotomous divisions; ramules  
not developed. Stem round in section, columnals  
composed of pentameres. *M.Sil.*, Eu.(Eng.).—  
FIG. 404,3. *\*M. loreus*, Wenlock.; 3a, post. view  
of crown and proximal part of stem,  $\times 0.7$ ; 3b,c,  
side view of columnal and proximal part of arms  
and anal sac,  $\times 5$ ; 3d, post. view of theca and  
proximal part of arms and stem,  $\times 1.5$ ; 3e, anal  
sac plates,  $\times 10$ ; 3f, diagram of stem divided  
into pentameres,  $\times 1.5$  (Bather, 1892b).

**Anthomocrinus** SCHMIDT, 1934, p. 79 [*\*Homo-  
crinus tenuis* BATHER, 1893a, p. 105; OD]. Cup  
steeply conical and elongate; small, oblique radi-  
anal and larger anal X in cup; radial articular  
facets peneplenary, less than equal to full width of  
plates, leaving rounded interradianal notches.  
Anal sac large and elongate. Arms slender,  
rounded, uniserial, branching isotomously on  
primibrachs 4 and secundibrachs 4. *M.Sil.-L.Dev.*,  
Eu.(Ger.-Sweden).—FIG. 404,1. *\*A. tenuis*  
(BATHER), *M.Sil.*, Gotl.; 1a,b, post. view of crown  
and part of attached stem, ant. view of theca,  
 $\times 1$  (Bather, 1893a).

**Atelestocrinus** WACHSMUTH & SPRINGER, 1886, p.  
221 [*\*A. delicatus*; SD S. A. MILLER, 1889, p.  
226] [= *Attelesocrinus* WACHSMUTH & SPRINGER,  
1886, p. 223 (*nom. null.*); *Atelestocrinus* BASSLER  
& MOODEY, 1943, p. 314 (*nom. null.*)]. Cup in-  
verted bell shaped; infrabasals and basals large,  
elongate; radials small, radial articular facets  
peneplenary, rounded; A radial narrow, armless;  
radianal large, elongate, and similar in size and  
shape to basals; anal X elongate, constricted medi-  
ally between posterior radials. Anal sac not  
known. Arms uniserial, branching on primi-  
brachs 2 to 5, ramules on opposite sides of every  
second secundibrach. *L.Miss.*, USA (Iowa).—  
FIG. 404,2. *A. robustus*; post. view of partial  
crown and stem,  $\times 1.5$  (Wachsmuth & Springer,  
1886).

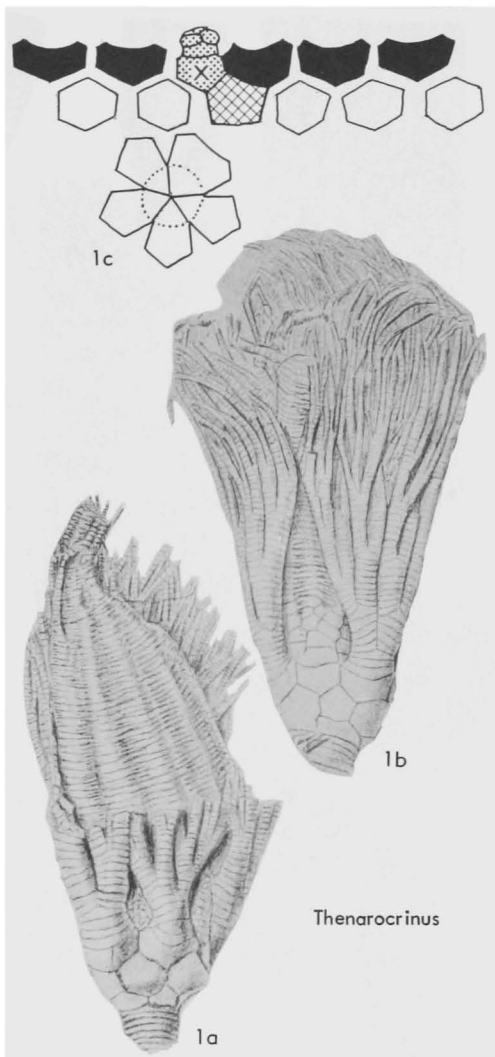


FIG. 403. Thenarocrinidae (p. T618).

**Bathericrinus** JAEKEL, 1918, p. 58 [*\*Botryocrinus  
ramosus* BATHER, 1891a, p. 394; M]. Cup small,  
low, plates smooth or basals with median longi-  
tudinal fold; radial articular facets almost as wide  
as radials, interradianal notches present; radianal  
small, quadrangular, anal X large and projecting  
above adjacent radials. Anal sac large, elongate,  
plates strongly plicate, distal extremity with ring  
of large spinose plates. Arms uniserial, branching  
isotomously on primibrachs 4, each arm with 2  
main rami; large ramules on opposite sides of  
every second secundibrach. *M.Sil.-L.Dev.*, Eu.  
(Eng.-Ger.).—FIG. 404,4a,b. *\*B. ramosus*  
(BATHER), *M.Sil.*, Eng.; 4a,b, post. and B-ray  
views of crown,  $\times 0.7$  (Bather, 1891a).—FIG.  
404,4c. *B. semipinnulatus* SCHMIDT, *L.Dev.*, Ger.;

