Subclass INADUNATA
Wachsmuth & Springer, 1885
[nom. transf. MOORE & LAUDON, 1943a, p. 21 (ex suborder Inadunata WACHSMUTH & SPRINGER, 1885, p. 228)] [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 subtegimonial; arms pinnulate or nonpinnulate. L.Ord.-U. Perm.; M. Trias.

Order DISPARIDA
Moore & Laudon, 1943
[nom. correct. in MOORE, in MOORE, LALICKER, & FISCHER, 1952a, p. 613 (pro Disparata MOORE & LAUDON, 1943a, D. 24)] [Diagnosis by GEORGES UBAGHS]

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 development 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 simplifications derived from complexities. Among the disparid crinoids illustrations are offered by 1) reduction in number of basalts from five to three to one, 2) lateral fusion of axillary brachials with each other and subjacent radials to produce the large multifaceted radial of Catillocrinidae, Anamesocrinidae, and Calceocrinidae (Fig. 320), 3) fusion of infer-and superradials to yield simple undivided radials as in Haplocrinidae and Piscocrinidae 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.

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Inadunata—Disparida
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

[Bis p. 16 (pro Homocrinidae nom. transl. Ubachs, 1953, p. 746, ex Homocrinidae Kirk, 1914, p. 479)] [Materials for this superfamity 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 uniseral, atomous arms to a ray; anal X typically placed between C and D radials. Arms atomous, isotomously as wide as radials, or composite and superradial; anal X typically placed between C and D ray, and with large, simple radials; anal X incorporated in cup between C and D radials. Arms atomous, isotomously 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 rami 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 pentagonal proximally, tapering in width distally; primibrach 2 axillary in all rays, supporting 2 main rami in each ray. Long, slender, unbranched rami 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 cup.

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. (Niagara), 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, X8; 3c, A-ray view of crown and stem, X5 (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. kirki; 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. kirki; 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, quadrilateral 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 rami 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 cup. 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, X1 (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, columns 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, X2 (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, X2 (Meek, 1873).—Fig. 322.1f-g. *E. grandis (Meek).
Inadunata—Disparida—Homocrinacea

**Dryocrinus**

**Homocrinus**

**Fig. 321. Homocrinidae (p. T522).**

1a. Dryocrinus

1b. 

2a. 

3a

3b

3c

3d

3e

Daedalocrinus

**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, X3.3; 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. M.Ord. (Cincinnat.), USA (Iowa).—Fig. 323.2. *S. typus; 2a,b, plate diagram and D-ray view of...
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 CALCEOCRINIDAE
Meek & Worthen, 1869

[Calceocrinidae Meek & Worthen, 1869a, p. 73] [Chirocrinidae Angelin, 1878, p. 22; Chirocrinidae Zittel, 1879, p. 343; Cremartinidae Ulrich, 1886, p. 105; Cantocrinidae Jäkel, 1918, p. 88; Calceocrinites Jäkel, 1918, p. 86 (suborder) (partim)]

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 circllet subtriangular in outline consisting of four, three, or one plates which bears all or part of stem impression at apex of triangle and is muscledly hinged along base of triangle with radial plates; median (E) radial compound, with inferiradial forming middle part of all hinge contact with basals and superradial connected broadly to narrowly with inferiradial 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 inferiradials 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 branchials 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,
I nad unata-Disparida-Calceocrinacea T525
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, 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 (α), beta (β), gamma (γ), delta (δ), and so on. The single ramule attached to the main axil farthest from *E* is known as omega (ω) ramule. The features are illustrated in Figure 325.

Echinoidea-Crinoidea

**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* Bathuer, 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 isomorphously 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 ramiules 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*
RINGUEBERG (1889, p. 402) explicitly designated ~

Actually, neither [*A. thr

Anulocrinus RAMSBOTTOM, 1961, p. 8 [*A. thrai

Calceocrinus halli of attached stem (holotype of type species of Proclivoerinus RINGUEBERG), X2 (all Springer, 1926a). [Also Fig. 324,3.]

[HALL's original description and illustrations of Calceocri

were unaccompanied by a specific name, and therefore when RINGUEBERG (1889, p. 403) redescribed and figured a fragmentary fossil reported to be HALL's original speci

men of Calceocrinus, naming it C. halli, various authors, including BADELL (1938, p. 50), BADELL & MOOREY (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 RINGUEBERG. Accordingly, they cited C. halli RINGUEBERG as the type species of Calceocrinus. RINGUEBERG, 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. RINGUEBERG (1889, p. 402) explicitly designated C. typus as the type species of Calceocrinus and this action was accepted by KATER (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 "institutional" assignment 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 subse

quent 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 Chiroerinus chrysalis HATL., 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 (1885, p. 205 [281]) were first to do this when they explicitly designat

Chiroerinus chrysalis as the type species.]

Anulocrinus RAMSBOTTOM, 1961, p. 8 [*A. thrae

vensis; OD]. Crown pendent, subparallel to stem, like Cremocrinus in having 4 basals and 4 arm-bearing rays, E arm unbranched or divided isotomously on about the sixth primibrach and fifth secundibrach, 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 supraregal wider than high, narrowly touching slender inferradial, which is slightly sinusoid sided and appreciably taller than wide; large undivided lateral radials of A and D rays, forming most of opposite sides of cup; B supraregal small, subquadrangular, B and C inferradials spear shaped, in type species C supraregal (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 thick

ening distally until height may appreciably exceed diameter (MOORE, 1962a; RAMSBOTTOM, 1961).
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. 327a; 328. C. fletcheri (Salter), M.Sil.(Wenlock.), Eng.(Dud-
Inadunata—Disparida—Calceocrinacea

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

Chirocrinus

Chiropinna

Cremacrinus

Chiropinna

Anulocrinus

ley); 327,4, D-ray view of nearly complete crown (holotype) with part of attached stem, ×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
Chirocrinus

*C. punctatus* (N.Y.).—Fig. 326,3.

Sigler, 1969, p. 340

*T.530 Echinodermata-Crinoidea*

rate axial arms 1-4 (anal plates stippled) (Moore, 1926a).—Fig. 327,4-6. *C. punctatus*, U.Sil. (Black River), Minn.; 1a-b, D-ray view of crown and E-ray view of cup, ×2 (Springer, 1926a).—Fig. 327,1e-c. *C. tubuliferus* Springer, M.Sil. (Beech River), USA (Tenn.); 1e, 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 Id between D ray and stem; all ×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 admedian edge of A and D radials. Main axial 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, ×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 adjoined 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).
Echinodermata—Crinoidea

*Eochalysiocrinus* 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, ×8 (Prokop, 1970).

*Eophalysiocrinus* Arendt, 1965, p. 90 [*Eohalysiocrinus? 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. (USSSR).—Fig. 326.1. *E. tuberculatus* (Yakovlev); 1a, E ray, ×2; 1b, basal, ×3; 1c,d, int. and lat. views of cup, ×2.3 (Arendt, 1965).


*Grypocrinus* Strimple, 1963, p. 59 [*G. genuinus*; OD]. Basals unknown, probably 3; E-ray infer- and superradial narrowly separated by the 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, ×0.7 (Strimple, 1963a).

*Halsyocrinus* 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 radical, inferradials of B- and C-rays that adjoin above stem impression and beneath fused superradial of these rays, and 3-plate basal circle in which median element along hinge is low, acute plate (Moore, 1962a). L. Dev.–M. Dev.—L. Miss.—Osg. N. Am. (Iowa–Ind.–Ky.–Tenn.).—Fig. 326.4a–h. *H. dactylus* (Hall), L. Miss. (Osg.), USA (Iowa); A- and E-ray views of crown, ×1.6 (Springer, 1926a).—Fig. 326.4c, H. nodosus (Hall), L. Miss. (Osg.), USA (Ind.); A-ray view of crown, ×1 (Springer, 1926a).—Fig. 326.4d. *H. perplexus* (Shumard), L. Miss. (Osg.), USA (Ky.); exterior of cup showing radials and basals fully extended from hinge, ×1.3 (Springer, 1926a). [Also Fig. 324.5.]

*Senarioscrinus* Schmidt, 1934, p. 16 [*S. maucherii*; 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. (EMS.), Eu. (W.Ger.).—Fig. 330.1. *S. maucherii*, Hunsrück Sh., near Bundenbach; la, view of holotype from D-ray side, E arm at right and elongate anal sac left, ×0.85 (Schmidt, 1934); lb,c, tip of anal sac, D-ray view of crown, ×0.85, enl. (Moore, 1962a).

*Synchirocrinus* Jaeckel, 1918, p. 86 [*S. anglicus* (=Calceocrinus nitidus Bather, 1893a, p. 91); OD]. [=Cheirocrinus anglicus, in Murchison, 1859, p. 535 (nom. nud.); Cheirocrinus Salter, 1873, p. 118 (type, C. serialis); SD Moore, 1962a, p. 26 (non Eckwald, 1856, nec Hall, 1860); Pendulocrinus Salter, 1859, p. 535 (nom. nud.);] Crown with perfect bilateral symmetry, resembling *Cheirocrinus* 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 *Deltacrinus* in its well-marked, curved main-axils and much more numer-
ous axil-arms. It most closely resembles *Halysio­
crinus*, but differs especially in its more robust
beta-ramules and largely concealed axil-arms.]——
Fig. 330,2a. *S. tucanus* (Bather), U.Sil.(Wen­
lock.), 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, X2 (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 show­
ing only beta-ramules visible in upper part of
crown, X1.3 (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 con­
cal axil-arms, X2 (Springer, 1926a). [Also Fig.
324,4; 331,1.]

Superfamily PISOCRINACEA

Angelin, 1878

[nom. trans., Moore & Lane, in Moore & Stirmple, 1973,
p. 16 (ex Pisocrinidae Angelin, 1878, p. 20).] [Materials
for this superfamily prepared by R. C. Moore and N.
Gary Lane]
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 Allageocrinidae, Catilloocrinidae, and Anamesocrinidae some large multifaceted radials with threadlike unbranched arms. Small stem transversely round. *M.Sil.* (Wenlock, Niagaran)-*U.Dev.*

**Family PISOCRINIDAE Angelin, 1878**

[Poecilocrinidae ANGELIN, 1878, p. 20] [Poecilocrinidae De LORIOL, 1882-84, p. 46; Triacrinidae JAEKEL, 1918, p. 89; Carrocrinidae 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, interfacial 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 interfacial 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 $B$ interfacial comprise most of the theca. Anal $X$ small, situated above cup and in contact with upper corners of $C$ and

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**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.
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, X2; 1e-g, U.Sil., Eng.; lat., dorsal, and ventral views of cup, X2 (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-
between 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.; 5a-d, C-ray, AE-interray, B-ray, and E-ray views of cup and proximal brachials, X1; 5e, plate diagram of cup, X1; 5f, lat. view of crown and stem, X0.5 (Schmidt, 1934).

Cicerocrinus 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. Secundibrachs bear stout unbranched ramiules on alternate sides of every second brachial. U.Sil., Eu.(Eng.-Sweden-USSR).—Fig. 332,3.*C. elegans*, Eng.; 3a, lat. view of crown and stem, X1.5; 3b, lat. view of arms, X2 (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*; 2a-d, diagrams of lat. view of cup, basal view, plate diagram of cup, X2, 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 circlct 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. 332,4a,b.*P. ollula* (Angelín), U.Sil., Boh.; basal and B-ray view of cup, X5 (Bouška, 1956).—Fig. 332,4c,d.*P. quinguelobus* (Bather), U.Sil., Boh.; CD-interray and basal views of cup, X5 (Bouška, 1956).

Triacrinus Münster, 1839, p. 3 [*T. pyriformis*; SD Wächsmuth & 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 pententalate in oral or aboral view. U.Sil.-U.Dev., Eu.(Ger.-Gotl.-Boh.-USSR).—Fig. 333,1a-e. *T. regnellii* Bouška, U.Sil., Boh.; 1a-e, CD-interray, E-ray, BC-inter-

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**Fig. 333. Pisocrinidae (p. T536-T537).**
Family ALLAGECRINIDAE
Carpenter & Etheridge, 1881

[Allagecriniæ Carpenter & Etheridge, 1881, p. 292]

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 conical or bowl shaped; basal radials 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 interray remarkably developed in several genera. Ord.; ?Sil.; Dev.-Perm.

