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## Part T ECHINODERMATA 2

VOLUME 3

By GEORGES UBAGHS, R. C. MOORE, H. WIENBERG RASMUSSEN, N. GARY LANE,  
ALBERT BREIMER, H. L. STRIMPLE, J. C. BROWER, RUSSELL M. JEFFORDS,  
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MICHEL ROUX, HERTHA SIEVERTS-DORECK, R. O. FAY, and R. A. ROBISON

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PART T  
ECHINODERMATA 2  
CRINOIDEA

By GEORGES UBAGHS, R. C. MOORE, H. WIENBERG RASMUSSEN, N. GARY LANE,  
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VOLUME 3

ARTICULATA

By H. WIENBERG RASMUSSEN

[Geologisk Museum, København]

[For table of contents see Volume 2, p. T404-T405]

CLASSIFICATION

By H. WIENBERG RASMUSSEN  
and HERTHA SIEVERTS-DORECK

[Geologisk Museum, København; Stuttgart, Germany]

Several years ago, SIEVERTS-DORECK wrote a preliminary manuscript for the *Treatise* following the classification she had proposed in 1952 (in MOORE, LALICKER, & FISCHER's *Invertebrate Fossils*) and almost identical with her contribution to the French *Traité* (in UBAGHS, 1953), although slightly expanded. It also included short diagnoses of the fossil genera and figures selected for the *Treatise*. This manuscript, which was to have included all Articulata with the exception of one order and one family, was never completed. In 1956 the editors first discussed with WIENBERG RASMUSSEN the possibility of taking over part of this assignment and in 1972 RASMUSSEN accepted responsibility for the entire section, except for Dadocrinidae written by H. A. LOWENSTAM and Roveocrinida by R. E. PECK.

During 1972-75 a new description of the Articulata was completed by RASMUSSEN, following the classification of recent comatulids by A. H. CLARK and the classification of other groups by SIEVERTS-DORECK, in both cases with minor modifications due to new studies of fossil Articulata. Recent families also were included and recent genera recorded. The Articulata are classified here as seven orders, the characteristics and affinities of which are commented on in the section on Evolution of Articulata.

The concept of Crinoidea Articulata was introduced by MILLER in 1821 as a division of the family Crinoidea with the following definition: "The joints resting on the first or superior columnar joint, and forming the cup containing the viscera, articulate by liplike and transverse processes, having a minute perforation." He proposed the name Articulata "in allusion to the articulating insertion of the joints forming the cup containing the viscera," and he assigned three genera to the division: 1) *Apiocrinites*, n. gen. (2 species), 2) *Pentacrinites vel Pentacrinus* (1 recent and 4 fossil species), and 3) *Encrinites* (1 species). The new monotypic genus *Eugeniocrinites*, now included in the Articulata, comprised the small division Coadunata, with "joints of the pelvis anchylosed to the first columnar joint." The genera *Comatula* and *Marsupites*, now included in the Articulata, were not assigned to any division by MILLER, but he did recognize *Comatula* LAMARCK as a true crinoid "defined with sufficient precision as a *Pentacrinus* destitute of the column," and *Marsupites* was considered to be the "immediate link between the Crinoidea Inarticulata and the Euryale."

J. MÜLLER (1843), in his anatomical study of "*Pentacrinus caput Medusae*," introduced a subdivision of the Articulata, as now understood, into three families: Articulata (=MILLER's Articulata + Comatula), Tessellata (=MILLER's Semiarticulata + Inarticulata as well as a few additional similar genera and *Marsupites*), and Costata (for *Saccocoma*). *Holopus* was given no

special assignment. The Articulata were characterized by the movable articulation between radials and the primibrachials, the absence of plates between radials, and the leathery composition of the tegmen with or without calcareous plates.

F. ROEMER (1855, in BRONN's *Lethaea Geognostica*) classified Articulata, as now understood, in two suborders and nine families: Astylida, without articulated column (families Holopocrinidae, Cyathidocrinidae, Marsupitidae, Saccocomidae, and Comatulidae), and Stylida, with articulated column (families Pentacrinidae, Apiocrinidae, Eugeniocrinidae, and Encrinidae, including *Dadocrinus*).

BRONN (1860) adopted the classification by J. MÜLLER. Later, ZITTEL (1879), in *Handbuch der Paläontologie*, adopted the classification by MÜLLER and families by ROEMER with the addition of Plicatocrinidae. NEUMAYR (1889) followed ZITTEL's classification but used the name Pentacrinacea for Articulata.

In 1880 WACHSMUTH and SPRINGER (p. 247 [22]) designated all Mesozoic and younger crinoids as Stomatocrinoidea, but later (1885, p. 226 [4]) adopted the name Neocrinoidea, introduced as replacement by CARPENTER (in CARPENTER & ETHERIDGE, 1881, p. 296) for this group, corresponding to the Articulata. In 1886 WACHSMUTH & SPRINGER (p. 64 [140]) transferred the name Articulata to a suborder of Paleozoic crinoids (including Ichthyocrinidae and Crotaocrinidae), but in 1897 they used Articulata for two suborders, the Paleozoic Articulata Impinnata for the Ichthyocrinidae [=Ichthyocrinidae] and the Articulata Pinnata for the Articulata as now used.

E. J. CHAPMAN (1883) introduced the name Canaliculata for the Articulata, emphasizing the important character of the axial nerve running in canals inside basals, radials, and brachials.

ZITTEL in 1895 adopted in principle the system outlined by WACHSMUTH and SPRINGER for Paleozoic crinoids containing the orders Larviformia, Camerata and Fistulata, and he proposed the addition of a new order Flexibilia for the Paleozoic Articulata of WACHSMUTH and SPRINGER (1885) (*non* MILLER, 1821). The name Articulata of MILLER (1821) and MÜLLER (1843) was thus restricted to post-Paleozoic

crinoids.

BATHER (1899b) introduced an entirely new classification, which he followed in LANKESTER's *Treatise on Zoology* (1900a). He considered crinoids without infrabasals in the cup and crinoids with infrabasals in the cup as two completely separated lines of evolution, which he classified as subclasses under the names of Monocyclica and Dicyclica. In Monocyclica the base of the cup consists of one circlet of plates (the basals). In Dicyclica the base of the cup consists of two circlets of plates (basals and infrabasals). All orders hitherto accepted were considered polyphyletic, including monocyclic as well as dicyclic crinoids. The post-Paleozoic crinoids now classified as Articulata are referred to several groups in BATHER's classification as shown in the following tabulation:

#### *Arrangement of Articulata in Classification by Bather (1899)*

- Subclass Monocyclica Bather, 1899
  - Order Monocyclica Inadunata Bather, 1899 (Plicatocrinidae, Hyocrinidae, Saccocomidae)
- Subclass Dicyclica Bather, 1899
  - Order Dicyclica Inadunata Bather, 1899
    - Suborder Dendrocrinoidea Bather, 1899 (Pentacrinidae, Uintacrinidae, Marsupitidae, Bathycrinidae)
  - Order Flexibilia Zittel, 1895
    - Grade Pinnata Wachsmuth & Springer, 1897 (Apiocrinidae, Bourguenocrinidae, Antedonidae, Atelecrinidae, Actinometridae, Thaumatoocrinidae, Eugeniocrinidae, Holopodidae, Eudesicrinidae)

BATHER's classification was used by BIESE (1934-39) in all sections of the *Fossilium Catalogus* concerned with post-Paleozoic crinoids.

MATSUMOTO (1929) followed BATHER's arrangement of the Articulata with minor modifications, and he included taxa recognized by other paleontologists and zoologists.

#### *Classification of Post-Paleozoic Crinoids by Matsumoto (1929)*

- Subclass Monocyclica Bather, 1899
  - Order Monocyclica Inadunata Bather, 1899
    - Suborder Costata Müller, 1843
- Subclass Dicyclica Bather, 1899
  - Order Articulata Miller, 1821
    - Suborder Uintacrinacea Zittel, 1879
    - Suborder Encrinacea Matsumoto, 1929

Suborder Pentacrinacea Neymayr, 1889 (Isocrinidae Matsumoto, 1929; Pentacrinitidae Gray, 1842)

Order Coadunata Miller, 1821

Order Comatulida Clark, 1908

Order Holopoda Matsumoto, 1929

JAEKEL in 1894 divided crinoids in two subclasses, Cladocrinoidea (=Camerata of WACHSMUTH & SPRINGER) and Pentacrinoida (=Flexibilia + Inadunata + Articulata). He did not accept BATHER's division of crinoids in Monocyclica and Dicyclica, and in 1918 he published his *Phylogenie und System der Pelmatozoen* with the following classification of post-Paleozoic crinoids:

*Classification of post-Paleozoic Crinoids  
by Jaekel (1918)*

Subclass Pentacrinoida Jaekel, 1894

Order Articulata Miller, 1821

Suborder Typica Jaekel, 1918 (Encrinidae, Holo-  
crinidae, Pentacrinidae, Millericrinidae, Apio-  
crinidae, Thiolliericrinidae, Rhizocrinidae)

Suborder Libera Jaekel, 1918 (Comatulidae,  
Uintacrinidae, Marsupitidae)

Suborder Compacta Jaekel, 1918 (Sclerocrinidae,  
Eugeniocrinidae, Phyllocrinidae, Holopodi-  
dae)

Order Costata Müller, 1843

Suborder Hyocrinites Jaekel, 1918 (Eudesicri-  
nidae, Plicatocrinidae, Hyocrinidae, Sacco-  
comidae)

The number of genera of recent crinoids accepted by CARPENTER in his *Report on the Challenger Expedition* (1884, 1888), less than 20, was greatly increased in the years to follow, and especially through A. H. CLARK's publications since 1907.

In the 1913 edition of VON ZITTEL and EASTMAN's *Text-book of Paleontology*, SPRINGER, assisted by A. H. CLARK, harmonized the classification of recent and fossil crinoids. All post-Paleozoic crinoids except the Encrinidae were now classified as Articulata, and this concept has been adopted in the *Treatise*.

*Classification of Articulata by Springer and  
Clark (in von Zittel & Eastman, 1913)*

Order Articulata Miller, 1821

Family Bourgueticrinidae de Loriol, 1882 (incl.  
Rhizocrinidae, Bathycrinidae)

Family Phrynocrinidae A. H. Clark, 1907

Family Apiocrinidae d'Orbigny, 1840

Family Pentacrinidae Gray, 1842

Section Pentacrinids Gray, 1842

Section Thiolliericrinids A. H. Clark, 1908

Section Comatulids A. H. Clark, 1908 (ex  
Fleming, 1828)

Tribe Innatantes A. H. Clark, 1909

Subtribe Marsupitids d'Orbigny, 1852

Subtribe Uintacrinids Zittel, 1879

Tribe Oligophreata A. H. Clark, 1909

Tribe Macrophreata A. H. Clark, 1909

Family Plicatocrinidae Zittel, 1879

Family Saccocomidae d'Orbigny, 1852

Family Eugeniocrinidae Roemer, 1855

Family Holopidae Zittel, 1879 (=Holopodidae  
Zittel, 1879)

SPRINGER and CLARK characterized the Articulata by the complete muscular articulation of radials with the brachials, the exposed mouth and ambulacral furrows, the nerve canal perforating the calcareous substance of radials and brachials, the arms always uniserial and pinnulate, the absence of anal plate or other interradiial elements in the cup of adult specimens, the leathery tegmen with or without calcareous elements and the dicyclic or cryptodicyclic cup, although commonly infrabasals and basals in some genera may be atrophied.

CLARK further elaborated a subdivision of recent comatulids into two suborders, Oligophreata and Macrophreata, and a large number of superfamilies and families. This classification is followed in his large *Monograph of the Existing Crinoids* (1915-67).

GISLÉN (1924) slightly modified the classification of comatulids proposed by CLARK, and he also considered fossil comatulids. Instead of the two suborders proposed by CLARK, he divided comatulids into four groups: Comasterida, Mariametrida, Thalassometrida, and Macrophreata.

In preparation of Articulata for the *Treatise*, SIEVERTS-DORECK proposed a classification including six orders. This classification, including very short diagnoses, was reproduced by MOORE in MOORE, LALICKER, & FISCHER's *Invertebrate Fossils* (1952, p. 614).

In 1953, UBAGHS published, in J. PIVETEAU's *Traité de Paléontologie* (vol. 3, p. 756-765), a contribution by SIEVERTS-DORECK, including classification of fossil Articulata and diagnoses of all groups above genus-level, and a record of fossil genera included.

*Classification of Fossil Articulata  
by Sieverts-Doreck (1952, 1953)*

Subclass Articulata Miller, 1821

Order Isocrinida Sieverts-Doreck, 1952

Suborder Isocrinina Sieverts-Doreck, 1952 (Holocrinidae, Isocrinidae, Pentacrinidae, Thioliericrinidae)

Order Comatulida Clark, 1908

Suborder Comasterina Gislén, 1924 (Comasteridae)

Suborder Mariametrina Gislén, 1924 (Solanocrinidae)

Suborder Thalassometrina Gislén, 1924 (Conometridae, Thalassometridae, Notocrinidae, Asterometridae)

Suborder Macrophreatina Clark, 1909 (Palaeantonidae)

Order Millericrinida Sieverts-Doreck, 1952

Suborder Millericrinina Sieverts-Doreck, 1952 (Dadocrinidae, Millericrinidae, Apiocrinidae)

Suborder Bourgueticrinina Sieverts-Doreck, 1953 (Bourgueticrinidae, Bathyrcrinidae)

Order Uintacrinida von Zittel, 1921 (Marsupitidae, Uintacrinidae)

Order Roveacrinida Sieverts-Doreck, 1952 (Saccocomidae, Roveacrinidae)

Order Cyrtocrinida Sieverts-Doreck, 1952 (Cyclocrinidae, Sclerocrinidae, Phyllocrinidae, Eugeniocrinidae, Plicatocrinidae, Eudesicrinidae, Holopodidae)

WIENBERG RASMUSSEN (1961) in a monograph on Cretaceous crinoids and A. H. MÜLLER (1963) in his *Lehrbuch der Paläozoologie* followed the classification by SIEVERTS-DORECK.

In the course of further investigations of fossil articulates, RASMUSSEN found the affinity of Bourgueticrinina to Millericrinida dubious, and he raised the suborder to the level of order. Also, the sequence of orders has been changed, leading to the outline of the Articulata adopted in this volume.

Subclass ARTICULATA  
Zittel, 1879

[*nom. trans. Moore, 1890, p. 50 (ex suborder Articulata ZITTEL, 1879, p. 280). = Articulata MILLER, 1821, p. 13 (division) (part). Comatocrinoides WACHSMUTH & SPRINGER, 1886, p. 22. Nucrinoides CARPENTER & ETHERIDGE, JR., 1887, p. 109. Crinoides E. J. CHAPMAN, 1882, p. 115; non Articulata (Fam. Crinoidea) & SPZINGER, 1886, p. 140 (=Fam. Crinoidea) (part).] (Materials for this subclass from the collection of RASMUSSEN, with contributions from AL. LOWENSTAM, and HERTRA*

Column generally cryptocyclic, generally with 5-6 subbasals, five basals and 5-6 distals, although rare individual

variations in number of plates occur. Infra-basals distinct and exposed on surface of cup only in Holocrinidae and Uintacrinida, small and concealed or missing in all other groups, at least in the adults, but may be indicated by orientation of column according to the law of WACHSMUTH & SPRINGER. A true monocyclic origin of any Articulata is not indicated. Fusion or reduction in number of basals occur in Hyocrininae and Bathyrcrininae. Basals generally small; may be strongly reduced and transformed in most comatulids and are missing in Cyrtocrinida. No anal plates or compound radials and normally no plates separating radials or basals in the postlarval skeleton.

Arms always uniserial, although distal brachials may well be wedge shaped. Articulations between radial and arm and between some or all brachials muscular and with distinct fulcral ridge, although sculpture of articular face may be reduced in radials and proximal brachials of Apiocrinidae. Nonmuscular articulations, either synarthry, syzygy, symmorph, or synostosis, found in almost all species. Radials and brachials always perforated by a nerve canal, passing through fulcral ridge of muscular and synarthrial articulations. Arms generally divide at primibrachs 2 and commonly further divided, and with nonmuscular articulation at primibrachs 1 to 2. Very few species have arms undivided or with first division at other points. Arms generally free, but proximal brachials may be movably connected by interbrachial plates. Tegmen always flexible, with calcareous spicules or grains or with an irregular pattern of thin plates. Larger oral plates may occur. Mouth and ambulacral grooves always open to exterior.

Pinnules always present, articulated to all or most brachials, which are not axillary or with a nonmuscular distal articulation. A proximal pinnule gap, a few proximal brachials with muscular articulation but no pinnule, may occur.

Column circular, elliptical or five-sided in section, with or without cirri on nodals. Columnal articulations synarthrial, symplectial, cryptosymplectial or synostial. Central canal narrow. Attachment by distal cirri, radix, or terminal disc. Column transformed to a cirriferous centrodorsal in

postlarval comatulids, missing or transformed to a centrale in Uintacrinida, missing in Roveacrinida, and may not be distinguished in fused basis of sessile Holo-podina. *L.Trias-Holo.*

[The name *Articulata* ZITTEL, 1879, is a homonym of *Articulata* HUXLEY (1869, p. 116) established for a class of the Phylum Brachiopoda. Although, as pointed out in the preface to this volume (p. xxii), the Law of Priority lacks any force under the *International Code of Zoological Nomenclature* in application to suprafamilial taxa, it has been the policy of the *Treatise* editors to avoid as far as possible use of such homonyms for suprafamilial taxa. In the present case, however, we can see no justification for suppressing ZITTEL's name, because the name *Articulata* has been used for both brachiopods and crinoids for over a century and suppression of the name for a group of crinoids would certainly deviate from long-established usage.—Editors]

## Order MILLERICRINIDA

Sieverts-Doreck, 1952

[Millericrinida SIEVERTS-DORECK, in MOORE, LALICKER & FISCHER, 1952, p. 614; emend. RASMUSSEN, herein, to include Hyocrinina and exclude Bourgueticrinina] (=Apio-crinacea STEINMANN, 1903, p. 185)

Cup large, composed of five basals and five radials; infrabasals generally missing, but present in Dadocrinidae and in a few specimens of Millericrinidae; in Hyocrinina basals may be five or three, or fused to a basal circlet without trace of sutures. In Apiocrinidae proximal brachials (with modified articulations) and interbrachial plates included in thecal structure; in Millericrinidae the primibrachials meet laterally or are separated, and in Hyocrinidae arms are narrow and completely separated. Arms divided at primibrachs 2 in Millericrinina, and often further divided, but undivided or only with distal divisions in Hyocrinina. Nonmuscular articulations synarthrial or synostosial; there is no syzygy. Tegmen with cover of small polygonal plates, which may continue into interbrachial plates.

Column generally long, cylindrical, attached by stout radix or expanded terminal disc. No nodals or cirri. A few species (*Liliocrinus pratti*) have a short column, apparently unattached. Articular face of columnals entirely covered with numerous feeble, radiating crenulae, which may divide. Crenulae evenly distributed or arranged more or less discretely in five interradsial groups. Central canal narrow to moderate. Proximal part of column often modified, five sided, or nearly circular in outline and enlarged, forming a conical transition to the cup. Crenulae may be restricted to

marginal zone in some species of Millericrinidae, and are absent in proximal synostosial articulations of Hyocrinidae. Uppermost columnal greatly enlarged in Millericrinidae and some Apiocrinidae, included as a five-sided plate in dorsal side of cup; proximal articulation of such a proximale high, pyramidal, often reaching central cavity of cup. *M.Trias., L.Jur.-L.Cret.; L.Paleoc.; Holo.*

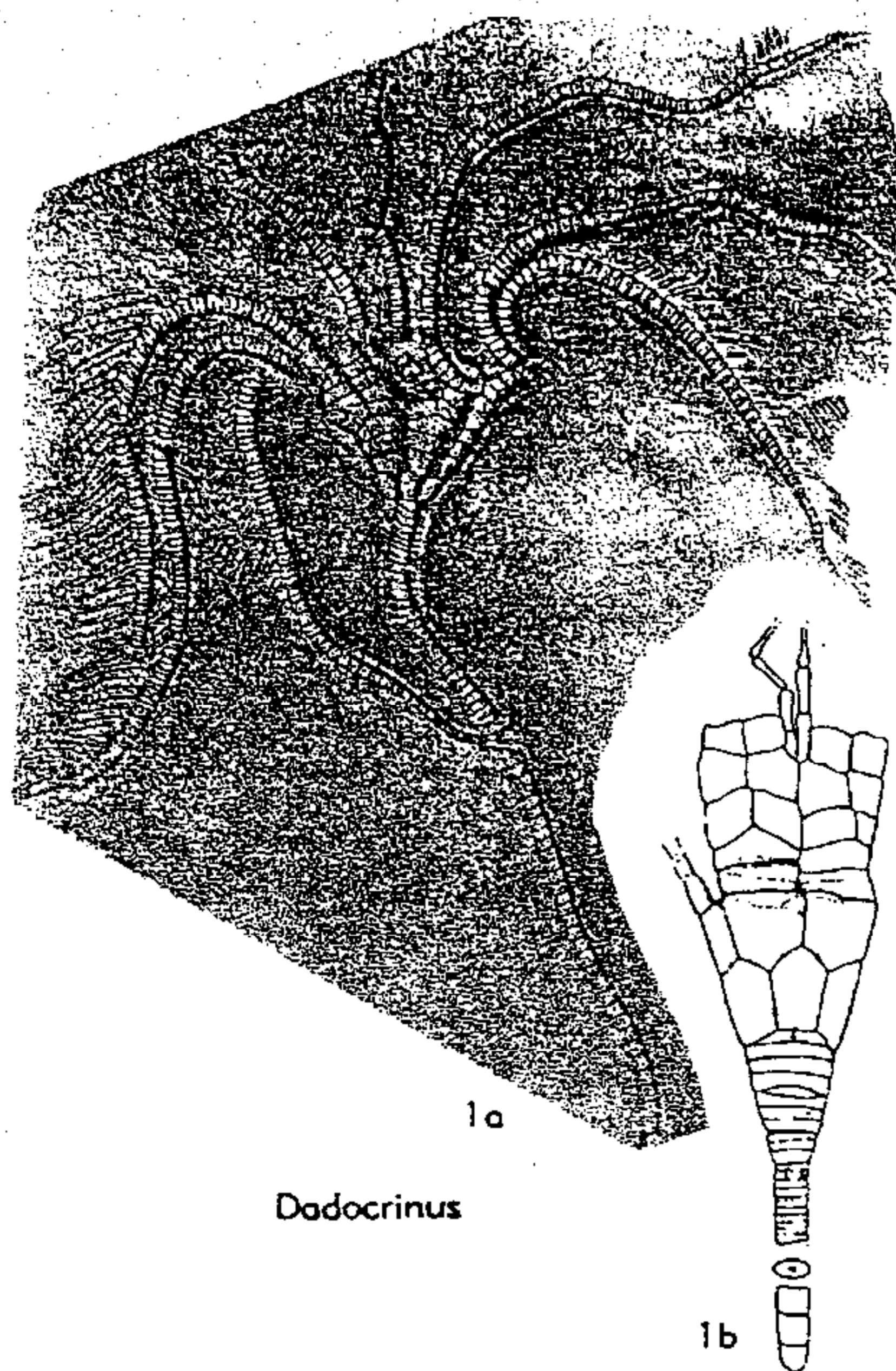
## Suborder MILLERICRININA

Sieverts-Doreck, 1952

[*nom. transl.* SIEVERTS-DORECK in URAGES, 1953, p. 761 (ex Millericrinida SIEVERTS-DORECK in MOORE, LALICKER, & FISCHER, 1952, p. 614); emend. RASMUSSEN, herein] (SIEVERTS-DORECK divided the order Millericrinida into two suborders, Millericrinina and Bourgueticrinina. RASMUSSEN (1969) classified Bourgueticrinina as an order. Hyocrinina is introduced as a new suborder by RASMUSSEN, herein)

Cup large and stout, thick walled, with five large basals and five large radials separated by distinct sutures. Radial articulations for arms generally wide, primibrachials in most species joined laterally or connected by interradsial plates. Arms divided at primibrachs 2 and may be further divided once or twice with variable intervals. Primibrachs 1 to 2 nonmuscular. First pinule on secundibrach 2. A few nonmuscular articulations may occur in arm branches. Proximal brachial articulations reduced or modified in Apiocrinidae. Central cavity of cup moderate to large, bottom with central depression corresponding to basal ring and lower part of radial ring below ridge or vault containing commissural nerve canal. Interradsial nerve canal in ridge on inner wall of basals divided into branches continuing to each of two superposed radials, where nerve canals from two basals meet and form the radial canal. Bottom of central depression below commissural canal is subdivided by interradsial ridges into five elliptical depressions, which may be smooth or have an ornament of irregular furrows.

Column stout, cylindrical, generally long and attached by a stout radix, but reduced and short in a few species of Millericrinidae (*Liliocrinus pratti*). Proximal part of column with the usual pattern of crenulae on the articular face or modified in species with pentagonal outline of proximal columnals. Diameter of column gradually in-



Dadocrinus

FIG. 549. Dadocrinidae (p. 7818).

creasing in upper part of column in most Apiocrinitidae. Uppermost columnal may articulate to underside of basal circlet with a flat or slightly convex proximal articular face divided by five ridges separating the joint faces toward each basal, as in some Apiocrinitidae, or uppermost columnal may form a large, five-sided plate included as a "proximale" forming dorsal part of cup, often reaching bottom of central cavity, and with articular face toward basals forming high rim. *M.Trias., L.Jur.-L.Cret.*

**FAMILY DADOCRINIDAE**

Lowenstam, 1942

[Lowenstam, 1942c, p. 1832] [Text for this family prepared by H. A. LOWENSTAM]

Column cryptocyclic, concealed; arms acyclic, acroserial, branching; primibrachial on second primibrach, secundibrachial on second or U-shaped; primibrachial on second and secundibrach, pinaculiferous on consecutive brachials; columnal articulation at primibrachs 1-2,

and may be present in distal arm regions. Tegmen flexible, coarsely granulose in oral region, with larger interambulacral plates in some at proximal edges. Stem without cirri, proximal columnals pentagonal, uniform in diameter or expanding conically toward calyx base; mid-stem and root near columnals circular, mid-stem columnals straight or slightly convex; root encrusting. *M.Trias.*

Dadocrinus VON MEYER, 1847, p. 575 [*\*Encrinus gracilis* VON BUCH, 1845; M] [= *Calathocrinus* VON MEYER, 1847, p. 576 (type, *C. digitatus*; M; according to BEYRICH, a synonym of *Dadocrinus gracilis*); *Cremaocrinus* JAEKEL, 1918, p. 70 (type, *Apiocrinus recubariensis* CREMA, 1896, = *Millericrinus recubariensis* BATHER, 1897) (non *Cremaocrinus* ULRICH, 1886); *Recoarocrinus* GISLÉN, 1924, p. 201 (nom. subst. pro *Cremaocrinus* JAEKEL, 1918) (obj.)]. Characters of family. *M.Trias.* (*L.Anis.*), C.Eu.-S.Eu.—FIG. 549, 1a. *D. kunischi* WACHSMUTH & SPRINGER, 1887, Silesia; lat. view, X1 (Kunisch, 1883).—FIG. 549, 1b. *\*D. gracilis* (VON BUCH); diagram., X5 (Bather, 1897).

**Family MILLERICRINIDAE**  
Jaekel, 1918

[*Millericrinidae* JAEKEL, 1918, p. 69]

Cup truncated conical or bowl shaped, often low and wide, to hemispherical, almost spherical. Radial articulations for arms muscular, with distinct fulcral ridge, dorsal ligament fossae moderate, interarticular ligament fossae low, wide and deep, ventral muscular impressions shallow, at elevated inner margin of articular face. Primibrachs 1 to 2 and secundibrachs 1 to 2 synarthrial. Primibrachials often meet laterally, but they may be separated. Few or generally no interbrachial plates. [Small, rudimentary, concealed infrabasals were shown by DE LORIOLO (1884), in specimens of *Angulocrinus orbigny* (DE LORIOLO) and *Liliocrinus polydactylus* (D'ORBIGNY).] Column cylindrical, smooth or with ornament of spines, tubercles, or ridges. Proximal part of column often pentagonal in section. Articular face of columnals with radiating crenulae generally occupying entire surface, commonly arranged in five groups, in pentagonal columnals commonly restricted to marginal zone. Generally no increase in diameter of column below cup, or only an extremely short conical transition below



uppermost columnal. Uppermost columnal enlarged as a five-sided plate forming dorsal part of cup. Proximal face of this uppermost columnal strongly convex, generally reaching bottom of central cavity, and with a pyramid of steep joint faces toward surrounding basals. Distal articulation of uppermost columnal is concave. *L. Jur.*-*U. Jur.*

Although isolated columnals similar to *Millericrinus* are found in the Middle Triassic of Italy and Hungary, they have been referred by BATHER (1909) to other genera. Most Lower Jurassic species referred to *Millericrinus* are columnals with crenulae restricted to a marginal zone.

*Millericrinus* D'ORBIGNY, 1841, p. 36, *emend.* ROLLIER, 1911, p. 7 [*\*Encrinites milleri* VON SCHLOTHEIM, 1823; p. 89; SD ROLLIER, 1911] [= *Ceriocrinus* DESOR (*ex* KOENIG), 1845, p. 215 (*obj.*), *non* WHITE, 1880b] [DESOR recorded *Ceriocrinus* KOENIG with the type species *Apiocrinus milleri* although *Ceriocrinus* was used by KOENIG in the unpublished second part of "Icones fossilium" in the combination *C. celator* for a figured specimen never identified, and with reservation for *C. milleri*. Since never published by KOENIG, and only by AGASSIZ, 1836, among synonyms of *Apiocrinus*, the name *Ceriocrinus* is here considered a junior synonym of *Millericrinus*, taking name and date from DESOR, 1845]. Cup large, more or less five-sided, often rather low and wide. Basals forming more or less horizontal underside of cup and often part of sides. Radials steep. Articular face for arms narrow and separated, to wide and meeting laterally. Column cylindrical or in proximal part pentagonal. Proximal part not increasing in diameter toward cup. Uppermost columnal enlarged as a five-sided proximale included in cup, with proximal end reaching central cavity, and with articular face toward surrounding basals forming steep pyramid. In *M. charpyi* fused proximal columnals form a high columnar proximale. Articular face of columnals with crenulae generally arranged in 5 groups. [The genus was subdivided by ROLLIER (1911) in subgenera *Millericrinus*, *Angulocrinus*, *Liliocrinus*, and "*Cupulocrinus*" (= *Orbignycrinus*), here treated as genera.] *M. Jur.*-*U. Jur.*, *Eu.* (France-Ger.-Switz.-Port.).—FIG. 550, 1a, e-h. *\*M. milleri* (VON SCHLOTHEIM), *U. Jur.*, France; 1a, ventral face of basal circlet (radials removed),  $\times 1$ ; 1e-g, cup,  $\times 1$ ; 1h, proximal columnal,  $\times 2$  (de Loriol, 1884).—FIG. 550, 1b-d. *M. charpyi* DE LORIOI, *U. Jur.*, France; 1b-d, basal circlet with proximale, ventral, lat., and dorsal,  $\times 1.5$  (de Loriol, 1884). [= *Millericrinites* BUVIGNIER, 1852, p. 263 (*nom. van.*); *Millecrinus* EBRAY, 1864, p. 232 (*nom. null.*).]

*Angulocrinus* ROLLIER, 1911, p. 4, 9 [*\*Millericrinus nodotianus* D'ORBIGNY, 1841, p. 59; SD RASMUSSEN, herein] [ROLLIER based this genus on the cup of *Millericrinus regularis* D'ORBIGNY and *M. nodotianus* D'ORBIGNY as figured, by DE LORIOI (1883). Since only *M. nodotianus* was based by D'ORBIGNY on specimens with a preserved cup, this species is here designated as type of the genus]. Cup truncated conical, not tumid, increasing in diameter upward from edge of enlarged uppermost columnal, which is more or less included as a rounded to five-sided proximale in cup with a five-sided pyramidal proximal face toward the basals. Column cylindrical, commonly ornamented with tubercles or spines. Upper part of column five-sided with columnals alternating in height and diameter. Articular face of columnals with radiating crenulae often arranged in five groups, especially in proximal part of column. Crenulae may in some species be restricted to a marginal zone of articular face. [Small, concealed infrabasals were shown by DE LORIOI (1884) in specimens of *A. orbignyi*. According to HESS (1975), occurrences and form indicate a possible identity of type species with *Encrinites echinatus* VON SCHLOTHEIM, 1820, *Millericrinus aculeatus*, *M. beaumonti*, *M. calcar*, *M. dilatatus*, *M. horridus*, *M. ornatus*, *M. regularis*, *M. scalaris*, and *M. subechinatus* D'ORBIGNY, 1841, *M. bruckneri*, *M. knorri* DE LORIOI, 1878, and *M. etrocheyensis* DE LORIOI, 1883.] *M. Jur.* (*Callov.*)-*U. Jur.* (*Kimmeridg.*), *Eu.* (France-Ger.-Port.-Switz.).—FIG. 550, 2a, b, g, h. *\*A. nodotianus* (D'ORBIGNY), *U. Jur.*, France; 2a, b, g, h, cup, proximale and column,  $\times 1$  (de Loriol, 1884).—FIG. 550, 2j-m. *A. regularis* (D'ORBIGNY), *U. Jur.*, France; 2j, arm with pinnules,  $\times 3$ ; 2k, crown and column,  $\times 2.5$ ; 2l, m, part of pinnule, *enl.* (de Loriol, 1883).—FIG. 550, 2e, f, n-q. *A. orbignyi* (DE LORIOI), *U. Jur.*, France; 2e, underside of basal circlet; 2f, ventral face of proximale with infrabasals,  $\times 2.5$ ; 2n-q, column,  $\times 2.5$  (de Loriol, 1883).—FIG. 550, 2c, d, i. *A. elatus* (DE LORIOI), *U. Jur.*, France; 2c, column,  $\times 1$ ; 2d, i, distal and proximal articulations in column,  $\times 3$ ,  $\times 2.5$  (de Loriol, 1884).

*Liliocrinus* ROLLIER, 1911, p. 6 [*\*Millericrinus polydactylus* D'ORBIGNY, 1841, p. 41; SD RASMUSSEN, herein] [ROLLIER based this genus on *Apiocrinites rosaceus* (VON SCHLOTHEIM, 1823) as figured by GOLDFUSS (1831, pl. 56, fig. 3) and by QUENSTEDT (1858, pl. 87, fig. 20), and on *Millericrinus polydactylus* D'ORBIGNY as figured by DE LORIOI (1884, pl. 109). Since DESOR (1845, p. 217) has demonstrated that the identity of the species first recorded is ambiguous, *M. polydactylus* is here designated as type species]. Cup truncated conical to bowl shaped, not tumid, increasing in diameter upward from edge of rather wide uppermost columnal. Basals and radials large. Radial articular face for arms low and wide. Column cylindrical,

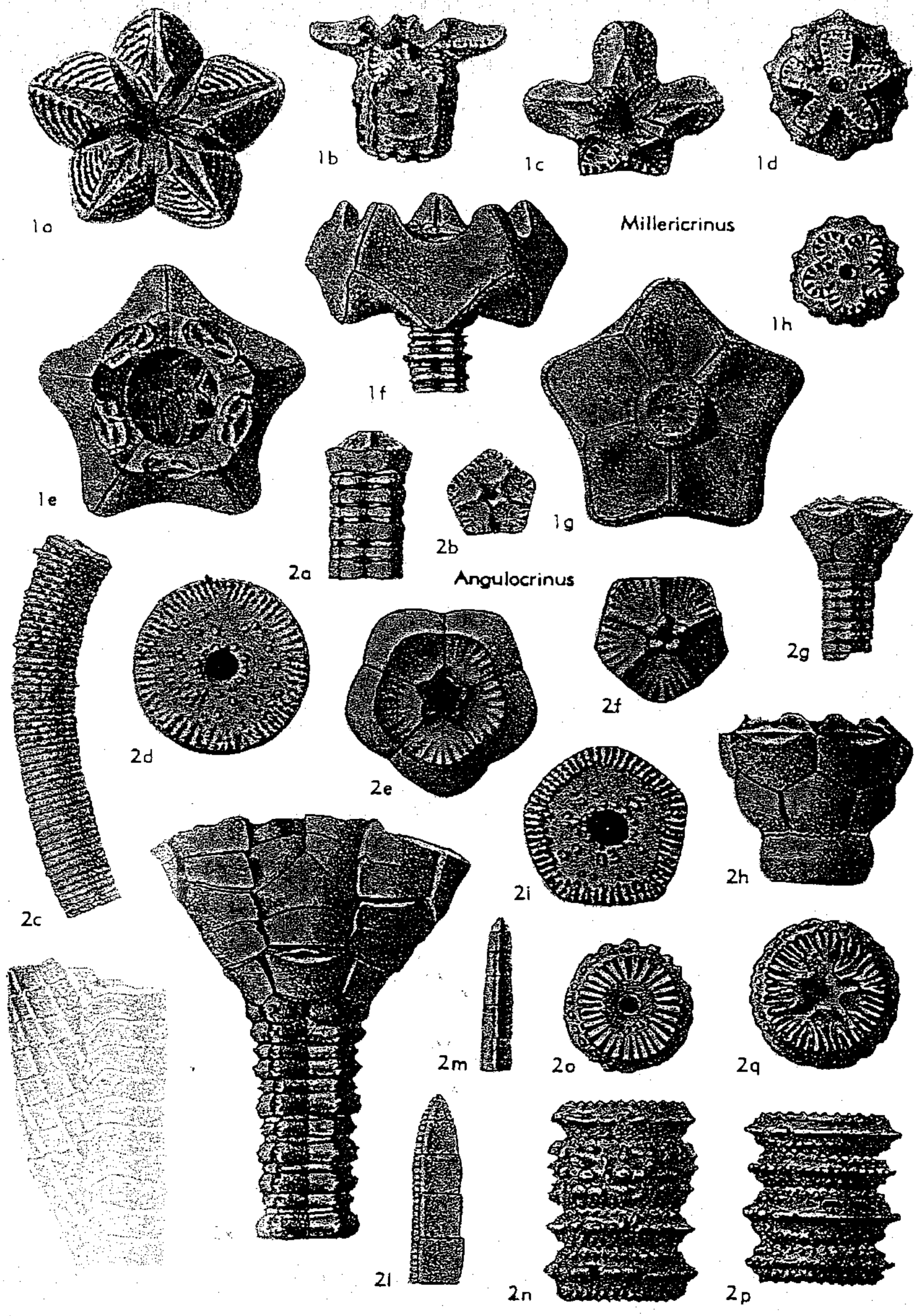
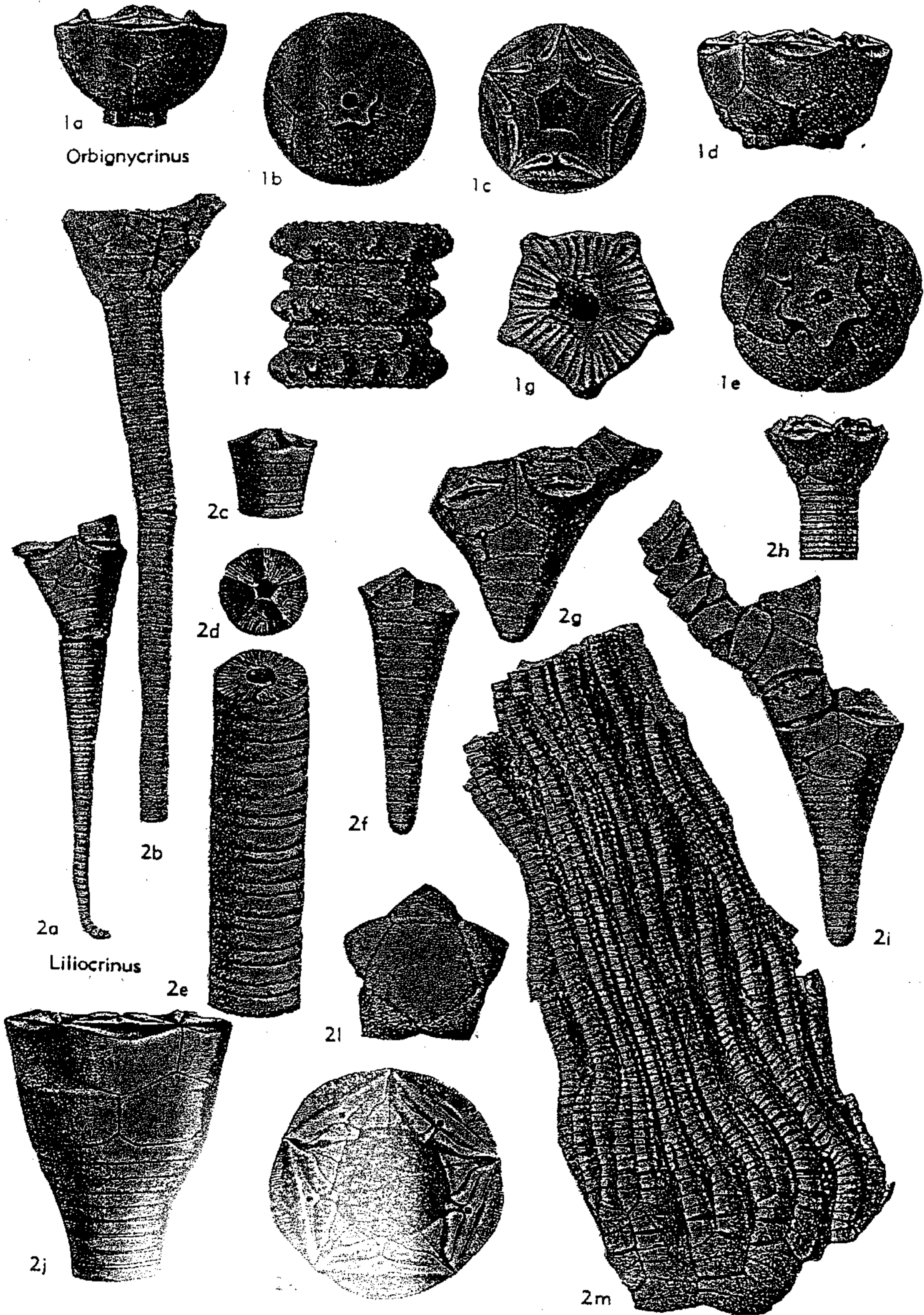


FIG. 550. Millericrinidae (p. 7819).



columnals uniform or alternating in size in upper part of column. Upper columnals slightly increasing in diameter toward cup, not five-sided. Articular face of columnals entirely covered by radiating crenulae, not separated in groups. Proximal articular face of uppermost columnal more or less pyramidal or conical to almost flat. [The aberrant *Encrinites prattii* GRAY, 1828b, has a similar crown and a short to very short, tapering column. It may be attached provisionally to this genus. Small, concealed infrabasals are shown by DE LORIOI (1884) in specimens of *L. polydactylus*.] *M. Jur.* (*Bathon.*)-*U. Jur.* (*Kimmeridg.*), Eu. (Eng.-France-Ger.-Switz.).—FIG. 551, 2*h, m*. \**L. polydactylus* (D'ORBIGNY), *U. Jur.*, France; 2*h*, cup and column,  $\times 1$ ; 2*m*, arms,  $\times 1$  (de Loriol, 1884).—FIG. 551, 2*c-e, j, k*. *L. munsterianus* (D'ORBIGNY), *U. Jur.*, Ger.; 2*c-e*, column; and 2*j, k*, cup, all  $\times 1$  (Goldfuss, 1831).—FIG. 551, 2*a, b, f, g, i, l*. *L. prattii* (GRAY), *M. Jur.*, Eng.; 2*a, b, g, i*, cup and column (2*a*,  $\times 2$ ; 2*b*,  $\times 1.5$ ; 2*g, i*,  $\times 3$ ); 2*f*, column with proximale,  $\times 2$ ; 2*l*, cup with column reduced to proximale,  $\times 4$  (Carpenter, 1882).

*Orbignycrinus* BIESE, 1935, p. 478, *nom. subst. pro Cupulocrinus* ROLLIER, 1911, p. 7, *non* D'ORBIGNY, 1850, p. 23, 46 [\**Millericrinus cupuliformis* D'ORBIGNY, 1841, p. 51; SD SIEVERTS-DORECK, herein]. Cup smooth, bowl shaped, almost hemispherical, composed of large and high basals and somewhat lower radials. Rather small proximale with pentalobate articulation for the column. Ventral side of cup almost circular, articular face for arms low and wide, almost horizontal, meeting in interradial sutures and surrounding shallow radial cavity. Radial articular face with distinct ridge, dorsal and interarticular ligament fossae low and wide, concave, ventral muscular fossae not distinctly indicated, arms unknown. Column five-sided, columnals strongly alternating, crenulae arranged in 5 groups and more or less restricted to a marginal zone. *M. Jur.* (*Bathon.*)-*U. Jur.* (*Kimmeridg.*), Eu. (France-Switz.).—FIG. 551, 1*a-c*. \**O. cupuliformis* (D'ORBIGNY), *U. Jur.*, France; 1*a-c*, cup with proximal columnal,  $\times 2$  (de Loriol, 1884).—FIG. 551, 1*d, e*. *O. icauensis* (DE LORIOI), *M. Jur.*, France; 1*d, e*, cup with proximal columnal,  $\times 2.5$  (de Loriol, 1883).—FIG. 551, 1*f, g*. *O. cotteai* (DE LORIOI), *M. Jur.*, France; 1*f, g*, column,  $\times 3$  (de Loriol, 1883).

*Pomatocrinus* DESOR, 1845, p. 217 (*ex* KOENIG) [\**Encrinites mespiliformis* VON SCHLOTHEIM, 1820, p. 332; M] [This genus name was introduced in the combination *P. jaegeri* by KOENIG in the second part of "*Icones fossilium sectiles*," never published, but distributed to a few people. The specimen figured by KOENIG but undescribed has never been identified. It shows resemblance to *E. mespiliformis*, although this species was figured on the same plate as *Symphytocrinus? mespiliformis*. *Pomatocrinus* was recorded by AGASSIZ (1836, p. 195) as a synonym of *Apiocrinus* and

was first used by DESOR (1845) for *E. mespiliformis*. ROLLIER (1911, p. 6) maintained the name *Pomatocrinus* for one of the groups into which he divided *Millericrinus*] [QUENSTEDT (1857, p. 715), recorded *Apiocrinites mespiliformis* as resembling the fruit of medlar (*Mespilus*); the name *Mespilicrinus* therefore was considered suitable, but was not established for this genus, and the name *Mespilocrinites* was used in the same publication (p. 198, 514), and *Mespilocrinus* in later publications for species of *Cyclocrinus*, but preoccupied by DE KONINCK & LE HON, 1854]. Cup large, almost spherical, thick walled, composed of very large basals, smaller radials and a rather large proximale surrounding almost spherical central cavity. Sutures distinct. All plates in cup jointed in flat, slightly rough faces. No trace of infrabasals. Radial articular face for arms large and wide, meeting along interradial sutures. Articulation muscular with distinct fulcral ridge, dorsal and interarticular ligament fossae, and small ventral muscular fossae. Primibrachs meet laterally. Arms divided at primibrachs 2. Articulation at primibrachs 1-2 and secundibrachs 1-2 synarthrial. Isolated brachials referred by QUENSTEDT to type species indicate arms further divided and first pinnule on secundibrach 2. Inner wall of central cavity has interradial ridges or furrows probably corresponding to nerve canals from basals undivided to surface of proximale and divided upward in branches to radials. Uppermost columnal or proximale five-sided in outline, forming dorsal plate of spherical cup, and continued as high, five-sided, truncated pyramid inside basal circlet to bottom of central cavity. Underside has a concave articular face, circular in outline, to receive fine granulated proximal face of next columnal, which together with a few succeeding, very low columnals form very short, slightly conical transition to cylindrical column. Columnals generally rather high and smooth. Articular face with fine, radiating crenulae, closely placed, not in separated groups. Crenulae may be modified to granulae in central area of articular face. Central canal narrow to moderate. [Genus is closely similar to a group of *Apiocrinites* except for the unmodified articular face of radials and proximal brachials. It differs from *Orbignycrinus* in column and proximale.] *L. Jur.*-*U. Jur.*, Eu. (Ger.-France-Port.-Spain-Switz.-USSR).—FIG. 552, 1*a-d*. \**P. mespiliformis* (VON SCHLOTHEIM), *U. Jur.*, Port.; 1*a*, proximale and two basals,  $\times 1$ ; 1*b-d*, cup,  $\times 1$  (de Loriol, 1891).—FIG. 552, 1*e-g*. *P. fleuriausianus* (D'ORBIGNY), *U. Jur.*, France; 1*e, f*, cup and column,  $\times 0.6$ ,  $\times 1.5$ ; 1*g*, section,  $\times 0.9$  (d'Orbigny, 1841).

#### Family APIOCRINITIDAE d'Orbigny, 1840

[*nom. correct.* RASMUSSEN, herein (*pro* Apiocrinitidae D'ORBIGNY, 1840, p. 1)]

Cup very large, pyriform or ovoid to hemispherical or globular, very thick walled. Plates meet in flat joint faces with radiating ridges or less regular granulation. Central cavity moderate to large, with central depression in bottom. Interradial ridges containing nerve canals in basals subdivide central depression into five radial elliptical depressions and continue in a branch to each of two superposed radials, where they meet in radial nerve canals connected by commissural canal bordering central depression. Petaloid elliptical depressions may be smooth or have a pattern of closely placed furrows. Primibrachials with or without small interbrachial plates laterally joined and included in thecal structure. Interbrachial plates variable in number, generally few; smaller plates may be concealed, wedged in between other plates and not reaching outer surface. Arms divided at primibrachs 2; may be further divided. Articulation of radial with primibrach 1 muscular, primibrachs 1-2 and secundibrachs 1-2 synarthrial, but articular face of radials and primibrachials and commonly some secundibrachials modified by reduction of articular ridge, small interarticular ligament fossae and very small ventral muscular fossae; dorsal ligament fossae greatly enlarged and modified, flat or concave with feeble radiating crenellae or irregular rugosity. Synarthrial ridge of primibrach 1-2 also reduced, low and wide, and may disappear. Column long, cylindrical, smooth, slightly increasing in diameter toward distal end, and rapidly increasing below cup. Columnals low, generally uniform, but may alternate with very low, presumably new columnals below enlarged uppermost part of column. Articular face with fine, uniform, radiating crenulae covering entire face, not separated in groups. Large and stout irregular radix. Variable number of proximal columnals with increasing diameter form conical transition between cup and column. *L. Jur.-L. Cret.*

The distinction of *Millericrinus* and *Apio-crinites* as genera, and of Millericrinidae and Apiocrinidae as families, was based on several differences not always correlated, such as reduction and modification of proximal brachial articulations, the inclusion of fixed brachials and interbrachial plates in

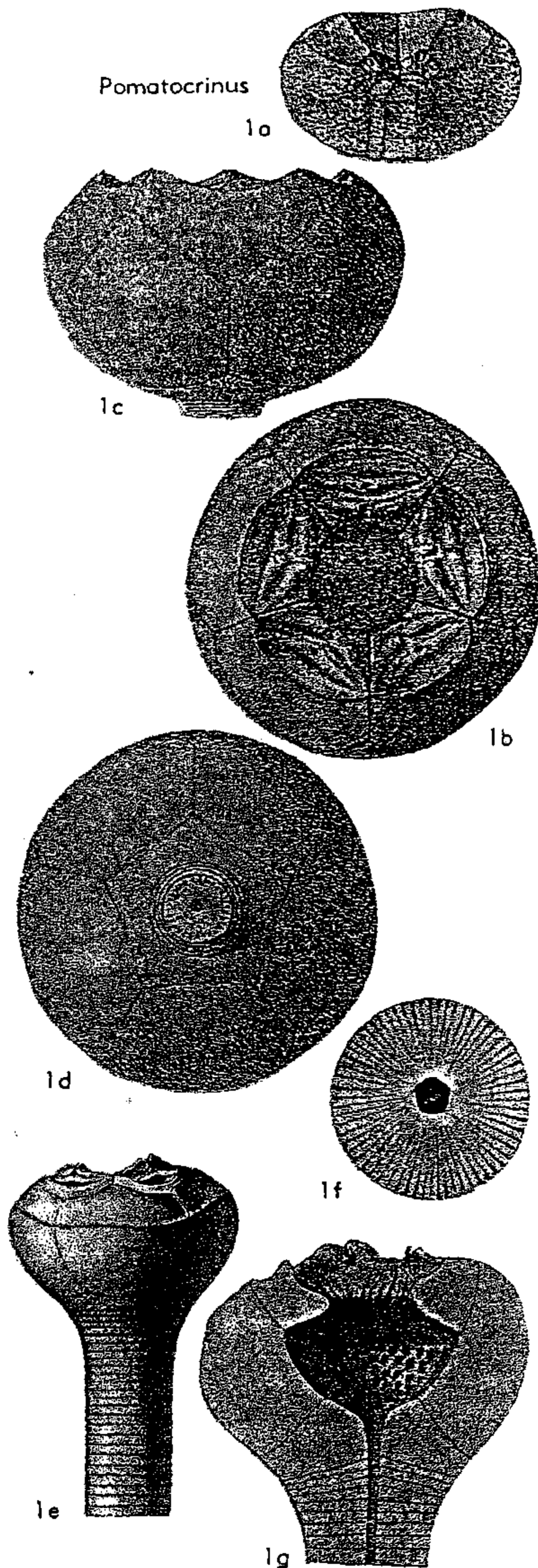


FIG. 552. Millericrinidac (p. T822).

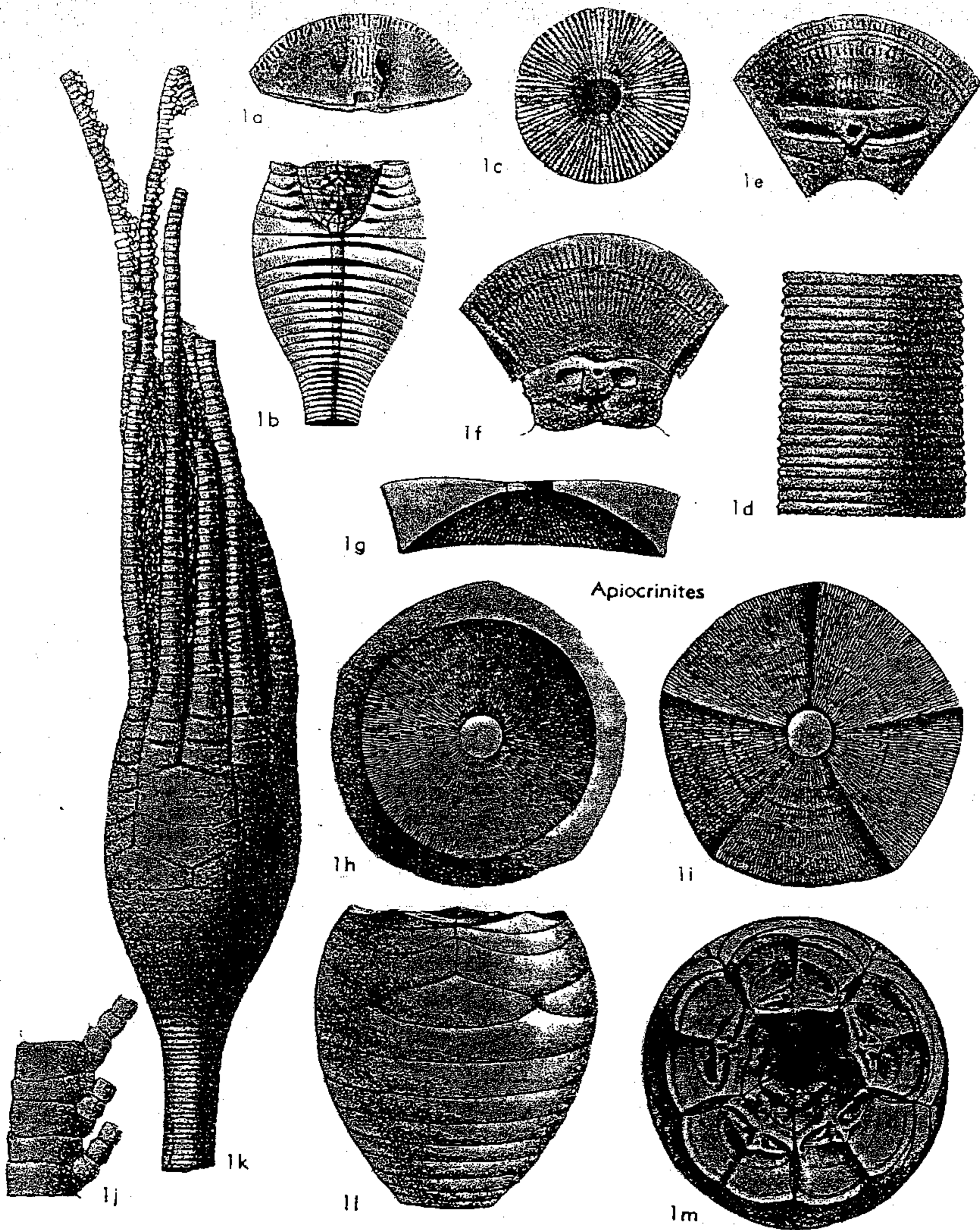


FIG. 553. Apiocrinitidae (p. T825).

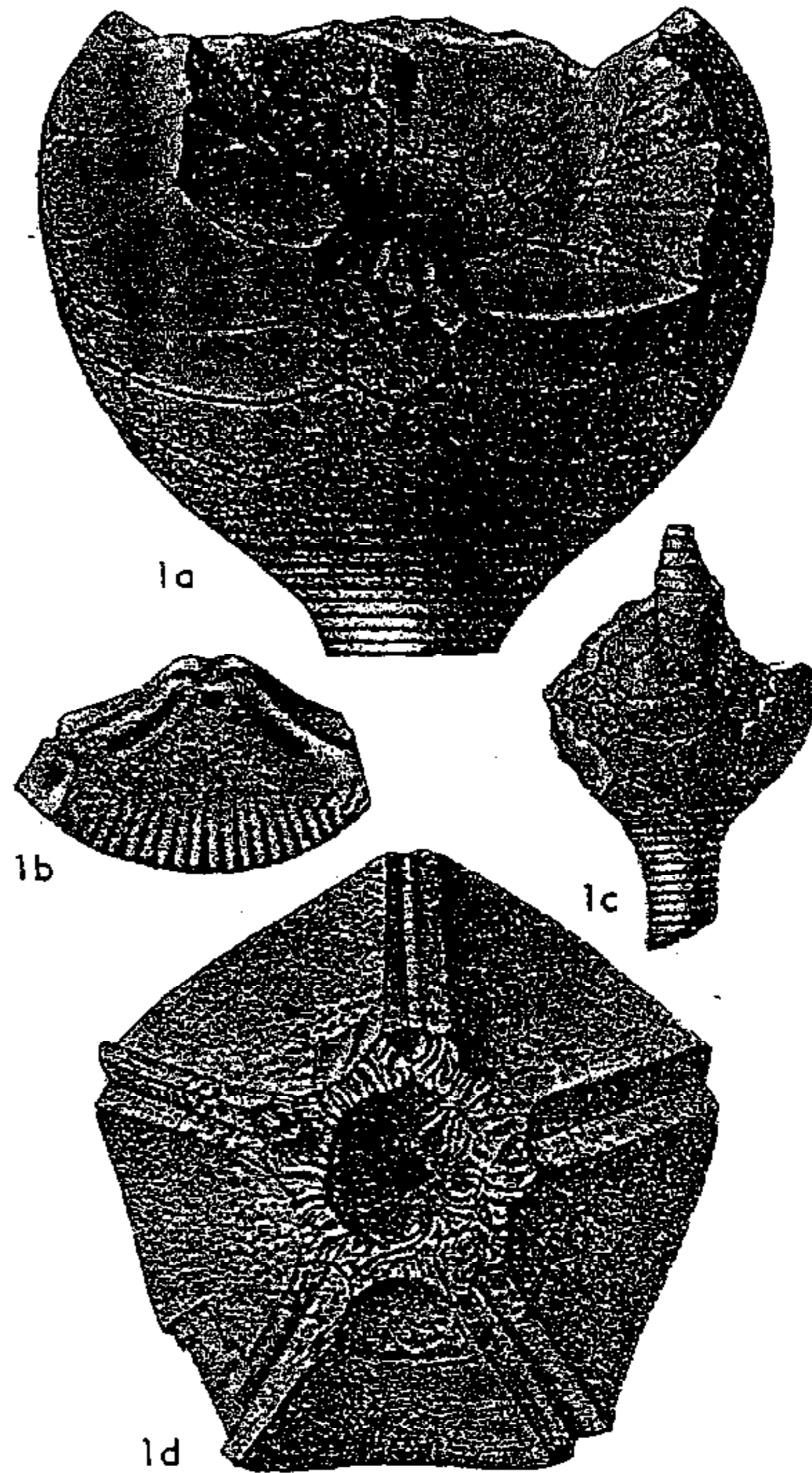
the thecal structure, the enlargement of several proximal columnals forming a long and gradual transition between column and cup, and the flat proximal articular face of the uppermost columnal, all typical to *Apio-*  
*crinites*. Many species of *Apio-*

*crinites*, including the type species, agree with this description; however, there are other species generally referred to the genus, but with almost spherical cup and only a single or a few enlarged proximal columnals, the uppermost one with a high, pyramidal prox-

imal face. These species may well be intermediate between *Pomatocrinus* and *Guettardicrinus*. It is possible, by taking reduced brachial articulations as a decisive characteristic, that advanced forms of more than one evolutionary line have been united polyphyletically in the family Apiocrinitidae.

Apiocrinites MILLER, 1821, p. 17 [\**A. rotundus* (= *Encrinites parkinsoni* VON SCHLOTHEIM, 1820, p. 332); SD D'ORBIGNY, 1840, p. 20] [= *Apiocrinus* AGASSIZ, 1836, p. 195 (nom. van.)] [By emendation D'ORBIGNY (1840) left *A. rotundus* (= *A. parkinsoni*) as only original species maintained in restricted genus *Apiocrinus*]. Theca typically pear shaped to ovoid, greatest diameter at basal or radial circlet. Proximal part of column with increasing diameter forming long and gradual transition from column to cup and confluent with surface of cup. Primibrachials, without or with a few small polygonal interbrachial plates, meeting laterally. All or most secundibrachials free. Arms divided at primibrachs 2 and in some species further divided once or twice with variable interval. First pinnule at secundibrachs 2. The large and conical proximal part of column found typically in *Apiocrinites* consists of discoidal columnals with flat proximal articular face and concave distal articular face, leaving empty central spaces between columnals. Proximal face of uppermost columnal is flat or slightly convex with 5 radiating ridges separating joint faces toward the basals. [Several species generally referred to *Apiocrinites* have a hemispherical to almost spherical cup and a very short conical proximal part of the column, in some species only a single, five-sided proximale with convex to pyramidal proximal face included in the dorsal side of the cup as in *Pomatocrinus*, but with insufficiently known, presumed modified and reduced articulations in the radials and proximal brachials. These species may perhaps belong to *Pomatocrinus* or be intermediate in the evolution from *Pomatocrinus* toward *Guettardicrinus*.] L. Jur.-L. Cret., Eu. (Eng.-France-Ger.-Hung.-Italy-Pol.-Spain-Switz.-Yugo.-USSR)-Afr. (Alg.)-N. Am. (Mex.).—FIG. 553, *1a, b, g-m*. \**A. parkinsoni* (VON SCHLOTHEIM), M. Jur., France, Ger.; *1a*, distal face of primibrach 1,  $\times 3$  (de Loriol, 1882); *1b*, sec. of cup,  $\times 0.8$  (Goldfuss, 1831); *1g-i*, uppermost columnal,  $\times 1$  (Goldfuss, 1831); *1j*, fragment of arm with pinnules,  $\times 4$  (de Loriol, 1882); *1k*, crown and column,  $\times 1$  (de Loriol, 1882); *1l, m*, cup,  $\times 1$  (Goldfuss, 1831).—FIG. 553, *1e, f*. *A. elegans* (DEBAY), M. Jur., France; *1e, f*, articular face of radial,  $\times 3$ ,  $\times 2$  (de Loriol, 1882).—FIG. 553, *1c, d*. *A. polycephalus* (DESOR), U. Jur., France; *1c, d*, columnal,  $\times 1$  (de Loriol, 1882).

*Guettardicrinus* D'ORBIGNY, 1840, p. 21 [\**G. dilatatus*; M] [= *Guettardicrinus* BRONN, 1851, p.



*Guettardicrinus*

FIG. 554. Apiocrinitidae (p. T825).

123 (nom. van.)]. Cup very large, up to 76 mm in diameter, hemispherical to almost spherical. Proximal columnals low, circular in outline, strongly increasing in diameter, forming low and wide, conical bottom of cup. Uppermost columnal with low, conical proximal joint face just reaching central cavity and with low ridges separating flat or slightly convex, feebly crenulate synostosal joint faces toward basals. Basals and radials rather low and wide. Radials and proximal brachials separated by several small polygonal interbrachial plates, variable in number. Primibrachs 1-2 and secundibrachs 1-2 included in thecal structure, all stout and connected by modified, generally synostosal articulations with feeble granulation on joint faces. U. Jur. (Oxford.), Eu. (France-Switz.).—FIG. 554, *1a, d*. \**G. dilatatus*, France; *1a*, cup,  $\times 0.8$ ; *1d*, distal face of radial circlet,  $\times 1$  (de Loriol, 1882).—FIG. 554, *1b, c*. *G. rathieri* (D'ORBIGNY), France; *1b*, distal face of primibrach 1,  $\times 3.5$ ; *1c*, cup,  $\times 0.8$  (de Loriol, 1883).

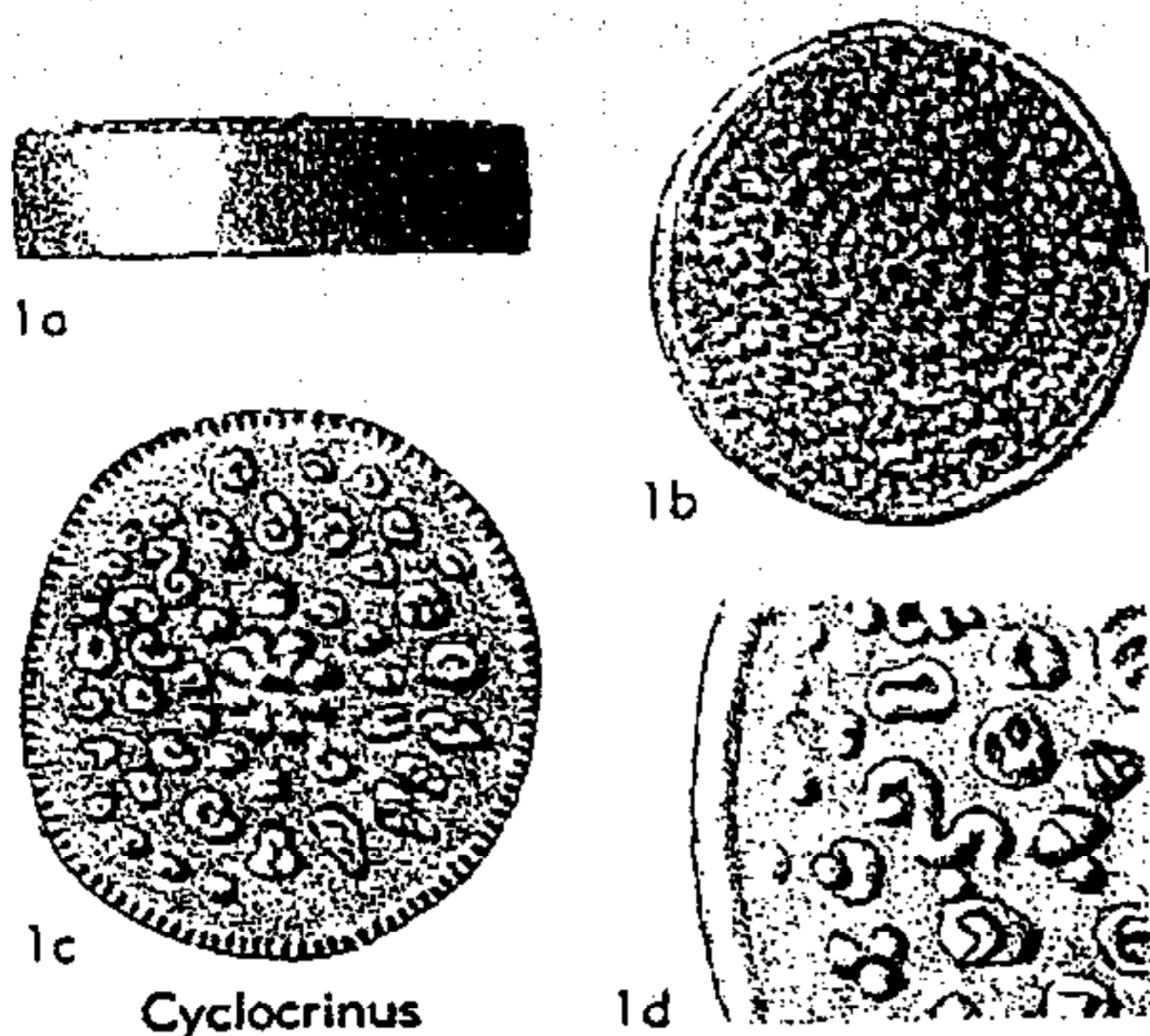


FIG. 555. Cyclocrinidae (p. T826).

### Family CYCLOCRINIDAE Sieverts-Doreck, 1953

[Cyclocrinidae SIEVERTS-DORECK in UBAGHS, 1953, p. 764]

Family of uncertain affinity, referred by SIEVERTS-DORECK to Cyrtocrinida. Only columnals of *Cyclocrinus* are known. Typical *Cyclocrinus* have very large, cylindrical columnals with narrow central canal and with flat articular face ornamented by numerous small, more or less irregular tubercles, pustules or small groups of tubercles or vermiculi. There may be a fine crenulation along the edge. Some minor columnals with one or two small, circular sockets, and a columnal with roof-shaped articular face indicating a division may perhaps belong to a radix. Large columnals indicate a large crinoid with long and stout column as in most Millericrinida. *L.Jur.-L.Cret.*

Some specimens often referred to *Cyclocrinus* have much smaller columnals with a combination of tubercles and marginal crenulae on the articular face, and may well belong to Cyrtocrinida. One of these species, *Apiocrinites amalthei* QUENSTEDT, 1852, p. 612, is type species of *Mespilocrinus* QUENSTEDT, 1856, p. 198 (*non Mespilocrinus* DE KONINCK & LE HON, 1854, *nec Mespilocrinus* QUENSTEDT, 1857, p. 715). The presumed uppermost columnal of this species, figured by QUENSTEDT (1876, pl. 104, fig. 105b) was interpreted by SIEVERTS-DORECK (1958b), as a fused radial circlet, and supports the interpretation of this species as belonging to Cyrtocrinida.

*Cyclocrinus* D'ORBIGNY, 1850, p. 291 [\**Bourgueticrinus rugosus* D'ORBIGNY, 1841, p. 96; SD DE LORIOI, 1886, p. 2] [= *Acrochordocrinus* TRAUTSCHOLD, 1859, p. 112 (type, *A. insignis*; M)]. Characters of family. *L.Jur.-L.Cret.*—FIG. 555, 1. \**C. rugosus* (D'ORBIGNY), M.Jur., France; 1a,b, columnal,  $\times 1$ ; 1c,d, small columnal,  $\times 2.5$ , enl. (de Loriol, 1886).

### Suborder HYOCRININA Rasmussen, new suborder

Column long, slender, rounded, without nodals or cirri. Articulations symplectial with radiating crenulae. Proximal part of column with numerous discoidal columnals, often slightly five-sided or six-sided in section and with tubercles forming vertical series, and alternating in size due to successive formation of new columnals between several columnals in a proximal zone, not just between cup and uppermost columnal. Distal part of column cylindrical with higher columnals. Attached to substrate by expanded terminal disc, no radix. Thin-walled hollow cup formed by basals and radials; infrabasals not observed. Basals in Calamocrininae five, in Hyocrininae either three or basals fused to a basal circlet without distinct sutures. Radials five, thin and flat, separated by distinct sutures. The radial circlet may be asymmetrical in *Anachalypsicrinus* due to difference in size of radials. Interradial nerve in furrow on inner side of basals dividing in a branch to each of two superposed radials, where nerves unite to radial nerve in canal. Arms considerably narrower than radials, and completely separated laterally. Arms are normally undivided except in *Calamocrinus*, where irregular distal branching takes place. Nonmuscular, apparently synostosial articulations at brachials 1-2 and with generally short intervals through arms. Short pinnule gap corresponding to one pair of pinnules, first pinnule about brachial 4 to brachial 6, below 4th muscular articulation. Pinnules long with many pinnulars. Tegmen with small plates, central mouth and commonly large oral plates. *L.Tert.(Dan.); Holo.*(recent, 705-4,640 m.).

### Family HYOCRINIDAE Carpenter, 1884

[Hyocrinidae CARPENTER, 1884, p. 217]

Characters of suborder. *L.Tert.; Holo.*



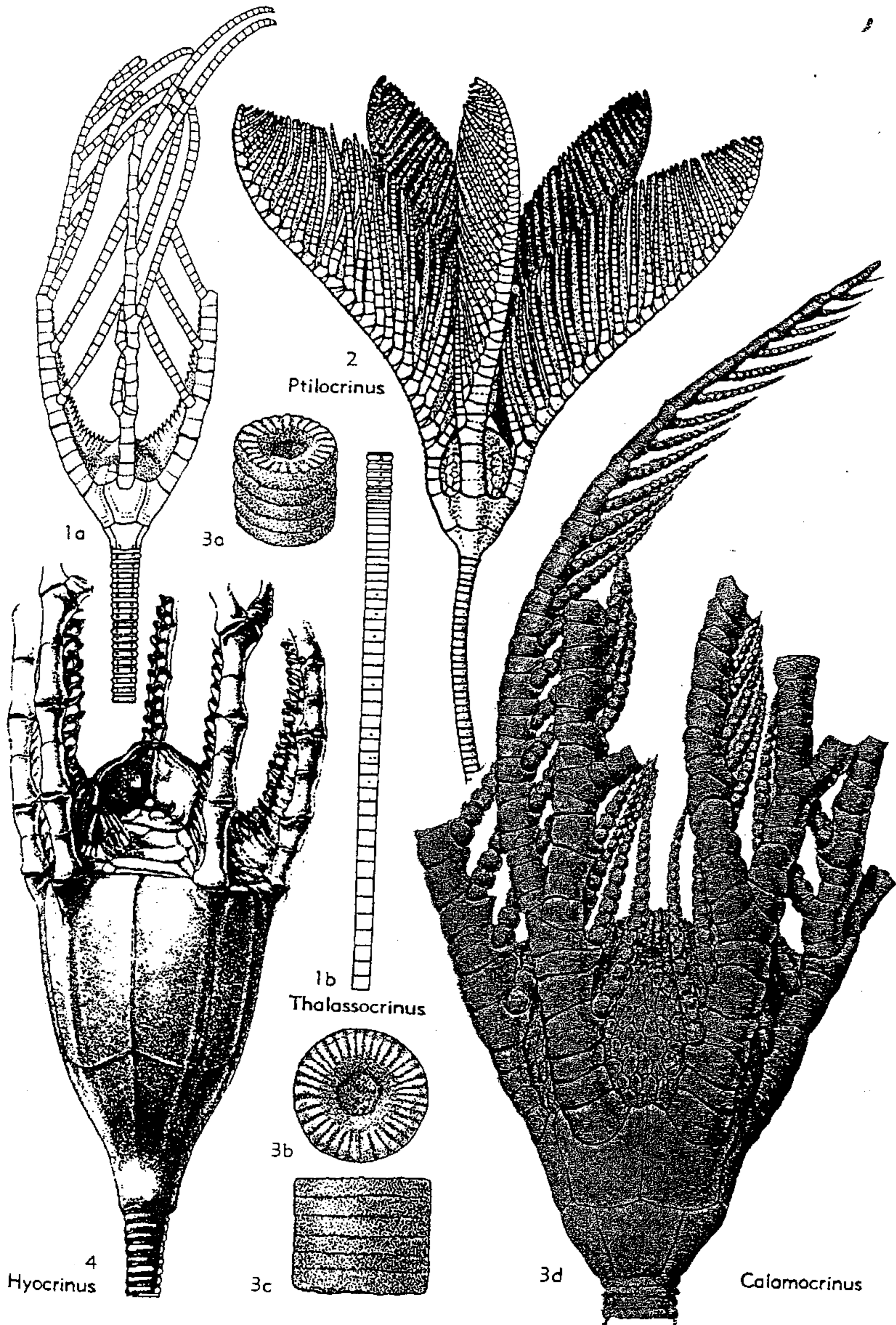


FIG. 556. Hyocrinidae (Hyocrininae) (1,2,4), (Calamocrininae) (3) (p. T828).