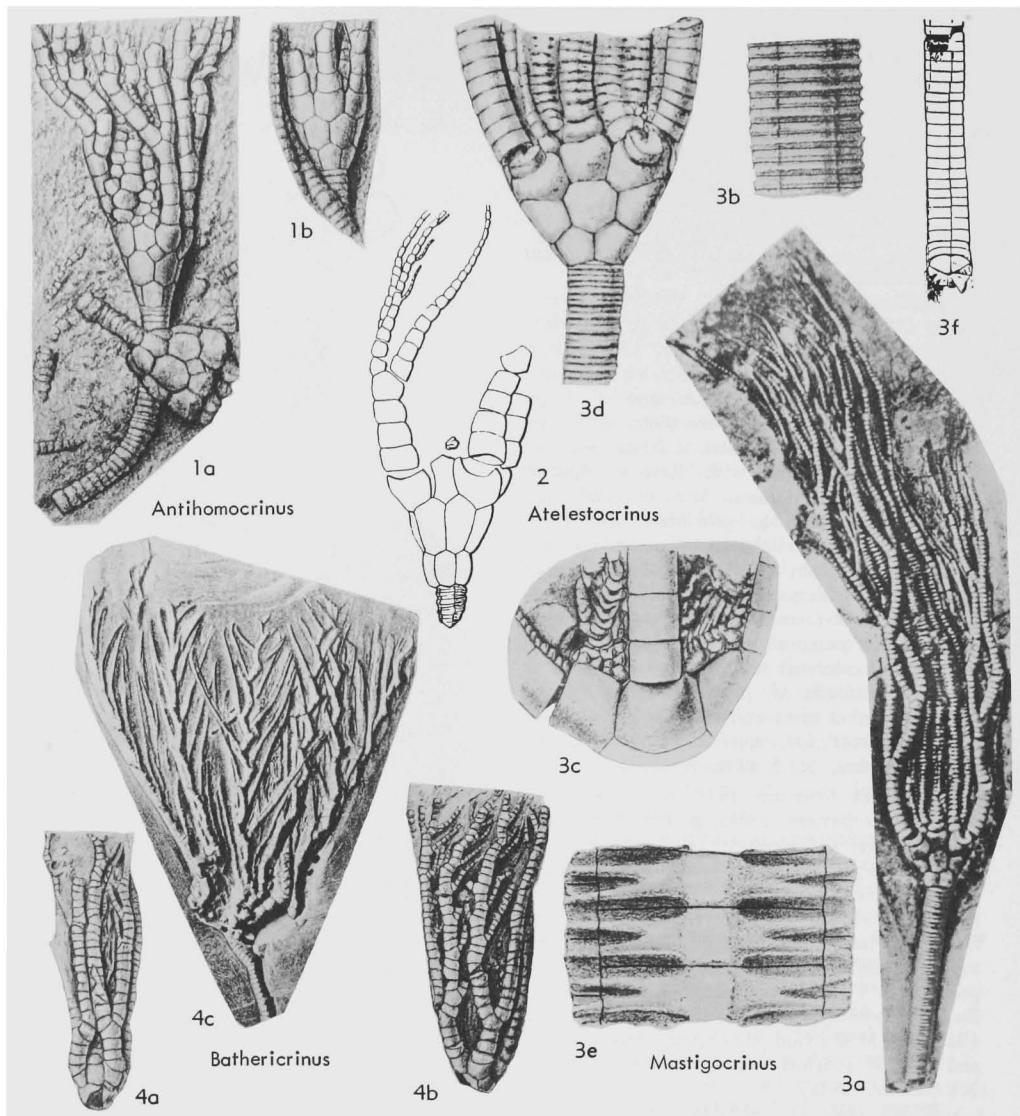


FIG. 404. Mastigocrinidae (p. T621-T622).

lat. view of crown,  $\times 1$  (Schmidt, 1934).

**Belanskicrinus** STRIMPLE & LEVORSON, in STRIMPLE *et al.*, 1969, p. 18 [*\*Bactrocrinus westoni* BELANSKI, 1928, p. 177; OD]. Cup straight sided, steeply conical, cirlet of partially fused upflared infrabasals tending to break away from basals, extra plates common between basals and radials; 3 anals in cup, anal sac exceptionally tall and slender. Arms 10, uniserial, branching isotomously on primibrachs 4 or 5. Stem transversely round, tapering distally from cup. *M.Dev.*, USA (Iowa). FIG. 405, 1. *\*B. westoni* (BELANSKI), Shellrock F. (Mason City Member), near Rockport, Floyd Co., Iowa; 1a, AB-interray view of crown,  $\times 1.7$ ; 1b,

D-ray view of hypotype crown,  $\times 1.8$ ; 1c, lat. view of crown showing anal sac,  $\times 1.8$  (Strimple & Leverson, 1969).

**Cradeocrinus** GOLDRING, 1923, p. 347 [*\*C. elongatus*; OD]. Crown tall and slender. Cup narrowly conical; infrabasals small, upright; basals large and elongate; radials small; deep depressions at junctures of radial-basal sutures; radial articular facets almost as wide as radials, each supporting 3 or 4 large, rounded primibrachs; each ray with 2 main rami above primaxil, with long slender ramules given off alternately on opposite sides of every third or fourth secundibrach. *U.Dev.-L.Miss.*, N.Am.(N.Y.-Mont.-Alta.).—FIG. 406, 2. *\*C.*

*elongatus*, U.Dev., N.Y.; 2a,b, lat. views of crown and part of attached stem,  $\times 1.5$  (Goldring, 1923).

**Dictenocrinus** JAEKEL, 1918, p. 59 [*\*Botryocrinus decadactylus* BATHER, 1891b, p. 395 (= *Cyathocrinus decadactylus* SALTER, 1873); SD BASSLER, 1938, p. 87]. Cup high, steeply conical; plates smooth or with inconspicuous longitudinal folds on basals; radial articular facets slightly narrower than radials. Anal sac elongate, narrow, composed of several rows of wide, low, strongly plicate plates, recurved at distal tip, with anal opening just below sac summit on anterior side, large spinose plates may cap summit. Arms uniserial, branching on primibrachs 3 to 5, with 2 main rami or with one or two higher branches; brachials bearing ramules; stout covering plates on arms and ramules. Stem subpentagonal in section, columnals simple or composed of pentameres. *U.Sil.-L.Dev.*, Eu.(Ger.-Eng.).—FIG. 406,4. *D. cyathiformis* (HAARMANN), L.Dev., Ger.; post. view of crown and stem,  $\times 1$  (Haarmann, 1921).

**Eifelocrinus** WANNER, 1916, p. 200 [*\*Ptilocrinus dohmi* WANNER, 1916, p. 344a; OD] [= *Ptilocrinus* WANNER, 1916a, p. 343 (obj.), non CLARK, 1907]. Cup steeply conical; plates convex; radial articular facets occupying nearly full width of radials. Anal sac slender, about one-third as long as arms, confined to posterior interray of tegmen, composed of several rows of hexagonal plicate plates, distal extremity may bifurcate; tegmen composed of large interradial plates, small median orals, and interlocking ambulacral plates in each radial area. Arms uniserial, long and slender, one main ramus to each ray; heterotomous armlets alternate sides of every second brachial; armlets composed of long, stout main branch and side ramules given off distally from opposite sides of every second plate. Stem subpentagonal in section proximally, becoming round distally and tapering to a prehensile point. *L.Dev.*, Eu.(Ger.).—FIG. 406,5. *\*E. dohmi* (WANNER); post. and ant. views of 2 reconstructions of crown and stem,  $\times 0.7$  (Wanner, 1916a).