Family ALLAGECRINIDAE
Carpenter & Etheridge, 1881

[Allagecriniæ Carpenter & Etheridge, 1881, p. 292]

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 conical or bowl shaped; basal radials 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 interray remarkably developed in several genera. Ord.; ?Sil.; Dev.-Perm.

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; basal radials 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 interray remarkably developed in several genera. Ord.; ?Sil.; Dev.-Perm.

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 Desmacriorcinus, Kallimorphocrinus, and Trophocrinus excluded), and 2) distinct to strongly accentuated development of homocrinoid bilateral symmetry. Commonly, the C radial is developed as an aural radial but in some allagecrinine forms it is not.
### Table 6. Arms and Basal Plates of Allageocrinidae and Catillocrinidae.

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

<table>
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<tr>
<th></th>
<th>D</th>
<th>E</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Total</th>
<th>BB</th>
<th>Ref.</th>
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<td>3</td>
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<td>4</td>
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<td>1</td>
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<td>5</td>
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<td>1</td>
<td>1</td>
<td>1</td>
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<td>5</td>
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<td><em>Metallagecrinus dux</em></td>
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<td>5</td>
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<td><em>Xenocatillocrinus wrighii</em></td>
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*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). Circlet 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 columns narrowing distally. U.Dev.—L.Miss. (Kinderhook—Otto.), USA (Mo.—N. Mex.); L.Carb. (Visean), Eu. (Scot.). — Fig. 335, 7a—d. *A. austini*, L.Carb. (Visean), Scot.; 7ab, 7c, 7d—f, E- and B-ray views of specimen with attached proximal primibrachs and part of tapering stem, X10; 7c, d, C-ray and dorsal views (A ray below) of cup, X10 (all Wright, 1951—54). — Fig. 335, 7e—j. *A. americanus* (Rowley), U.Dev. (Louisiana Ls.), USA (Mo.); C-ray and ventral views of cup, X20 (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, 2. *D. weldenensis* (Strimple & Koenig), L.Miss. (Welden F.), USA (Okla.); 1a—c, ventral, CD-interray, and A-ray views of holotype, X17; 1d—f, ventral, CD-interray, and dorsal...
views of paratype, ×17 (Strimple & Koenig, 1956).

** Isoallagecrinus Strimple, 1966, p. 105 [*Allagecrinus basleri 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. (Atokan)-L. Perm. (Wolfcamp.), USA (Texas-Okl.-Kans.-Mo.-Ill.). —— Fig. 335,3. *b. basleri (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, ×4; 3b,c, ventral (A ray above) and dorsal (A ray below) views of typical cup, ×4; 3d, dorsal view of small immature stage showing stelliform shape of cup, ×4 (all Strimple, 1938).

** Kallimorphocrinus J. M. Weller, 1930, p. 15 [*K. austrinus (≡ K. austrinus austrinus), p. 17; OD] [= Aidemocrinus J. M. Weller, 1930, p. 28 (type, A. australis; 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. australis* (Weller), Table 6), left shoulder of C radial not beveled for support of anal plate; summit with circlet 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*, *Aloeatilloerinus*) 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-Ortog.), USA (Okla.-Mo.-N. Mex.-Nev.); L. Carb. (Visean), Eu. (Scot.); L. Penn. (Morrown.), USA (Ind.-Ill.-Mo.). —— Fig. 335,4. *K. australis, L. Penn., USA (Ind.); 4a,b, lat. and dorsal views of holotype, ×20; 4c, ventral view of another specimen, ×20 (all J. M. Weller, 1930).

** Metallagecrinus Strimple, 1966, p. 109 [*Allagecrinus quinquembrachiatus Wanner, 1929b, p. 24; OD].** Cup evenly expanded upward, truncate conical; basals 3 or solidly fused, low to medium in height and visible from side; radials 5, subequal, each normally with single arm facet; circlot of 5 orals moderately elevated, posterior oral separating *BC* and *DE* orals; like *Kallimorphocrinus* in lacking anal notch. L. Perm. (Artinsk.-U. Perm. (Basle bed), Eu. (USSR)-Indon. (Timor). —— Fig. 335,8. *M. quinquembrachiatus (Wanner), U. Penn., Morrown. (Basle); 8a,b, A-ray and dorsal views of holotype, ×5; 8c, ventral view of holotype (A ray directed upward), ×7.5; 8d,e, B-ray and ventral views of another specimen, ×5; 8f, CD-interray views of another cup, ×5 (all Wanner, 1929b).

**Stereostrachocrinus Mathers, 1915, p. 108 [*S. pustulossus*, 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. (Morrown.), USA (Okla.-Ark.). —— Fig. 335,6. *S. pustulossus, Brentwood Ls. mbr., Bloyd Sh., NW. Ark. (Washington Co.); 6a,b, side and outer surface of typical arm, ×1.5 (Moore & Plummer, 1938).

**Thaminocrinus Strimple & Watkins, 1969, p. 217 [*Allagecrinus biplex 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 circlot in adults. L. Carb. (Visean), Eu. (Scot.). —— Fig. 336,1. *T. biplex (Wright); 1a-d, C-ray, E-ray, ventral, and B-ray views of typical specimen, ×12 (Wright, 1941).

**Trophocrinus Kirk, 1930, p. 210 [*T. timidus*, OD].** Calyx tall conical to pyriform, morphologically similar to *Kallimorphocrinus* except for hypertrophic extensions of summit parts of some radials so as to form pucklike 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 circlot evenly domelike, with posterior oral distinctly largest. [Kirk’s inter-

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**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.]

<table>
<thead>
<tr>
<th>Species</th>
<th>D</th>
<th>E</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allagecrinus austini</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Allagecrinus americanus</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Isoallagecrinus pecki</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Kallimorphocrinus angulatus</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>
Fig. 334. Diagrammatic dorsal side views (not to scale) showing structure of allagecinid 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).

Examination of the marginal extensions borne by some radials as development of a type of brood pouch is discounted, especially since such pouches appear in T. bicornis (Strimple &
Fig. 335. Allagecinidae (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, X25; 2c,d, ventral (posterior oral down) and dorsal (C radial down) views of holotype, X25 (Kirk, 1930).

Wrightocrinus Moore, 1940, p. 92 [*Allagecinus jakovlevi Wanner, 1929b, p. 15; OD]. Calyx small (height 1.5 to 4.5 mm.), pyriform or low

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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 columns next to cup, tapering distally. L.Miss. (Oasg.-), USA (Ky.-Tenn.-Ind.-Iowa).—Fig. 337, 2a-e. *C. tennesseae, New Providence F., USA (Ky.); 2a-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 x1 (Moore & Laudon, 1943a).—Fig. 337, 2d,e. C. wachsmuthii (MEEK & WORTHEN), up. Burlington Ls., USA (SE. Iowa). 2d, B-ray view of well-preserved crown, x1.5 (Wachsmuth & Springer, 1886); 2e, BC-interray view of another crown, x1.5 (Springer, 1923a).

**Acologicrinus** Kesling & Paul, 1971, p. 228 [*A. hydraulicus; OD*]. Cup truncate conical below rounded midheight and vertical sides above; basal circllet 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., Otossee Gr., Russell and Scott Counties, SW. Va., and Hawkins County, SE. Tenn.; 2a-c, dorsal, D-ray, and E-ray views of holotype, X4 (Kesling & Paul, 1971); 2d, plate diagram showing proximal parts of arms (Moore, n. based on Kesling & Paul, 1971, fig. 3).

[Acolocrinus is like Allagecrinidae and at least five catillocrinid genera (Catillocrinus, Wrightocrinus, Eucatillocrinus, Allotaxocrinus, and Paracatillocrinus) in having a tripartite basal circlet with 1 small and 2 large plates, although only in Paracatillocrinus 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 BC 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 arm left parts of radials links Acolocrinus with Agostocrinidae.]

**Agostocrinidae** Kesling & Paul, 1971, p. 222 [*A. xenus; OD*]. Cup round bowl shaped, truncate with 3 equal basals, 5 moderately tall radials with prominent leafward 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-
Fusinotata—Disparida—Allagecrinacea

Fig. 337. Catillocrinidae (p. T542, T545-T547).

fully 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-
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 circlet of Myocrinus, 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.]

Allocatillocrinus WANNER, 1937, p. 109 [*Allagocrinus carpenteri* WACHSMUTH, 1882, p. 48; OD]. Crown tall and slender. Cup generally similar to
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 (III.-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 (Okl.); 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 Allocatillocrinus stage), all X3 (Moore, 1940b).—Fig. 339,13. *A. carpenteri (Wachsmuth), U.Miss.(Chester); 13a, B-ray view of crown from Monroe Co., Illinois, X 1.5 (Moore & Laudon, 1943a); 13b, C-ray view of crown with attached stem from Tennessee, X 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 circle 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. (?Atokan), USA (Alaska).—Fig. 340.2. *E. bradleyi (Meek & Worthen), Miss.(Kekuk), Crawfordsville, Ind.; C-ray view of incomplete crown with attached long stem and anal tube, X1 (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.Ferm., 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 X2 (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 flange-like part and laterally less extended subshperical 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 (Okl.).—Fig. 337,6. *M. bulbosus, Altamont Ls., Tulsa Co., Okla.; 6a-c, 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 X5 (Moore & Strimple, 1942).

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Mycoerinus SCHULTZE, 1867, p. 110 [*M. boletus; M*]. Cup with lower half consisting of massive, vertical-sided basal circlet composed of 2 or 3 plates and upper half of broadly flaring radial circlet similar to Catillocrinus in having wide multifaceted A and D radials, others bearing single arms (Fig. 334; 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, ×2; 1d-f, basal circlet from A-ray, ventral, and dorsal sides, ×2 (all Schultze, 1867).

Neocatillocrinus WANNER, 1937, p. 117 [*N. incissus; OD*]. Cup moderately small (greatest width about 9.5 mm.), bowl shaped, with low, fused, vertical-sided circlet, visible from side, surmounted by strongly bulbous radials, in all except E ray divided into upper and lower halves by transverse constriction as in Metacatillocrinus, lower parts rather evenly bulbous and upper parts flaring sideward; arm distribution on radials similar to that of Allocatillocrinus (Fig. 334,7), left shoulder of C radial with attachment for anal plate. U.Per.(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, ×3 (Wanner, 1937).

Paracatillocrinus 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 circlet composed of 3 or 2 plates or single fused plate, visible from side; strongly convex radials flare outward, distribution of arms in pattern of Catillocrinus (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 columns. U.Per.(Basleo beds), Indon.(Timor, Basleo).—Fig. 340,1a-e, i-k. *P. granulatus; 1a-c, CD-interray, A-ray, and dorsal (CD interray upward) views of holotype, ×2 (Wanner, 1916a); 1d,e, dorsal (B ray downward) and ventral (B ray upward) views of paratype, ×2 (Wanner, 1916a); 1i,j, complete crown with attached proximal part of stem from A- and D-ray sides, ×2 (Wanner, 1930a); 1k, complete specimen (reconstr.) showing presumed mode of attachment and pendent attitude of crown, ×1 (Wanner, 1930a).—Fig. 340,1f-h. P. ellipticus WANNER, BC-interray, dorsal (BC interray upward), and ventral (BC interray downward) views of cup with attached proximal columnal, ×2 (Wanner, 1924).

Xenocatillocrinus WANNER, 1937, p. 119 [*X. wrighti; OD*]. Cup very low, turreted-discoid (greatest width about 10.5 mm.), with vertical-sided basal circlet 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.Per.(Basleo beds), Indon.(Timor,
Family ANAMESOCRINIDAE
Golding, 1923

[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, X3 (Goldring, 1923); 3d, plate diagram of cup and arm bases (radials and superradials black, inferradials horizontally ruled, anal X stippled), X7 (Moore, 1962b).