## Subfamily HYOCRININAE Carpenter, 1884

[*nom. transl.* A. M. CLARK, 1973b, p. 268 (ex Hyocrinidae CARPENTER, 1884)]

Basal cirlet with three basals, unequal in size and separated by more or less indistinct sutures, or fused without sutures. Arms normally undivided, considerably narrower than radials. Nonmuscular articulations with varying frequency, up to more than half of brachial articulations. Tegmen of moderate height and with large oral plates. Proximal part of column may be slightly pentagonal or hexagonal and tuberculate in *Gephyrocrinus*, *Anachalypsicrinus*, and *Thalassocrinus*. Recent, Pac.-Atl.-Antarctic [480-4,640 m.].

*Hyocrinus* THOMSON, 1876, p. 47 [\**H. bethellianus*; M]. Recent.—FIG. 536,4. \**H. bethellianus*; X6 (Carpenter, 1884). [See also Fig. 13, 18, 31, p. T26-T47.]

*Anachalypsicrinus* A. M. CLARK, 1973, p. 269 [\**A. neferiti*; M]. Recent.

*Gephyrocrinus* KOEHLER & BATHER, 1902, p. 68 [\**G. grimaldii*; M]. Recent.

*Ptilocrinus* A. H. CLARK, 1907, p. 551 [\**P. pinnatus*; M]. Recent.—FIG. 556,2. \**P. pinnatus*; enl. (Clark, 1915). [See also Fig. 12, 18, 28, 33, p. T25-T49.]

*Thalassocrinus* A. H. CLARK, 1911, p. 473 [\**T. pontifer*; M]. Recent.—FIG. 556,1. \**T. pontifer*; 1a,b, X1.5 (Clark, 1915).

## Subfamily CALAMOCRININAE A. M. Clark, 1973

[Calamocrininae A. M. CLARK, 1973b, p. 268]

Basal cirlet with five basals separated by distinct sutures. Arms almost as wide as radials, irregularly branching distally from brachial 10 or brachial 11 and more distal. Considerably less than half of brachial articulations are nonmuscular. Tegmen high, orals inconspicuous. Column rounded. *L. Tert. (Dan.)*; *Holo.*

*Calamocrinus* AGASSIZ, 1890, p. 165 [\**C. diomedae*; M]. Fossil columnals have been referred to this genus. *L. Tert. (Dan.)*, W. Greenl., recent in Pac. (Galapagos Is.-Panama, 705-1,410 m.).—FIG. 556,3d. \**C. diomedae*, recent; X2 (Agassiz, 1892).—FIG. 556,3a-c. *C. ilimanangei* RASMUSSEN, *L. Tert. (Dan.)*, Greenl.; 3a-c, column, X8.2 (Rasmussen, 1972a).

## Order CYRTOCRINIDA Sieverts-Doreck, 1952

[CYRTOCRINIDA SIEVERTS-DORECK in MOORE, LALICKER, & FISCHER, 1952, p. 614] [=Coadunata MILLER, 1821, p. 110; suborder Compacta JAEKEL, 1918, p. 75]

Cup composed of stout radials, no basals apparent, with or without dorsal element interpreted as fused basal cirlet or as proximale formed by modified columnal or fused columnals, and articulated to short column or directly to expanded attachment disc. Articular face of columnals with radiating marginal crenulae or granulae. In suborder Holopodina, radial cirlet directly connected to or fused with dorsal element attached to substrate. Columnals when present more or less cylindrical to barrel shaped and without nodals or cirri. Cup often oblique or attached in oblique position to proximale or other dorsal element. Ventral side of theca commonly protected by interradial projections from cup or by stout proximal brachials, which may form a complete cover when retracted. Arms divided at primibrachs 1 or primibrachs 2, no further division. Articulation of primibrachs 1-2 synostomial or muscular. All secundibrachials generally muscular, but syzygy with very few radiating culmina occur in *Gammarocrinites*. No synarthry. First pinnule on secundibrachs 1 or 2. [These forms are all restricted to hard-bottom, reef sediments or other solid surfaces for attachment.] *L. Jur.-Mio.*; *Holo.*

## Suborder CYRTOCRININA Sieverts-Doreck, 1952

[*nom. transl.* ARENDT, 1974, p. 84 (ex Cyrtocrinida SIEVERTS-DORECK, in MOORE, LALICKER, & FISCHER, 1952, p. 614)]

Cup with or without proximale or fused basal cirlet, articulated to a column or radix. *L. Jur.-U. Cret.*

Isolated columnals probably belonging to this suborder have been described as species of *Eugeniocrinites*. The genus *Leiocrinus* D'ORBIGNY, 1850, is based on similar corroded and indeterminable columnals (see p. T927).

Some species generally referred to *Cyclocrinus* and based on rather small columnals with tuberculate articular face and marginal crenulae may well belong to this suborder. The part of a cup referred by SIEVERTS-DORECK (1958) to *Cyclocrinus amalthei* (QUENSTEDT) shows an undivided dorsal element in the cup, indicating that at least this species may be referred to *Tetracrinus*.

## Family PLICATOCRINIDAE Zittel, 1879

[Plicatocrinidae ZITTEL, 1879, p. 346, 387 (emend. JAEKEL, 1893, p. 620)]

Cup consisting of radial circlet with three to eight radials, generally four or six, separated by distinct sutures and connected by close synostosis to proximal ossicle generally interpreted as a fused basal circlet without sutures. Underside attached to slender column with lenticular, cylindrical or barrel-shaped columnals. Articular face of columnals with radiating marginal crenulae or ridges, commonly rather few and arranged more or less distinctly in groups equal to number of radials. Dorsal element or presumed basal circlet variable in form, with central depression or cavity in continuation of radial cavity and with smooth, concave joint face toward each radial plate. Axial nerve canal in radials continues downward as two canals closely adjacent to mid-radial line, down into dorsal element, and a commissural canal connects radials. Arms divided at primibrachs 1. All brachial articulations muscular, no syzygy, synarthry, or synostosis. Secundibrachials wedge shaped and each with pinnule except secundibrach 1 in *Tetracrinus*. Pinnules unique, with fused pinnulars forming long spines or slightly curved rods, V-shaped in section with large and wide ambulacral furrow. Muscular articulation between brachial and pinnules and a few synostosomal articulations in proximal pinnules, but distal pinnules completely fused without articulations or sutures. Column presumably short, attachment unknown. *L. Jur.-U. Jur.*

The family was originally established by ZITTEL to include *Plicatocrinus* and *Hyocrinus*. Subsequently, *Hyocrinus* was transferred by CARPENTER (1884) to a new family, Hyocrinidae, and *Tetracrinus* was transferred by JAEKEL (1893) from Eugeniocrinidae to Plicatocrinidae. The affinity of Plicatocrinidae to Hyocrinidae was discussed by JAEKEL (1893) and by GISLÉN (1939).

*Plicatocrinus* MÜNSTER, 1839, p. 89 [\**P. hexagonus*; SD SIEVERTS-DORECK, 1964, p. 135] [MÜNSTER introduced this genus in combination with two new species, *P. hexagonus* and *P. pentagonus*. DE LORIO (1879, p. 245) and JAEKEL (1893a, p. 640) considered *P. pentagonus* a synonym of *P. hexagonus*, and SIEVERTS-DORECK, 1964, p. 133, re-

corded *P. hexagonus* as type]. Cup rather high conical, more or less stellate in section with rounded radial ridges and interradial embayments, composed of 4 to 8, generally 6, rather high, subtriangular, thin-walled radials attached to bowl-shaped or funnel-shaped dorsal element, and surrounding large and deep radial cavity continued into dorsal elements. Articulation for arms low and wide, elliptical or crescentic, generally occupying less than full width of radial plate. Dorsal ligament fossa outwardly sloping, interarticular ligament fossae and ventral muscular fossae horizontal or inwardly sloping, equal in size, forming bands separated by narrow edge and parallel to fulcral ridge. First pinnule on secundibrach 1. Columnals rather high cylindrical. *U. Jur. (Oxford.-Portland.)*, *Eu. (Eng.-Ger.-Switz.-Pol.)*.—FIG. 557, 1a-g. \**P. hexagonus*, *U. Jur.*, Ger.; 1a, cup,  $\times 4$ ; 1b-d, radials,  $\times 4$ ; 1e, dorsal element,  $\times 4$ ; 1f, g, column,  $\times 4$  (Jaekel, 1893).—FIG. 557, 1h-j. *P. sp.*, *U. Jur.*, Pol.; 1h, pinnule,  $\times 10$ ; 1i, j, proximal pinnule segment,  $\times 10$  (Jaekel, 1893).

*Tetracrinus* MÜNSTER, 1839, p. 88 [\**Eugeniocrinites moniliformis* MÜNSTER, in GOLDFUSS, 1829, p. 165; M]. Cup low, compact, variable in form, width almost equal to column, rounded or angular in section, with 3 to 6, often 4, rather compact radials forming the rather low conical radial circlet, separated by a constriction and suture from compact dorsal element, which may be discoidal, lenticular, barrel shaped, or low subconical, resembling a columnal. Radial cavity moderate, continued in shallow central depression in dorsal element, generally less than half diameter of cup. Articular face for arms large and broad, occupying entire distal edge of cup and meeting along interradial sutures. Interarticular ligament fossae large, ventral muscular fossae small. First pinnule on secundibrach 2. Columnals lenticular to barrel shaped or cylindrical, almost as wide as cup, height and diameter strongly variable within short fragments of column. Articular face with few crenulae or ridges commonly in four groups. *L. Jur. (M. Lias.)-U. Jur. (Portland.)*, *Eu. (France-Ger.-Pol.-Switz.)*.—FIG. 557, 2a, g, h. *T. sp.*, *U. Jur.*, Ger.; 2a, fused pinnule,  $\times 11.6$ ; 2g, h, proximal and distal face of dorsal element,  $\times 9.5$ ,  $\times 11$  (Sieverts-Doreck, 1964).—FIG. 557, 2b-f. \**T. moniliformis* (MÜNSTER), *U. Jur.*, France, Ger.; 2b-d, cup,  $\times 4$  (de Loriol, 1882); 2e, f, column with dorsal element of cup,  $\times 4$  (Jaekel, 1893).

## Family SCLEROCRINIDAE Jaekel, 1918

[Sclerocrinidae JAEKEL, 1918, p. 75, based on type genus *Sclerocrinus* JAEKEL, 1891a, according to BATHER (1900a, p. 197), a junior synonym of *Gammarocrinites* QUENSTEDT, 1857, p. 654, but maintained by JAEKEL (1907) and family name never replaced (here retained according to Code, Art. 40)]

Cup compact, low and wide, barrel shaped to conical, often more or less oblique and attached in oblique position to column.

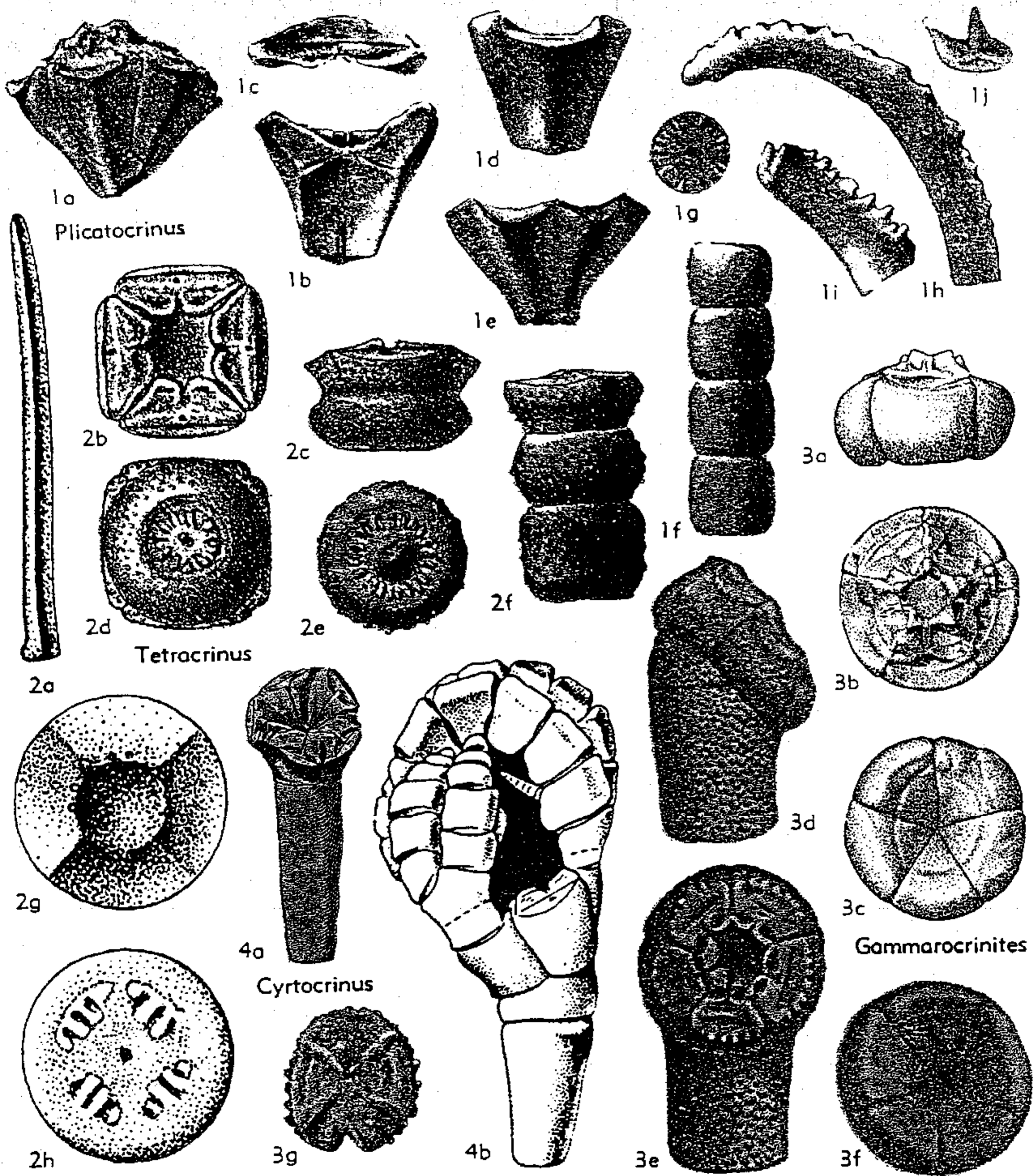


FIG. 557. Plicatocrinidae (1,2); Sclerocrinidae (3,4) (p. T829-T831).

Cup consisting of five radials separated by distinct sutures. No trace of basals. Under-side of cup rather wide, more or less concave, with articular face toward column smooth, granulated or with marginal crenulation. Radial cavity rather narrow to wide. Radial articular face for arms large and wide, meeting along interradial suture, not separated by interradial projections from the cup. Ventral muscular fossae small.

Brachials stout. Arms divided at primi-brachs I. Column presumably short, uppermost columnal commonly oblique or with strongly sloping proximal articular face, producing angle between cup and column. Columnals barrel shaped or cylindrical to slightly conical, often very high, presumably as result of fusion of several columnals. Articular face of columnals with radiating marginal crenulae. Attachment in *Cyrtocri-*

by irregular terminal disc or radix with short, stout branches and few or no articulations. *U. Jur. (Oxford.)-L. Cret. (Hauteriv.)*.

*Gammarocrinites* QUENSTEDT, 1857, p. 654 [*\*Eugeniocrinites compressus* GOLDFUSS, 1829, p. 164; SD RASMUSSEN, herein] [= *Sclerocrinus* JAEKEL, 1891a, p. 621 (type, *S. strambergensis*; SD RASMUSSEN, 1961, p. 217)] [The genus name *Gammarocrinites* was proposed conditionally for *Eugeniocrinites compressus*, *E. nutans*, and unspecified allied species. Both species originally included have been referred to genera subsequently established by JAEKEL in 1891. BATHER (1900a, p. 197), recorded *Sclerocrinus* as a junior synonym of *Gammarocrinites*, and since QUENSTEDT's genus is available and valid, the type species is here designated in agreement with BATHER's interpretation. JAEKEL (1907, p. 276) incorrectly rejected the name *Gammarocrinites* for missing diagnosis]. Cup low, compact, barrel shaped, more or less oblique, with wide and deep, concave basis, obliquely attached to top of column and distinctly overhanging uppermost columnal. Radial cavity rather small. Radial articular face large, almost flat and triangular, outwardly sloping. Primibrach *I* axillary. Secundibrachials low, with muscular articulation and pinnule socket, or syzygial with few (4-5) radiating culmina. Columnals cylindrical, diameter distinctly less than base of cup. [Relation of cup to column in reconstruction by JAEKEL (1907) is in disagreement with type species figured by GOLDFUSS.] *U. Jur. (Oxford.)-L. Cret. (Valangin.)*, Eu. (Aus.-Czech.-France-Ger.-Hung.-Italy-Switz.-USSR).—FIG. 557, 3a-c, g. *G. strambergensis* (JAEKEL), 3a-c, L. Cret., France; cup, X2.5 (Rasmussen, 1961); 3g, U. Jur., Czech.; syzygial secundibrach, X6 (Jaekel, 1891).—FIG. 557, 3d-f. *\*G. compressus* (GOLDFUSS), U. Jur., Ger.; 3d, e, cup with proximale, X4; 3f, underside of cup, X4 (Goldfuss, 1829). [= *Gammarocrinus* BATHER, 1900a, p. 197 (nom. van.).]

*Cyrtocrinus* JAEKEL, 1891, p. 602, *emend.* JAEKEL, 1907, p. 278 [*\*Eugeniocrinites nutans* GOLDFUSS, 1829, p. 164; SD JAEKEL, 1907, p. 281] [BATHER (1900a, p. 197) considered *Cyrtocrinus* a junior synonym of *Torynocrinus*. By designating *C. nutans* as type species, JAEKEL (1907) separated *Cyrtocrinus* from *Torynocrinus* (= *Hemicrinus*)]. Similar to *Gammarocrinites*, but surface of cup often confluent with top of column, and underside less concave. Radial cavity wide and shallow. Articular face for arms low and wide, outwardly sloping, covering rather thin edge of cup. Arms divided at primibrachs *I* or axillary primibrachs *I-2* incompletely fused. Secundibrachials rather stout, enrollable, with flattened sides. Column short, often irregularly curved, with few, cylindrical columnals, which may be very long. *U. Jur. (Oxford.)-L. Cret. (Valangin.)*, Eu. (Aus.-Czech.-France-Ger.-Hung.-Switz.-USSR, Crimea).—FIG.

557, 4. *\*C. nutans* (GOLDFUSS), U. Jur., Ger.; 4a, cup with proximale, X2 (Jaekel, 1907); 4b, reconstr., X2 (Arendt, 1974; after Jaekel 1907).

### Family HEMICRINIDAE Rasmussen, 1961

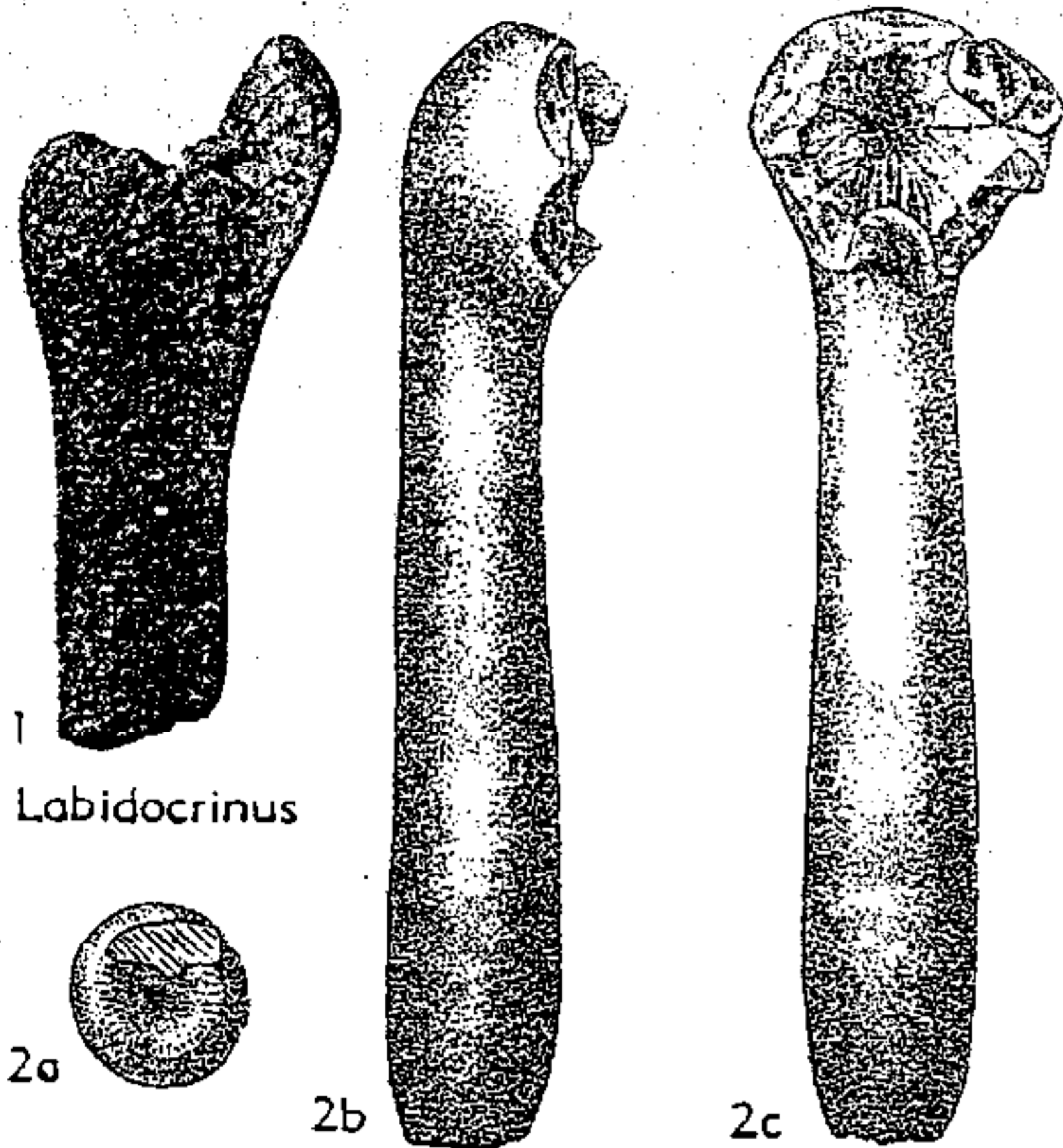
[*Hemicrinidae* RASMUSSEN, 1961, p. 233]

Cup low and wide bowl shaped, more or less oblique or irregular, often elliptical in outline, formed by five distinctly asymmetrical radials different in size and form, fused, generally at right angle with a slender conical, cylindrical or claviform proximale formed by unjointed top of the column; compared in original descriptions with a saucepan (*cuilleron*) or a ladle. Sutures often indistinct. Articular face for brachials rather low and wide, covering generally thick edge of bowl and surrounding wide and shallow radial cavity. Articular faces may meet laterally, but commonly one or two are drawn away from margin of cup to more dorsal position, or may form a large projection to side or down along proximale; or two radial articulations, often adjacent to proximale, may be separated by a space, embayment or projection from rest of cup or from proximale. Distal articulation of proximale concave with radiating marginal crenulae. Free columnals unknown, and proximale may have articulated directly to radix, which is similar to proximale, cylindrical to conical with irregularly expanded distal end attached to substrate. Brachials referred by JAEKEL to this group are stout primibrachs *I* axillary with strongly tumid or swollen surface. *U. Jur. (Tithon.)-L. Cret. (Alb.)*.

[In spite of considerable individual variation in species of *Hemicrinus*, SZÖRÉNYI (1959) established two subgenera of this genus. Evolution of genus was presumably from *Sclerocrinidae* by fusion in cup and column and further loss of symmetry and regularity. ARENDT (1974) included *Cyrtocrinus* (but not *Sclerocrinus*) in the present family.]

*Hemicrinus* D'ORBIGNY, 1850, p. 90 [*\*H. astierianus* (= *Cyrtocrinus granulatus* JAEKEL, 1891a, p. 611); M] [= *Koninckocrinus* SEELEY, 1864, p. 277 (nom. nud.); *Torynocrinus* SEELEY, 1866, p. 173 (type, *T. canon*; M)]. Characters of family. *U. Jur. (Tithon.)-L. Cret. (Alb.)*, Eu. (Czech.-Hung.-France-Eng.-USSR, Crimea).

*Hemicrinus* (*Hemicrinus*). Cup rounded to elliptical in outline, more or less tumid to hemis-

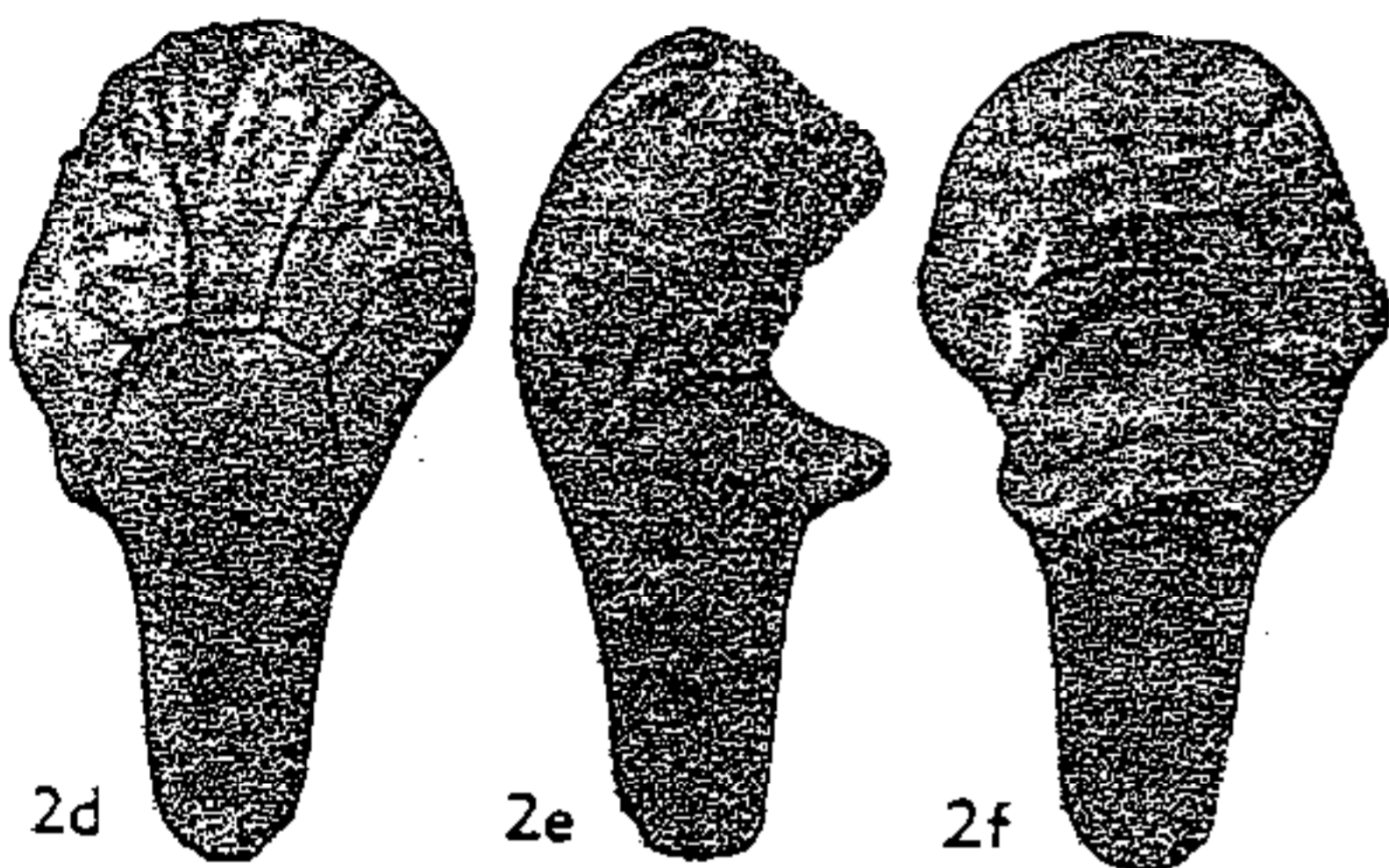


1  
Labidocrinus

2a

2b

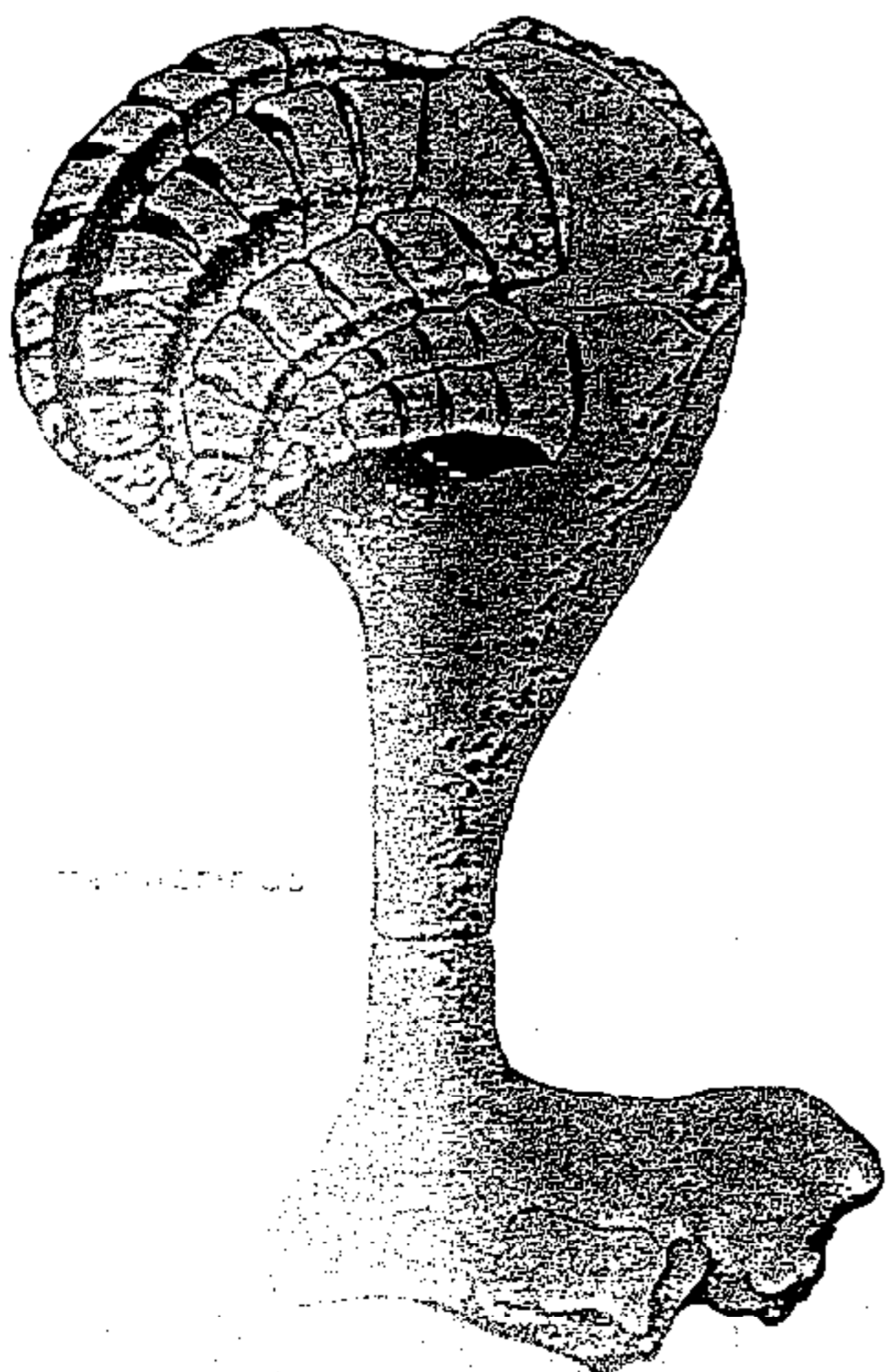
2c



2d

2e

2f



spherical, forming a right angle with proximale. Edge of cup thick walled. *Ujur.* (Tishon.)-*L.Cret.* (Alb.), Eu. (Czech.-Eng.-France-Hung.-USSR, Crimea).—FIG. 558, 2a-c. *H. (H.) canon* (SEELEY), *L.Cret.*, Eng.; 2a-c, cup with proximale,  $\times 1.25$  (Rasmussen, 1961).—FIG. 558, 2d-g. \**H. (H.) astierianus*, *L.Cret.*, France; 2d-f, cup with proximale,  $\times 2.5$  (Rasmussen, 1961); 2g, reconstr.,  $\times 3.4$  (Arendt, 1974, after Jaekel, 1907).

*Hemicrinus* (*Collarocrinus*) SZÖRÉNYI, 1959, p. 250 [\**Torynocrinus* (*C.*) *phialaeformis*; OD]. Similar to *Hemicrinus*. Cup flattened, 2 radials drawn down toward proximale and only slightly projecting, resembling a collar between cup and proximale. Probably within normal variation in species of *Hemicrinus*. *L.Cret.* (Apt.), Eu. (Czech.-Hung.).

*Hemicrinus* (*Labidocrinus*) SZÖRÉNYI, 1959, p. 253 [\**Torynocrinus* (*L.*) *labiatus*; OD]. Cup more or less terminal on proximale, not perpendicular to proximale. Edge of cup thin walled, divided by deep embayment in larger section with 3 radials, and shorter section with 2 radials. *L.Cret.* (Neocom.), Eu. (Hung.).—FIG. 558, 1. \**H. (L.) labiatus*; cup with proximale,  $\times 2$  (Szörényi, 1959).

Family EUGENIACRINITIDAE

Roemer, 1855

[*nom. correct.* RASMUSSEN, herein (ex *Eugeniocrinidae* ROEMER, 1855, in BRONN & ROEMER, 1851-56, p. 227)] [The family was reestablished without knowledge of previous establishment by DE LOBIOL, 1879, p. 196 (as *Famille des Eugeniocrinidées*) and by ZITTEL, 1879, p. 346]

Cup broad conical to funnel shaped or bowl shaped, in *Pilocrinus* almost cylindrical, consisting of five radials. Outline rounded to more or less five-sided. Sutures often indistinct. Articulations for arms large and wide, outwardly sloping to almost vertical, separated by generally small, inter-radial projections of radial plates except in *Proholopus*, and surrounding wide and shallow to deep radial cavity. Arms divided at primibrachs 2. Primibrachs 1-2 synostosomal. Primibrachials large and broad, primibrachs 2 in *Eugeniacrinites* and *Lonchocrinus* with a very large median prolongation more or less upward and inwardly directed between and beyond articulations for small secundibrachials. Articular face for column similar in size to underside of cup or a little smaller; face flat or concave and may have radiating marginal crenulae, or an irregular marginal granulation as articular face of columnals. Columnals few, high, cylindrical to barrel shaped. Attachment by stout, ir-

regularly expanded terminal disc or short radix without articulations. *M. Jur.* (*Bathon.*)-*U. Cret.* (*Campan.*).

The axial nerve canals seen in a silicified cup of *Eugeniocrinites cariophilites* show a short interrarial nerve canal starting from the central canal well above the dorsal end of the cup, dividing in a branch to each of two radials, and more distally two branches unite to a radial axial canal connected by a commissural canal to the canal of other radials. The proximal interrarial canal may indicate original or juvenile basal plates never observed.

Isolated columnals probably belonging to Cyrtocrinina have been described as species of *Eugeniocrinites*.

*Eugeniocrinites* MILLER, 1821, p. 111 [*\*E. quin-quangularis* (= *Encrinites cariophilites* VON SCHLOTHEIM, 1813, p. 68, ex *Caryophyllite* KNORR, in KNORR & WALCH, 1755; *E. caryophyllatus* GOLDFUSS, 1829, p. 163; *Pentacrinus? paradoxus* GOLDFUSS, 1831, p. 200; *Eugeniocrinus angulatus* D'ORBIGNY, 1850, p. 383; *Eugeniocrinus impressus* D'ORBIGNY, 1850, p. 383); M] [= *Eugeniocrinus* AGASSIZ, 1836, p. 195 (*nom. van.*)] [The type species was first recorded by WAGNER (1684) under the name *Caryophyllos aromaticos*, as the petrified fruit of clove tree (*Eugenia caryophyllata*). It was referred by LHWYD (1699) to the crinoids, and has since been recorded under pre-Linnean names such as *Caryophyllitarum* by ROSINUS (1718), *Caryophyllis* by SCHEUCHZER (1752), *Caryophyllite* by KNORR (1755); also quoted by WALCH (1762) as *Caryophyllitea*, and by KNORR & WALCH (1769) as *Caryophyllites*. Also the unavailable (unpublished) name *Symphytocrinus caryophyllum* KOENIG is based on this species]. Cup conical to funnel shaped or reel shaped. Radial articular face for arms steep, low and wide, with small dorsal ligament fossa, deeply excavated interarticular fossae and low ventral muscular fossae, separated by ridge parallel to fulcral ridge. Articular faces are separated by small interrarial projections. Radial cavity wide and rather shallow. Underside of cup entirely occupied by almost flat articular face for column. Columnals cylindrical to slightly conical, often high. Uppermost columnal with diameter as base of cup, commonly closely attached to cup. Articular face of columnals with marginal granulation. Primibrachs 2 large, with compact, spear-head-shaped median prolongation above small, lateral, articular face for secundibrachials, and joining as projection over ventral side of theca when retracted. *M. Jur.* (*Bathon.*)-*L. Cret.* (*Neocom.*). Eu. (Czech.-France-Ger.-Italy-Port.-Switz.-USSR).—FIG. 559, 1. *\*E. cariophilites*

(VON SCHLOTHEIM), *U. Jur.*, Ger.; *1a*, partly silicified and corroded cup with nerve canals exposed, ca.  $\times 4$  (Jaekel, 1891a); *1b*, axillary primibrach 2,  $\times 3.4$  (Arendt, 1974, after Jaekel, 1907); *1c, d*, cup with column,  $\times 3.5$  (Jaekel, 1891a); *1e, f*, reconstr. with arms spread out and retracted,  $\times 2$  (Rasmussen, 1969). [= *Eugeniocrinites* AGASSIZ, 1846 (*nom. null.*); *Eugeniocrinus* AGASSIZ, 1846 (*pro Eugeniocrinus* AGASSIZ, 1836) (*nom. null.*).]

*Lonchocrinus* JAEKEL, 1907, p. 297 [*\*L. dumortieri*; M] [Genus based on axillary brachials referred by DE LORIOI with reservation to *Eugeniocrinus dumortieri* DE LORIOI, 1882 (p. 132), and another axillary included together with cup similar to *Phyllocrinus intermedius* JAEKEL in reconstruction of unnamed *Lonchocrinus*, n. sp. Since affinity of axillary with only nominal species quoted is stated to be uncertain, JAEKEL is here considered to have established a new species *Lonchocrinus dumortieri* based on the axillary brachial described by DE LORIOI]. Presumed primibrachs 2 axillary with long, slender, pointed median prolongation, interpreted by JAEKEL as defensive spine. Proximal articulation synostosomal. [Similar brachials have been referred by DE LORIOI (1879, p. 230) to *Phyllocrinus gracilis* and (DE LORIOI, 1882, p. 167), to *Phyllocrinus fenestratus* (DUMORTIER, 1871). According to JAEKEL, the cups described as *Phyllocrinus intermedius* JAEKEL, 1891a (p. 654) and *Eugeniocrinus granulatus* REMEŠ, 1902 (p. 203) may belong to this genus.] *M. Jur.* (*Callov.*)-*L. Cret.* (*Neocom.*), Eu. (Czech.-France-Hung.-Switz.-USSR).—FIG. 559, 5. *L. sp.*, *U. Jur.*, Czech.; axillary primibrachial,  $\times 3$  (Jaekel, 1907).

*Pilocrinus* JAEKEL, 1907, p. 290 [*\*Eugeniocrinus moussoni* DESOR, 1845, p. 220 (= *Eugeniocrinites coronatus* QUENSTEDT, 1852, p. 615); M] [Transferred by RASMUSSEN, 1961, from Sclerocrinidae to Eugeniocrinitidae]. Cup low and wide, almost cylindrical, slightly restricted at midheight. Articulation for arms wide, outwardly sloping, separated by interrarial projections of the radial plates. Underside of cup wide and deep concave with rather large articular face for column. Columnals barrel shaped, distinctly narrower than cup. Articular face of columnals with irregular marginal tubercles. [According to JAEKEL (1891a) and HESS (1975), the primibrachials described as *Gymnocrinus* may belong to *P. moussoni*. The only Upper Cretaceous specimen of Cyrtocrinina is a cup of *P. moussoni* from the Lower Campanian near Hanover in Germany.] *U. Jur.* (*Oxford.*)-*U. Cret.* (*Campan.*), Eu. (Czech.-France-Ger.-Switz.-USSR, Crimea).—FIG. 559, 3. *\*P. moussoni* (DESOR), *U. Cret.*, Ger.; *3a-c*, cup,  $\times 4$  (Rasmussen, 1975).

*Proholopus* JAEKEL, 1907, p. 292 [*\*Eugeniocrinus holopiformis* REMEŠ, 1902, p. 203; OD] [= *Pseudolopus* JAEKEL, 1907, p. 274, 281, 307 (*nom. null.*)]. Cup five-sided conical, often slightly

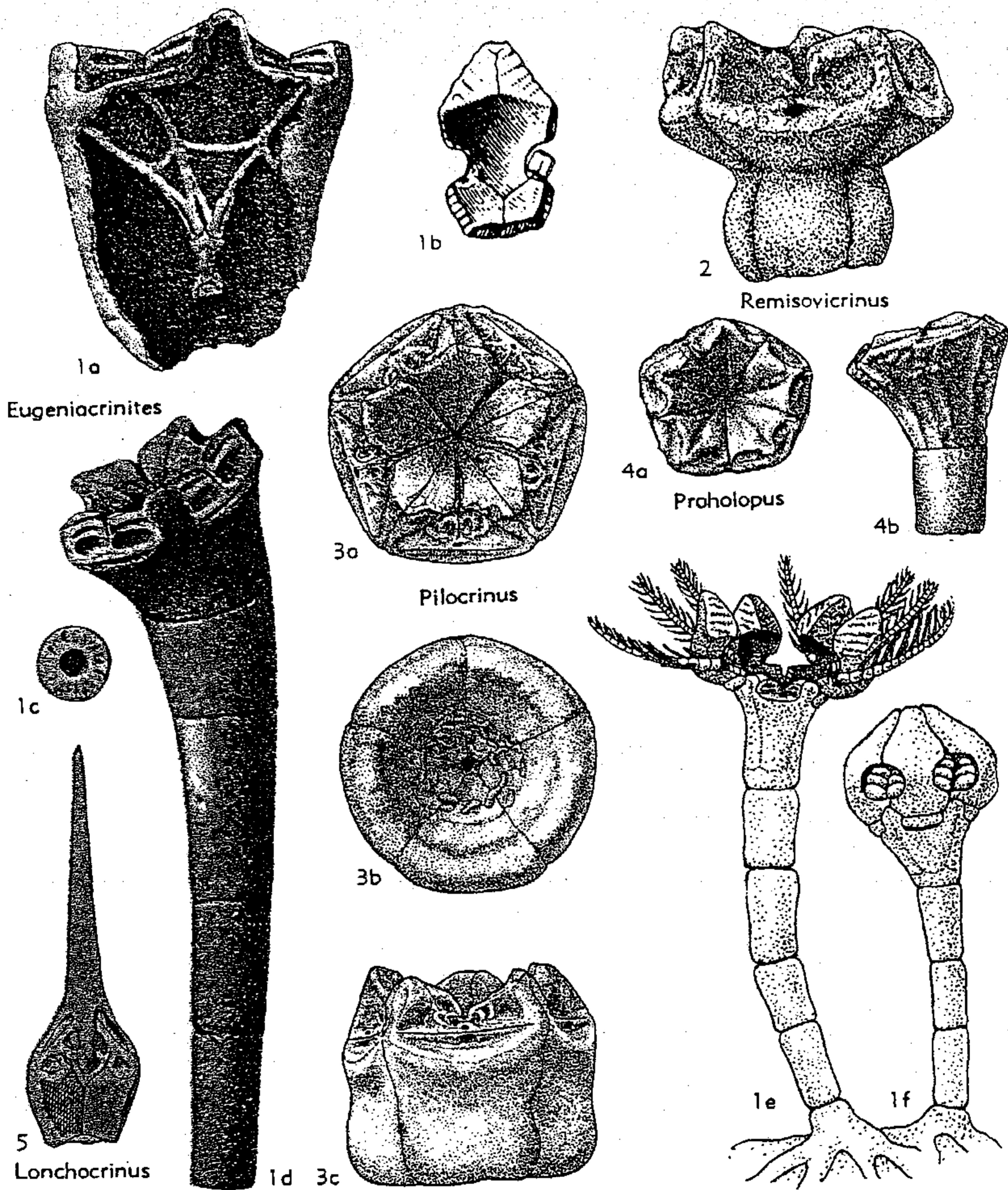


FIG. 559. Eugeniocrinitidae (p. T833-T835).

oblique, with large and deep radial cavity. Articular face for brachials low and wide, horizontal or outwardly sloping, covering rather thin upper edge of cup, and not separated by interradian projections. Columnals cylindrical, articular face slightly concave. *U. Jur. (Tithon.)-L. Cret. (Hauteriv.)*, Eu. (Czech.-France-USSR, Crimea).—  
FIG. 559.4. \**P. holopiformis* (REMEŠ), L. Cret., France; 4a,b, cup with columnal,  $\times 2.5$  (Rasmussen, 1961).

*Remisovicrinus* ARENDT, 1974, p. 100 [\**R. taprakensis*; M]. Cup funnel shaped, with a barrel-shaped lower part separated by a constriction from strongly conical, low and wide upper part. Radial articular face for arms large and wide, separated by narrow interradian projections of cup. Articular faces almost vertical, with inconspicuous dorsal ligament fossa but distinct ligament pit, and large, deeply excavated ventral fossae. Underside of cup with concave, circular articular face for column



showing traces of marginal granulation. *U. Jur.* (*up. Callov.-low. Oxford.*), USSR (Crimea).—FIG. 559, 2. \**R. taprakensis*, *U. Jur.*, USSR; lat. view of cup,  $\times 4$  (Rasmussen, n, after Arendt, 1974).

Family PHYLLOCRINIDAE Jaekel, 1907

[Phyllocrinidae JAEKEL, 1907, p. 303]

Cup consisting of five radials, sutures often indistinct. From conical or rounded lower part, cup continues in very large and high interradiial projections separating generally very small articulations for arms. Outline rounded to subpentagonal, interradiial projections often with concave surface, most in juvenile specimens. Column generally rather thin, columnals cylindrical, rather high, articular face with radiating marginal crenulae, fixation unknown. *M. Jur.* (*Bajoc.*)-*L. Cret.* (*Neocom.*).

Some genera referred to this family appear connected by intermediate forms and their distinction is uncertain. They are here maintained as subgenera. *Psolidocrinus* may be intermediate between this family and Eugeniocrinitidae.

*Phyllocrinus* D'ORBIGNY, 1850, p. 110 [\**P. malbosianus*; M] [JAEKEL (1907, p. 304) incorrectly recorded *Eugeniocrinus granulatus* as type of genus]. Cup with large, ventral, interradiial projections separating small muscular radial articulations. *M. Jur.* (*Bajoc.*)-*L. Cret.* (*Neocom.*), Eu. (Aus.-Czech.-France-Hung.-Italy-Rumania-Switz.-USSR, Crimea)-N.Z.

*Phyllocrinus* (*Phyllocrinus*). Interradiial projections directed upward, in type species not curved inward or outward at the top and not united above the arms. Articulations for arms very small, placed at periphery in bottom of deep and narrow radial incision. Radial incision commonly restricted above brachial articulation. Arms unknown. [Axillary brachials with a long distal spine have been referred by DE LORIO (1882, p. 132 and 167) to *Eugeniocrinus* and *Phyllocrinus* but established by JAEKEL (1907, p. 297) as a new genus *Lonchocrinus* and referred to Eugeniocrinitidae.] Column unknown except for cylindrical uppermost columnal sometimes attached to cup. *M. Jur.* (*Bajoc.*)-*L. Cret.* (*Neocom.*), Eu. (Aus.-Czech.-France-Hung.-Italy-Rumania-Switz.-USSR, Crimea)-N.Z.—FIG. 560, 2. \**P. (P.) malbosianus*, *L. Cret.*, France; 2a-c, cup,  $\times 2.5$  (Rasmussen, 1961).

*Phyllocrinus* (*Apsidocrinus*) JAEKEL, 1907, p. 304 [\**A. remesi*; M]. Like *Phyllocrinus*, but large, interradiial, ventral projections of radials are curved inward at top and in adult specimens may meet and may fuse above arms. Primibrachs

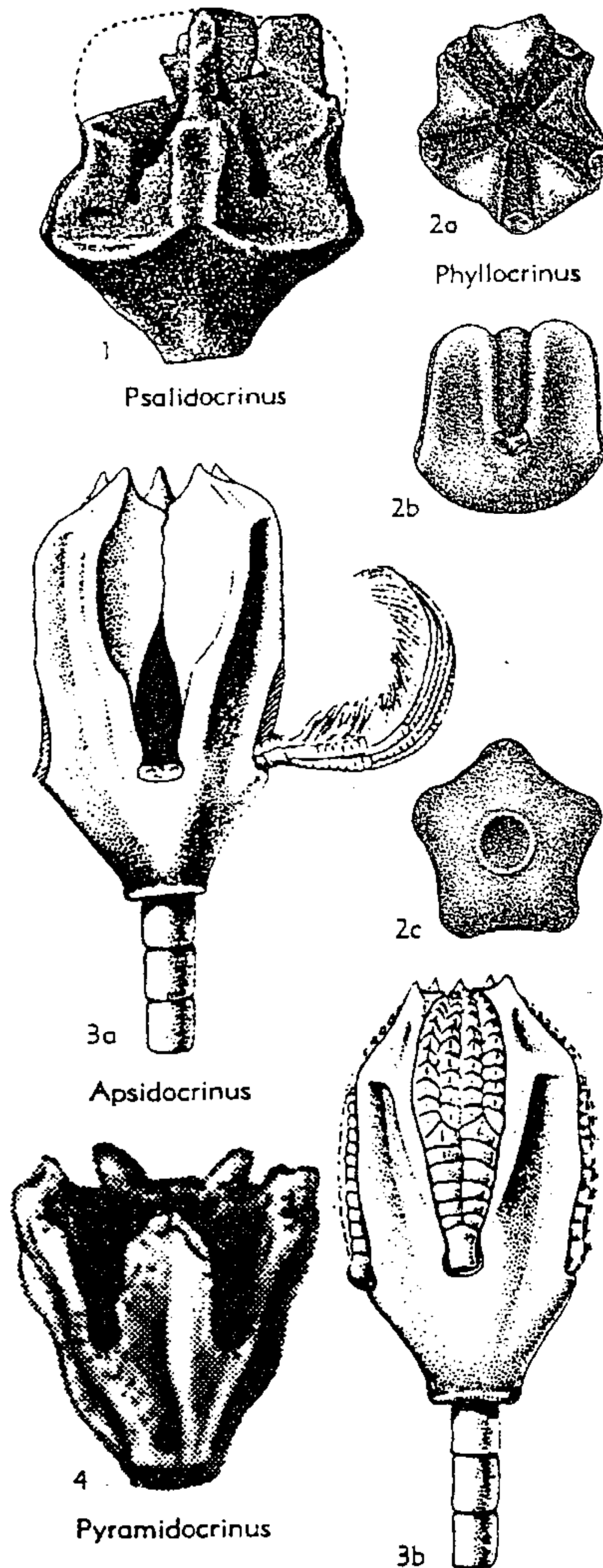


FIG. 560. Phyllocrinidae (p. T835-T836).

1-2 (according to JAEKEL) fused to axillary with small articulations for secundibrach and no median prolongation. *U. Jur.* (*Tithon.*)-*L. Cret.* (*Neocom.*), Eu. (Czech.-Hung.).—FIG. 560, 3. \**P. (A.) remesi*, *U. Jur.*, Czech.; 3a, b, reconstr.,  $\times 4.2$  (Arendt, 1974, from Jaekel, 1907).

*Phyllocrinus* (*Pyramidocrinus*) REMEŠ, 1912, p. 162 [\**Phyllocrinus cyclamen* REMEŠ, 1902, p. 205; M]. Like *Phyllocrinus*, but interrarial projections distally diverging and not meeting above arms. *U. Jur. (Tithon.)-L. Cret. (Neocom.)*, Eu. (Czech.-Hung.).—FIG. 560,4. \**P. (P.) cyclamen*, *U. Jur.*, Czech.; lat. view of cup,  $\times 2.5$  (Remeš, 1902).

*Psalidocrinus* REMEŠ in REMEŠ & BATHER, 1913, p. 346 [\**Eugeniocrinites* sp. cf. *strambergensis* REMEŠ, 1912, p. 161 (= *P. remeši* BATHER in REMEŠ & BATHER, 1913, p. 352); M] [Genus based by REMEŠ on a specified specimen established by BATHER in same publication as a new species]. Brachial articulations of radials large and wide as in *Eugeniocrinites*, but interrarial projections large and stout as in *Phyllocrinus*, and radial cavity correspondingly restricted or even covered by top of projections. Arms and column unknown. *U. Jur. (Tithon.)*, Eu. (Czech.).—FIG. 560,1. \**P. remeši* BATHER, Czech.; lat. view of cup,  $\times 2$  (Remeš & Bather, 1913).

## Suborder HOLOPODINA Arendt, 1974

[Holopodina ARENDT, 1974, p. 150]

Cup with radials and dorsal element connected by close synostosis or completely fused without trace of sutures, and attached directly to substrate by slightly expanded base. No articulated column. Arms divided at primibrachs 1 or 2, all brachial articulations muscular. Some arms may be reduced or obliterated. *L. Jur.*; *U. Jur.-Mio.*; *Holo.*

### Family EUDESICRINIDAE Bather, 1899

[Eudesicrinidae BATHER, 1899b, p. 923] [=Cotyledermidae THOMAS WRIGHT, 1876, p. 94 (*recte* Cotyledermatidae)]

Cup bowl shaped, more or less thick walled, often oblique, composed of five radials separated by distinct sutures and connected by close synostosis to compact, undivided dorsal element of similar width as radial circlet, interpreted as fused basal circlet or columnal structure without any sutures, furrows or nerve canals; attached by slightly expanded basis to substrate. Radial cavity moderate to large, generally reaching or continued into dorsal element. Articular face for arms low and wide, horizontal or sloping inward, covering more or less five-sided upper edge of cup and meeting in interrarial center. Ligament fossae commonly reduced. Arms interpreted from isolated brachials appear short and stout, divided at primibrachs 1 and with muscular

articulation at primibrachs 1-2. [Family differs from Holopodidae by preserved sutures in cup and by two primibrachials connected by muscular articulation.] *L. Jur.*

*Eudesicrinus* DE LORIOI, 1882, p. 99 [\**Plicatocrinus mayalis* DESLONGCHAMPS, in DESLONGCHAMPS & DESLONGCHAMPS, 1858, p. 171; M]. Cup bowl shaped to bell shaped, rather thick walled, often oblique, composed of 5 radials generally unequal in size, one commonly considerably larger than others. Radials separated by distinct sutures from each other and from dorsal element. Radial cavity rather large, in some specimens reaching the basal structure. Radial articular faces occupy entire distal edge. A rather small dorsal ligament fossa with ligament pit, apparently rather large inter-articular ligament fossae and small ventral muscular fossae, horizontal or sloping inward. Stout isolated brachials referred to this genus indicate arms divided at primibrachs 2, primibrachs 1 stout, meeting laterally in flat surface with curved furrows; articulation primibrachs 1-2 muscular. Secundibrachials stout, with muscular articulation and pinnule. *L. Jur. (Pliensbach.-Toarc.)*, Eu. (France); ?*L. Jur.*, Eu. (Eng.).—FIG. 561,1. \**E. mayalis* (DESLONGCHAMPS), France; 1a,b, cup,  $\times 5$  (de Loriol, 1884).

*Cotylederma* QUENSTEDT, 1852, p. 631 [\**C. lineata* QUENSTEDT, 1856, p. 161; SM] [=Cotylecrinus DESLONGCHAMPS, 1859, p. 54 (*nom. van.*); *Cotylederma* DE LORIOI, 1879, p. 249 (*nom. van.*)]. Cup low shield shaped or bowl shaped to cylindrical, only slightly oblique, 0.3 to 14 mm. in diameter. Radial cavity large and wide, continued into dorsal element, which may show concentric growth lines in some specimens. Radial articulation for arms with a small dorsal ligament pit but no distinct ligament fossae, large ventral fossae without distinct differentiation, probably muscular as in *Cyathidium* and *Holopus*. [Cup often attached to shell of ammonites, but also found on *Pecten*, on crinoid columns, on cup of dead specimens of *Cotylederma*, or directly on bottom.] *L. Jur. (Pliensbach.-Toarc.)*, Eu. (Eng.-France-Ger.).—FIG. 561,3a,d. \**C. lineata*, Ger.; 3a, cup on ammonite,  $\times 0.8$  (Quenstedt, 1858); 3d, dorsal element attached on ammonite,  $\times 4$  (Sieverts, 1932c).—FIG. 561,3b,c. *C. docens* DESLONGCHAMPS, France; 3b,c, ventral and lat. views of cup,  $\times 3$  (de Loriol, 1883).

### Family HEMIBRACHIOCRINIDAE Arendt, 1968

[Hemibrachiocrinidae ARENDT, 1968c, p. 156]

Similar to Eudesicrinidae, but with reduced number of arms, and with cup generally fused in adult specimens. Cup compact, thick walled, almost cylindrical, more

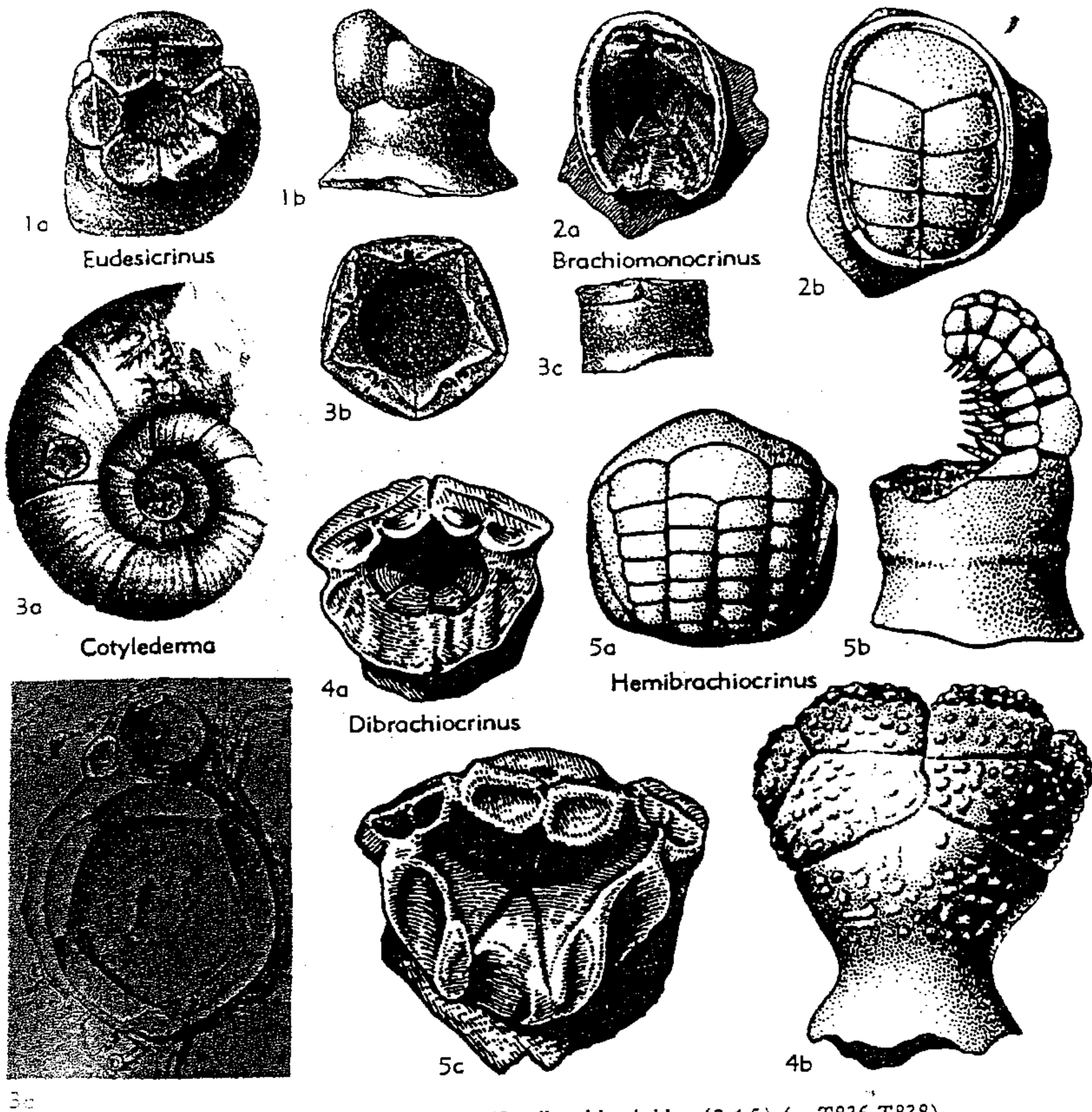


FIG. 561. Eudesicrinidae (1,3); Hemibrachiocrinidae (2,4,5) (p. T836-T838).

Cup irregular, generally elliptical in outline, with large central cavity, and attached to a slightly expanded base. Cup composed of one or three radials and an undivided axial element, in adult specimens fused, or nearly without trace of sutures. Edge of cup with one, two, or three articulations, with or without trace of modified, displaced, articular face for retracted arms. Articular face with a conspicuous dorsal ligament pit, and with a narrow fissure without distinct radial articular face. Median arm stout, axillary, arms short, form-

ing cover over ventral side of cup when retracted, tip of arms leaning on opposite edge of cup. *L.Cret. (Valangin.-Barrem.)*.

*Hemibrachiocrinus* ARENDT, 1968, p. 156 [*\*H. manesterensis*; M]. Edge of cup with a large radial articular face, and on each side a smaller articular face for arms, 2 opposite arms atrophied. Median arm with stout, axillary primibrach 1. *L.Cret. (low.Barrem.)*, USSR (Crimea).—FIG. 561, *\*H. manesterensis*; 5a,b, reconstr., X4; 5c, cup X5.5 (Arendt, 1974).

*Brachiomonocrinus* ARENDT, 1974, p. 159 [*\*. simplex*; OD]. Cup with 1 large and 2 small radials, and with a narrow edge, more or less elliptical in outline. Single, large radial articular face for arm in narrow end of edge. Arm divid-

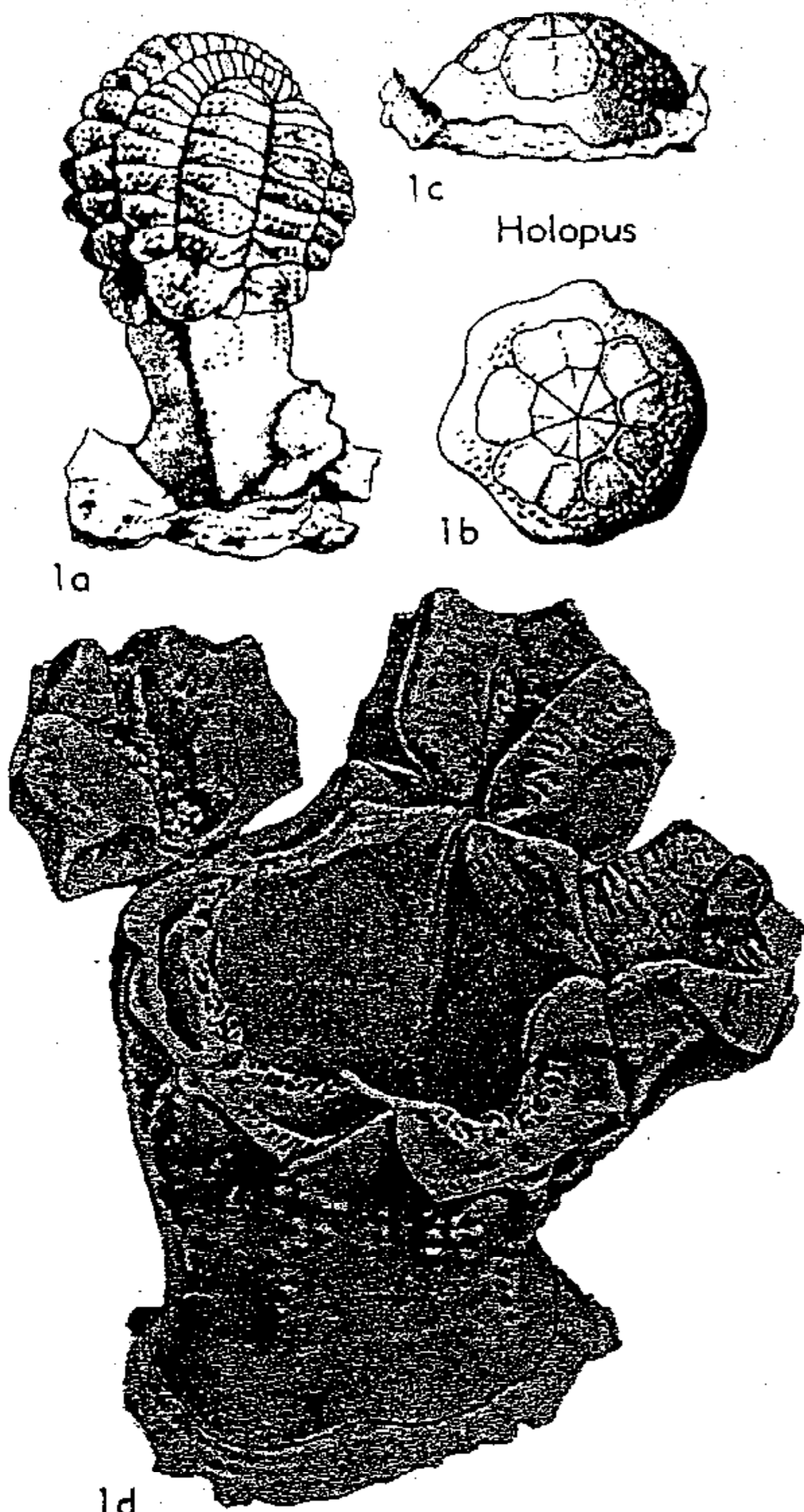


FIG. 562. Holopodidae (p. T838-T839).

at primibrach 1. *L.Cret.(low.Valangin.-low.Barrem.)*, USSR(Crimea).—FIG. 561,2. \**B. simplex*; 2a, cup,  $\times 6$ ; 2b, reconstr.,  $\times 10$  (Arendt, 1974).

*Dibrachiocrinus* ARENDT, 1968, p. 156 [\**D. biasalaensis*; M]. Cup thick walled, with 5 radials, and with 2, often rather large, radial articular faces for arms meeting, generally roof shaped in the highest point of edge. Arms divided at primibrachs 1. Basement in adult specimens more or less elliptical in outline. *L.Cret.(low.Valangin.-low.Barrem.)*, USSR(Crimea).—FIG. 561,4. *D. solovjevi* ARENDT; 4a, cup,  $\times 8$ ; 4b, reconstr.,  $\times 10$  (Arendt, 1974).

#### Family HOLOPODIDAE Zittel, 1879

[*nom. correct.* BATHER, 1899b, p. 923 (ex Holopodidae ZITTEL, 1879, p. 346)] [incl. *Cyathidiocrinidae* and *Holopocrinidae* ROEMER, 1855 in BRONN & ROEMER, 1851-56, p. 226]

Cup shield shaped or bowl shaped to tubular, often irregular, variable according to space and environment, attached by

slightly extended base to substrate without articulation or column. Surface may be smooth or rugose, commonly with radial ridges or rows of granules. No sutures in cup, only articular face for arms demonstrates cup composed of fused radials. No indication of possible basals or columnal structure that may form part of cup and attachment. Radial cavity moderate to very large with rim occupied by articular face for brachials. Articular face with narrow and very deep ligament pit but small or no dorsal ligament fossa. Arms divided at primibrachs 1 or the axillary primibrachial generally interpreted as fused primibrachs 1-2. Proximal brachials often stout and tumid. All brachial articulations are muscular, and all secundibrachials with pinnule. Arms when retracted form cover over ventral side of theca. *U.Jur.(Tithon.)-Mio.; Holo.*

*Holopus* D'ORBIGNY, 1837, p. 1 [\**H. rangii*; M (ICZN Op. 73, 1922)]. Cup tubular, more or less irregular, commonly with radial ridges or rows of tubercles. Wall of cup very thick, radial cavity moderate. Upper edge more or less five-sided. Radial articular face for arms rather large, sloping slightly outward. Interarticular ligament fossae large. Radials and arms different in size, more or less distinctly arranged as group of 3 larger arms and group of 2 smaller arms. Arms stout, strongly curved, each branch with up to 25 to 30 brachials forming spiral and meeting laterally as cover over ventral side of theca when retracted. Proximal 3 to 10 large secundibrachials are succeeded by distinctly smaller brachials. Some brachials may be irregular, often smaller and triangular to fit within cover. Orals large, triangular. [A presumed juvenile specimen 3 mm. in diameter is shield shaped with a complete cover formed by 5 large plates interpreted as primibrachs 1 and 5 smaller triangular plates interpreted as primibrachs 2. No observation is made of the inner side of these plates or of a concealed tip of the arm to support the interpretation. About 12 recent specimens have been found, all in the Caribbean Sea at depths of about 200 m. except for one specimen said to have been brought up with a fishing line, estimated from less than 10 m. According to BATHER (1928, p. lxxv), they have been obtained from the underside of rock ledges or from the roofs of submarine caves. According to MACURDA & MEYER (1974, p. 394), dives off Jamaica in 1972 have shown that *Holopus* is common here at depths of 270 to 300 meters, cemented to vertical outcrops. A fossil species from the Lower Tertiary (Paleoc.) of northern Italy is based on a small cup belong-

ing to *Holopus* or *Cyathidium*.] ?L.Tert.(Paleoc.), Eu.(Italy); recent, Carib.S.—FIG. 562, I. \**H. rangii*, recent; 1a, crown,  $\times 1.2$  (Arendt, 1974, after Carpenter, 1884); 1b,c, presumed juvenile,  $\times 6.6$  (Arendt, 1974, after Carpenter, 1884); 1d, cup and primibrachial,  $\times 3$  (Carpenter, 1884).

*Cyathidium* STEENSTRUP in MICHAELIS & SCHERK, 1847, p. 119, 150 [\**C. holopus*; M] [= *Micropocrinus* MICHELIN, 1851, p. 93 (type, *M. gastaldii*; M); *Pseudocypressocrinus* VALETTE in LAMBERT & VALETTE, 1934, p. 59 (type, *P. senessei*; M)] [*Micropocrinus* was never figured and not described in detail, but the specimen was identified by JAEKEL (1891a, p. 621) and by RASMUSSEN (1961, p. 239)]. Cup variable, from shield shaped to low and wide bowl shaped or irregular conical with rather narrow base to long, irregular, tubular shape, depending on space and environment. Cup directly attached to substrate with its narrow to wide, often slightly expanded and irregular underside. Radial cavity large and wide, often with narrow midradial furrow, which may be followed from articular face almost to bottom of cavity. Cup may be moderately thin walled or in some species very thick walled; commonly more or less oblique and may overgrow and incorporate coral branches, bryozoans or other foreign objects, not only at basis but in some specimens also in side wall of cup. Upper edge of cup more or less five-sided, occupied by low and wide articulations for arms meeting in interradial points or just separated by very small projections at interradial edge, continued and enlarged inward, forming thickened interradial areas in the radial cavity. Radial articular face for arms with a straight, crenulate fulcral ridge, narrow and very deep dorsal ligament pit, no distinct dorsal or interarticular ligament fossae but inward-sloping ventral muscular fossae. Primibrachs 1 axillary, rather thin and flat to very thick, compact and tumid. Secundibrachs 1 moderate to large, more or less triangular. Large five primibrachs 1 and ten secundibrachs 1 together form a close and solid cover over ventral side of theca and enrolled distal end of ten arms when retracted, and form and size of each secundibrach 1 may be modified to fit within this cover. These stout primibrachs 1 as well as secundibrachs 1 meet laterally in flat joint faces with a pattern of curved furrows. Inner surface of secundibrach 1 shows a narrow, median ambulacral furrow to the more or less inward-directed articulation for small succeeding brachial, and side furrow to articulation for first pinnule near proximal abradial edge of plate. Secundibrachs 2 and succeeding secundibrachials small, all with muscular articulation and pinnule. *U. Jur.* (*Tithon.*)-*U. Tert.* (*Mio.*); Eu. (Aus.-Czech.-Denm.-France-Ger.-Italy-Neth.-Swed.); recent in mid-Atl. (380-900 m.).—FIG. 563, 1a-d, g, j. \**C. holopus*, L.Tert. (Dan.), Denm.; 1a, specimen in presumed natural orientation,  $\times 2.5$ ; 1b,d, ventral side of

primibrachs 1 and secundibrachs 1,  $\times 5$ ; 1c, lat. view of secundibrachs 1 with succeeding brachials and with first pinnule,  $\times 5$ ; 1g, smaller cup inside larger,  $\times 2.5$ ; (1a-d, g, Rasmussen, 1961); 1i, several specimens (2 reconstructed) on shell of oyster,  $\times 1$  (Rasmussen, 1969).—FIG. 563, 1e, f, h. *C. senessei* (VALETTE), U.Cret. (Santon.), France; 1e, f, ventral face of cup and primibrach 1,  $\times 2.5$ ; 1h, specimen recombined,  $\times 2.5$  (Rasmussen, 1961).