**Follicrinus** SCHMIDT, 1934, p. 74 [*\*Taxocrinus arebei* FOLLMAN, 1887, p. 118; OD]. Cup small, conical, as wide as high; radial articular facets penepenary; radianal and anal X in cup. Anal sac greatly inflated, balloon shaped, composed of numerous, small stellate plates. Arms slender, uniserial, spreading, with 3 or 4 isotomous branches. *L.Dev.*, Eu.(Ger.).—FIG. 406,6. *\*F. arebei* (FOLLMAN); 6a, lat. view of crown and attached part of stem,  $\times 0.5$ ; 6b, sketch of anal sac and disarticulated arm fragments,  $\times 1$  (Schmidt, 1934).

**Goniocrinus** MILLER & GURLEY, 1890, p. 32 [*\*G. sculpitilis*; OD] [= *Goniocrinus* SPRINGER, 1913, p. 218 (nom. null.)]. Cup small, plates convex with depressions at corners; infrabasals low; small oblique radianal and anal X in cup, supporting elongate anal sac which has posterior longitudinal

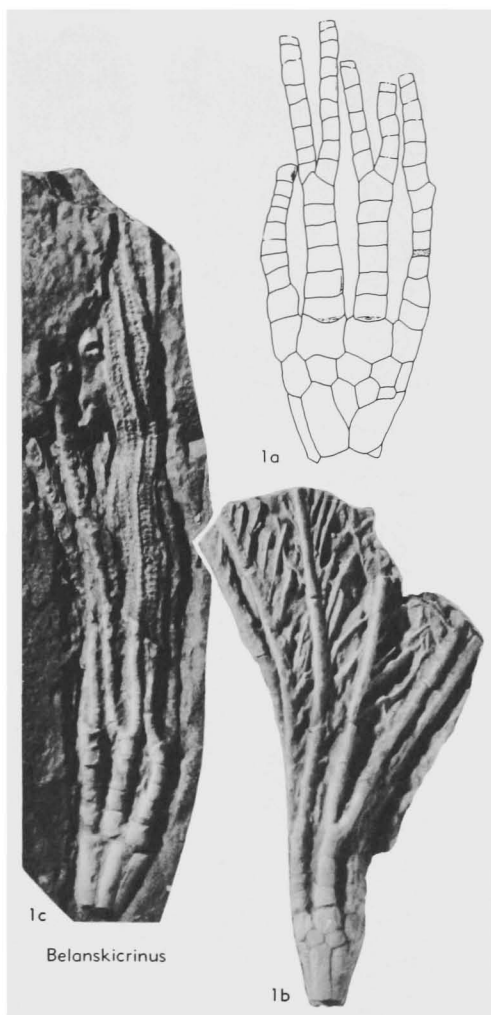


FIG. 405. Mastigocrinidae (p. T623).

row of larger anal plates that resemble brachials, radial articular facets curved, nearly as wide as radials, small interradial notches distinct; primibrach 3 axillary, supporting 2 main rami in each ray, with long, stout ramules alternating on opposite sides of every third or fourth secundibrach proximally and every second secundibrach distally. Stem transversely pentagonal, with proximally directed cirri on nodals just below cup. *L.Miss.*, N.Am.(Ind.-Iowa-Can.).—FIG. 406,1. *\*G. sculpitilis*, Iowa; 1a,b, lat. views of crown,  $\times 2$  (Miller & Gurley, 1890).

**Itacrinus** GOLDRING, 1923, p. 344 [*\*I. flagellum*; OD]. Cup small, low, with highly convex plates; radianal large, anal X partly out of cup; radial articular facets almost as wide as radials, supporting 2 or 3 primibrachs in each ray. Anal sac slender,