Family HAPLOCRINITIDAE
Bassler, 1938

[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. sphaeroides (=Eugeniocrinites mespiliformis Goldfuss, 1831, p. 213) (subj.; M) [=Asterocrinus Münster, 1839, p. 4 (type, A. murchisoni); Asterocrinites Roemer, 1851, p. 390; Haplocrinus Roemer, 1855, p. 63 (nom. van.); Aplocrinus d’Orbigny, 1852, p. 63 (nom. van.))]. Theca small, bipyrmaiidal; 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 sums; 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, X8 (Wachsmuth & Springer, 1886).—Fig. 341, 2e-f. H. clio (Hall), M.Dev., N.Y.; dorsal, ventral, C+, and D-ray views of theca, X4 (Goldring, 1923).

Family TUNGUSKOCRINIDAE
Arendt, 1963

[Cup with homocrinid (E-ray) bilateral symmetry. Arms branching once isoto-
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 superradial, supporting longitudinal series of large tube plates which taper in width distally. Arms stout, rounded, branching once isomously 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. 341,1. *T. ivanovae*; la-c, post., dorsal, and ant. views of crown, X1.3 (Arendt, 1963).
Superfamily HETEROOCRINACEA
Zittel, 1879

[nom. correct. Moore & Lane, in Moore & Strimple, 1973, p. 17, pro Heterocrinidae Usinger, 1953, p. 347 (nom. transl. ex Heterocrinidae Zittel, 1879, p. 340)] (=Heterocrinites JAEKEL, 1918, p. 84 (suborder) [parsum]) [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. (Cincinnat.).

Family HETEROOCRINIDAE Zittel, 1879

[=Heterocrinidae DE LORIOL, 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 isomotomously several times. M.Ord. (Mohawk)-U.Ord. (Cincinnat.).

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. (Cincinnat.). Can. (Ont.)-USA (Ohio-Ky.-N.Y.).—Fig. 342.2. *H. heterodactylus* HALL, U.Ord., Ohio; 2a, D-ray view of crown, X2 (Meek, 1873); 2b, AB-inter-ray view of cup, X4 (Moore, n; Univ. Chicago 3136); 2c,d, plate diagrams of cup and parts of crown, 2d 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*; 1a,b, C-ray and E-ray views of cup, X1.3, X1.7; 1c, A-ray view of arms, X1.7; 1d,e, E-ray and C-ray diagrams of cup; 1f-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).

Atypocrinus ULRICH, 1925, p. 85 [*Heterocrinus (Atypocrinus) corryvillensis* 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 heteromorphously on every fourth or fifth brachial. U.Ord. (Cincinnat.). USA (Ohio).—Fig. 342.3. *A. corryvillensis* ULRICH; 3a, D-ray view of crown, X1.5 (Ulrich, 1925); 3b, ant. view of crown, X2 (Ulrich, 1925); 3c, plate diagram of cup (inferradials horizontally ruled, superradials black, fixed primibrachs vertically ruled, anal plates stippled) (Moore 1962b).

Columbocrinus 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*; 4a,b, A-ray view of cup and plate diagram of cup and proximal arms (symbols as in Fig. 342.3c) (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 anal. First primibrachs fixed in cup; second primibrachs axillary in all rays; brachials thin, rounded; arms heteromorphous, 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. (Cincinnat.). USA (Ohio).—Fig. 343.3. *D. crusus* ULRICH; 3a, plate diagram (symbols as in Fig. 342.3c) (Moore, 1962b, after Ulrich, 1925); 3b-d, cross sec. of cup, column, and anal sac, X1 (Ulrich, 1925); 3e,f, post. and B-ray views of crown, X1.5 (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*; 2a,b, plate diagrams of crown

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and anal sac, X1 (Symbols in 2a as in Fig. 342,3c) (Moore, 1962b, Ulrich, 1925).

**Ohiocrinus** 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. (Cincinnat.), USA (Ky.-Ind.-Ohio).—Fig. 343,1a,b. *O. laxus* (Hall), U.Ord., Ohio; 1a,b, post. and AB-interray views of crown, X2, X1.5 (Meek, 1873).—Fig. 343,1c-e. *O. braunii* Ulrich, U.Ord., Ind.; 1c-e, E-ray and post. views of crown, and sketch of anal sac, X3.6 (Ulrich, 1925).

**Superfamily**

**MYELODACTYLACEA**

S. A. Miller, 1883

*[nom. transf. Moore & Lane, in Moore & Stimple, 1973, p. 17 (ex Myelodactylidae S. A. Miller, 1883a, p. 278)]* =superfamily Iocrinidae URBACH, 1953, p. 744 (nom. transl. ex Iocrinidae Moore & Laudon, 1943, p. 29) [non order Myelodactylidae 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.
Column transversely pentagonal, round, or bilaterally symmetrical subcrescentic and disposed in 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 isomorphously or heteromorphously. *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.
**Echinodermata—Crinoidea**

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), 7U.Dev.(Chenung);* Eu.(Gtol.-Eng.-Oer.)-USA (N.Y.-Tenn.-Ind.-W.Va.-Ill.).—Fig. 344,ia-d. *M. convolutus*, U.Sil., N.Y.; 1a,b, lat. views of coiled stem and cirri, X 1; 1c, inward side of distal columnals showing concave inner surface and cirral sockets along edges, X 1.5; 1d, articular surface of distal columnal, X 4 (Springer, 1926b).

---Fig. 344,1e-i. M. *keyserensis* SPRINGER, L. Dev., W.Va.; 1e, lat. view of stem and crown, X 1.5; 1f,g, views of stem and cirri from side and in plane of coil, X 1; 1h,i, E-ray view of partial crown and plate diagram, X 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, X 1 (Springer, 1926b).

**Crinobracchatus MOORE, 1962, p. 43 *[Myelodactylus brachiatus HALL, 1852, p. 232; OD]*. Crown poorly known, apparently like *locrinus* 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 outward; 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, X 1.5; 3b,c, lat. views of distal part of stem, X 2; 3d, X 1.5 (Springer, 1926b).

**Eomyelodactylus FORKSTE, 1919 *[Myelodactylus] rotundatus FORKSTE, 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 Lc.), USA(Ohio).—Fig. 344,4. *E. rotundatus* FORKSTE; 4a,b, lat. view of column and articular surface of column showing pentameres and lens-shaped lumen, X 1.5, X 4 (Forseste, 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, heteromorphous, branching repeatedly; cirrals short, round 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, X 1, X 1.5; 1c,d, C-ray and E-ray views of cup, X 6; 1e, plate diagram of cup and proximal brachials, X 1 (Springer, 1926b); 1f-k, same species from Gotland, X 6; 1l, anal tube plates from right and left sides, X 6; 1m,n, lat. and transvers. views of distal columnals and cirri, X 3; 1o, lat. view of crown and column, X 1.5; 1p, lat. view of partial crown and proximal stem, X 3 (Bather, 1893a).

**Family IOCRINIDAE Moore & Laudon, 1943**

[=Iocrinidae MOORE & LAUDON, 1943a, p. 29] Compound radial in C ray only; super­radial supports anal X on left side and free arm on right. Arms with many isomorphous 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 (locri­nus) polyxo HALL, 1866, p. 5 (=Heterocrinus suberasus 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 isomorphously up to 8 times. Column transversely pentobalte. ?L.Ord.(Arenig.), M. Ord.(Llanvirn.)-U.Ord., Eu.(Wales-Eng.), USA (Ill.-Ohio-N.Y.)-Can.(Ont.).—Fig. 346,2a,b. *I. suberasus* (MEEK & WORTHEN), U.Ord., Ohio; lat. views of crown, X 1 (Hall, 1872).—Fig. 346,2c-f. I. crassus (MEEK & WORTHEN), U.Ord., Ohio; 2c,d, A- and D-ray views of cup, X 1.5 (Hall, 1872); 2e,f, A-ray and CD-interray views of crown, X 1.5 (Meek, 1873).

**Caleidocrinus WAAGEN & JAHN, 1899, p. 106 *[C. multiramous; SD Bassler, 1938, p. 56] [=Caleidocrinus WAAGEN & JAHN, 1892, p. 399 (nom. nud.); Caleidocrinus JAEKEL, 1902, p. 1075 (obj.) (nom. var.)]*. Cup small, low, plates arranged as in Iocrinus. Small, rounded interbrachial plates present between proximal parts of arms above radials. Arms isomorphous, branching repeatedly. Stem transversely round. M.Ord.(Llanvirn.), Eu.
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 isotonously 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 brachia Is vertically ruled, anal plates stippled) (Moore, 1962b); 1b,c, AE-interray and C-ray views of crown, X5 (Lane, n; Springer Coll., U.S. Natl. Museum).

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, X2.25 (Wetherby, 1880b); 2b, AE-interray view of crown, X3.75; 2c, d, post. and ant. views of proximal part of crown and stem, X6 (Moore, 1962b).

Rameyocrinus Bates, 1968, p. 406 [*Dendrocrinus cambriensis Hicks, 1873, p. 50; OD]. Cup composed of 7 or 8 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 brachia not fixed in cup. Arms strongly rounded, branching isotomously 3 or more times. Stem transversely wide, quadirolobate, 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, X5 (Bates, 1968).

Ristnacrinus Opik, 1934, p. 3 [*R. marinus; OD]. Cup high conical, truncate below; basals fused with proximal columnal or absent, not visible; large quadratic 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, 1. *R. marinus*; 1a, E-ray view of crown and stem, X2; 1b, C-ray view of cup and proximal arms, X2.9 (Opik, 1934).

**Superfamily**

**ANOMALOCRINACEA**

Wachsmuth & Springer, 1886

[nom. transl. Moore & Lane, in Moore & Strimple, 1973, p. 17 (for 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)]


Anomalocrinus MEEK & WORTHEN, 1865, p. 148

[*Heterocrinus? (Anomalocrinus) incurvus MEEK & WORTHEN, 1865b, p. 148; M] [=Ataxiacrinus Lyon, 1869, p. 464 (type, *A. caponiiformis*); 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 circle. 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.(Cincinnat.), USA(Ohio).—Fig. 349, 1. *A. incurvus* (Meek & Worthen); 1a,b, post. and ant. views of crown, X1; 1c, articular surface of columnal, X2 (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
its admedian 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, ×1; 2b, c, plate diagram and arms of one ray with ramules given off on inward sides, ×2; 2d, e, aboral surface of brachials and ramules and articular surface, ×4 (Ulrich, 1925).

**Glaucocrinus** 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.),

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*Fig. 348. Eustenocrinidae (p. T554-T555).*
N.Am.(Can., Ont.).—Fig. 349,3. *G. falco[neri]; post. view of crown, X1 (Parks & Aleck, 1912).

Superfamily
BELEMNOCRINACEA
S. A. Miller, 1883

[nom. transl. Moore & Lane, in Moore & Srymple, 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.; UPerm.

Family BELEMNOCRINIDAE
S. A. Miller, 1883

[Belemnocrinidae S. A. Miller, 1883a, p. 276] [=Belemn. nocrinidae 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 rambles. L.Miss., USA (Iowa-Mo.).—Fig. 350,1.

*Belemnocrinus* White, 1862, p. 14 [*B. typus; M*] [non Belemnocrinus Munier-Chalmes, 1876, p. 105, =Belocrinus (blastoid)]. Cup small, narrow and tall; basals 5, elongate, conspicuously larger than radials, which are small and quadrangular. Radial 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 rambles 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, X1 (Wachsmuth & Springer, 1885).

*Whiteocrinus* Jaeckel, 1918, p. 58 [*Belonocrinus 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 with cirriferous nodals. L.Miss., USA (Iowa).—Fig. 350,3. *W. florifer (Wachsmuth & Springer); lat. view of crown, X1 (Wachsmuth & Springer, 1885).

Family HOLYNOCRINIDAE
Bouska, 1948

[Holynocrinidae Bouska, 1948, p. 521]

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**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, X2 (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, X1.5 (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, ×2, and plate diagram of theca (Schmidt, 1942).

**Family PYGMAEOCRINIDAE**

Strimple, 1963

[Pygmaeoocrinidae STRIMPLE, 1963a, p. 36]

Theca small, with perfect pentameral 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** Bouska, 1947, p. 2 [*P. keitneri;
I nad unata-Disparida-Belemnocrinacea T559

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 five 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. *S. conicus* (MueLLER), M.Dev., Ger.; 2a-d, C-ray, D-ray, ventral, and dorsal views of cup, X2 (Schultze, 1867).