[Originally only the cup was known, but NIELSEN (1913) published a reconstruction of the type species including proximal brachials found at the type locality, and RASMUSSEN (1961) made improvements in reconstruction of the arms. A complete specimen with retracted arms was found later by a private collector and agrees in all details with the reconstruction.

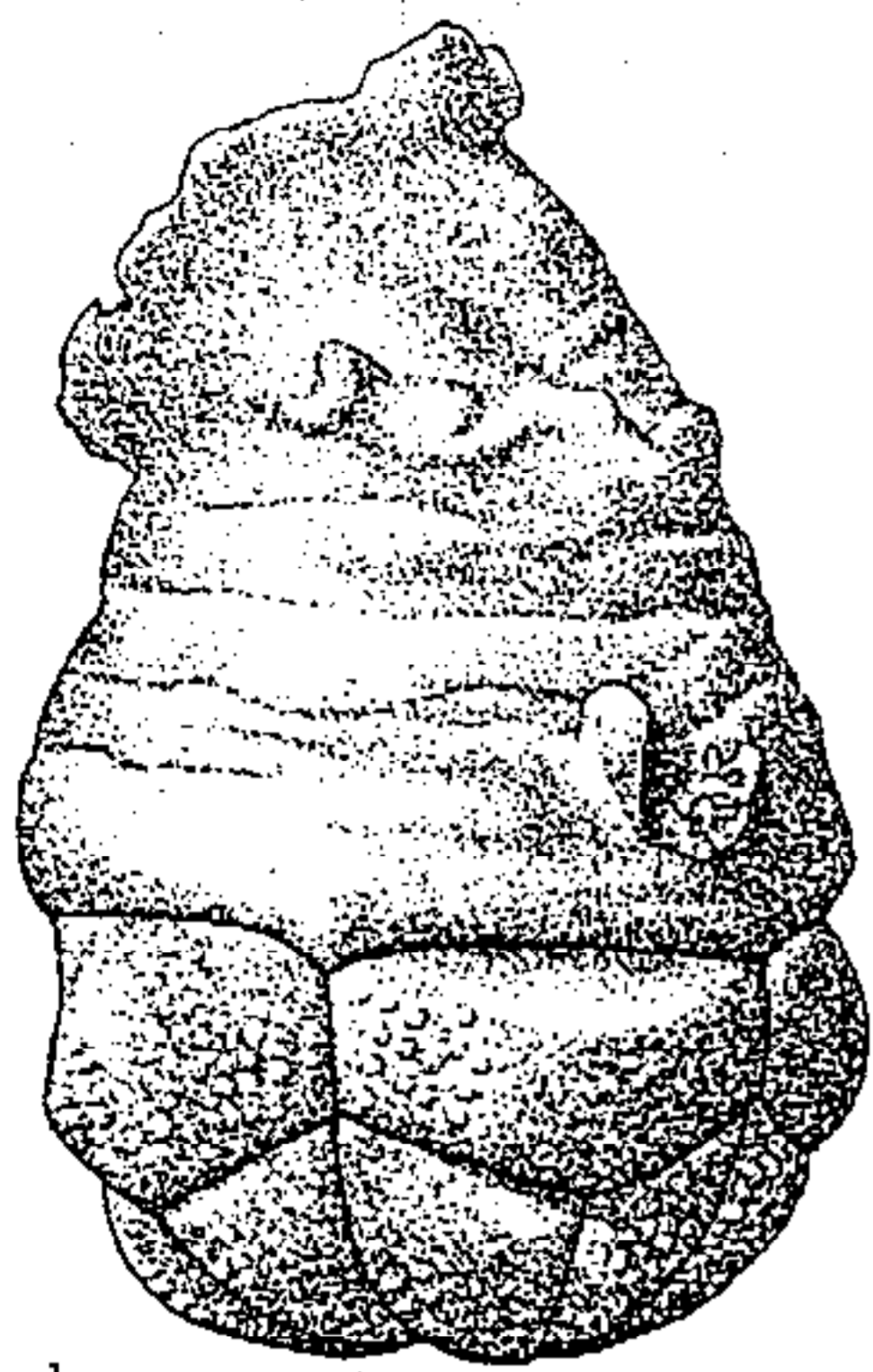
A German expedition (1967) and a French expedition (1971) in the mid-Atlantic found living specimens of a species closely similar to the type species (CHERBONNIER & GUILLE, 1972; FECHTER, 1973). The living species is seen to have 25 to 39 secundibrachs forming the small and slender arm, enrolled under the cover of secundibrach 1 when retracted. The pinnules have one to four pinnulars. The mouth is central and there are five small, triangular oral plates. The color is greenish, almost black.

Juvenile specimens are low and shield shaped, similar to the presumed young of *Holopus*. A living juvenile described by FECHTER has two plates in each ray, interpreted by him as two primibrachials.

Fossil *Cyathidium* is restricted to hard bottom. The type species is found often in numerous specimens gregarious in the bryozoan and coral limestone attached more or less upside down on walls and ceiling of burrows and cavities and below overhanging walls. New specimens are often attached to the cups of dead specimens. According to RASMUSSEN (1972b, p. 88), they are restricted within the photic zone to such sheltered places in the same way as stromatoporoids (sclerosponges). The living specimens found are attached to boulders on the bottom in 380 to 900 m. off the Azores and at Great Meteor Bank.]

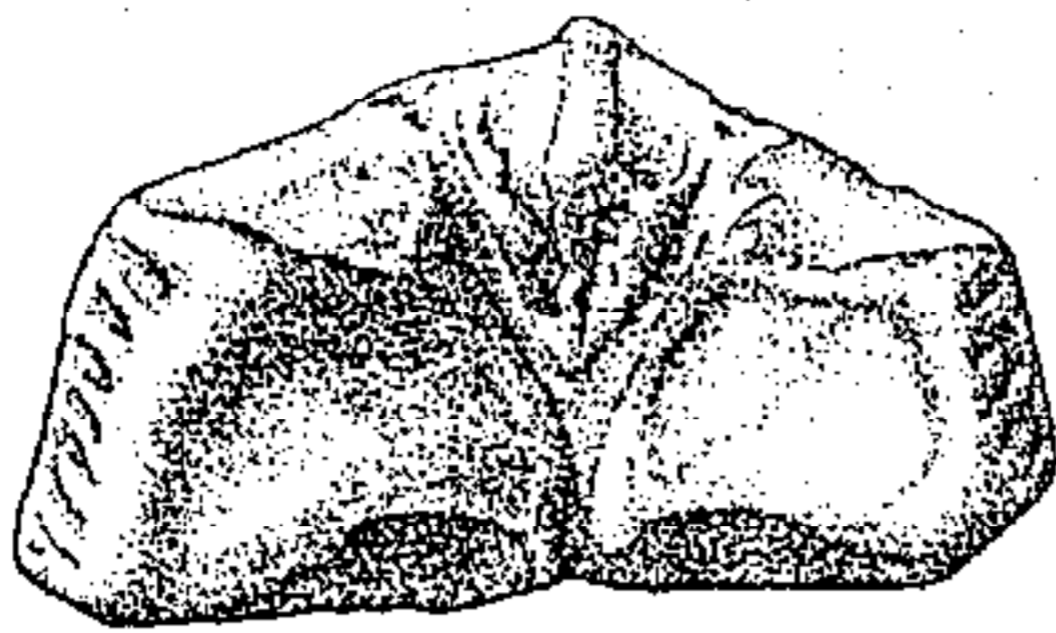
### Suborder and Family UNCERTAIN

*Gymnocrinus* DE LORIO, 1879, p. 249 [\**G. moeschi*; M]. Genus based on specimen originally interpreted as sessile cup, but according to JAEKEL (1891a, p. 633 and 1907, p. 288) an axillary primibrach 2 with extremely thickened sides united ventrally and enclosing the radial furrow in a canal. Proximal articular face is synostiosial, distal articulations muscular with large interarticular ligament fossae laterally surrounding small ventral



1a

Cyathidium



1b



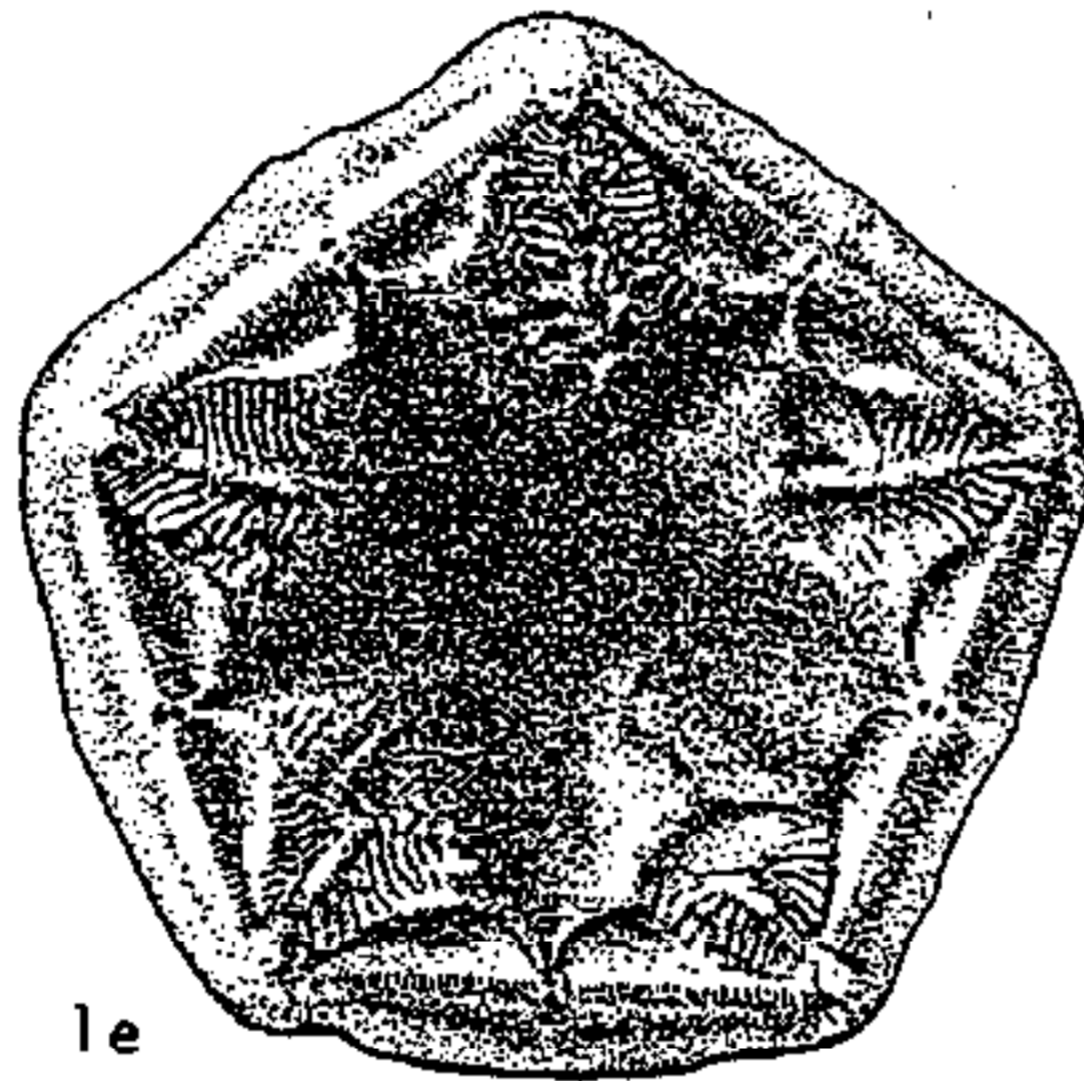
1c



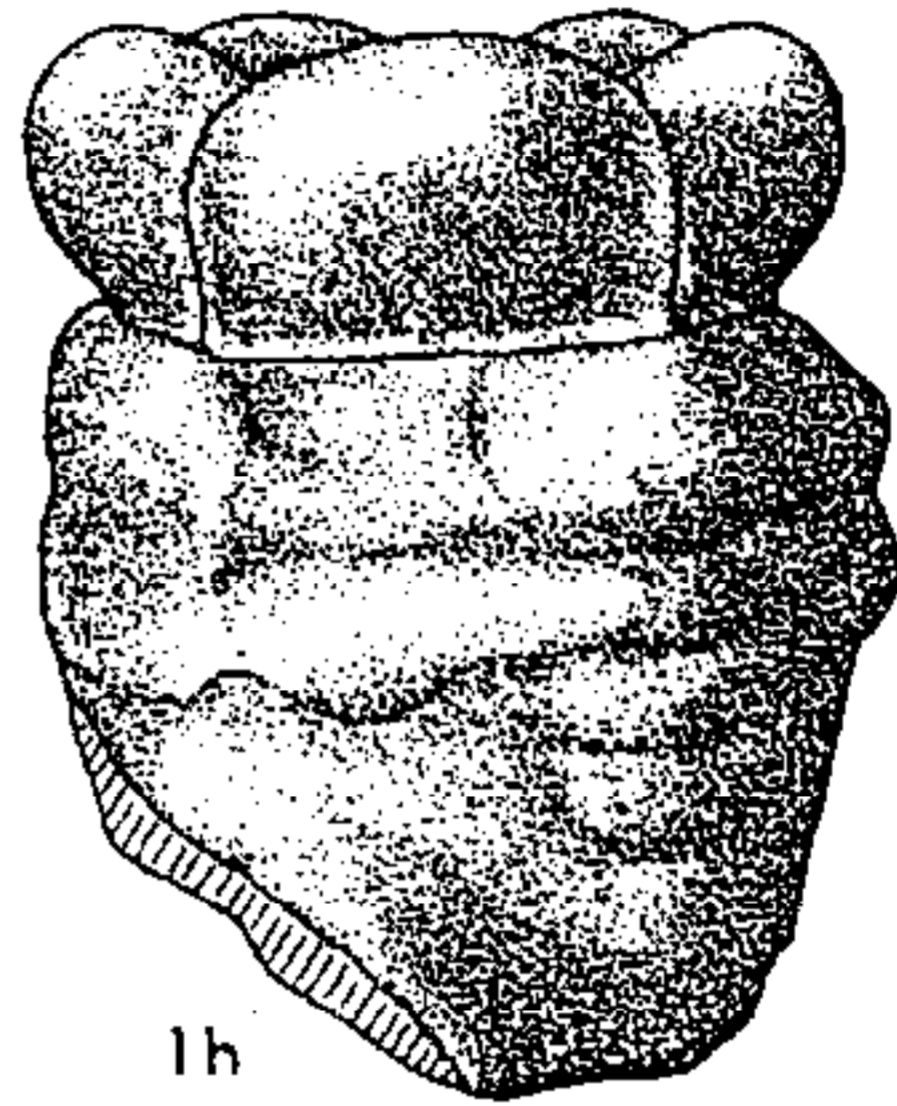
1d



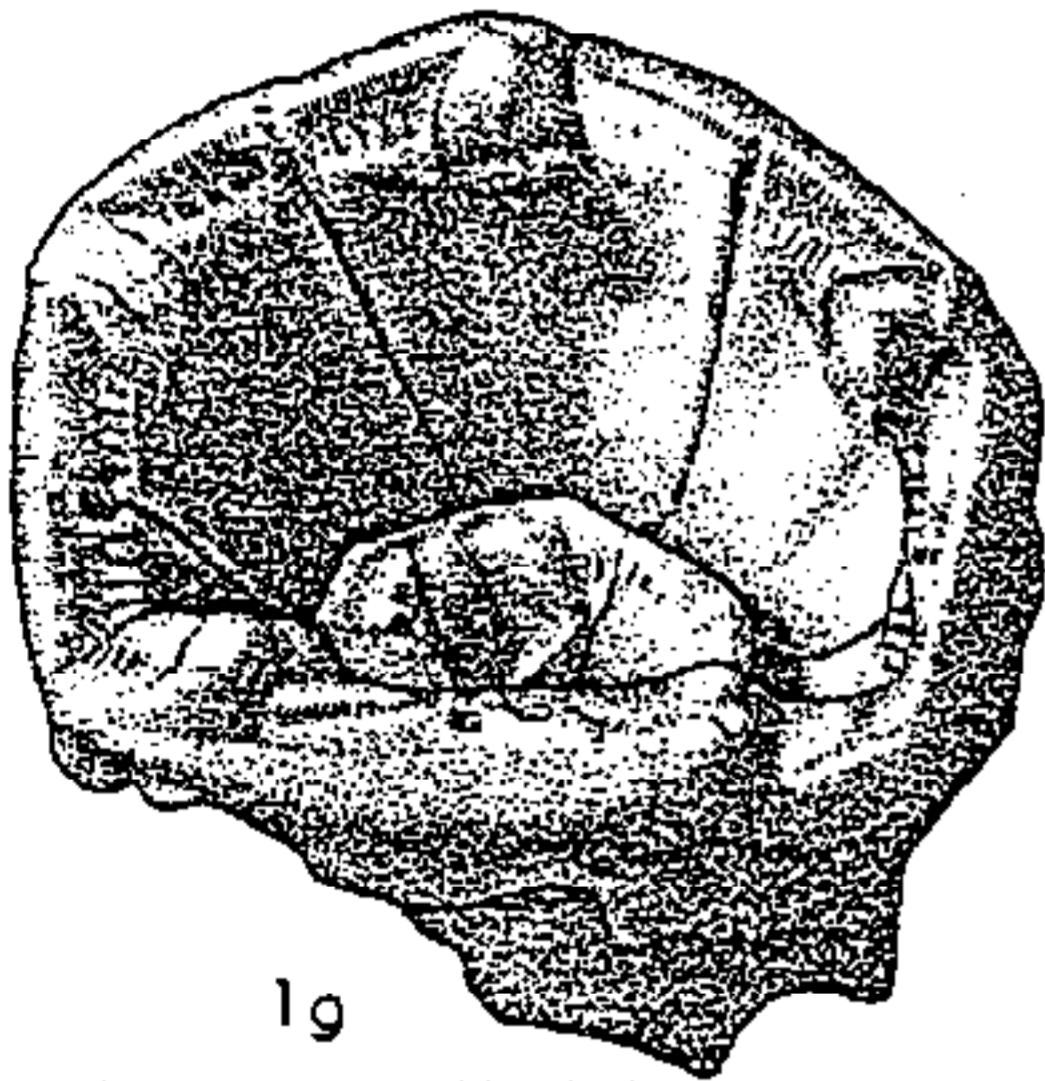
1f



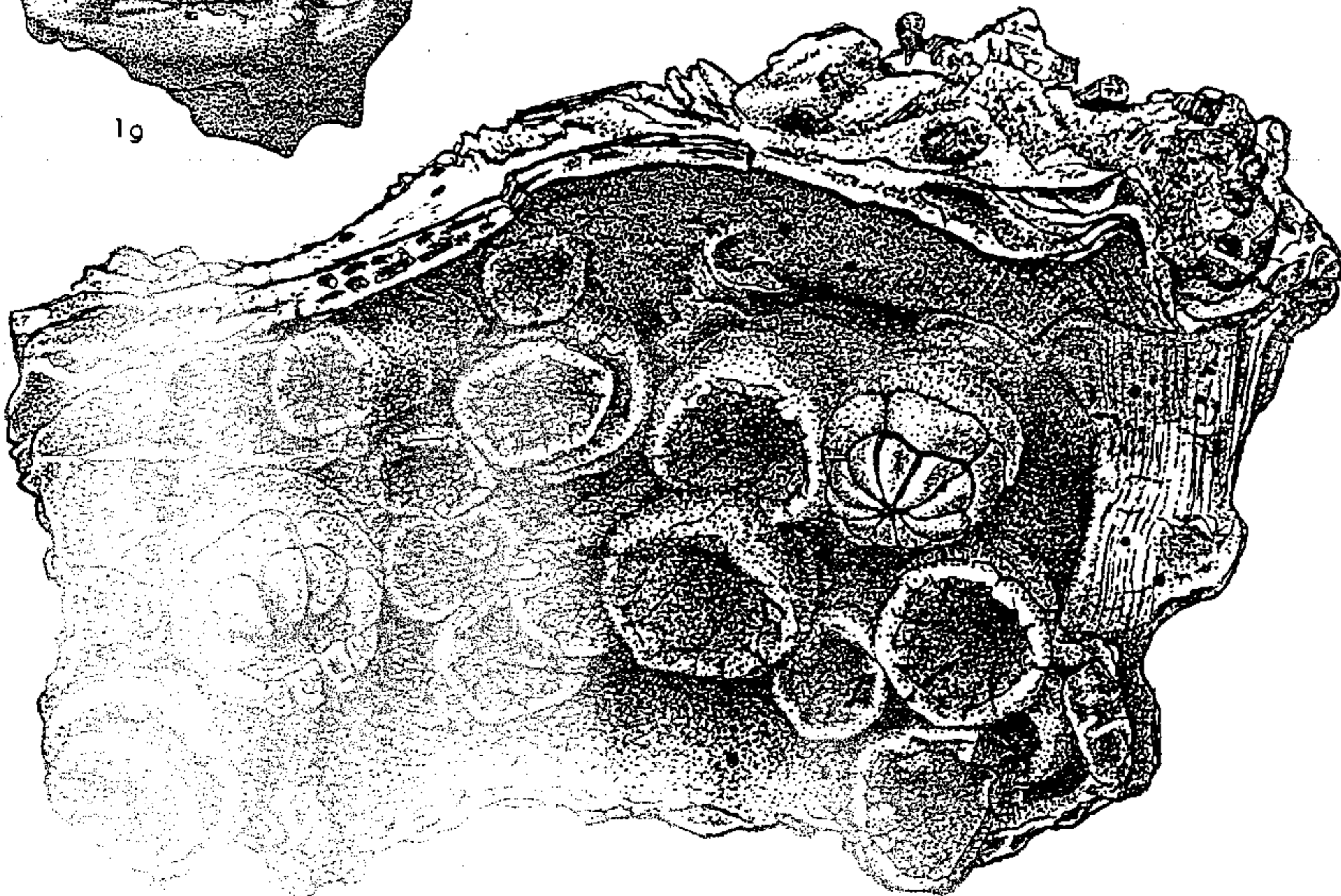
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1h



1g



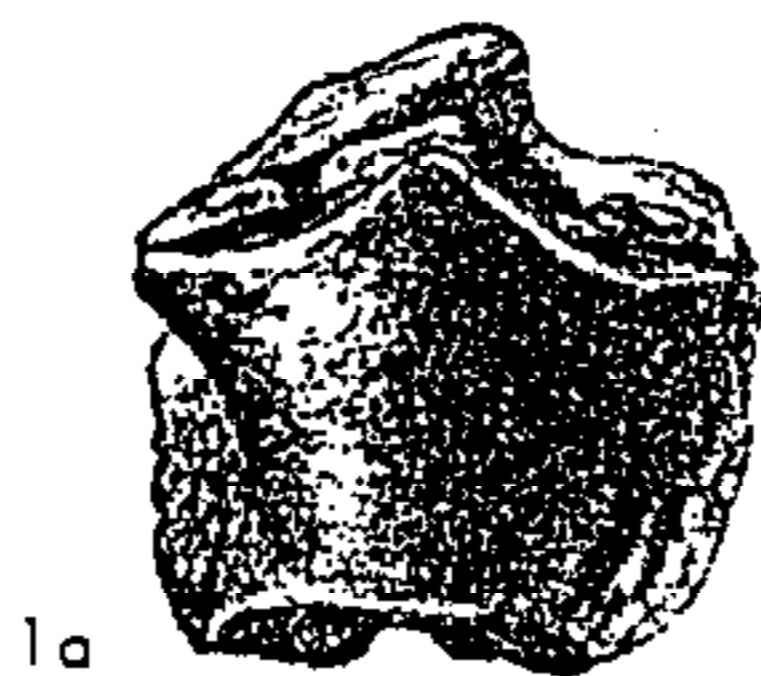
Helopidae (p. 7834)

muscular fossae. [Such brachials may, according to JAEKEL, belong to *Pilocrinus moussoni* or other Cyrtocrinida with large primibrachials. Axillary primibrachials with similarly thickened ventral side, but with a muscular proximal articulation are found in the Upper Jurassic (Tithon.) of Czechoslovakia.] *U. Jur. (Oxford.)*, *Eu. (France-Switz.)*; *L. Cret. (Neocom.)*, *Eu. (Hung.)*.—FIG. 564, 1. \**G. moeschi*, *U. Jur.*, France; 1a, b, axillary primibrach 2,  $\times 4$  (Jaekel, 1891a).

## Order BOURGUETICRINIDA Sieverts-Doreck, 1953

[*nom. transl.* RASMUSSEN, 1969, p. 376 (*ex Bourgueticrinina* SIEVERTS-DORECK in UBAGHS, 1953, p. 762), *emend.* RASMUSSEN, herein, to include Bourgueticrinidae, Bathycrinidae, Phrynocrinidae, and Porphyrocrinidae]

Cup small, slender, compact, commonly fusiform, conical, pyriform or funnel shaped, composed of five basals and five radials surrounding narrow central canal or very shallow radial cavity, lacking trace of infrabasals; central plug may be developed in canal inside radial ring by calcification of connective tissue. Specimens with four or six radials and arms occur. Basals and radials meet in closed sutures or may fuse as basal ring or cup; interrarial nerve canal near inner edge of basals, in some genera branching to superposed radials and meeting inside them to form radial axial canal, or interrarial nerve may continue undivided from basals into sutures between radials before branching into pair of radials; an additional commissural canal inside the radials is present in Bourgueticrinidae but not in Bathycrinidae (Fig. 565). Straight muscular articular face between radials and first brachials generally occupies entire width of radials. Arms undivided or branched on primibrachs 2, with distal bifurcations found only in a species of *Phrynocrinus*. Nonmuscular articulations, either synostosomal, synarthrial, or trifascial, alternate with muscular articulations in arms, and first to second primibrachs connected by nonmuscular articulation in all genera except *Dunnocrinus*. There is no syzygy. Pinnulation complete from second brachial in *Dunnocrinus* and secondibrach 2 in *Bourgueticrinus*, all other genera with a proximal pinnule gap. First pinnule from about seventh to tenth brachial. Columnals circular or elliptical in section and united by synarthry, with a shallow fulcral ridge corresponding to greater diameter except



1a

Gymnocrinus



1b

FIG. 564. Suborder and Family Uncertain (p. T839, T841).

for very juvenile columnals of some species, varying throughout column and different on proximal and distal faces of each columnal; a variable number of proximal columnals, largest in juvenile specimens, are low, cylindrical discs united by synostosis or fused (in *Bourgueticrinus*) to a proximale incorporated in cup by ankylosis. No true cirri occur on column, which is attached to solid objects by an irregular terminal plate or to soft bottom sediment by branched radicular cirri borne by some distal columnals, generally at one or both ends of their fulcral ridges, or less commonly by other parts of columnals. Radicular cirrals free, cylindrical ossicles of variable length, united by synostosis. Some radicular cirri may be attached to shells or other solid objects by a terminal plate. Individuals of living species commonly incomplete when captured, and fossil specimens generally are found as cups and dissociated columnals. Discrimination of taxa is based mainly on structure of the cup. *U. Cret. (Turon.)-L. Paleoc. (Dan.)*; ?*M. Paleoc. (Heers.)*; *Eoc. Mio.*; *Holo.*

The Bourgueticrinida include all Articulata having a permanent column with synarthrial articulations and no true cirri or centrodorsal. They are mainly small crinoids restricted to soft sea bottom, attached by a terminal plate or by branched radicular cirri.

Family BOURGUETICRINIDAE  
de Loriol, 1882

[nom. correct. CARPENTER, 1884a, p. 6, 25 (pro Bourgueticrinidées DE LORIOLO, 1882, p. 64), emend. GISLÉN, 1924, p. 206-212]

Form of cup varies, commonly fusiform or pyriform; composed of a proximale superposed by five basals and five radials of variable size, separated by more or less distinct close sutures but not fused (basals atrophied or missing in one species); articular face of radials wide, with large muscular areas, surrounding narrow central canal. Primibrachs 1-2 synostiosial or synarthrial, primibrach 2 axillary; secundibrachs 1-2 flat synarthrial, and first pinnule is abaxial on secundibrach 2, non-muscular articulation on secundibrachs 4-5 and scattered through more distal part of arms (pers. commun., A. GALE); discrete sutures in proximale of some specimens indicate its formation by fusion of a few disc-shaped proximal columnals, articular face at base of proximale wide and circular, joined synostiosially to topmost columnal, or elliptical, joined synarthrially to column; uppermost free columnals cylindrical and slightly shorter than more distal ones or elliptical in section and similar to more distal columnals; synarthrial articulation with proximale and full size of uppermost free columnal found in many specimens indicate that formation of new columnals below proximale is restricted to juveniles; form and size of columnals changing during growth and varying through a single column (cylindrical, barrel shaped, or with elliptical section at ends and constricted medially); branched radicular cirri present on some distal columnals. *U.Cret.(Turon.)-L.Paleoc.(Dan.)*, ?*M.Paleoc.(Heers.)*; *Eoc.*

*Bourgueticrinus* D'ORBIGNY, 1841, p. 95 [\**Apicrinites ellipticus* MILLER, 1821, p. 33; OD] [= *Mesocrinus* CARPENTER, 1881b, p. 130 (type, *M. suedicus*; OD, according to Code, Art. 68 a, i); *Volvula* VALETTE, 1917, p. 86 (ex *Volvula* LHWYD, 1699, p. 52, pre-Linnean); *Metapicrinus* JAEKEL, 1918, p. 70 (type, *M. minutus*; OD)]. Characters of family. *U.Cret.(Turon.-Maastricht.)*, Eu. (Belg.-USSR, Crimea-Ukraine-Denm.-Eng.-France-Ger.-Neth.-Pol.-Swed.)-USA (Ala.); *L. Paleoc.(Dan.)*, ?*M.Paleoc.(Heers.)*, Eu. (Denm.-

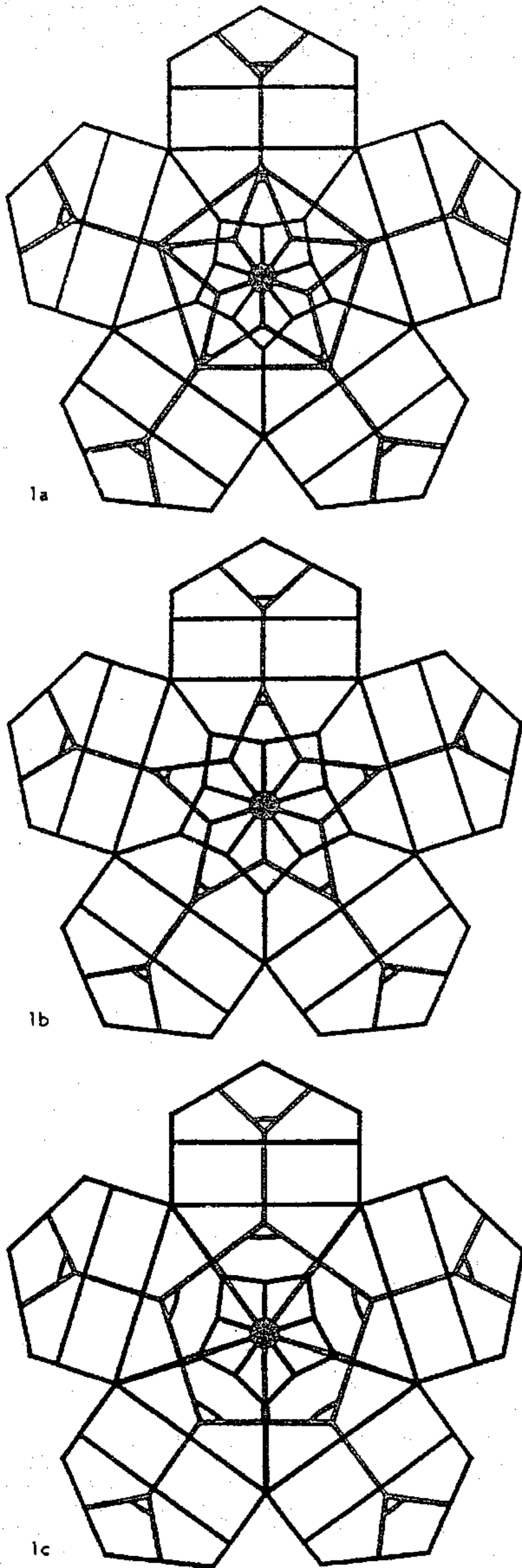


FIG. 565. Diagram of nerve canals in cup and

primibrachials of Bourgueticrinida (Rasmussen, n).  
—1a. *Bourgueticrinus*.—1b. *Rhizocrinus*.—  
1c. *Bathycrinus*.



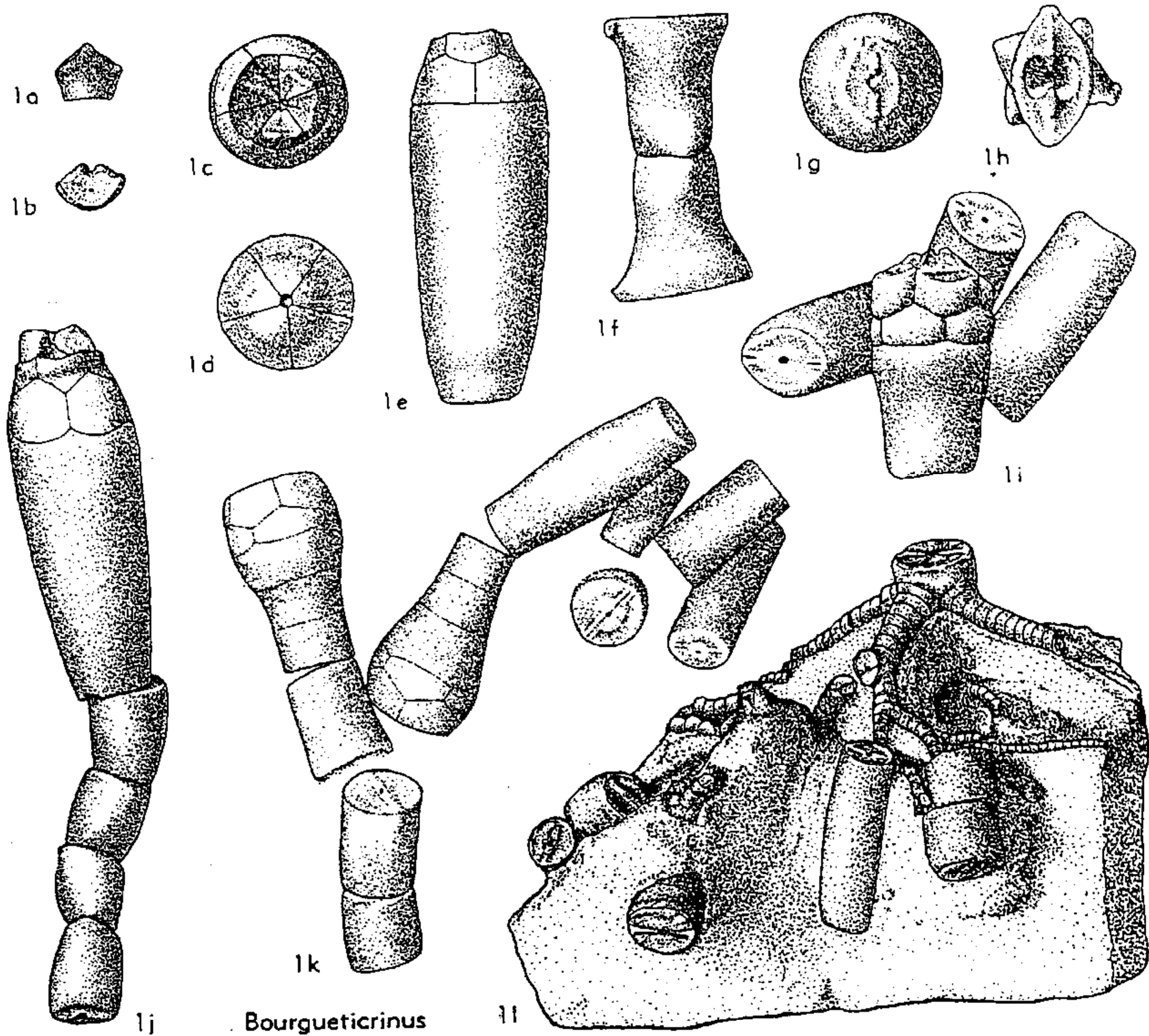


FIG. 566. Bourgueticrininidae (p. T842-T843).

Swed.-Italy); *Eoc.*, USA (N.J.).—FIG. 566, *1a,b,f,h,j*. *B. danicus* NIELSEN, L.Tert. (Dan.), Denm.; *1a,b*, primibrach 2,  $\times 5$ ; *1f,h*, distal columnals,  $\times 5$ ; *1j*, cup and column,  $\times 5$  (Rasmussen, 1961).—FIG. 566, *1c-e,g*. *B. hagenowii* (GOLDFUSS), U.Cret. (Maastricht), Denm.; *1c,e*, cup with proximale and 3 radials preserved; *1d*, ventral face of proximale; *1g*, underside of proximale,  $\times 2.5$  (Rasmussen, 1961).—FIG. 566, *1i*. *B. hureae* (VALETTE), U.Cret. (Santon), Eng.;  $\times 2.5$  (Rasmussen, 1961).—FIG. 566, *1k,l*. \**B. ellipticus* (MILLER), U.Cret. (Santon), Eng.; *1k*, cup with columnals,  $\times 2.5$  (Rasmussen, 1961); *1l*, radix and columnals,  $\times 1$  (after Rasmussen, 1961).

#### Family BATHYCRINIDAE Bather, 1899

[Bathycrinidae BATHER, 1899b, p. 922 (*emend.* GISEN, 1924, p. 206-212)] [=Rhizocrinidae] JAEKEL, 1894, p. 118]

Small Bourgueticrinida with fusiform, conical or funnel-shaped cup composed of five basals superposed by five radials surrounding narrow central canal or low ra-

dial cavity; species or specimens with four, six, or seven radials instead of five occur. Fusion may take place between all plates of cup or between basals only. Interradial nerve canal may divide in basals with branch to each superposed radial, or may be continuous and undivided in sutures between radials before branching, both types lacking separate commissural canal in radials. Proximal brachials closely approximating laterally, commonly rather wide and flat, articulation of primibrachs 1-2 synostiosial, synarthrial, or trifascial except in *Dunnocrinus*. Arms divided at primibrachs 2 or unbranched. Nonmuscular articulations numerous. First pinnule on second brachial in *Dunnocrinus*, other genera with a proximal pinnule gap until seventh brachial or more distal. Proximale absent. Union of basal circlet with uppermost columnal circular, smooth, synostiosial, or hav-

ing ten shallow ligament pits. Proximal zone of stem with variable number of low cylindrical, disc-shaped columnals with synostosomal articulations, number decreasing in adults, and gradual transition to distal parts of column with higher columnals, synarthrial articulations, and elliptical outline of articular face; columnals below proximal zone elongate subcylindrical, barrel shaped, or with medial constriction and elliptical section at ends, which have synarthrial articulations with variable orientation of fulcral ridges. Axial canal of tall, slender columnals usually enlarged toward articular face as in some small, late species of *Bourgueticrinus*. Rarely, some columnals may be divided by synostosomal articulations. Stem attached by radicular cirri. [Indeterminable columnals of Tertiary Bathycrinidae have been recorded under different generic names (*Rhizocrinus*, *Conocrinus*, *Bourgueticrinus*). Recent species are mainly bathyal and abyssal.] *U.Cret.* (*Maasticht.*)-*L.Paleoc.* (*Dan.*); *Eoc.-Mio.*; *Holo.*

*Bathycrinus* THOMSON, 1872, p. 772 [\**B. gracilis*; M (ICZN Op. 73, 1922)] [= *Ilycrinus* DANIELSEN & KOREN, 1877, p. 45 (type, *I. carpenterii*; OD)]. Cup with low ring of fused basals forming angle with higher, conical ring of 5 radials separated by sutures; radial cavity wide and shallow. Interradial nerve canals run from basals to sutures between radials before branching to pair of radials. Arms divided on primibrachs 2; non-muscular trifascial articulation between primibrachs 1 and 2, secundibrachs 1 and 2 and every 3rd articulation in proximal part of arms, and every second articulation in distal part of arms. Several proximal columnals (generally more than 10) are low. *Paleoc.* (*Dan.*), *Eu.* (*Denm.*); *Holo.*, cosmop. (abyssal, worldwide).—FIG. 567,1. *B. windi* RASMUSSEN, *Dan.*, *Denm.*; 1a-c, ventral, lat., dorsal views of cup; 1d,e, proximal columnals; 1f,g, distal columnal; 1h, isolated radial; 1i,j, primibrach 1; 1k-m, primibrach 2; all  $\times 10$  (Rasmussen, 1961). [See also Fig. 25, p. T38.]

*Conocrinus* D'ORBIGNY, 1850, p. 332 [\**Bourgueticrinus thorenti* D'ARCHIAC, 1846, p. 200; M] [= *Tormocrinus* JAEKEL, 1891a, p. 657 (type, *T. veronensis*; M)]. [The date 1847 given by D'ORBIGNY only indicates delivery of manuscript.] Juvenile specimens similar to *Democrinus* in having conical or fusiform cup composed of very high basals followed above by small radials, but articulation between cup and stem is extremely narrow. Sutures between basals may be indistinct. Adult specimens characterized by excessive growth and commonly fusion of basals, which may cover small radials except for their elliptical articular

face, which in large specimens may appear sunken between interradian projections of basals or radials extending upward between arms and surrounding shallow ventral cavity. Also, uppermost columnals may be overgrown by basals. Column as in other Bathycrinidae with large opening of axial canal. *Eoc.-Mio.*, S.Eu.—FIG. 567,3a,b. \**C. thorenti* (D'ARCHIAC), *Eoc.*, Italy; 3a,b, cup of old specimen.  $\times 4$  (Jaekel, 1891a).—FIG. 567,3c,d. *C.* sp., *Eoc.*, S.France; diagram.,  $\times 4$  (Rasmussen, n). [= *Formocrinus* POMPECKJ, 1913, p. 481 (nom. null.) (err. pro *Tormocrinus* JAEKEL, 1891a).]

*Democrinus* PERRIER, 1883, p. 450 [\**D. parviti*; M] [= *Rhizocrinus* (*Bythocrinus*) DÖDERLEIN, 1912, p. 4, 11 (introduced as subgenus for *Rhizocrinus chuni* DÖDERLEIN, 1907, and *R. (Bythocrinus) braueri* DÖDERLEIN, 1912, without designation of type species)]. Cup variably slender conical, cylindrical, or fusiform, composed of 5 very high, slender basals forming greater part of cup and superposed by 5 short radials surrounding narrow central canal. Sutures distinct. Radial articular facets large. Articulation of basal circlet with top of stem smooth and circular, with diameter corresponding to base of cup. Growth of cup mainly affects basal circlet, height increasing more than width, mature specimens attaining slender, more cylindrical form. Interradial nerve canal extends from basals in sutures between radials before dividing. Arms 5, undivided. Every second brachial articulation is synostosomal, synarthrial, or trifascial. Synostosomal articulations may be modified, a short median ridge from axial canal to dorsal edge of proximal articular face fitting into a furrow in distal face of preceding brachial. Few (generally less than 6) low proximal columnals have synostosomal articulations. More distal columnals resemble those of other Bathycrinidae. *U.Cret.* (*Maasticht.*), *Eu.* (*Denm.-Ger.*); *L.Paleoc.* (*Dan.*); *Eoc.*, *Eu.* (*Denm.-Swed.-Eng.*); *Holo.*, worldwide, 66 m. to more than 4,000 m. in temp. and tropic seas.—FIG. 567,4a,b. *D. londinensis* (FORBES), *Eoc.*, *Eng.*; 4a,b,  $\times 3.3$  (Rasmussen, 1972a).—FIG. 567,4c. *D. braueri* (DÖDERLEIN) var. *japonica*, recent, Japan;  $\times 9$  (Gislén, 1927). [See also Fig. 28, 31, p. T42, T47; Fig. 211, p. T324.]

*Dunnocrinus* MOORE, 1967, p. 8 [\**D. mississippiensis*; M]. Cup slightly conical, almost cylindrical, rather low, height similar to diameter, consisting of basals and radials almost equal in size, separated by distinct sutures. Base circular, corresponding to top of column. Most fossil specimens broken along suture between basals and radials. Articular face of radials with steep, high and narrow muscular fossae; radial cavity narrow. Arms 5, undivided. Brachials with rounded dorsal side and from brachial 2 strongly wedge shaped with oblique muscular articulations. Primibrachs 1-2 muscular. Nonmuscular articulations generally at brachials 3-4 or brachials 4-5 and with variable intervals of 2 to 7. Pinnulation complete, first

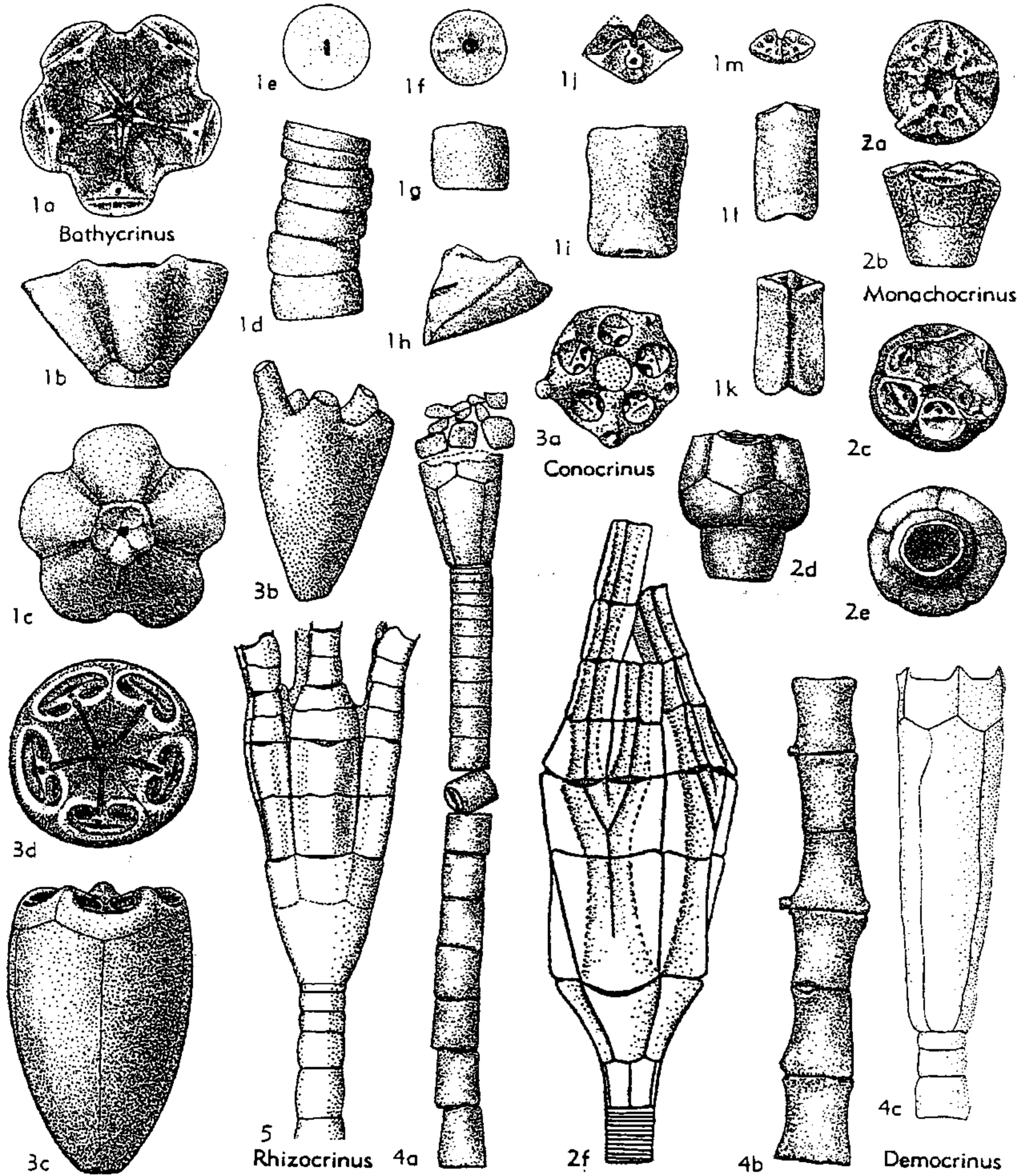
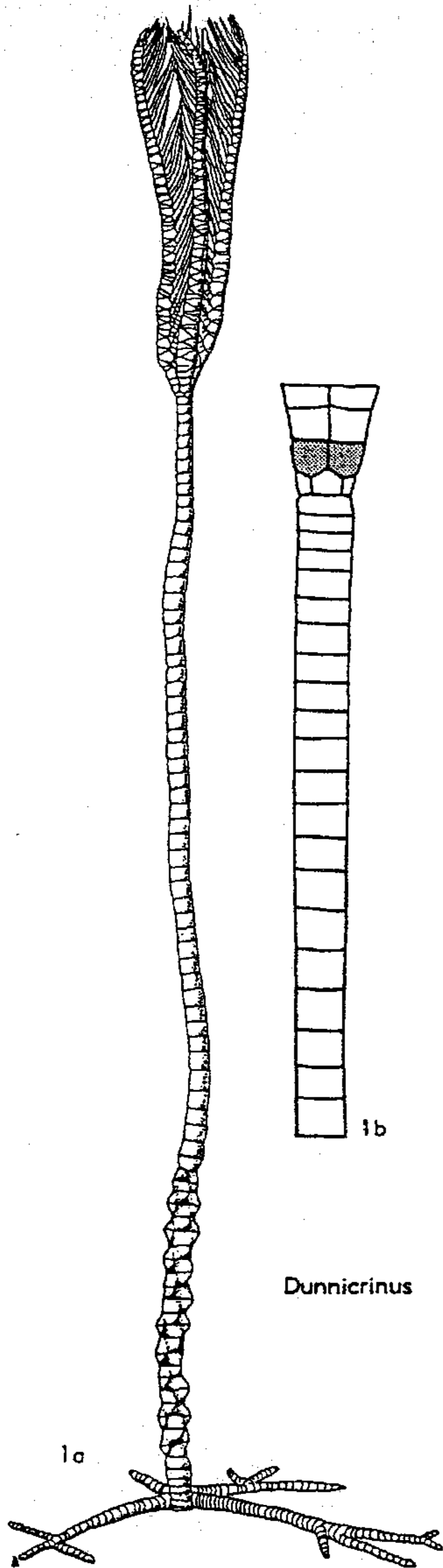


FIG. 567. Bathyrcrinidae (p. T844, T846).

pinnule on brachial 2, each pinnule with about 25 pinnulars, equal in length and diameter and with straight muscular articulations. Column in proximal part cylindrical, with cylindrical to slightly barrel-shaped columnals, height similar to diameter, circular to slightly elliptical in section and with articulations almost synostosomal in the few uppermost columnals, at least in juvenile specimens. Distal columnals stout, similar to *Bourgueticrinus* with a narrow axial canal, and elliptical in section with synsartorial articulations. Lowermost part of columna with branched radicular cirri.

Uppermost columnals are generally low, and new, extremely low columnals may be introduced immediately below basal circlet during juvenile growth. They appear on surface of column first in the radial points below interbasal sutures, thus resembling infrabasals. After formation of new columnals has ceased in adult specimens, the uppermost columnal grows to a size equal to other columnals, similar in diameter, but in some specimens higher, thus approaching the proximale of *Bourgueticrinus*. *U.Cret.* (Maastricht.), USA (Miss.); ?*U.Cret.*, USA (N.J.).—FIG. 568, 1. \**D. missis-*



Dunnicrinus

FIG. 568. Bathycrinidae (p. T844-T846).

*sippiensis*, Miss.; 1a, reconstr. individual,  $\times 0.6$ ; 1b, part of column and attached crown (radials shaded),  $\times 2$  (Moore, 1967).

*Monachocrinus* A. H. CLARK, 1917, p. 390 [*M. sexradiatus*; OD] [The genus was recorded and characterized by CLARK (in VON ZITTEL, 1913, p. 230) and included (CLARK, 1915a) in a key to the genera of Bourgueticrinidae. Seven species were indicated but not by name. In another publication by CLARK (1915a) the species *Bathycrinus caribbeus* CLARK (1908f) and *B. paradoxus* CLARK (1909g), were assigned to this genus. Diagnosis and designation of the type were given by CLARK (1917b, p. 390), with short description of the type species. A full description of *M. sexradiatus* as a "new species" was given in 1923 by CLARK (1923b, p. 19)]. Similar to *Bathycrinus* with conical to funnel-shaped cup. No angular boundary occurs between basals and radials. Basal circlet almost equal in height and diameter, radial circlet of similar height, widening upward. Basals may be fused and radials and arms, generally 5, may be 4 or 6; arms divide on primibrachs 2; every 2nd brachial articulation is synarthrial or trifascial. Proximal columnals, generally more than 10, are low and disc shaped. [Some small cups from the Upper Cretaceous (Santon.-Maastricht.) of France, Germany, and Denmark and from the Lower Tertiary (Dan.-Heers.) of Denmark and Sweden have been referred with reservation to this genus.] U.Cret. (Santon.)-L.Paleoc. (Dan.), Eu. (Denm.-Ger.-Swed.-France); Holo., worldwide. [Abyssal in temperate and tropical seas, ca. 1,000-4,600 m.]—FIG. 567, 2a, b. *M.?* *gallicus* RASMUSSEN, U.Cret., France; 2a, b, cup,  $\times 8$  (Rasmussen, 1961).—FIG. 567, 2c-e. *M.?* sp. aff. *regnelli* RASMUSSEN, Santon., Ger.; 2c-e, cup with columnal,  $\times 4$  (Rasmussen, 1975).—FIG. 567, 2f. *M. paradoxus* (CLARK), recent; enl. (Clark, 1915a).

*Rhizocrinus* SARS, 1868, p. 1 [*R. lofotensis* (nom. nud., Sars, 1864, p. 127); M (ICZN Op. 73, 1922)]. Cup small, conical, seldom funnel shaped or almost cylindrical; basals and radials fused, only sutures between radials visible in some specimens, showing that basals are slightly higher than radials. Number of radials and arms 4 to 7, generally 5. Interradial nerve canals divide in basals with branch to each of superposed radials; radial cavity low and wide. Arms undivided, with every 2nd brachial articulation synostosal or cryptosynarthrial. Proximal columnals generally less than 5, low and disc shaped. During growth height of cup increases in relation to diameter and diameter of columnals increases in relation to height. Recent at depths of 140 to 3,475 m., mainly North Atlantic, rarely in Caribbean and Indonesia.—FIG. 567, 5. *\*R. lofotensis*; cup with part of arms and column,  $\times 10$  (mod. from A. M. Clark, 1970). [See also Fig. 8, 211, p. T22, T324.]

## Family PHRYNOCRINIDAE

A. H. Clark, 1907

[Phrynocrinidae A. H. CLARK, 1907a, p. 510, *emend.* A. M. CLARK, 1973b, p. 276]

Cup low and broad conical, almost discoidal, with five basals and five slightly larger radials separated by distinct sutures; infrabasals unknown; no proximale. Arms diverging from their base, divided at primibrachs 2 or in their distal part; nonmuscular articulations at primibrachs 1-2 and more distal with variable intervals, generally three or four muscular articulations. First pinnule about at brachials 8-10. Columnals stout, as wide as base of cup, circular to elliptical in section, all with synarthrial articulations. Proximal columnals may be low, discoidal, but only one or two uppermost columnals remain discoidal in adults. Fixation by irregular terminal disc, no radicular cirri. Recent, Pac.(Japan) and N.Atl. [Bathyal, 600-2,432 m.]

*Phrynocrinus* A. H. CLARK, 1907, p. 507 [\**P. nudus*; M]. Arms divided only in distal part. Recent, Japan.—FIG. 569,1. \**P. nudus*;  $\times 3$  (Clark, 1973b).

*Zeuctocrinus* A. M. CLARK, 1973, p. 276 [\**Z. gislénii*; M]. Arms divided at primibrachs 2. Recent, N.Atl.—FIG. 569,4. \**Z. gislénii*;  $\times 3$  (Clark, 1973b).

## Family PORPHYROCRINIDAE

A. M. Clark, 1973

[Porphyrocrinidae A. M. CLARK, 1973b, p. 281]

Cup high and slender, cylindrical to slightly conical, with five basals and five radials separated by distinct sutures; radials slightly higher to much higher than basals. Arms in *Porphyrocrinus* undivided, closely approximating laterally, every second to every third brachial articulation nonmuscular; first pinnule about brachials 8-10; in *Naumachocrinus* only first brachial known. Column long and stout, diameter equal to cup. Several proximal columnals low discoidal, circular in section with synostosal articulations. More distal columnals sub-circular to elliptical in section with synarthrial articulations. A few distal columnals in *Porphyrocrinus* may be united by articulation with marginal crenulae. Fixation in *Porphyrocrinus* by terminal disc, no radicular cirri, fixation in *Naumachocrinus* unknown. [For possible affinity with the Jurassic *Dolichocrinus* DE LORIO, 1891,

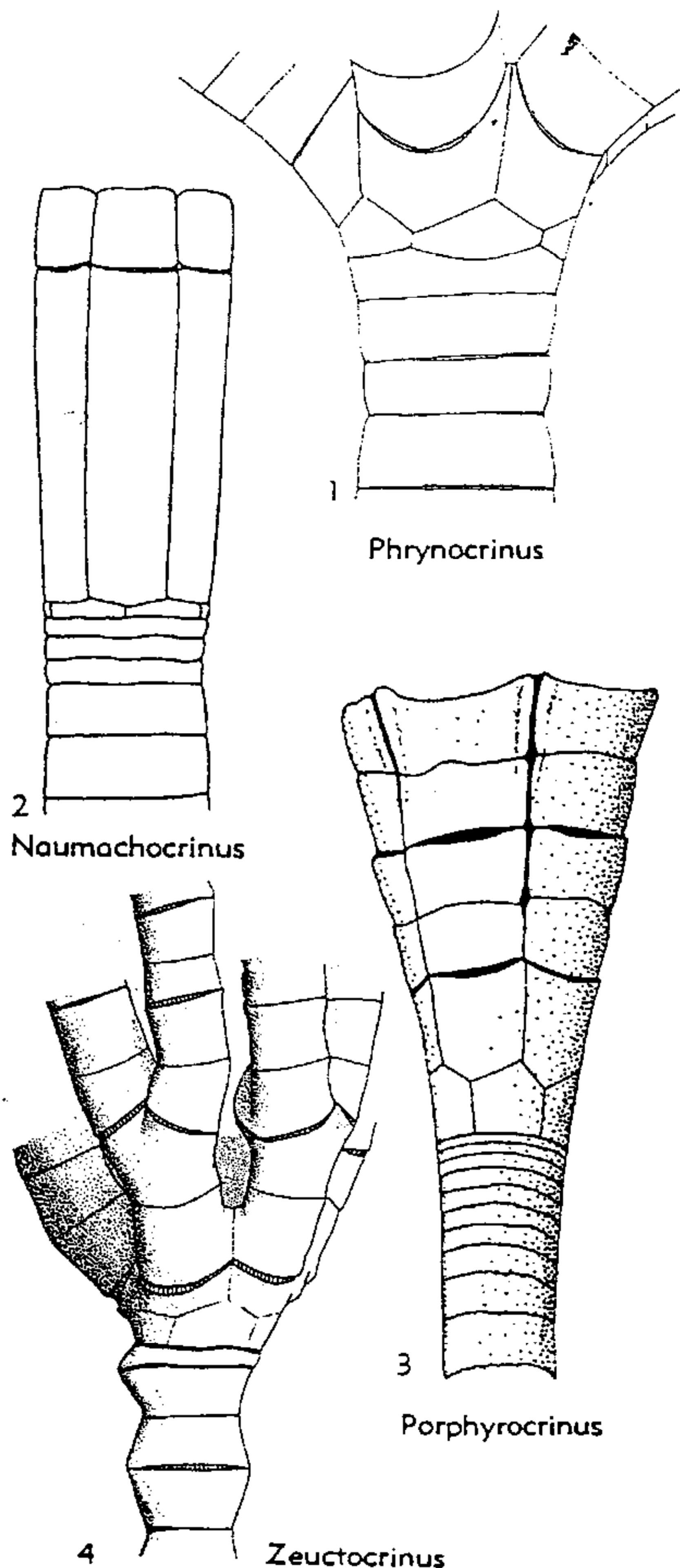


FIG. 569. Phrynocrinidae (1,4); Porphyrocrinidae (2,3) (p. T847).

based on a radial circlet similar to *Naumachocrinus*, see p. T926.] Recent, Pac. and Ind.O. (345-1,000 m.).

*Porphyrocrinus* GISLÉN, 1925, p. 91 [\**P. verrucosus*; M]. Recent, Pac. and Ind.O.—FIG. 569,3. \**P. verrucosus*;  $\times 7.5$  (Gislén, 1925b).

*Naumachocrinus* A. H. CLARK, 1912, p. 196 [\**N. hawaiiensis*; M]. Recent, Pac.—FIG. 569,2. \**N. hawaiiensis*;  $\times 6$  (mod. from Clark, 1973b).

## Order ISOCRINIDA Sieverts-Doreck, 1952

[Isocrinida SIEVERTS-DORECK in MOORE, LALICKER, & FISCHER, 1952, p. 614] (=Order Pentacrinoidea NEUMAYER, 1889, p. 471, 478 (in part))

Cup rather small, dicyclic with exposed infrabasals in Holocrinidae, but cryptodicyclic with very small, concealed infrabasals or without infrabasals in other families. Basals very high in Holocrinidae, rather small in other families. Radials with large muscular articular face toward arms. Arms divided once or more, first division isotomous, generally at primibrachs 2, seldom more distal, further divisions isotomous or heterotomous. Primibrachs 1-2 and generally secundibrachs 1-2 cryptosyzygial or synarthrial. Furthermore, nonmuscular articulations, generally cryptosyzygy but also synarthry or symmorphy, may occur, generally at brachials 3-4, but also more distal. Tegmen plated, flexible, with central mouth; high in Holocrinidae and Pentacrinitidae, low in Isocrinidae. First pinnule on first brachial 2 not axillary, and all pinnules free except in *Seirocrinus* where proximal pinnules are reduced and incorporated in tegmen. Ambulacral grooves generally open, but may apparently be more or less permanently closed by ambulacral plates in tegmen of some genera.

Column generally long, pentalobate or pentagonal to circular in section. Nodals with cirri always present. Cirri placed radially on column, generally five in number from each nodal, but may be less. Columnal articulations symplectial, crenulae arranged along margin and adradial in a petaloid pattern, in *Proisocrinus* with uniform, radiating marginal crenulae and no petaloid pattern in median and distal part of column. Articulation between nodal and infranodal cryptosymplectial to almost smooth synostosal.

Formation of new nodals takes place during growth at top of column, immediately below the cup, succeeded by insertion of internodals between proximal nodals and subsequently by further generations of internodals between proximal internodals in proximal part of column. Column is therefore composed of nodals and generations of internodals strongly increasing in height, and commonly in diameter and form.

Smallest internodals may even be concealed from surface of column, which is more or less compensated during further growth, so that alternation is generally inconspicuous in median and distal part of column. Also, form of columnals modified during growth from pentalobate to more pentagonal or rounded, and radial pores present in proximal sutures disappear. Form and ornamentation of columnals commonly useful in distinction of fossil species, but proximal columnals generally indeterminable. Columnals in small, juvenile specimens rather high and slender. During growth of a specimen, columnal diameter increases more than height, as seen in new proximal columnals as well as in previously formed distal columnals, with diameter generally almost uniform throughout entire length of column. Occasionally, however, secondary growth in early formed columnals is greater, and diameter of column therefore increases toward distal end (*Proisocrinus*), or secondary growth may be minor, resulting in a slight decrease of columnal diameter toward distal end. This is most distinct in Jurassic *Seirocrinus* and in recent *Annacrinus*, *Chladocrinus*, and some species of *Metacrinus*. Internodal length is small in upper part of column, where new columnals continue to be inserted, but larger and fairly uniform in median and greater part of column. It may decrease slightly again in most distal part of column, indicating that number of internodals inserted during juvenile life was often inferior to number inserted during more adult stages in the proximal part of column. Also, cup may be modified during growth, generally becoming relatively wider, basals relatively smaller and often separated, and radials wider and more outwardly directed. *L. Trias.-Mio.; Holo.*

All recent and fossil Isocrinida studied have a column broken at the distal end. If complete, the column is terminated at the cryptosymplectial articulation below a nodal, and the axial canal is closed by secondary skeletal material. A radix has never been observed, but juvenile specimens may have been attached by a terminal disc. A presumed terminal disc is observed in a single column referred to *Hypalocrinus naresianus* (CARPENTER, 1884a, pl. 30a, fig.

4; refigured, Fig. 8, p. T22). It is found that adult isocrinids live attached to the bottom by distal verticils of cirri. If the column is long, the distal part lies along the bottom and only the crown with the proximal part of the column is elevated, in recent specimens up to one meter above the bottom. From time to time the crinoid may lose hold and drift away until it is caught again by the cirri grasping in the sediment or by attaching to some obstacle on the bottom. In this connection a distal part of the column may break off.

In the Lower Jurassic bituminous shales of Holzmaden, Germany, the columns of *Seirocrinus* may have reached a length of 16 meters or more, presumably due to absence of water movements, or, if broken, they may have drifted away and in some cases attached themselves to sunken trunks, where their presence has been interpreted as pseudoplanktonic by several authors (see RASMUSSEN, 1977, and p. T339).

Recent deep-water photographs (MACURDA & MEYER, 1974; 1976) show the isocrinid *Cenocrinus* elevated from the attached distal part of its column at 200- to 300-meter depth near Jamaica, and *Isocrinus* and *Endoxocrinus* standing upright from the bottom, attached by distal cirri at a depth of 400 to 600 meters near Florida.

A few, uncertain records of columnals from the Lower Triassic of Europe (Alps) and North America (Idaho) have been referred to *Balanocrinus* and *Isocrinus*.

#### Family HOLOCRINIDAE Jaekel, 1918

[Holocrinidae JAEKEL, 1918, p. 67]

Small Isocrinida with high, cylindrical to barrel-shaped or oviform dicyclic cup. Infrabasals exposed, visible on surface as a rather low, contiguous infrabasal circlet. Basals higher than wide, radials lower. Cup thick walled with narrow central cavity. Radial articular face for arms wide. No interbrachial plates, proximal brachials laterally joining. Arms divided at primibrachs 2, and in *Moencrinus* further divided at some secundibrachs 2. Nonmuscular, presumably cryptosynsial or synostosomal articulations at primibrachs 1-2, secundibrachs 1-2 and more distal may occur. First pinule from secundibrach 2. Tegmen high, plated or granulated. Column pentalobate

to circular in section. Proximal columnals pentalobate, low, uniform or alternating. Nodals larger than internodals with two to five, generally five, circular or elliptical cirrus sockets, directed more or less upward. Articulations in column symplectial with short marginal crenulae in a more or less petaloid pattern. Articulation between nodal and infranodal cryptosymplectial or synostosomal. *M.Trias.*

*Holocrinus* WACHSMUTH & SPRINGER, 1886, p. 139

[\**Encrinus beyrichi* PICARD, 1883, p. 199; M]. Cup high, almost barrel shaped to oviform. Arms divided at primibrachs 2, no further division, exceptional division at primibrachs 3 in some arms may occur. A high tegmen with numerous plates including smaller marginal and larger central plates reaching about secundibrachs 3 is found in *H. beyrichi* and in a specimen with part of crown referred to *H. wagneri* (BENECKE, 1887). Column subpentagonal to circular in section, proximal columnals pentagonal to pentalobate, low, generally alternating in height and diameter, distal columnals almost uniform. Internodes with 10 to 16 internodals, in proximal part about 7. Nodals with 5 cirrus sockets, in *H. wagneri* 2 to 3 sockets, on side of nodal, often close to upper edge. Sockets circular to elliptical, generally with distinct fulcral ridge. Cirri long, cylindrical to elliptical in section, directed more or less upward. Articular face of columnals with short, marginal crenulae in a petaloid pattern similar to other small columnals of isocrinids. *M.Trias.* (*Anis.*), Eu.(Ger.-Hung.).—FIG. 570,2. *H. wagneri* (BENECKE), Ger.; 2a,c, crown and column,  $\times 2.5$  (Wagner, 1887); 2b, tegmen with slightly disturbed arms,  $\times 4$  (Wagner, 1891).

*Moencrinus* HILDEBRAND, 1926, p. 259 [\**M. deeckei*; M]. Cup high, almost cylindrical. Basals very high. Narrow central cavity enlarged toward upper end of radial circlet. Indication of a flexible tegmen with granulated surface without distinct trace of plates. Arms divided at primibrachs 2 and some secundibrachs 2. Nonmuscular articulations at primibrachs 1-2, secundibrachs 1-2 and apparently every second brachial articulation. Column rounded subpentagonal to slightly pentalobate in its entire length. Proximal columnals low but uniform, not alternating. Nodals few, internodes long, about 17 internodals or more. Articular face of columnals with more or less distinct marginal crenulae, which may be short and uniform, or may be longer in radial marginal area, thus limiting a more or less petaloid or stellate, smooth central area. Nodals with 5 rounded cirrus sockets facing outward or, especially in proximal part of column, slightly upward. Cirri short, circular in section. *M.Trias.* (*Anis.*), Eu.(Ger.).—FIG. 570,1. \**M. deeckei*;

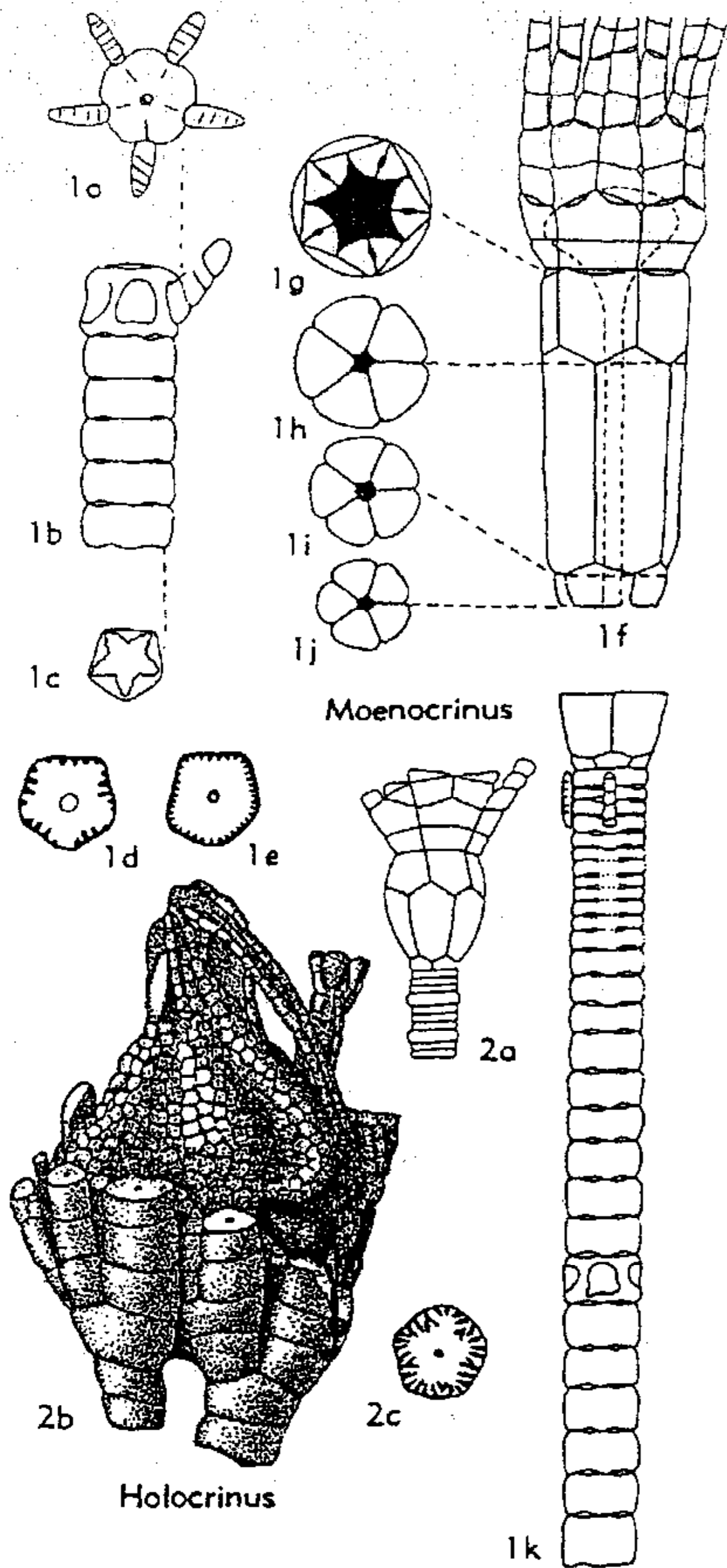


FIG. 570. Holocrinidae (p. T849-T850).

1a-c, column,  $\times 5$ ; 1d,e, articular face of columnals,  $\times 5$ ; 1f, crown, central cavity indicated by dotted line,  $\times 4.5$ ; 1g-j, sections, articular face of radials,  $\times 4.5$ ; 1k, column and part of cup,  $\times 4.5$  (Hildebrand, 1926).

#### Family ISOCRINIDAE Gislén, 1924

[Isocrinidae GISELÉN, 1924, p. 218] [=Isocrinidae MATSUMOTO, 1929, p. 31 (jr. syn. homonym)]

Cup rather small, low, cryptodicyclic. Small, concealed infrabasals present in some genera. Basals rather small, exposed, separated on surface by lower point of radials or united as low basal circlet. Radials larger, without distinct median prolongation

of lower edge to cover uppermost columnals. Radial articular face for arms large, muscular, with distinct muscular and ligament fossae. Arms divided at primibrachs 2 except in *Metacrinus*, where first division may vary from primibrachs 4 to primibrachs 7. Further divisions are found in most genera, but generally few, up to quartaxil, or in *Endoxocrinus* up to sixth division. In *Endoxocrinus* all divisions after primibrachs 2 are endotomous, inner branches remaining undivided. Other genera are more or less isotomous, although with minor variations, thus absence of distal divisions in inner branches are found in some arms within several genera. The difference in pattern of ramification of arms in Isocrinidae and Pentacrinidae is thus less distinct than generally stated. Increase in number of brachial divisions by augmentative regeneration is found in *Endoxocrinus* and *Teliocrinus*. Cryptosyzygy generally present at primibrachs 1-2 and more distal, but may be replaced by synarthry in brachials 1-2 and by symmorphy in more distal articulations. Synarthrial articulations, when present, may vary from almost flat to deeply embayed, concavity facing distally. Pinnulation complete, all pinnules free. Tegmen low.