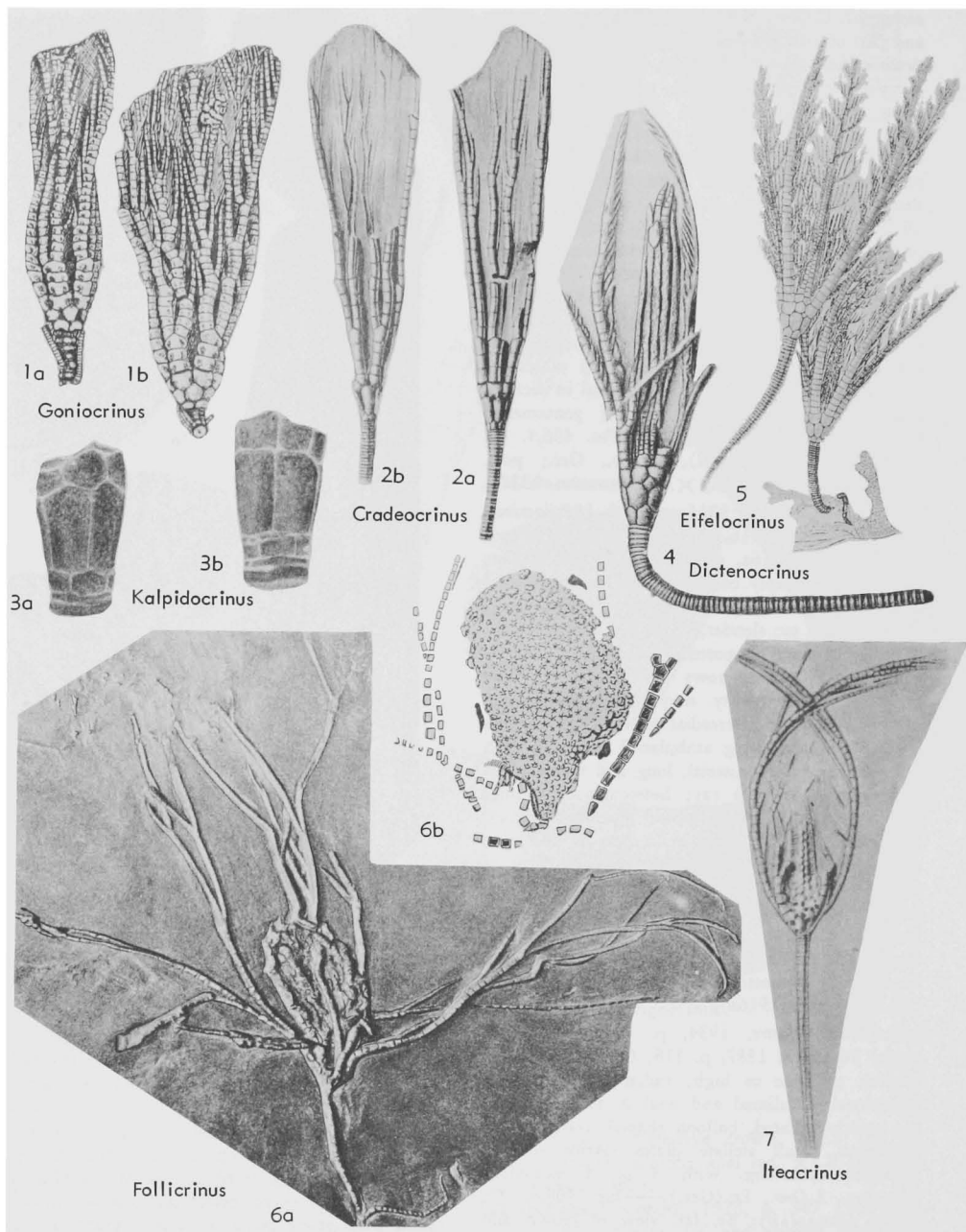


FIG. 406. Mastigocrinidae (p. T622-T625).

elongate, composed of several longitudinal rows of delicate plates. Arms uniserial, slender, rounded, with two main isotomous rami in each ray heterotomously supporting long, slender ramules on opposite sides of every second or third brachial. Stem transversely pentagonal. *U.Dev.*, USA(N.Y.).

—FIG. 406.7. \**I. flagellum*; post. view of crown and part of stem,  $\times 1$  (Goldring, 1923). **Kalpidocrinus** GOLDRING, 1954, p. 17 [\**K. eriensis*; OD]. Cup cylindrical, tall; infrabasals low, but steeply upflared; basals very large and elongate, radials small, one anal plate (anal X or radial)

in cup directly above *CD* basal; arm facets wide, penepenary. Stem transversely subpentagonal. *M.Dev.*, USA (N.Y.).—FIG. 406,3. \**K. eriensis*; 3a,b, *A*-ray and post. views of cup and proximal columnals,  $\times 4$  (Goldring, 1954).

**Lasiocrinus** KIRK, 1914, p. 482 [\**Homocrinus scoparius* HALL, 1859b, p. 102; OD]. Cup conical, wide at base; infrabasals elongate, steeply upflared; radials longer than wide, with straight linear facets occupying nearly full width of plates, deep interradial notches present; radianal small, quadrangular; anal *X* large, in line with posterior radials. Anal sac long, composed of several longitudinal rows of small hexagonal plates. Arms uniserial, branching isotomously on fourth primibrachs and heterotomously above, with long, stout ramules alternately on opposite sides of every fourth to ninth brachial. *L.Dev.-L.Miss.*, Eu.(Ger.)-USA (Iowa-N.Y.).—FIG. 407,3. \**L. scoparius* (HALL), *L.Dev.*, N.Y.; 3a,b, ant. and post. views of crown with short attached part of stem,  $\times 2$  (Kirk, 1914).

**Nassoviocrinus** JAEKEL, 1918, p. 54 [\*?*Heterocrinus pachydactylus* SANDBERGER & SANDBERGER, 1855, p. 402; M]. Cup high, conical, plates with elongate, longitudinal ridges; radianal small, quadrangular; anal *X* large; radial articular facets slightly narrower than radials. Anal sac short, pyramidal, composed of few large plates proximally, sac plates diminishing in size distally. Arms elongate, slender, brachials quadrangular; primibrachs 6 to 8 axillary; distal parts of arms or ramules not known. Stem transversely pentagonal; columnals composed of pentamerer. *L.Dev.-U.Dev.*, Eu.(Ger.)-USA (Iowa).—FIG. 407,1. \**N. pachydactylus* (SANDBERGER & SANDBERGER), *L.Dev.*, Ger.; post. view of partial crown and stem,  $\times 0.7$  (Jaekel, 1918).

**Polycrinus** JAEKEL, 1918, p. 55 [\**P. ramulatus*; OD]. Cup low, broad, truncate below; infrabasals barely visible in side view; radials large, radial articular facets nearly as wide as radials; radianal absent from cup; anal *X* between posterior radials. Anal sac large, with posterior longitudinal row of large, quadrangular plates, anterior side composed of small plates. Arms uniserial, robust, branching isotomously on primibrachs 4 to 6, with 2 main rami and widely spaced, long, slender ramules on alternate sides of rami. Stem round, wide proximally, tapering distally. *M.Ord.*, Eu.(Boh.).—FIG. 407,2a. \**P. ramulatus*; *D*-ray view of partial crown and stem,  $\times 0.7$  (Jaekel, 1918).—FIG. 407,2b. *P. kosoviensis* JAEKEL; *DE*-interray view of crown and stem,  $\times 0.7$  (Jaekel, 1918).

**Quantoxocrinus** WEBBY, 1965, p. 12 [\**O. ussheri*; OD]. Crown small, slender. Cup conical, infrabasals large and steeply upflared; radial articular facets curved, nearly equal to radials in width, small interradial notches; 3 anal plates in cup. Anal sac large, erect or recurved, composed of

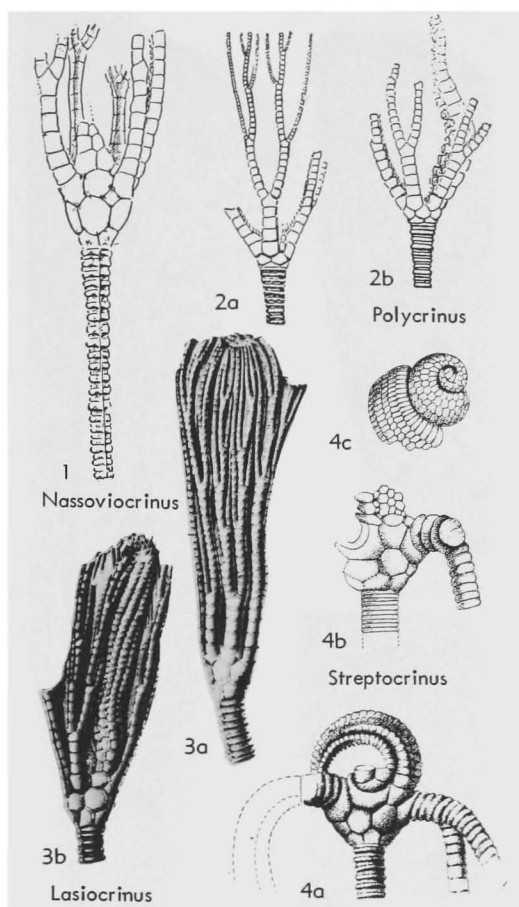


FIG. 407. Mastigocrinidae (p. T625-T626).

several vertical rows of hexagonal, plicate plates. Arms uniserial, isotomous with 2 main rami, bearing ramules, primibrachs 4 or 5 axillary. Stem transversely pentagonal. *M.Dev.*(*Givet.*), Eu.(Eng.); *U.Dev.*, USA (Iowa).—FIG. 408,1. \**O. ussheri*; 1a-c, post., C- and B-ray views of crown,  $\times 2.8$  (Webby, 1965).