Family SYNBA ThOCRINIDAE

S. A. Miller, 1889

[Cup small; 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.]

Storthingocrinus SCHULTZE, 1867, p. 181 [*Platy­
crinus 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* (MÜL­
LER), M.Dev., Ger.; 2a-d, C-ray, D-ray, ventral, and dorsal views of cup, X2 (Schultze, 1867).

FIG. 351. Pygmaeocrinidae (p. T558-T559).
Echinodermata—Crinoidea

**Synbathocrinus** 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, X2 (Strimple, 1952c).

**Phimocrinus** Schultze, 1866, p. 29 [*P. laevis*; *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, X2 (Schultze, 1867); 1d, plate diagram of cup (radials black, A ray upward) (Moore, n).


**Stylocrinus** Sandberger & Sandberger, 1856, p. 399 [*S. scaber* (attributed to *Platyocrinus scaber* Goldfuss [nom. nud.] by Sandberger & Sandberger); M]. Cup low; basals 5, or rarely 3, with small basal in DE interray; 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, X3, X6, X12 (Sandberger & Sandberger, 1856).

**Taidocrinus** Tolmachyev, 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 interray downward in 5b,c), X2 (Wanner, 1916a).

**Thelocrinus** 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. 352. Synbathocrinidae (p. T559-T560).](image_url)

interray and ventral views of adult cup, X10; 1g,h, ii,j, 1k,l, 1m,n, 1o,p, CD-interray and ventral views of successively more mature juvenile cup, X10 (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, X2 (Strimple, 1952c).

**Phimocrinus** Schultze, 1866, p. 29 [*P. laevis*; *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, X2 (Schultze, 1867); 1d, plate diagram of cup (radials black, A ray upward) (Moore, n).


**Stylocrinus** Sandberger & Sandberger, 1856, p. 399 [*S. scaber* (attributed to *Platyocrinus scaber* Goldfuss [nom. nud.] by Sandberger & Sandberger); M]. Cup low; basals 5, or rarely 3, with small basal in DE interray; 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, X3, X6, X12 (Sandberger & Sandberger, 1856).

**Taidocrinus** Tolmachyev, 1924, p. 289 [*T. poljewowi*; 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 interray downward in 5b,c), X2 (Wanner, 1916a).

**Thelocrinus** 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. 352. Synbathocrinidae (p. T559-T560).](image_url)

interray and ventral views of adult cup, X10; 1g,h, ii,j, 1k,l, 1m,n, 1o,p, CD-interray and ventral views of successively more mature juvenile cup, X10 (Moore & Ewers, 1942).
Family ZOPHOCRINIDAE
S. A. Miller, 1892

[Cophocrinidae S. A. Miller, 1892b, p. 642] (=Tiaracrinidae Bathër in Lancaster, 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
Fig. 354. Synbathocrinidae (p. T560).

interoral 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, ×4 (Springer, 1926b); 1c-e (Tenn.), dorsal, lat., and ventral views, ×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, ×1.5; 1c, dorsal view of another specimen, ×1.5 (Strimple, n).

Tiaracrinus Schultze, 1867, p. 226 [*T. quadrifrons; M] [=Staurosoma Barrande, 1887, p. 21 (obj.); (type, S. rarum Barrande, 1887, =T. quadrifrons)]. 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 epispira. 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. quadrifrons; M.Dev., Ger.; 2a,b, CD-interray and dorsal views, ×2; 2c,d, dorsal and ventral views, ×3 (Springer, 1926b).

Superfamily PERITTOCRINACEA Ubaghs, 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 endothecal 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, *Peritocrinus* 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 *Peritocrinus*. 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. Peritocrinids are here classified as a separate superfamily of the Disparida because they do not seem to be closely related to any other Ordovician dispers.

**Family PERITOCRINIDAE Abel, 1920**  
[Peritocrinidae *Abel*, 1920, p. 254]

Cup globose, composed of four basals, five large radials, radial, anal $X$, and numerous small to medium-sized accessory plates between primary cup plates and smaller triangular accessory ones. Stem, arms, and tegmen unknown. **Up.L.Ord. or low.M.Ord.**

*Peritocrinus* **Jaekel**, 1902, p. 1093 [*Porocrinus radiatus* Beyrich, 1879, p. 61; SD Bassler, 1938, p. 150]. Peritocrinids with endothecal pore slits extending across sutures between all cup plates, including accessory plates. Enlarged proximal columnals composed of tetramerides. Arms and tegmen unknown. **Up.L.Ord. or low.M.Ord., Eu.(NW.USSR).**—Fig. 357,1a-c. *P. radiatus* (Beyrich); 1a, plate diagram; 1b,c, ant. and post. views of cup, X5 (Ubaghs, 1971a).

*Tetracionocrinus* **Ubaghs**, 1971, p. 333 [*Peritocrinus transitor* Jaekel, 1918, p. 49]. Peritocrinids with raised hollow ridges extending across sutures between all cup plates, including accessory plates. Enlarged proximal columnals composed of tetramerides. Arms and tegmen unknown. **Up.L.Ord. or low.M.Ord., Eu.(NW.USSR).**—Fig. 357,1a-c. *P. transitor* (Jaekel); 1a, plate diagram; 1b,c, ant. and post. views of cup, X5 (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;**

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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 appendages have been drastically modified 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 radianal 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 radianal. 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 radianal 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 radianal (Fig. 364,2a). In relatively advanced genera such as Hybocrinus, Hybocystites, and Tripatocrinus, the anal X has moved down to become part of the cup above the radianal 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 pentameral symmetry. Because only one radial is compound (C radial plus radianal 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 circlets of cup plates, location of the hydropore and anal opening, comparison of the combined C radial plus radianal 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
T566 Echinodermata—Crinoidea

Tripatocrin

**Fig. 360.** Plate diagram of *Tripatocrinus* (Hybocrinacea, Cornucrinidae) (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 overlayering 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. 364,1c). 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. 365,1d). 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 *Cornucrinus*, 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, Cornucrinus*), 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,
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 ambulacra, 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": \( (A,C,D) \preceq (B,E) \) 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 disclike, 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*, *Hybobystites*). In most specimens of *Hybobystites*, 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.

HYBCRINID 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 paedomorphic 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), 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; O 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, parablastoids, and blastoids)
Order HYBOCRINIDAE Zittel, 1879

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 multiplicated 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, x1 (Billings, 1859); 1e,f, side and oral views of well-preserved theca showing multiplicated anal pyramid, hydropore, and ambulacral cover plates, x1 (Springer, 1911b).

Hoplocrinus Grewingk, 1867, p. 7 [*Apiocrinus dipentas LEUCHTENBERG, 1843, p. 17; M]. Cup slightly asymmetrical; radial 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-
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. dipentas* (Leuchtenberg), USSR; 2a, plate diagram (a, anus) (Sprinkle, n); 2b, complete specimen showing thecal shape, ?X1 (Grewingk, 1867). —Fig. 364, 2c,d. *H. laevis* Myannil, USSR (Est.); side
views of specimen with slightly enlarged proximal stem and attached arm, ×1.1 (Myannil, 1959).

---Fig. 364,2e. H. estonii ÖPIK, USSR(Est.); specimen showing details of crushed summit, incl. anal X, U-shaped brachials, and scattered ambulacral cover plates, ×1.2 (ÖpiK, 1935).---

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

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, ×2 (Grewingk, 1867).

Family HYBOCYSTITIDAE Jaekel, 1918

[nom. correct. Regnell, 1948a, p. 2 (pro Hybocystidæ 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,
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 periopercular 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 ambulacrum, orals, and ornamented radials, ×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, ×2; Ig, ventral view showing peristomial and ambulacral cover plates in place, anal pyramid, and hydropore, ×1.5; Ih, ant. view of abnormal specimen with ambulacrum from aborted or damaged A-ray arm extending down over cup onto proximal portion of stem, ×1.3; II, peristomial cover plates and hydropore, ×2.2; Ij, 3 rows of peristomial cover plates, ×8 (1e-j, Springer, 1911b).

Family CORNUCRINIDAE Regnél, 1948

[Coronariaeidae Regnél, 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 Regnél, 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, ×1.5; 1e-f, periproct and ambulacral cover plates, ×2.5, ×4; Ig, post. view of another specimen with long stem segment attached, ×1.3 (1b-g, Regnél, 1948a).—Fig. 366,1h-j. C. longicornis Regnél, U.Ord.; 1h, separate radial, ×1; Ii, (reconstr.) complete specimen in life position, ×1 (both Regnél, 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), ×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, ×1 (all Sprinkle, 1973b).

Order CORONATA Jaekel, 1918

[Coronata Jaekel, 1918, p. 109]

By R. O. Fay

Crinozoans with three circles of regularly arranged thecal plates, without pores and infolds of any type, with five biseri ally arranged arms. Basal circle 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-

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1 The author, R. O. Fay, would prefer to raise the order Coronata to the level of subclass because of incorporation of the lower brachial circle 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 interradial in position, each abutting against interradial and adjacent cover plates. Single large anal opening on aboral side of anal interradial plate at its junction with adjacent radial limbs, with four subtriangular cover plates.

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 Jäkeli, 1918, p. 110)


*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.; 7 M. Sil., Eu.(Eng.).—Fig. 367; 368,1. *S. angulatus, USA(N.Y.); 367, A ambulacrum, X31; 368,1a, oral view, X5; 368,1b, D-ray view, X4; 368,1c, anal view, X15; 368,1d, oral view with A-ray arms in place, X4.9; 368,1e, side view of A amb., showing aboral face of arms, X20 (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, X14 (Fay, 1960); 1b-d, side view, X8; right ant. (AB) interambulacrum showing deeply weathered coronal process with divided coelomic cavity appearing like 2 pores, X24; “C” ambulacrum showing cover plates and primaxil in place, X18 (Fay, n; Illinois Dept. Geology).—Fig. 369,1e. *S. osgoodensis* S. A. Miller, Niagara, Ind.; A ambulacrum showing sutures between interambulacral plates and radial plate, X22 (Fay, n).

*Mespilocystites* Barrande, 1887, p. 162 [*M. bohemicus; M*] [=Mespilocystis Bath, 1889c, p. 269 (obj.)]. Theca cup shaped, almost as wide as high, with coronal processes as long as theca, and apparently with interradial plates visible in side view, with strong ornamentation of thecal plates similar to pore-rhombs. *M. Ord.(D-D,) (Llandeil.-Caradoc.) , Eu.(Czech.).—Fig. 370,1. *M. bohemicus; 1a-c, oral, side, and aboral views, all X10 (Fay, 1962b); 1d, plate layout of B and C radials, X10 (Fay, n; Univ. Oklahoma Dept. Geology 2380A, 2380B, 2380C).

*Paracystis* Stjöberg, 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. ostrogothica*, Chasmops Ls., Östergötland; 2a-e, A, B-C, E, aboral, and oral views, all X5 (Regnéll, 1945).
Fig. 368. Stephanocrinidae (p. T575, T577).
Inadunata—Coronata

**Stephanoblastus** Jaekel, 1918, p. 110 [*Rhombitera? 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. (E3) (Ladlovi.), Eu.(Czech.).* —Fig. 368,3. *S. mirus* (Barrande), near Loděnice; 3a–d, side views, ×5 (Barrande, 1887); 3e, side view, ×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; 2a–c, oral, (A–B), aboral, anal, and side coronal process views, all ×10 (Jaekel, 1927a).
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. 10; 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.(Tremodoc.)-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 radial present but may decrease in number, arms simple or multibranched, 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,
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 isomtomously 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.-V.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

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

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 isomtomous with few to many branches, or rarely heterotomous. M.Ord.-U.Miss.; U.Perm.