Column pentalobate or pentagonal to circular in section. Proximal columnals pentalobate, alternating, and with radial pores in sutures. Nodals with circular to transverse elliptical cirrus sockets, commonly with distinct fulcral ridge. Cirrus sockets five or less in each nodal placed on side, in some genera near to upper or lower edge. Columnal articulations symplectial with distinct crenulae along edge and adradial, forming a petaloid pattern. Petals never extremely narrow or separated by large radial spaces. Internodal length varying from one or two internodals in a species of *Endoxocrinus* to more than 30 in specimens of *Isselicrinus*. *Trias.-Mio.; Holo.*

Several previous authors, using the genus name *Pentacrinus* in the sense of MILLER (1821), have included most recent and fossil isocrinids under this name. Genera of fossil isocrinids have been based mainly on patterns of columnal articulations (*Balanocrinus*, *Isocrinus*, *Austinocrinus*), size of basals (*Cainocrinus*), and arrange-



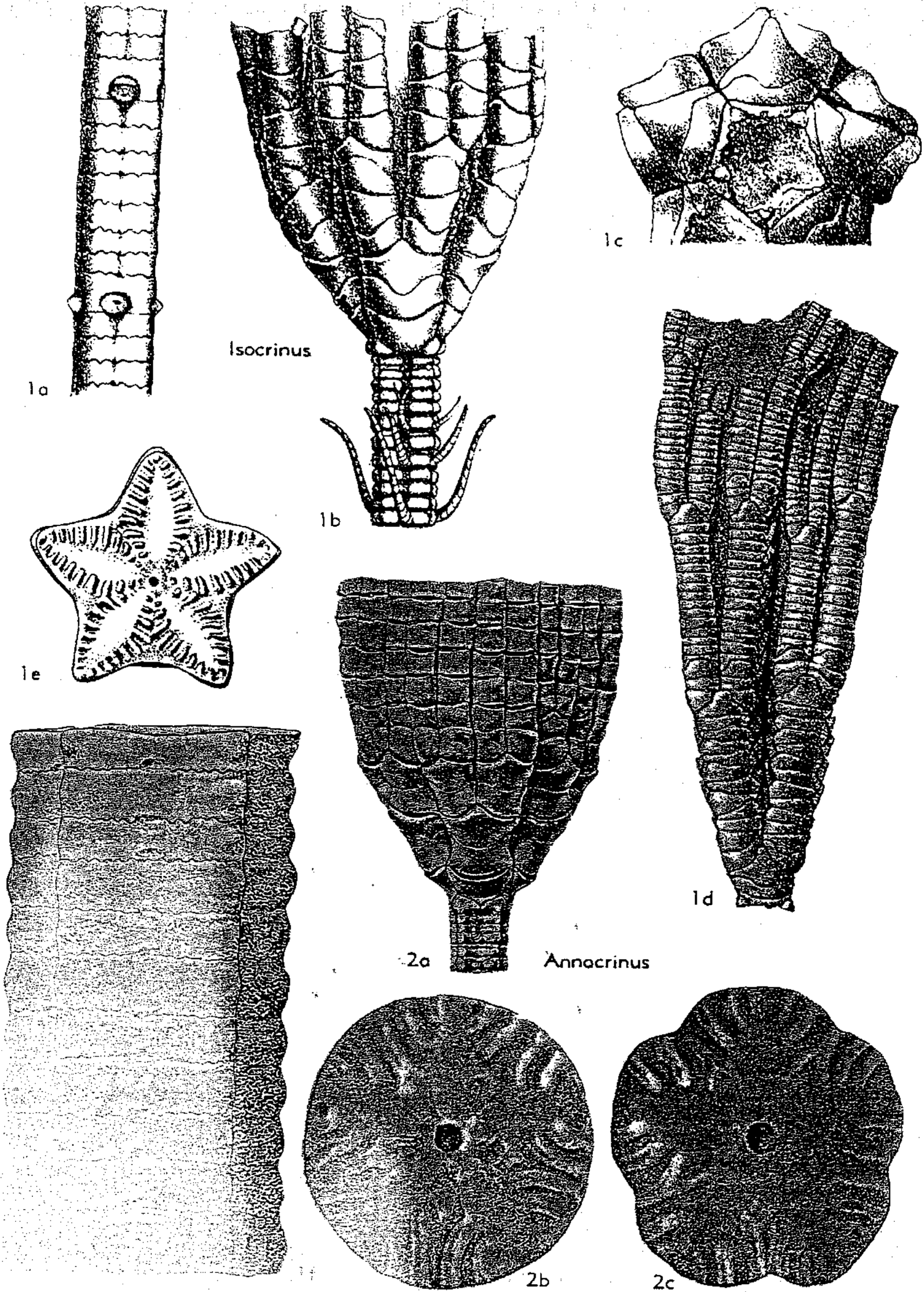
ment of cirrus sockets (*Isselicrinus*, *Doreckicrinus*), whereas recent genera and a few recently established fossil genera are based mainly on brachial ramification and articulations. A subdivision of this large family has been considered, but no distinct and separate lines of evolution have been demonstrated within the group, and different kinds of subdivision may be based on column, brachial articulations and ramification.

The only Lower Triassic species recorded is based on badly preserved, stellate columnals showing no details of the articular face. A single cup of an isocrinid is found in the Middle Triassic of Hungary, and a few isolated brachials in Middle Triassic of Hungary and Middle to Upper Triassic of New Zealand. Middle and Upper Triassic columnals of the *Isocrinus* type are described from central and southern Europe, mainly in the Alpine area, from North America, Kashmir, Indonesia, and New Zealand. Among Middle Triassic specimens from Northern Italy are also *Balanocrinus*. The Middle Triassic columnals from Hungary show a large variation including forms resembling *Isocrinus*, *Balanocrinus*, and columnals with very long crenulae in the radial areas as in recent *Annacrinus*. The Upper Triassic Alaskan *Isocrinus gravinae* BATHER, 1918, with its narrow petals is more similar to Pentacrinitidae than other Triassic species described. Isocrinids are widely distributed from the Lower Jurassic to the present day. Recent species are found from shallow water to a depth of about 2,500 meters, although they occur mainly between 200 and 1,000 meters.

*Isocrinus* VON MEYER in AGASSIZ, 1836, p. 195 [*\*Isocrinites pendulus* VON MEYER, 1836, p. 57 (= ?*Pentacrinus amblyscalaris* THURMANN in THURMANN & ÉTALLON, 1862, p. 351); SM] [= *Isocrinites* VON MEYER, 1836, p. 57 (*nom. van.*); *non Isocrinus* J. PHILLIPS, 1841, p. 30]. Cup low and wide, truncated conical. Basals small, separated on surface of cup. Arms divided at primibrachs 2 and further divided about 3 times with large intervals. Articulations on primibrachs 1-2 and secundibrachs 1-2 embayed synarthrally; secundibrachs 2-3 muscular; symmorphy present, generally at secundibrachs 3-4 or tertibrachs 3-4 or both. Cryptosyzygy may occur. First pinnule at secundibrach 2. Column rounded subpentagonal to pentalobate, proximal columnals pentalobate, alternating in size, and with radial

pores in sutures. Internodes generally rather short, about 5 to 10 internodals. Nodals with 5 large, elliptical cirrus sockets, almost as high as nodal, facing outward. Articulation of columnals with elliptical petals and a gradual continuation of marginal and adradial crenulae reaching greatest length in radial marginal areas, there forming an oblique angle with radial axis, and diminishing toward the interradial point and toward center of articular face. [The recent species *Pentacrinus blakei* CARPENTER (1882d), generally referred to *Neocrinus* (= *Chladocrinus*), was transferred by RASMUSSEN (1961) to *Isocrinus*, and agrees with this genus in structure of cup and proximal brachials, although the arms are undivided after the axillary secundibrachs 4, and the cirrus sockets are directed more downward from the nodals. Fossil columnals of Isocrinidae, with articulation similar to *Isocrinus* are generally referred to that genus, although such columnals may be found within several genera of this family. Such columnals are known from the ?Lower Triassic and Middle Triassic to Holocene. Crowns of *Isocrinus* are found from Lower Jurassic to Lower Cretaceous and recent. The only recent species, *I. blakei*, is found living in the Caribbean Sea (219-707 m.).] *Trias.-Cret.*, worldwide; recent, Carib.S. —FIG. 571, 1a, b. *I. blakei* (CARPENTER), recent; 1a, column; 1b, crown;  $\times 3$  (Carpenter, 1884a). —FIG. 571, 1c-f. *\*I. pendulus* (VON MEYER), U. Jur., France; 1c, dorsal side of cup, damaged,  $\times 2$ ; 1d, crown,  $\times 2$  (de Loriol, 1887); 1e, f, column,  $\times 6$  (Hess, 1972a). [See also Fig. 26, p. T39.]

*Annacrinus* CLARK, 1923, p. 11 [*\*Pentacrinus wyvillethomsoni* W. THOMSON, 1872, p. 767 (*ex* JEFFREYS, 1870, *nom. nud.*); M]. Cup low and wide, truncated conical. Basals form a contiguous circlet, lower edge of basals may have a small median prolongation downward, covering interradial edge of uppermost columnal. Arms divided at primibrachs 2 and secundibrachs 2, with no further divisions. Articulations at primibrachs 1-2, secundibrachs 1-2, tertibrachs 1-2 cryptosyzygial, further synostosis or cryptosyzygy rare. First pinnule on tertibrach 2. Proximal columnals pentalobate, alternating in size, and with radial pores in the suture. Distal columnals almost circular in section. Internodes long, generally with 20 to 40 internodals, but less in proximal part of column. Nodals with 5 large, elliptical to almost circular cirrus sockets, occupying entire height of nodal and directed more or less upward. Cirri rather short. Articular face of columnals with elliptic petals and long crenulae more or less restricted to radial marginal areas as in some columnals of the Middle Triassic *Isocrinus tyrolensis* (LAUBE) and *I. scipio* BATHER. Recent, E. Atl. [1,330-2,002 m.]. —FIG. 571, 2. *\*A. wyvillethomsoni* (THOMSON); 2a, crown and column,  $\times 2$ ; 2b, c, articular face of distal and proximal colum-



Isocrinus

Annocrinus

FIG. 114. Crinoidae (p. T851, T853).

×15 (Carpenter, 1884a).  
*Austinocrinus* DE LORIO, 1889, p. 153 [\**A. rothpletzi* (= *Pentacrinus erckerti* DAMES, 1885, p. 153; ?*Pentacrinus sulcifer* EICHWALD, 1871, p. 133, sp. indet.); M] [= *Austinocrinus* (*Penroseocrinus*) SIEVERTS-DORECK, 1953a, p. 114 (type, *Balanocrinus mexicanus* SPRINGER, 1922b, p. 1)].  
 Column stout, columnals low, rounded subpentagonal to circular in section, proximal columnals pentalobate. Articular face of columnals with 5 elliptical petals and stout crenulae, which may in proximal, pentalobate columnals form a pattern similar to *Annacrinus* with crenulae more or less restricted to radial marginal area and strongly reduced toward center of articular face and missing in interradial point of petals. In pentagonal columnals crenulae in radial submarginal area may be very long. In more distal, cylindrical columnals this petaloid pattern occupies only central part of articular face and is surrounded by a secondary zone with large number of very long and fine, radiating crenellae and culminae, which may be closely placed or form small, isolated groups, or crenulae may be interrupted and form 2 or 3 concentric zones. Internodes long, 16 to 19 internodals in specimens observed. Nodals are slightly enlarged, mainly where cirri are attached. Generally less than 5 cirrus sockets, often 1 or 2, in a nodal. In proximal, pentalobate nodals sockets are directed strongly upward, almost reaching edge between nodal and supranodal. In more distal part of column the cirrus socket is very large, almost circular, facing outward or slightly upward, generally covering entire height of nodal and most of supranodal, in some specimens also part of infranodal. Articulation between nodal and infranodal more or less cryptosymplectial. [An isolated crown from the Lower Campanian of North Germany has been referred by JAEKEL (1904a) with reservation to *A. rothpletzi* STOLLEY (1892) from the same locality. Small infrabasals are completely surrounded by the basal circlet. Basals are stout, but separated on side of cup by lower point of radials. Arms are divided at primibrachs 2. There is no division at secundibrachs 2; more distal brachials are unknown. The articulation at primibrachs 1-2 is synostosial or cryptosyzygial. Some columnals of the Middle Triassic *Isocrinus tyrolensis* (LAUBE) and *I. candelabrum* BATHER may have very long, radial, marginal crenulae resembling the pattern of *Annacrinus* and five-sided proximal columnals of *Austinocrinus*. The Middle Triassic column referred by LAUBE (1865) to *Pentacrinus laevigatus* is cylindrical with a similar articular face and nodals with 2 to 3, seldom 5, large, circular cirrus sockets as in *Austinocrinus*.]  
 U.Cret. (Campan.-Maastricht.), Eu. (Cauc.-Denm.-Eng.-Ger.-Neth.-Spain)-Asia (Turkistan-Asia M.)-Afr. (Tunisia)-S.N.Am. (Mex.)-W.Indies (Cuba).  
 —FIG. 572, 1a-c, j. *A. rothpletzi* STOLLEY,

Campan., Ger.; 1a-c, proximal columnals, ×5; 1f-h, columnals, distal internodal and nodal, ×5; 1i, crown, ×1 (Rasmussen, 1961, after Jaekel, 1904a).—FIG. 572, 1d,e. \**A. erckerti* (DAMES), Maastricht., USSR; 1d,e, columnals, ×2.5 (Rasmussen, 1961).

*Balanocrinus* AGASSIZ in DESOR, 1845, p. 214 [\**Pentacrinites subteres* MÜNSTER in GOLDFUSS, 1831, p. 176; OD] [Genus proposed by AGASSIZ for a column (*Millericrinus?*) with deformation, incorrectly interpreted as cup of *Pentacrinites subteres*. Name first published by DESOR for *P. subteres* and species with similar articulation in the column]. Column pentagonal or circular in section, seldom stellate, rounded subpentagonal, or pentalobate in presumed proximal columnals. Articular face of columnals with short and uniform radiating crenulae along margin and with narrow radial ridges or ribbons of minute crenulae or granules. Small adradial crenulae when present perpendicular to marginal crenulae and without any gradual transition, except that a single pair of crenellae or culminae may form an intermediate angle in some specimens. Articulation between nodal and infranodal cryptosymplectial. Internodes apparently long in most species, but may be only 7 internodals. Nodals slightly larger than internodals, and with 5 often rather small cirrus sockets facing outward or slightly upward. [Cups have never been identified in species maintained within this genus, but isolated radials and brachials found together with columnals of *B. pentagonalis* (GOLDFUSS) are referred by HESS (1972a) to this species. They indicate rather small basals, presumably separated on side of cup; arms divided at primibrachs 2 and apparently further divided; articulation at primibrachs 1-2 and secundibrachs 1-2 flat synarthrial or trifascial, secundibrachs 3-4 synostosial or cryptosyzygial; further cryptosyzygial articulations more distal may have feeble marginal crenulae; there is no symmorphy.] M.Trias.-Cret. (Neocom.), Eu. (France-Ger.-Hung.-Italy-Pol.-Port.-Spain-Switz.-USSR)-Afr. (Alg.-Tunisia); ?Cret. (Santon.), Eu. (France); ?Cret. (Cenoman.), Afr. (Madagascar).—FIG. 573, 1a,b,f-j. *B. pentagonalis* (GOLDFUSS), U.Jur., Ger.; 1a,b, column, ×5 (de Loriol, 1887); 1f, radial; 1g, brachial cryptosyzygy; 1h, distal face of primibrach 1; 1i, proximal face of secundibrach 4; 1j, proximal face of secundibrach 2, all ×10 (Hess, 1972a).—FIG. 573, 1c-e. \**B. subteres* (MÜNSTER), U.Jur., Ger.; 1c,d, articular face, ×2.6; 1e, column, ×1.5 (Goldfuss, 1831).

*Cainocrinus* FORBES, 1852, p. 33 [\**C. tintinnabulum* (emend. RASMUSSEN, 1972, p. 26); M] [*Pictetocrinus beaugrandi* DE LORIO in DE LORIO & PELLAT, 1875, p. 298, was referred to *Cainocrinus* by DE LORIO (1877) and was incorrectly designated lectotype of this genus by BIESE (1930). New specimens of the type species were described

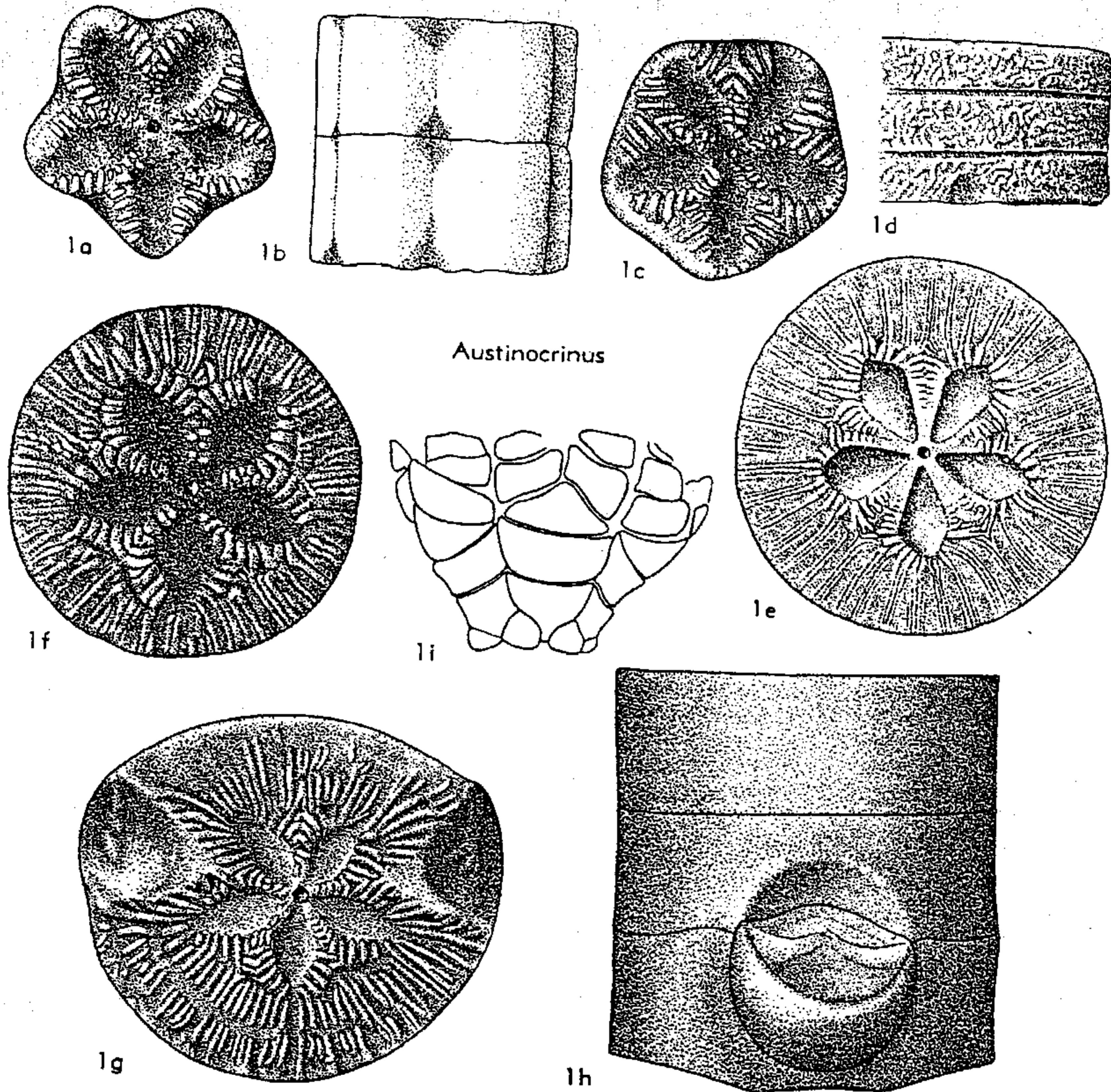


FIG. 572. Isocrinidae (p. T853).

by RASMUSSEN, 1972]. Cup truncated conical to almost hemispherical. Small infrabasals present, but not exposed, completely surrounded by basals forming a contiguous basal circlet. Lower edge of basals with median prolongation covering the interradiial edge of uppermost columnals. Arms divided at primibrachs 2 and secundibrachs 4; no further divisions. Articulation at primibrachs 1-2 flat synostosomal, secundibrachs 1-2 synarthrial, secundibrachs 2-3 muscular, secundibrachs 3-4 symmorphial, tertibrachs 1-2 muscular, tertibrachs 2-3 symmorphial. Further symmorphial articulations may occur distally, all other brachial articulations muscular. First pinnule on secundibrach 2. Column pentalobate, proximal columnals alternating in size. Length of internodes up to 15 internodals, generally about 7, but less in proximal part of column. Nodals with 5 circular to elliptical cirrus sockets. Articular face of columnals similar to

*Isocrinus* with elliptical petals surrounded by crenulae. Articulation between nodal and infranodal cryptosymplectial. *L.Tert.(Eoc.)*, *Eu.(Eng.)*; ?*L.Tert.(Paleoc.)*, *Eu.(Pol.)*.—FIG. 573,2. \**C. tintinnabulum*, *Eoc.*, *Eng.*; 2a, ventral side of basal circlet with infrabasals,  $\times 10$ ; 2b, arm,  $\times 5$ ; 2c,d, column,  $\times 8$ ; 2e, crown and column,  $\times 11$  (Rasmussen, 1972).

*Cenocrinus* THOMSON, 1864, p. 2 [\**Isis asteria* LINNÉ, 1767, p. 1288 (= *Encrinus caput medusae* LAMARCK, 1816, p. 435); M (ICZN Op. 638, 1962)]. Cup bowl shaped, basals rather small, separated on surface of cup. Arms divided at primibrachs 2, about secundibrachs 2-6 and further divided with variable intervals, distal brachial series with more than 6 brachials. All brachials 1-2 cryptosyzygial, all other brachial articulations muscular. Column rounded subpentagonal to pentalobate. Proximal brachials pentalobate, alternat-

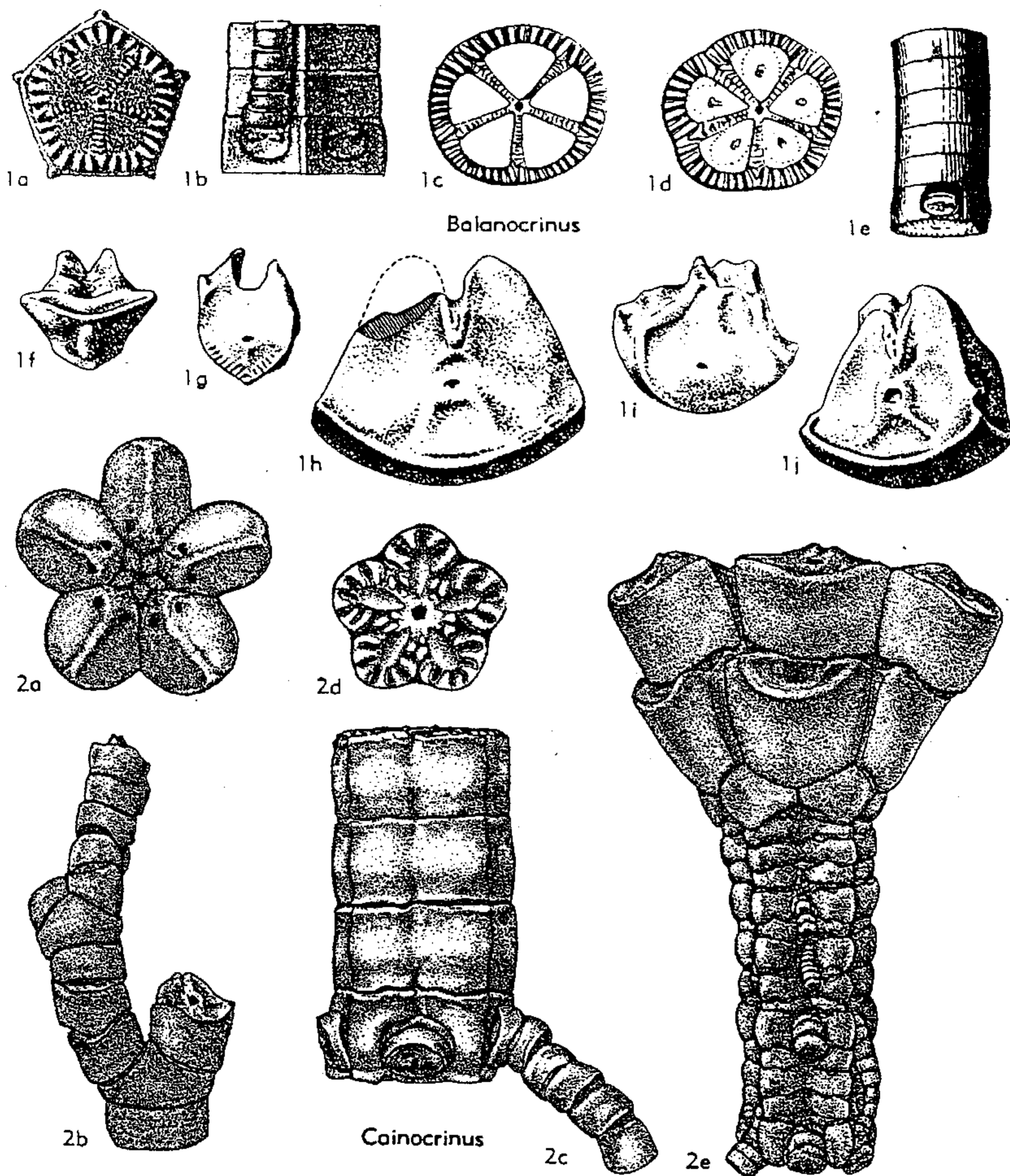
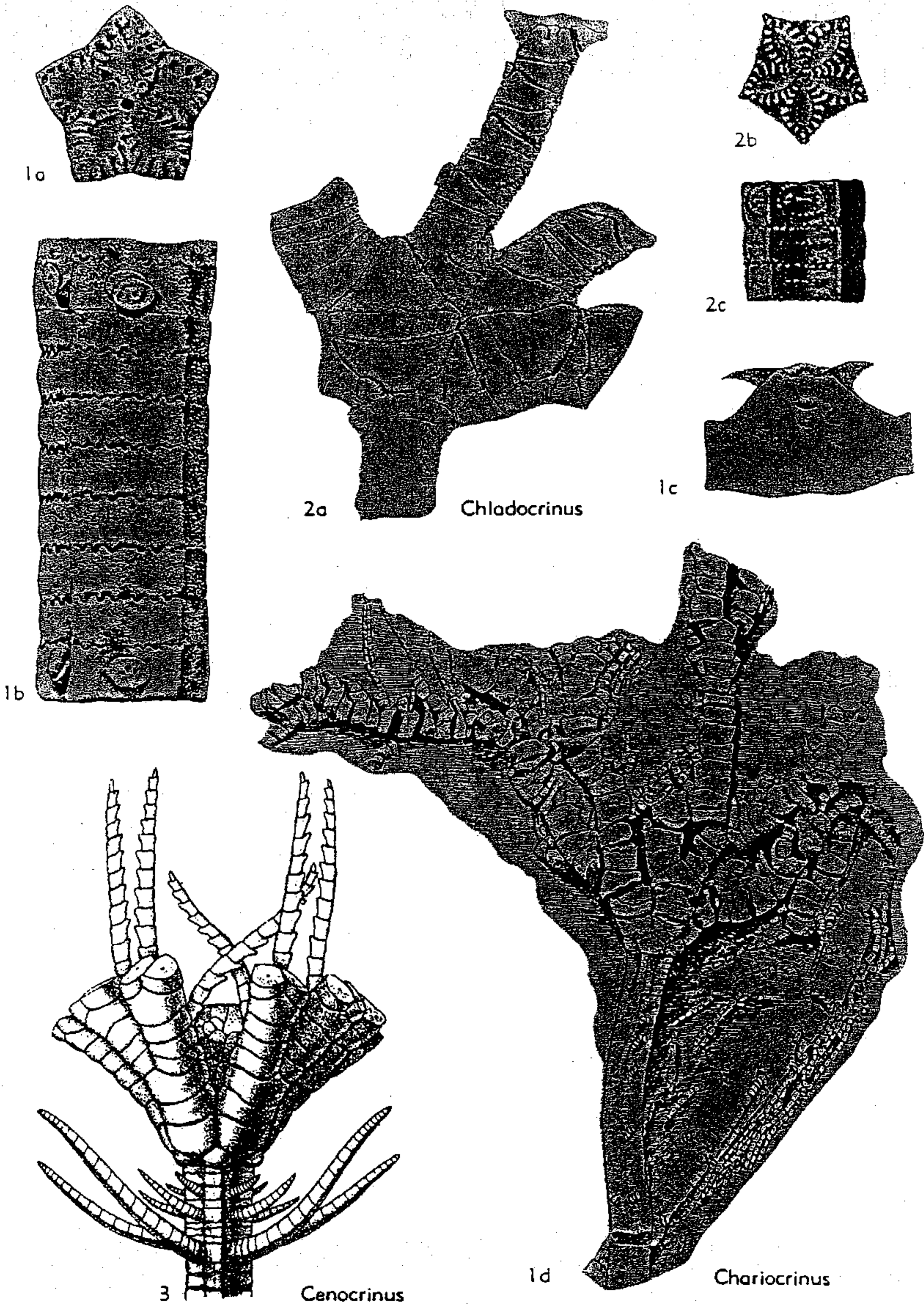


FIG. 573. Isocrinidae (p. T853-T854).

ing in size and with radial pores in the suture. Articular face of columnals as in *Isocrinus*. Internodes of 13-21 internodals, less in proximal part of column. Nodals slightly larger than internodals, and with 5 large, elliptical cirrus sockets facing outward. Cirri long. Recent, Carib.S. [0-585 m.].—FIG. 574,3. \**C. asterius* (LINNÉ); crown with column,  $\times 1.7$  (Carpenter, 1884a). (See also Fig. 20; p. T33.)

*Chariocrinus* HESS, 1972, p. 197 [\**Isocrinus andreae* DESOR, 1845, p. 213; OD]. Cup low and wide, with rather large basals forming a contiguous

basal circelet. Arms divided at primibrachs 2 and further divided at least once in distal part of arms. Primibrachs 1-2 and secundibrachs 1-2 slightly embayed synarthrial, or almost trifascial, secundibrachs 3-4 cryptosyzygial to slightly embayed almost symmorphial. Column pentagonal to stellate with rather high columnals, proximal columnals pentalobate, low, and with radial pores; most distal part of column subcircular in section. Internodes generally rather short, up to 15 internodals, but commonly less than 8. Nodals slightly larger than internodals, with five small to rather



2a Chladocrinus

3 Cenocrinus

1d

Chariocrinus

FIG. 574. Isocrinidae (p. T854-T857).

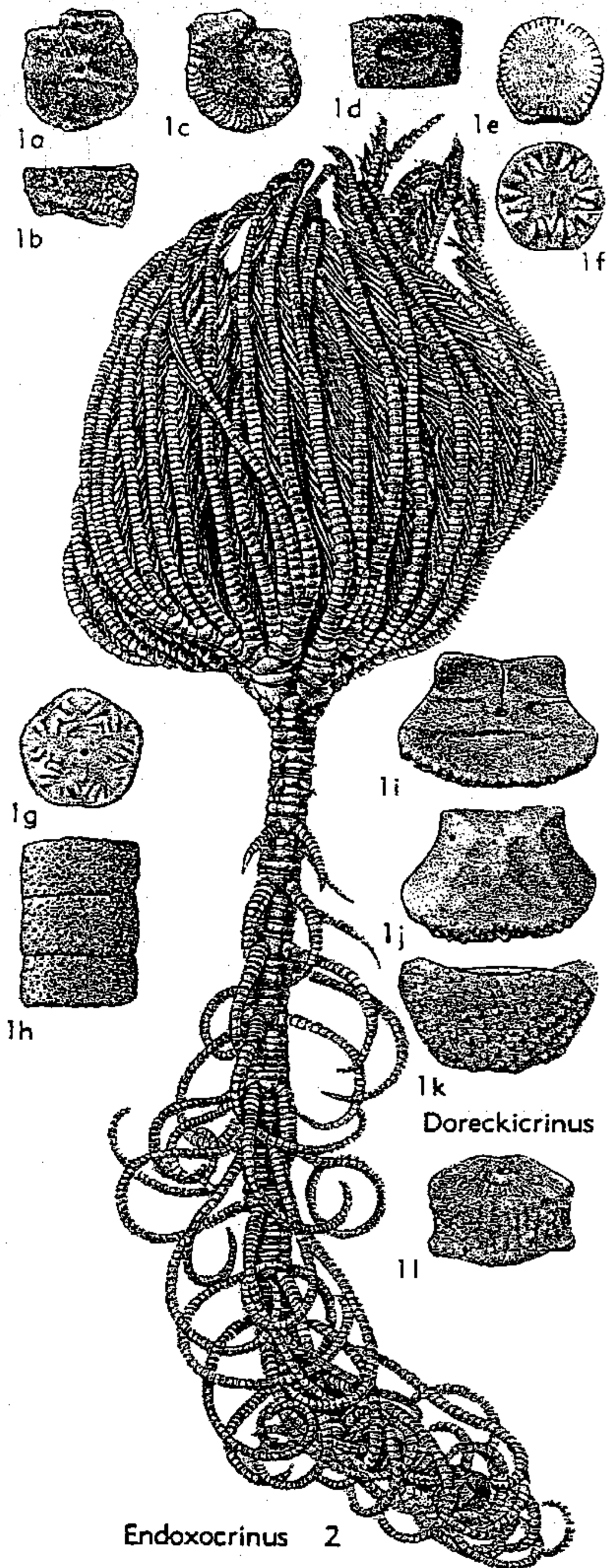
large cirrus sockets. Cirri long and slender, circular to elliptical in section. Articular face of columnals with small marginal and radial submarginal crenulae, rapidly diminishing toward center of articular face, pattern in some species approaching that of *Balanocrinus*. Articulation between nodal and infranodal cryptosymplectial. M.Jur.(Bajoc.)-U.Jur.(Oxford.), Eu.(France-Ger.-Switz.).—FIG. 574,1a,b. *C. wuerttembergicus* (OPPEL), M.Jur., Switz.; 1a,b, column,  $\times 10$  (Hess, 1972a).—FIG. 574,1c,d. \**C. andreae* (DESOR), M.Jur., Switz.; 1c, primibrach 1,  $\times 10$ ; 1d, crown with column,  $\times 2.5$  (Hess, 1972a).

*Chladocrinus* AGASSIZ, 1836, p. 195, *emend.* SIEVERTS-DORECK, 1971, p. 314 [\**Pentacrinites basaltiformis* MILLER, 1821, p. 62; SD SIEVERTS-DORECK, 1971] [= *Neocrinus* THOMSON, 1864, p. 7 (type, *Pentacrinus* (*Neocrinus*) *decorus*; M)] [This genus was introduced for species of "*Pentacrinus*" but with greater distance between nodals, thus corresponding to definition of *Seirocrinus* GISLÉN, 1924, and also included the later type of *Seirocrinus*. SIEVERTS-DORECK (1971) designated as type species *Pentacrinus basaltiformis*, which is similar to recent *Neocrinus*]. Basals variable from small and separated to rather large, forming contiguous basals circlet, commonly with median prolongation of lower edge covering interrarial edge of uppermost columnals. Arms divided at primibrachs 2 and further divided with variable intervals. Articulation at primibrachs 1-2 and secundibrachs 1-2 more or less embayed synarthrial. Cryptosyzygial or synostiosial articulations generally at secundibrachs 3-4 and more distal. No symmorphy. Column pentagonal in section with sharp edges to pentalobate, in recent species more rounded. Internodes often long, up to 20 internodals. Nodals slightly larger than internodals with 5 elliptical to almost circular cirrus sockets. Articular face of columnals as in *Isocrinus*. [The type species of *Chladocrinus* has arms divided 3 to 4 times, the recent *Neocrinus decorus* only 2 or 3 times and with shorter intervals. The recent *Pentacrinus blakei* has symmorphial articulation at secundibrach 3-4 and was transferred by RASMUSSEN, 1961, from *Neocrinus* to *Isocrinus*.] L.Jur. (Hettang.-Pliensbach.), Eu.(Aus.-Belg.-Bulg.-Eng.-France-Ger.-Hung.-Ire.-Italy-Scot.-Spain-Switz.-USSR); L.Cret., Eu.(Eng.-France-Ger.-USSR)-N. Am.(Greenl.)-Australia; L.Tert.(Oligo.), N.Am. (Ore.); recent, Carib.S. [100-1,219 m.].—FIG. 574,2. \**C. basaltiformis* (MILLER), L.Jur., Ger., Switz.; 2a, crown,  $\times 3.2$  (Sieverts-Doreck, 1971); 2b,c, column,  $\times 3$  (de Loriol, 1879). (See also Fig. 10, 11, 15, 21, 23, 27, 29, 30, 32, 33, p. T23-T49.)

*Doreckicrinus* RASMUSSEN, 1961, p. 77 [\**Pentacrinus miliaris* NIELSEN, 1911, p. 100; OD]. Nodals with less than 5 cirrus sockets, columnals elliptical in outline, centrally pitted on one side, and often

considerably smaller than height of nodal. Column circular to rounded subpentagonal, rarely pentalobate in section. Columnals moderate to high. Articular face with uniform marginal crenulae and faint adradial ridges as in *Balanocrinus*, or few and large crenulae more or less restricted to radial marginal areas as in *Annacrinus*, seldom with narrow elliptical petals surrounded by numerous crenulae. Articulation between nodal and infranodal cryptosymplectial to smooth, synostiosial. Radials and proximal brachials referred to type species indicate cup rather large with radials more or less overhanging basals. Arms divided at primibrachs 2 but apparently not at secundibrachs 2. Articulation primibrachs 1-2 and secundibrachs 1-2 cryptosyzygial. More distal cryptosyzygy may occur. First pinnule at secundibrach 2. [There is a great resemblance to the recent species *Endoxocrinus alternicirrus* (CARPENTER), 1884a, p. 321, in structure of column, articular face of columnals, nodals with less than 5 cirri and cryptosyzygial articulations in proximal brachials.] U.Cret.(Maastricht.)-L. Tert. (Dan.), Eu. (Denm.-Italy-Neth.).—FIG. 575,1. \**D. miliaris* (NIELSEN), L.Tert. (Dan.), Denm.; 1a-c, secundibrach 2; 1d-f, nodal; 1g,h, columnals; 1i-k, radial; 1l, primibrach 1; all  $\times 4$  (Rasmussen, 1961).

*Endoxocrinus* A. H. CLARK, 1908, p. 151 [\**Encrinurus parvae* GERVAIS, 1835, p. 49 (= *Pentacrinus muelleri* ØRSTED, 1857, p. 202); OD] [= *Isocrinus* (*Diplocrinus*) DÖDERLEIN, 1912, p. 21 (type, *Pentacrinus maclearanus* THOMSON, 1877b, p. 113; SD CLARK, 1923a, p. 11)]. Cup rather low, basals small and separated to rather large, forming contiguous basal circlet. Lower edge of basals more or less cover uppermost columnals. Radials with or without median projection of lower edge, separating basals. Arms divided at primibrachs 2 and secundibrachs 2 and further divided with intervals of 2 or 3 brachials, but all divisions after primibrachs 2 or after secundibrachs 2 are heterotomous, restricted to outer branches, inner branches remaining undivided. Cryptosyzygy in all brachials 1-2, and may occur also more distally in undivided branches of some species. Column commonly rather short, rounded pentagonal to pentalobate in section. Proximal columnals pentalobate, strongly alternating and with radial pores. Internodes short, 1 to 11 internodals. Nodals with generally 5 elliptical to almost circular cirrus sockets facing outward or slightly downward, occupying generally entire height of nodal and may be extended to infranodal or supranodal. *E. alternicirrus* has less than 5 cirri in each nodal. Articular face of columnals similar to *Isocrinus*, often with rather uniform crenulae. [*Endoxocrinus* and *Diplocrinus* have been distinguished by the pattern of brachial ramification and number of brachials separating each division, but both characters vary within the species or specimens; therefore, they are considered here as synonymous.] Recent, W.



Endoxocrinus 2

FIG. 575. Isocrinidae (p. T857-T858).

Atl.-Indon. [154-1,097 m.].—FIG. 575,2. \**E. parrae* (GERVAIS), W.Atl.;  $\times 0.8$  (Carpenter, 1884a). (See also Fig. 20-21, p. T33, T35.)

*Hypalocrinus* A. H. CLARK, 1908, p. 152 [\**Pentacrinus naresianus* CARPENTER, 1882d, p. 167; M]. Similar to *Isocrinus* except for arms undivided after primibrachs 2. Basals small, generally separated on

surface of cup by lower point of radials. Arms divided at primibrachs 2 only. Articulation at primibrachs 1-2 and secundibrachs 1-2 embayed synarthrial; symmorphy at secundibrachs 3-4 and more distally. Column rounded subpentagonal to circular in section, proximal columnals pentalobate. Internodes generally about 10 to 15 internodals. Nodals higher and with 5 almost circular cirrus sockets pointing more or less downward from lower part of nodal. Infranodals deep, lobate. Articular face of columnals similar to *Isocrinus*. Recent, Pac. [612-2,468 m.].—FIG. 576,1. \**H. naresianus* (CARPENTER); 1a, crown,  $\times 2$ ; 1b, column,  $\times 2.4$ ; 1c, articular face of columnal,  $\times 8$  (Carpenter, 1884a). (See also Fig. 8, p. T22.)

*Isselicrinus* ROVERETO, 1914, p. 177, emend. RASMUSSEN, 1954, p. 553 [\**I. insculptus* (= ?*Pentacrinus didactylus* D'ARCHIAC, 1846, p. 200); M] [= *Lipocrinus* RASMUSSEN, 1953, p. 416 (type, *Pentacrinites subbasaltiformis* MILLER, 1821, p. 140)] [Genus based on crushed column presumably of *P. didactylus*, but interpreted by ROVERETO as proximal part of conical column]. Cup large, forming wide and low bowl. Small infrabasals present but concealed, completely surrounded by basal cirlet. Basals large, lower edge with median projection covering interrational edge of uppermost columnals. Upper ends of basals form bottom of wide and shallow central cavity, outer sides of basals more or less covered by surrounding large radials. Arms divided at primibrachs 2 and may be further divided with large intervals. Articulations at primibrachs 1-2 and secundibrachs 1-2 cryptosyzygial, secundibrachs 2-3 and secundibrachs 3-4 muscular. Succeeding brachials may all be muscular, but isolated brachials indicate that cryptosyzygial and symmorphial articulations may be present in some species. Column cylindrical, pentalobate or pentagonal to stellate in section. Articular face of columnals in most species similar to *Balanocrinus* with uniform marginal crenellae and with adradial ridges or ribbons of minor crenellae or granules, but some specimens, and especially small or pentalobate columnals, have a more or less gradual transition from marginal to adradial crenellae similar to *Isocrinus*, although petals generally wide, guttiform, almost subtriangular. Nodals with a variable number of cirrus sockets, less than five, rather small, facing downward from lower edge of nodal. Cirri short and slender. Articulation between nodal and infranodal may be cryptosymplectial, but in some specimens almost equal to other columnal articulations. U.Cret.(Maastricht.)-U.Tert.(Mio.), Eu. (Armenia-Aus.-Cauc.-Crimea-Denm.-Eng.-France-Ger.-Hung.-Italy-Spain-Swed.-Switz.-Yugo.) - Afr. (Tunisia-Alg.)-Asia (Borneo)-N.Am. (W.Greenl.-N.J.)-W.Indies (Cuba-Haiti).—FIG. 576,2a-f. *I. paucicirrus* (NIELSEN), L.Tert.(Dan.), Denm.; 2a, two basals of large cup,  $\times 5$ ; 2b, dorsal side of cup,  $\times 2.5$ ; 2c, proximal articulation of primibrach



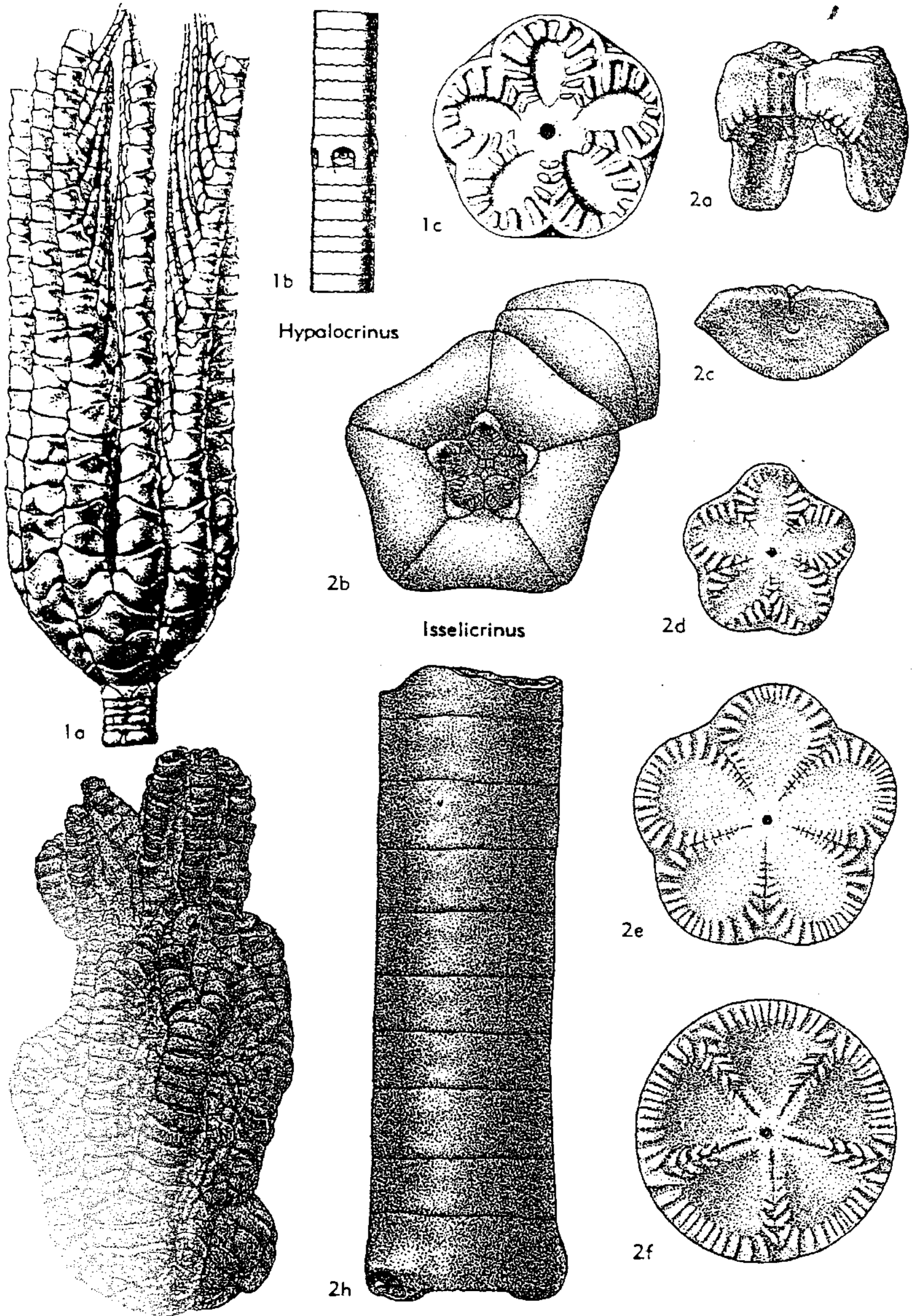


FIG. 576. Isocrinidae (p. T858, T860)

2,  $\times 2.5$ ; 2d-f, articular face of columnals,  $\times 5$  (Rasmussen, 1961).—FIG. 576, 2g, h. 1. *subbasaltiformis* (MILLER), L.Tert.(Eoc.), Denm.; 2g, crown,  $\times 1.8$ ; 2h, column,  $\times 5$  (Rasmussen, 1972a).

*Metacrinus* CARPENTER, 1882, p. 167 [*\*Metacrinus wyvillei* CARPENTER, 1884a, p. 358; SD CLARK, 1908c, p. 527 (ICZN Op. 73, 1922)] [= *Saracrinus* CLARK, 1923a, p. 9 (type, *Metacrinus nobilis* CARPENTER, 1884a, p. 351; OD)]. Cup low and wide. Small, concealed infrabasals present. Basals generally large, forming contiguous basal cirlet; lower edge with median projection covering interradial edge of uppermost columnals. Arms divided at primibrachs 4 to primibrachs 7 and further divided twice or more. Cryptosyzygial articulation at primibrachs 1-2, in species with 7 primibrachials also at primibrachs 4-5 or 5-6, further at secundibrachs 2-3 or secundibrachs 3-4 and in more distal parts of arms. Other brachial articulations muscular. No synarthry. All axillaries follow an oblique muscular articulation. First pinnule on primibrach 2. Column pentagonal or pentalobate to rounded subpentagonal. Articular face of columnals similar to *Isocrinus*, crenellae rather short. Length of internodes 5 to 13 internodals, less in proximal part of column. Nodals larger than internodals and with 5 rather large, elliptical to circular cirrus sockets facing outward or slightly upward. Cirri long. Recent, Pac.-Indon. [55-1,133 m.].—FIG. 577, 2. *M. angulatus* CARPENTER; 2a, b, column; 2c, crown;  $\times 3$  (Carpenter, 1884a). (See also Fig. 20, p. T33.)

*Nielsenicrinus* RASMUSSEN, 1961, p. 94 [*\*Pentacrinus obsoletus* NIELSEN, 1913, p. 97; OD]. Cup hemispherical to bowl shaped. Small, concealed infrabasals may be present. Basals may be small and separated on surface of cup or large forming contiguous basal cirlet. Arms divided at primibrachs 2 and further divided with large intervals. Articulation primibrachs 1-2 flat, cryptosyzygial, secundibrachs 1-2 almost flat, synarthrial, secundibrachs 3-4 cryptosyzygial. Column pentalobate to rounded subpentagonal in section. Articular face as in *Isocrinus* with elliptical petals and with marginal and adradial crenulae in gradual transition, reaching greatest length in radial marginal area. Length of internodes about 6 to 17 internodals, less in proximal part of column. Nodals larger than internodals and with 5 rather large, elliptical cirrus sockets facing outward. *Cret.*(*Neocom.-Maastricht.*), *L.Tert.*(*L.Paleoc.*, *Dan.*; *M.Paleoc.*, *Heers.*), *Eu.*(*Aus.-Belg.-Denm.-Eng.-France-Ger.-Neth.-Swed.-Switz.*).—FIG. 578, 1a-c, f, g. *N. fionicus* (NIELSEN), *Dan.*, *Denm.*; 1a-c, cup,  $\times 5$ ; 1f, g, column,  $\times 5$  (Rasmussen, 1961).—FIG. 578, 1d, e, h-j. *\*N. obsoletus* (NIELSEN), *Dan.*, *Denm.*; 1d, e, column,  $\times 5$ ; 1h, i, articular face of secundibrach 1,  $\times 5$ ; 1j, articular face of primibrach 1,  $\times 5$  (1d, e, h, j, Rasmussen, 1961; 1g, crown and column recombined,  $\times 5$ , Rasmussen, 1969).

—FIG. 578, 1k. *N. chavannesi* (DE LORIO), *L.Cret.*, *Switz.*; crown,  $\times 4$  (Rasmussen, 1961).

*Teliocrinus* DÖDERLEIN, 1912, p. 22 [*\*T. asper* (= *Hypalocrinus springeri* A. H. CLARK, 1909), p. 650; M] [= *Comastrocrinus* A. H. CLARK, 1912c, p. 252 (type, *Hypalocrinus springeri* A. H. CLARK, 1909); OD)]. Cup low and wide, bowl shaped. Small, concealed infrabasals present. Basals small, generally separated on side of cup. Arms divided at primibrachs 2 and further divided with variable intervals of 1-6 brachials. Cryptosyzygy at primibrachs 1-2 and generally at brachials 2-3 or brachials 3-4 of succeeding brachial series, in undivided distal branches also more distal. Number of arm divisions increasing during growth by augmentative regeneration, each division generally following a cryptosyzygy. Synarthry may occur at brachials 1-2. Column subpentagonal to pentalobate. Articular face similar to *Isocrinus*. Diameter of column may be slightly increasing from distal to proximal end of column. Proximal columnals pentalobate, alternating in size and with radial pores in the sutures. Internodes with 7 to 15, generally 10 to 11 internodals, less in proximal part of column. Nodals larger than internodals, and with 5 almost circular cirrus sockets facing outward and commonly reaching lower edge of the nodal. Cirri rather long. Recent, Ind.O. [366-1,280 m.].—FIG. 577, 1. *\*T. springeri* (CLARK); 1a, b, crown and column,  $\times 1$  (Clark, 1915a).

## GENERA DUBIA

*Carpenterocrinus* CLARK, 1908, p. 319 [*\*Pentacrinus mollis* CARPENTER, 1884a, p. 338; M]. Dubious genus, based on imperfect, maybe abnormal or regenerating specimen of *Isocrinidae*. Cup with proximal brachials and 3 columnals incompletely calcified, leathery; tegmen extensively plated. Columnals strongly pentalobate, low discoidal, almost bowl shaped with the interradial edges bent upward, covering lower edge of basal cirlet. Lower face of preserved column with a petaloid pattern but no trace of crenulae. Basals high, forming conical or pyramidal basal cirlet. Brachials with more or less flattened to concave surface. Arms divided at primibrachs 2 and presumably at secundibrachs 2, division of ambulacra on tegmen indicating 20 arm branches. Articulation primibrachs 1-2 apparently nonmuscular. Recent, Pac., off Japan [1,020 m.].

*Picteticrinus* DE LORIO, in DE LORIO & PELLAT, 1875, p. 298 [*\*P. beaugrandi*; M] (junior homonym of *Picteticrinus* ÉTALLON, 1857, p. 282 (*nom. nud.*)). Genus rejected as homonym by DE LORIO (1878, p. 111) and type species transferred to *Cainocrinus* FORBES; the latter rejected by CARPENTER and BATHER as indeterminate. BIESE (1930) incorrectly made *P. beaugrandi* type species of *Cainocrinus*. According to HESS (1972a, p. 206), *P. beaugrandi* may possibly belong to

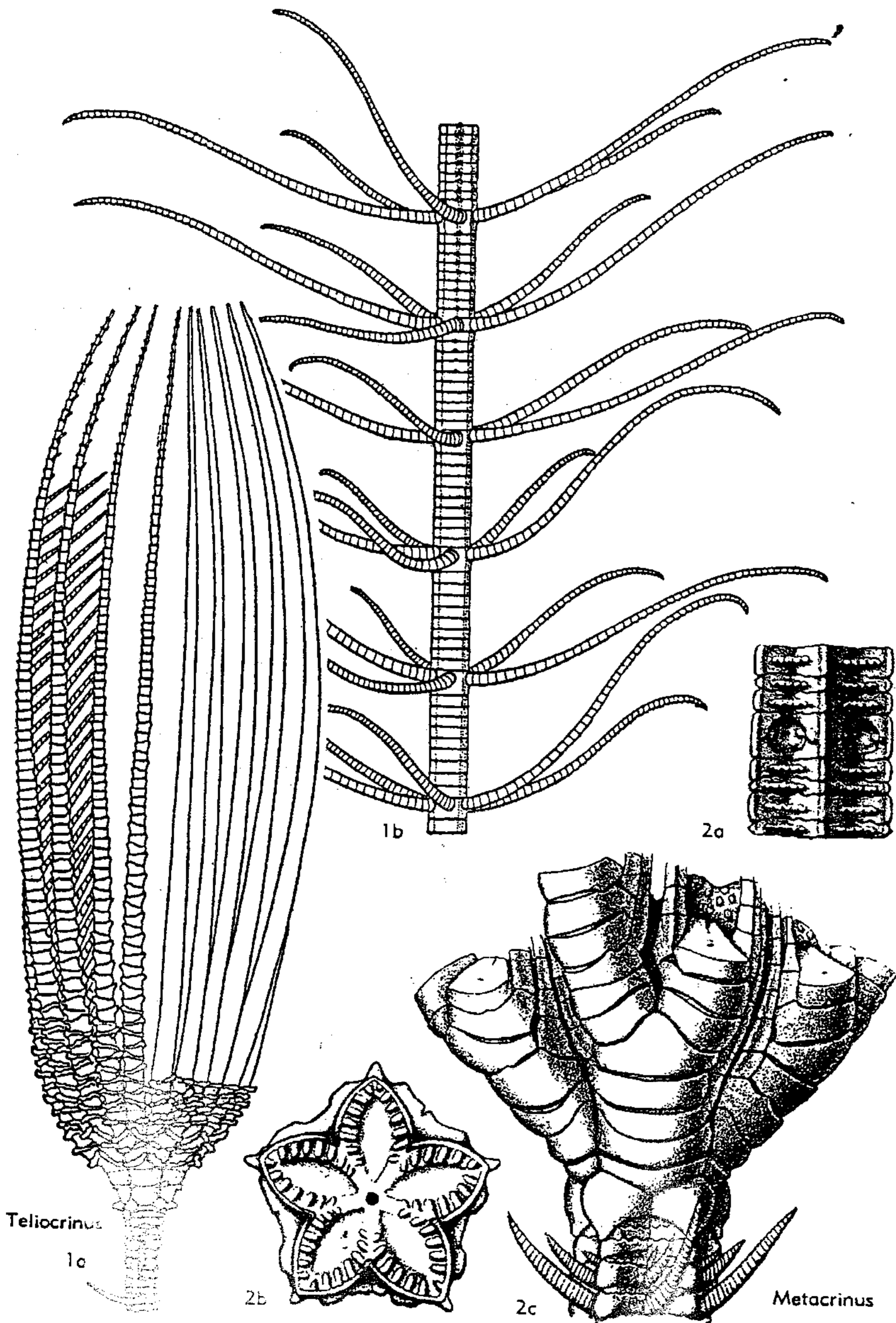


FIG. 577. Isocrinidae (p. T860).

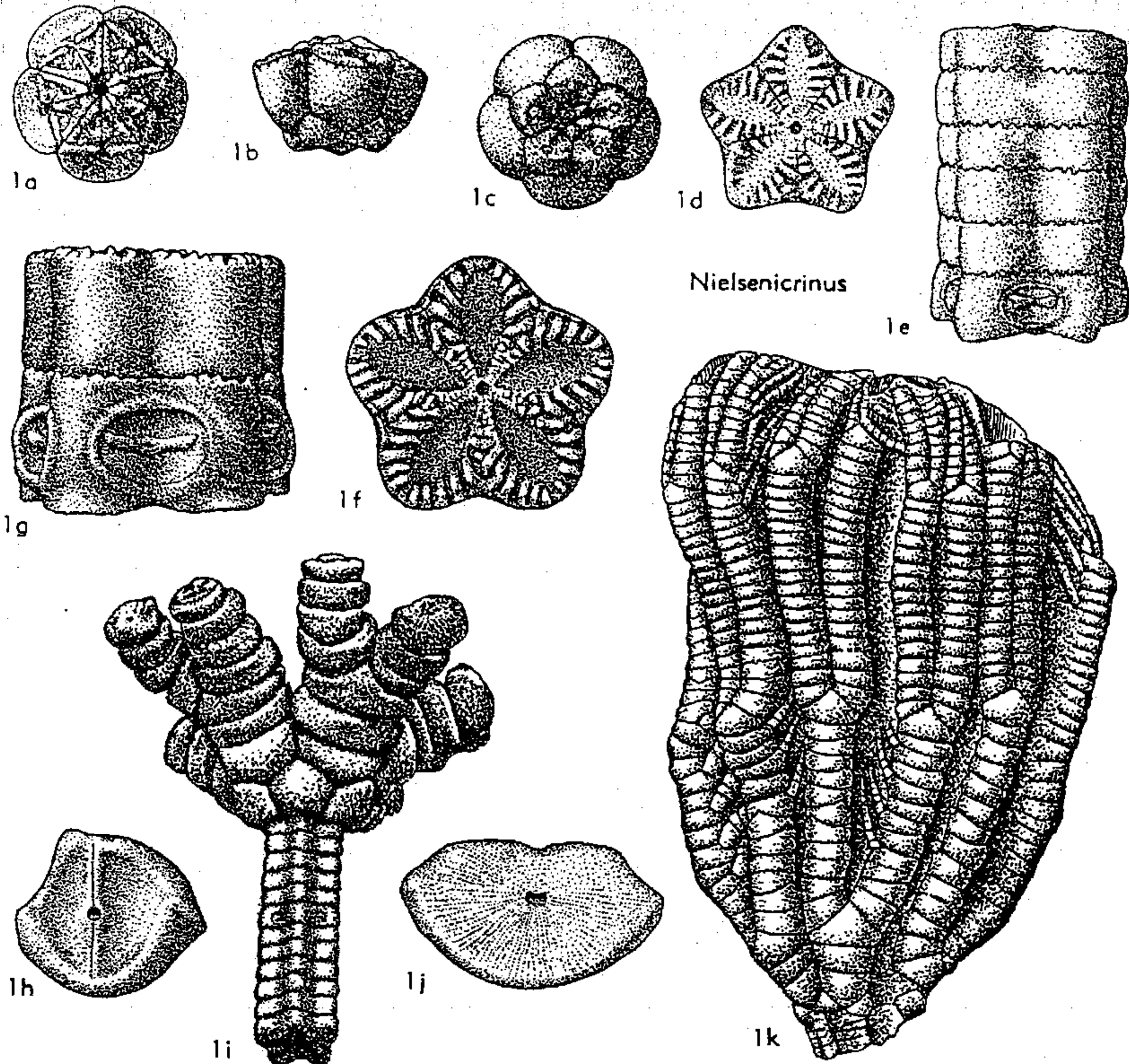


FIG. 578. Isocrinidae (p. T860).

*Chariocrinus*]. Cup rather low and wide, basals large, forming contiguous circlet; lower edge of basals with inconspicuous median prolongation partly covering interradial edge of uppermost columnal. Arms divided at primibrachs 2, some arms further divided once or twice with variable intervals. Articulation primibrachs 1-2 flat, presumably cryptosyzygial. Column stellate, proximal columnals alternating in height and with radial pores in the sutures. Internodes with about 9 internodals, less in proximal part of column. Articular face of columnals with short and uniform marginal and adradial crenulae. Nodals larger than internodals and with 5 rather small elliptical cirrus sockets facing outward or slightly upward. *U. Jur.* (Portland.), Eu. (France).

*Polycerus* FISCHER VON WALDHEIM, 1811. Proposed to replace name *Pentacrinus* for Isocrinida including *Polycerus stoloniferus* (a synonym of *Pentacrinus basaltiformis*, according to BRONN, 1848) and

the recent "palmier marin" (= *Isis asteria*, type of *Cenocrinus*).

*Tauriniocrinus* ROVERETO, 1939, p. 616 [*\*Pentacrinus gastaldi* MICHELOTTI, 1847, p. 59; OD]. Genus of Isocrinidae, insufficiently characterized. Crown unknown. Column pentalobate or rounded subpentagonal, seldom circular in section. Columnals commonly alternating in height, proximal columnals with radial pores in the suture. Length of internodes unknown, but may reach 14 internodals or more. Articular face of columnals similar to *Isocrinus*, crenellae not very long, generally leaving a smooth radial marginal area. Nodals higher than internodals, with 5 rather large, elliptical cirrus sockets occupying entire height of nodal and facing outward. Very rarely less than 5 sockets. *Tert. (Oligo.-Mio.)*, Eu. (Aus.-Czech.-France-Italy).

## Family PENTACRINITIDAE Gray, 1842

[Pentacrinitidae GRAY, 1842, p. 119] [=Pentacrinidae D'ORBIGNY, 1852, p. 147 (emend. GISEN, 1924, p. 218); incl. Pentacrinacea D'ORBIGNY, 1852 (nom. transl. STEINMANN, 1907, p. 204), and Pentacrininae D'ORBIGNY, 1852 (nom. transl. BATHER, 1900, p. 182), both ex Pentacrinidae D'ORBIGNY, 1852]

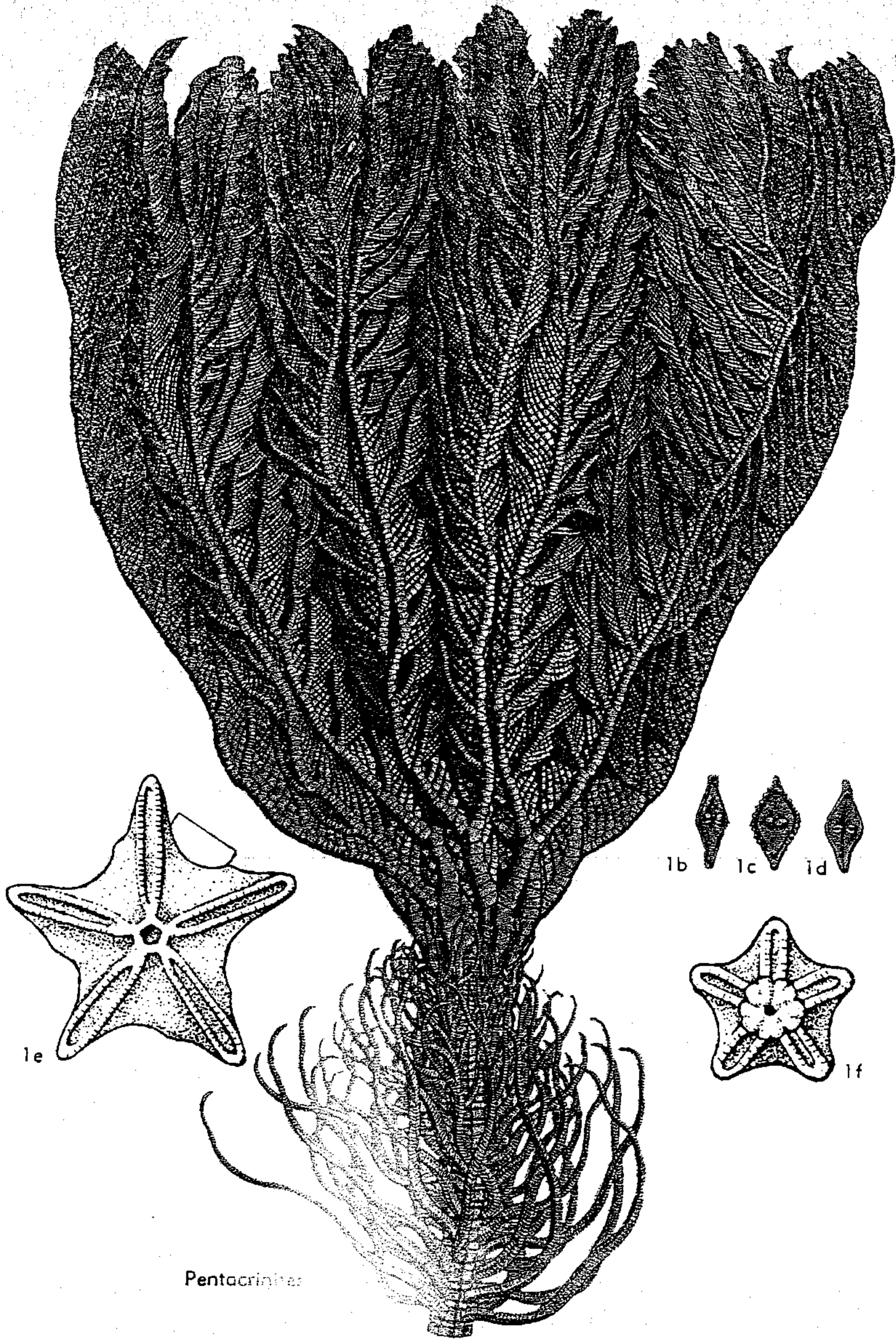
Cup low, bowl shaped. Infrabasals small, concealed. Basals may be rather prominent although separated by radials; lower edge of basals more or less curved downward, covering interrational edges of uppermost columnals. Radial large, with generally very large median ridge or point separating basals and curved downward as a spine or crest to cover several proximal columnals, in some specimens subdivided by one or two sutures. Articular face of radials often slightly more narrow than radial plates. Large and distinct dorsal and interarticular ligament fossae; ventral muscular fossae not distinct. Arms divided at primibrachs 2 and further divided several times with variable intervals of generally more than four brachials. Divisions at primibrachs and secundibrachs isotomous, generally all succeeding divisions heterotomous, restricted to outer branches in relation to secundibrachs, long inner branches remaining undivided. Articulation at primibrachs 1-2 and secundibrachs 1-2 synostiosial or cryptosynarthrial, generally rather flat, with a deep median ventral incision and slightly concave lateral areas. Further nonmuscular articulations may occur; thus, according to HESS (1955), synarthry may occur at primibrachs 1-2, secundibrachs 1-2, and secundibrachs 3-4 and syzygy at secundibrachs 6-7 in *Pentacrinites dargniesi*. Muscular articulations show no distinct differentiation of ventral muscular fossae. First pinnule at secundibrach 2. Interbrachial plates connecting proximal brachials apparently up to quartibrach 1 and continuing in numerous small plates of high tegmen reaching about fifth or sixth arm division. Proximal pinnules in *Pentacrinites* free, in *Seirocrinus* included in tegmen, and more or less reduced. Mouth central, ambulacral furrows in tegmen, according to JAEKEL (1891a), not distinct, presumably covered by irregularly arranged plates and maybe permanently closed. Low anal pyramid with rather few, low and wide plates with lateral projections and a nodulous surface.

Column pentalobate, stellate or pentag-

onal to almost circular in section, extremely variable in length from a few centimeters to more than 15 meters. Diameter of column generally slightly decreasing toward distal end of moderate to long columns. Uppermost columnals may form small pyramidal top of column, concealed by surrounding lower end of radials. Columnals very strongly alternating; smaller columnals may be partly or entirely concealed by larger. Proximal part of column formed mainly or only by nodals, but more distal parts also with exposed internodals; in *Seirocrinus*, very few nodals in distal part of very long columns. Nodals with 5 generally small cirrus sockets, often narrow elliptical to rhombic in outline, facing outward or somewhat upward. Where nodals are closely placed, sockets may be oblique or may be placed alternating right and left of midradial line. Articular face of columnals with very narrow petals surrounded by a slightly crenulate edge or ridge and separated by large, more or less triangular, smooth or rugose radial areas. Cirri short or long, rounded in section or laterally compressed. *L. Jur.-U. Jur.*

[British specimens of *Pentacrinites fossilis* are found on the underside of bedding planes with remains of fossil wood, and interpreted by BUCKLAND (1837, p. 436-437) and later authors as pseudoplanktonic, attached to the underside of drifting logs or bits of wood. WALTHER (1897, p. 227) reported *Seirocrinus subangularis* (= *S. fasciculosus*) attached to wooden logs in the Lower Jurassic *Posidonia* shale of Württemberg in Germany. Only ABEL (1927, p. 950) in his comment to illustration of the specimen (Fig. 215) claimed that the crinoids had attached themselves to a sunken trunk.

It is inconceivable that larval crinoids attached to a floating trunk would remain attached several years and reach the adult size of about 0.8 meters in diameter of the crown before the trunk stranded or sank to the bottom, water-logged and overgrown by *Pseudomytiloides*. Moreover, the long and tapering distal parts of the columns all were discarded before the columns (only 0.3-2 m. long) attached themselves to the trunk. Since adult Isocrinida could hardly swim but could move only by drifting near the bottom, the pseudoplanktonic hypothesis is here rejected (RASMUSSEN, 1977).



Pentacrinites

Other specimens of *Seirocrinus subangularis* from the bituminous shales of Holzmaden (Württemberg) show distally tapering stems up to 18 meters long, presumably maintained due to absence of water movements. They are mutually entangled and presumably lay on the bottom with distal parts of the columns. The interpretation by SEILACHER *et al.* (1968) of their columnal growth pattern as inverse due to a pseudo-planktonic habit, hanging down from floating trunks, is contradicted by the same growth pattern in recent Isocrinidae living on the bottom.]

*Pentacrinites* BLUMENBACH, 1804, no. 70 (*ex Pentacrinus* AGRICOLA, 1546, p. 262), *emend.* BATHER, 1898b, p. 245 [\**P. fossilis* (= *P. britannicus* VON SCHLOTHEIM, 1813, p. 100, obj.; *P. briareus* MILLER, 1821, p. 56); M] [= *Pentacrinus* MILLER, 1821, p. 45 (*nom. van.*); *Extracrinus* AUSTIN & AUSTIN, 1847, p. 95 (type, *P. briareus* MILLER, 1821; OD, p. 107)] [AUSTIN & AUSTIN, 1847 incorrectly considered *Pentacrinus* established by MILLER (1821), with *P. caput-medusae* as type species, and used the name *Pentacrinus* for all Isocrinidae. They were followed by most authors until BATHER, 1898, and by some later authors]. Column short, generally less than 0.5 m., but may reach 1 m., pentalobate to stellate or sub-pentagonal in section. Internodes very short, proximal part of column showing nodals only, distal part with a few internodals, commonly 3 to 4 larger and intercalated smaller internodals. Cirri numerous and very long, often narrow, elliptical to rhombic in section with dorsal and ventral ridge. Cirri directed more or less upward, commonly covering column and cup completely. Articular face of columnals with smooth radial areas. Pinnules all free. *L. Jur.* (Hettang.)-*U. Jur.* (Oxford), *Eu.* (Czech.-Eng.-France-Ger.-Pol.-Switz.-USSR); ?*Jur.*, N.Am.—FIG. 579, 1a. \**P. fossilis*, *L. Jur.*, Ger.;  $\times 0.7$  (Goldfuss, 1931).—FIG. 579, 1b-d. *P. collenoti* (DE LORIO), *L. Jur.*, France; 1b-d, cirrals,  $\times 5$  (de Loriol, 1888).—FIG. 579, 1e, f. *P. dargniesi* (TERQUEM & JOUDRY), *M. Jur.*, Switz.; 1e, articular face of columnal; 1f, articular face of distal columnal with small intercalated internodal,  $\times 4$  (Hess, 1955). [= *Pentacrinite* GUETTARD, 1761 (*nom. null.*); *Pentacrinus* WIEGMANN, 1838 (*nom. null.*) (*err. pro Pentacrinite*); *Heterocrinus* FRAS, 1858, p. 327 (*non* HALL, 1847).]