**Streptocrinus** WACHSMUTH & SPRINGER, 1886, p. 224 (148) [\**Ophiocrinus crotalurus* ANGELIN, 1878, p. 24; M] [= *Ophiocrinus* ANGELIN, 1878, p. 24 (obj.) (*non* SALTER, 1856, *nec* SEMPER, 1868)]. Cup low bowl shaped; infrabasals small; radianal absent; radial articular facets large, concave, directed abmedially and occupying most of outer surface of radials. Anal sac recurved and spirally coiled, tapering distally, composed of regular rows of alternating hexagonal plates. Arms recumbent and directed downward proximally; primibrachs wide and thin, primibrachs 1 to 4 axillary, 2 main rami to an arm, apparently with ramules; ambulacral groove with cover-

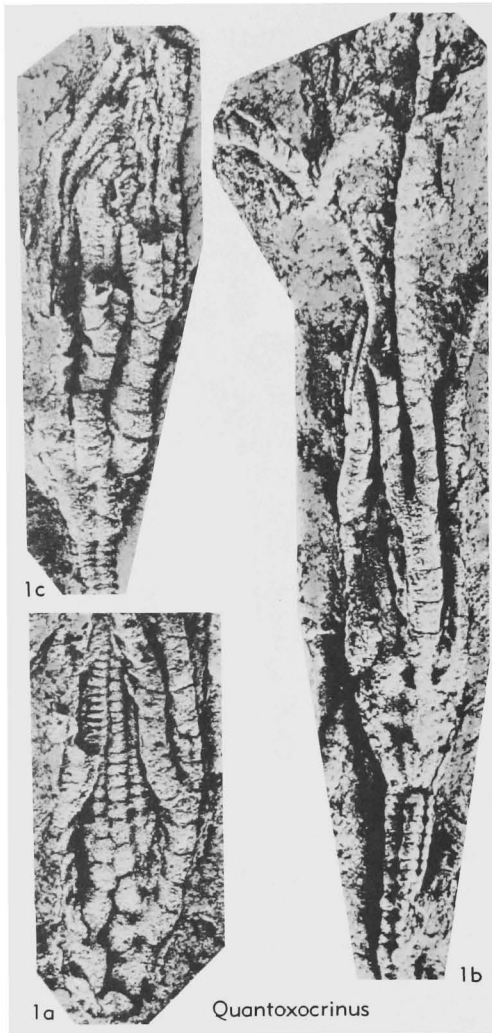


FIG. 408. Mastigocrinidae (p. T625).

ing plates. Stem transversely round. *U.Sil.*, Eu. (Sweden).—FIG. 407, *A*. \**S. crotalurus* (ANGELIN), Gotl.; *4a-c*, *D*-ray view of theca showing part of arms, stem, and coiled anal sac, post. view of partial theca and arm, spiral anal sac, all  $\times 1$  (Angelin, 1878).

### Superfamily MEROCRINACEA S. A. Miller, 1890

[*nom. transl.* MOORE & LANE in MOORE & STRIMPLE, 1973, p. 19 (ex Merocrinidae S. A. MILLER, 1890, p. 352)]  
[Materials for this superfamily prepared by R. C. MOORE and N. GARY LANE]

Crown tall, slender cylindrical or moderately expanded upward. Cup straight-sided

narrowly to broadly conical; five upflared infrabasals clearly visible from side; basals and radials large, arm facets plenary, occupying full width of radials, anals mostly three in cup. Anal sac prominent. Arms well rounded externally, branched isotomously at or near base and isotomously or heterotomously higher in crown, mostly bearing ramules. Stem circular in section or rarely pentagonal. ?*L.Ord.*, *M.Ord.-U.Ord.*; *U.Sil.-L.Dev.*

### Family MEROCRINIDAE S. A. Miller, 1890

[Merocrinidae S. A. MILLER, 1890, p. 352] [=Merocrinidae AUSTIN & AUSTIN, 1843, p. 205, *pro* Merocrinoidea AUSTIN & AUSTIN, 1842, p. 110 (invalid, no type-genus named)]

Radial articular facets wide. Infer- and axillary superradial present in *C* ray, supporting anal *X* and longitudinal series of anal plates on left side and branched arm on right. *M.Ord.-U.Ord.*

The Merocrinidae, composed so far as now known of the single genus *Merocrinus*, differ from most other dendrocrinines in having an inferradial and superradial (Fig. 394, *A*). This character indicates a primitive evolutionary stage. The cup is perfectly symmetrical, inasmuch as the inferradial corresponds exactly in size and shape to the four adjacent radial plates. The superradial and *X* plates are not incorporated in the cup, but there is no indication that they have been displaced upward from an original position within the cup. As in *Iocrinus*, the radials and inferradial of *Merocrinus* may be interpreted to represent the most archaic of all structural plans among inadunate crinoids, in which there is no differentiation of compound radials (consisting of unfused primitive radials, otherwise known as inferradials, and primitive first brachials, otherwise called superradials) and "simple" radials (consisting of fused lower elements of the rays). If this diagnosis is correct, it is pertinent to call attention to the cyclic course of normal evolutionary changes in the cup of inadunate crinoids, that is, from initial or near-initial perfect pentamerous symmetry to bilateral symmetry, and finally back to perfect pentamerous symmetry.

The radial articular facets of the Merocrinidae are wide (plenary), which suggests

origin of the group in an unknown stock that surely stands far apart from the early Cyathocrinina. The characters of the cup, arms, and strikingly armlike anal tube most closely resemble those of some families of Disparida, but this similarity is not known to have significance as to genesis of *Merocrinus*. The repeated isotomous branching of the arms indicates an early evolutionary stage, but not the most primitive one, in development of this part of the organism. No descendants of the Mero-crinidae are known.