**Family CYATHOCRINITIDAE**

Bassler, 1938

[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.): Sacrocomatis MEK & WORTTHEN, 1870, p. 25]. Cup bowl shaped to globose, with flat or gently convex base; radials
Fig. 372. Morphological features of representative Cyathocrinacea (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, radial plate; stippled, plates of anal series; heavy black line, plane of bilateral symmetry.]
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 isomously twice or more, first on axillary primibrachs 1 to 7; ambulacral covering plates large, stout, commonly preserved. Stem round or pentagonal in section. *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, X1; 373,1d, post. view of crown, X1 (Wright, 1951-54).—Fig. 373,le. *C. milleri (M'Coy), L.Carb.(Tournais.), Eu.(Ire.); lat. view of crown, X2 (M'Coy, 1862). [Revision of M'Coy's species of Irish crinoids by G. SEVASTOPOLO has resulted in transfer of *Atocrinus M'Coy in Griffith, 1844, from *Cyathocrinites to *Platy­crinites (G. SEVASTOPOLO, pers. comm.)]
Echinodermata—Crinoidea

?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 ex­ventral view of Gissocrinus T582 Echinodermata-Crinoidea

Gissocrinus ANGELIN, 1878, p. 10

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, declivately 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, Bateleo).—Fig. 373, 2f-g. *C. exornatus; 2f-g, ventral view of theca and proximal arms, ×1 (Wanner, 1937).—Fig. 375, 2h. C. gracilis WANNER; 2h, B-ray and dorsal views, ×2; 2h, ventral view of theca, ×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, =Actinocrinus? 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 isomerically 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, ×2 (Bather, 1893a).—Fig. 373, 3c,d. G. campanula BATHER, U.Sil., Gotland; 3c,d, dorsal and post. views of crown, ×1.5 (Bather, 1893a).

[Barycrinidae Jaekel, 1918, p. 59]

Family BARYCRINIDAE Jaekel, 1918

Crown large, cup broad bowl shaped; radials with relatively wide articular facets which are semicircular in outline, concave, and strongly declivately, 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 isomerically on primibrachs 2 or 3 and bearing nonpinunate ramules given off on alternate sides from every second brachial. Anal sac short, stout; anal opening terminal. Column transversely round, columns divided into pentameres or not. L.Dev.(Ems.); L.Miss.(Osag.)-U.Miss.(Merr.).

Barycrinus WACHSMUTH & WORTHEN, 1866c, p. 338 [*Cyathocrinus sparsus HALL, 1858b, p. 625; OD] [=Pottocrinus JILLSON, 1960, p. 37 (type, P. quintillus; OD)]. Crown large; commonly with anal X and radial in cup, rarely with anal X only (Fig. 372, 2). Arms long, robust, primibrachs 2 axillary, followed by isomerous or unbranched half-rays. Every second brachial generally a subaxial, supporting branched armlets or unbranched ramules. Anal sac low, with large plates, anal opening terminal. Circular columns composed of discrete pentameres. L.Miss.(Osag.).-U.Miss.(Meramec.), N.Am.(C.U.S.A.).—Fig. 372, 2; 374, 1a,b. *B. sparsus (HALL), Osag., USA(Ind.); 372,2, plate diagram (radials black, radial cross ruled, anal X stippled) (Moore, n); 374, 1a,b, post. and dorsal (C ray up) views, ×1 (Hall, 1858b).—Fig. 374, 1c,d. B. sp., Osag.(Keokuk), Iowa; 1c,d, radials, showing large, rounded articular facets, ×1 (Springer, 1911c).

Pellecrinus KIRK, 1929, p. 15 [*Cyathocrinus hexadactylus LYON & CASSEDAY, 1860, p. 74; M] [=Vasocrinus LYON ausctt. prior to 1929 (non Vasocrinus LYON, 1857, emend. KIRK, 1929a)]. Crown large. Cup low bowl shaped, commonly with anal X and radial, rarely with anal X only. Arms long, slender, dividing isomerically on primibrachs 3, regularly heteromorphous, with armlets alternately on opposite sides of each second brachial, which is subaxial; armlets similarly bearing ramules alternately on opposite sides of each second brachial. Anal sac conical, with longitudinal series of large plates above anal X. Columns divided into pentameres. L.Miss.(Osag.), N.Am.(C.U.S.A.).—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, ×1 (Hall, 1872).

Sinulacrinus BREIMER, 1962, p. 153 [*S. costatus;
Family EUSPIROCRINIDAE

Bather, 1890

[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 isotoomously 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.).]

Euspirocrinu$^*$ ANGE$^*$, 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 isotoomously 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, 3a,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, X1.5; 375,3b,c, post. view of crown and ant. view of theca, X1.5; 375,3d, ventral view of tegmen, X1.5 (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 isotoomously 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, X1 (Springer, 1926a).

Caecocrinus XIU, 1962, p. 46 [*C. stellifer; OD]. Cup low, bowl shaped, with moderate basal concavity, basals and radial plates 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; radial facets wider than high, and apparently with wide radial facets. Radial 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; OD]. Cp 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 isotoomously 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. *C. stellifer, 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, X1 (Springer, 1926a).
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, radianal, 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, ×1 (Hall, 1852); 4b, plate analysis of post. side of cup (radials black, radianal cross ruled, anal X and other analns stippled) (Hall, 1852, mod.).

Pariscrinus WACHSMUTH & SPRINGER, 1880, p. 109 [*Potericrininus perplexus MEERK & WORTHEN, 1869c, p. 138; OD]. Cup bowl to cone shaped, as wide as high; infrabasals large, visible in side view; radials polygonal, with narrow horseshoe-shaped articular facets; anal X, radianal, and right tube plate in cup. Arms narrowly rounded, branching isometrically several times, primibrachs 3 or 4 axillary. Anal sac large and porous or short and without pores, anal opening terminal. Madreporeite present on anterior side of tegmen at base of anal sac. [Devonian species have separate axial canal in radials.] M.Sil.(Niagaran)-L. Carb.(Tournefly), Eu.(Ger.-Eng.-Belg.-Iren.-USSR)-USA(Ind.-N.Y.-Ill.-Iowa).—Fig. 375,Ja,b. P. silvicrusus SPRINGER, U.Sil., USA (Ind.-Iowa); 1f,g, ant. and D-ray views of crown, ×1.5 (Springer, 1926a).—Fig. 375,Je-g. P. curtis (MÜLLER), M.Dev.(Givet.). Ger.; 1a,b, post. views of cup and partial crown, ×1; 1e-e, lat. view and transv. sections of stem, 1c,d; 1x2; 1e, 6 (Schultz, 1867).

Vascrinus LYON, 1857, p. 485 [*V. valens; OD] [non Vascrinus LYON, pre-1929 acct. (=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, 3 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 4 peripheral canals. Stem large, transversely round, with large central axial canal and 4 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 isometric 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,Je. L. briareus (SCHULTZE); post. view of crown, ×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 (radial 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,Ja,b, D-ray and post. views of incompl. crown, ×1.5 (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 radial 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 columnns with large obscurely quadripartite axial canal. M.Dev., USA (Ind.).—Fig. 372,Je; 375.8. *C. romingeri; 372,6a,b, plate diagrams of cup (radials black, radial cross ruled, anal X and higher anal plates stippled) (Moore, n; 1962b); 375,Ja,b, D-ray and post. views of incompl. crown, ×1.15 (Kirk, 1934).

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

Superfamily GASTEROCOMACEA
Roemer, 1854


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

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 isometrically three times or more, many slender arms in upper part of crown. Stem large, transversely round, with large central axial canal and 4 peripheral canals. M.Dev.(Givet.); L.Miss.(Osag.).
Family GASTEROCOMIDAE
Roemer, 1854

[Gasterocomidae Roemer, 1854, p. 299] [=Gasterocomidae 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; radial 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; Gasterocoma Beyrich, 1871, p. 50 (nom. van.).] Theca globular; infrabasals low, fused, barely visible in side view; arm facets horseshoe shaped, very steeply declivete, 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, X2 (Springer, 1911c); 377,5, plate diagram of cup (radials black, anal X stippled) (Moore, 1962b).

**Kopficrinus** 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, X1.3 (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 isomorphously 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; 5a,b, dorsal view of crown and C-ray view of cup, X1 (Goldring, 1923).

Myrtlocrinus Sandberger & Sandberger, 1856, p. 388 [*M. elongatus; M] [=Tripleurusinus 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., M.americanus Hall, N.Y.; 3a,b, lat. and dorsal views of theca, X2 (Springer, 1911c); 3c, ventral view of theca, X1 (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,la-d, CD-interray, ventral views of 2 specimens, and dorsal view of cup, X3 (Schultze, 1867); 377,6, plate diagram of cup (radials black, anal X stippled) (Moore, n).

Schutzicrinus 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; 2a, lat. view of crown and stem, X2; 2bc, articular surfaces of nodal and internodal, X1,3, X2; 2d, dorsal view of cup, X1,3 (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; 2a,b, ventral and DE-interray views of cup, X1 (Jaekel, 1895).

Family SPHAEROCRINIDAE

Jaekel, 1895

[Sphaeroocrinidae 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 radialan present; anal opening in side of cup or through low, flat tegmen; posterior oral larger than others and a madreporite where known; arms branching isomorphously or unbranched in one genus (Palaeocrinus) where known. M.Ord.; M.Sil.; M.Dev.

Sphaeroocrinus Roemer, 1851, p. 369 [*Cylindricites geometricus Goldfuss, 1831, p. 189; OD] [=Sphaeroocrinus Steiningera, 1853, p. 38 (nom. var.)]. Theca globose; infrabasals 5 or rarely 3; radials pentagonal, articular facets semicircular, with large axial canals; radianal 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 tegminal area composed of numerous small irregular plates. Arms and stem unknown. M.Dev. (Givet.), Eu.(Ger.).—Fig. 378,1a-c. S. paucisculptus Wanner; A-ray, CD-interray, and ventral views of theca, X1,15 (Wanner, 1942a).—Fig. 378,1d-f. *S. geometricus (Goldfuss); 1d, AB-interray view of typical specimen from Kerpen; 1e,f, dorsal and ventral views of smooth-surfaced theca, from same locality, all X1 (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; radianal 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.(Chasy.-Mohawk.), USA (Minn.-Ky.)-Can.—Fig. 377,4; 378,2. *P. striatus, Chazy., Que.; 377,4, plate diagram of cup (radials black, radianal cross ruled, anal X and higher analas stippled) (Moore, 1962); 378,2a,b, AB-interray and ventral views of theca, X2 (Lane, n; Springer Coll., U.S. Natl. Museum).

Thalamocrinus Miller & Gurlany, 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. 378,3a-c. *T. ovatus; CD-interray, ventral, and dorsal views of cup, X1 (Springer, 1926a).—Fig. 378,3d. T. cylindricus Miller & Gurley; CD-interray view of cup, X1 (Springer, 1926a).

Family POROCRINIDAE
Miller & Gurley, 1894

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 declivat; 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.-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); 379,2a, lat. view of crown, X3.3 (Lane, n; Springer Coll., U.S. Natl. Museum); 379,2b,c, post. and ventral views of cup, X7 (Lane, n); 379,2d,e, E-ray view of crown, X2.7, and plate diagram (Kesling & Paul, 1968).

Triboloporus Kesling & Paul, 1968, p. 13 [*T. cryptopicatus; 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. cryptopicatus, Va.; 1a-d, ventral, oblique CD-interray, C-ray, and d-ray views, X2.7; 1e, thecal diagram; 1f, CD-interray view, X5.3 (Kesling & Paul, 1968).

Family CARABOCRINIDAE Bather, 1899

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

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 superradianal in cup, infer- and superradianal in contact with 2 infrabasals, CD and BC basals, superradianal above infer- and superradianal, 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 superradianal cross ruled, anal X stippled) (Moore, 1962b). [Restudy of Sardeson’s type specimens by J.
Brower, results as yet unpublished, reveals that Strophocrinus is a junior subjective synonym of Caraboainus.—J. Brower (pers. comm., Aug., 1968).

Family CROTALOCRINITIDAE

Bassler, 1938

[Crotalocrinidae, 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.).

Crotalocrinitites 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, X2 (Springer, 1926a).—Fig. 380,1d. C. pulcher (Hisinger), Gotl.; lat. view of crown, X0.7 (Springer, 1926a).—Fig. 380,1e. C. sp., Gotl.; ventral view of theca, X1 (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, X1.5 (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 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, X2; 2c,d, CD-interray and dorsal views

Fig. 380. Crotalocrinididae (p. T591).
Enallocrinus D'ORBIGNY, 1850, p. 46 [*Apiocrinites 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);

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. 381. Crotalocrinitidae (p. T591-T592).
ommens with wide circular lumen about four-fifths width of stem. L.Dev., USSR (C. Urals).——
Fig. 382.3. *P. subiricus; 3a,b, lat. view of fragmentary proximal columnals and cup, and dorsal view of arm fragment, ×1.3 (Lane, n; mod. from Arendt & Gekker in Orlov, 1965).
Perneroocrinus Boužka, 1946, p. 18 ["P. paradoxus; OD"]. Crown large, mushroom shaped; stem, cup,
Fig. 383. Petalocrinidae (p. T594).