*Seirocrinus* GISLÉN, 1924, p. 118 [\**Pentacrinites subangularis* MILLER, 1821, p. 45 (= *Pentacrinites fasciculosus* VON SCHLOTHEIM, 1813, p. 56; *Pentacrinus hiemeri* KOEHLER, 1847, p. 2; *Extracrinus lepidotus* AUSTIN & AUSTIN, 1847, p. 106; *Pentacrinites briaroides* QUENSTEDT, 1852, p. 607; *Penta-*

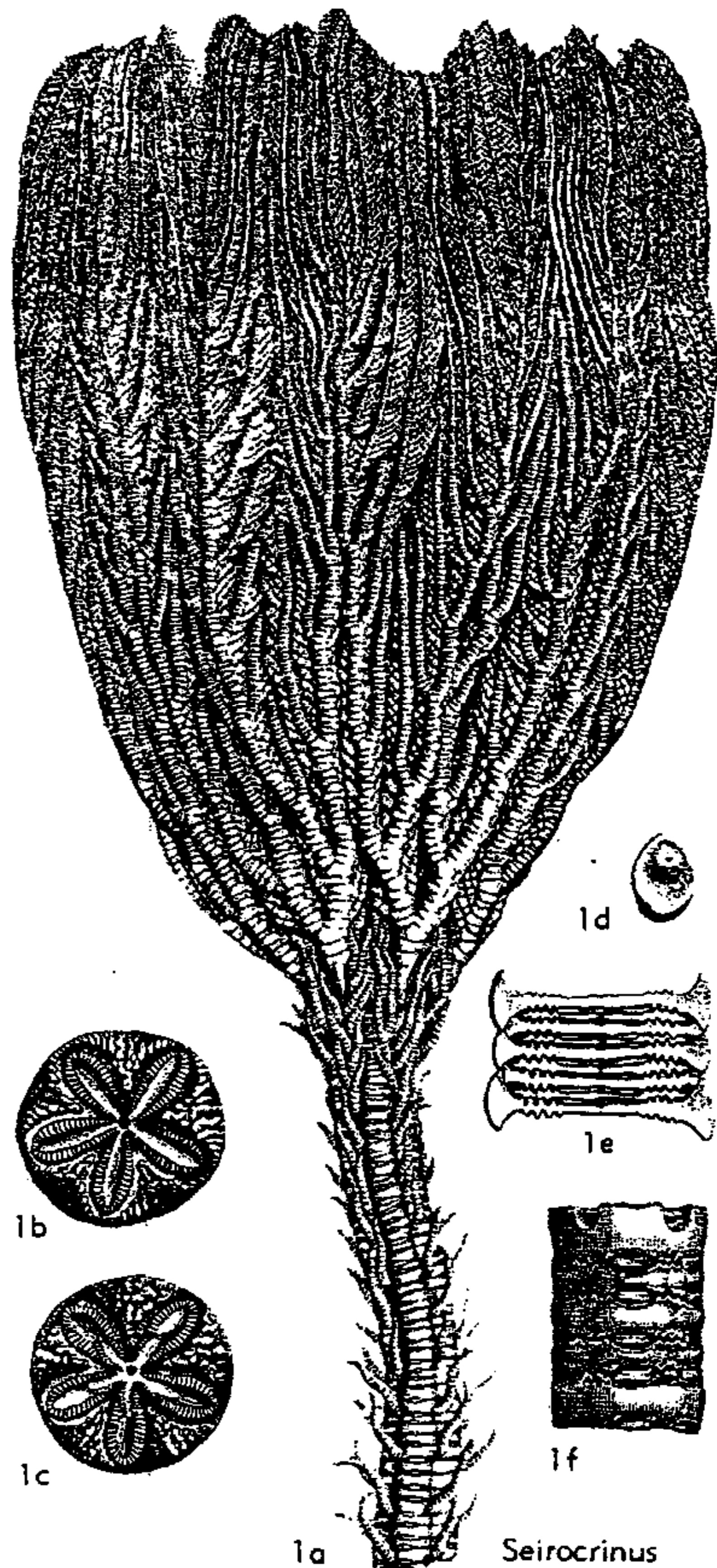


FIG. 580. Pentacrinitidae (p. T865-T866).

*crinites colligatus* QUENSTEDT, 1852, p. 608); OD]. Tegmen very high, proximal pinnules reduced and included in tegmen, first distinct pinnule about tertibrach. Column often very long, from less than 20 cm. to more than 4 m., maybe 18 m., rounded subpentagonal to circular in section. Columnals strongly alternating throughout entire length of column, smaller internodals partly or completely concealed by larger columnals. Length of internodes gradually increasing to more than 100 internodals in distal part of long columns. Nodals with 5 very small cirrus sockets, rounded or oviform in outline, facing outward or upward. Cirri short and slender, rounded in section or with a ridge. Cirri may be adpressed in oblique furrows

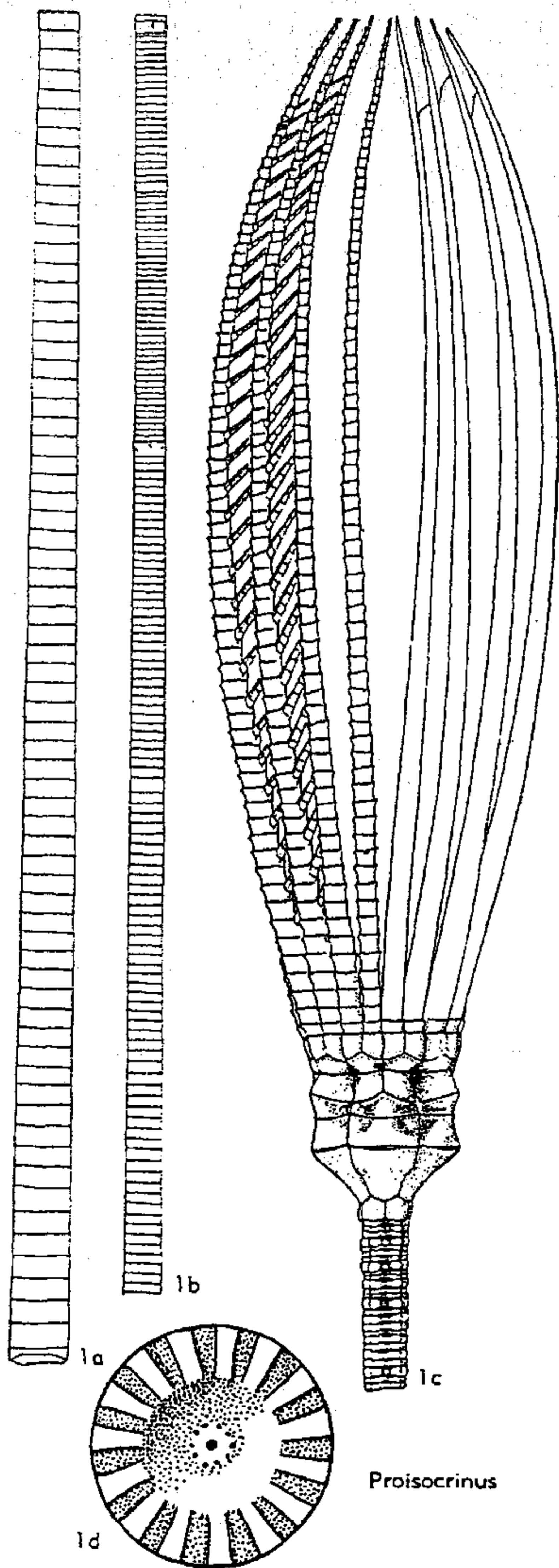


FIG. 581. Proisocrinidae (p. T866-T867).

in surface of column. Articular face of columnals with granulated or vermiculate radial areas. *L. Jur.*-*M. Jur.*, Eu. (Eng.-Ger.-Italy-Bulg.-Port.-Switz.)-Asia (Turkey-Indon.)-N. Am. (Alaska).—FIG. 580, J.

\**S. fasciculosus* (VON SCHLOTHEIM), *L. Jur.*, Ger.; *1a*, crown and column,  $\times 0.9$ ; *1b*, articular face of columnal,  $\times 1.4$ ; *1c*, articular face of columnal with intercalated small internodal,  $\times 1.9$ ; *1d*, articular face of cirral,  $\times 2.25$ ; *1e*, sec. through column showing small concealed columnals intercalated between larger,  $\times 2.25$ ; *1f*, columnal with nodal,  $\times 1.5$  (Goldfuss, 1831). [Also see Fig. 215, p. T339.]

### Family PROISOCRINIDAE

Rasmussen, new family

Cup with a rather low, cylindrical circlet of five basals and a larger, broad conical circlet of five radials, pentalobate in outline. Articulations for arms wide, occupying entire upper edge of cup. Arms divided at primibrachs 2 and secundibrachs 2. Proximal brachials broad and in lateral apposition. Articulation of primibrachs 1-2 and secundibrachs 1-2 are nonmuscular, all other articulations muscular; first pinnule on tertibrach 2.

Column very long with numerous columnals; only known specimen has a column more than 84 centimeters long and with more than 442 columnals. Radix unknown. Diameter of column 5 or 6 millimeters, slowly increasing in distal part of column to 11 millimeters. Proximal part of column pentalobate in section with columnals alternating in size. Nodals with five small cirri and rounded cirrus sockets occur with rapidly increasing intervals, succeeding internodes having 1, 1, 3, 4, 5, 8, 14, 25, 38, and 38 internodals. In distal nodals belonging to median part of the column, cirrus sockets obliterated. Median and distal part of column cylindrical with columnals not alternating in size, but slightly increasing distally. Articular face of columnals in proximal part with petaloid markings not precisely described, in median and distal part of column having rather few and large radiating marginal crenulae surrounding a depressed central area. Recent.

This family is established for the genus *Proisocrinus*, generally referred to the *Isoocrinus* group, due to structure of crown and presence of nodals with cirri. It does not fit into families previously established.

*Proisocrinus* A. H. CLARK, 1910, p. 387 [*\*P. ruberrimus*; M]. Characters of family. Recent, Pac. (Philip. Is.).—FIG. 581, J. *\*P. ruberrimus*; *1a, b*, proximal and distal part of column,  $\times 0.6$ ;



1c, crown with column,  $\times 0.9$ ; 1d, articular face of median columnal,  $\times 5.4$  (Clark, 1910d).

## Order COMATULIDA

A. H. Clark, 1908

[Comatulida A. H. CLARK, 1908g, p. 135, established as an order to cover the family Comatuladae FLEMING, 1828 (=Comatulidae D'ORBIGNY, 1852, p. 138), but including Uinacrinida, and excluding (CLARK in VON ZITTEL & EASTMAN, 1913) Thiolliericrinidae. Herein, Thiolliericrinidae are included in and Uinacrinida are excluded from the order.]

Articulata in which larval column is normally obliterated except for cirriferous uppermost columnal or fused uppermost columnals enlarging and forming a centrodorsal attached to cup. *L. Jur.-L. Paleoc.*; *Eoc.-Holo.*

In Comatulida the cirriferous uppermost columnal or series of coalesced proximal columnals during the stalked larval stage, called the pentacrinoid, is enlarged and is incorporated in the cup as a centrodorsal with cirri. The larval column distal of the centrodorsal is obliterated. The adult comatulid is thus free to move around creeping or swimming, and may do so if environments become severe, but generally they remain attached to the substrate by the cirri. Only by proterogenetic evolution is the larval column maintained in the adult of Thiolliericrinidae.

The centrodorsal was interpreted by A. H. CLARK as a single nodal, not a series of coalesced nodals, and this may be correct insofar as no new columnals are formed proximal to the centrodorsal. However, after the formation of the first five cirri, which are radially placed as in other dicyclic or cryptodicyclic crinoids, growth of the centrodorsal continues at its upper end, and new parts with cirrus sockets and cirri are added there, although not individualized as single columnals, and never observed as single columnals in the ontogeny of modern comatulids. In the Jurassic and Lower Cretaceous Paracomatulidae, however, the conical centrodorsal is composed of a series of closely joined, very low columnals separated by distinct sutures and articulated by a petaloid pattern of crenellae, similar to the column of *Pentacrinites*, each columnal having five cirri attached either midradially forming five vertical columns or adradially, alternating in position with cirri on the columnal below, thus forming 10 vertical

columns on the centrodorsal. The more or less conical centrodorsal with cirri arranged in 10 columns as found in many fossil and modern comatulids thus appears to be a primitive feature in comatulids. The originally conical to rounded, almost hemispherical centrodorsal may be modified during growth, the diameter generally increasing more than height and apical cirri and sockets becoming obsolete, so that many adult centrodorsals are more or less truncated or discoidal with a cirrus-free flattened to concave dorsal area. Also, the arrangement of cirrus sockets may be modified, most simply by intercalation of new sockets in the radial areas between the 10 columns, thus increasing the number of columns from 10 to 15 or 20, but often the arrangement of sockets becomes so irregular that vertical columns are not obvious. The arrangement is then generally described as irregular horizontal rows or circles or verticils.

After the development of some cirri in the uppermost columnal of the pentacrinoid young, the rest of the column below the centrodorsal is discarded, and the comatulid is without articulated column or permanent attachment for the rest of its life. Due to the separation between centrodorsal and larval column, a five-rayed perforation appears at the dorsal pole, corresponding to the central canal of the column. This opening is soon closed by calcareous deposits, but may be seen in some specimens as a radial, star-shaped impression in the centrodorsal cavity (CARPENTER, 1888, pl. 2, fig. 2b). In very few specimens, recent and fossil, the apical area shows a faint, petaloid impression with interradial rays. This may be the remains of a scar from a pentagonal larval column. If we accept the theory that the centrodorsal is formed by fusion of several columnals, we may imagine that obliteration of the column occurs exceptionally between two of the enlarged columnals in the juvenile centrodorsal, leaving this scar (Fig. 590,2c).

The ventral side of the centrodorsal has a central pit, the centrodorsal cavity, where the chambered organ and surrounding nerve capsule are lodged. The diameter of this centrodorsal cavity may vary from less than 0.2 to more than 0.5 of the centrodorsal diameter, decreasing relatively during

growth. The greatest diameter of the cavity is found in modern Atelecrinidae and some of the Antedonacea, especially Zenometrinac and Pentametrocrinidae, but is about 0.25 to 0.3 of the centrodorsal diameter in adult forms of most other comatulids. This size was regarded by CLARK (1909h) as an important feature in the subdivision of Comatulida into two suborders, Oligophreata and Macrophreata, but the distinction is not sharp and hardly natural, and these suborders are not recognized in the present text.

Fine canals run from the centrodorsal cavity to each cirrus. The opening of these canals may form one to four vertical columns in each radial section of the centrodorsal cavity. This arrangement of pores in the centrodorsal cavity occurs also in specimens where sockets do not form distinct vertical columns, but whether this is a general feature is unknown.

The ventral side of the centrodorsal is divided into five radial sections by five interradial ridges or furrows. In each of these we may find a radial pit or depression or branched furrows for the reception of coelomic diverticulae of unknown function in Decameridae, most Mariametracea, Astero-metridae and Notocrinacea, and a few other comatulids such as *Antedon bifida*. In many Astero-metridae and Notocrinacea the radial pits are very deep and in juvenile specimens may have continued as canals to the apical surface to form five small radial pits around the apex. Such a pattern is described as a radial dorsal star.

The arrangement of cirri in radial groups, the radial orientation of the first cirri formed, and the commonly pentagonal outline of the centrodorsal with interradial angles indicate a dicyclic or cryptodicyclic structure of comatulids, according to the rule of WACHSMUTH and SPRINGER. Yet, infrabasals are found only in the early larval stage of a few species. Basals are well developed in the larval stage of all comatulids. In the oldest comatulids (such as *Archaeometra*) the basals form a stellate circlet of five rather stout plates, exposed in the interradial point, joined centrally and articulated to the centrodorsal with a petaloid pattern of crenulae similar to that found in *Pentacrinites*. In most recent comatulids and

recent Atelecrinidae, the basals maintain their larval character as a ring of large plates, although they may gradually shrink during growth. This may well be the result of a proterogenetic evolution, since it is not found in stalked crinoids, from which comatulids apparently evolved. In Decameridae the proximal (inner) ends of the basals grow into large plates, forming a stout basal circlet surrounded by the radial circlet. In all other comatulids the basals are more or less reduced. Generally, they form five slender, interradial rods lodging in the shallow interradial furrows in the centrodorsal. In many Mesozoic species they may show faint crenulae. They may be exposed on the surface in the interradial point between centrodorsal and radials or they may be concealed. In Mariametracea and most Antedonacea the basals are further reduced and only the inner ends with perforation for nerves are preserved and fused to a perforate, stellate plate called a rosette.

Radials occur invariably in a circlet of five; only two recent genera of Antedonacea, *Promachocrinus* and *Thaumatoocrinus*, have five additional radials (pararadials) with arms similar to the primary radials but in interradial position and retarded during early growth. The radials generally have a rather low, free dorsal surface, but may be concealed in the midradial area by the centrodorsal and first brachial.

The arms are undivided in Pentametrocrinidae, *Eudiocrinus*, *Atopocrinus*, and some fossil species of Solanocrinitacea. A few fossil species of Solanocrinitacea have arms divided at primibrachs 1. In all other comatulids the arms divide at primibrachs 2, and some have arms further divided one to several times at intervals of generally two or four brachials. The articulation of primibrachs 1-2 and generally also succeeding brachials 1-2 are synarthrial with exception of some Solanocrinitacea with undivided arms and muscular articulation, and the syzygial articulation of primibrachs 1-2 in Zygomitridae, *Eudiocrinus*, and some species of *Comatula*, *Comatulella*, and *Comaster*. Syzygial articulations are found generally at brachials 3-4 and, with variable intervals, more distal. Pinnulation is generally complete with first pinnule outside on a brachial 2, which is not axillary. The

most proximal pinnules are formed later during the ontogeny than succeeding pinnules and indicate that comatulids evolved from crinoids with reduced proximal pinnules.

### Superfamily PARACOMATULACEA Hess, 1951

[*nom. transl.* RASMUSSEN, herein (*ex* Paracomatulidae Hess, 1951, p. 208)]

Centrodorsal rather low to very high conical, composed of closely united, five-sided columnals still articulated in Paracomatulidae but fused to a centrodorsal unit in Atelecrinidae and all other known comatulids. Cirrus sockets arranged in five or 10 columns, exceptionally 15. Sockets may increase in size toward the upper edge of the centrodorsal except for a juvenile uppermost one; sockets commonly projecting or with projecting lateral edges, and with a distinct fulcral ridge or pair of tubercles. Basals large, compact plates, united centrally around a narrow central pore as in *Archaeometra*, *Decameros*, and *Promacocrinus*, never transformed to a rosette. In Paracomatulidae, stellate basal circlet articulates with centrodorsal with pattern of narrow interradial petals bound by short, uniform crenulae (as in column of *Pentacrinites* or basals of *Archaeometra*). In Atelecrinidae large basal plates may reach thecal surface not only as interradial triangles but in some species as a contiguous circlet of large plates between centrodorsal and radials as in pentacrinoid young of other comatulids. Radials with large, free dorsal surface, commonly recumbent or overhanging. Articular face of radial generally large and steep to almost vertical, but in *Archaeometra* low and wide, generally flat. Dorsal ligament fossa small; axial canal large. Interarticular ligament fossa small and indistinct to rather large, triangular or oblique four-sided. Ventral muscular fossae low to very high. Arms either articulated with synarthry at brachials 4-5, or arms divided at primibrachs 2 only, with synarthry at primibrachs 1-2 and secundibrachs 3-4. Synarthry at primibrachs 1-2 and secundibrachs 3-4. Synarthry at primibrachs 1-2 often with sparse radiating ridges. Pinnules commonly more numerous than in *Archaeometra*.—L. Paleoc.; Holo.

### Family PARACOMATULIDAE Hess, 1951

[Paracomatulidae Hess, 1951, p. 208]

Centrodorsal low to high conical, composed of closely jointed but not fused columnals. Each columnal with five cirrus sockets either midradial, forming five vertical columns on centrodorsal, or adradial, displaced to alternating sides, forming 10 columns on centrodorsal. Single columnals very low, although height increases toward adradial cirrus sockets. Sockets elliptical and more or less projecting, often overhanging one below. Axial canal narrow. Fulcral ridge or tubercles indistinct to rather prominent. Lower edge may be slightly crenulate; lateral edges may be strongly projecting and spinelike or not. Central canal of upper columnals may be slightly enlarged, forming narrow centrodorsal cavity. Basals united around narrow central canal and exposed interradially below radials, but not united to contiguous ring of plates on surface. Basals articulated to centrodorsal with petaloid pattern of five narrow, elliptical, interradial petals bound by large number of small, uniform crenulae. Same pattern may probably be found between single columnals of centrodorsal. Radials with low to large overhanging dorsal surface. Articular face of radials steep, almost vertical, very high and rather concave. Low, dorsal ligament fossa with ligament pit and very large axial canal. Interarticular ligament fossae triangular or four-sided, moderate to rather large. Ventral muscular fossae large and high, separated by median ridge or wide median furrow and ventral notch. Ventral edge of radial circlet stellate due to angle between muscular fossae of each radial. Radial cavity moderate to rather small. Arms divided at primibrachs 2 only, primibrachs 1-2 and secundibrachs 1 and 2 synarthrial, secundibrachs 3-4 syzygial. Distal syzygial articulations with few radiating ridges may occur with intervals of about five muscular articulations. First pinnule at secundibrach 2. Synarthrial articulation at primibrachs 1-2 may be rather wide elliptical or narrow and strongly pointed toward ventral edge. L. Jur. (Toarc.)-L. Cret. (Hauteriv.).

*Paracomatula* was described by Hess

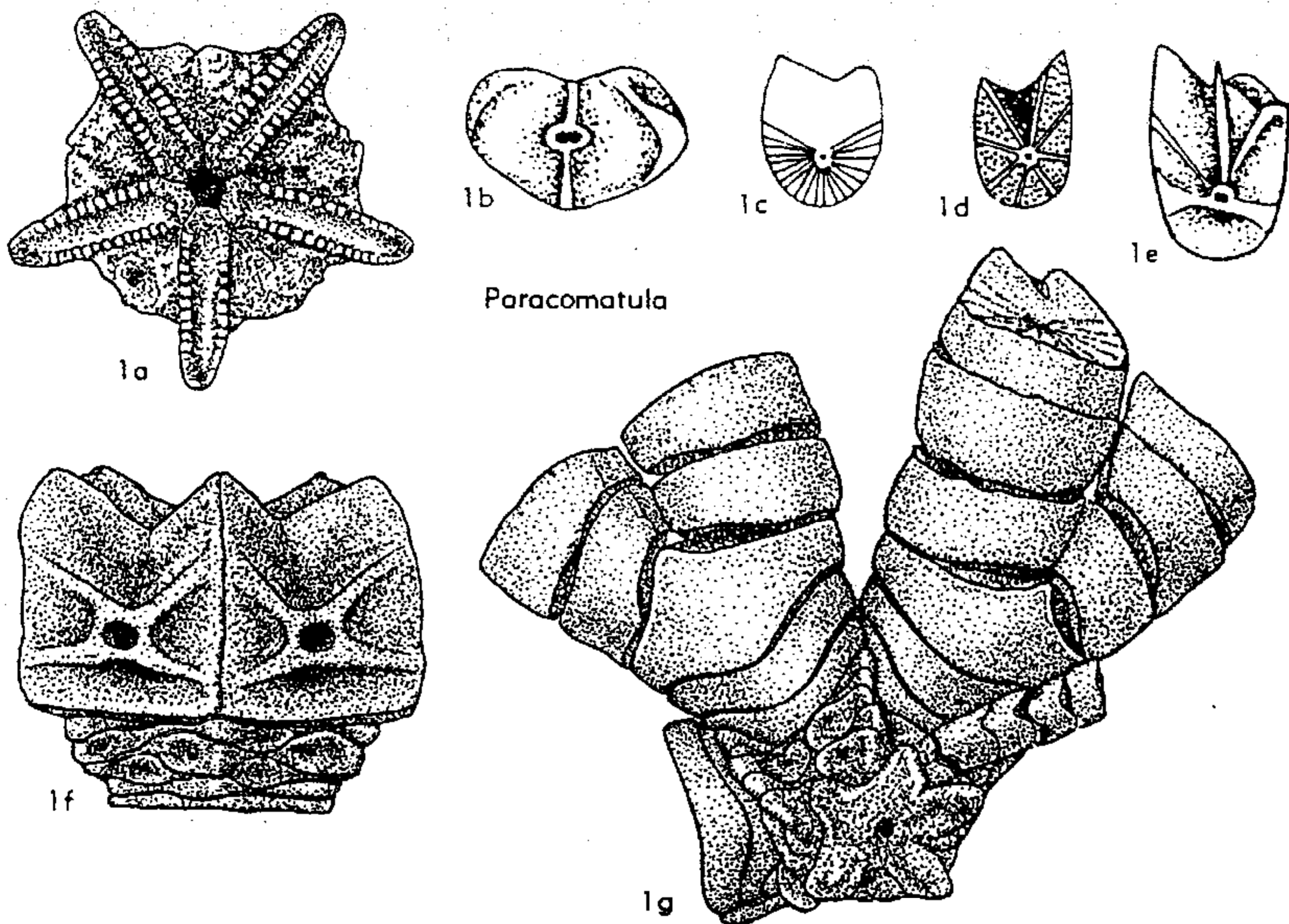


FIG. 582. Paracomatulidae (p. T870-T871).

(1951), and interpreted as a form derived from Pentacrinitidae by evolution parallel to Comatulida, but not directly involved in the evolution of comatulids. The present description of the family is extended to include not only *Paracomatula* but also two new genera from the Lower and Upper Jurassic of South Germany and a species from the Lower Cretaceous of Hungary, studied by SIEVERTS-DORECK, but still unpublished.

One of these new genera has a low and wide, conical centrodorsal with two to four columnals, each with a large, protruding, midradial elliptical cirrus socket, forming together five columns of sockets, each socket overhanging the one below. The other has a high and slender, conical centrodorsal with about 10 columnals and adradial cirrus sockets forming 10 columns on the centrodorsal. The sockets have strongly projecting, crenulate, lateral edges, and the centrodorsal is very similar to the centrodorsal of *Atopocrinus* except for its articulation, although it remains of an original articulation which may be indicated by a suture in

the centrodorsal of *Atopocrinus*. This new genus shows remarkable similarity to Atelecrinidae in centrodorsal, theca, and proximal brachials, and may call for a reconsideration of comatulid phylogeny and systematics. The Paracomatulidae may form a connecting link from Pentacrinitidae to Atelecrinidae and related groups as well as to Solanocrinitacea, and more specially *Archaeometra* with its stout and crenulate basals and its radials with large articular face and high ventral muscular fossae. The paracomatulids also demonstrate the compound nature of the comatulid centrodorsal, formed by fusion of several columnals, and the occurrence among primitive comatulids of large basals and of cirri arranged in vertical columns.

*Paracomatula* Hess, 1951, p. 209 [*P. helvetica*; M]. Centrodorsal truncated conical or low columnar, five-sided, composed of about 5 stellate columnals. Upper columnals 3, with more or less protruding elliptical cirrus sockets with rather indistinct fulcral ridge. Sockets adradial to alternating sides, forming together 10 short columns separated by interrarial ridges. Basals exposed in-

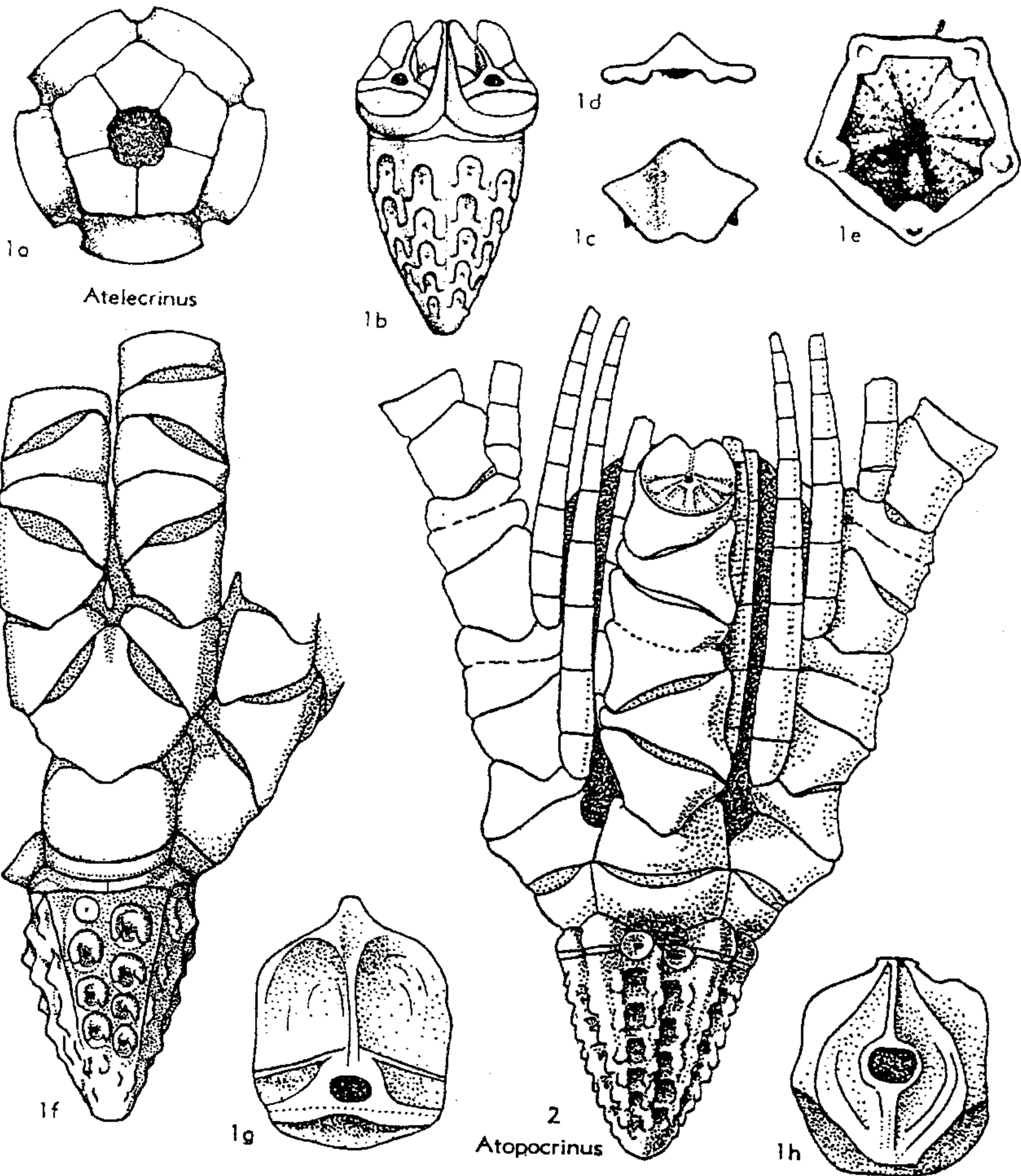


FIG. 583. Atelecrinidae (p. T872).

terradially. Radials with large, almost horizontal, free dorsal surface. Synarthrial articular face at primibrachs 1-2 low and wide. *M. Jur. (U. Bajoc.)*, Eu. (Switz.).—FIG. 582, 1. \**P. helvetica*, M. Jur., Switz.; 1a, ventral face of "centrodorsal,"  $\times 9$ ; 1b, distal face of primibrach 1,  $\times 4$ ; 1c, distal face of secundibrach 3,  $\times 4$ ; 1d, syzygy of distal brachial,  $\times 4$ ; 1e, muscular articulation,  $\times 4$ ; 1f, cup with "centrodorsal,"  $\times 7.3$ ; 1g, crown and "centrodorsal,"  $\times 6$  (1a, f, Rasmussen, n, after Hess, 1951; 1b-e, Hess, 1951; 1g, Rasmussen, n).

Family ATELECRINIDAE Bather, 1899

[Atelecrinidae BATHER, 1899b, p. 923]

Centrodorsal conical or subconical, higher than wide except in some species of *Jaekelometra*. Cirrus sockets with narrow axial canal and distinct fulcral ridge or tubercles and more or less prominent edge, which laterally may form stout elevation or spine on each side of socket. Sockets arranged in

10 vertical columns (15 in *Atelecrinus conifer*), and commonly separated by interradial ridges or space, sometimes also by a radial ridge or space. Ridges may appear serrate due to projecting lateral margins of cirrus sockets. Trace of articulation in centrodorsal may perhaps be indicated by a suture in *Atopocrinus*. Ventral side of centrodorsal concave in *Jaekelometra* with a centrodorsal cavity about 0.3 of centrodorsal diameter and often surrounded by radial depressions or shallow pits, in other genera with a single, very wide cavity. Interradial furrows or ridges not always present. Basals form a ring of plates, large and contiguous on surfaces also of adult specimens of *Jaekelometra* and *Sibogacrinus*, but more or less reduced during growth and exposed on surface only as interradial triangles in most *Atelecrinus* and *Atopocrinus*. Basals continue as thin plates to center, covering ventral side of centrodorsal except for central pore, and, in *Jaekelometra* a radial depression or pit in suture between basals communicating with radial pits in centrodorsal. Species with reduced basals, not contiguous on surface, may have a subradial cleft. Radial plates moderate to high, commonly overhanging or recumbent. Articular face of radial in *Jaekelometra* low and wide, almost triangular, in *Atelecrinus* rather steep and high with large, ventral, muscular fossae having almost parallel sides and broad, rounded, ventral edge divided by median ridge and notch. Arms in *Atopocrinus* undivided, brachials 1-2 synarthrial and brachials 4-5 syzygial. In other genera arms divided at primibrachs 2, primibrachs 1-2 and secundibrachs 1-2 synarthrial; syzygy at secundibrachs 3-4 and with variable interval of 2 to 4 muscular articulations. Syzygy with rather few ridges. First pinnule at brachial 2 or pinnules missing in proximal part of arms. Mouth and anus slightly excentric. *J.Cret.-L.Paleoc.; Holo.* [recent in Pac. and Atl.O., 532-1,633 m.].

*Atelecrinus* CARPENTER, 1881, p. 166 [\**A. balanoides* (= *A. cubensis* CARPENTER, 1881c, p. 166; *A. pourtalesi* A. H. CLARK, 1907d, p. 155, *invalid nom. subst. pro A. cubensis* CARPENTER, 1881c, non *Antedon cubensis* POURTALES, 1869, p. 356; *A. helgae* A. H. CLARK, 1913b, p. 4); SD CARPENTER, 1888, p. 71]. Basals rather small, often separated on surface. Arms divided at primibrachs

2. Cirrus sockets with projecting lateral edges. No proximal pinnules. Recent.—FIG. 583,1. \**A. balanoides*; 1a, underside of cup,  $\times 10$ ; 1b, cup with centrodorsal,  $\times 8$ ; 1c,d, basal,  $\times 14$ ; 1e, ventral face of centrodorsal,  $\times 10$  (1a-e, Clark, 1915a; after Carpenter, 1881); 1f, crown and centrodorsal,  $\times 10$  (mod. from A. M. Clark, 1970); 1g,h, proximal and distal face of primibrach 1,  $\times 16$  (Gislén, 1924).

*Atopocrinus* A. H. CLARK, 1912, p. 150 [\**A. sibogae*; OD]. Basals separated on surface. Arms 5, undivided. Primibrachs 1-2 synarthrial, primibrachs 4-5 syzygial with few radiating ridges. First pinnule on primibrach 2. Cirrus sockets with projecting lateral edges. Recent.—FIG. 583,2. \**A. sibogae*;  $\times 4$  (Clark, 1915a).

*Jaekelometra* GISLÉN, 1924, p. 162 [\**Atelecrinus belgicus* JAEKEL, 1902, p. 1084; OD]. Centrodorsal low to high conical, sides more or less convex, with cirrus sockets in 10 more or less distinct columns often separated by interradial or radial ridge or space. Sockets with more or less distinct fulcral ridge or tubercles but no spinelike projection of lateral margin. Ventral side of centrodorsal flat or concave, with increasing concavity during growth. Rather narrow to moderate centrodorsal cavity, commonly surrounded by large and shallow radial depressions or pits. Interradial furrows may be present but are often indistinct or missing. Basals large, often forming on surface a contiguous circlet of plates, variable in height, and also united as thin plates in bottom of large and deep radial cavity, covering ventral side of the centrodorsal except for a narrow central perforation. Radial depressions or pits in suture between basals may continue in centrodorsal as radial pits. Basal plates may be more or less reduced in adult of some species. Radials observed in type species large and high, slightly recumbent, with median crest. Articular face of radial low and wide, almost triangular, with very low and indistinct interarticular ligament fossae and rather low, very wide muscular fossae. Radial cavity large. *U.Cret. (Campan.-Maastricht.)*, Eu.(Belg.-Neth.-Swed.); *L.Tert.(Dan.)*, Eu.(Denm.).—FIG. 584,1a,b. *J. meijeri* RASMUSSEN, Maastricht., Belg.; 1a,b, lat. and ventral side of centrodorsal with three reduced basals preserved,  $\times 5.3$  (Rasmussen, 1961).—FIG. 584,1c-g. \**J. belgica* (JAEKEL), Maastricht., Neth.; 1c, ventral face of centrodorsal,  $\times 5.3$ ; 1d,e, centrodorsal with basal circlet,  $\times 5.3$  (1c-e, Rasmussen, 1961); 1f,g, lat. and ventral face of cup,  $\times 4$ ,  $\times 5.3$  (Gislén, 1924).

*Sibogacrinus* A. H. CLARK, in CLARK & CLARK, 1967, p. 832 [\**Atelecrinus anomalus* A. H. CLARK, 1912e, p. 153; OD]. Basals very large, contiguous. Arms divided at primibrachs 2. Cirrus sockets without lateral projections. No proximal pinnules. Recent.—FIG. 584,2. \**S. anomalus* (CLARK);  $\times 7$  (Clark, 1915a).

Superfamily  
SOLANOCRINITACEA  
Jaekel, 1918

[*nom. transl.* RASMUSSEN, herein (ex subfamily Solanocrinitinae JAEKEL, 1918, p. 73)]

Centrodorsal discoidal to truncated conical or columnar with flat or concave, cirrus-free dorsal side. No radial dorsal star. Larval column with synarthrial articulations maintained in adults of Thiolliericrinidae. Cirrus sockets generally large, with narrow axial canal, distinct fulcral ridge or tubercles and no marginal crenulae, arranged in 10 to 20 vertical columns or in a few irregular, marginal circles. Reduction and obliteration of cirrus sockets take place in Thiolliericrinidae. Centrodorsal cavity very narrow, less than 0.2 of centrodorsal diameter. Ventral side of centrodorsal in Decameridae and at least some *Comatulina* with coelomic impressions or furrows not observed in other members. Basals stout, centrally united, in Decameridae forming large rhombic plates surrounded by the radial circlet and forming bottom of large and shallow radial cavity. In other families, basals rod shaped, visible in interradial point or concealed, and may be visible in narrow bottom of the large and deep radial cavity. Radials with large to small, free dorsal surface or concealed. Radial articular face steep, commonly low and wide. Ventral muscular fossae generally low. Radial cavity large. Arms undivided or divided at primibrachs 1 or primibrachs 2. Species with further arm divisions at secundibrachs 1 or secundibrachs 2 or more distal may occur. Synarthry in arms very flat, observed only at primibrachs 1-2 of species with arms divided. Syzygy when present with only few radiating ridges. *L. Jur. (Pliensbach.)-U. Cret. (Coniac.)*.

Family SOLANOCRINITIDAE  
Jaekel, 1918

[*nom. correct.* RASMUSSEN, herein, pro Solanocrinitidae GISEN, 1924, p. 145 (ex subfamily Solanocrinitinae JAEKEL, 1918, p. 73)]

Centrodorsal large, discoidal to columnar or truncated conical to almost hemispherical. Dorsal side flat or concave, often rugose or with irregular furrows. Cirrus sockets closely placed, often large, arranged in 10 to 15 columns (exceptionally up to 20), or

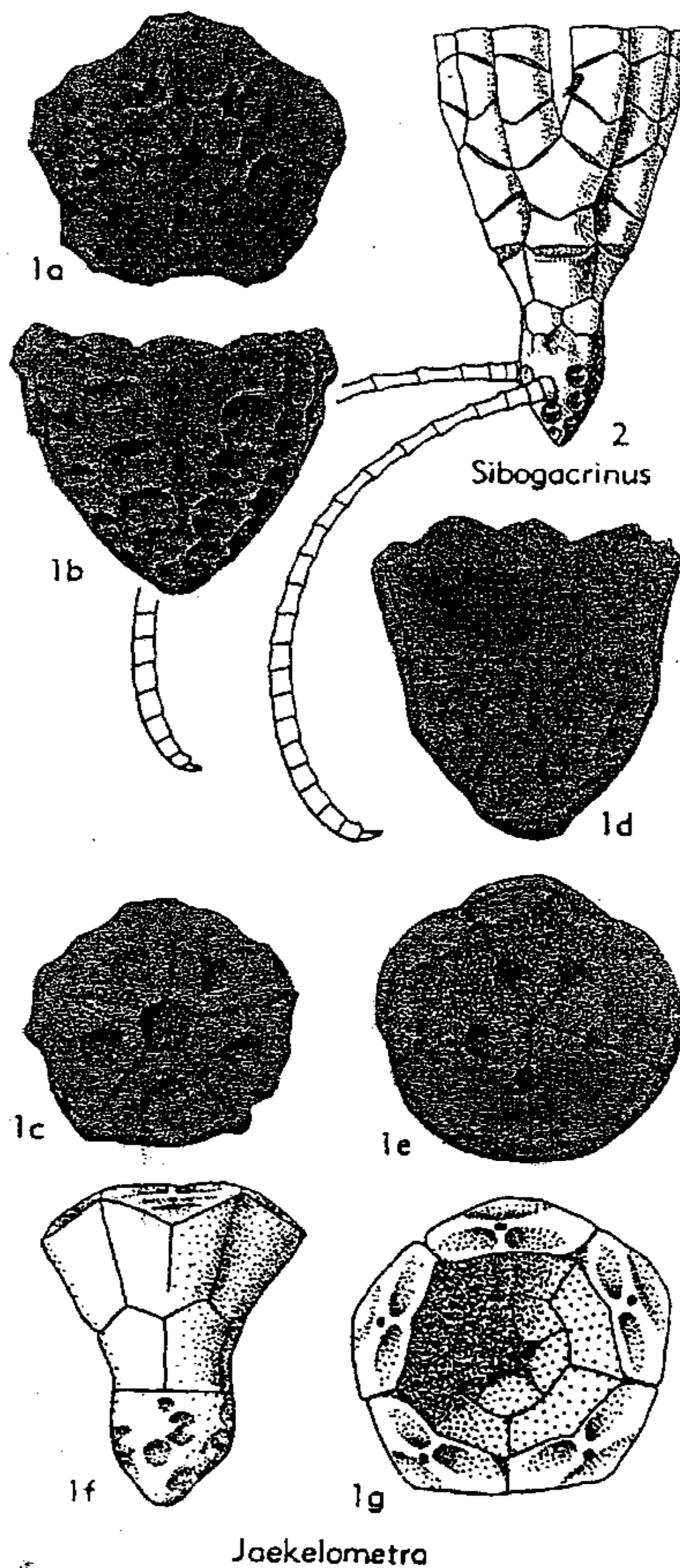
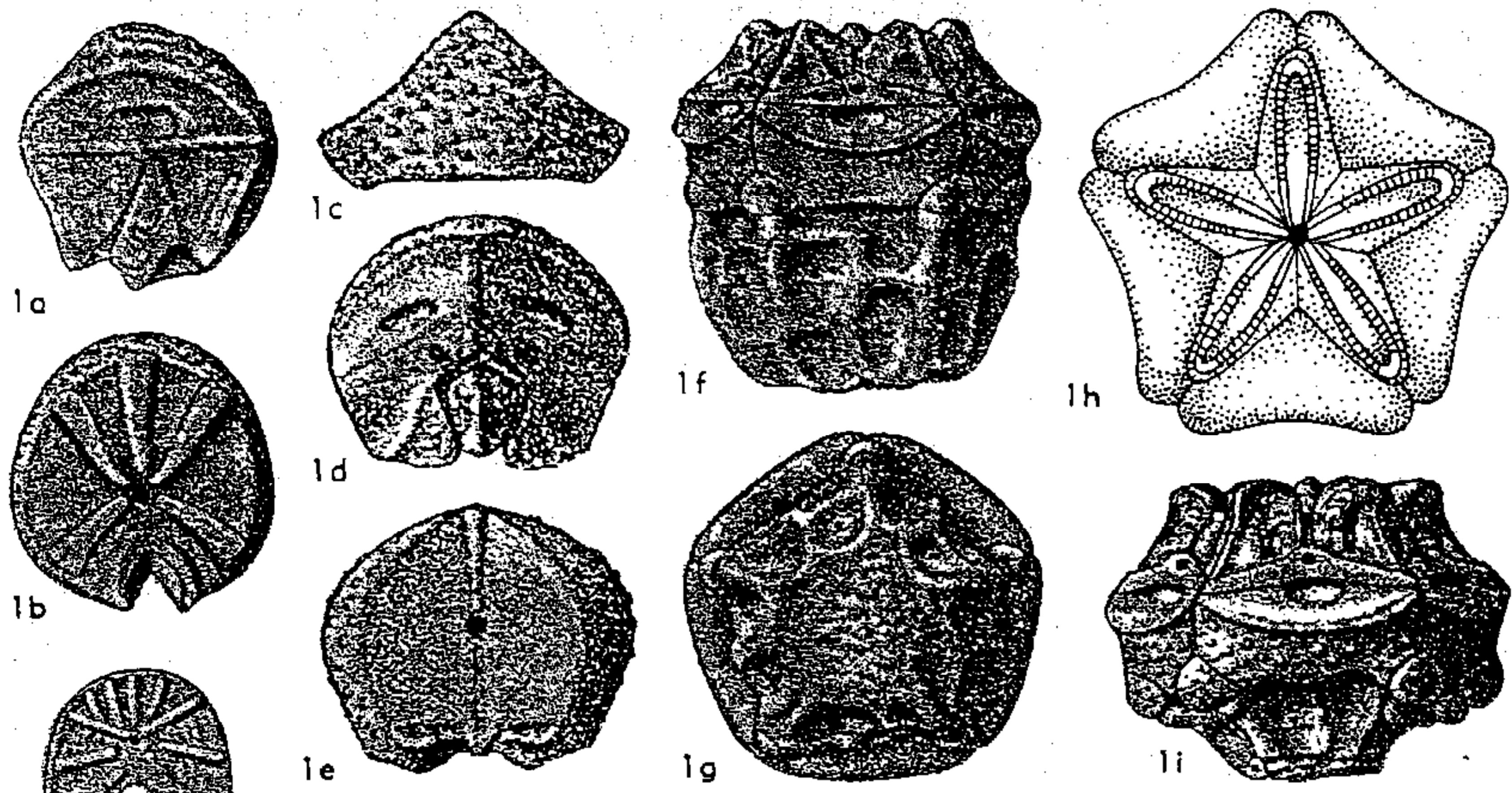
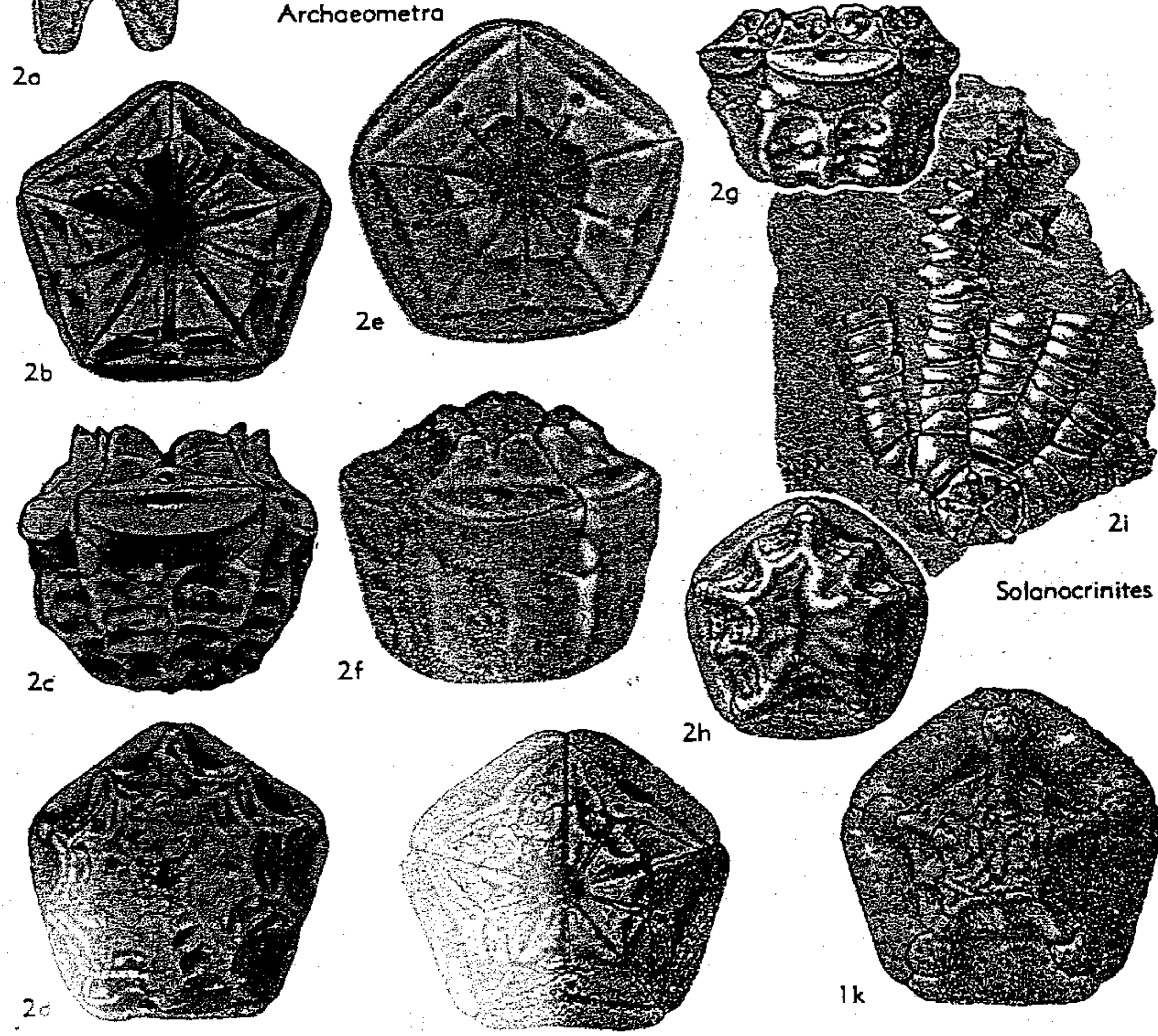


FIG. 584. Atelecrinidae (p. T872).

in *Palaeocomaster* one or two irregular marginal circles. Stout rod-shaped basals often exposed in interradial point, meeting centrally without forming large plates in bottom of radial cavity. Ventral side of centrodorsal with radiating, commonly short coelomic furrows in at least some species of *Comatulina*, but not in other genera, although secondary furrows along each side of the basal rods may occur in corroded specimens. Articulation between basals and centrodorsal may be narrow petaloid and



Archaeometra



Solanocrinites



crenulate, specially in *Archaeometra*. Free dorsal surface of radials rather large to low or concealed. Interarticular ligament fossae and ventral muscular fossae generally low and wide, forming narrow bands in *Solanocrinites* and *Comatulina*, but may be higher and triangular in *Archaeometra* and *Palaeocomaster*. Arms undivided or divided at primibrachs 1 or primibrachs 2, exceptionally at some secundibrachs 2 or more distal. *L. Jur. (Pliensbach.)-U. Cret. (Coniac.)*.

The discoidal centrodorsal with large cirrus-free dorsal area, the stout basal rays, the large radial cavity, and, in *Palaeocomaster*, the arrangement of cirrus sockets in irregular circles may indicate affinity to Comasteracea.

*Solanocrinites* GOLDFUSS, 1829, p. 166 [\**S. costatus*; SD DE LORIOI, 1889, p. 526; *emend.* CARPENTER, 1881a, p. 192 (taking GOLDFUSS, pl. 50, fig. 7a,b, as lectotype of *S. costatus*)] [= *Milleria* HARTMANN, 1830, p. 45, *ex* GOLDFUSS MS. (type, *M. costata* = *Solanocrinites costatus*); *Solacrinus* AGASSIZ, 1836, p. 196 (*nom. van.*); *Solanocrinus* MÜNSTER, 1839, p. 89 (*nom. van.*)]. Centrodorsal moderately high discoidal or truncated conical, more or less five-sided, with 10 columns of 1 to 3 large cirrus sockets. Dorsal side flattened or concave, commonly rugose or with radiating irregular furrows. Rod-shaped basals generally exposed in interradial point. Free surface of radials often moderately large and may be slightly overhanging. Interarticular ligament fossae rather low. Ventral muscular fossae low, forming narrow bands along ventral edge or low triangular areas separated by a median notch. Arms divided at primibrachs 1 or primibrachs 2. Syzygial articulations observed in *S. depressus* (D'ORBIGNY) with very few radiating ridges. *M. Jur. (Dogger)-U. Jur. (Malm)*, Eu. (Ger.-France-Switz.).—FIG. 585, 2a,g-i. *S. depressus* (D'ORBIGNY), U. Jur., France; 2a, brachial syzygy,  $\times 3$ ; 2g,h, cup with centrodorsal,  $\times 3$ ; 2i, crown, centrodorsal missing,  $\times 1$  (de Loriol, 1886-89).—FIG. 585, 2b-d. *S. lambertsi* SIEVERTS-DORECK, U. Jur., Ger.; 2b-d, cup with centrodorsal, ventral, lat., dorsal,  $\times 3.5$  (Sieverts-Doreck, 1958a).—FIG. 585, 2e,f. \**S. costatus*, U. Jur., Ger.; 2e,f, ventral and lat. side of cup with centrodorsal,  $\times 2.6$  (Goldfuss, 1829).

*Archaeometra* GISLÉN, 1924, p. 156 [\**Solanocrinus asper* QUENSTEDT, 1857, p. 659; OD]. Similar to *Solanocrinites*. Centrodorsal truncated conical to columnar, dorsal side flattened or concave, rugose, often about half the upper diameter of centrodorsal. Sides with 10 columns of 1 to 3 cirrus sockets. Rod-shaped basal rays very stout, forming considerable part of thecal underside toward centrodorsal, and centrally united with rather large

joint faces, but not distinct in narrow bottom of radial cavity. They are well exposed, commonly rather large and prominent on interradial surface. Underside of basals may show a narrow petaloid pattern of short crenulae toward centrodorsal, not covering full width of basal rays. There may be a subradial cleft. Radials large, may or may not be greatly overhanging. Articular face of radials rather high. Interarticular ligament fossae triangular, slightly excavated and smooth. Ventral muscular fossae rather high triangular, slightly elevated and rugose, separated by a median notch and furrow. Radial cavity moderate to rather large. Brachials observed in *A. aspera* (QUENSTEDT) and *A. scrobiculata* (MÜNSTER, in GOLDFUSS) show primibrachs 1-2 synarthrial or cryptosynarthrial, primibrachs 2 axillary, and also syzygial articulations with very few ridges. Brachials low disc shaped to slightly wedge shaped and lower in pinnular side, mentioned as "reversion" by GISLÉN, 1924, for some recent comatulids. *M. Jur. (Bajoc.)-U. Jur. (Portland.)*, Eu. (Czech.-Eng.-France-Ger.-Switz.).—FIG. 585, 1a-e,j-k. \**A. aspera* (QUENSTEDT), U. Jur., France; 1a, muscular articulation,  $\times 4$ ; 1b, brachial syzygy,  $\times 5$ ; 1c-e, primibrach 2,  $\times 5$ ; 1i-k, cup with centrodorsal,  $\times 4$  (de Loriol, 1886-89).—FIG. 585, 1j,g. *A. scrobiculata* (MÜNSTER), U. Jur., France; 1j,g, cup with centrodorsal,  $\times 6$  (de Loriol, 1889).—FIG. 585, 1h. *A. cheltonensis* (CARPENTER), M. Jur., Eng.; underside of cup with radial and basal circlet,  $\times 4$  (mod. from Carpenter, 1881a).

*Comatulina* D'ORBIGNY, 1852, p. 139 [\**C. costata*: OD (*pro Solanocrinites costatus* GOLDFUSS, 1829, *partim*, taking GOLDFUSS, pl. 50, fig. 7c (=d) as type (Code, 70b)) (= *Antedon d'orbignyi*, invalid *nom. subst.* CARPENTER, 1881a, p. 197)]. Centrodorsal truncated conical to truncated subhemispherical, in adult specimens with more than 10 (generally 11-15, exceptionally up to 20) columns of one to three large, closely placed cirrus sockets. Dorsal side of centrodorsal flat or concave, generally with irregular furrows or granulated, commonly about half upper diameter of centrodorsal or less. Ventral side of centrodorsal may have irregular furrows around centrodorsal cavity. Rod-shaped basal rays just visible in interradial point, or concealed, united around center, but not expanded, and not conspicuous in narrow bottom of radial cavity. Radials with moderate to low, free surface or concealed, may be a little overhanging. Articular face of radial moderately steep, rather low. Interarticular ligament fossae low and wide, may be triangular. Ventral muscular fossae low and wide, may be triangular and separated by median notch and furrow. Primibrachs 1 axillary; further division at secundibrachs 2 or more distally may occur. *U. Jur. (Oxford.-Portland.)*, Eu. (France-Ger.-Port.-Switz.), Afr. (Alg.); *L. Cret. (Valangin.)*, Eu. (France-Switz.); *U. Cret. (Coniac.)*, Eu. (Ger.).—FIG. 586, 2a-d. *C. beaugrandi* (DE LORIOI),



FIG. 585. Palaeocrinitidae (p. T875-T877).

U. Jur., France; 2a, b, lat. and dorsal views of cup with centrodorsal; 2c, underside of cup with radi-

als and basals; 2d, ventral face of centrodorsal; X3 (de Loriol, 1889).—FIG. 586, 2e-g. *C. in-*

*fracretaceus* (OOSTER), L.Cret., Switz.; 2e-g, cup with centrodorsal,  $\times 2.5$  (Rasmussen, 1961).—FIG. 586,2h,i. \**C. costata*, U.Jur., Ger.; 2h,i, cup with centrodorsal,  $\times 2.6$  (Goldfuss, 1829).—FIG. 586,2j-l. *C. geureyi* (DE LORIO), L.Cret., France; 2j-l, cup with centrodorsal,  $\times 2.5$  (Rasmussen, 1961).

*Palaeocomaster* GISLÉN, 1924, p. 142 [\**Actinometra guirandi* DE LORIO, 1889, p. 535; OD]. Centrodorsal rather low discoidal, dorsal area commonly large, flat, and smooth or rugose. Cirrus sockets crowded, in 1 to 3 irregular marginal circles, not forming distinct columns. Rod-shaped basal rays often exposed in interradial point. Free surface of radials very low or concealed. Articular face moderately high, wide, steep to vertical. Interarticular ligament fossae triangular. Ventral muscular fossae moderate to small, triangular, or reduced to narrow bands along ventral edge. Radial cavity wide. Arms of *P. calloviensis* (CARPENTER) from the Middle Jurassic (Callov.) of England show primibrachs 1-2 and secundibrachs 1-2 synarthrial, primibrachs 2 axillary and secundibrachs 3-4 syzygial with few ridges. [*Antedon morierci* DE LORIO is a Lower Jurassic (Pliensbach.) centrodorsal from France, and *Antedon carabocufi* DE LORIO a radial circlet from the same locality, both probably belonging to this genus and among the oldest comatulids known.] L.Jur.(Pliensbach.), Eu.(France); M.Jur.(Bathon.-Callov.), Eu.(Eng.); U.Jur.(Oxford.-Portland.), Eu.(Eng.-France).—FIG. 586,1a-c. \**P. guirandi* (DE LORIO), U.Jur., France; 1a-c, cup with centrodorsal,  $\times 9$  (de Lorio, 1889).—FIG. 586,1d-h. *P. calloviensis* (CARPENTER), M.Jur., Eng.; 1d, synarthry at primibrachs 1-2,  $\times 8$ ; 1e, syzygy at secundibrachs 3-4,  $\times 8$ ; 1f, muscular articulation,  $\times 8$  (1d-f, Gislén, 1925a); 1g,h, crown with centrodorsal,  $\times 2$  (Carpenter, 1882a).

### Family DECAMERIDAE Rasmussen, new family

Centrodorsal discoidal to truncated conical with one or two irregular circles of large cirrus sockets. Dorsal side flat or convex. Ventral side with coelomic furrows or depressions. Basals centrally united, with or without rod-shaped interradial prolongations forming basal rays. Free surface of radials large, commonly overhanging, to low or concealed. Articular face of radials steep, low and wide. Interarticular ligament fossae wide, rather low. Ventral muscular fossae very low, forming narrow band along ventral edge. Radial cavity large. The coelomic impressions may indicate affinity to Mariametracea. L.Cret.

*Decameros* D'ORBIGNY, 1850, p. 121 [\**D. ricorde-*

*anus*; SD RASMUSSEN, 1961, p. 253] [*Decameros* LINCK, 1733, is a *nom. van.* for *Decacnemos* LINCK, 1733, first quoted by AGASSIZ (1836, p. 193), as a synonym of *Comatula* (without nomenclatorial status, Code, Art. 11d). It was used by D'ORBIGNY, 1850, in combination with two species described, and maintained in 1852 as a genus different from *Decacnemos* BRONN, 1825, p. 6,7, ex LINCK, 1733, which is a synonym of *Antedon* DE FREMINVILLE, 1811, *nom. conserv.*]. Centrodorsal large, low discoidal, dorsal side large, flat or slightly arched, ventral side with feeble, radiating and meandering furrows. Large, stout, rhombic basals surrounded by radial ring and forming large pentagon in bottom of wide and shallow radial cavity. Interradial prolongations forming basal rays not present. Radials with low, free surface or concealed in midradial area. Specimens of *D. wertheimi* PECK & WATKINS from the Albian of Texas show that juvenile thecae have a truncated, conical centrodorsal and overhanging radials as in *Pseudoantedon*, cirrals are rounded in section, length not exceeding width, and there are 5 undivided arms with first pinnule from primibrachs 1. Brachial articulations all muscular, no synarthry or syzygy. L.Cret.(Valangin.-Apt.), Eu.(France-Spain-Switz.-Yugo.); L.Cret.(Alb.), USA (Texas).—FIG. 587,3. \**D. ricordeanus*, France; 3a, cup with centrodorsal, one radial missing; 3b, ventral face of centrodorsal; 3c,d, cup with centrodorsal;  $\times 2.5$  (Rasmussen, 1961).

*Coelometra* RASMUSSEN, new genus [\**Antedon campichei* DE LORIO, 1879, p. 269; OD]. Centrodorsal rather high, truncated subconical to almost hemispherical, dorsally more or less rounded, sides incompletely covered by large cirrus sockets. Ventral surface of centrodorsal with large V-shaped coelomic impression in radial areas as in modern *Zygometa* or *Himerometridae*. Stout, rod-shaped basal rays exposed in interradial point or concealed. Radials greatly overhanging centrodorsal, with large, free surface tumid to swollen. Radial cavity large, deep, funnel shaped. Primibrachs 1 axillary, secundibrachs 1-2 oblique muscular. L.Cret.(Valangin.), Eu.(France-Switz.).—FIG. 587,2. \**C. campichei* (DE LORIO), Switz.; 2a, ventral face of centrodorsal,  $\times 2.5$ ; 2b, secundibrach 1,  $\times 2.5$ ; 2c, primibrach 1,  $\times 2.5$ ; 2d-f, cup with centrodorsal, lectotype,  $\times 2.5$  (Rasmussen, 1961).

*Pseudoantedon* VALETTE, 1933, p. 217 [\**P. icauensis* (= *Comatula* (*Ophiocrinus*) *hiselyi* DE LORIO in DE LORIO & GILLIÉRON, 1869, p. 57); M]. Centrodorsal small, discoidal with steep or sloping sides, dorsal side flattened. Ventral side with indistinct coelomic furrows. Basals united centrally, forming small pentagon in bottom of large and shallow radial cavity, basal rays not reaching interradial surface. Radials greatly overhanging centrodorsal, with free surface almost flat, more or less turned downward. Arms 5 undivided, with

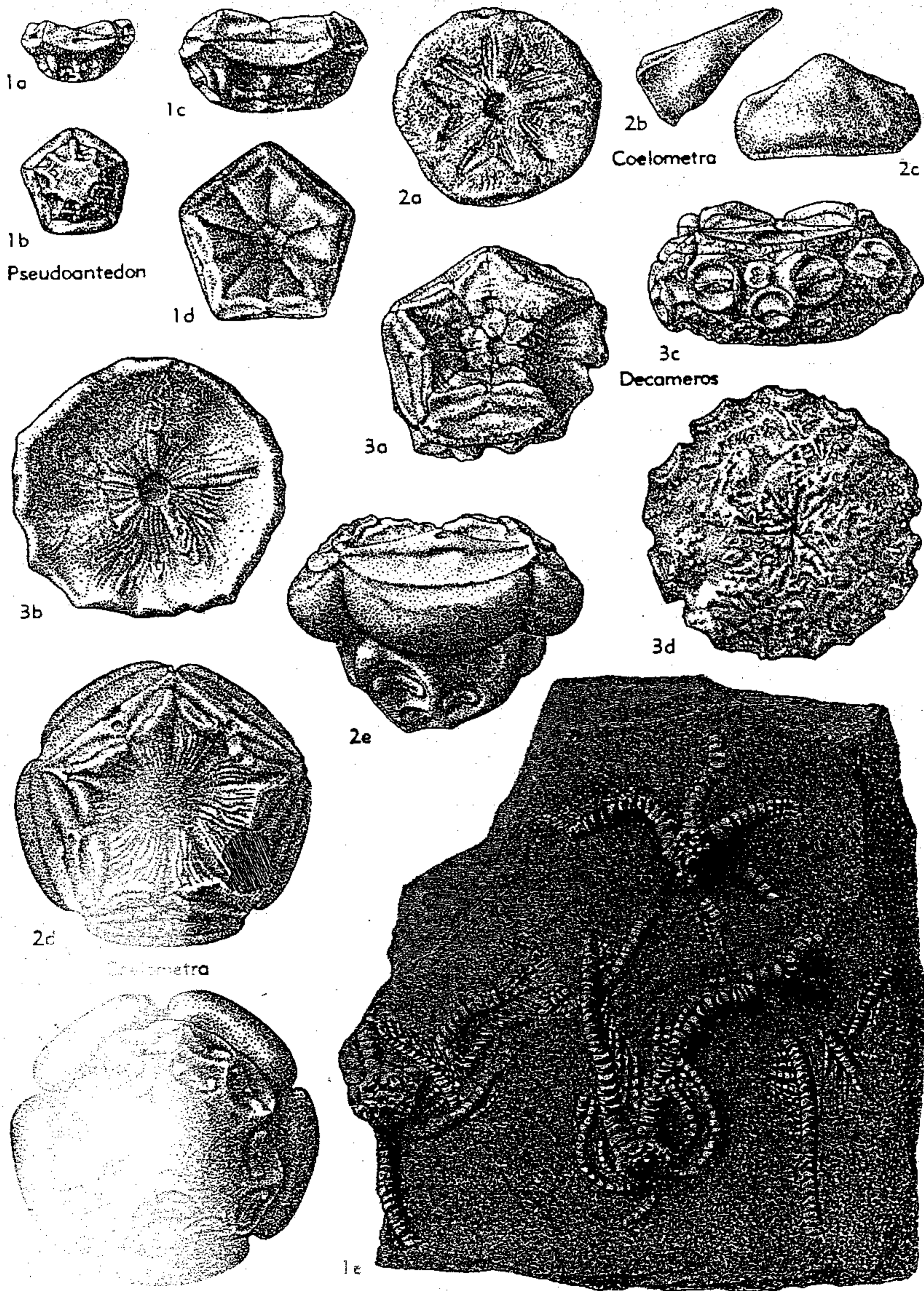


FIG. 587. Decameridae (p. T877-T879).

...brach I, and apparently complete pinnulation. No indication of synarthry

or syzygy. Pinnulars not carinate. Cirrals rounded, without dorsal spines. *L.Cret.(Valangin.-Barrem.)*, Eu.(France-Switz.).—FIG. 587,1a,b. \**P. icauensis*, France; 1a,b, cup with centrodorsal,  $\times 2.5$  (Rasmussen, 1961).—FIG. 587,1c-e. *P. hiselyi* (DE LORIOI), Switz.; 1c,d, cup with centrodorsal,  $\times 2.5$  (Rasmussen, 1961); 1e, crown and centrodorsal with cirri,  $\times 1$  (de Loriol, 1879).

### Family THIOLLIERICRINIDAE

A. H. Clark, 1908

[Thiolliericrinidae CLARK, 1908b, p. 209]

Centrodorsal truncated conical to discoidal, dorsal side with large, circular to elliptical synarthrial articulation and narrow axial canal toward articulated column. Sides of centrodorsal with cirrus sockets arranged in 10 vertical columns of one to three sockets, or lacking, or irregularly arranged forming one or more irregular circles. Sockets may be large, with distinct fulcral ridge, or they may be small, rounded, widely separated, more or less reduced to small, rudimentary depressions with or without fulcral ridge, or sockets may be completely lost. Some specimens have small rudimentary sockets along upper edge of centrodorsal additional to large and well-developed sockets on sides. Rod-shaped basal rays generally exposed in interradial points, but may be concealed. Free dorsal surface of radials rather large to very small or concealed. Articular face of radials low and wide, moderately sloping. Interarticular ligament fossae low, ventral muscular fossae low, forming narrow bands along ventral edge, or indistinct. Radial cavity moderate to wide and shallow, funnel shaped, with radial and interradial furrows. Isolated axillary primibrachs I were referred by REMÉŠ (1905) to *Thiolliericrinus*. Column presumably short, columnals large, barrel shaped or subcylindrical to hourglass shaped with synarthrial articulation of different orientation in the two ends. [Genera have been based on arrangement of cirrus sockets and degree of cirrus reduction, although this may well apply to adult specimens only, and transition forms are found in undetermined material from Nattheim, Germany. If growth and variation have been more fully studied, the distinction of genera may be maintained with reservation. Columnals have previously only been referred to *Bourgueticrinus* to which they can hardly be dis-

tinguished. Attachment by expanded terminal disc without root-branches has been recorded by ÉTALLON (1859, p. 445) and is present in the Nattheim material. They are stout, irregularly rounded, tumid to conical discs with synarthrial articulation often in oblique position indicating upright growth from uneven or sloping substrate. The underside shows attachment surface to shells, isolated columnals or unknown bodies.] *M.Jur.(Bathon.)-L.Cret.(Hauteriv.)*.

The Thiolliericrinidae are a group of Upper Jurassic and Lower Cretaceous crinoids with cup similar to contemporary *Solanocrinites*, but unique among comatulids in maintaining a column similar to that of *Bourgueticrinus* or juvenile pentacrinoid larvae of comatulids. They were considered by DE LORIOI (1877-79) as probably related to *Bourgueticrinus*, by DE LORIOI (1880) as comatulids with a preserved larval column, by A. H. CLARK (1915a) as a form from which comatulids and *Pentacrinites* evolved, by JAEKEL (1918) as ancestral form of first comatulids, and by GISLÉN (1924) as a group derived from the same ancestral form as *Solanocrinites*. They are here interpreted as a proterogenetic evolution from contemporary *Solanocrinitidae*, restricted and adapted to reef environments.

Columnals similar to Thiolliericrinidae are found in the Paleozoic *Platycrinidae* and in Upper Cretaceous *Bourgueticrinus*. The presence of such columnals in the Bathonian Bradford Clay in England is the only indication of Thiolliericrinidae in the Middle Jurassic.

*Thiolliericrinus* ÉTALLON, 1859, p. 445 [\**T. flexuosus*; M (not *Apiocrinites flexuosus* GOLDFUSS, 1831, p. 186, which is incorrectly recorded by several authors)] [Although ÉTALLON considered the species described by him most likely identical with *Apiocrinites flexuosus* GOLDFUSS, based on isolated columnals, he established *T. flexuosus* as a new species in his own name (Et.) as shown in his text, p. 445-446, and in the number of new species recorded, p. 413. The genus and type species are described by ÉTALLON (1859) and figured by DE LORIOI (1877-79). To avoid secondary homonymy with *Apiocrinites flexuosus* GOLDFUSS, which, although indeterminable, most likely belongs to a genus of this family, GISLÉN (1924, p. 187) introduced as a *nom. subst. pro T. flexuosus* ÉTALLON the name *T. javieri* taken from the label-name *Humberticrinus javieri* used in the collection by ÉTALLON and quoted by

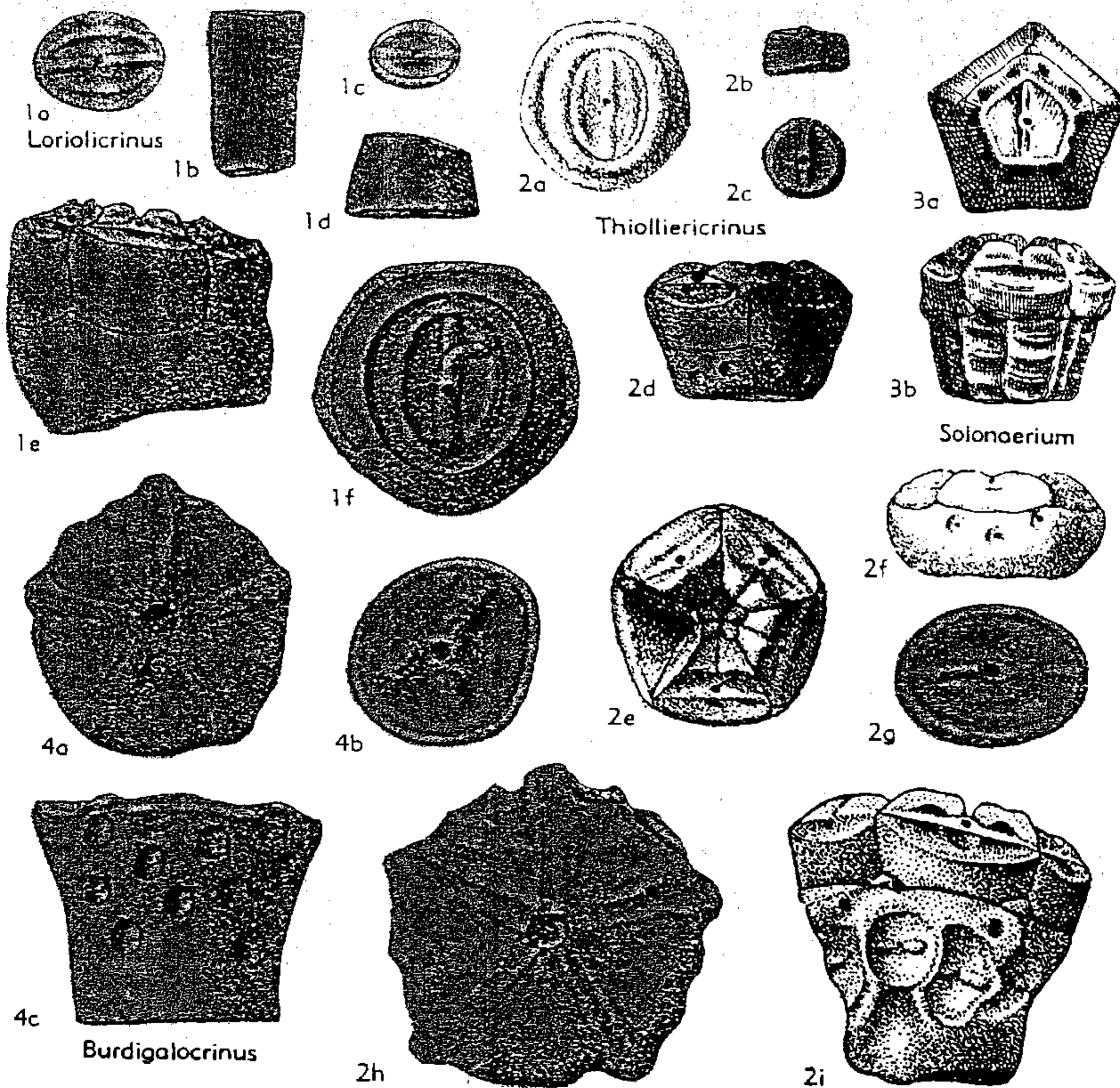


FIG. 588. Thiollicricrinidae (p. 7879-7881).

DE LORIO (1879, p. 195)]. Radials with large, vertical or slightly recumbent free dorsal surface at least in type species. Basals may be concealed (in type species) or exposed. Centrodorsal truncated conical with only few cirrus sockets forming a single circle. In type species, sockets very small, widely separated, elliptical or circular in outline, with or without articular ridge. Other species referred to this genus may have large, well-developed cirrus sockets or small, vestigial sockets or both. [GISEN (1924), at variance with the type species, restricted the genus to species with large cirrus sockets. Axillary brachials with strongly swollen dorsal surface and with muscular proximal articulation, probably primitive, are referred by REMES (1905) to the genus *U. Jur.* (Oxford-Tithon.), *L. Cret.* (Vauxville-Beaumont), Eu. (Czech.-France-Ger.-Portugal).]—FIG. 588,

2a-d. \**T. flexuosus*, U. Jur., France; 2a, d, dorsal and lat. side of cup with centrodorsal,  $\times 3$ ; 2b, c, columnal,  $\times 1.5$  (2a, de Loriol, 1889; 2b-d, de Loriol, 1879).—FIG. 588, 2e, f. *T. heberti* DE LORIO, U. Jur., France; 2e, f, cup with centrodorsal, one radial missing,  $\times 2$  (de Loriol, 1889).—FIG. 588, 2g-i. *T. ribeiroi* DE LORIO, U. Jur., Port.; 2g, h, dorsal articulation of centrodorsal, and ventral face,  $\times 4$  (de Loriol, 1891); 2i, cup with centrodorsal, recombined from de Loriol, 1891,  $\times 4$  (Bather, 1900a).