**Merocrinus** WALCOTT, 1884, p. 208 [\**M. typus*; OD]. Characters of family. Cup small, short, extending laterally only short distance beyond uppermost columnal; infrabasals wide, low, visible in side view; basals short. Arms long, bifurcating isotomously several times, 6 or more primibrachs to a ray. Cup plate in *C* ray, which is identical to normal radials of other rays, is homologous to inferradial and next higher plate with form and position of axillary; first primibrach bears a normal arm on its right shoulder and strong longitudinal series of anal tube plates on its left shoulder, is equivalent to a superradial. This latter plate has been termed anibrachial. The presence of two radianals in the *C* ray has been long recognized as an archaic structure correlated with a primitive evolutionary character. Stem transversely round, stout, composed of quite thin columnals. *M.Ord.-U.Ord.*, N.Am.(N.Y.-Ky.-Ohio)-Eu.(Eng.).—FIG. 409,3a. \**M. typus*, *M.Ord.*, N.Y.; *CD*-interray view of crown and part of stem,  $\times 1$  (Moore & Laudon, 1943a).—FIG. 409,3b. Plate diagram of cup (radials black, *C* inferradial horizontally ruled; anal *X* and sac plates stippled; *PS*, plane of bilateral symmetry) (Moore, 1962b).

### Family CUPULOCRINIDAE Moore & Laudon, 1943

[Cupulocrinidae MOORE & LAUDON, 1943a, p. 52]

Infra- and superradial present in *C* ray only; anal *X* in line with radials, supporting longitudinal row of large anal sac plates; radial articular facets fully as wide as radials. *M.Ord.-U.Ord.*

The Cupulocrinidae constitute an independent line of Ordovician dicyclic inadunates that seem to be related closely to the Flexibilia. They do not give rise to known descendants. The posterior side of the cup is primitive in having the radianal directly below the right posterior (*C*) radial; there are two other anals in the cup. The cupulocrinids differ from most other Ordovician

cladids in having radial articular facets that are fully equal to the greatest width of the radial plates. The anal sac differs also from that of associated inadunates.

**Cupulocrinus** D'ORBIGNY, 1850, p. 23 [\**Scyphocrinus heterocostalis* HALL, 1847, p. 85; M] [= *Scyphocrinus* HALL, 1847 (*non* ROEMER, 1849) (obj.)]. Cup conical; infrabasals 5; radianal directly in line below *C* radial. Anal sac composed of small, loosely united plates except for longitudinal row of large plates on posterior side. Brachials wide, low; arms branch several times isotomously, third of fourth primibrachs axillary, no pinnules. *M.Ord.-U.Ord.*, N.Am.(Ont.-N.Y.-Ky.-Ohio)-Eng.—FIG. 409,2a,b. *C. jewetti* (BILLINGS, 1857), *M.Ord.*, Ont.; 2a,b, post. views of crown,  $\times 1$  (Springer, 1911b).—FIG. 409,2c. *C. kentuckiensis* SPRINGER, *M.Ord.*, Ky.; post. view of crown,  $\times 1$  (Springer, 1911b).—FIG. 409,2d. Plate diagram of *Cupulocrinus* (radials black, radianal cross ruled, anal *X* and sac plates stippled) (Moore, n).

### Family ONTARIOCRINIDAE Jaekel, 1918

[Ontariocrinidae JAEKEL, 1918, p. 83] [Materials for this family prepared by N. GARY LANE]

Poorly known and may be unrecognizable or incorrectly assigned. Diagnosis same as for *Ontariocrinus*. *M.Ord.*

**Ontariocrinus** JAEKEL, 1918, p. 83 [\**O. deviatius*; OD]. Cup wide, bowl shaped, plates thin; infrabasal circlet low, wide, with 4 plates; basals apparently 4; radials 5, *C* radial in contact with infrabasals; radianal directly above infrabasals, anal *X* above radianal and between posterior radials; radial articular facets narrow, rounded; proximal brachials uniserial, rounded; cup plates with prominent radiating ridges. Stem wide, columnals thin. [Known only from JAEKEL's (1918) brief description and text-figures. Similar crinoids have not been described from the well-known Kirkfield locality from which JAEKEL's specimen is reputed to have been collected. Inquiry at the University of Greifswald indicates that the holotype is not present in their collections.] *M.Ord.*, Can.(Ont.).

### Family OTTAWACRINIDAE Moore & Laudon, 1943

[Ottawacrinidae MOORE & LAUDON, 1943a, p. 55] [Materials for this family prepared by N. GARY LANE]

Cup cylindrical, radianal directly below *C* radial, anal *X* above truncate *CD* basal and at left above radianal, radials followed by fixed primibrachs in each ray forming part of cup (two above *C* radial, three above others). Stem quinquepartite. ?*L.Ord.*, *M.Ord.*, ?*U.Ord.*