Family PETALOCRINIDAE
Weller & Davidson, 1896

[Petalocrinidae Weller & Davidson, 1896, p. 167]

Cup small, radial 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).--Fig. 383, 1a,b. P. inferior BATHER, Iowa; 1a,b, ventral and dorsal views of arm plate, ×1 (Springer, 1926a).--Fig. 383, 1c-e. *P. mirabilis, Iowa; 1c,d, ventral and dorsal views of arm plates, artificially mounted, ×1; 1e, dorsal view of crown with arm-fans broken away, ×2 (Springer, 1926a).

Superfamily CODIACRINACEA
Bather, 1890


Theca small, typically globose or cone shaped; radials five, three, one, or absent; infrabasals five, three or fused; radial absent, anal X present only primitively or secondarily; tegmen low, covered by wide proximal columnal; radial wide, low, separated on posterior side by pentagonal anal X; CD basal truncate above 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 I occupying one-half to full width of radial; primaxil is narrow, secondibrach I in contact with lateral edge of radial; secondibrachs 2 and tertibrachs I 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. dariae, Que.; 1a-d, CD-interray, dorsal, BC-interray, and ventral views of partial crown, ×1 (Kirk, 1933).

Family CODIACRINIDAE
Bather, 1890

[nom. transl. et corr. JAECKEL, 1895, p. 63 (ex subfamily Codiacrinites BATHER, 1890b, p. 385) [=Embyocrinidae WANNER, 1916a, p. 130; Hypocrinidae WANNER, 1916a, p. 88]]
Fig. 384. Morphological features of representative Codiacrinacea (Codiacrinidae) (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.Per.
Subfamily CODIACRININAE Bather, 1890
[ *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, ×2 (Schultze, 1867).

Abrachiocrinus WANNER, 1920, p. 29 [*Sycocrinites clausus AUSTIN & AUSTIN, 1843, p. 206; OD]. Theca pear shaped; composed of 4 circles (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.(Tournaisi).*, 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, ×3; 1f-g, diminutive juvenile theca and columnar articular views, ×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 facets; orals large, protruding, each with conspicuous elongate depression above radial facet that may have partly enclosed short, atomous arm. *L.Miss.-U.Perm.*, USA(Mo.-Ind.).—Fig. 385,3. *A. scissurus*, L.Penn., Ind.; 3a-b, CD-interray and dorsal views of theca, ×30 (Peck & Connolly, 1951).

Asymmetrocrinus WANNER, 1937, p. 130 [*A. poteriocrinoides* (OD)]. Cup cone shaped, asymmetrical, composed of 3 circles 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,A. *A. poteriocrinoides*; 385,8a-d, CD-interray, ventral, B-ray, and A-ray views of cup, ×3 (Wanner, 1937); 386,4a-c, dorsal, post., and ventral views of holotype (radials black), ×3 (Arendt, 1970a).

Cranocrinus WANNER, 1929, p. 41 [*C. timoricus*; OD]. Theca composed of 4 circles; 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 declivous, 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.Perms.*, 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, ×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, ×10 (Arendt, 1970a).

Cyonocrinus 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.(Viséan).*; *U.Perm.*, Eu.(Eng.-Indon.(Timor, Basleo).—Fig. 384,7; 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, ×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 circles 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 circle around cup, isolated between projecting distal edges of basals; oral 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, ×3 (Wanner, 1916a).

Hydopporocrinus 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-
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, ×5.3; 2e-i, diagram. views of theca from EA-, DE-, CD-, BC-, and
**Fig. 386. Codiacrinidae (Codiocrininae) (p. T596-T599).**

*AB-interray sides (radials black, anus oblique ruled), ×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, circlot 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 ambulacr al groove; opening at top of cup narrow; anal opening between C and D radials, notch ing top of CD basal and sides of radials. U.Perm., Indon. (Timor, Basleo).—Fig. 384,2; 385,2. *H. schneid eri; 384,2, plate diagram of cup (radials black) (Moore, n); 385,2a,b, CD-interray, and ventral views of cup, X2 (Wanner, 1916a).

Lecyi thioerinus 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. 384,3; 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, X2 (White, 1880b).

Paracydonocrinus Are ndt, 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, Krasnoyarsk).—Fig. 386,1. *P. diviensis: 1a-e, A-ray, AB- and CD-interray, dorsal, and ventral (A ray downward) views of holotype cup, X2; 1f, plate diagram of cup (radials black), X 2.5 (all Are ndt, 1970a).

Tenagocrinus Wanner, 1929, p. 48 [*Embryocrinus sul cus 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, X5 (Wanner, 1929b).

Thyridocrinus Kirk, 1944, p. 388 [*Lecythioerinus? problematicus Springer, 1926a, p. 133; OD] [=Prolecythioerinus Are ndt, 1970a, p. 117 (obj.)]. Differs from Lecythioerinus 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 subvertcal radial ar-

Lecythioerinus 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. 384,3; 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, X2 (White, 1880b).

Paracydonocrinus Are ndt, 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, Krasnoyarsk).—Fig. 386,1. *P. diviensis: 1a-e, A-ray, AB- and CD-interray, dorsal, and ventral (A ray downward) views of holotype cup, X2; 1f, plate diagram of cup (radials black), X 2.5 (all Are ndt, 1970a).

Tenagocrinus Wanner, 1929, p. 48 [*Embryocrinus sul cus 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, X5 (Wanner, 1929b).

Thyridocrinus Kirk, 1944, p. 388 [*Lecythioerinus? problematicus Springer, 1926a, p. 133; OD] [=Prolecythioerinus Are ndt, 1970a, p. 117 (obj.)]. Differs from Lecythioerinus 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 subvertcal radial ar-
ticular facets horseshoe shaped, with central round canal opening; A, B, and E rays with biseri ally arranged cover plates traversing ambulacra on distal part of radials leading to tegmen. M.Sil.(Ni agaran), USA.—Fig. 386,5. *T. problematicus (Springer), Laurel Ls., USA (Ind.); 5a-c, dorsal, post., and ventral views of theca (radials black), X4 (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 edge 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 circlot; 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. 384,4; 387,3a-c. *B. hieroglyphicus, U.Perm., Timor; 384,3, plate diagram of cup (radials black, anal X stippled) (Moore, n); 387,3a-c, CD-interray, dorsal, and ventral views of cup, X1.5 (Wanner, 1916a).—Fig. 387,3d,e. B. rex Wanner, U.Perm., Timor; 3d,e, CD-interray and ventral views of cup, X0.7 (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 (Krasnoyarsk).—Fig. 387,4. *N. antiquus; 4a,b, post. and ventral views of cup, X2 (Wanner, 1924).

Subfamily THECIDICRININAE Wanner, 1930
[nom. transl. et correct. Lane, 1967, p. 11 (ex section Thecidicrinites Wanner, 1930a, p. 3)]

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

Thecidicrinus Wanner, 1916, p. 111 [*T. piri-formis; OD]. Theca high, cone shaped; 3 infrabasals in funnel-shaped circlot; 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,
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. *T. piriformis; Indon. (Timor, Basleo).—Fig. 384,6; 387,1. *T. piriformis; 384,6, plate diagram of cup (radials black, anal stippled) (Moore, n); 387, 1a-c, CD-interray, E-ray, and ventral views of theca, X1.5 (Wanner, 1916a).
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 radial not definitely identified; tegmen narrow, flat, with 5 orals, posterior one larger and a madreporite, tegmen with central, oval opening. L.Carb. (Tour.)--Fig. 387.5. *E. rugosus; 5a-e, AB-interray, CD-interray, ventral, A-ray, and dorsal views of theca, X1.5 (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 basal 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); 387.2a-d, A-ray, CD-interray, dorsal, and ventral views of theca, X1.5 (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 Bathur, 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. 388. Morphological features of representative Codiacrinacea (Sycocrinitidae, Streblocrinidae) (plate diagrams, not to scale). [Letters and patterns as in Fig. 372.]
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-e, CD-interray, E-ray, and
A-ray views of cup, ×2 (Wright, 1951-54).

Allosycocrinus WANNER, 1924, p. 141 [*A. pusil­
lus; OD]. Like Sycocrinites except anal opening
forms notch in distal edge of one of nonarm­
bearing radials, and is strongly variable in posi­
tion; tegmen a vault of 5 small oral plates.
U.Perm., Indon.(Timor, Basleo).—Fig. 389,3.
*A. pusillus; 5a,b, CD-interray, and ventral views
of cup, ×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 ra­
dial 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. 388,3; 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-interray, dorsal, and ventral views
of cup, ×0.7 (Wanner, 1916a).
Monobrachiocrinus Wanner, 1916, p. 103 [*M. ficeformis; 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, Krasnofiimsk-Sicily).—Fig. 388,2; 389,3c-e. *M. ficeformis, Basleo beds, Timor; 389,2, plate diagram of cup (D radial black) (Wanner, n); 389,3c-e, dorsal, ventral, and CD-interray views of cup, ×1.5 (Wanner, 1916a).—Fig. 389,3a,3f. M. granulatus Wanner, Basleo beds, Timor; 3a,3f, BC-interray and dorsal views of theca, ×1.5 (Wanner, 1924); 3f, reconstr. (with Embryocrinus hanieli), ×1 (Wanner, 1920).

Parasycocrinus 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; 4a-e, ventral, dorsal, E-ray, post., and D-ray views of cup, ×2 (Marez Oyens, 1940b).

Family STREBLOCRINIDAE Lane, 1967

[Strebrocriinidae 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 interradial 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

[Strebrocriinidae Lane, 1967, p. 12] [incl. Filidococrininae Annex, 1970a, p. 184]


Streblocrinus Koenig & Meyer, 1965, p. 393 [*S. brachiatus; OD]. Theca small, composed of 4 circles of plates; infrabasals 5, low; basals large, elongate; 3 small spoutlike radicals 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 interradial 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); 390,5a-g, ventral, CD-interray, BC-interray, AB-interray, dorsal, AE-interray, and DE-interray views of theca, ×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; 6a,b, lat. and ventral views of theca, X3 (Wanner, 1929b).

Coeonostis Girty, 1908, p. 109 [*C. richardsoni; OD] (≡Coenostis 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.(Ozark.), 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); 390,2a-d, ventral and lat. views of large cup, CD-interray views of 2 small thecae, ×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 interradial position; CD oral larger than others, with minute, central hydropore. L.Miss.(Ozark.), USA(N.Mex.-Mo.); L.Penn., USA(Ind.); U.Perm., Indon.(Timor, Basleo).—Fig. 390,4. *D. scrobiculus, L.Penn., Ind.; 4a-c, CD-interray, E-ray, and ventral views of theca, ×1.5 (Weller, 1930a).

Hemistreptacron Yakovlev, 1926, p. 52 [*H. abrachiatus; 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 interradial position; anal opening large, between CD oral and basal, not in midline of these plates, shifted somewhat to left side of basal and right side of oral; CD oral with hydropore. L.Perm., Eu.(USSR, Krasnofiimsk)-U.Perm. Indon.(Timor, Basleo).—Fig. 390,1. *H. abrachiatus, L.Perm., USSR; 1a-d, post., ant., dorsal, and ventral views of theca, ×5 (Yakovlev & Ivanov, 1956).

Pilidiocrinus 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.
Tythocrinus J. M. WELLER, 1930, p. 35 [*T. compositus; OD] [=Octocrinus PECK, 1936, p. 291 (type, O. inconstetus)]. 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. inconsevus (PECK). L.Miss., Mo.; 3a,b, post., and dorsal views of large individual; 3c,d, dorsal and post. views of small individual, X30 (Peck & Connelly, 1951).—Fig. 390,3e,f. *T. comptus, L.Miss., Mo.; 3e,f, dorsal and post. views of theca, X30 (Peck & Connelly, 1951).