*Burdigalocrinus* JAEKEL, 1918, p. 71 [\**B. lorioli* (ex *Thiollicricrinus ribeiroi* partim DE LORIO, 1891, pl. 29, fig. 17); M]. Centrodorsal rather high, truncated conical, with several small, rounded cirrus sockets without distinct articular ridge. Sockets widely separated, irregularly arranged, not restricted to a single circle on centrodorsal.

*U. Jur. (Oxford.)*, Eu. (Port.).—FIG. 588, 4. \**B. lorioli*, Port.; 4a-c, centrodorsal,  $\times 4$  (de Loriol, 1891).

*Loriolicrinus* JAEKEL, 1918, p. 72 [\**Thiollicrinus insuetus* DE LORIOL, 1891, p. 167; M]. Centrodorsal discoidal or subcylindrical with no trace of cirrus sockets. Basals may be concealed. Radials with rather large free surface. *U. Jur. (Oxford.)*—*L. Cret. (Hauteriv.)*, Eu. (Port.).—FIG. 588, 1. \**L. insuetus* (DE LORIOL), *U. Jur.*, Port.; 1a-d, columnals,  $\times 1.5$ ; 1e-f, cup with centrodorsal,  $\times 3$  (de Loriol, 1891).

*Solonaerium* ÉTALLON, in THURMANN & ÉTALLON, 1862, p. 341 [\**S. costatus*; M; (pro *Solanocrinites costatus* GOLDFUSS, 1831, pl. 51, fig. 2, partim)] [ÉTALLON (1862, p. 222), recorded the specimen figured by GOLDFUSS, pl. 51, fig. 2 (non pl. 50, fig. 7) as a species probably belonging to *Thiollicrinus*, and in another publication (THURMANN & ÉTALLON, 1862, p. 341), the same specimen is recorded as *Solonaerium costatus*. QUENSTEDT (1876, p. 176) included the same specimen in his new species *Comatula sigillata*]. Centrodorsal rather high, truncated conical, with large, closely touching cirrus sockets arranged in 10 columns of 2 or 3 sockets. Radials with a large, free dorsal surface, somewhat recumbent or overhanging. *U. Jur. (Kimmeridg.)*, Eu. (Ger.).—FIG. 588, 3. \**S. costatum*; 3a,b, cup with centrodorsal,  $\times 1.5$  (Goldfuss, 1831).

## Superfamily COMASTERACEA

A. H. Clark, 1908

[*nom. correct.* RASMUSSEN, herein (pro *Comasterida*, *nom. transl.* GISLÉN, 1924, p. 229 [established as a superfamily taxon although named tribe], ex family *Comasteridae* A. H. CLARK, 1908g, p. 135)]

Centrodorsal rather low to very low discoidal, never conical or columnar. Dorsal side cirrus-free, large, flattened, slightly convex to slightly concave. Radial dorsal star absent, but there may be a narrow depression of dorsal pole. Interradial impressions in dorsal area may occur (Fig. 590, 2c, also known in fossil *Notocrinacea*). Ventral surface of centrodorsal with rather narrow cavity, less than 0.3 of centrodorsal diameter except for very small specimens, and with interradian furrows for basals, but no radial pits or coelomic impressions. Cirrus sockets generally rather large, without distinct ornament, closely crowded forming one or two, seldom three, irregular circles, never forming vertical columns. Adult specimens of several genera within all three subfamilies may have extremely low centrodorsals with only a single circle of cirrus sockets, or

centrodorsal may be reduced to a thin, flat, pentagonal or stellate plate with few or no cirrus sockets, and often impressed in dorsal side of cup, not projecting below radials. Basals rod shaped, generally exposed in interradian point. A subradial cleft may occur, especially in large specimens. Radials with a low, free surface, commonly concealed in midradial area, but may form a narrow margin along interradian edges separating arm bases. In specimens with reduced centrodorsal, radials may be overhanging with a large trapezoidal surface exposed. Articular face of radials very steep to vertical and almost flat. Interarticular ligament fossae large, high and wide, generally higher than dorsal ligament fossa, and separated by broad and shallow midradial furrow, which is commonly constricted between muscular fossae. Ventral border of interarticular fossae straight or slightly curved, horizontal or slightly sloping. Ventral muscular fossae low, always smaller than interarticular ligament fossae, forming narrow bands along horizontal ventral edge. Radial cavity large, with a spongy calcareous filling in recent specimens. Arms divided at primibrach 2 and often further divided. Primibrachs 1-2 and secundibrachs 1-2 synarthrial or in some species syzygial, never embayed. Pinnulation complete except in *Comatilia*, where there is a pinnule gap after the first pair. Oral pinnules slender, flagellate, with numerous short pinnulars. Distal pinnulars of at least some oral pinnules form a comb of high, uniform projections not found in other comatulids, although indicated in some *Heliometrinae*. In many species posterior arms may be retarded during growth or remain short and without ambulacral groove. Generally anal tube is more or less central and mouth subcentral to marginal at least in adult specimens. Mouth very rarely central and anal tube more or less marginal, mainly in juvenile and small specimens. *Tert. (Eoc., Mio.-Plio.)*; *Holo.* [recent in *Pac.O.-Ind.O.-Atl.O.-Carib.-Gulf Mex.* (0-1,710 m.)].

The more or less marginal mouth, modified posterior arms and specialized pinnules indicate *Comasteridae* as a specialized group among the comatulids. They resemble *Solanocrinitacea* in the discoidal centrodorsals, large cirrus-free area, stout cirrus sock-

## Family COMASTERIDAE

A. H. Clark, 1908

[Comasteridae A. H. CLARK, 1908g, p. 135] [=Actinometridae BATHER, 1899b, p. 923] [The family name Comatulidae FLEMING, 1828 (=Comatulidae D'ORBIGNY, 1852, p. 138) based on *Comatula* was used for all comatulids as in the order Comatulida CLARK, 1908g]

Characters of superfamily. *Tert.*(*Eoc.*, *Mio.-Plio.*); *Holo.*

The genus *Palaeocomaster* including some of the oldest comatulids known was referred by GISLÉN, 1924, to this family, but is here transferred to Solanocrinitacea. The family has been divided into three subfamilies not sharply distinguished from each other.

## Subfamily COMASTERINAE A. H. Clark, 1908

[*nom. transl.* A. H. CLARK, 1909h, p. 175 (*ex* Comasteridae A. H. CLARK, 1908g, p. 135)] [=Actinometrinæ JAEHEL, 1918, p. 74]

Centrodorsal discoidal, moderate to low, with or without a central depression. Cirrus sockets in one to three irregular circles, or may be absent. Cirri may be well developed and stout, but are commonly small and weak or reduced. Some or all cirri with spine or tubercle on distal cirrals. Centrodorsal in adult specimens of all genera included may be reduced to a small, stellate plate, slightly or not projecting below radial circlet, and with few, commonly reduced cirrus sockets or without sockets. Radials with a low, free surface or concealed in specimens with unreduced centrodorsal, but overhanging and with a trapezoidal surface when centrodorsal is reduced. Articular face of radials with interarticular ligament fossae high and wide. Ventral muscular fossae low, not projecting at interrarial edge, forming narrow bands along almost horizontal ventral edge and slightly curved downward along wide midradial furrow. Arms divided at primibrachs 2 and always further divided, often several times, with intervals of four or, variably, four and two. Brachials 1 to 2 synarthrial except in *Comaster*, where juvenile cryptosynarthry is commonly changed during growth to a smooth articular face or a syzygy with radiating ridges or a concentric pattern of tubercles. A pinnular comb is found not only in oral pinnules but also in some genital pinnules. Mouth marginal or submarginal. *U.Tert.*(*Mio.-Plio.*); recent in Pac. and Ind.O. [0-548 m.].

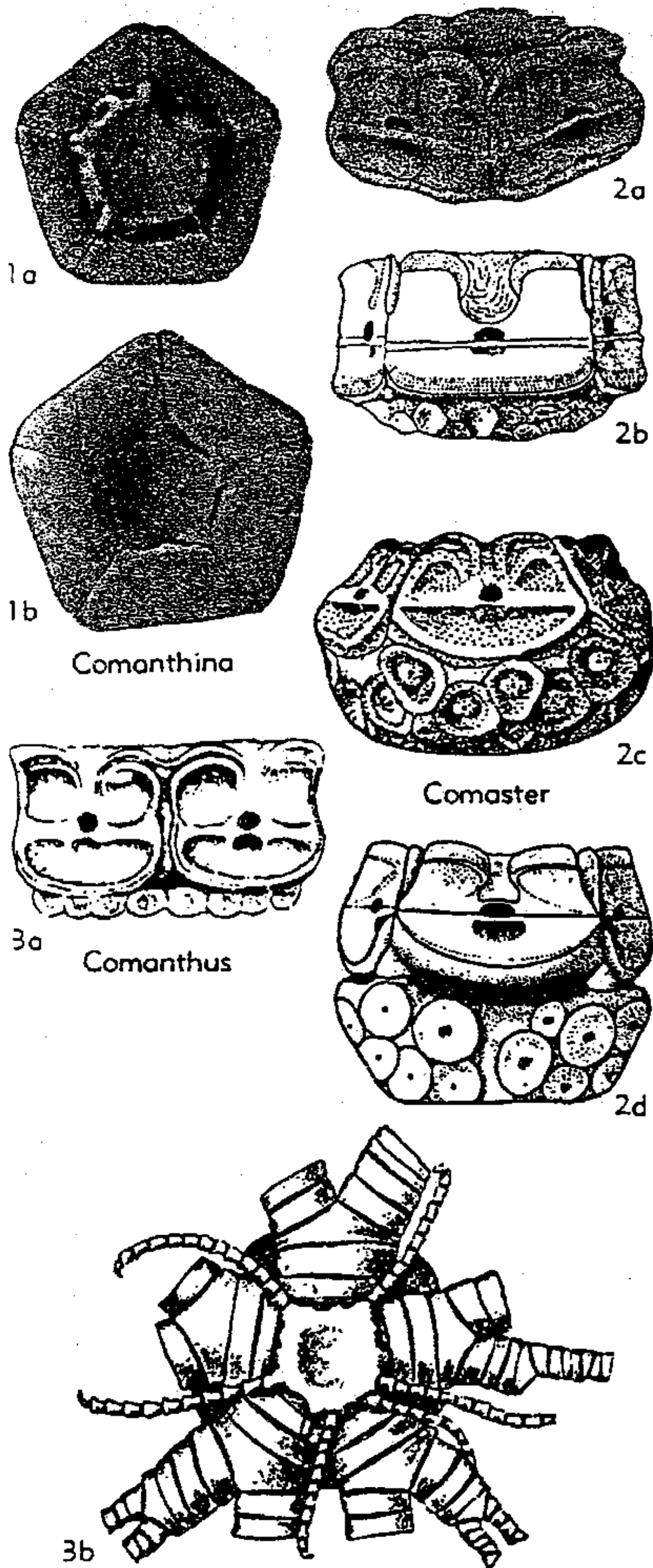


FIG. 589. Comasteridae (Comasterinae) (p. T883).

ets, rod-shaped basals, steep articular face of radials with low muscular fossae, and large radial cavity. Several Jurassic and Cretaceous species have been recorded under the genera *Actinometra* (=Comatula) and *Palaeocomaster* but here transferred to Solanocrinitacea.



- Comaster AGASSIZ, 1836, p. 193 [*\*Comatula multiradiata* LAMARCK, 1816, p. 534; (= *Alecto multiradiata*) J. MÜLLER, 1841, p. 188]; OD; emend. A. H. CLARK, 1909c] [= *Phanogenia* LOVÉN, 1866, p. 231 (type, *P. typica*; OD)]. Tertiary comatulids referred to *Actinometra* and *Palaeocomaster* may well belong to this or a closely related genus. Arms divided at primibrachs 2, and generally at secundibrachs 4 and tertibrachs 2. Synarthrial articulation at brachials 1-2 reduced or modified in adult specimens. *U.Tert.(Mio.)*, Eu. (France-Italy-Hung.); *U.Tert.(Plio.)*, Asia (Indon.); recent, Pac. O.-Ind.O. (0-290 m.).—FIG. 589,2a. *C. formae* (NOELLI), Mio., Italy;  $\times 5$  (Rasmussen, n, after Noelli, 1901).—FIG. 589,2b. *C. fruticosus* CLARK, recent;  $\times 5$  (Clark, 1921).—FIG. 589,2c. *C. seranensis* (SIEVERTS), Plio., Indon.;  $\times 9$  (Sieverts, 1933a).—FIG. 589,2d. *C. brevicirrus* (BELL), recent;  $\times 10$  (Clark, 1921).
- Comantheria A. H. CLARK, 1909, p. 142 [*\*Antedon briareus* BELL, 1884, p. 163; OD]. Recent.
- Comanthina A. H. CLARK, 1909, p. 142 [*\*Actinometra nobilis* CARPENTER, 1888, p. 336 (= *Actinometra schlegelii* CARPENTER, 1881d, p. 210); OD]. Arms divided at primibrachs 2, secundibrachs 4, and at tertibrachs 2 of abradial branches, tertibrachs 4 of adradial branches. Recent.—FIG. 589,1. *\*C. schlegelii* (CARPENTER); 1a,b, cup with reduced centrodorsal,  $\times 3.5$  (Carpenter, 1888).
- Comanthus A. H. CLARK, 1908, p. 220 [*\*C. intricata* (= *Alecto parvicirra*) J. MÜLLER, 1841, p. 185]; SD A. H. CLARK, 1908i, p. 203] [= *Goldfussia* NORMAN, 1891, p. 387 (type, *G. multiradiata*; M; pro *Comatula multiradiata* as figured in GOLDFUSS, 1831, p. 202, non LAMARCK) preoccupied by *Goldfussia* CASTELNAU, 1843; *Bennetia* A. H. CLARK, 1909i, p. 142 (type, *Alecto benneti*) J. MÜLLER, 1841, p. 187; OD]; *Cenolia* A. H. CLARK, 1916c, p. 48 (type, *Comatula trichoptera*) J. MÜLLER, 1846, p. 178; M]. Arms divided at primibrachs 2 and with variable intervals of 2 or 4. Recent.—FIG. 589,3. *\*C. parvicirrus* (MÜLLER); 3a, cup with centrodorsal,  $\times 7$  (Carpenter, 1879b); 3b, crown with reduced centrodorsal,  $\times 6$  (Carpenter, 1888). [= *Validia* CLARK, 1909, p. 142; *Vania* CLARK, 1911, p. 756.]
- Subfamily CAPILLASTERINAE A. H. Clark, 1909  
[Capillasterinae A. H. CLARK, 1909h, p. 175]
- Centrodorsal rather low discoidal. Cirri rather numerous, in one to three irregular circles. Distal cirrals with dorsal spine or tubercle. Centrodorsal reduced and cirrus-free only in a single species of *Capillaster*. Articular face of radials with interarticular ligament fossae much wider than high. Border between interarticular and ventral fossae horizontal or sloping toward interradial edge. Ventral muscular fossae more or less extended outward at interradial margin. In *Comatilia* free surface of radials prolonged along interradial edges, separating base of arms, and interarticular and ventral fossae are triangular. Arms divided at primibrachs 2 and commonly further divided at secundibrachs 2, seldom at secundibrachs 1, 3, or 4 and tertibrachs 2, 3, or 4. Synarthrial articulation at primibrachs 1 to 2, secundibrachs 1 to 2 and often tertibrachs 1 to 2. A pinnule gap occurs after first pair of pinnules in *Comatilia*. Mouth generally excentric to marginal, but in several species central. *Tert.(Eoc.)*; recent [in Pac.O.-Ind.O.-Atl.O.-Carib.S. (0-1,710 m.)].
- Capillaster A. H. CLARK, 1909, p. 87 [*\*Actinometra sentosa* CARPENTER, 1888, p. 325; OD]. Arms divided at primibrachs 2, secundibrachs 2, or secundibrachs 4, and often further divided with intervals of 2, 3, or 4. Recent.—FIG. 590,1. *C. multiradiatus* (LINNÉ); 1a, cup with centrodorsal,  $\times 5$  (Clark, 1921); 1b, cirrus,  $\times 5$  (Clark, 1915a); 1c, oral pinnule,  $\times 4$  (Carpenter, 1888).
- Comanthoides A. H. CLARK, 1931, p. 240 [*\*Comanthus spanochistum* H. L. CLARK, 1916, p. 17; OD]. Recent.
- Comatella A. H. CLARK, 1908, p. 207 [*\*Actinometra nigra* CARPENTER, 1888, p. 304; OD]. Arms divided at primibrachs 2, some or all at secundibrachs 2, and often further divided with intervals of 2. Abradial branches commonly most divided. Recent.—FIG. 590,2a,b. *\*C. nigra* (CARPENTER); 2a, cup with centrodorsal,  $\times 4$ ; 2b, ventral face of centrodorsal;  $\times 4.9$  (2a, Clark, 1921; 2b, Clark, 1915a).—FIG. 590,2c. *C. maculata* (CARPENTER); dorsal side of centrodorsal,  $\times 6$  (Clark, 1915a).
- Comatilia A. H. CLARK, 1909, p. 365 [*\*C. iridometrifomis*; OD]. Arms divided at primibrach 2 only. No pinnule from brachial 5 to brachial 10. Articular face of radials separated by high and steep interradial edges. Recent.—FIG. 590,6. *\*C. iridometrifomis*;  $\times 20$  (Clark, 1921).
- Comatonia A. H. CLARK, 1916, p. 115 [*\*Actinometra cristata* HARTLAUB, 1912, p. 473; OD]. Recent.
- Comissia A. H. CLARK, 1909, p. 501 [*\*C. luetkeni*; OD]. Recent.
- Ctenantedon MEYER, 1972, p. 53 [*\*C. kinziei*; M]. Recent.
- Leptonemaster A. H. CLARK, 1909, p. 498 [*\*L. venutus*; OD]. Arms divided at primibrach 2 only. Pinnulation complete. Recent.—FIG. 590,4. *\*L. venutus*;  $\times 10$  (Clark, 1921).
- Microcomatula A. H. CLARK, 1931, p. 287 [*\*M. mortenseni*; OD]. Recent.
- Nemaster A. H. CLARK, 1909, p. 503 [*\*N. grandis*; OD]. Recorded by HOWE (1942, p. 1192) from

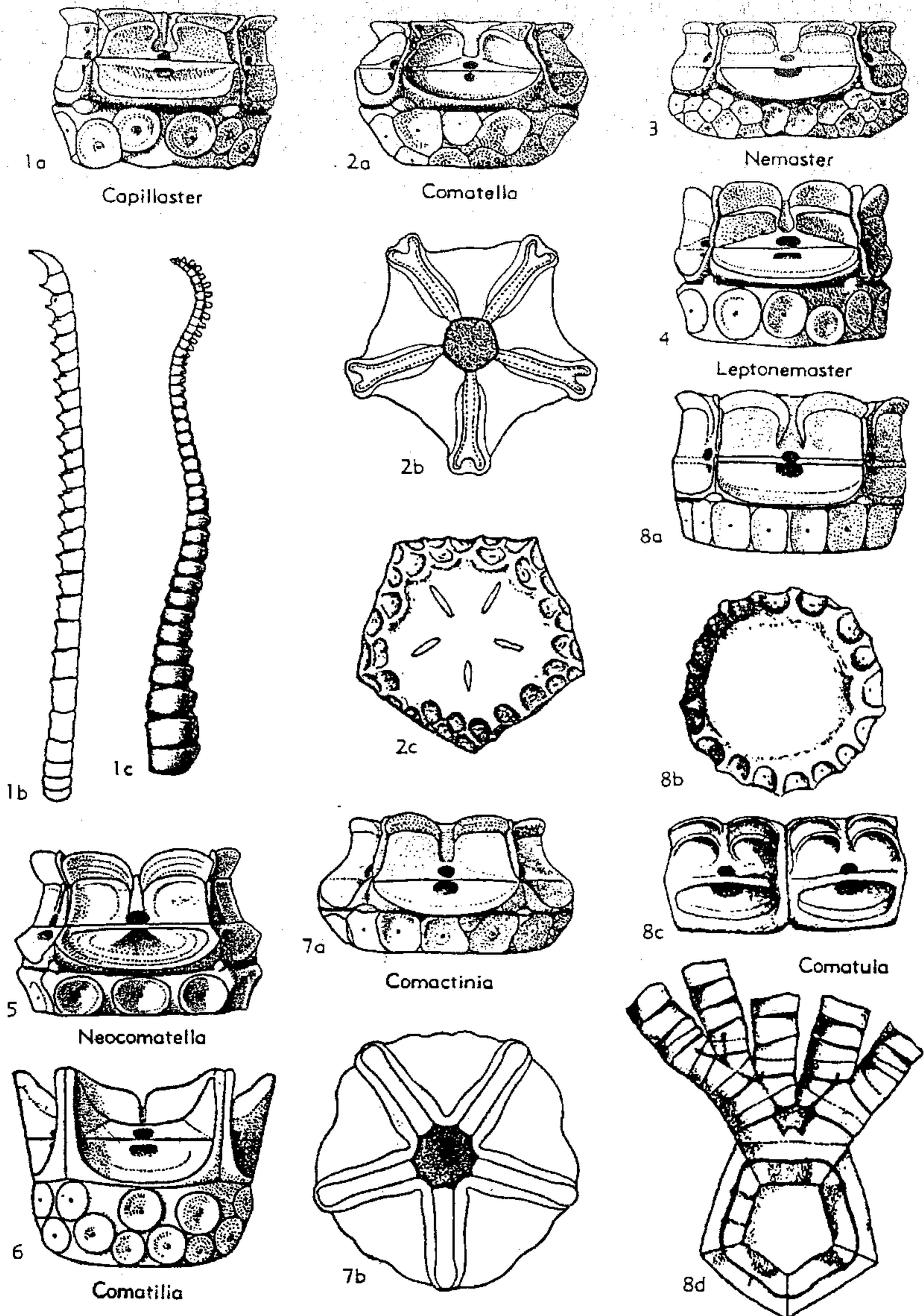


FIG. 590. Comasteridae (Capillasterinae) (1-6), Comactiniinae (7,8) (p. T883-T885).

Eocene of North America (S.Car.). Arms divided at primibrachs 2, secundibrachs 4, generally terti-

brachs 3 and often quartibrachs 3. Abradial branches often less divided. *L.Tert.(Eoc.)*, N.Am.

(S.Car.)-recent.—FIG. 590,3. *N. discoidea* (CARPENTER); X7 (Clark, 1921).

*Neocomatella* A. H. CLARK, 1909, p. 177 [\**Antedon alata* POURTALÈS, 1878, p. 215; OD]. Arms divided at primibrachs 2, at some secundibrachs 2 and exceptionally at tertibrachs 2 of abradial branches. Recent.—FIG. 590,5. *N. pulchella* (POURTALÈS); X8 (Clark, 1921). [= *Neomatella* CLARK, 1909 (*nom. null.*).]

*Palaeocomatella* A. H. CLARK, 1912, p. 18 [\**Actinometra difficilis* CARPENTER, 1888, p. 93; OD]. Recent.

Subfamily COMACTINIINAE A. H. Clark, 1909

[Comactiniinae A. H. CLARK, 1909h, p. 175]

Centrodorsal low discoidal with rather few cirri, generally less than 20, in one or two irregular circles. Cirrals without dorsal spines or tubercles. Adult specimens of *Comatula* commonly with extremely low centrodorsal and very few, scattered cirrus sockets or with centrodorsal reduced to a thin, flat, pentagonal or stellate plate without cirri and not protruding below dorsal surface of radial circlet. Articular face of radials with interarticular ligament fossae about as high as wide, with upper border slightly curved, almost horizontal or sloping toward midradial furrow. Ventral muscular fossae wide and low to moderate, not higher than interarticular fossae, somewhat protruding at interrarial edge, and may curve down along the midradial furrow. Arms divided at primibrachs 2 and in *Comatula* may be further divided at secundibrachs 2, seldom also at some tertibrachs 2. Primibrachs 1 very low. Primibrachs 1 to 2 and secundibrachs 1 to 2 synarthrial or in *Comatula* and *Comatulella* syzygial. Mouth marginal or submarginal. Recent, in Pac.-Ind.-O.-Carib.-Gulf Mexico [0-984 m.].

*Comatulella* A. H. CLARK, 1909, p. 498 [\**Alecto echinoptera* J. MÜLLER, 1841, p. 183; OD]. Arms divided at primibrachs 2 only. Primibrachs 1-2 and secundibrachs 1-2 synarthrial. Recent.—FIG. 590,7. *C. echinoptera* (MÜLLER); 7a, cup with centrodorsal, in ventral face of centrodorsal; X7 (Clark, 1915a). [See also FIG. 590,8a, b, c, d.]

*Comatulella* A. H. CLARK, 1911, p. 130 [\**C. solaris*; *Actinometra* VON GRAFF, 1883, p. 132 (*nom. null.*); *Actinometra* FILHOL, 1885, p. 213 (*nom. null.*); *Actinometra* HARTLAUB, 1891, p. 97 (*nom. null.*); *Actinometer* SPRINGER, 1903, p. 220 (*nom. null.*); *Actinometra* CLARK, 1912, p. 91 (*nom. null.*), all *err. pro Actinometra* MÜLLER, 1841.].

adult specimens be reduced and cirrus-free. [The Jurassic and Cretaceous species previously referred to *Actinometra* and *Palaeocomaster* appear with few exceptions to belong to Solanocrinacea and hardly any to Comasteridae. The Tertiary species referred to *Actinometra* or *Palaeocomaster* from the Miocene of France, Italy and Hungary and from the Pliocene of Indonesia probably belong to *Comaster* or related genera of Comasteridae.] Recent.—FIG. 590,8a. *C. pectinata* (LINNÉ); X7 (Clark, 1921).—FIG. 590,8b. \**C. solaris*; X7 (Clark, 1915a, after Carpenter, 1881).—FIG. 590,8c, d. *C. rotalaria* (LAMARCK); 8c, lat. view of cup, X6 (Clark, 1921, after Carpenter, 1888); 8d, dorsal side of crown, X3 (Clark, 1915a, after Carpenter, 1888). [= *Actinometra* CARPENTER, 1881, p. 204 (*nom. null.*); *Actinometra* VON GRAFF, 1883, p. 132 (*nom. null.*); *Actinometra* FILHOL, 1885, p. 213 (*nom. null.*); *Actinometra* HARTLAUB, 1891, p. 97 (*nom. null.*); *Actinometer* SPRINGER, 1903, p. 220 (*nom. null.*); *Actinometra* CLARK, 1912, p. 91 (*nom. null.*), all *err. pro Actinometra* MÜLLER, 1841.]

*Comatulella* A. H. CLARK, 1911, p. 130 [\**Comatula brachiolata* LAMARCK, 1816, p. 535 (= *Alecto rosea* J. MÜLLER, 1841, p. 182); M]. Recent.

*Comatulides* A. H. CLARK, 1918, p. 24; *nom. subst. pro Cominia* A. H. CLARK, 1909f, p. 497 (non BROWN, 1844) [\**Comanthus decameros* A. H. CLARK, 1908k, p. 221; OD]. Recent.

Superfamily MARIAMETRACEA

A. H. Clark, 1909

[*nom. transl.* RASMUSSEN, herein (*ex* subfamily Mariametridae A. H. CLARK, 1909h, p. 176)] [= *Mariametrida* GISELÉN, 1924, p. 230, established as a superfamily rank taxon although named tribe]

Centrodorsal low hemispherical to discoidal with a cirrus-free, flattened to concave dorsal side, which is smooth or tuberculate, seldom rugose or with traces of obliterated cirrus sockets. No dorsal star. Cirrus sockets without distinct ornament or with slightly elevated rim around axial canal closely placed in one to three, seldom four, irregular marginal circles. Marginal crenulae and distinct fulcral ridge or tubercles may be present in cirrus sockets of fossil genus *Discometra*. Dorsal side of cirrals rounded or carinate, with or without dorsal spines, in Colobometridae with transverse ridge or with transverse row of two to four spines. Ventral side of centrodorsal with interrarial ridges. Centrodorsal cavity narrow to moderate, less than 0.3 of centrodorsal diameter. Several genera have shallow radial coelomic depressions or

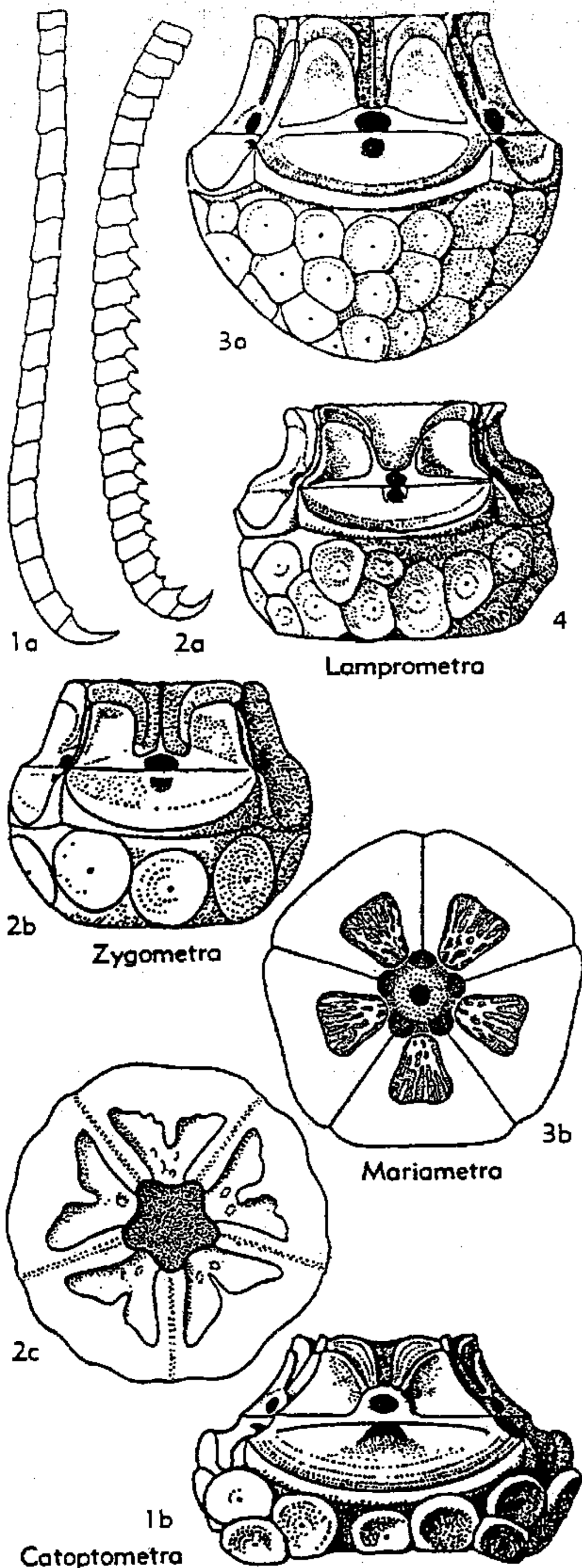


FIG. 591. Mariametridae (3,4); Zygometridae (1,2) (p. T887).

radiating furrows in ventral side of centrodorsal and proximal side of radials. In fossil genus *Discometra* coelomic canals are found near the proximal surface of the ra-

dials. Small radial pits around centrodorsal cavity found in *Cyllometra*. Basal rosette but no rod-shaped basals except in fossil specimens referred to *Himerometra*. Radials with a low, free surface, commonly concealed in midradial area, very seldom moderate to high as in *Amphimetra* and in juvenile specimens. Articular face of radials often rather flat, moderately sloping to almost vertical, and often separated by narrow interrarial margins. Interarticular ligament fossae large, high and broad. Ventral muscular fossae generally small, commonly forming a narrow crescentic band along ventral edge and midradial furrow. In *Colobometra*, muscular fossae triangular, and in *Cyllometra*, large and high. Wide midradial furrow with or without median ridge, except in *Cyllometra*, which has only a narrow midradial ridge. Radial cavity moderate to large, in juvenile specimens often very large, with spongy calcareous filling. In *Eudiocrinus* the five arms undivided with first pinnule on brachials 2 and second pinnule on brachials 4, but no pinnule on brachials 3. In other genera arms divide at primibrach 2 and are further divided with intervals of two or four, often different in inner and outer branches. Synarthrial, flat articulations at brachials 1-2 except for primibrachs 1-2 of Zygometridae and Eudiocrinidae. Syzygial articulations at brachials 3-4 and with variable, often large intervals in distal branches, in Zygometridae and Eudiocrinidae syzygy also at primibrachs 1-2. Oral pinnules may be more or less carinate. One or more proximal pinnules, generally the first inner pinnule ( $P_a$ ), absent in Colobometridae. Genital and distal pinnules not carinate except for trace of carination in the most proximal pinnulars. Ambulacral covering plates inconspicuous or absent. Mouth central. *Tert.*(*Eoc.-Mio.*); recent.

#### Family MARIAMETRIDAE A. H. Clark, 1909

[*nom. transl.* A. H. CLARK, 1911c, p. 649 (ex subfamily Mariametridae A. H. CLARK, 1909h, p. 176) (incl. Stephanometridae A. H. CLARK, 1911c, p. 649, *nom. transl.* ex subfamily Stephanometridae A. H. CLARK, 1909h)]

Centrodorsal low hemispherical to discoidal with a flattened, often rather small, slightly convex to concave, cirrus-free dorsal area. Cirrus sockets closely placed in one

to four irregular circles on the sloping sides. Distal cirrals dorsally carinate or with dorsal spines. Ventral side of centrodorsal described for species of *Mariametra* and *Lamprometra* with interradiar ridges and with undivided coelomic impression in each radial area. No rod-shaped basal rays. Articular face of radial steep, interarticular fossae large and high. Ventral muscular fossae low, curved along ventral edge and midradial furrow. Arms divided at primibrachs 2, secundibrachs 2, generally tertibrachs 2 and exceptionally at quartibrachs 2. Synarthry at brachials 1-2, syzygy at brachials 3-4. Recent, in Pac.O.-Ind.O. [0-245 m.].

*Mariametra* A. H. CLARK, 1909, p. 144 [\**Himerometra subcarinata* A. H. CLARK, 1908b, p. 237; OD]. Centrodorsal hemispherical to high discoidal with sloping sides. Third pinnule larger than second ( $P_3 > P_2$ ). Recent.—FIG. 591,3. \**M. subcarinata* (CLARK); 3a, cup with centrodorsal, enl.; 3b, underside of radial cirlet; enl. (3a, Clark, 1921; 3b, Clark, 1915a).

*Dichrometra* A. H. CLARK, 1909, p. 12 [\**Alecto flagellata* J. MÜLLER, 1841, p. 186 (= *Alecto elongata* J. MÜLLER, 1841, p. 187); OD]. Recent.

*Lamprometra* A. H. CLARK, 1913, p. 143 [\**Antedon imparipinna* CARPENTER, 1882c, p. 505; OD]. Centrodorsal low to rather high discoidal. Second pinnule larger than third. Recent.—FIG. 591,4. *L. palmata* (MÜLLER); ×10 (Clark, 1921).

*Liparometra* A. H. CLARK, 1913, p. 143 [\**Himerometra grandis* A. H. CLARK, 1908k, p. 222; OD]. Recent.

*Oxymetra* A. H. CLARK, 1909, p. 13 [\**Antedon erinacea* HARTLAUB, 1890, p. 177; OD] [= *Selenometra* A. H. CLARK, 1911b, p. 541 (type, *Antedon finschii* HARTLAUB, 1890, p. 176; OD)]. Recent.

*Pelometra* A. H. CLARK, 1941, p. 459 [\**P. ambonensis*; OD]. Recent.

*Stephanometra* A. H. CLARK, 1909, p. 9 [\**Antedon monacantha* HARTLAUB, 1890, p. 179 (= *Antedon protectus* LÜTKEN in CARPENTER, 1879a, p. 19; *Antedon marginata* CARPENTER, 1888, p. 230; *Antedon flavomaculata* BELL, 1894, p. 400; *Himerometra heliaster* A. H. CLARK, 1908f, p. 242; *Himerometra acuta* A. H. CLARK, 1908f, p. 242); OD]. Recent.

### Family ZYGOMETRIDAE

A. H. Clark, 1908

[Zygometridae A. H. CLARK, 1908g, p. 135]

Centrodorsal rather large, dorsal side flattened or slightly concave, often with granulation, radiating furrows or obliterated cirrus sockets. One to four marginal circles

of sockets. Cirri smooth or with dorsal spines. Distal cirrals may be compressed or may be swollen at articulations. Ventral side of centrodorsal in *Catoptometra* smooth, but in *Zygometra* with large, paired or V-shaped radial impressions. Articular face of radials rather flat, moderately sloping to almost vertical. Ventral muscular fossae curved as narrow bands along ventral edge and midradial furrow. Arms divided at primibrachs 2 and generally several times with intervals of four or two brachials. Synarthry at brachials 1 to 2 except primibrachs 1 to 2. Syzygy at primibrachs 1 to 2 and brachials 3 to 4. Proximal brachials may be in lateral contact. Recent, Pac.O.-Ind.O. [0-914 m.].

*Zygometra* A. H. CLARK, 1907, p. 347 [\**Antedon microdiscus* BELL, 1884, p. 163; OD] [= ?*Hypnometra* LOVÉN, 1869, p. 54 (type, *H. sarsi*; M), based on detached tegmen and visceral mass probably belonging to this species]. Distal cirrals short, and with prominent dorsal spine. Recent.—FIG. 591,2. *Z. comata* CLARK; 2a, cirrus, ×5; 2b, cup with centrodorsal, ×10; 2c, ventral face of centrodorsal, ×10 (2a,c, Clark, 1915a; 2b, Clark, 1921).

*Catoptometra* A. H. CLARK, 1908, p. 505 [\**Antedon hartlaubi* A. H. CLARK, 1907c, p. 72; OD]. Cirrals long and without dorsal spine. Recent.—FIG. 591,1. \**C. hartlaubi* (CLARK); 1a, cirrus, ×4; 1b, cup with centrodorsal, ×10 (1a, Clark, 1915a; 1b, Clark, 1921).

### Family EUDIOCRINIDAE

A. H. Clark, 1907

[Eudiocrinidae A. H. CLARK, 1907f, p. 344]

Centrodorsal discoidal, dorsal side flat, smooth or rugose. One or two irregular marginal circles of cirrus sockets. Ventral side of centrodorsal without coelomic impressions. Articular face of radial rather flat, gently sloping. Ventral muscular fossae crescentic, forming narrow band along ventral edge and midradial furrow. Arms five, undivided. Syzygy at brachials 1-2 and brachials 5-6, synarthry at brachials 3-4. First pinnule at primibrachs 2 interpreted as suppressed arm since next pinnule follows at brachials 4, thus corresponding to secundibrachs 2 after a synarthrial articulation and succeeded by a syzygy at secundibrachs 3-4. Recent, Pac.O.-Ind.O. [36-183 m.].

*Eudiocrinus* CARPENTER, 1882, p. 493, *nom. subst.* pro *Ophiocrinus* SEMPER, 1868, p. 68, *non* SALTER,

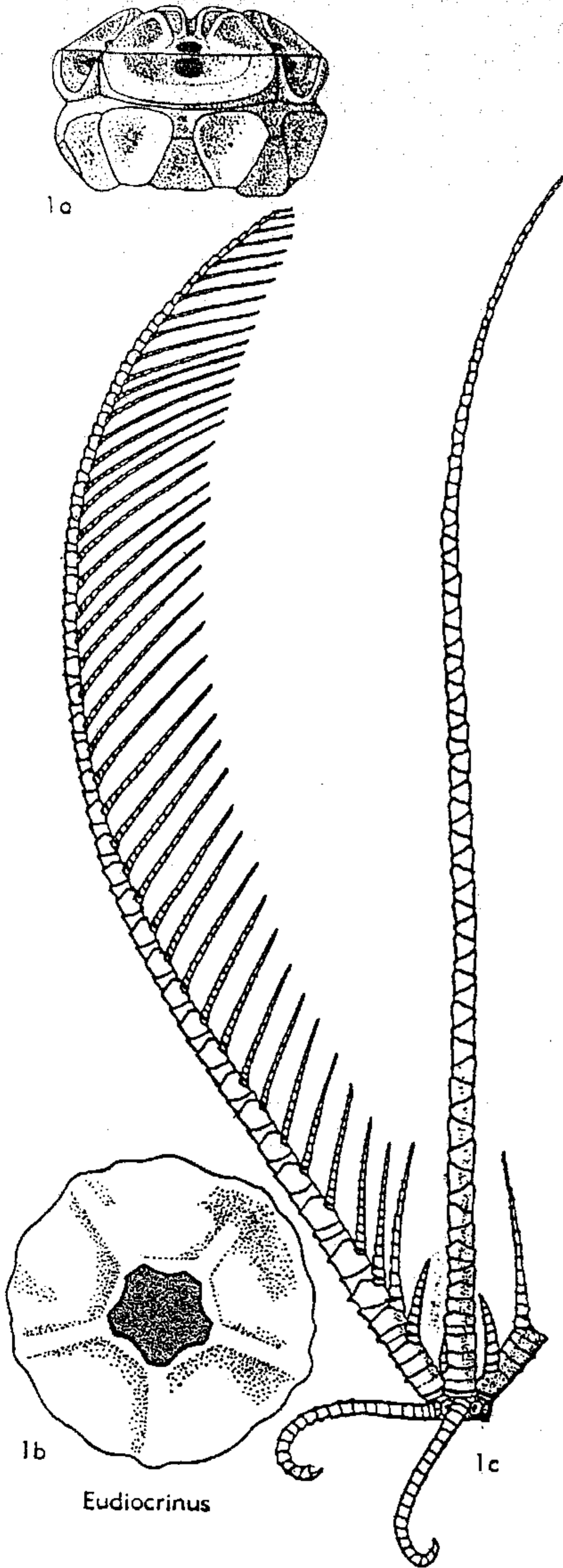


FIG. 592. Eudiocrinidae (p. T887-T888).

1856, nec ANGELIN, 1875 (\**Ophiocrinus indivisus* (= *E. granulatus* BELL, 1894, p. 396); M]. The Lower Cretaceous *Prodocrinella hiselyi* (DE

LORIOLE IN DE LORIOLE & GILLIÉRON, 1869) was referred by DE LORIOLE (1869, 1879) to this genus under the synonym *Ophiocrinus*, but there is no agreement in size of radials or in articulation of brachials or in distribution of pinnules. Characters of family. Recent.—FIG. 592, *1a, b*. *E. ornatus* CLARK; *1a*, cup with centrodorsal,  $\times 10$  (mod. from Clark, 1921); *1b*, ventral face of centrodorsal,  $\times 14$  (Clark, 1915a).—FIG. 592, *1c*. *E. pinnatus* CLARK;  $\times 2$  (Clark, 1915a).

### Family HIMEROMETRIDAE

A. H. Clark, 1908

[Himerometridae A. H. CLARK, 1908g, p. 135]

Centrodorsal in juvenile specimens often low hemispherical with rather narrow, concave, cirrus-free dorsal area, in adult specimens discoidal with large, flat or slightly concave dorsal area. Cirrus sockets without distinct ornament except in *Discometra*, where lateral tubercles and marginal crenulae may occur. Cirrus sockets in one to three, seldom four, irregular lateral circles. Cirrals with dorsal tubercle or spine in *Heterometra*, *Amphimetra*, and some species of *Himerometra*, but not in *Craspedometra* and *Homalometra*. Ventral side of centrodorsal with interrarial ridges. Basal rosette but no rod-shaped basals except in a fossil species referred to *Himerometra*. Coelomic canals found inside radials near their proximal surface in *Discometra*, and seen as paired impressions or radiating furrows in ventral side of centrodorsal and proximal side of radials in other genera. Radials with very low free surface or concealed in midradial area except for a few small species of *Amphimetra* with a higher radial surface. Articular face of radial moderately sloping to very steep. Interarticular ligament fossae large and high. Ventral fossae low, curved along ventral edge and more or less continued along part of midradial furrow. Arms divided at primibrachs 2 and generally at secundibrachs 2 or secundibrachs 4, often further divided with variable intervals of either two or four. Synarthry at brachials 1-2, syzygy at brachials 3-4. Oral pinnules enlarged, greatest length at  $P_D$  and  $P_1$  in *Himerometra* and at  $P_2$ - $P_3$  in other genera, unknown in fossil species. *Tert. (Eoc. Mio.)*; recent in Pac.O.-Ind.O. [0-183 m.].

*Himerometra* A. H. CLARK, 1907, p. 355 [\**Antedon crassipinna* HARTLAUB, 1890, p. 185 (= *Ac-*

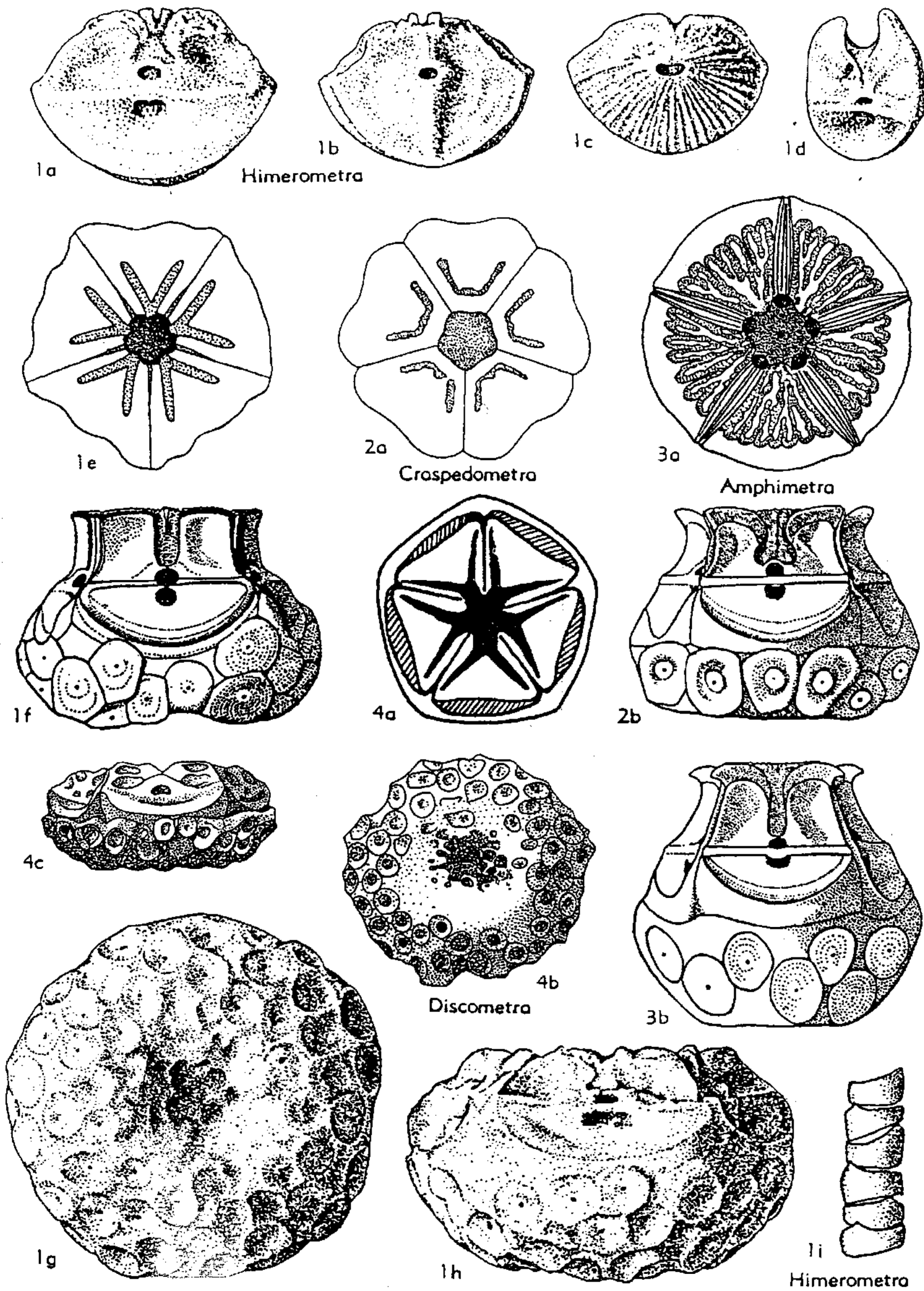


FIG. 593. Himerometridae (p. T888-T890).

*Himerometra robusta* CARPENTER, 1881d, p. 201; OD]. Cap. low hemispherical to

discoidal with concave to deeply depressed dorsal area. Cirrus sockets without distinct ornament,

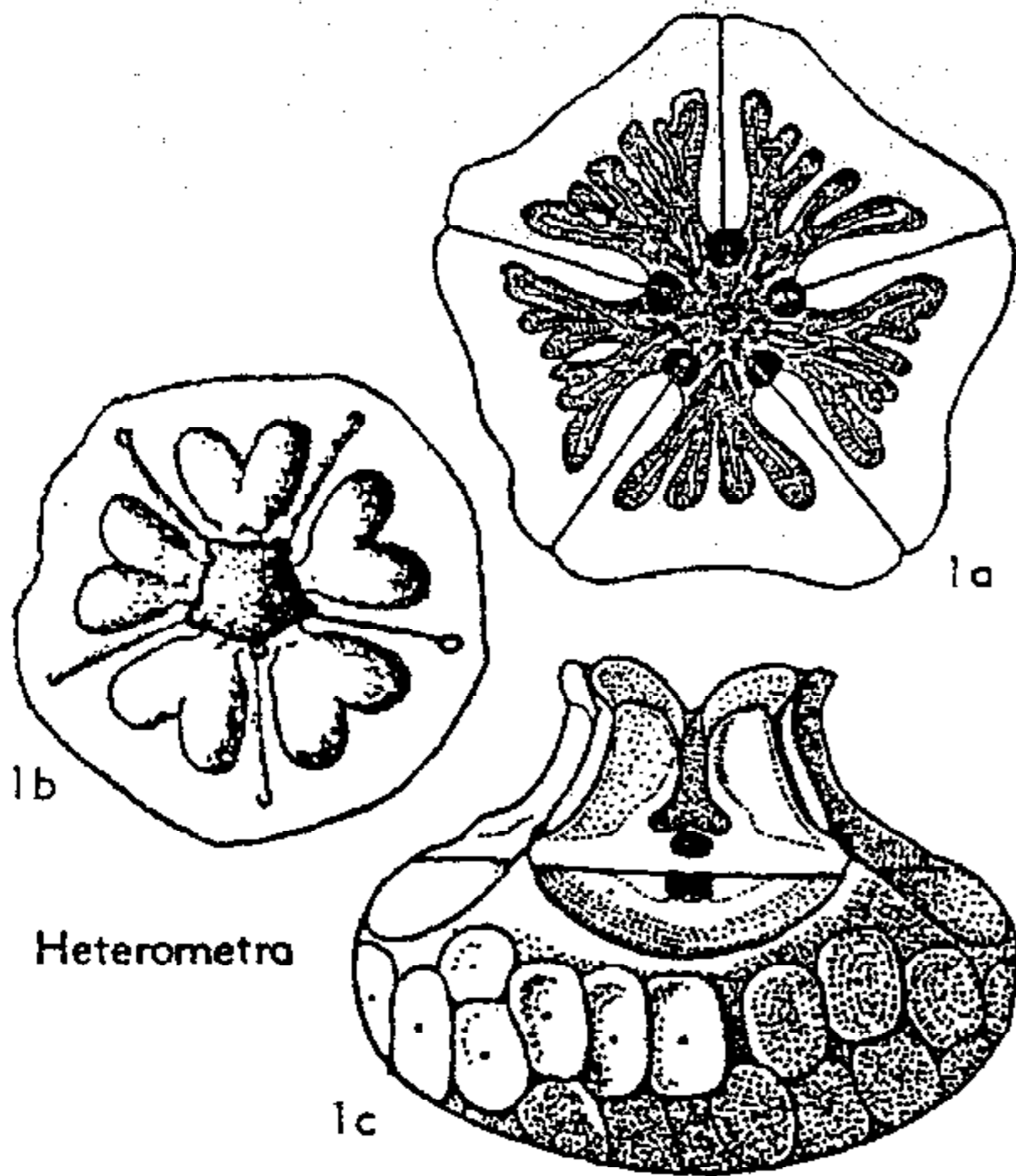


FIG. 594. Himerometridae (p. T890-T891).

closely placed in two or three irregular marginal circles. Cirrals with or without dorsal spines. Ventral side of centrodorsal with interrarial ridges and Y-shaped coelomic furrows. Basal rosette, but no rod-shaped basal rays in recent species. Radials with a low free surface or concealed. Articular face steep. Interarticular ligament fossae very large, separated by wide midradial furrow. Ventral muscular fossae form narrow bands along ventral edge. Radial cavity large. Arms divided at primibrachs 2 and secundibrachs 4, exceptional at secundibrachs 2, and often at tertibrachs 2 of inner branches and tertibrachs 4 of outer branches. Proximal brachials narrow, laterally free and well separated. Pinnules from secundibrachs 2 and tertibrachs 2 larger than succeeding pinnules. Proximal pinnules may be carinate. The Eocene species *H. bassleri* GISLÉN differs in absence of coelomic furrows and presence of rod-shaped basals. In the Oligocene *H. grippae* ANDERSON basals and coelomic furrows are unknown. *Tert.*(*Eoc.*), USA (S.Car.-La.); *Oligo.*, Eu.(Ger.); recent, Pac.O.-Ind.O.[0-57 m.].—FIG. 593,1a-d,g-i. *H. bassleri* GISLÉN, *Eoc.*, N.Am.; 1a,b, proximal and distal face of primibrach 1,  $\times 7$ ,  $\times 6$ ; 1c, distal face of secundibrach 3,  $\times 6$ ; 1d, distal brachial, muscular articulation,  $\times 10$ ; 1g,h, cup with centrodorsal,  $\times 6$ ; 1i, part of arm,  $\times 6$  (Gislén, 1934).—FIG. 593,1e,f. *H. martensi* (HARTLAUB); recent, 1e, ventral face of centrodorsal; 1f, cup with centrodorsal;  $\times 7$  (1e, Clark, 1915a; 1f, Clark, 1921).

*Amphimetra* A. H. CLARK, 1909, p. 6 [*\*Comatula* (*Alecto*) *milberti* J. MÜLLER, 1846, p. 178 (= *Alecto tessellata* J. MÜLLER, 1841, p. 184;

*Comatula jacquinoli* J. MÜLLER, 1846, p. 178); OD]. Centrodorsal low hemispherical to discoidal. Ventral side with radiating coelomic furrows. Free surface of radials low except for small species. Recent.—FIG. 593,3. *A. ensifer* (CLARK); 3a, underside of radial circlet,  $\times 7$ ; 3b, cup with centrodorsal,  $\times 8$  (3a, Clark, 1915a; 3b, Clark, 1921).

*Craspedometra* A. H. CLARK, 1909, p. 8 [*\*Antedon acuticirra* CARPENTER, 1882c, p. 509 (= *Antedon ludovici* CARPENTER, 1882c, p. 510; *Antedon australis* CARPENTER, 1882c, p. 510; *Antedon bipartipinna* CARPENTER, 1882c, p. 512); OD]. Centrodorsal discoidal, ventral side with radiating coelomic furrows. Recent.—FIG. 593,2. *\*C. acuticirra* (CARPENTER); 2a, ventral face of centrodorsal,  $\times 7$ ; 2b, cup with centrodorsal,  $\times 8$  (2a, Clark, 1915a; 2b, Clark, 1921).

*Discometra* GISLÉN, 1924, p. 180 [*\*Eugeniocrinus? rhodanicus* FONTANNES, 1877, p. 669) (?= *Antedon meneghinianus* FONTANNES, 1880); OD]. Centrodorsal low arched with concave cirrus-free dorsal area to discoidal with flattened or concave dorsal side. Cirrus sockets with indistinct articular ridge or tubercles closely placed in 3 to 5 irregular circles. Trace of marginal crenulae in well-preserved sockets have been reported. Cirrals without dorsal spines. Ventral side of centrodorsal with interrarial ridges, no rod-shaped basal rays. Centrodorsal cavity very narrow, less than 0.2 of centrodorsal diameter. Y-shaped coelomic canals inside radial plates close to proximal surface. Radials with a low, free surface or concealed. Articular face of radials rather flat, low, and steep. Interarticular ligament fossae rather large, separated by wide midradial area. Ventral muscular fossae low, curved along ventral edge. Radial cavity large. Synarthrial articulations at brachials 1-2. Syzygial articulations present. *Tert.*(*Mio.*), Eu.(Aus.-France-Ger.-Hung.-Italy)-Afr.(Alg.).—FIG. 593,4. *\*D. rhodanica* (FONTANNES), *Mio.*, Hung.; 4a, section through lower part of radial circlet, coelomic canals shown in black,  $\times 2.7$  (Fontannes, 1880); 4b,c, cup with centrodorsal,  $\times 8$  (Vadasz, 1915).

*Heterometra* A. H. CLARK, 1909, p. 11 [*\*Antedon quinqueduplicava* CARPENTER, 1888, p. 262 (= *Antedon clemens* CARPENTER, 1888, p. 229; *Antedon anceps* CARPENTER, 1888, p. 254); OD] [= ? *Alecto* LEACH, 1815, p. 61 (type, *A. horrida* (= ? *Comatula* (*Alecto*) *reynaudi* J. MÜLLER, 1846, p. 178); SD A. H. CLARK, 1908c, see p. T927)]. Centrodorsal hemispherical to discoidal with flat dorsal area. Ventral side of centrodorsal with radiating coelomic furrows in paired depressions. [Two specimens of this genus were found recently in the Eocene of Louisiana (STRIMPLE, unpublished).] Recent.—FIG. 594,1a,c. *H. reynaudi* (MÜLLER); 1a, underside of radial circlet,  $\times 7$ ; 1c, cup with centrodorsal,  $\times 8$  (1a, Clark, 1915a; 1c, Clark, 1921).—FIG. 594,1b. *\*H. quinqueduplicava* (CARPEN-



TER); ventral face of centrodorsal,  $\times 8$  (Clark, 1915a, after Carpenter, 1888).

Homalometra A. H. CLARK, 1918, p. 72 [\**Antedon denticulata* CARPENTER, 1888, p. 130; M]. Recent.

### Family COLOBOMETRIDAE

A. H. Clark, 1909

[Colobometridae A. H. CLARK, 1909g, p. 145 (incl. Pontiométridae A. H. CLARK, 1909h, p. 175)]

Centrodorsal discoidal, dorsal side flattened to slightly concave, smooth or tuberculate. Cirrus sockets without distinct ornament or with slightly elevated rim around axial canal, closely placed in one to three irregular marginal circles. Some or all cirrals with serrate or tuberculate dorsal transverse ridge or a transverse row of two or three tubercles or spines, placed distally in proximal cirrals and medially in distal cirrals, although in *Pontiometra* and *Cotylometra* most cirrals have only a single dorsal spine. Ventral side of centrodorsal in *Pontiometra* with several irregular radiating coelomic furrows, in *Cyllometra* with interrarial ridges and a small radial pit. No rod-shaped basal ray. Articular face of radials steep, separated along interrarial margin. Fulcral ridge in *Pontiometra* divided by narrow ligament. Interarticular ligament fossae moderate and triangular to large and high, separated by wide and shallow midradial furrow except in *Cyllometra*, which has a narrow median ridge. Ventral muscular fossae small and vestigial to low, slightly curved along ventral margin, or small and triangular (*Colobometra*). In *Cyllometra* it is high. Arms divided at primibrachs 2 and often further divided with intervals of two or four brachials. Brachials 1-2 synarthrial, brachials 3-4 syzygial. Some proximal brachials may be laterally extended. One or more proximal pinnules, generally the first inner pinnule ( $P_a$ ) may be absent in some arms. Some proximal pinnulars in genital pinnules may be laterally expanded. Recent, Pac.O.-Ind.O.-Carib.S. [0-329 m.].

*Colobometra* A. H. CLARK, 1909, p. 5 [\**Antedon perspinosa* CARPENTER, 1881d, p. 178; OD]. Recent.

*Alisometra* A. H. CLARK, 1947, p. 112 (no type designated). Recent.

*Analcidometra* A. H. CLARK, 1911, p. 779 [\**Oligometra caribbea* A. H. CLARK, 1908b, p. 238; M]. Recent.

*Austrometra* A. H. CLARK, 1916, p. 115 [\**Oligometra thetidis* H. L. CLARK, 1909, p. 522; OD]. Recent.

*Basilometra* A. H. CLARK, 1936, p. 304 [\**B. boschmai*; OD] [= *Rhadinometra* GISLÉN, 1936, p. 15 (type, *R. dawydovi* (= *B. boschmai*); OD)]. Recent.

*Cenometra* A. H. CLARK, 1909, p. 8 [\**Himetometra unicornis* A. H. CLARK, 1908l, p. 216 (= *Antedon bella* HARTLAUB, 1890, p. 174; *Antedon abotti* A. H. CLARK, 1907d, p. 148; *Cenometra delicata* A. H. CLARK, 1909c, p. 398; *Cenometra insueta* A. H. CLARK, 1909g, p. 146); OD]. Centrodorsal low hemispherical or high discoidal with sloping sides and 2 to 3 circles of cirri. Arms divided at primibrachs 2, some or all secundibrachs 2, and seldom some abradial tertibrachs 2. Second pinnule very large and curved. Recent.—FIG. 595,2. \**C. bella* (HARTLAUB); 2a, cup with centrodorsal,  $\times 7$ ; 2b, lat. view,  $\times 1.5$  (2a, Clark, 1921; 2b, Clark, 1915a).

*Clarkometra* GISLÉN, 1922, p. 142 [\**C. elegans*; OD]. Recent.

*Cotylometra* A. H. CLARK, 1916, p. 116 [\**Oligometra gracilicirra* A. H. CLARK, 1908l, p. 221; OD]. Recent.

*Cyllometra* A. H. CLARK, 1907, p. 356 [\**Antedon manca* CARPENTER, 1888, p. 226; OD]. Centrodorsal discoidal with 1 to 2 circles of cirri. Ventral side of centrodorsal may have small radial pits. Arms divided at primibrachs 2, generally at secundibrachs 2 and often some at tertibrachs 2. Recent.—FIG. 595,1. \**C. manca* (CARPENTER); 1a, ventral face of centrodorsal,  $\times 8$  (Carpenter, 1888); 1b, cirrus,  $\times 8$  (Clark, 1915a); 1c, cup with centrodorsal,  $\times 8$  (Carpenter, 1888).

*Decametra* A. H. CLARK, 1911, p. 31 [\**D. moebius*; SD A. H. CLARK, 1911g, p. 774] [= *Prometra* A. H. CLARK, 1912c, p. 321 (type, *Colobometra chadwicki* A. H. CLARK, 1911c, p. 30; OD)]. Recent.

*Embryometra* GISLÉN, 1938, p. 12 [\**E. mortensenii*; OD]. Recent.

*Epimetra* A. H. CLARK, 1911, p. 542 [\**E. nymphea*; OD]. Recent.

*Gislenometra* A. H. CLARK, 1947, p. 57 [\**G. perplexa*; OD]. Recent.

*Iconometra* A. H. CLARK, 1929, p. 643 [\**I. speciosa*; OD]. Recent.

*Oligometra* A. H. CLARK, 1908, p. 126 [\**Antedon serripinna* CARPENTER, 1881d, p. 182 (= *O. pulchella* A. H. CLARK, 1908k, p. 226; *O. concinna* A. H. CLARK, 1912c, p. 172); OD]. Centrodorsal low discoidal with a single circle of cirri. Arms divided at primibrachs 2 only. Recent.—FIG. 595,4. \**O. serripinna* (CARPENTER); 4a, cup with centrodorsal,  $\times 12$ ; 4b,c, cirrus,  $\times 8$  (4a, Clark, 1921; 4b,c, Clark, 1915a).

*Oligometrides* A. H. CLARK, 1913, p. 37 [\**Comatulula adeonae* LAMARCK, 1816, p. 535 (= *Ante-*

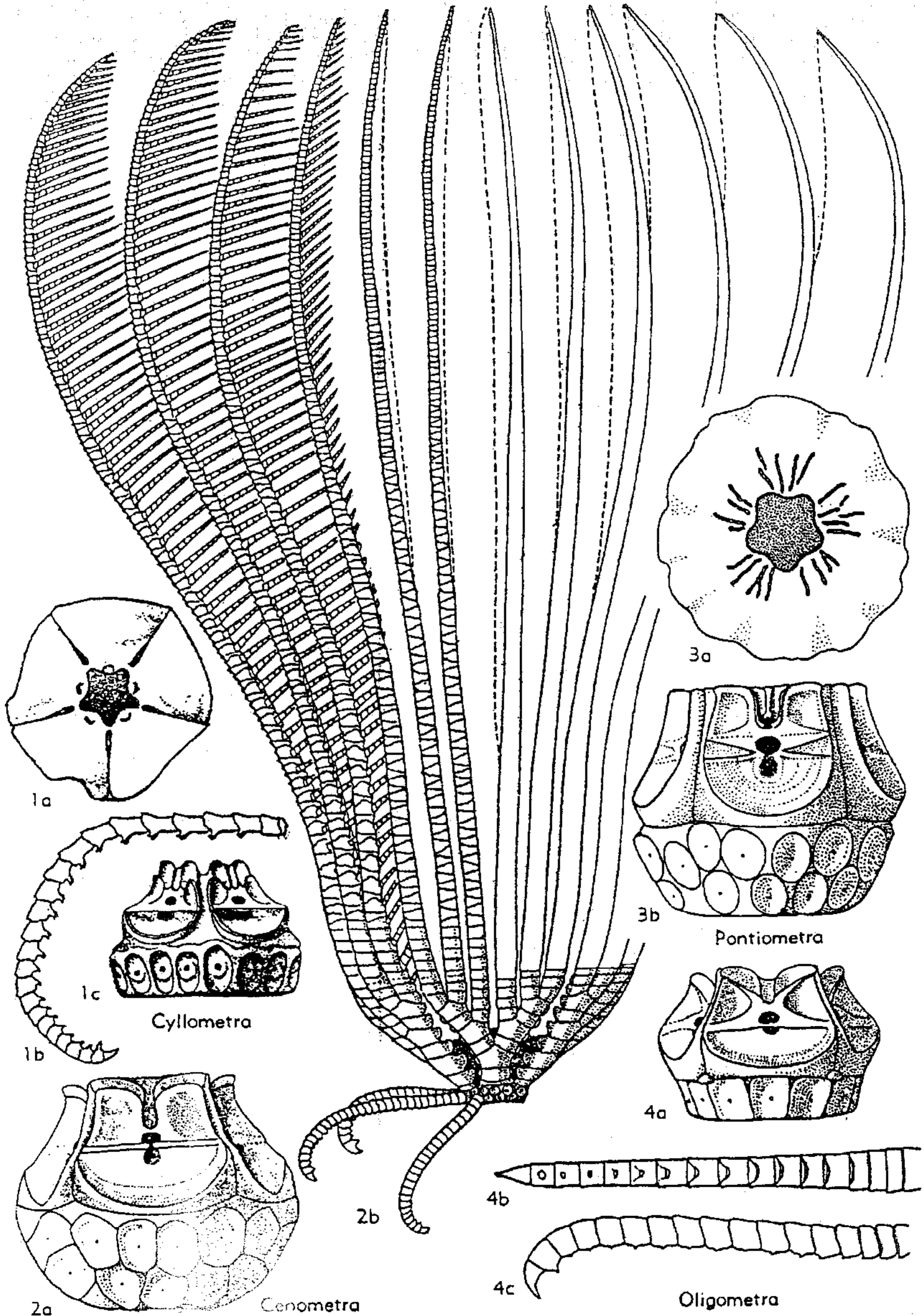


FIG. 595. Colobometridae (p. T891, T893).

*don bidens* BELL, 1884, p. 158); M]. Recent.  
*Petasometra* A. H. CLARK, 1912, p. 25 [\**Antedon clarac* HARTLAUB, 1890, p. 174; OD]. Recent.  
*Pontiometra* A. H. CLARK, 1907, p. 354 [\**Antedon andersoni* CARPENTER, 1889, p. 306 (= *P. insperatus* A. H. CLARK, 1909c, p. 397); OD]. Centrodorsal low hemispherical to rather high discoidal with 2 to 3 circles of cirri. Ventral side of centrodorsal with irregular radiating coelomic furrows. Arms divided at primibrachs 2, secundibrachs 2, generally tertibrachs 2, and often some quartibrachs 2, exceptionally some quinquibrachs 2. Recent.—FIG. 595,3. \**P. andersoni* (CARPENTER); 3a, ventral face of centrodorsal,  $\times 7$ ; 3b, cup with centrodorsal,  $\times 6$  (3a, Clark, 1915a; 3b, Clark, 1921).

## Superfamily TROPIOMETRACEA

A. H. Clark, 1908

[*nom. transl.* RASMUSSEN, herein (ex Tropiometridae A. H. CLARK, 1908g, p. 135)] [=Tropiometrida A. H. CLARK, 1932b, p. 560, incl. Thalassometroida A. H. CLARK, 1908j, p. 722; Thalassometrida GISLÉN, 1924, p. 231 (*nom. van.*)]

Comatulids with distinctly prismatic pinnules, triangular in section with a dorsal keel (unknown in most fossil species). Taking a carinate section of pinnules as a decisive feature in CLARK's concept of this superfamily, a considerable variation in other features is found. Centrodorsal hemispherical or conical to truncated conical, columnar or discoidal. Adult specimens often with flattened, cirrus-free dorsal area, which may be rugose or tuberculate. With or without a radial dorsal star, radial pits and subradial cleft. Cirrus sockets large, without distinct ornament or with articular tubercles and in some genera with marginal crenellae. Sockets arranged in (five or) 10 distinct columns or irregular and crowded, tending to form 10, 15 or 20 lateral columns. Cirrals with or without dorsal spine. Centrodorsal cavity narrow to moderate, generally less than three-tenths of centrodorsal diameter except for very small specimens. Rod-shaped basals present, generally exposed in interradial points. Surface of radials variable, often low or concealed, but may be moderate to large and recumbent or overhanging. Articular face of radials gently sloping to steep, almost vertical and often high. Ventral muscular fossae low and wide or high and wide or narrow. Radial cavity narrow to wide. Arms divided at primibrachs 2 and commonly at secundibrachs 2 and tertibrachs

2, seldom quartibrachs 2, in some species secundibrachs 4 and tertibrachs 4. Synarthry at brachials 1-2 may be flat or embayed, often narrow. Syzygy at brachials 3-4, seldom at brachials 1-2 or distal branches. Further syzygy with variable intervals through distal branches. Pinnulation complete. Distal pinnules extend beyond tip of arm. Ambulacral covering plates often distinct along pinnules. Mouth central. *U. Jur.*; *U. Cret.-L. Paleoc.*; *Eoc.-Plio.* [recent, *Pac.O.-Ind.O.-Atl.O.*, 0-3,000 m.].

## Family TROPIOMETRIDAE

A. H. Clark, 1908

[Tropiometridae A. H. CLARK, 1908g, p. 135]

Centrodorsal large, thick discoidal to low columnar with large, flattened, cirrus-free dorsal area. Cirrus sockets large, without distinct ornament, arranged in a few irregular lateral circles, tending to form 15 or 20 short columns. Cirri stout, rather short, without dorsal spines. Cirrals short, generally wider than long, 20 to 40 in number. Distal cirrals may be laterally compressed. No dorsal star. Shallow radial depressions at edge of centrodorsal cavity may be indicated. Rod-shaped basals present, not united around center, distally tapering and seldom exposed on surface. Free surface of radials low and outward-sloping, or concealed. Radial articular face steep and wide, meeting along interradial suture. Ventral muscular fossae large, wide, and rounded with proximal muscular plate. Muscular fossae about twice as high as interarticular ligament fossae, and separated from these by a ridge almost parallel to fulcral ridge. Radial cavity wide; no central plug. Primibrachs 1 low and wide; primibrachs 2 axillary; no further division of arms. Synarthry at primibrachs 1-2 and secundibrachs 1-2. Syzygy at secundibrachs 3-4 and with intervals of generally 4 to 9 muscular articulations. Brachials wider than long. Pinnules without distinct ambulacral covering plates. Recent, *Pac.O.-Ind.O.-Atl.O.* [trop. and subtrop., 0-508 m.].

*Tropiometra* A. H. CLARK, 1907, p. 349 [\**Comatula carinata* LAMARCK, 1816, p. 535 (= ?*Alecto carinata* LEACH, 1815, p. 63); OD]. Characters of family. Recent.—FIG. 596,5. \**T. carinata* (LAMARCK);  $\times 6$  (Clark, 1921).

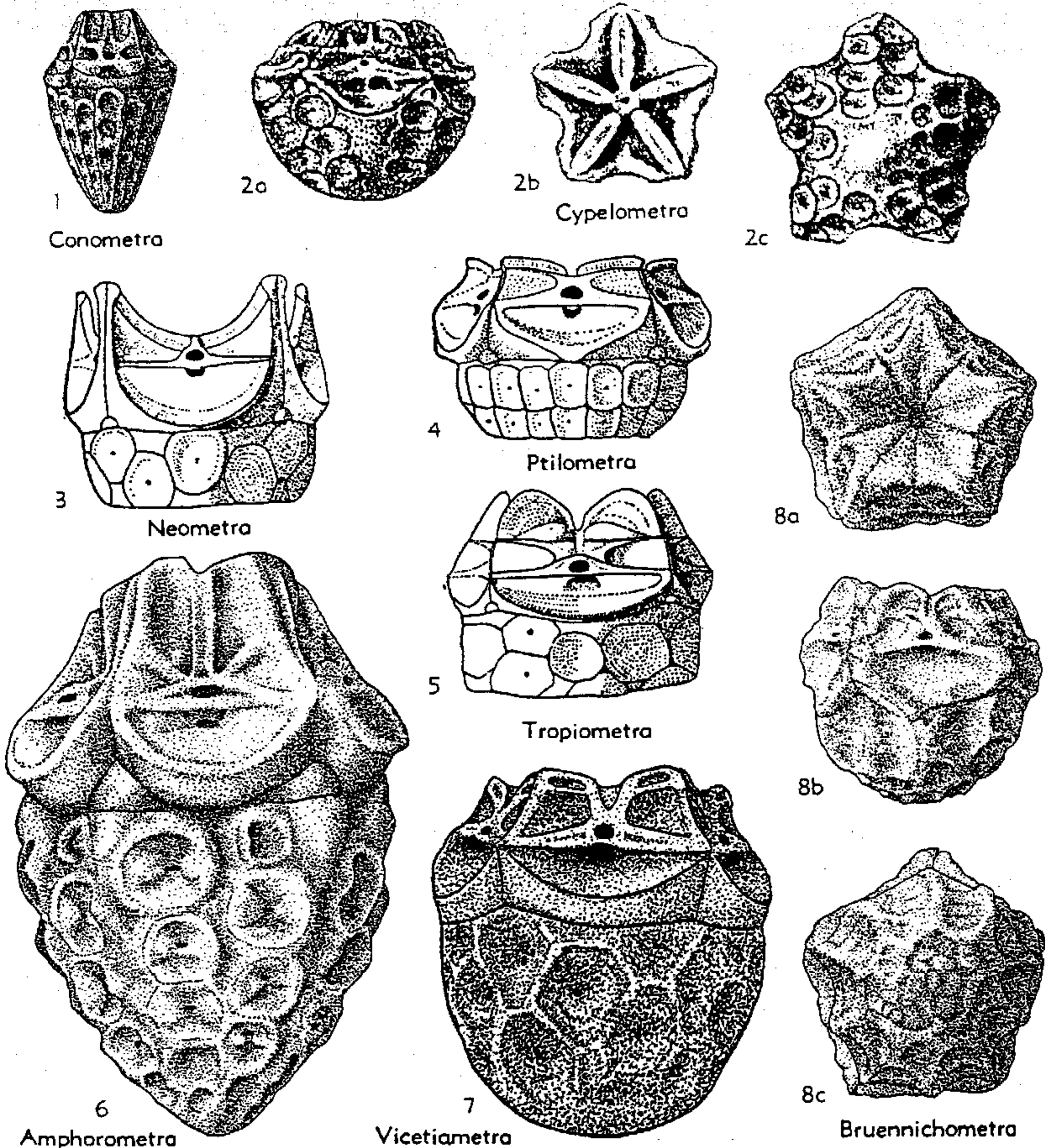


FIG. 596. Tropiometridae (5); Conometridae (1,2,6-8); Calometridae (3); Ptilometridae (4) (p. T893, T896-T898).