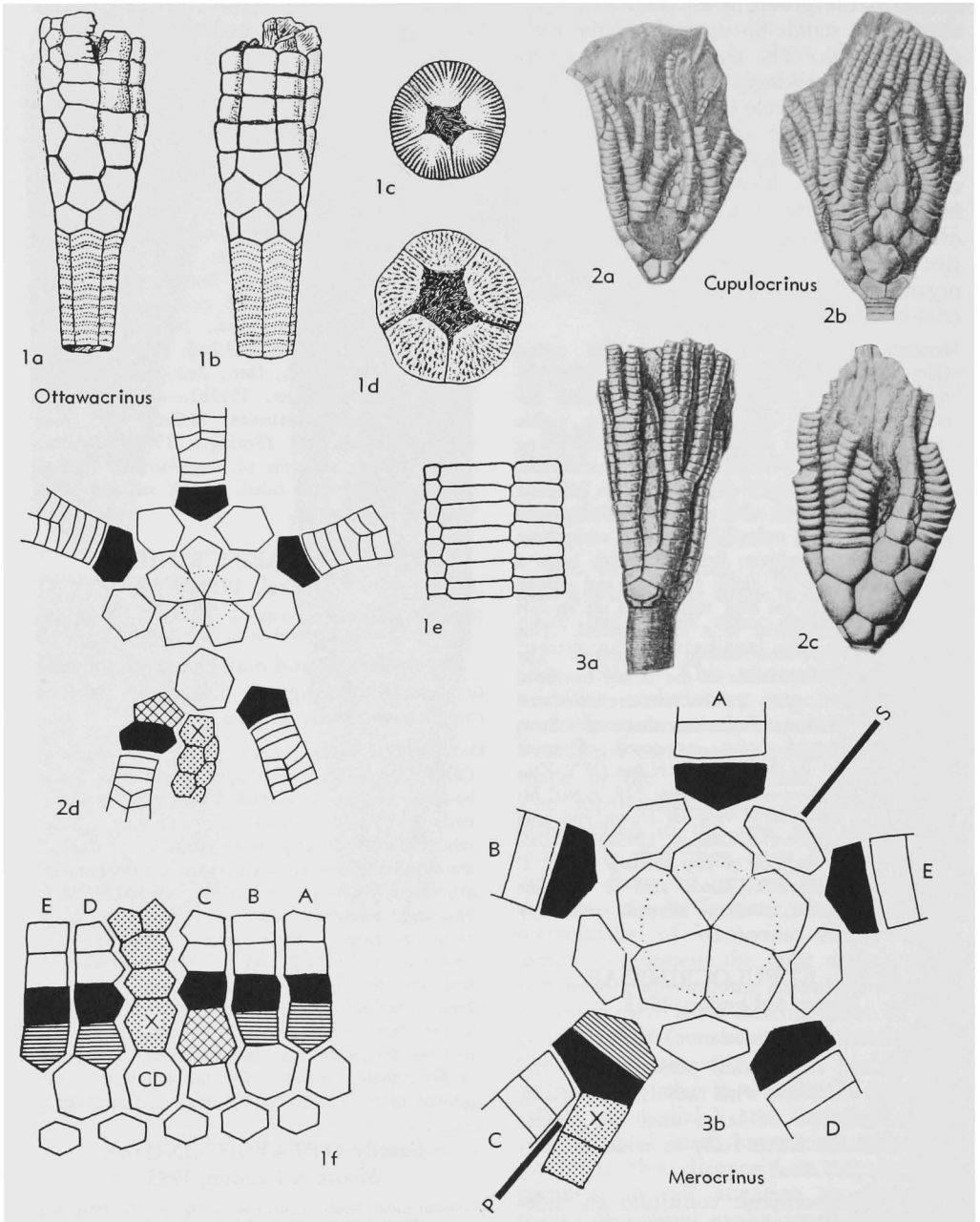


FIG. 409. Merocrinidae (3); Cupulocrinidae (2); Ottawacrinidae (1) (p. T627-T629).

Primitive features of *Ottawacrinus* are its nearly vertical-sided narrow cup, the presence of a radianal directly below the C radial, and presence of fixed brachials in the cup. The anal X and higher anal plates

are directly above the distally truncate CD basal.

*Ottawacrinus* W. R. BILLINGS, 1887, p. 49 [\**O. typus*; M]. Characters of family, articular facets on superradials wide, straight, and sutures beneath

first primibrachs slightly gaping; large anal X directly above truncate *CD* basal supporting longitudinal row of hexagonal anal plates, most proximal 2 of which are within cup. Arms with several primibrachs, distal parts of arms and ramules unknown. Stem subcircular in transverse section, each columnal composed of pentameres; lumen large, pentagonal. *M.Ord.*, Can.(Ont.); ?*Ord.*, S.Am.(Arg.).—FIG. 394,2; 409,1. \**O. typus*, *M.Ord.*, Ont.; 394,2, post. side of cup showing anals (inferradial anal ruled, super-radial cross ruled, anal X and higher anals stippled) (Moore, n); 409,1a,b, post., ant. views of cup,  $\times 3$  (Bather, 1913b); 409,1c-e, articular faces of proximal and distal columnals, and side view of columnals,  $\times 5$  (Bather, 1913b); 409,1f, plate diagram (radials black, inferradials horizontally ruled, radial cross ruled, anal X and other anals stippled) (Moore, n).

### Family METABOLOCRINIDAE Jaekel, 1918

[Metabolocrinidae JAEKEL, 1918, p. 83] [Materials for this family prepared by N. GARY LANE]

Infra- and superradial present in *C* ray; *B*- and *D*-ray radials simple, other radials not known. Arms with two main rami, ramules present on admedial side of every second secundibrach. *M.Ord.*; *U.Sil.-L.Dev.*

**Metabolocrinus** JAEKEL, 1902, p. 1100 [\**M. rossicus*; M]. Crown oval, compact. Cup low, broad, bowl shaped, base wide and flat; infrabasals low, barely visible in side view, mostly covered by wide stem; basals large; radials pentagonal, inferradial in *C* ray equivalent to primitive radial, superradial axillary, simple radials in *B* and *D* rays, other radials not known; large, quadrangular anal plate directly above *CD* basal and between posterior radials, supporting longitudinal row of large, wide, low anal sac plates. Arms stout, each with 2 main rami, primibrachs 1 or 2 axillary; long, stout ramules on admedial side of arms in each ray borne by successive second secundibrach. Stem transversely round. *M.Ord.*, Eu. (Est.).—FIG. 410,3. \**M. rossicus*; *C*-ray view of diagram. reconstr. of crown,  $\times 1.5$  (Jaekel, 1918).

[In the plate diagram of the cup of this genus JAEKEL (1918, p. 85), reconstructed the anterior side of the cup with compound radials in the *E* ray, which would indicate that the symmetry of the cup was comparable to that of the Heterocrinacea, which are monocyelic inadunate crinoids. The illustration of the crown of *Metabolocrinus* by JAEKEL shows clearly infrabasals plates below the basals, but his reconstruction of the cup cannot be accepted in this respect until the type or other authentic specimens have been re-studied.]

**Cyliocrinus** JAEKEL, 1918, p. 60 [\**Melocrinus?* *rigidus* ANGELIN, 1878, p. 20; OD]. Cup small, low, with wide truncate base; radial articular facets as wide as radials; radialian small, quadrangular. Anal sac ?recurved, lateral plates strongly plicate, base of sac situated in concavity formed

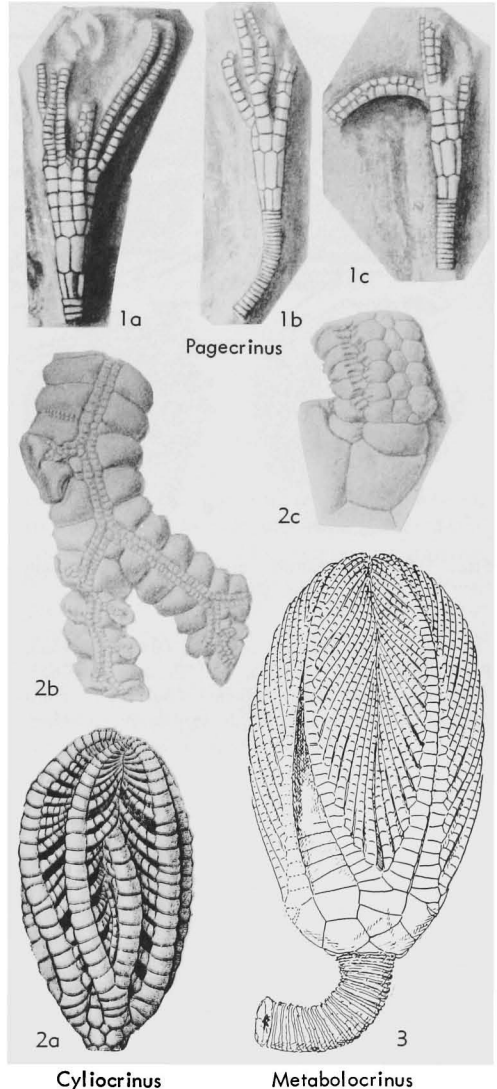


FIG. 410. Metabolocrinidae (p. T629-T630).