Subfamily PENTECERCININAE Lane, 1967

[?Unclad.] Cladida—Cyathocrinina

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, X22 (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.Perms., Eu.(USSR, Krasnousfimsk)-U.Perms., Indon.(Timor, Basleo).—Fig. 391,5. *A. clavulus, U.Perms., Timor; 5a-c, A-ray, CD-interray, and ventral views of theca, X8.7 (Wanner, 1924).

Clistocrinus Kirk, 1937, p. 106 [*C. pyiformis; OD] [=Chlorocrinus Kirk, 1937b (nom. van.); non Cleistoerinus 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. pyiformis; 2a-d, CD-interray, A-ray, ventral, and dorsal views of theca, X4.5 (Kirk, 1937a).

Lageniocrinus deKoninc, in deKoninc & LeHon, 1854, p. 187 [*L. seminulum; M]. Theca small; cup cone shaped; infrabasals 3, small one in A-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., ?Visen), Eu.(Belg.-Eng.); L.Penn., USA (Ind.).—Fig. 391,3a-e. *L. seminulum, L.Carb.(Visen), Belg.; 3a-e, CD-interray, BC-interray, and AB-interray views of theca, X2.6 (Kirk, 1940e).
Superfamily and Family UNCERTAIN

Elicrinus 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, horse-shoe 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, x71 (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 basal forms sides of concavity and mostly 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, x3; 1d, detail of radials and food grooves, x3 (Springer, 1926a).

Suborder DENDROCRININA Bather, 1899

[nom. correct. Moore, in Moore, Lalicker, & Fischer, 1952, p. 613 (pro suborder Dendrocrinoida 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 pendant 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 circle, 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 isomorphously or heterotomously, few or very many, brachials arranged uniserially or biserially, pinnulate or lacking pinnule. 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. Although dendrocrinines are present in the Ordovician and Silurian, they are neither abundant nor diverse. The few genera that have been
Inadunata—Cladida—Dendrocrinina

The radial articular facets are divisible into three types: 1) small circular or semicircular, 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 peneplenary (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 facetal 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 facetal 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 isomously and heterotomously, mostly numerous, brachials unserial, in some genera laterally bearing ramules. Stem transversely circular or less commonly pentagonal. M.Ord.—U.Dev.
Cup steeply conical; infrabasals strongly upflared, visible from side; radianal 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 radianal 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 ....... *Bactroerinites*

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; anal in cup 2 ...........
   ........................................... *Alsopocrinus*

II. Infrabasals 5; anal in cup 3 or 4.
   a. Radial directly below C radial, anal sac very tall cylindrical with plicate plates; arms branching first on primibrachs 5-7 ......... *Dendrocrinus*
   b. Radial obliquely left below C radial; arms many (60 or more), branching first on primibrachs 3 .......... *Grenpria*
   c. Radial obliquely left below C radial; arms few, branching on primibrachs 3 ............ *Estonocrinus*

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 radianal 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 isomotomously; primibrachs 5 to 7 axillary. Radial articular facets narrow, rounded, with outward-downward slope and wide interradial 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, X1; 1b, fragment of anal sac, X2; 1c, post. view of theca and slender uniserial arms, X1 (Hall, 1852); 1d, plate diagram (radials black, radial cross ruled, anal plates stippled) (Moore, n).——Fig. 395, 1e-j. D. caducus (Hall, 1866), U.Ord., Ohio; 1e-f, ant. and lat. views of crown, X2 (Moore, n; Univ. Chicago 230A, 230B).

**Alsopocrinus** TANSEY, 1924, p. 181 [*A. anna*; M]. Cup small, truncated below; infrabasals 3, small azymous 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; radianal 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, X2 (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; radialan, 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, X1.5 (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, infraradianals oblique ruled.]

Bactrocrinites SCHNUR, 1849, p. 22 [*Poteriocrinus fusiformis ROEMER, 1844, p. 61; M] [=Bactrocrinus QUENSTEDT, 1875, p. 533 (nom. van.)]. Theca narrow and very tall; infrabasals and basals
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. oklahomaeensis* STRIMPLE, U.Sil., Okla.; 2a,b, BC and post. views of theca, X1 (Strimple, 1952c).—Fig. 396,2c,d. *B. reimanni* GOLDRING, M.Dev., N.Y.; ant. and post. views of theca, X2 (Goldring, 1954).—Fig. 396,2e,f. *E. fusiiformis* (ROEMER), M.Dev., Ger.; post. and ventral views of theca, X2 (Schultze, 1867).

**Estonocrinus** 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, radial 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
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, ×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 radianal in line with basals, supporting anal X and an anal sac plate above; small interbrachial plates above interradial 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,
Parisangulocrinus **SCHMIDT**, 1934, p. 59 [*Poterioocrinus 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, X1 (Schmidt, 1934).
Inadunata—Cladida—Dendrocrinina

Family BOTRYOCRINIDAE

Wachsmuth & Springer, 1886

[nom. transl. Bather, 1899, p. 921 (ex section Botryocrinidae 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, radi-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. Armes uniserial, typically heterotomous, with two main rami, but may be isomotous with numerous branches, or with single ramus; armlets 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.-UDev.

[Wachsmuth & Springer (1886, p. 191) clearly used the name Botryocrinites to discriminate a suprageneric assemblage of crinoids and not as synonymous with Botryo-crinus 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 Botryoerinus and several other members of the family a quadrangular radianal occurs obliquely below the C radial at left (Fig. 394,6). Also, the arms divide heterotomously, as well as isoto-mously. Some crinoids placed in the family show a tendency toward disappearance of the radianal plate, which is an evolutionary specialization.

Key to Genera of Botryoerinizae

A. Cup steep-sided conical, radial articular facets narrow horseshoe shaped; 2 anal plates in cup (small radianal, large anal X) ................................................. Ancyrocrinus

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 holdfast ......................................... Ancyrocrinus

II. Arms 10 or more, branching first on primibrachs 4-5; anal sac tall, stem transversely round ..................................... Gothocrinus

B. Cup wide conical; radianal small or lacking, anal sac slender, tall ................................................. Gothocrinus

I. Very diminutive, partly ill known; infrabrassals 5, except Parabotryoerinus; 1-4 anal plates in cup, anal sac tall; arms 10-40 or more, branching first on primibrachs 2-8, commonly bearing ramules ................................................. a. Infrabrassals 3; anal plates in cup 2; arms 10 ............................................. Parabotryoerinus

b. Large anal X; arms 10, branching on primibrachs 2, ramules abundant ...

............................................. Imitatorinus
c. Anal plates in cup 3, anal sac extremely slender and tall; arms ?10, branching on primibrachs 12-3 ...... ............................................. Schmidtorinus
d. Anal plates in cup 3, anal sac cylin-drical and very tall; arms 10, branch-ing on primibrachs 4, widely spaced armlets 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. Radianal 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 ............................................. Botryoerinus

2. No anal plates in cup above anal X; anal sac unknown; arms 10 or more, branching on primibrachs 3-4 ......... Jahnnerinus

3. No anal plates in cup above small anal X; anal sac and arms unknown; cup plates strongly fluted ............................................. Costalocrinus

b. Radianal absent, anal X small; arms 5 ............................................. Sigambrocrinus
c. Cup anal unknown, anal sac cylindric, composed of short and wide hexagonal plates; arms 10 or more, first branching on primibrachs 2-4 ............................................. Pandoracrinus

Botryoerinus Angelin, 1878, p. 24 [*B. ramosisiminus; SM Bather, 1893a, p. 117] [=Sicyoerinus Angelin, 1878, p. 23 (type, S. cucurbitaceus)]. Cup conical, plates smooth or ornamented with radial ridges, spines or longitudinal folds; infrabrassals 5, upflared; radianal small, quadrangular;
Botryocrinus

**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-Ind.-Ind.), Can. (Ont.).

**FIG. 398, la,b.** *B. schultzei* HAARMANN, L. Dev., Ger.; la, diagram of post. part of cup, X 1; 1b, view of anal sac plates, X 2 (Schmidt, 1942).

**FIG. 398, lc-lf.** *B. dilatatus* (ANGELIN), M. Sil., Gotl.; lc, A-ray view of cup and stem, post. view of theca and proximal parts of arms and anal sac, X 1.5; ld, part of anal sac, X 10; le, arm, X 1.5 (Bather, 1893a).—**FIG. 398, lg-li.** *B. ramosissimus*, U. Sil., Gotl.; lg, A-ray view of crown and stem, post. view of theca and proximal parts of arms and anal sac, X 1.5; lh, lat. view of cup with arm removed, showing tegmen, X 3; li, A-ray view of cup, X 1.5 (Bather, 1893a).

**Ancyrocrinus** HALL, 1862, p. 118 [*A. bulbosus*; SD S. A. MILLER, 1889, p. 223]. Cup cone shaped, broadly truncate below; radianal 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, grapnel-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, X 1; 4b, B-ray view of crown and stem, X 1; 4c, post. view of cup and proximal brachs, X 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; radial plates 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, medi ally projecting edges of prismatic and postero lateral edges of radials, which together form large concave surface projecting ad medi ally and presumably providing support for an anal sac. Arms, anal sac, and stem not known.

_Gastrocrinus_ **Jaekel**, 1895, p. 60 [*Poteriocrinus patulatis* Möller, 1859, p. 192; M]. Cup small, low, poorly known; plates stellate. Ana l 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, ×0.5 (Schmidt, 1934).

_Gothocrinus_ **Bather**, 1893, p. 114 [*G. gracili; OD]. Cup steeply conical; plates smooth; basal 5; small pentagonal radial 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. gracili; Gotl.; 2a, crown with attached stem, ×1.5; 2b, theca and proximal brachials, ×3 (Bather, 1893a).

_Imitocrinus_ **Schmidt**, 1934, p. 104 [*Cyathocrinus gracilior* Roemer, 1863, p. 149; OD]. Cup small, low, conical, with smooth plates; radial 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, ×1 (Schmidt, 1934).

_Jahnocrinus_ **Jaekel**, 1918, p. 54 [*J. minutus; M]. Cup low bowl shaped; infrabr asals small, low; basal plates with prominent longitudinal median folds; radial articular facets one-half as wide as radials; radial plates 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, ×4 (Jaekel, 1918).

_Pandoracrinus_ **Jaekel**, 1918, p. 57 [*P. pinnulatus; OD]. Cup low, broad, with smooth plates; infrabr asals low or possibly entirely covered by stem; radial articular facets small and narrow; radial and anal X unknown. Anal sac apparently large, composed of wide, low, hexagonal plates. Arms branching at least twice isomorphously; primibrachs 2 to 4 axillary; brachials with 12 ramules on each side possibly joined laterally. Stem transversely round. _M.Dev., Eu._ (Boh.-Eng.).—Fig. 400.4. *P. pinnulatus; Boh.; lat. view of incomplete crown and proximal part of stem, ×2 (Jaekel, 1918).

[The type species of this genus is poorly known and the holotype of _P. pinnulatus_ may be a monocylic inadunate referable to the Disparida. _Jaekel_ (1918) placed together within his suborder Meterocrinidae five genera, two of which are now accepted as monocylic inadunates (Iocrinus, Calleidocrinus), one clearly has infrabr asals (Menocrinus), and two others (Pandoracrinus, Vosekocrinus), all of which _Jaekel_ illustrated as lacking infrabr asals, but nevertheless assigned by him to the dicyclic Botryocrinidae. _Jaekel_ believed that these apparently monocylic crinoids had secondarily lost their infrabr asal 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; infrabr asals small, 3, barely visible in side view; radials larger than basal s; radial plates 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, ×1; 3b, brachials and ramules, ×3 (Yakovlev, 1941b).

_Rhadinocrinus_ **Jaekel**, 1895, p. 87 [*R. rhenanus; OD]. Cup small, cone shaped, plates smooth; infrabr asals upf lared; radial articular facets strongly curved at outer margins, two-thirds as wide as radials; 3 anal plates in cup, radial plates 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 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. rhenanus_ (Roemer), L.Dev.; lat. view of crown and stem, ×0.7 (Schmidt, 1934).—Fig. 400.1b. *R. rhenanus, L.Dev.; post. view of crown and prox-
Imatalocrinus

Gothocrinus

Schmidtocrinus 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

Gastrocrinus

Jahnocrinus

Imitatocrinus

FIG. 399. Botryocrinidae (p. T615).
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, X2 (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, ×1 (Schmidt, 1942).