### Family PTEROCOMIDAE

Rasmussen, new family

Centrodorsal very small, conical or truncated conical to low columnar or discoidal, often with a large, rounded or flattened, smooth dorsal side. No radial dorsal star; no radial pits in ventral surface of centrodorsal. Centrodorsal cavity narrow, 0.2 to 0.3 of centrodorsal diameter. Few, large cirrus sockets, one to three in each radial side. Sockets without distinct ornament or with articular tubercles and marginal crenel-

lae. Rod-shaped basals exposed in interradial point or concealed, united around central cavity. No subradial cleft. Radials with greatly overhanging, almost horizontal, smooth free surface. Articular face of radials almost vertical, wide and high. Ventral muscular fossae large, separated from interarticular ligament by slightly oblique ridge. Ventral edge wide, concave, with or without a median incision. Radial cavity very large and wide. *U. Jur.*; *U. Cret.-L. Paleoc.*

*Pterocoma* AGASSIZ, 1836, p. 193 [*Comatula pinnata* GOLDFUSS, 1831, p. 203 (= *Asteriatites pen-*

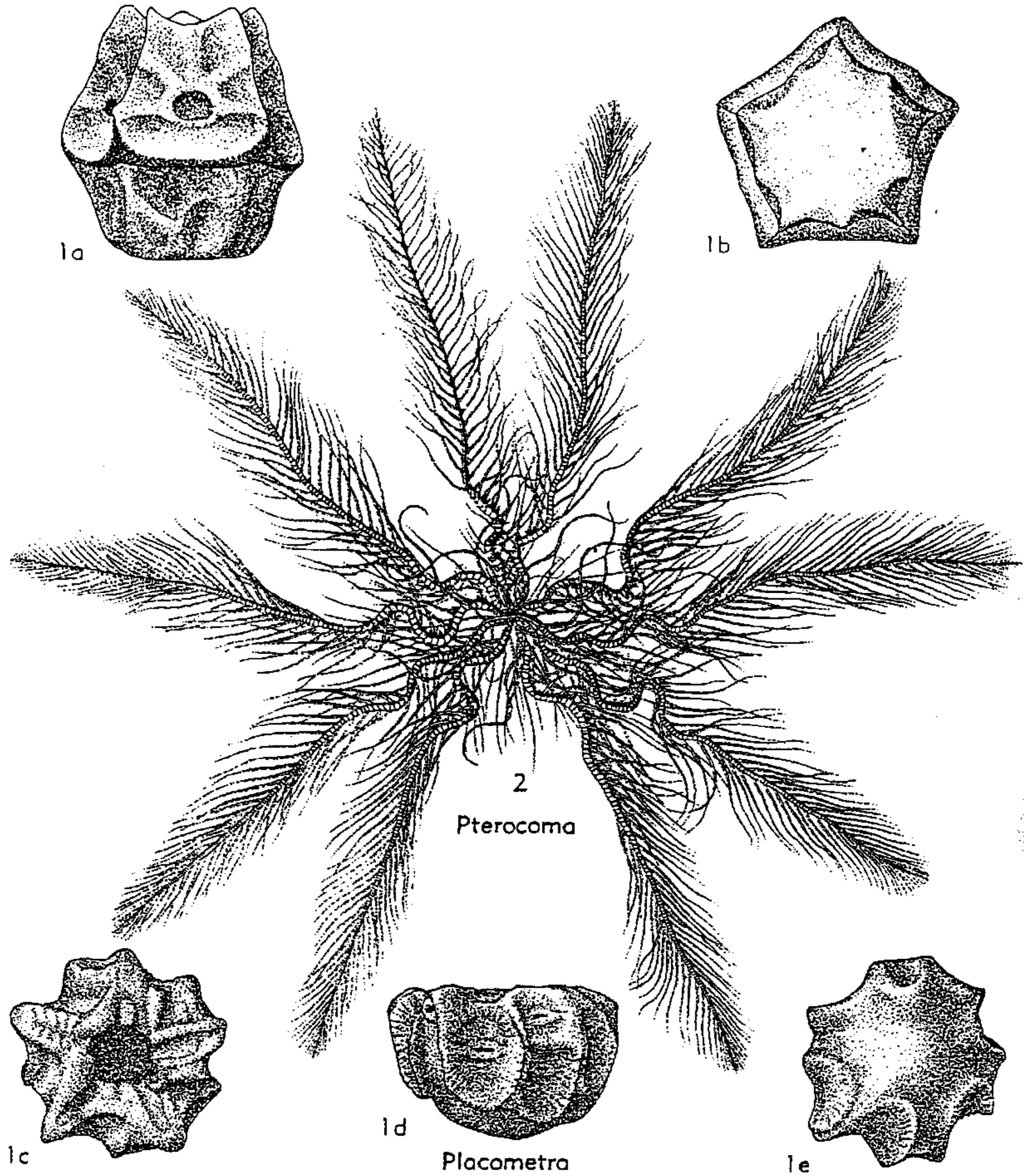


FIG. 597. Pterocomidae (p. T894-T896).

*natus* VON SCHLOTHEIM, 1813, p. 68, *pro* KNORR & WALCH, 1768, pl. 51); M] [= *Comatulithes* VON SCHLOTHEIM, 1823, p. 47, name not available (*Code*, Art. 20), used in combination *C. mediterrancaeformis pro Ophiurites pennatus* VON SCHLOTHEIM, 1820, p. 326 (= *Asteriatites pennatus*, obj.); *Comaturella* MÜNSTER, 1839, p. 85 (type, *C. wagneri*; M)]. [The names *Asteriatites* and *Ophiurites* have been used for *Pterocoma* and *Saccocoma*; see also p. T927. The name *Geocoma* used by FRAAS (1878) for this species was established by D'ORBIGNY (1850, p. 381) for an ophiuroid]. Centrodorsal discoidal, less than 2 mm.

in diameter, dorsal side apparently flattened. Cirrus sockets 10 in a single marginal circle. Cirri up to 25 mm., slender, with about 25 long cirrals without dorsal spines. Distal cirrals very long and slender, length 2 or 3 times width or more, laterally compressed. Cirri tapering to a point, without opposing spine. Centrodorsal cavity about 0.3 of centrodorsal diameter. No radial pits. Rod-shaped basals exposed on surface in interradial point, and apparently united around a central canal in bottom of radial cavity. Free dorsal surface of radial ring contiguous, almost horizontal, low in midradial area, but continued along inter-

radial suture, separating neighboring primibrachials. Articular face of radials almost vertical, wide, with distinct muscular fossae and wide upper margin divided by a median notch. Primibrachs 1 low and wide. Primibrachs 2 axillary, no further division of arms. Primibrachs 1-2 and secundibrachs 1-2 synarthrial. Syzygial articulations with many radiating crenulae at secundibrachs 3-4 and with intervals of 4 to 5 secundibrachials. Arms up to 130 mm. in length. Secundibrachials rather long, slightly oblique, distal brachials more than twice as long as wide, slender, and articulations almost perpendicular to arm. Pinnules long, up to 15 mm., with 15 to 20 pinnulars, extremely slender, swollen at the articulations, apparently without terminal hooks or comb, but with a longitudinal ridge or crest, which may be serrate. Short proximal pinnulars 1 or 2, succeeded by very long pinnulars, length 4 to 7 times greatest width, not differentiated in size or form. Most distal pinnules, although extremely slender, appear as long as more proximal ones. Ambulacral groove distinct. Large covering plates have been recorded. Surface of cirri, brachials and pinnulars with fine, reticulate to longitudinal ornament. [The present description is based on preparation of a few, insufficiently exposed specimens from the Upper Jurassic limestone of Solnhofen.] *U. Jur.*, Eu. (Ger., Solnhofen); *U. Cret. (Turon.)*, Asia (Lebanon).—FIG. 597, 2. \**P. pennata* (VON SCHLOTHEIM), *U. Jur.*, Ger. (Solnhofen);  $\times 0.5$  (Goldfuss, 1831).

*Placometra* GISLÉN, 1924, p. 162 [\**P. mortenseni*; OD]. Centrodorsal high conical or truncated conical to low columnar, generally with large, rounded or flattened, smooth dorsal side. No radial dorsal star, but central pit or feeble interradial impressions may be present. No radial pits in ventral side of centrodorsal. Centrodorsal cavity 0.2 to 0.3 of centrodorsal diameter, and with overhanging edge. A few very large, high elliptical cirrus sockets, 1 to 3 in each radial side (often only one large, and at the ventral margin a small juvenile socket). Sockets without distinct ornament or with articular tubercles and marginal crenulae. Rod-shaped basals not exposed. Radials, known only in type species, with narrow, overhanging, almost horizontal, smooth surface. Articular face very high and wide, almost vertical, meeting articular face of neighboring radial along interradial suture. Ventral muscular fossae large, median ridge faint, ventral edge wide, concave, without median incision. Brachials, pinnules and cirri unknown. *U. Cret. (Turon.)-L. Tert. (Dan.)*, Eu. (Denm.-Eng.-Ger.).—FIG. 597, 1a, b. \**P. mortenseni*, *U. Cret. (Turon.)*, Eng.; 1a, b, lat. and dorsal side of cup with centrodorsal,  $\times 14$  (Rasmussen, 1961).—FIG. 597, 1c-e. *P. laticirra* (CARPENTER), *U. Cret. (Maastricht.)*, Ger.; 1c-e, centrodorsal,  $\times 14$  (Rasmussen, 1961).

### Family CONOMETRIDAE Gislén, 1924

[Conometridae GISLÉN, 1924, p. 159]

Centrodorsal conical or truncated conical to hemispherical with or without rounded or flattened dorsal area. No dorsal star, no radial pits. Cirrus sockets without distinct ornament or with feeble articular tubercles. Sockets arranged in 10, exceptionally 15, distinct columns of three to six sockets, increasing in size upward, and often separated by radial or interradial spaces or ridges. Centrodorsal cavity narrow, 0.2 to 0.3 of centrodorsal diameter or in very small specimens larger. Rod-shaped basals exposed in interradial points or concealed. Radials generally with a free dorsal surface. Articular face of radials generally high, with high and narrow ventral muscular fossae surrounding narrow radial cavity, but may be lower and wider with rather low and wide muscular fossae, and radial cavity funnel shaped, strongly widened at ventral edge. *U. Cret. (Cenoman.)-L. Paleoc.*; *Eoc.-Mio.*

This family includes fossil genera resembling modern Tropiometracea in form of centrodorsal and radials and in arrangement of cirrus sockets. Pinnules are unknown. The genera *Placometra* and *Jaekelometra* have been transferred to other families.

*Conometra* GISLÉN, 1924, p. 166 [\**Alecto alticeps* PHILIPPI, 1844, p. 540; OD]. Similar to *Amphorometra* but with 15 distinct columns of 4 to 5 cirrus sockets, or crowded, tending to form 20 columns. Centrodorsal high conical. Basals not exposed. No subradial cleft. Ventral muscular fossae moderate to high. Radial cavity narrow. *Tert. (Eoc.-Mio.)*, Eu. (Italy).—FIG. 596, 1. \**C. alticeps* (PHILIPPI), *Eoc.*, Italy;  $\times 5$  (Philippi, 1844).

*Amphorometra* GISLÉN, 1924, p. 159 [\**Glenotremites conoideus* GOLDFUSS, 1840, p. 286; OD]. Centrodorsal conical or slightly truncated conical. No radial pits, no dorsal star or dorsal impressions. Centrodorsal cavity 0.2 to 0.3 of centrodorsal diameter, in very small specimens up to 0.5 of diameter, with overhanging edge. Cirrus sockets with narrow axial canal and indistinct fulcral ridge, but no marginal crenellae. Sockets arranged in 10 distinct columns. Proximal cirrals short, smooth, higher than wide, elliptical in section, not carinate. Rod-shaped basals exposed in interradial point or concealed. Generally with a subradial cleft. Radials generally with a free dorsal surface. Articular face of radial high, rather flat and steep. Ventral muscular fossae high and

narrow, separated from interarticular ligaments by oblique ridge. Radial cavity narrow. *U. Cret. (Cenoman.-Maastricht.), L. Tert. (Dan.), Eu. (Czech.-Denm.-Eng.-Ger.-Neth.)-Afr. (Tunisia).*—FIG. 596,6. *A. brydonei* GISLÉN, *U. Cret. (Campan.), Eng.*;  $\times 10$  (Rasmussen, 1961).

*Bruennichometra* RASMUSSEN, 1961, p. 339 [*\*Antedon danica* NIELSEN, 1913, p. 100; OD]. Centrodorsal truncated conical to hemispherical with a flattened, cirrus-free, rugose or granulated dorsal area. No dorsal star or radial pits. Centrodorsal cavity narrow, about 0.2 to 0.3 of centrodorsal diameter, relatively smaller in large specimens. Large cirrus sockets with fulcral ridge or tubercles, but no marginal crenulae, forming 10 short columns of 1 to 3 sockets. Rod-shaped basals concealed, united around center. No subradial cleft. Radials with small or no free dorsal surface. Edge of the radials may project downward in the midradial area between the uppermost cirrus sockets. Articular face of radials flat, low, wide, steep, almost vertical. Ventral muscular fossae similar to interarticular ligament fossae or smaller. Ventral edge wide, slightly curved with a shallow median incision. Muscular fossae separated from ligaments by diagonal or almost horizontal ridge. Radial cavity funnel shaped, narrow, but greatly expanded at the top. Proximal brachials smooth or granulated, commonly with median crest. Primibrachs 2 axillary, primibrachs 1 to 2 and secundibrachs 1 to 2 synarthrial. Primibrachs 1 laterally joining neighboring plates. Distal brachials with muscular and syzygial articulations. *L. Paleoc. (Dan.), Eu. (Denm.)*.—FIG. 596,8. *B. granulata* (NIELSEN), *Dan., Denm.*; *8a-c*, cup with centrodorsal,  $\times 10$  (Rasmussen, 1961).

*Cypelometra* GISLÉN, 1924, p. 159 [*\*Antedon iheringi* DE LORIO, 1902, p. 22; OD]. Centrodorsal hemispherical to subconical, dorsally rounded. Cirrus sockets with indistinct articular tubercles form 10 columns of 3 to 4 sockets well separated by a slightly vermiculate radial area. Rod-shaped basal rays commonly concealed, but may be exposed in interradial point. Centrodorsal cavity narrow. Radials with very low, free surface. Articular face of radials gently curved. Interarticular ligament fossae rather small. Ventral muscular fossae similar in shape, separated by midradial ridge. Radial cavity narrow. *U. Tert. (Mio.), S. Am.*—FIG. 596,2. *\*C. iheringi* (DE LORIO); *2a-c*, cup with centrodorsal; *2b,c*, ventral and dorsal views;  $\times 2$  (de Loriol, 1902).

*V. albertinii* MALACOVA, 1950, p. 6 [*\*V. albertinii*; *U. Cret. (Campan.), Eng.*]. Centrodorsal hemispherical to truncated subconical, dorsally rounded, cirrus-free, slightly flattened. No dorsal star or impression. Cirrus sockets with distinct ridge or ornament. Muscular fossae more or less forming 15 columns of 2 sockets. Basals not exposed. Ventral edge low. Articular face low,

wide, rather steep. Interarticular ligament fossae large. Ventral muscular fossae very low, forming narrow bands along ventral edge. Midradial furrow. Radial cavity large. *Tert. (up. Eoc.), Eu. (Italy)*.—FIG. 596,7. *\*V. albertinii*; cup with centrodorsal,  $\times 8.5$  (after Malacoda, 1950).

## Family CALOMETRIDAE.

A. H. Clark, 1911

[Calometridae A. H. CLARK, 1911c, p. 649]

Centrodorsal discoidal to low hemispherical with a large, flattened, cirrus-free dorsal side. No dorsal star. Large cirrus sockets without distinct ornament are crowded in one or two (seldom three) irregular lateral circles, often corresponding to 15 to 20 short, irregular columns. Cirrals short, distal ones with ridge or spine. Ventral side of centrodorsal without radial pits. No subradial cleft. Rod-shaped basals exposed in interradial point or concealed. Free surface of radials low or lacking in midradial area, but continued from lateral area along interradial suture, separating crescentic articular face of neighboring radials. Articular face of radials steep and wide, with strongly reduced, low muscular fossae forming narrow, curved bands along concave ventral edge of radial. Radial cavity very wide. Arms divided at primibrachs 2 and commonly further divided at secundibrachs 2 (exceptionally at secundibrachs 4), tertibrachs 2 and quartibrachs 2. Synarthry at brachials 1-2, syzygy at brachials 3-4 and more distally with intervals of 2 to 7. First pinnule small and slender, with two proximal pinnulars expanded. Pinnules with distinct ambulacral covering plates. Recent, in Pac.O.-Ind.O. [500-600 m.].

*Calometra* A. H. CLARK, 1907, p. 362 [*\*Antedon callista* A. H. CLARK, 1907d, p. 135; OD]. Recent.

*Gephyrometra* A. H. CLARK, 1912, p. 184 [*\*Antedon versicolor* A. H. CLARK, 1907d, p. 132; OD]. Recent.

*Neometra* A. H. CLARK, 1912, p. 181 [*\*Antedon multicolor* A. H. CLARK, 1907d, p. 130; OD]. Arms widely separated, and branching under a very large angle at primibrachs 2, some or all secundibrachs 2, and commonly some tertibrachs 2. Second and third pinnules long. Recent.—FIG. 596,3. *\*N. multicolor* (CLARK);  $\times 9$  (Clark, 1921).

*Pectinometra* A. H. CLARK, 1912, p. 185 [*\*Antedon flavopurpurea* A. H. CLARK, 1907d, p. 134; OD]. Recent. [= *Pectinometra* GISLÉN, 1924, p. 54 (nom. null.).]

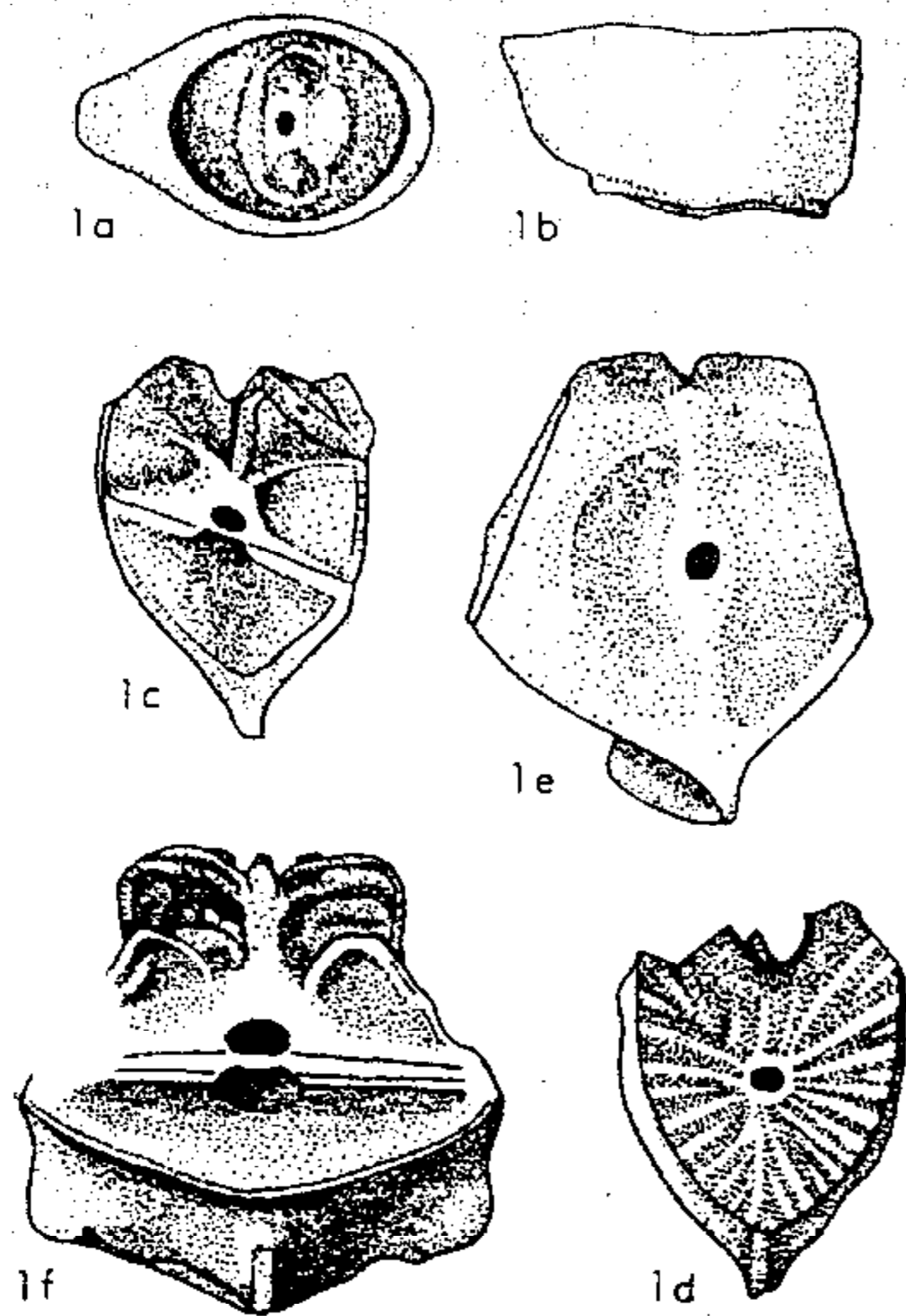


FIG. 598. Isolated plates referred to Asterometridae, Plio., Indon.; 1a,b, cirral,  $\times 12$ ; 1c-e, synarthrial, syzygial and muscular articulations,  $\times 12$ ; 1f, radial,  $\times 5$  (Sieverts, 1933a).

*Reometra* A. H. CLARK, 1934, p. 14, *nom. subst. pro Oreometra* CLARK, 1912c, p. 179 (*non Oreometra* AURIVILLIUS, 1910) [*\*O. mariaae* CLARK, 1912; OD]. Recent.

#### Family PTILOMETRIDAE A. H. Clark, 1914

[*nom. transl.* GISLÉN, 1934 (*ex subfamily Ptilometrinae* A. H. CLARK, 1914b, *emend.* GISLÉN, 1924)]

Centrodorsal large, rather high discoidal to low columnar with a flat, cirrus-free dorsal side. Cirrus sockets without distinct ornament are arranged in 15 to 20 irregular lateral columns of two to four sockets. No dorsal star, nor radial pits. Cirrals rather short, distal cirrals with ridge or spine. Rod-shaped basals exposed on surface in interradial point. No subradial cleft. Radials with low, free surface. Articular face steep, low and wide. Ventral muscular fossae low, forming a narrow band along ventral edge of radial. Radial cavity wide. Arms divide at primibrachs 2, some or all at secundibrachs 2, and in some specimens at some tertibrachs 2. Synarthrial articulation

at brachials 1-2, syzygial articulations at brachials 3-4 and more distal with intervals of 4 to 9. Pinnules with distinct ambulacral covering plates. Recent [Australia, 0-113 m.].

*Ptilometra* A. H. CLARK, 1907, p. 358 [*\*Alecto macronema* MÜLLER, 1841 (error for *Comatula macronema* MÜLLER, 1846, p. 179); OD]. Characters of family. Recent.—FIG. 596,4. *P. australis* (WILTON);  $\times 6$  (Clark, 1921).

#### Family ASTEROMETRIDAE Gislén, 1924

[*Asterometridae* GISLÉN, 1924, p. 231]

Centrodorsal rather small, five-sided, low columnar to truncated subconical with cirrus-free, flattened, low conical to concave apex, often with five radial tubercles, each of which may show pits or canals, forming a dorsal star. Large cirrus sockets without distinct ornament are arranged in 10 vertical columns of two to three (or four) sockets, often separated by radial and inter-radial furrows or ridges. Ventral surface of centrodorsal similar to *Notocrinidae* with narrow but multiple, deep radial pits, which in juvenile specimens may form canals to dorsal star. Cirri long and slender with more than 50 cirrals. Cirrals may be laterally compressed with distal projection or spine on ventral side, and in distal cirrals with a dorsal spine. Length of cirrals may exceed their width. Rod-shaped basals generally exposed on surface in interradial point, not united around centrodorsal cavity. No subradial cleft. Radials with free dorsal surface. Articular face of radials moderately sloping, ventral muscular fossae steep, high and narrow. Radial cavity narrow to moderate, with central plug. Arms divided at primibrachs 2, generally at secundibrachs 2 and often at some tertibrachs 2 and quartibrachs 2. Synarthry at brachials 1-2, syzygy at brachials 3-4 and more distally with intervals of 5 to 12. Pinnules with distinct ambulacral covering plates. Radials and proximal brachials often with a median ridge, distal brachials angular in section (Fig. 598). *U.Tert.(Plio.)*; recent, Pac.O. [5-256 m.]. [Radials, brachials and cirrals from the Pliocene of Indonesia have been referred by SIEVERTS (1933b) to this family without record of genus or species. GISLÉN (1924) referred this family to *Notocrinacea*, also having radial pits, but CLARK



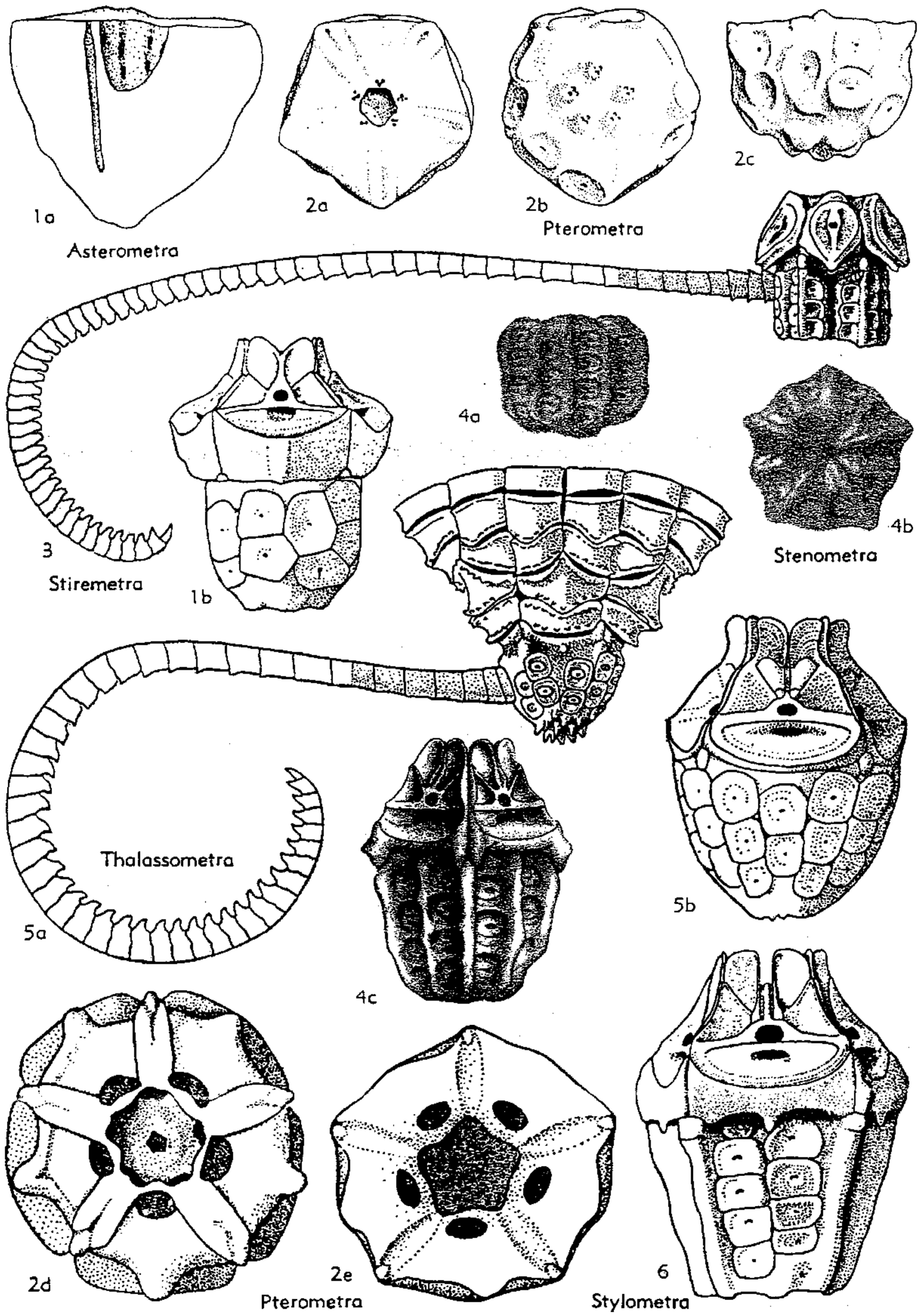


FIG. 599. Asterometridae (1,2); Thalassometridae (3-6) (p. T900-T901).

1947) placed the family in Tropiometridae.]

*Asterometra* A. H. CLARK, 1907, p. 358 [\**Antedon macropoda* A. H. CLARK, 1907d, p. 136; OD]. Arms divided at primibrachs 2, and often some secundibrachs 2. Cirrals without constriction or spine. Recent.—FIG. 599,1a. *A. anthus* (CLARK); sec. through centrodorsal with coelomic canals,  $\times 10$  (Gislén, 1924).—FIG. 599,1b. \**A. macropoda* (CLARK),  $\times 6$  (Clark, 1921).

*Pterometra* A. H. CLARK, 1909, p. 177 [\**Ptilometra trichopoda* A. H. CLARK, 1908i, p. 224; OD]. Arms divided at primibrachs 2, secundibrachs 2, some or all tertibrachs 2, and often some quartibrachs 2. Distal cirrals with ventral ridge or spine, and centrally more or less constricted. Recent.—FIG. 599,2a-c. *P. pulcherrima* (CLARK); 2a-c, centrodorsal,  $\times 6$  (A. M. Clark, 1972).—FIG. 599,2d,e. \**P. trichopoda* (CLARK); 2d, underside of cup; 2e, ventral face of centrodorsal;  $\times 16$  (Gislén, 1924).

### Family THALASSOMETRIDAE A. H. Clark, 1908

[Thalassometridae A. H. CLARK, 1908g, p. 136]

Centrodorsal variable, conical or hemispherical to truncated conical, columnar or discoidal, with rounded or flattened, cirrus-free, rugose to tuberculate or spiny dorsal area. No dorsal star, no radial pits. Cirrus sockets large, without distinct ornament or with articular tubercles, arranged in 10 distinct lateral columns of two to four sockets on side of conical, truncated conical or columnar centrodorsals, or irregularly crowded and tending to form 10 or 15 columns of one to three sockets, mainly in larger, truncated or discoidal centrodorsals. Cirri long and slender with 25 to more than 80 cirrals. Distal cirrals short, generally with prominent dorsal processes or spines. Rod-shaped basals exposed in interrarial point or concealed. A subradial cleft may be present. Radials with low, free surface or concealed. Articular face moderately sloping, more or less angularly bent. Muscular fossae steep, high and narrow, separated from interarticular ligament by diagonal ridge. Radial cavity narrow. Arms divided at primibrachs 2 and generally at secundibrachs 2 or secundibrachs 4, further divided with interval of two or four brachials may occur in some arms. Synarthry at brachials 1-2, syzygy at brachials 3-4, or exceptionally at brachials 2-3 of distal branches. Centrodorsal articular articulations with various numbers of 2 to 17,

generally 4 to 9. Brachials may be dorsally rounded or laterally compressed and with dorsal ridge or spines. Often with marginal spines. First pinnule longer and more stout than second. Some proximal pinnulars may be enlarged. Pinnules with distinct ambulacral covering plates. *U.Tert.(Mio.)*; recent in Pac.O.-Ind.O.-Atl.O. [22-about 3,000 m.].

*Thalassometra* A. H. CLARK, 1907, p. 359 [\**Antedon villosa* A. H. CLARK, 1907d, p. 138; OD]. Arms divided at primibrachs 2, in some species at secundibrachs 4 and secundibrachs 2, seldom at tertibrachs 4. Brachials dorsally rounded. Recent.—FIG. 599,5a. *T. marginata* CLARK;  $\times 4$  (Clark, 1915a).—FIG. 599,5b. \**T. villosa* (CLARK);  $\times 9$  (Clark, 1921).

*Aglaometra* A. H. CLARK, 1913, p. 47 [\**Antedon valida* CARPENTER, 1888, p. 104; SD A. H. CLARK, 1950]. Recent.

*Cosmiometra* A. H. CLARK, 1909, p. 16 [\**Thalassometra komachi* A. H. CLARK, 1908i, p. 311 (= *Antedon aster* A. H. CLARK, 1907d, p. 145); OD]. Recent.

*Crotalometra* A. H. CLARK, 1909, p. 80 [\**C. rustica*; M]. Recent.

*Daidalometra* A. H. CLARK, 1916, p. 116 [\**Antedon hana* A. H. CLARK, 1907d, p. 137; OD]. Recent.

*Horacometra* A. H. CLARK, 1918, p. 160 [\**Antedon duplex* CARPENTER, 1888, p. 212; M]. Recent.

*Kochlermetra* A. H. CLARK, 1950, p. 100 [\**Antedon porrecta* CARPENTER, 1888, p. 250; OD]. Recent.

*Leilametra* A. H. CLARK, 1932, p. 379 [\**L. necopinata*; OD]. Recent.

*Lissometra* A. H. CLARK, 1918, p. 147 [\**Antedon alboflava* A. H. CLARK, 1907d, p. 145; M]. Recent.

*Oceanometra* A. H. CLARK, 1916, p. 606 [\**Thalassometra gigantea* A. H. CLARK, 1908b, p. 222; OD]. Recent.

*Parametra* A. H. CLARK, 1909, p. 15 [\**Antedon orion* A. H. CLARK, 1907d, p. 143; OD]. Recent.

*Stenometra* A. H. CLARK, 1909, p. 14 [\**Antedon quinquecostata* CARPENTER, 1888, p. 215; OD]. Centrodorsal truncated conical to columnar with 10 columns of 2 to 4 cirrus sockets separated by interrarial ridges and alternating along midradial line. Arms divided at primibrachs 2 and secundibrachs 2. Brachials laterally compressed and carinate. [*Antedon pellati* DE LORIOI, 1897, is herein referred to this genus.] *U.Tert.(low.Mio.)*, Eu. (France); recent, Pac.O. [141-457 m.].—FIG. 599,4a,b. *S. pellati* (DE LORIOI), Mio., France; 4a,b, lat. and dorsal side of centrodorsal,  $\times 3$  (de Lorioi, 1897).—FIG. 599,4c. \**S. quinquecostata* (CARPENTER), recent;  $\times 6$  (Carpenter, 1888).

Stiremetra A. H. CLARK, 1909, p. 15 [\**Antedon acutiradia* CARPENTER, 1888, p. 113; OD]. Centrodorsal hemispherical or truncated conical to columnar, in some species five-sided columnar with 10 columns of cirrus sockets separated by interradii ridges and wide radial furrows. Arms divided at primibrachs 2, exceptionally at secundibrachs 2 or secundibrachs 4. Proximal brachials more or less carinate, distal brachials dorsally rounded. [*Antedon stellatus* NOELLI, 1901, is herein referred to this genus.] *U. Tert. (Mio.)*, Eu. (Italy); recent, Pac.O.-Ind.O.-Ad.O. [649-2,468 m.].—FIG. 599,3. *S. carinifera* CLARK, recent;  $\times 3$  (Clark, 1915a).

Stylometra A. H. CLARK, 1908, p. 245 [\**Antedon spinifera* CARPENTER, 1881c, p. 158; OD]. Centrodorsal with 10 columns of cirrus sockets separated by interradii ridges. Arms divided at primibrachs 2, secundibrachs 2, some tertibrachs 2, seldom quartibrachs 2. Distal brachials laterally compressed and carinate. Recent.—FIG. 599,6. \**S. spinifera* (CARPENTER);  $\times 8$  (Clark, 1921).

### Family CHARITOMETRIDAE

A. H. Clark, 1909

[*nom. transl.* A. H. CLARK, 1911g, p. 728 (*ex subfamily Charitometrinac* A. H. CLARK, 1909a, p. 2)]

Centrodorsal hemispherical, conical or truncated conical to discoidal with a rounded or flattened, cirrus-free, often rugose or tuberculate dorsal area, in some species of *Monachometra* with a radial dorsal star. No radial pits in ventral surface of centrodorsal. Cirrus sockets often with distinct articular tubercles, and in some genera with marginal crenellae. Sockets large, forming 10 distinct columns (in *Chondrometra* 5 or 10), or irregularly crowded, tending to form 10 to 15 short columns. Cirri short and stout. Cirrals without dorsal spines, may be laterally compressed. Rod-shaped basals exposed in interradii point or concealed. Commonly with a subradial cleft. Radials with a small, free surface or often concealed. Articular face of radials moderately sloping, not angularly bent. Muscular fossae high and narrow. Radial cavity narrow. Arms divided at primibrachs 2 and often at secundibrachs 2 or secundibrachs 4, exceptionally at some tertibrachs 2 or tertibrachs 4. Synarthry at brachials 1-2, syzygy at brachials 3-4 or in distal branches at brachials 1-2, and with variable interval of 2 to 26, generally 6 to 11. Arms may be dorsally rounded or laterally compressed

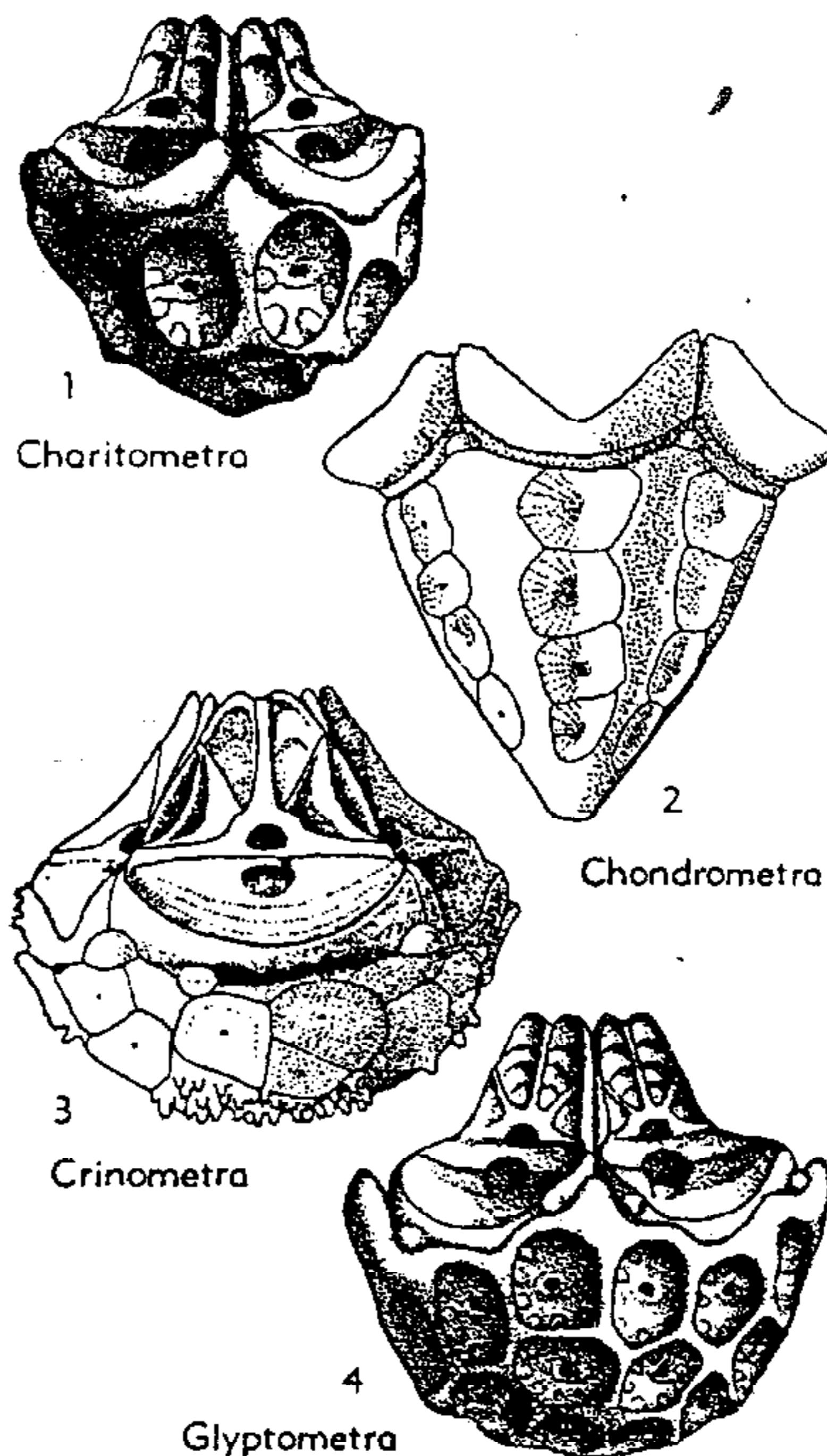


FIG. 600. Charitometridae (p. T901-T902).

and carinate, often with rugose or tuberculate surface. First and second pinnule slender, with numerous short pinnulars. Some proximal pinnulars may be enlarged and broadened. Pinnules with distinct ambulacral covering plates. Recent, Pac.O.-Ind.O.-Atl.O. [55-2,194 m.].

Charitometra A. H. CLARK, 1907, p. 360 [\**Antedon incisa* CARPENTER, 1888, p. 124; OD]. Centrodorsal hemispherical, cirrus sockets irregularly arranged. Sockets with marginal crenulae. Arms divided at primibrachs 2 only. Genital pinnules greatly expanded near proximal end. Recent.—FIG. 600,1. \**C. incisa* (CARPENTER);  $\times 6$  (Carpenter, 1888).

Chlorometra A. H. CLARK, 1909, p. 21 [\**Antedon garettiana* A. H. CLARK, 1907d, p. 142; OD] [= *Diodontometra* GISLÉN, 1922, p. 121 (type, *D. bocki*; M)]. Recent.

Chondrometra A. H. CLARK, 1916, p. 608 [\**Chlorometra robusta* A. H. CLARK, 1911b, p. 558; OD]. Centrodorsal conical or truncated with 5 or 10 columns of cirrus sockets. Arms divided at primi-

brachs 2 only. Distal brachials laterally compressed and carinate. Recent.—FIG. 600,2. \**C. robusta* (CLARK);  $\times 5$  (Clark, 1915a).

*Crinometra* A. H. CLARK, 1909, p. 22 [\**Comatula brevipinna* POURTALÈS, 1868, p. 111; OD]. Centrodorsal hemispherical to discoidal, dorsal area generally tuberculate, cirrus sockets irregularly arranged tending to form 10 to 15 columns. Arms divided at primibrachs 2, secundibrachs 2 or secundibrachs 4, and commonly at some tertibrachs 2. Brachials dorsally rounded. Recent.—FIG. 600,3. \**C. brevipinna* (POURTALÈS);  $\times 7$  (Clark, 1921).

*Glyptometra* A. H. CLARK, 1909, p. 18 [\**Antedon tuberosa* CARPENTER, 1888, p. 126; OD] [= *Pachylometra* A. H. CLARK, 1909a, p. 20 (type, *Antedon distincta* CARPENTER, 1888, p. 247; OD); *Crossometra* CLARK, 1916b, p. 606 (type, *Pachylometra investigatoris* A. H. CLARK, 1909b, p. 82; OD); *Calypometra* A. H. CLARK, 1916b, p. 608 (type, *Charitometra lateralis* A. H. CLARK, 1908b, p. 226; OD)]. Centrodorsal hemispherical or truncated conical. Cirrus sockets irregularly arranged, tending to form 10 or 15 columns. Sockets often with marginal crenulae. Arms divided at primibrachs 2, commonly at some or all secundibrachs 2 or secundibrachs 4, in some species also some tertibrachs 2 or tertibrachs 4. Recent.—FIG. 600,4. *G. inaequalis* (CARPENTER);  $\times 6$  (Carpenter, 1888).

*Monachometra* A. H. CLARK, 1916, p. 607 [\**Pachylometra fragilis* A. H. CLARK, 1912g, p. 79; OD] [= *Perissometra* A. H. CLARK, 1916b, p. 606 (type, *Antedon flexilis* CARPENTER, 1888, p. 217; OD); *Monachomera* PRESTON, 1924 (*nom. null.*)]. Recent.

*Poecilometra* A. H. CLARK, 1907, p. 361 [\**Antedon acoela* CARPENTER, 1888, p. 132; OD]. Recent.

*Strotometra* A. H. CLARK, 1909, p. 19 [\**Antedon hepburniana* A. H. CLARK, 1907d, p. 139; OD]. Recent.

## Superfamily NOTOCRINACEA Mortensen, 1918

[*nom. transl. et correct.* RASMUSSEN, herein (*ex family Notocrinidae* MORTENSEN, 1918, p. 10)] [= *Notocrinida* GISLÉN, 1924, p. 231 (established as a superfamily rank taxon although named subtribe), *emend.* A. H. CLARK, 1967, p. 1)]

Centrodorsal conical, truncated conical or hemispherical to discoidal. Dorsal area in adult specimens generally cirrus-free or with traces of obliterated cirrus sockets, often rugose. Most genera with five pits radially around apex or apical depression, forming radial dorsal star, in large specimens commonly in a depressed dorsal area. Some specimens also with shallow and indistinct, lanceolate interradiol pits around dorsal pole. Centrodorsal narrow to

moderate, 0.2 to 0.3 of centrodorsal diameter, always surrounded by, or exceptionally fused with, five radial pits for coelomic extensions outside chambered organ and nerve capsule of centrodorsal cavity. Cirrus sockets generally large, with more or less distinct articular tubercles, and in most fossil genera with marginal crenulae. Cirrus sockets in small or conical centrodorsals arranged in 10 columns, but in larger specimens of *Glenotremites* and *Remesimetra* increase in number during growth, tending to form 20 lateral columns on large, hemispherical to discoidal centrodorsals, and obliterated in dorsal area. In *Semiometra* sockets small, without distinct ornament, and closely alternating, without forming columns on very low discoidal centrodorsal. Rod-shaped basals present, often exposed in interradiol point. With or without subradial cleft. Radials with a low, free dorsal surface or concealed, may be more or less concave, reaching edge of centrodorsal only in interradiol points. Articular face of radials generally rather low and wide, but in *Semiometra* very high. Muscular fossae distinct, similar in size to interarticular ligament fossae or higher. Radial cavity narrow to wide and funnel shaped. Arms divided at primibrachs 2, no further divisions. Synarthrial articulations at primibrachs 1-2 and secundibrachs 1-2, syzygial articulations at secundibrachs 3-4 and more distally with variable intervals. Arms and pinnules dorsally rounded, not carinate. Pinnules short. No distal comb or dorsal crest in oral pinnules. Modern genera viviparous and with ambulacral covering plates moderately developed or missing. Mouth central. *M. Jur. (Bathon.)-U. Cret. (Maastricht.)*; ?*Eoc.*; recent, Antarctic and Austral. regions [0-640 m.].

## Family NOTOCRINIDAE Mortensen, 1918

[*Notocrinidae* MORTENSEN, 1918, p. 10]

Moderate to very large *Notocrinacea* with conical, truncated conical or hemispherical to discoidal centrodorsal, often wider and dorsally more flattened or concave in large specimens. Dorsal side of centrodorsal with a distinct dorsal star except in *Schlueterometra* and adult specimens of *Notocrinus*. Commonly with shallow interradiol impres-

sions. Ventral side of centrodorsal with distinct, commonly large and deep, radial pits. Cirrus sockets in *Notocrinus* and *Semiometra* without distinct ornament, in other genera with distinct articular tubercles and marginal crenulae. Sockets arranged in 10 to 20 columns or small and closely alternating without forming columns. Rod-shaped basals generally exposed in interradial point. With or without a subradial cleft. Radials with a low, free surface, or concealed and reaching edge of centrodorsal only in the interradial points. Articular face of radials rather steep and flat or concave. *M. Jur. (Bathon.)-U. Cret. (Maastricht.)*; ?*Eoc.*; recent.

*Notocrinus* MORTENSEN, 1917, p. 206 [\**N. virilis*; M]. Centrodorsal conical or truncated conical. Radial dorsal star consisting of five radial pores surrounding central pore or pit present in juvenile specimens. Cirrus sockets without distinct ornament arranged in 10 columns, or in large specimens crowded, tending to form 20 columns. Apical area cirrus-free, pointed or truncated, rugose. Cirri stout, rather long. Cirrals rather short and wide, distal cirrals laterally compressed. Ventral side of centrodorsal with five simple, very deep radial pits. Rod-shaped basals stout, centrally united, exposed in interradial point or concealed. No subradial cleft. Free dorsal surface of radial low to moderate. Articular face of radials rather steep and wide, not angularly bent or concave. Ventral muscular fossae rather wide, triangular, larger than interarticular ligament fossae. Ventral edge wide, with a broad and shallow median embayment. Radial cavity moderate. Arms large. Distal syzygial articulations with variable interval of 2 to 20. Pinnules with small ambulacral covering plates, but large side plates. Gonads in arm instead of in pinnules. Recent, Antarctic reg. [80-640 m.].—FIG. 601, 1. \**N. virilis*; 1a, cup with centrodorsal,  $\times 6$ ; 1b, underside of radials and basals,  $\times 8$ ; 1c, sec. through centrodorsal with radial pits,  $\times 8$  (1a-c, Gislén, 1924); 1d, crown and centrodorsal,  $\times 4$  (after Mortensen, 1918).

*Glenotremites* GOLDFUSS, 1829, p. 159 [*emend.* RASMUSSEN, 1961, p. 277 (The name was extended to a collective group name by GISLÉN, 1924, p. 123, but restricted by RASMUSSEN, 1961)] [\**G. paradoxus* (= *Antedon semiglobosus* SCHLÜTER, 1878, p. 41; *Antedon essenensis* SCHLÜTER, 1878, p. 40; *Antedon rugosa* CARPENTER, 1880a, p. 49; *Antedon perforata* CARPENTER, 1880b, p. 549; *Antedon lundgreni* CARPENTER, 1880b, p. 550; *Antedon striata* CARPENTER, 1880b, p. 551; *Comatula tetensi* WEGNER, 1913, p. 182; *Antedon minutissimus* VALETTE, 1917, p. 169; *G. batheri* GISLÉN, 1924, p. 128; *G. calcaratus* GISLÉN, 1925a,

p. 12; *G. adregularis* GISLÉN, 1925a, p. 14; *G. alternatus* GISLÉN, 1925a, p. 16; *G. parvistellatus* GISLÉN, 1925a, p. 17; *G. intermedius* GISLÉN, 1925a, p. 20; *Sphaerometra senonica* GISLÉN, 1925a, p. 25; *Antedon chateleti* VALETTE, 1932, p. 393); M] [= *Glenocrinus* D'ORBIGNY, 1852, p. 138 (*nom. van.*); *Sphaerometra* GISLÉN, 1924, p. 169 (type, *Antedon semiglobosus* SCHLÜTER, 1878, p. 41; OD)]. Centrodorsal hemispherical to discoidal with a radial dorsal star. Dorsal area in adult specimens cirrus-free and flattened or concave. Interradial dorsal impressions may be present. Cirrus sockets large, with a large axial canal, lateral articular tubercles and marginal crenulae. Sockets irregularly crowded, tending to form columns increasing in number from 10 to 20 during growth. Centrodorsal cavity narrow, 0.2 to 0.3 of centrodorsal diameter, surrounded by deep, single or double radial pits, which may exceptionally fuse with the centrodorsal cavity, primarily or secondarily. Rod-shaped basals exposed in interradial point and separated around central canal. Radials cover the entire ventral side of the centrodorsal and form a low, free dorsal surface. Articular face of radials rather large and steep, flat or concave, with distinct muscular fossae and interarticular ligament fossae separated by an oblique ridge. Radial cavity rather small to moderate. Primibrachs 2 axillary. Primibrachs 1-2 and secundibrachs 1-2 synarthrial. Pinnules and distal part of arms observed only in *G. loveni* (CARPENTER, 1880a) show syzygial articulations at secundibrachs 3-4, secundibrachs 9-10 and more distal with interval of 5 joints. Pinnules dorsally rounded, not carinate. *Cret. (Alb.-Santon.)*, Eu. (Czech.-Eng.-Ger.-Pol.).—FIG. 602, 1. \**G. paradoxus*, U. Cret. (Turon.), Eng.; 1a-c, small specimen,  $\times 5$ ; 1d-e, centrodorsal of small specimen,  $\times 5$ ; 1f-h, larger centrodorsal,  $\times 5$  (Rasmussen, 1961).

*Loriolometra* GISLÉN, 1924, p. 167 [\**Comaster retzii* LUNDGREN, 1875, p. 66; OD]. Centrodorsal large, high, columnar or slightly conical with rounded dorsal side and a dorsal pit or radial dorsal star. Faint interradial dorsal impressions may be present. Cirrus sockets large, with a large axial canal, lateral articular tubercles and marginal crenulae. Sockets arranged in 10 distinct columns, also in large specimens. Centrodorsal cavity about 0.2 of centrodorsal diameter. Radial pits simple, very wide and deep, exceeding depth of centrodorsal cavity. Rod-shaped basals exposed in interradial point, and separated around central canal. Radials cover the entire ventral side of the centrodorsal and form a contiguous, free dorsal surface. Deep subradial cleft. Articular face of radials steep, almost vertical, with large and wide, triangular, ventral muscular fossae. Radial cavity wide. Primibrachs 1-2 synarthrial. Arms divided at primibrachs 2. Syzygial articu-

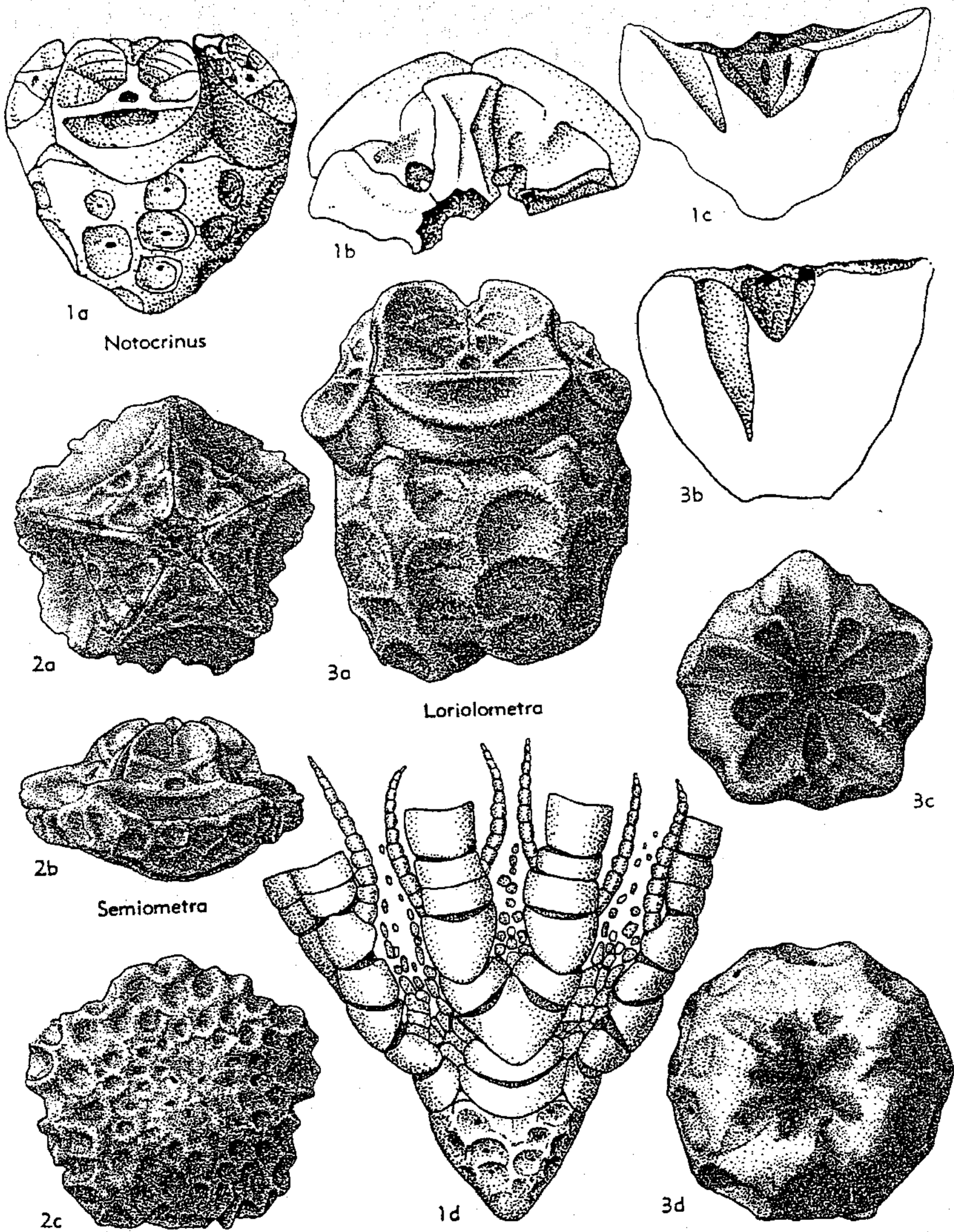


FIG. 601. Notocrinidae (p. T903-T904, T906).

lations occur among secundibrachials. *U.Cret.* (*Campan.*), Eu.(France-Swed.).—FIG. 601,3.  
 \**L. retzii* (LUNDGREN), Swed.; 3a, cup with centrodorsal, X5 (Rasmussen, 1961); 3b, sec. through centrodorsal, X5 (Gislén, 1924); 3c,d, ventral

and dorsal face of centrodorsal, X5 (Rasmussen, 1961).

*Remesimetra* SIEVERTS-DORECK, 1958, p. 255 [*Glenotremites discoidalis* GISLÉN, 1925a, p. 10; OD]. Centrodorsal rounded subconical to large,

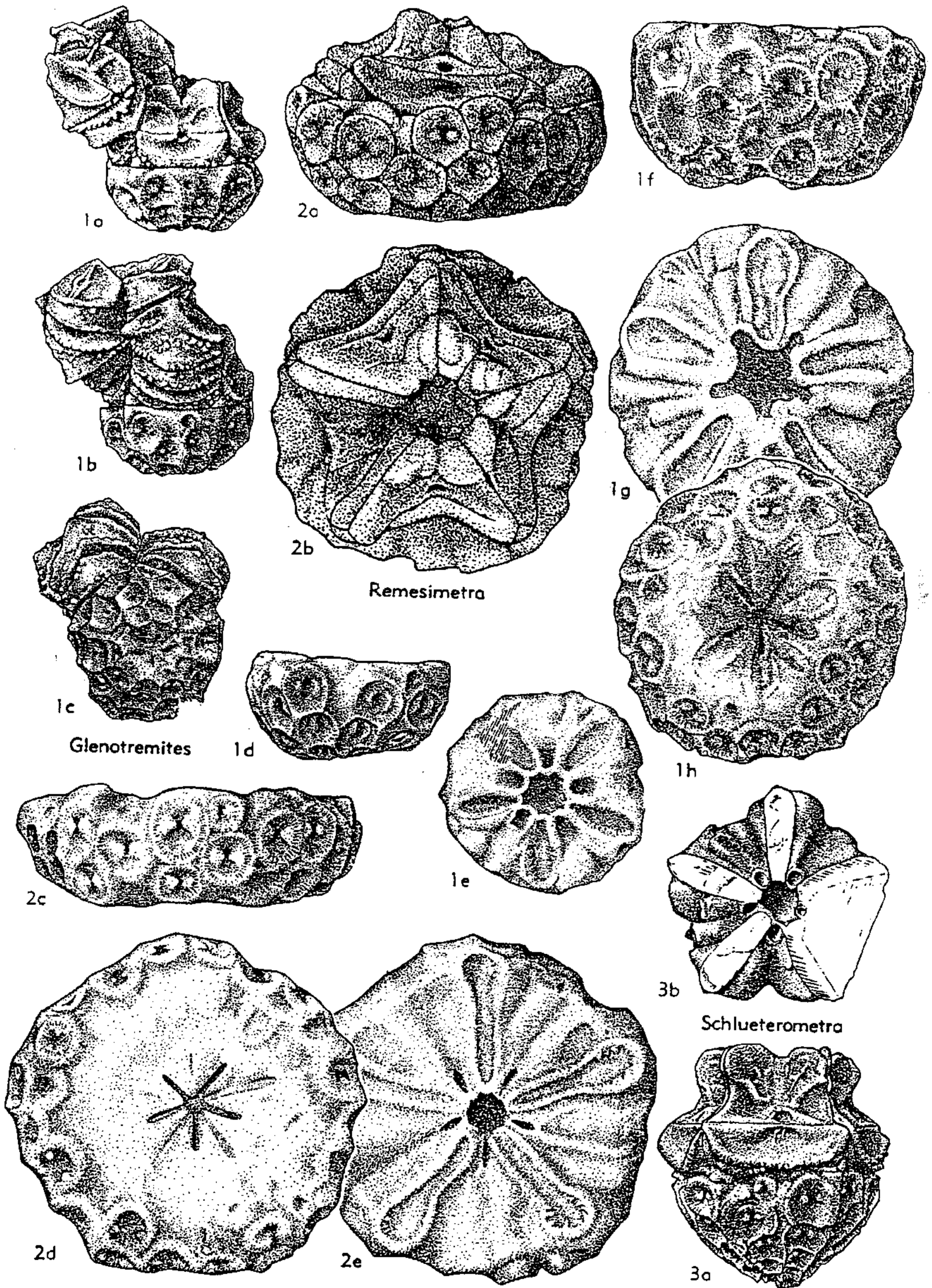


FIG. 602. Notocrinidae (p. T903, T906).

discoidal with a radial dorsal star. Interradial dorsal impressions may be present. Large cirrus sockets with articular tubercles and marginal crenulae are arranged in 20 irregular columns in adult specimens. Centrodorsal cavity narrow. Radial pits narrow. No subradial cleft. Radials reach edge of centrodorsal only in interradial points, leaving a marginal area of centrodorsal uncovered by radial plate. No free dorsal surface of radials. Articular face of radials flat or concave. Radial cavity rather narrow. *Cret. (Alb.-Cenoman.)*, Eu. (Czech.-Eng.).—FIG. 602,2. \**R. discoidalis* (GISLÉN), Cenoman., Czech.; 2a,b, cup with centrodorsal, one radial missing, X4 (after Sieverts-Doreck, 1958a); 2c-e, centrodorsal, X5 (Rasmussen, 1961).

*Schlueterometra* RASMUSSEN, 1961, p. 318 [\**S. voighti*; OD]. Centrodorsal conical with a pointed dorsal apex. No dorsal star. Cirrus sockets with articular tubercles and marginal crenellae arranged in 10 distinct columns, increasing in size upward. Centrodorsal cavity narrow, about 0.2 of centrodorsal diameter and surrounded by deep, single radial pits. Rod-shaped basals exposed in interradial point, and separated around central canal. Deep subradial cleft. Radials cover entire ventral side of centrodorsal and form low, contiguous free surface. Articular face of radials rather steep, ventral muscular fossae triangular, large and wide. Radial cavity large, funnel shaped. *U.Cret. (Coniac.-Santon.)*, Eu. (Ger.).—FIG. 602,3. \**S. voighti*, Santon.; 3a, cup with centrodorsal; 3b, ventral face of centrodorsal; X5 (Rasmussen, 1961).

*Semiometra* GISLÉN, 1924, p. 172 [\**Antedon impressa* CARPENTER, 1881b, p. 135; OD]. Centrodorsal low, disc shaped with 5 distinct pits around apex, forming radial dorsal star. Cirrus sockets small, closely placed, often regularly alternating, not forming columns. Sockets without distinct articular tubercles or marginal crenulae. Centrodorsal cavity about 0.2 to 0.3 of centrodorsal diameter and surrounded by small, shallow radial pits. Rod-shaped basals present but not always exposed on surface. Radials reach edge of centrodorsal only in interradial points, leaving ventral surface of centrodorsal uncovered by radial plates in considerable areas along radial margins. No free surface on radial plates. Articular face of radials more or less concave, subtriangular with high, often narrow muscular fossae. Radial cavity often narrow, but may be funnel shaped, extended at upper edge along interradial suture. Brachials known in one species possibly belonging to this genus. Primibrachs 2 axillary. Primibrachs 1-2 and secundibrachs 1-2 subradial. Syzygial articulations occur among secundibrachials. First pinnule on secundibrachs 2. In the Lower Cretaceous *Semiometra* was described by ATKINS, 1975, from Texas some specimens further divided at secundibrachs 2 and 3. [The Middle Jurassic (Bathon.) *Antedon* *normanensis* CARPEN-

TER and the Upper Jurassic (Oxford.) *Antedon petuclerci* CAILLET are here referred to *Semiometra*.] *M. Jur. (Bathon.)*, Eu. (Eng.); *U. Jur. (Oxford.)*, Eu. (France); *L. Cret. (Alb.)*, N. Am. (Texas); *U. Cret. (Cenoman.-Maastricht.)*, Eu. (Belg.-Czech.-Eng.-France-Ger.-Neth.-Swed.); ?*L. Tert. (Eoc.)*, Eu. (Italy).—FIG. 601,2. \**S. impressa* (CARPENTER), *U. Cret. (Campan.)*, Swed.; 2a-c, cup with centrodorsal, X10 (Rasmussen, 1961).

Family APOROMETRIDAE

H. L. Clark, 1938

[Aporometridae H. L. CLARK, 1938, p. 41]

Small Notocrinacea with a low, hemispherical or low, rounded to almost conical centrodorsal with a more or less flattened dorsal side, rugose from obsolete sockets. Ventral side of centrodorsal with shallow radial pits. A spongy calcareous structure of centrodorsal below centrodorsal cavity near apex, but no dorsal pit or radial dorsal star. Cirrus sockets with indistinct ornament or with articular tubercles, but no marginal crenulae, arranged in 10 columns of one to four sockets. Cirrals smooth, no dorsal spines, distal part of cirri dorsoventrally flattened. Rod-shaped basals exposed in interradial point or concealed. No subradial cleft. Radials with low, free dorsal surface. Articular face of radials low and wide, angularly bent at fulcral ridge with a low dorsal ligament fossa almost vertical, small interarticular ligament fossa and ventral muscular fossae almost horizontal. Radial cavity moderate, without central plug. Syzygial articulations at secundibrachs 3-4, secundibrachs 7-8 and distal generally with interval of 2. No distinct ambulacral covering plates. Viviparous, gonads and marsupia in pinnules. Recent, Australia [9-40 m.].

*Aporometra* H. L. CLARK, 1938, p. 41 [\**Himero-metra paedophora* H. L. CLARK, 1909, p. 524; OD]. Characters of family. Recent.

Superfamily ANTEDONACEA

Norman, 1865

[*nom. transl.* RASMUSSEN, herein (ex family Antedonidae NORMAN, 1865, p. 101, =suborder Antedonida A. H. CLARK, 1908), p. 723; suborder Macrophreata A. H. CLARK, 1909h, p. 174; here excluding Atelecrinidae; non Antedonacea STEINMANN, 1903, used for all comatulids]

Centrodorsal variable, discoidal or hemispherical to rounded subconical, conical or columnar. Cirrus sockets generally small



and numerous, closely placed, often closely alternating in several circles, but may tend to form several indistinct columns, and in Zenometrinae forming 10 to 20 distinct columns. Sockets without distinct ornament. Basals often transformed to a rosette. Rod-shaped basals usually reduced or absent, but recorded from specimens of *Nanometra* and Heliometrinae, and present and commonly exposed in Zenometrinae. Centrodorsal cavity moderate, about 0.3 of centrodorsal diameter in most Antedoninae, Thysanometrinae, Heliometrinae and Isometrinae, and rather large to very large in Perometrinae, Bathymetrinae, Zenometrinae and Pentametrocrinidae. Small radial pits may be present in ventral surface of centrodorsal in specimens of *Antedon* but not found in other genera. Radials 10 (5 radials and 5 pararadials) in *Promachocrinus* and *Thaumatocrinus*, but five in all other Antedonacea as well as in other comatulids. Ventral muscular fossae high and almost vertical on thin, muscular flange of radial, and meeting in midradial line at an angle of about 90 degrees. Radial cavity narrow or funnel shaped, without calcareous filling (no central plug). Arms undivided in Pentametrocrinidae, and divided at primibrachs 2 in Antedonidae. Synarthry at brachials 1-2 often embayed. Syzygy at brachials 3-4 and generally at brachials 9-10, and distal with short intervals. Distal brachials strongly wedge shaped. Pinnules cylindrical to flattened, not carinate. Mouth central. *Cret.-L. Paleoc.; Eoc.; Mio.; Pleist.-Holo.*; recent, worldwide [0-5,220 m.].

#### Family ANTEDONIDAE Norman, 1865

[Antedonidae NORMAN, 1865, p. 101 (incl. herein Palaeantodidae GISLÉN, 1924, p. 170)]

Arms divided at primibrachs 2, further division at secundibrachs 2 or secundibrachs 4 in some of the arms has been found in a few specimens. This very large family has been subdivided into several subfamilies. [GISLÉN (1924, p. 231) proposed a grouping in forms with more or less arched to hemispherical centrodorsal, moderate centrodorsal cavity, closely alternating cirrus sockets and synarthrial articulations not very narrow or strongly embayed, including Antedoninae, Perometrinae and Thysanometrinae, and forms with conical to columnar centrodorsal, large centrodorsal cavity,

more or less columnar arrangement of cirrus sockets, and synarthrial articulations commonly narrow and strongly embayed, including Zenometrinae, Bathymetrinae, Heliometrinae, and Isometrinae (as well as Pentametrocrinidae and Atelecrinidae), but this was rejected by A. H. CLARK (1931).] *Cret. (Alb.-Maastricht.)-L. Paleoc.; Eoc.; Mio.; Pleist.-Holo.*, worldwide [0-5,220 m.].

#### Subfamily ANTEDONINAE Norman, 1865

[*nom. transl.* A. H. CLARK, 1909h, p. 176 (ex Antedonidae NORMAN, 1865)]

Centrodorsal discoidal to low hemispherical or rounded subconical, generally with a small cirrus-free, smooth, rugose or tuberculate dorsal area. Cirrus sockets closely placed, often small, forming two to three irregular circles on low centrodorsals, three or four regularly alternating circles in higher centrodorsals and up to six circles in conical centrodorsals; exceptionally up to 100 sockets including obsolete sockets of dorsal area. Cirri 10 to 40, rather short, generally with less than 20 cirrals, dorsally rounded without dorsal spines or processes and never carinate. Centrodorsal cavity moderate. Shallow, small radial pits may be present in specimens of *Antedon bifida*. Basal rosette, no rod-shaped basals. Radials generally follow edge of centrodorsal without free surface in midradial area, and may be further restricted, not covering radial margin of centrodorsal. Articular face of radial gently sloping, wider than high. Ventral muscular fossae moderate, slightly larger than interarticular ligament fossae, and broadly rounded, more or less four-sided, generally wider than high, separated by broad midradial ridge with median furrow, and shallow notch. Synarthrial articulation at brachials 1-2 flat or slightly embayed. In a few specimens of *Antedon* further division at secundibrachs 2 or secundibrachs 4 has been found in some of the arms. Recent genera distinguished mainly on length and structure of proximal pinnules. *Tert. (Eoc., Mio.); Pleist.-Holo.* [recent, Pac.O.-Ind.O.-Atl.O., 0-932 m.].

*Antedon* DE FREMINVILLE, 1811, p. 349, *nom. conserv.* [*\*A. gorgonia* (= *Asterias bifida* PENNANT, 1777, p. 55, *pro Decacnemos rosacea* LINCK, 1733, p. 55, *pro Decempeda cornubiensium* LHWYD, 1699); M (ICZN Op. 73, 1922)] [= *Decacnemos* BRONN, 1825, p. 6-7 (ex LINCK, 1733);

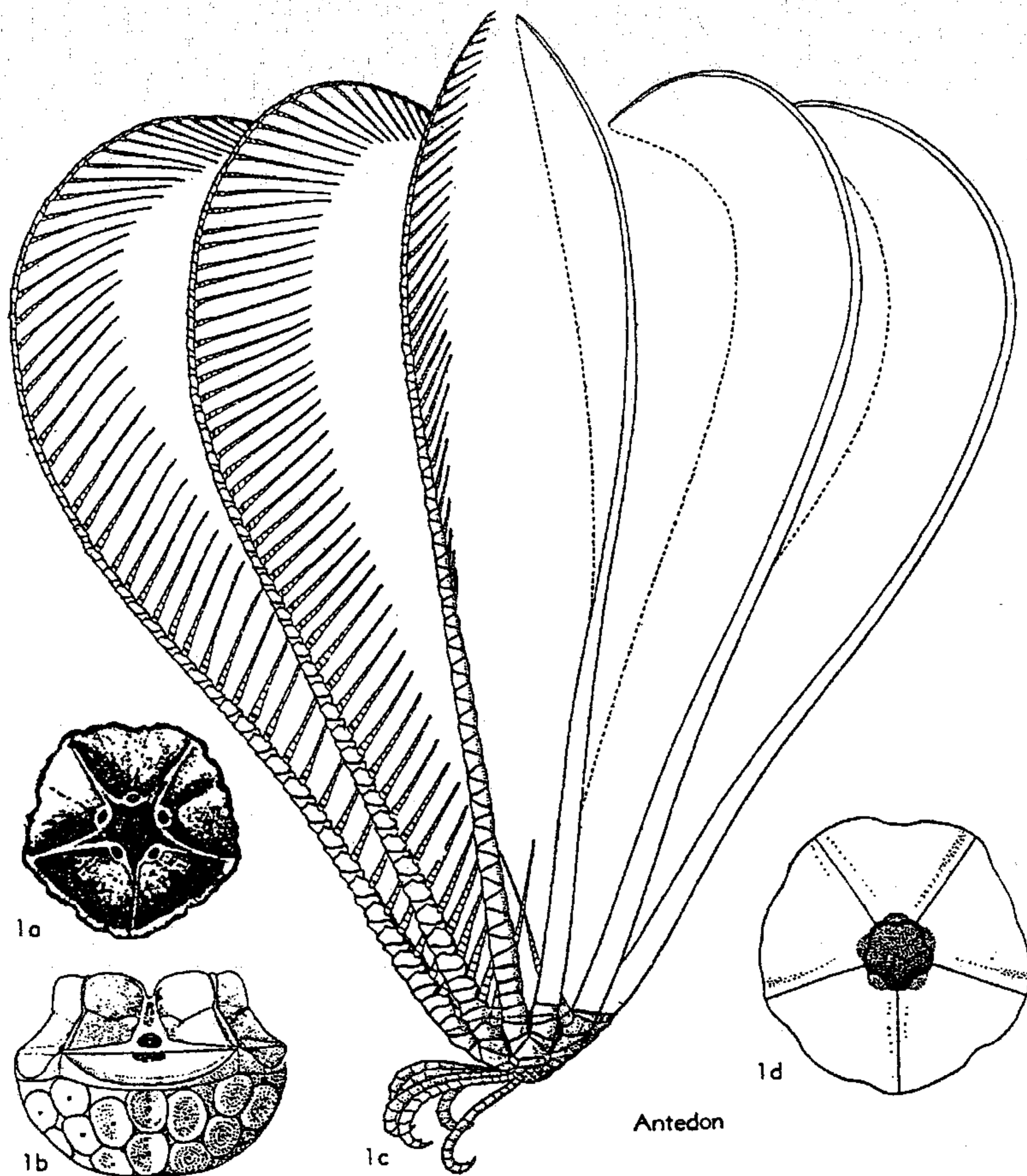


FIG. 603. Antedonidae (Antedoninae) (p. T907-T908).