by admedial part of anal X and posterior sides of *C* and *D* radials. Arms uniserial, massive, brachials large and quadrangular; primibrachs 3 axillary; 2 main rami to ray, each with large ramules alternately on opposite sides of each brach proximally, distally each brach bears 2 ramules, one on each side; ambulacral grooves of rami and ramules with stout cover plates. Stem transversely subpentagonal, columnals composed of pentameres. *U.Sil.*, Eu.(Swed.).—FIG. 410, 2a. \**C. rigidus* (ANGELIN), Gotl.; post. view of crown,  $\times 1.5$  (Angelin, 1878).—FIG. 410,2b,c. *C. scolopendra* (BATHER), Gotl.; ventral surface of arm showing cover plates of ambulacra, base

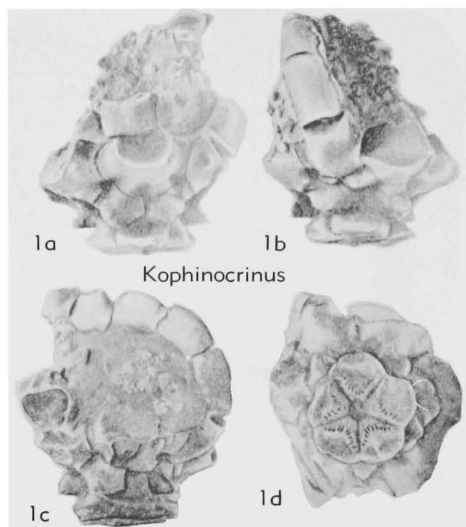


FIG. 411. Superfamily and Family Uncertain (p. T630).

of anal sac and adjacent cup,  $\times 3$  (Bather, 1893a). **Paterocrinus** KIRK, 1929, p. 1 [*\*P. gracilis*; OD]. Crown narrow and elongate. Cup high, cylindrical; infrabasals tall, basals very large and elongate; radials small with wide linear straight articular facets; fully equal to radials in width; single anal plate (anal *X* or radianal) directly above *CD* basal and in line with radials, supporting longitudinal row of large anal sac plates which resemble brachials. Anal sac stout, elongate, composed of 6 or 7 rows of hexagonal plates. Arms uniserial, rounded, primibrachs as wide as radials, primibrachs 3 or 4 axillary; 2 main rami to each ray; long, stout ramules given off alternately on opposite sides of every second secundibrach. *L. Dev.*, USA (Ind.).—FIG. 410, I. *\*P. gracilis*; 1a-c, D-ray, B-ray, and lat. views of crown and proximal part of stem,  $\times 2$  (Kirk, 1929).

### Superfamily and Family UNCERTAIN

**Kophinocrinus** GOLDRING, 1954, p. 36 [*\*K. spiniferus*; M]. Cup truncate conical, height approximately 0.5 of summit width, plates with prominent rounded ridges and furrows crossing sutures at right angles; infrabasal circlet swollen, expanded laterally; radials largest plates in cup, with outward-downward semicircular articular facets on middle part of summits, notches between upper corners of radials; 2 anal plates in cup, a very small quadrangular radianal and large anal *X*, latter supporting vertical series of large long narrow plates, bordered at sides by numerous small spinose plates. Arms unknown except for quad-

angular first primibrachs, which are wider than high. Stem unknown but impression of proximal columnal indicates large diameter and pentalobate outline with exceptionally large stellate lumen. *M.Dev.*, USA (N.Y.).—FIG. 411, I. *\*K. spiniferus*, Hamilton Gr.; 1a-d, A-ray, *CD*-interray, D-ray and dorsal views,  $\times 3$  (Goldring, 1954). [LANE]

### Suborder POTERIOCRININA Jaekel, 1918

[*nom. correct.* MOORE, in MOORE, LALICKER, & FISCHER, 1952, p. 614 (*pro* suborder Poteriocrinites JAEKEL, 1918, p. 60)] [=Poteriocrininitina UBAGHS, 1953, p. 752] [Materials for this suborder prepared by R. C. MOORE, H. L. STRIMPLE, and N. GARY LANE]

Crown much varied in shape, size, number of arms, and mode of branching, but arms prevailing pinnulate and biserial arrangement of brachials common. Cup high conical, gently convex-, flat-, or concave-based bowl shaped (craticuliform), or extremely low, discoid (patelliform). Radial articular facets narrow (angustary) to wide (peneplenary, plenary), with facetal surfaces declivate, planate, or rarely sursumate; transverse ridge, ligament pits and fossae, and muscle fields generally prominent. Four, three, two, one, or no anal plates in cup. Anal sacs virtually duplicate kinds found in the Dendrocrinina. Stem mostly round transversely. *L.Dev.-U.Perm.*; *M. Trias*.

The combined characters of the Poteriocrinina mark them as distinctly more advanced in evolution than the Cyathocrinina and Dendrocrinina. As a whole, they exhibit remarkable diversity, exceeding the other suborders in this regard and in number of recognized taxa at all levels. Inferred phylogeny of poteriocrinine families is indicated diagrammatically in Fig. 412.

### Superfamily POTERIOCRINITACEA Austin & Austin, 1842

[*nom. transl.* MOORE & STRIMPLE, 1973 (*ex* Poteriocrininitidae BASSLER, 1938, p. 20, *nom. correct. pro* fam. Poteriocrinidae AUSTIN & AUSTIN, 1842, p. 195)] [Materials for this superfamily prepared by R. C. MOORE and H. L. STRIMPLE]

Crown tall, formed of steeply conical cup and many-branched uniserial arms; radial articular facets narrow, with strongly rounded outer margins; three anal plates in cup. Anal sac tall, commonly reaching