**Superfamily MASTIGOCRINACEA**
Jacak, 1918

[nom. transl. MOORE & LANE in MOORE & STRIMPLE, 1973, p. 19 (ex Mastigocrinidae JAENEL, 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.

**Family AETHOCRINIDAE** Ubahgs, 1969

[Aethocrinidae Ubahgs, 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 inferradi­anals directly below C radial; CD interray containing six anal plates, lowest one interpreted by Ubahgs 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 straight­sided 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 branchials rather than summit edges of radia­lals. The free arms are uniserial, trans­versely round, and branched isomotomously 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, anal X and higher anal plates stippled); 402,1a. post. view of crown and stem (reconstr.), ×1; 402,1b, view of uncruished para­type with part of attached stem, ×1.7; 402,1c,d, opposite sides of crushed holotype, ×1.7 (all Ubahgs, 1969).

**Family THENAROCRINIDAE**
Jacak, 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 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 prompt­ent 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, ×0.7 (Bather, 1891a); 1c, plate diagram of cup (radials black, radial cross ruled, anal X and higher anal plates stippled) (Moore, n).
Family MASTIGOCRINIDAE
Jaekel, 1918

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 poteriocrinitids or botryocrinids.

Key to Genera of Mastigocrinidae

A. Cup very steep sided, narrow conical ........
   I. Infrabasals and basalts tall, narrow; anal sac tall, slender, composed of small polygonal or plicate plates, arms 10 ....
      a. Two anal plates in cup, radialal like basalts, 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. 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, Brs, primibrachs 1,2; IB, infrabasal; iR, interradial plate; X, primanal; Y, supplementary interradial; radials black, anal plates vertically ruled, interradial plates stippled.]
Fig. 402. Aethocrinidae (p. T618).

basals .......................... Belanskicrinus

II. Infrabasals low; 2 anal plates in cup

(a) Anal sac tall, with plicate plates; arms 10, branching isomotomously on primibrachs 3-5 ........................ Dictenocrinus

(b) Anal sac tall, composed of small polygonal plates; arms 60 or more, branching first isomotomously on primibrachs 4 and heterotomously higher in crown ........................................... Lasiodocrinus

c. Basals tall and slender, radials small, pits at plate angles; arms many, branching first isomotomously on primibrachs 3 or 4 and heterotomously higher in crown .... Cradecrinus

III. Infrabasals low; only anal X plate in cup; stem transversely pentagonal 

.......................................................... Kalpidoerinus

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 isomotomously on primibrachs 3 and heterotomously higher in crown; anal sac tall and slender .... Goniocrinus

b. Arms at least 10, branching isomotomously on primibrachs 6-8; anal sac short, distally pointed, composed of polygonal plates ........................ Nassovicrinus

II. Cup smooth plated; anal in cup 1 or 2 ..........................................................

a. Arms numerous, branching isomotomously on primibrachs 4 and heterotomously higher; anal plates in cup 2, anal sac with laterally directed summit spines ................................ Bathericrinus

b. Arms numerous, branching isomotomously 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 isomotomously on primibrachs 2 or 3 and heterotomously higher in crown; anal plates in cup 2 ..................................................... Iteacrinus

d. Arms 20-40, branching isomotomously 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 ........................................ Eifeloerinus

f. Arms 40 or more, first branching
Inadunata—Cladida—Dendrocrinina

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

........................................................................... Polyerinus

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

........................................................................... Streptoerinus

Mastigocrinus Bather, 1892, p. 194 [*M. loreus; OD]. Cup conical; infrabasals large, upflaring; radial articular facets peneplenary, slightly narrower 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, X0.7; 3b,c, side view of columnal and proximal part of arms and anal sac, X5; 3d, post. view of theca and proximal part of arms and stem, X1.5; 3e, anal sac plates, X10; 3f, diagram of stem divided into pentameres, X1.5 (Bather, 1892b).

Anthomocrinus Schmidt, 1934, p. 79 [*Homocrinus tenuis Bather, 1893a, p. 105; OD]. Cup steeply conical and elongate; small, oblique radial and larger anal X in cup; radial articular facets peneplenary, less than equal to full width of plates, leaving rounded interradial 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. 404.2. *A. tenuis (Bather), M.Sil., Gotl.; 1a,b, post. view of crown and part of attached stem, ant. view of theca, X1 (Bather, 1893a).

Atelestrocrinus Wachsmuth & Springer, 1886, p. 221 [*A. delicatus; SD S. A. Miller, 1889, p. 226] [=Atelestrocrinus Wachsmuth & Springer, 1886, p. 223 (nom. null.); Atelestrocrinus Bassler & Moody, 1943, p. 314 (nom. null.)]. Cup inverted 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 medially between posterior radials. Anal sac not known. Arms uniserial, branching on primibrachs 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, X1.5 (Wachsmuth & Springer, 1886).

Bathericrinus Jäckel, 1918, p. 58 [*Botryocrinus ramosus Bather, 1891a, p. 394; M]. Cup small, low, plates smooth or basals with median longitudinal fold; radial articular facets almost as wide as radials, interradial notches present; radial 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, X0.7 (Bather, 1891a).—Fig. 404.4c. *B. semipinnulatus Schmidt, L.Dev., Ger.;
Belanskicrinus Strimple & Leverson, in Strimple et al., 1969, p. 18 [*Bactrocrinus westoni* Belanski, 1928, p. 177; OD]. Cup straight sided, steeply conical, circler 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, X1.7; 1b, D-ray view of hypotype crown, X1.8; 1c, lat. view of crown showing anal sac, X1.8 (Strimple & Leverson, 1969).

Cradoeocrinus 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.*
**Inadunata—Cladida—Dendrocrinina**

elongatus, U.Dev., N.Y.; 2a,b, lat. views of crown and part of attached stem, X1.5 (Goldring, 1923).

**Dictenocrinus** Jaeckel, 1918, p. 59 [*Botryoerinus decadactylus* Bathé, 1891b, p. 395 (≡*Cyathoerinus decadactylus* Salter, 1873); SD Basler, 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, columns 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, X1 (Haarmann, 1921).

**Eifelocrinus** Wanner, 1916, p. 200 [*Ptiloerinus dohmi* Wanner, 1916, p. 344a; OD] (≡*Ptiloerinus 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, X0.7 (Wanner, 1916a).

**Follicrinus** Schmidt, 1934, p. 74 [*Taxocrinus arebei* Follman, 1887, p. 118; OD]. Cup small, conical, as wide as high; radial articular facets peneplenary; radial 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, X0.5; 6b, sketch of anal sac and disarticulated arm fragments, X1 (Schmidt, 1934).

**Goniocrinus** Miller & Gurley, 1890, p. 32 [*G. sculpitis*; OD] (≡*Goniocrinus Springer, 1913, p. 218 (nom. null.)). Cup small, plates convex with depressions at corners; infrabasals low; small oblique radial and anal X in cup, supporting elongate anal sac which has posterior longitudinal 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. sculpitis*; Iowa; 1a,b, lat. views of crown, X2 (Miller & Gurley, 1890).

**Iteacrinus** Goldring, 1923, p. 344 [*I. flagellum*; OD]. Cup small, low, with highly convex plates; radial 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,
elongate, composed of several longitudinal rows of delicate plates. Arms uniserial, slender, rounded, with two main isomous 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. Mastigocrinidae (p. T622-T625).

**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 radianal).
in cup directly above CD basal; arm facets wide, penepelary. 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 isomorphously 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).—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 pachydyctylus 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 pentameres. L.Dev.-U.Dev., Eu. (Ger.)-USA (Iowa).—Fig. 407,1. *N. pachydyctylus* (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 isomorphously 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. kosovensis* Jaekel; DE-interray view of crown and stem, \( \times 0.7 \) (Jaekel, 1918).

**Quantocrinus** 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 several vertical rows of hexagonal, plicate plates. Arms uniserial, isomorphous with 2 main rami, bearing ramules, primibrachs 4 or 5 axillary. Stem transversely pentagonal. M.Dev. (Givet.), Eu. (Eng.); L.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 crotalus 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-
Echinodermata—Crinoidea

Superfamily MEROCRINACEA
S. A. Miller, 1890

[nom. transl. Moore & Lane in Moore & Strimple, 1973, p. 19 (ex Merocrinidae S. A. Miller, 1890, p. 352)]

[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 isomorphously at or near base and isomorphously 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 Merocrinidae 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 infrerradianal and superradianal (Fig. 394. A). This character indicates a primitive evolutionary stage. The cup is perfectly symmetrical, inasmuch as the infrerradianal corresponds exactly in size and shape to the four adjacent radial plates. The superradianal 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 infrerradianal 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 infrerradials, 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 pentameric symmetry to bilateral symmetry, and finally back to perfect pentameric symmetry.

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

Fig. 408. Mastigocrinidae (p. T625).
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 isomotous 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 Merocrinidae 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 isomotously 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 infrerradial 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, X1 (Moore & Laudon, 1943a).—Fig. 409,3b. Plate diagram of cup (radials black, C infrerradial horizontally ruled; anal X and sac plates stippled; P9, 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 radialan 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 heterostictus Hall, 1847, p. 85; M] [=Scyphocrinus Hall, 1847 (non Romer, 1849) (obj.)]. Cup conical; infrabasals 5; radialan 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 isomotously, 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, X1 (Springer, 1911b).—Fig. 409,2c. C. kentuckiensis Springer, M.Ord., Ky.; post. view of crown, X1 (Springer, 1911b).—Fig. 409,2d. Plate diagram of Cupulocrinus (radials black, radialan cross ruled, anal X and sac plates stippled) (Moore, n.).

Family ONTARIOCRINIDAE
Jaekel, 1918

[Ontarioocrinidae 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 Ontariocinus. M.Ord.

Ontariocinus Jaekel, 1918, p. 83 [*O. deviatus; OD]. Cup wide, bowl shaped, plates thin; infrabasal circle low, wide, with 4 plates; basals apparently 4; radials 5, C radial in contact with infrabasals; radialan directly above infrabasals, anal X above radialan 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, 1942a, p. 55] [Materials for this family prepared by N. Gary Lane]

Cup cylindroconical, radialan directly below C radial, anal X above truncate CD basal and at left above radialan, radials followed by fixed primibrachs in each ray forming part of cup (two above C radial, three above others). Stem quinquepartite. ?P.Ord., M.Ord., ?U.Ord.
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 (inferradianal oblique ruled, superradial cross ruled, anal X and higher anals stippled) (Moore, n); 409,1a,b, post., ant. views of cup, ×3 (Bather, 1913b); 409,1c-e, articular faces of proximal and distal columnals, and side view of columnals, ×5 (Bather, 1913b); 409,1f, plate diagram (radials black, inferradians horizontally ruled, radial cross ruled, anal X and other anals stippled) (Moore, n).

**Family METABOLOCRINIDAE**

**Jaekel, 1918**

[Metabocrinidae **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. rosiscus*; 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 radianal, 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. rosiscus*: C-ray view of diagram, reconst. of crown, ×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 monocyclic inadunate crinoids. The illustration of the crown of **Metabolocrinus** by **Jaekel** shows clearly infrabasal places 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; radial small, quadrangular. Anal sac recurved, lateral plates strongly plicate, base of sac situated in concavity formed 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, ×1.5 (**Angelin, 1878**).—**Fig. 410,2b,c. C. scolopendra** (**Bather**), Gotl.; ventral surface of arm showing cover plates of ambulacra, base...
T630  Echinodermata-Crinoidea

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

Suborder POTERIOCRININA
Jaekel, 1918

KOPHINOCRINUS 10  SUPERFAMILY AND FAMILY UNCERTAIN

of anal sac and adjacent cup, ×3 (Bather, 1893a).

Pagecrinus 10  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 radial) 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. 410,1. *P. gracilis; 1a-c, D-ray, B-ray, and lat. views of crown and proximal part of stem, ×2 (Kirk, 1929).

Superfamily and Family UNCERTAIN

KOPHINOCRINUS 10  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-