*Hibernula* FLEMING, 1828, p. 494 (type, *Pentacrinus europaeus* THOMPSON, 1827, p. 1); *Phytocrinus* DE BLAINVILLE, 1830, p. 235, invalid, *nom. subst. pro Hibernula* FLEMING, 1828; *Ganymeda* GRAY, 1834, p. 15 (type, *G. pulchella*; M); ?*Kallispongia* WRIGHT, 1877, p. 754 (type, *K. archeri*; M; probably a synonym of *A. loveni* BELL, 1882); *Compsometra* A. H. CLARK, 1908g, p. 131 (type, *Antedon loveni* BELL, 1882a, p. 534; OD); *Reptometra* A. H. CLARK, 1937, p. 93 (type, *R. arabica*; M)]. Third pinnule similar to succeeding genital pinnules; second pinnule similar to third. First pinnule more than 1.5 length of second pinnule. Recent.—FIG. 603, 1a, c. \**A. bifida* (PENNANT);

1a, ventral face of centrodorsal,  $\times 7$  (Carpenter, 1879a); 1c,  $\times 1.8$  (Clark, 1915a).—FIG. 603, 1b, d. *A. mediterranea* (LAMARCK); 1b, cup with centrodorsal; 1d, ventral face of centrodorsal;  $\times 10$  (1b, Clark, 1921; 1d, Clark, 1915a). [= *Cintedon* MUNIER CHALMAS, 1891 (*nom. null.*).] *Andrometra* A. H. CLARK, 1917, p. 128 [\**Antedon psyche* A. H. CLARK, 1908f, p. 241 (= *Toxometra aequipinna* GISLÉN, 1922, p. 129); OD]. Recent. *Annametra* A. H. CLARK, 1923, p. 41, 52 [\**Cominia occidentalis* A. H. CLARK, 1915b, p. 164; M]. Recent. *Argyrometra* A. H. CLARK, 1917, p. 128 [\**Iridometra crispata* A. H. CLARK, 1908b, p. 218; OD].

Third pinnule similar to succeeding genital pinnules. First and second pinnule with elongate pinnulars. First pinnule either shorter or longer than third pinnule, and second pinnule intermediate. Recent.—FIG. 604,2. \**A. crisa* (CLARK); ×5 (Clark & Clark, 1967).

Dorometra A. H. CLARK, 1917, p. 128 [\**Antedon nana* HARTLAUB, 1890, p. 170; OD]. Recent.

Euantedon A. H. CLARK, 1912, p. 31 [\**Antedon moluccana* A. H. CLARK, 1912c, p. 129; OD]. Recent.

Eumetra A. H. CLARK, 1908, p. 230 [\**E. chamberlaini*; OD]. Recent.

Iridometra A. H. CLARK, 1908, p. 130 [\**Antedon adrestine* A. H. CLARK, 1907c, p. 340 (= *I. melpomene* A. H. CLARK, 1911b, p. 559); OD]. Recent.

Mastigometra A. H. CLARK, 1908, p. 229 [\**M. flagellifera*; OD]. Recent.

Palaeantedon GISLÉN, 1924, p. 182 [\**Antedon solutus* POMEL, 1887, p. 336; OD]. Centrodorsal arched to hemispherical, dorsally rounded without dorsal star or depression or significant cirrus-free area. Cirrus sockets numerous, small, without distinct ornament or with slightly elevated margin around axial pore. Sockets closely placed, alternating in circles without forming columns. Centrodorsal cavity about 0.3 of centrodorsal diameter. No radial pits or coelomic impressions. Indistinct interradii furrows in ventral side of centrodorsal may correspond to reduced rod-shaped basals not observed. Radials cover entire ventral side of centrodorsal, with free surface low or concealed. Articular face of radials gently sloping, rather high, with large, triangular interarticular ligament fossae. Ventral muscular fossae smaller, triangular. Radial cavity narrow to moderate. Primibrachs 1-2 synarthrial, primibrachs 2 axillary. *L.Tert.*(*Eoc.*), N.Am.(S.Car.); *U.Tert.*(*Mio.*), Eu.(Italy-Hung.)-Afr.(Alg.); *Quat.*, Afr.(Alg.).—FIG. 604,1a-e,k. *P. caroliniana* GISLÉN, *Eoc.*, N.Am.; 1a-c, centrodorsal, ×10; 1d,e, primibrach 2, ×14; 1k, radial, ×14 (Gislén, 1934).—FIG. 604,1f. *P. ambigua* (POMEL), *Mio.*, Alg.; ×8 (Pomel, 1885).—FIG. 604,1g-i. *P. pannoica* (VADÁSZ), *Mio.*, Hung.; 1g-i, centrodorsal, ×15 (Vadász, 1915).—FIG. 604,1j. \**P. soluta* (POMEL), *Mio.*, Alg.; 1j, cup with centrodorsal, ×8 (Pomel, 1885).

Toxometra A. H. CLARK, 1911, p. 560 [\**T. paupera*; OD] [= *Monilimetra* H. L. CLARK, 1938, p. 47 (type, *M. nomima*; OD)]. Recent.

Subfamily PEROMETRINAE A. H. Clark, 1909

[Perometrinae A. H. CLARK, 1909h, p. 176]

Centrodorsal rounded subconical, dorsal pole rounded, often rugose or tuberculate. Cirrus sockets closely placed, alternating in irregular circles, increasing in size upward. Cirri rather long, with 25 to 55 cirrals. Distal cirrals with dorsal spine or process.

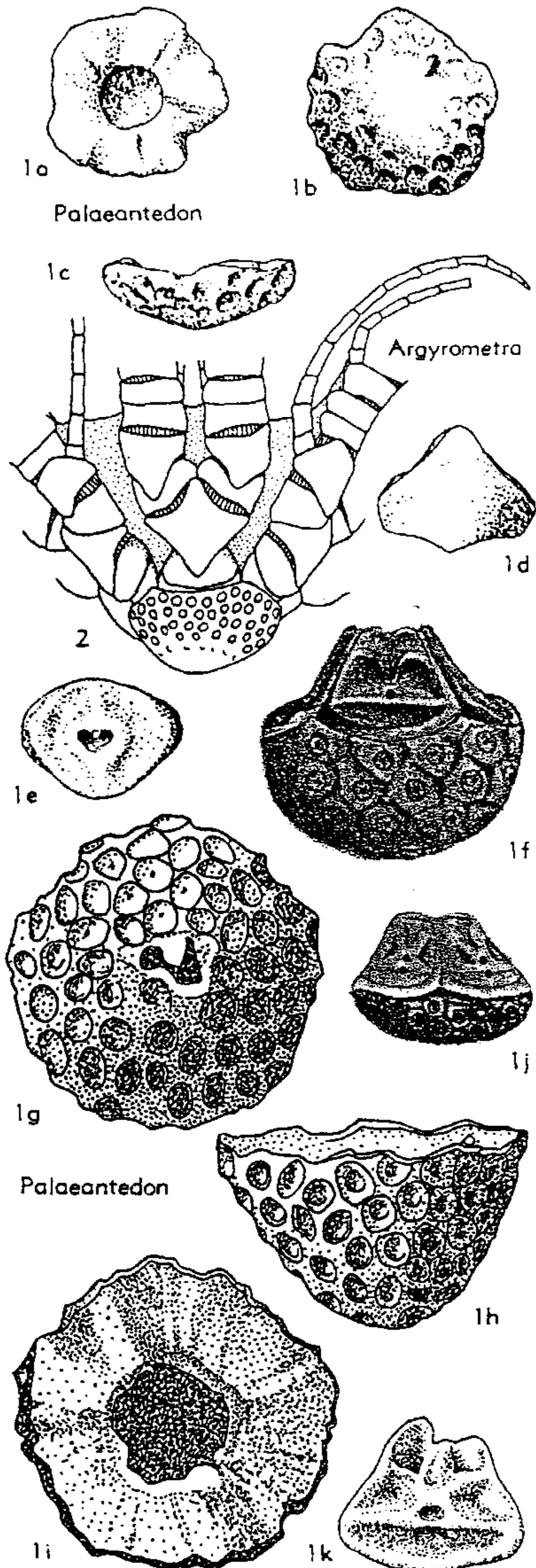


FIG. 604. Antedonidae (Antedoninae) (p. T908-T909).

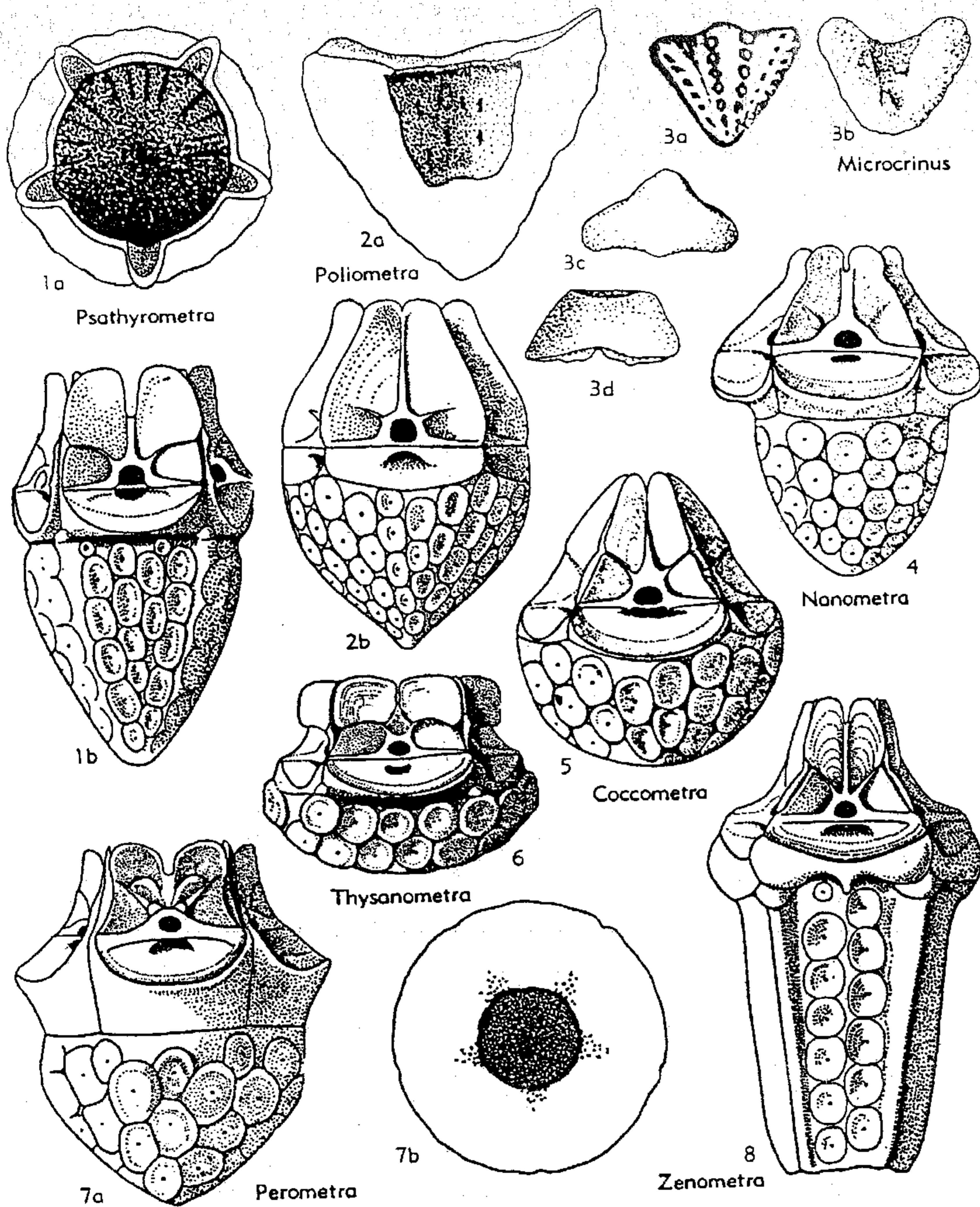


FIG. 605. Antedonidae (Perometrinae) (4,7), (Thysanometrinae) (5,6), (Zenometrinae) (1-3,8) (p. T911-T912).

Ventral side of centrodorsal smooth, without radial pits, interrarial furrows or ridges. Rod-shaped basals reported for a species of *Nanometra* but unknown in other species and genera. Centrodorsal cavity rather large, 0.3 to 0.4 of centrodorsal diameter. Radials usually prominent, often with free dorsal surface concave and projecting or

overhanging, but may be low and almost concealed in midradial area of some species. Articular face of radials gently sloping, rather wide, separated by narrow interrarial margin. Interarticular ligament fossae triangular, almost as high as ventral muscular fossae. Ridge separating interarticular from ventral fossae narrow, often indistinct.

Low, commonly wide, midradial ridge and notch. Radial cavity funnel shaped. Primibrachs 1 low, often narrow and laterally overhung by proximal end of primibrachs 2. Synarthrial articulations at brachials 1-2 usually embayed. Arms divided at primibrachs 2, further division at secundibrachs 2 in some arms observed in a species of *Perometra*. First pinnule stout, with rather few pinnulars. First or second pinnule may be missing in some species. Recent, Pac.O.-Ind.O.-Mex.Gulf [60-1,040 m.].

*Perometra* A. H. CLARK, 1907, p. 357 [\**Antedon diomedea* A. H. CLARK, 1907d, p. 146; OD]. Proximal brachials with smooth, flattened sides meeting neighboring arms. Recent.—FIG. 605,7. \**P. diomedea* (CLARK); 7a, cup with centrodorsal; 7b, ventral face of centrodorsal; X15 (7a, Clark, 1921; 7b, Clark, 1915a).

*Erythrometra* A. H. CLARK, 1908, p. 126 [\**Antedon ruber* A. H. CLARK, 1907d, p. 146; OD (= *E. rubra*, GISLÉN emend. 1922)]. Recent.

*Hypalometra* A. H. CLARK, 1908, p. 133 [\**Antedon defecta* CARPENTER, 1888, p. 206; OD]. Recent.

*Nanometra* A. H. CLARK, 1907, p. 348 [\**Antedon minor* A. H. CLARK, 1907d, p. 144 (= *Antedon bowersi* A. H. CLARK, 1907d, p. 148; *Antedon orientalis* A. H. CLARK, 1907e, p. 341; *Nanometra minckerti* A. H. CLARK, 1907f, p. 349, nom. subst. pro *Antedon minor* A. H. CLARK, 1907d, non *Antedon avenionensis* var. *minor* NICOLAS, 1898, p. 406); OD] [*N. bowersi* has priority among later recognized synonyms]. Proximal brachials with tuberculate, not flattened sides. Proximal and distal edge of brachials prominent, often tuberculate. Recent.—FIG. 605,4. *N. bowersi* (CLARK); X10 (Clark, 1921).

#### Subfamily THYSANOMETRINAE

A. H. Clark, 1909

[Thysanometrinæ A. H. CLARK, 1909h, p. 176]

Centrodorsal arched, hemispherical or low hemispherical to almost discoidal, with cirrus-free dorsal area. Cirrus sockets closely placed, forming three or four circles. There are 30 to 40 cirri. Cirrals long, slender, laterally compressed, without dorsal projections. No rod-shaped basals, but often interrarial ridges on ventral side of centrodorsal. Centrodorsal cavity moderate. Large species commonly with subradial cleft. Surface of radials low, more or less concealed in midradial area. Articular face of radials in *Thysanometra* steep, ventral muscular fossae wider than high, separated from interarticular ligament fossae by curved, almost horizontal ridge. Articular face in

*Coccometra* high and narrow, triangular, ventral muscular fossae high and narrow, subtriangular, separated from interarticular ligament fossae by oblique ridge. Radial cavity in *Thysanometra* moderate to rather large, in *Coccometra* narrow. Arms divided at primibrachs 2. Primibrachs 1 short, sides often converging and overhung by proximal part of primibrachs 2. Synarthrial articulations at brachials 1-2 flat to embayed. Recent, Pac.O.-Atl.O.-Carib.S. [14-1,046 m.].

*Thysanometra* A. H. CLARK, 1907, p. 351 [\**Antedon tenelloides* A. H. CLARK, 1907c, p. 73; OD]. Articular face of radials wider than high. Radial cavity moderate to large. Distal pinnules longer than proximal ones. Recent.—FIG. 605,6. \**T. tenelloides* (CLARK); X7 (Clark, 1921).

*Coccometra* A. H. CLARK, 1908, p. 128 [\**Comatula hagenii* POURTALÈS, 1868, p. 111; OD]. Articular face of radials high and narrow triangular. Radial cavity narrow. Distal pinnules shorter than proximal ones. Recent.—FIG. 605,5. \**C. hagenii* (POURTALÈS), X13 (Clark, 1921).

#### Subfamily ZENOMETRINAE A. H. Clark, 1909

[Zenometrinæ A. H. CLARK, 1909h, p. 176]

Centrodorsal conical or rounded subconical to columnar, often high or very high, in *Leptometra* more variable from conical to hemispherical or discoidal, dorsal side often rounded or truncated, and may be rugose or tuberculate in *Caryometra*. Cirrus sockets numerous, arranged in 10, 15 or 20 distinct columns, often 10 columns in juvenile specimens and new, shorter, and less regular columns inserted adradial during growth. Columns may be separated by interrarial ridges in *Zenometra*, by interrarial furrows in *Balanometra* and *Adelometra*, by interrarial spaces in *Sarametra*, *Psathyrometra*, and *Anisometra*, or may be without interrarial separation. Apical sockets often become obsolete. Cirri long, cirrals generally long, distal cirrals may be laterally compressed with or without dorsal spine or crest. Ventral side of centrodorsal with large centrodorsal cavity, often more than half of centrodorsal diameter. Rod-shaped basals commonly exposed, but absent in *Leptometra* and concealed or unknown in several species and genera. Subradial cleft common. Radials may be concealed, but generally a low to moderate free surface commonly overhanging or recumbent. Articular face of radials higher than wide,

rather steep, with ventral muscular fossae almost vertical. Interarticular ligament fossae triangular or ridge between interarticular and ventral fossae may be curved and more horizontal. Ventral muscular fossae very high and often narrow, separated by narrow median ridge and notch. Arms divide at primibrachs 2, further division at secundibrachs 2 or secundibrachs 4 may occur in some arms of *Adelometra*. Synarthrial articulations at brachials 1-2 often strongly embayed. Primibrachs 1 often with converging sides and laterally overhung by primibrachs 2. First pinnule absent in *Balanometra* and *Kempometra*. *L.Tert.* (*Eoc.*); recent, Antarctic reg.-Pac.O.-Ind.O.-Atl.O.-Medit. [20-3,426 m.].

*Zenometra* A. H. CLARK, 1907, p. 354 [*\*Antedon columnaris* CARPENTER, 1881c, p. 169 (= *Z. pyramidalis* A. H. CLARK, 1908b, p. 237); OD]. Centrodorsal high, truncated conical or columnar, with 10 columns of cirrus sockets separated by interrarial ridges. Recent.—FIG. 605,8. *\*Z. columnaris* (CARPENTER);  $\times 6$  (Clark, 1921).

*Adelometra* A. H. CLARK, 1907, p. 363 [*\*Antedon angustiradia* CARPENTER, 1888, p. 253; M]. Recent.

*Anisometra* JOHN, 1939, p. 204 [*\*A. frigida*; M]. Recent.

*Balanometra* A. H. CLARK, 1909, p. 177 [*\*Antedon balanoides* CARPENTER, 1888, p. 207 (= *Perometra elongata* A. H. CLARK, 19081, p. 229); OD]. Recent.

*Caryometra* A. H. CLARK, 1936, p. 247 [*\*Adelometra tenuipes* A. H. CLARK, 1908b, p. 236 (= *Antedon arcana* HARTLAUB, 1912, p. 402; *Psathyrometra acuta* A. H. CLARK, 1934a, p. 1); OD]. Recent.

*Cyclometra* A. H. CLARK, 1911, p. 87 [*\*C. flavescens*; M]. Recent.

*Eometra* A. H. CLARK, 1936, p. 248 [*\*Psathyrometra antarctica* A. H. CLARK, 1915b, p. 116; OD]. Recent.

*Eumorphometra* A. H. CLARK, 1915, p. 117 [*\*E. concinna*; OD]. Recent.

*Hybometra* A. H. CLARK, 1913, p. 54 [*\*H. senta*; OD]. Recent.

*Kempometra* JOHN, 1938, p. 161 [*\*K. grisea*; M]. Recent.

*Leptometra* A. H. CLARK, 1908, p. 129 [*\*Alecto phalangium* J. MÜLLER, 1841, p. 182; OD]. Recent.

*Microcrinus* EMMONS, 1858, p. 311 [*\*M. conoideus*; M]. Centrodorsal small, five-sided, conical, with rounded apex often primarily or secondarily perforated. Up to 1.4 mm. high and 2 mm. in diameter. Cirrus sockets with indistinct fulcral ridge arranged in 10 distinct columns of 2 to 4 sockets,

may be separated by interrarial ridges. Centrodorsal cavity deep and wide, about half of centrodorsal diameter. Basals rod shaped. Isolated brachials indicate arms divided at primibrachs 2 only. Primibrachs 1 moderately high, sides converging. Primibrachs 1-2 and secundibrachs 1-2 synarthrial. Syzygy probably at secundibrachs 3-4 and more distal. [Referred by GISLÉN (1934) to Zenometrinae. Specimens of *Microcrinus conoideus* recently found by G. R. BAUM (unpubl.) in the Eocene of USA (N.Car.) show a variation from typical "macrophreate" structure with a wide centrodorsal cavity and narrow, rod-shaped basals resting on interrarial septa to forms with large and deep radial pits as also found in specimens of *Jaekelometra*.] *L.Tert.* (*Eoc.*), N.Am. (N.Car.-S.Car.).—FIG. 605,3. *\*M. conoideus*, *Eoc.*, N.Am.; 3a, centrodorsal,  $\times 3.75$  (Emmons, 1858); 3b, broken centrodorsal,  $\times 12$ ; 3c, primibrach 2,  $\times 14$ ; 3d, primibrach 1,  $\times 14$  (3b-d, Gislén, 1934).

*Poliometra* A. H. CLARK, 1923, p. 7 [*\*Antedon proluxa* SLADEN in DUNCAN & SLADEN, 1881, p. 77 (= *Antedon hystrix* CARPENTER, 1884c, p. 374); M]. Centrodorsal conical to mitriform with 15-20 columns of cirrus sockets, not separated by interrarial ridges. Recent.—FIG. 605,2. *\*P. proluxa* (SLADEN); 2a, sec. through centrodorsal,  $\times 10$  (Gislén, 1924); 2b, cup with centrodorsal,  $\times 8$  (Clark, 1921).

*Psathyrometra* A. H. CLARK, 1907, p. 353 [*\*Antedon fragilis* A. H. CLARK, 1907c, p. 80 (= *P. borealis* A. H. CLARK, 1908b, p. 236; *P. profundorum* A. H. CLARK, 1908b, p. 237); OD]. Centrodorsal conical with cirrus sockets forming 10-40 columns, number increasing during growth. Sockets generally separated by interrarial spaces. Recent.—FIG. 605,1. *\*P. fragilis* (CLARK); 1a, ventral face of centrodorsal,  $\times 10$ ; 1b, cup with centrodorsal,  $\times 9$  (1a, Clark, 1915a; 1b, Clark, 1921).

*Sarametra* A. H. CLARK, 1917, p. 129 [*\*Zenometra triserialis* A. H. CLARK, 1908b, p. 219; OD]. Recent.

#### Subfamily BATHYMETRINAE A. H. Clark, 1909

[*Bathymetrinae* A. H. CLARK, 1909b, p. 177]

Centrodorsal conical or rounded subconical to low hemispherical. Cirrus sockets rather small, closely placed, generally numerous (25 to more than 100), covering almost completely sides of centrodorsal; they closely alternate, generally without distinct arrangement, often interpreted as alternating circles, but in many specimens with tendency to form columns, up to 30 in number. Size of sockets may increase slightly upward. *Bathymetra* differs by having only few cirri (10-15) in one or two circles. Cirrus-free dorsal area generally

small, pointed to rounded, and smooth, seldom rugose. Length of cirri moderate, apical cirri rather short. Cirrals laterally compressed and generally long, length one to six times width. Distal cirrals often dorsally carinate, may have dorsal spine. Centrodorsal cavity large. Basal rosette, no rod-shaped basals. Radials may have smooth, rather large, free surface in small species (*Bathymetra*), but generally very low and often concealed in midradial area of large species. Articular face of radials high and rather steep. Interarticular ligament fossae triangular or low and narrow ridge separating interarticular from ventral fossae may be almost horizontal, straight or curved. Ventral muscular fossae large and high, rounded subtriangular with rounded ventral edge, separated by low and narrow median ridge and small notch, forming angle of almost 90 degrees with each other. Radial cavity narrow. Arms divided at primibrachs 2 only. Synarthrial articulation at primibrachs 1-2 often embayed. Primibrachs 1 usually with parallel or converging sides, commonly laterally overhung by primibrachs 2. First pinnule stiff and slender with elongated pinnulars. Recent, worldwide except in Antarctic and Medit. [28-5,301 m.].

*Bathymetra* A. H. CLARK, 1908, p. 132 [\**Antedon abyssicola* CARPENTER, 1888, p. 191; OD]. Centrodorsal small, conical, with only 10-15 cirri. Radials with large, smooth surface. Recent.—FIG. 606,4. *B. carpenteri* CLARK; X11 (Clark & Clark, 1967).

*Boleometra* A. H. CLARK, 1936, p. 248 [\**Antedon clio* A. H. CLARK, 1907c, p. 79; OD]. Recent.

*Fariometra* A. H. CLARK, 1917, p. 130 [\**Trichometra explicata* A. H. CLARK, 1908l, p. 232; OD]. Recent.

*Hathrometra* A. H. CLARK, 1908, p. 130 [\**Alectro dentata* SAY, 1825, p. 153 (= *Asterias tenella* RETZIUS, 1783, p. 241); OD]. Centrodorsal high conical to mitriform with numerous cirri. Free surface of radials inconspicuous. Length of cirrals up to 3 times width. Recent.—FIG. 606,1. \**H. tenella* (RETZIUS); 1a, ventral face of centrodorsal; 1b, cup with centrodorsal; both X10 (1a, Clark, 1915a; 1b, Clark, 1921).

*Nepiometra* A. H. CLARK, 1917, p. 130 [\**Antedon laevis* CARPENTER, 1888, p. 187; OD]. Recent.

*Orthometra* A. H. CLARK, 1917, p. 129 [\**Trichometra hibernica* A. H. CLARK, 1913b, p. 2; OD]. Recent.

*Phrixometra* A. H. CLARK, 1917, p. 131 [\**Antedon longipinna* CARPENTER, 1888, p. 185; OD]. Cen-

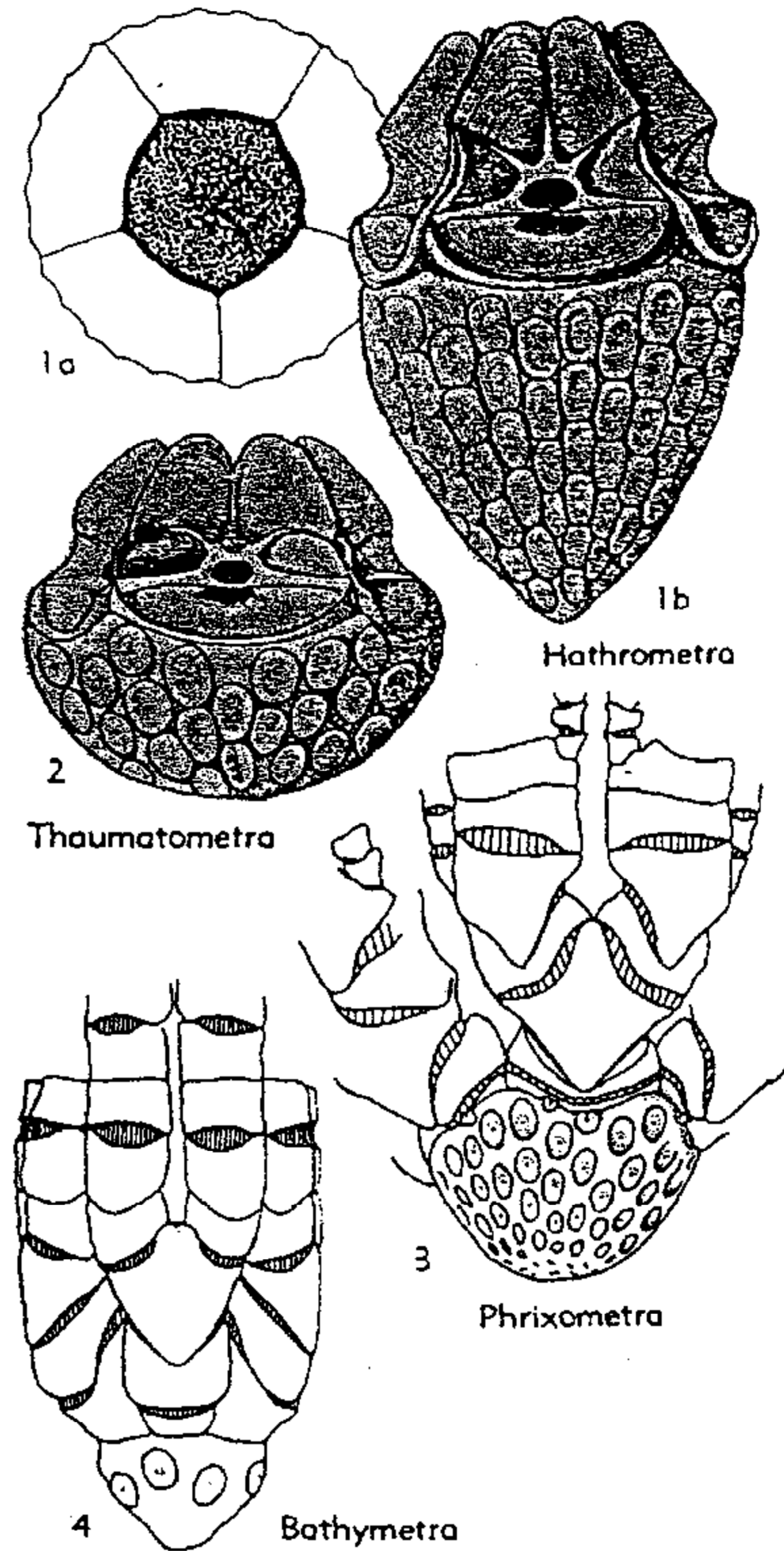


FIG. 606. Antedonidac (Bathymetrinae) (p. T913).

trodorsal rather low subconical to hemispherical with rather numerous cirrus sockets. Free surface of radials inconspicuous. Genital pinnules of female with marsupium. Recent.—FIG. 606,3. *P. exigua* (CARPENTER); X10 (Clark & Clark, 1967).

*Retiometra* A. H. CLARK, 1936, p. 248 [\**R. alascana*; OD]. Recent.

*Thaumatometra* A. H. CLARK, 1908, p. 127 [\**Antedon ciliata* A. H. CLARK, 1907c, p. 81 (= *Antedon tenuis* A. H. CLARK, 1907c, p. 80); OD]. Centrodorsal low subconical or hemispherical to almost discoidal with rather numerous cirrus sockets. Surface of radials inconspicuous or concealed. Cirrals strongly compressed. Recent.—FIG. 606,2. *T. tenuis* (CLARK); X8 (Clark, 1921).

*Tonrometra* A. H. CLARK, 1917, p. 130 [\**Antedon*

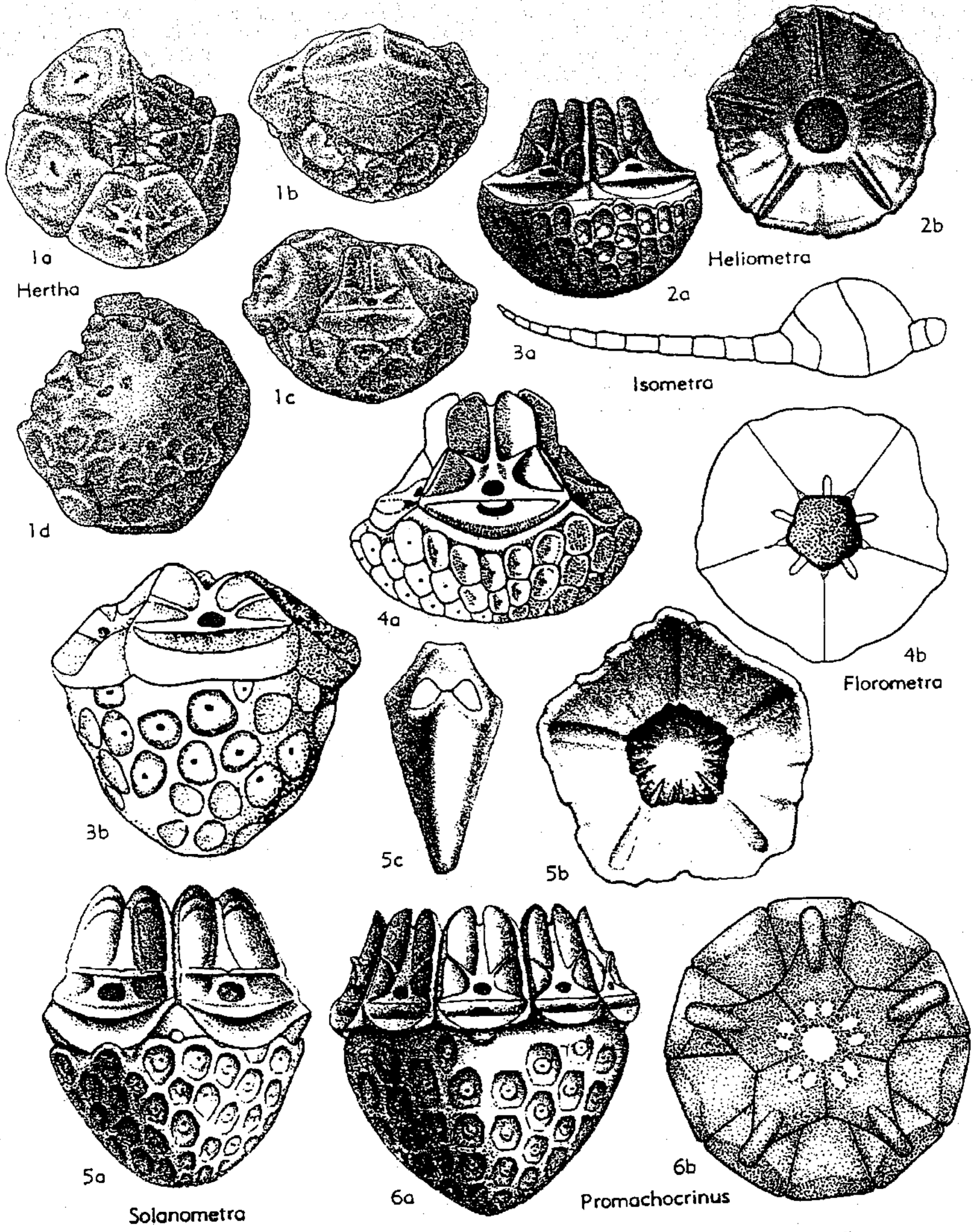


FIG. 607. Antedonidae (Heliometrinae) (1,2,4-6), (Isometrinae) (3) (p. T915-T916).

*remota* CARPENTER, 1888, p. 184; OD]. Recent.  
*Trichometra* A. H. CLARK, 1908, p. 131 [*\*Trichometra aspera* A. H. CLARK, 1908b, p. 229 (= *Antedon cubensis* POURTALES, 1869, p. 356); OD].  
 Recent.

Subfamily HELIOMETRINAE A. H. Clark, 1909  
 [Heliometrinae A. H. CLARK, 1909h, p. 176 (incl. subfamily Promachocrinae JAEKEL, 1918, p. 74)]

Centrodorsal rounded subconical, often with a cirrus-free apical area, to low hemi-



spherical with small, flattened, or concave cirrus-free dorsal area or deep dorsal pit. Cirrus sockets numerous, closely placed, often regularly alternating, forming 4 to 7 circles, and completely covering centrodorsal from its ventral edge to apical area. Cirri 30 to 200, long and stout, laterally compressed. Centrodorsal cavity moderate. Shallow radial pits or furrows may be present at edge of centrodorsal cavity in species of *Florometra*. Rod-shaped basals may be present in *Promachocrinus*, *Heliometra* and *Solanometra*, but often concealed, and absent in adults of most species. Radials with very low, free surface or concealed. Articular face of radials high, commonly rather concave with dorsal ligament fossa and interarticular ligament fossae outward sloping, and the ventral muscular fossae almost vertical, higher than the interarticular ligament fossae, narrow and separated by a median ridge and notch. Radial cavity moderate to rather large. In *Promachocrinus* the five basals form broad, flattened plates, united around center and with interrarial prolongations forming rod-shaped basal rays, followed by 10 radial and pararadial plates. The pararadials, which are interrarial in position (above basals), are retarded in larval development and early growth. Arms divide at primibrachs 2, further division at secundibrachs 2 of some arms very exceptional. Primibrachs 1 often with converging sides, may be overhung by lateral edge of primibrachs 2. Synarthrial articulations often embayed. First pinnule long, flagellate, with numerous short pinnulars. Proximal pinnules may be serrate, resembling a rudimentary comb as in Comasteracea. *L.Cret.-L.Paleoc.; Mio.; recent, Pac., Arctic, and Antarctic reg. [10-1,574 m.]*.

The Cretaceous and Tertiary genera *Hertha*, *Allionia*, and *Roiometra* may well belong to this subfamily.

*Heliometra* A. H. CLARK, 1907, p. 350 [*\*Alecto eschrichtii* J. MÜLLER, 1841, p. 183 (= *Alecto glacialis* OWEN, 1833, p. 120, *ex* LEACH, 1830 (*nom. nud.*); *Antedon quadrata* CARPENTER, 1884c, p. 375; *Antedon bartensi* CARPENTER, 1886, p. 9; *Antedon metica* A. H. CLARK, 1907c, p. 82; *Heliometra rupestris* A. H. CLARK, 1908f, p. 239]; OD]. Centrodorsal low hemispherical. Brachials rather high and smooth, without spines. Recent. —FIG. 607,2. *H. glacialis* (OWEN); 2a, cup with centrodorsal; 2b, ventral face of centrodorsal;

×3 (Carpenter, 1888).

*Allionia* MICHELOTTI, 1861, p. 353 [*\*A. oblita*; M]. Genus insufficiently known, based on rather low, arched, five-sided centrodorsal with small, closely placed cirrus sockets and a narrow dorsal pit. Ventral side of centrodorsal concave, with interrarial furrows for rod-shaped basals. Centrodorsal cavity rather narrow. *U.Tert.(Mio.)*, Eu. (Italy).

*Anthometra* A. H. CLARK, 1913, p. 60 [*\*Antedon adriani* BELL, 1908, p. 4; SD A. H. CLARK, 1914a, p. 3]. Recent.

*Florometra* A. H. CLARK, 1913, p. 62 [*\*Antedon eschrichti var. magellanica* BELL, 1882b, p. 651; M (subsequent designation of another type species by A. H. CLARK (1914a), is rejected by A. M. CLARK (in CLARK & CLARK, 1967), according to Code]. Centrodorsal subconical to almost hemispherical, often low or with a dorsal depression. Brachials rather high and with spines. Recent. —FIG. 607,4. *F. asperrima* (CLARK); 4a, cup with centrodorsal; 4b, ventral face of centrodorsal; ×5 (4a, Clark, 1921; 4b, Clark, 1915a).

*Hertha* VON HAGENOW, 1840, p. 664 [*\*H. mystica*; M]. Centrodorsal arched, from high, rounded, subconical to low, discoidal with a sharp ventral edge and a rounded dorsal side without depression or significant cirrus-free area. No dorsal star. Cirrus sockets small, without distinct ornament, closely placed without forming columns. Ventral side of centrodorsal without radial pits or coelomic impressions. Centrodorsal cavity rather narrow, less than 0.3 of diameter except in very small specimens. Rod-shaped basals present, but not exposed on surface. Radials without free dorsal surface may cover entire ventral side of centrodorsal or may leave radial marginal area uncovered. Articular face of radials high, gently sloping, often concave. Interarticular ligament fossae rather small, ventral muscular fossae high, rather narrow, subtriangular. Radial cavity narrow. Arms divide at primibrachs 2. Articulation at primibrachs 1-2 synarthrial. *U.Cret.(Maastricht.)*, Eu. (Denm.-Eng.-Ger.-Swed.); *L.Tert.(Dan.)*, Eu. (Denm.); ?*U. Tert.(Mio.)*, Eu. (Italy). —FIG. 607,1. *\*H. mystica*, *U.Cret.(Maastricht.)*, Denm.; 1a-d, ×10 (Rasmussen, 1961).

*Promachocrinus* CARPENTER, 1879, p. 385 [*\*P. kerguelensis* CARPENTER (1879b, p. 385, *nom. nud.*), 1881a, pl. 12 (= *P. vanhoeffenianus* MINCKERT, 1905b, p. 496; *P. joubini* VANEY, 1910, p. 158); SD CARPENTER, 1888, p. 348]. 10 radials, each with arm divided at primibrach 2. Recent. —FIG. 607,6. *\*P. kerguelensis*; 6a, cup with centrodorsal, ×6 (Carpenter, 1881a); 6b, underside of cup with radials, pararadials and basals, partly reconstr., ×6 (Rasmussen, n, mod. from Carpenter, 1888).

*Roiometra* A. H. CLARK, 1944, p. 304 [*\*R. columbiana*; M]. Cup and centrodorsal unknown, covered by numerous slender cirri in the only

specimens. Cirri very slender, more than 100, closely crowded in several alternating circles. They reach a length of 25 to 30 cirrals and 27 to 34 mm. from upper part of the centrodorsal, much shorter from apical area. Centrodorsal apparently hemispherical or subconical, about 12 mm. in diameter and 10 mm. high, without conspicuous cirrus-free apical area. Proximal cirrals elongated, length up to 3 to 4 times width, distal cirrals smooth, without dorsal spines, length 1 to 1.5 times width. Arms divide at primibrachs 2 only. Brachials 1-2 synarthrial. Syzygy at secundibrachs 3-4 and more distal. Distal edge of brachials tuberculate. Pinnules not stiff, pinnulars short, length not exceeding width. Proximal pinnulars more or less produced to a distal spine. Genus referred by CLARK to Palaeantedonidae and compared with large specimens of *Florometra*. *L.Cret. (Alb.)*, S.Am. (Colom.).

*Solanometra* A. H. CLARK, 1911, p. 727 [\**Antedon antarctica* CARPENTER, 1881a, p. 198 (= *Antedon australis* CARPENTER, 1888, p. 146; *Helio-metra glabra* A. H. CLARK, 1907f, p. 351, *nom. subst. pro Antedon australis* CARPENTER, 1888, p. 146, *non* CARPENTER, 1882c, p. 510, *ex* LÜTKEN, *nom. nud.*); SD A. H. CLARK, 1914a, p. 3]. Centrodorsal hemispherical to rounded subconical. Brachials very stout. Recent.—FIG. 607,5. \**S. antarctica* (CARPENTER); 5a, cup with centrodorsal,  $\times 6$ ; 5b, ventral face of centrodorsal,  $\times 6$ ; 5c, basal,  $\times 15$  (5a, Carpenter, 1881a; 5b,c, Carpenter, 1888).

#### Subfamily ISOMETRINAE A. H. Clark, 1917

[Isometrinae A. H. CLARK, 1917a, p. 127]

Centrodorsal conical to hemispherical. Cirrus sockets rather numerous, 25 to 63 arranged in irregular circles. Cirri stout with 30 to 75 short cirrals, apical cirri shorter. Centrodorsal cavity moderate. Rod-shaped basals apparently not present in adult specimens. Radials generally with free dorsal surface, often diverging. Arms divided at primibrachs 2 only. Proximal pinnules rather short and stout. Genital pinnules with expanded proximal pinnulars. Viviparous. Recent, in S.Atl. and Southern O. [79-1,097 m.].

*Isometra* A. H. CLARK, 1908, p. 133 [\**Antedon challengerii* A. H. CLARK, 1907f, p. 353, *nom. subst. pro Antedon lineata* CARPENTER, 1888, p. 183 (*non* POMEL, 1887, p. 335); OD]. Characters of subfamily. Recent.—FIG. 607,3. *I. vivipara* MORTENSEN; 3a, genital pinnule of female,  $\times 8$  (Clark & Clark, 1967); 3b, cup with centrodorsal,  $\times 16$  (Gislén, 1924).

#### Family PENTAMETROCRINIDAE

A. H. Clark, 1908

[Pentametrocrinidae A. H. CLARK, 1908g, p. 134] [=Thaumatocrinida HALCKEL, 1896b, p. 469; Thaumatocrinidae BATHER, 1899b, p. 923; Decametrocrinidae MINCKERT, 1905b, p. 494; Thaumatocrininae JAEKEL, 1918, p. 74]

Centrodorsal conical or rounded subconical to low arched or low conical, almost discoidal with cirrus-free dorsal area, which may be smooth, rugose or tuberculate. Cirrus sockets commonly numerous, from less than 20 to more than 150, closely placed in one to six irregular circles. Cirrals long, may reach a length of 2.5 to 5 times width, more or less laterally compressed. Centrodorsal cavity rather large. Ventral side of centrodorsal may show five ridges or elevations, in *Pentametrocrinus* interradial, in *Thaumatocrinus* below sutures separating true radials from interradial pararadials. Basals in adult transformed to rosette; no rod-shaped basals. Radials in *Pentametrocrinus* five, but in *Thaumatocrinus* 10, each with an undivided arm.

Juvenile *Thaumatocrinus* have five large basal plates, each succeeded by a small secondary radial (pararadial) from which interradial arms arise, retarded in growth compared to primary radials and arms, but gradually attaining same size and structure.

Radials may be concealed or show a low dorsal surface, which may project beyond edge of centrodorsal. Articular face of radial in *Thaumatocrinus* undescribed, in *Pentametrocrinus* rather steep, separated by lateral margins forming interradial furrows. Interarticular ligament fossae rather low, subtriangular, separated by a straight or curved, low and narrow ridge from large and high ventral muscular fossae. The two muscular fossae form angle of about 90 degrees with each other and are separated by a narrow midradial ridge and notch. Radial cavity rather narrow. Primibrachs 1-2 synarthrial. Syzygial articulations at brachials 4-5 and with variable intervals (2-13) more distal. First pinnule at brachials 2 or in most *Pentametrocrinus* at brachials 5. Recent, in Pac., Ind. and Atl.O. [254-3,290 m.].

*Pentametrocrinus* A. H. CLARK, 1908, p. 134 [\**Eudiocrinus japonicus* CARPENTER, 1882c, p. 499; OD]. 5 radials, each with an undivided arm. Recent.—FIG. 608,2. *P. semperi* (CARPENTER); cup with centrodorsal,  $\times 6$  (Carpenter,

1888).

*Thaumacrinus* CARPENTER, 1884, p. 919 [*\*T. renovatus* (= *Promachocrinus abyssorum* CARPENTER, 1888, p. 351); OD] [= *Decametrocrinus* MINCKERT, 1905b, p. 494 (type, *Promachocrinus abyssorum* CARPENTER, 1888; SD A. H. CLARK, 1906c, p. 516)]. 10 radials, each with an undivided arm. Recent.—FIG. 608, 1a. *T. naresi* (CARPENTER); X2 (Carpenter, 1888).—FIG. 608, 1b, c. *\*T. renovatus*; 1b, ventral face of centrodorsal, X6; 1c, juvenile, X12 (1b, Carpenter, 1888; 1c, Clark, 1915a, after Carpenter, 1884a).

## Order UINTACRINIDA Broili, 1921

[*nom. transl.* SIEVERTS-DORECK in MOORE, LALICKER & FISCHER, 1952, p. 614 (ex suborder Uintacrinacea BROILI in VON ZITTEL, 1921, p. 186)] [= suborder Innatantes CLARK, 1909b, p. 174]

Articulata with very large spheroidal theca. Cup composed of large thin plates including centrale without any trace of column, cirri or attachment; infrabasals present at least in some specimens; five basals and five radials; proximal brachials and interbrachials included in calyx; nerve canals branching in basal plate to each of superposed radials; commissural canal connecting nerve canals in radials, but without commissural connection in basals or infrabasals. Very long arms divided only at primibrachs 2; muscular articulations alternating with scattered syzygial joints between brachials; pinnulation complete, with first pinnule abaxial on secundibrachs 2. *U. Cret. (Santon.)*, worldwide.

### Family UINTACRINIDAE Zittel, 1879

[*Uintacrinidae* ZITTEL, 1879, p. 345, 375]

Theca large, globose, flexible, 6.25 to 75 mm. in diameter, adunate, composed of variable large number of thin polygonal, slightly arched, smooth plates, including fixed brachials, fixed pinnulars and fixed interbrachials; centrale small, five-sided, with angles radial in monocyclic specimens and interradian in dicyclic ones; five small presumed infrabasals present in about half of specimens, one to four in few and none in remainder; five basals and five radials, articulation between radials and first primibrachs modified straight muscular with reduced ventral fossae. Brachials to about secundibrachs 8 included in thecal structure, becoming gradually modified from flat, polygonal form of thecal brachials to low, free brachials with rounded section.

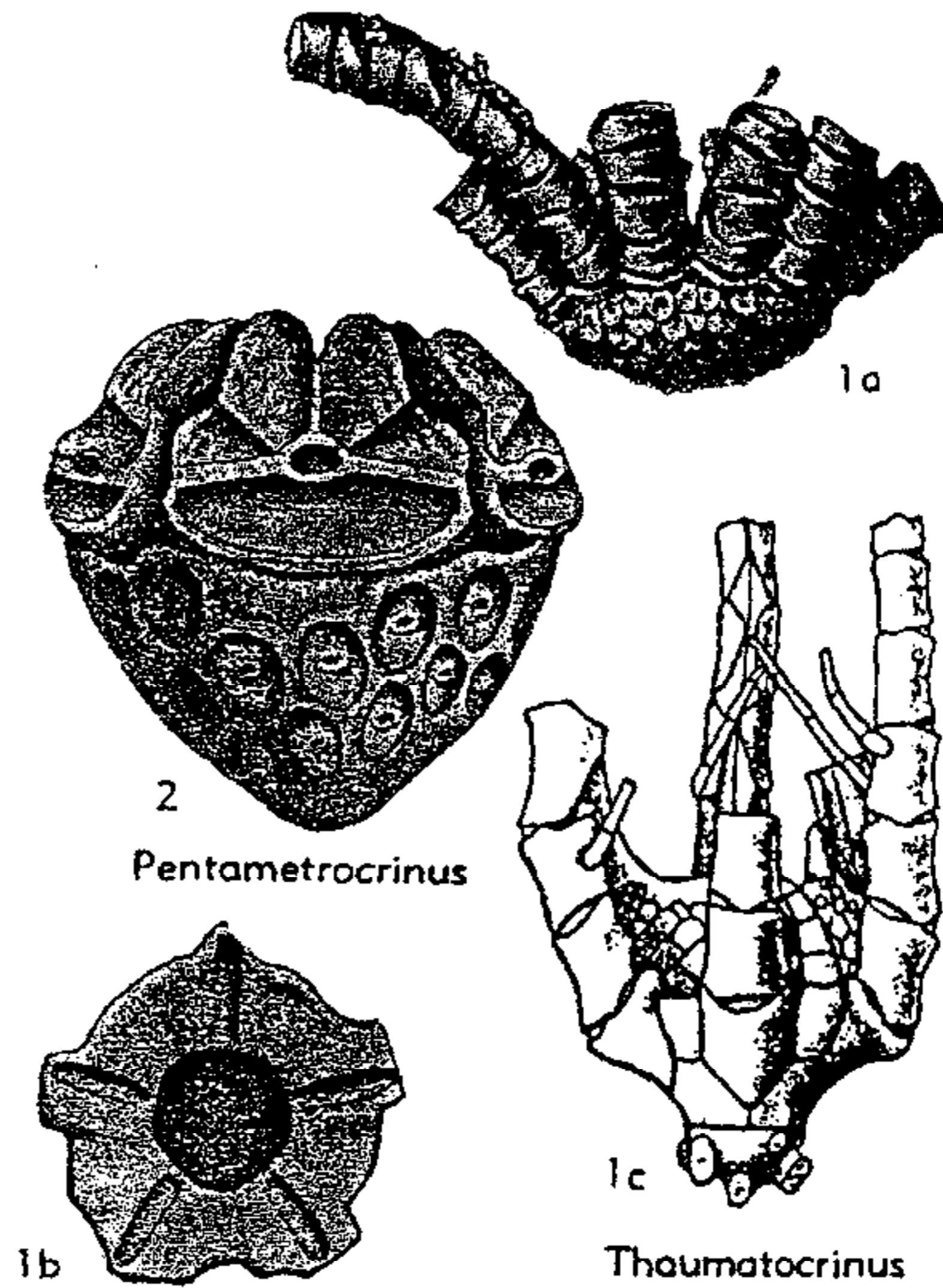


FIG. 608. Pentametrocrinidae (p. T916-T917).

Axillary second primibrachs followed by no further arm divisions; syzygial articulations with distinct radiating crenellae found between primibrachs 1 and 2 and between secundibrachs 1 and 2, generally also between secundibrachs 3 and 4, as well as 6 and 7, with intervals increasing from three to more than six in succeeding brachials; other arm articulations oblique, muscular, with small ventral fossae. Complete pinnulation beginning on abaxial side of secundibrach 2. Free part of arms, which may exceed one meter, composed of low, disc-shaped brachials, semicircular to almost circular in section.

Interradian areas of theca covered by a variable number of flat, polygonal plates, including fixed pinnulars and interbrachials; plates separating radials unusual. Interbrachials 3 to 23, intersecundibrachials 0 to 8, and interpinnular plates 0 to 3; numbers of these plates may increase during growth by intercalation of small new plates at any point in the interradian areas or distally in intersecundibrachial areas. Structure of thecal plates shows a dense outer layer and a less dense inner one com-

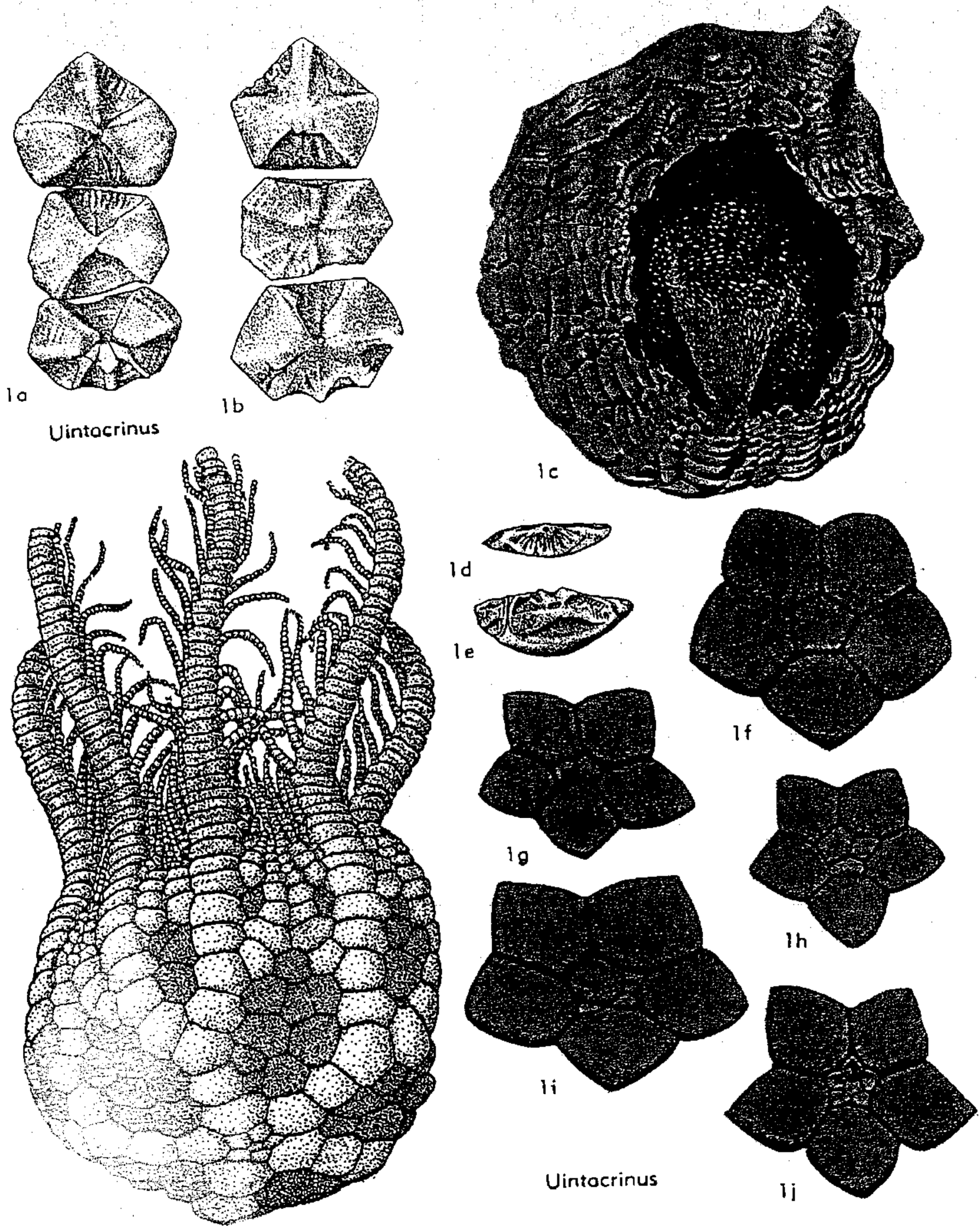


FIG. 609. Uintacrinidae (p. T919).

... around the axial canal, with branch to each of the lateral canals, but appears un-  
 ...  
 ... of ventral cover of  
 ... membrane in  
 ... with numer-

ous, small, irregular calcareous grains. Mouth marginal and ambulacral furrows with one anterior branch and two lateral branches on each side, all divided once. Ambulacral grooves without trace of covering plates or specialized ambulacral plates. A large, conical anal tube located centrally.

[*Uintacrinus* lived unattached as a planktonic crinoid. Local very rich accumulations of fossils belonging to this widely distributed, large but delicate echinoderm floater with "wingspread" of two meters or more found in Kansas may be gregarious, large, stranded groups (Fig. 216).] *U.Cret.(Santon.)*, worldwide.

UINTEGRINUS GRINNELL, 1876, p. 81 [\**U. socialis* (= *U. westfalicus* SCHLÜTER, 1878, p. 55); M]. Characters of family. *U.Cret.(Santon.)*, Eu.(N. Caucasus-Eng.-France-Ger.-Italy-Sweden)-N. Am. (Kans.-Mont.-Utah-Wyo.-B.C.)-W. Australia.—FIG. 609, 1. \**U. socialis*, N.Am., Eng. (1*a,b,d,e*, Eng.; 1*c,f-k*, USA); 1*a,b*, inner side of radial and primibrachials in different degree of corrosion,  $\times 2.5$  (Rasmussen, 1961); 1*c*, ventral face of cup with tegmen,  $\times 1$  (Springer, 1901); 1*d*, distal syzygy of primibrach 1,  $\times 2.5$ ; 1*e*, articulation of secundibrach 2 toward secundibrach 3 and pinnule,  $\times 2.5$  (1*d,e*, Rasmussen, 1961); 1*f-j*, basal circlet and variation in centrale and presumed infrabasals,  $\times 3$  (Springer, 1901); 1*k*, cup, interbrachial plates shown darker,  $\times 1$  (Rasmussen, n; after Springer, 1901).

### Family MARSUPITIDAE d'Orbigny, 1852

[Marsupitidae d'ORBIGNY, 1852, p. 138]

Theca large, subglobose or ovate, up to 65 mm. high and 60 mm. in diameter, composed of 16 large, thin, slightly arched, polygonal plates, including large centrale, five infrabasals, five basals and five radials, similar in size and meeting in close sutures; centrale five-sided, with angles disposed in terradially; infrabasals five-sided, basals six-sided, radials five-sided, with median embayment on distal edge for articulation with arms. As many as six small, thin interbrachials may separate proximal brachials of contiguous arms up to secundibrachs 2, and one to three intersecundibrachs may occur between proximal secundibrachs of some individuals, meeting brachial plates in loose sutures. Structure of thecal plates shows a dense outer layer formed by a regular network of calcite, and a less dense internal layer formed by an irregular network and commonly corroded along edges and especially around nerve canals.

Surface of thecal plates variable, generally with distinct, often radiating folds or ridges corresponding to courses of axial nerve canals inside the plates. Some specimens smooth, others ornamented by a large

number of narrow straight ridges or rows of granules parallel to main ridges or folds, perpendicular to edges of plates. This ornament due to folded structure of dense outer layer includes main ridges corresponding to nerve canals found in radials and basals between their outer and inner layers. Nerves divide in basals with branches to each of two superposed radials. A commissural canal is present in radial circlet but not in basal ring. Course of main ridges indicates that nerve canal branches from basals to each of two infra-basals and continues thence undivided to center of the centrale. Additional canals of unknown function (nerve-branches, ligaments, or connective tissue) run below finer ribs of strongly ornamented individuals.

Tegmen unknown. Proximal brachials rather low and wide, elliptical in section, not flattened like thecal plates, or with articular faces transformed to narrow bands as in *Uintacrinus*. Articular faces between radials and first primibrachs commonly are strongly curved, reducing mobility. Articulation is straight muscular, with straight or angular articular ridge, flat dorsal ligament fossa lacking distinct pit, and small ventral muscular fossae commonly separated indistinctly from interarticular ligament fossae.

Second primibrachs axillary, but no secundaxils observed. Syzygial articulations between primibrachs 1 and 2, secundibrachs 1 and 2, 3 and 4, and at greater intervals in succeeding parts of arms. Pinnulation complete with first pinnules borne by outer side of secundibrachs 2. *U.Cret.(Santon.)*, worldwide.

Marsupites MILLER, 1821, p. 134 [\**M. ornatus* (= *Encrinites testudinarius* VON SCHLOTHEIM, 1820, p. 339; *M. milleri* MANTELL, 1822, p. 184); *Sitularia trianguliformis* CUMBERLAND, 1826, p. 21; *M. mantelli* BRONN, 1848, p. 705; *M. laevigatus* FORBES in DIXON, 1850, p. 343; *M. americanus* SPRINGER, 1911c, p. 158; *M. lamberti* BESAIRIE, 1936, p. 203); M] [= *Sitularia* CUMBERLAND, 1826, p. 21 (type, *S. triangulariformis*; M); *Marsupiocrinites* DE BLAINVILLE, 1830, p. 244 (non PHILLIPS, 1839, p. 672) (nom. van.)]. [The name *Marsupites* was taken by MILLER (1821) from a manuscript by MANTELL published in 1822. The name *Marsupium* KOENA, recorded by AGASSIZ (1836, p. 194) is presumably a *nomen vanum*, origin untraced.] Characters of family. *U.Cret.(Santon.)*, Eu. (N.Caucasus-Crimea-Eng.-

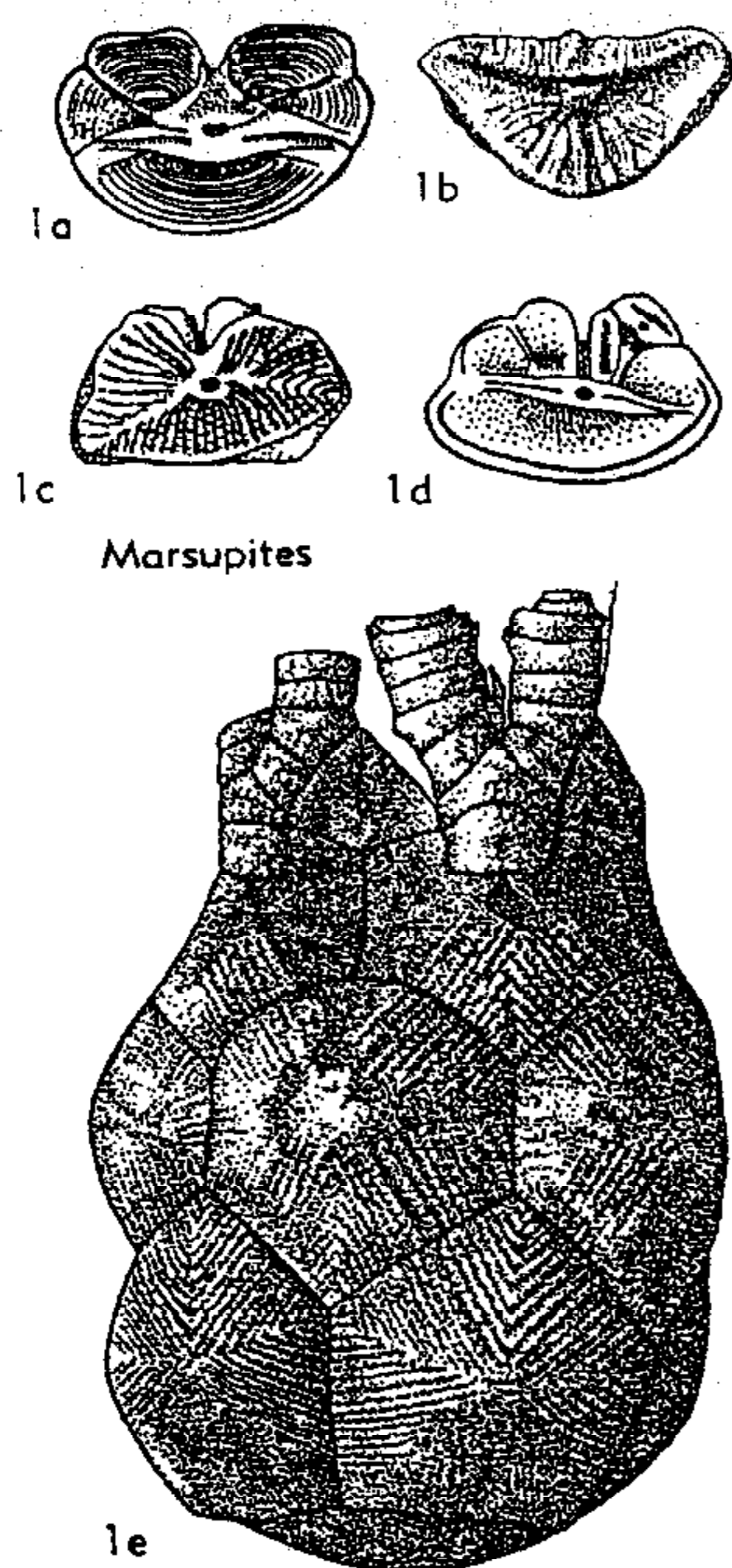


FIG. 610. Marsupitidae (p. T919-T920).

Eire-Ger.-France-Pol.-Asia (Turkmenia [Kopet-Dag]-India-W. Australia-Afr. (Algeria-Madag.)-N. Am. (Miss.-Texas).—FIG. 610, 1. \**M. testudinarius* (VON SCHLOTHEIM), U.Cret. (Santon.), Ger. (1a, c-e), Eng. (1b); 1a, articular face of radial, X3 (Sieverts, 1927); 1b, distal face of primibrach 1, X2.5 (Rasmussen, 1961); 1c, d, distal face of secundibrach 9 and secundibrach 11, X3 (Sieverts, 1927); 1e, cup with arms, X1 (Rasmussen, 1961).

### Order ROVEACRINIDA Sieverts-Doreck, 1952

[Roveacrinida SIEVERTS-DORECK in MODRE, LALICKER, & FISCHER, 1952, p. 614] [Materials for this order prepared by R. E. PECK]

Small stemless pelagic Articulata with theca composed of radials, small discrete or fused basals, and in some specimens, a centrale. Arms well developed or absent, those with arms having strong muscular articulations. Skeleton light and delicate to comparatively massive. *M.Trias.-U.Trias.; U.Jur.-U.Cret.*

### Family ROVEACRINIDAE Peck, 1943

[Roveacrinidae PECK, 1943, p. 461 (emend. RASMUSSEN, 1961, p. 360)]

Theca composed of fairly massive radials and fused (or exceptionally discrete) basals developed into a dorsal spine supporting radials or reduced to thin plate overgrown by radials surrounding two cavities (body and dorsal). Basals form floor of body cavity and in most individuals project into dorsal cavity as small tubercle (Fig. 611, 3d); dorsal cavity may be enclosed or open at base. Arms ten, bifurcating on second primibrach. Radial articular facets well developed, brachials joined by synarthrial unions or muscular articulations, generally alternating. Most brachials possess strong projecting serrated processes on borders of ventral process. *M.Trias.-U.Trias.; L.Cret.-U.Cret.*

PECK (1943) interpreted the covering of the dorsal cavity as a noncirriferous centro-dorsal. Subsequently, RASMUSSEN (1961) stated that roveacrinids lack a centrodorsal inasmuch as interrarial sutures can be traced across walls of the dorsal cavity to the bottom of the theca. In 1971 RASMUSSEN added observation that the walls of the dorsal cavity in the new genus *Roveacrinoides* were formed by basals. He also indicated probability that walls of the dorsal cavity in other Roveacrinidae are formed by basals overgrown by radials.

On very young specimens of *Poecilocrinus* sp. from the Duck Creek Formation, the delicate theca consists of five radials, five small basals forming a star-shaped base, and a small centrale. As growth proceeded, the proximal ends of the radials grew down and over the basals to completely enclose them and continue proximally to form the walls of the dorsal cavity. Interrarial sutures of many mature forms can be traced from ventral to dorsal ends on both interior and exterior of the theca.

Flooring of body cavity consists of fused basals. This conclusion is based on growth stages described above and on a single specimen of *Roveacrinus communis* in the British Museum, which shows lines in the flooring of the body cavity that have been interpreted by PECK (1955) and RASMUSSEN (1961) as interbasal sutures, and on specimens of *Roveacrinus nudus* RASMUSSEN.

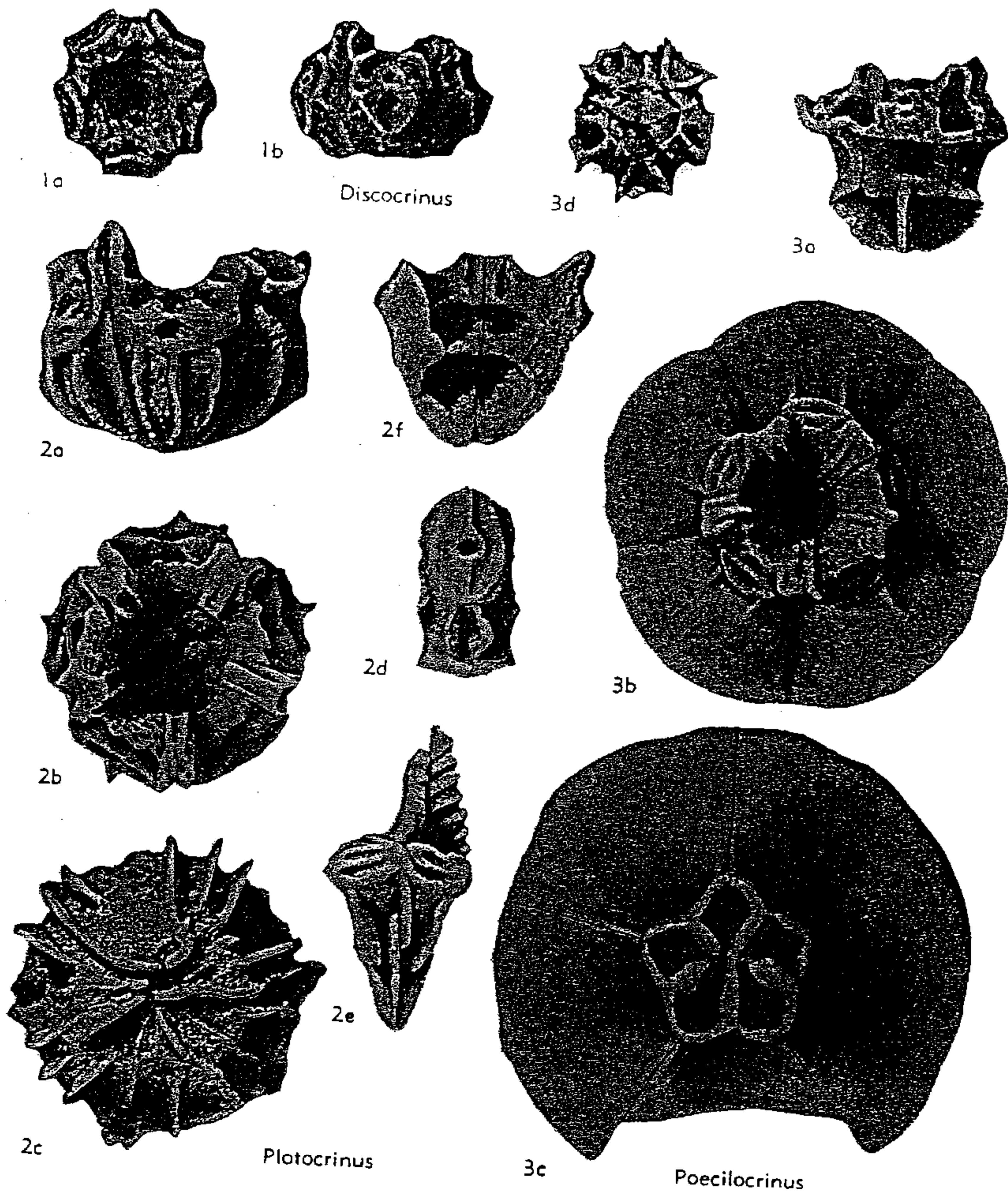


FIG. 611. Roveacrinidae (Roveacrininae) (p. T922).

Subfamily ROVEACRININAE Peck, 1943

[Roveacrininae PECK, 1943, p. 465; *emend.* PECK, herein]  
 [includes Drepanocrininae PECK, 1943; Styracocrininae PECK, 1955]

Radials forming theca with body cavity and dorsal cavity, latter closed in most specimens; basals small, generally fused, but discrete in a few individuals, forming thin partition between the two cavities. Arms ten, branching on second primibrach;

brachials connected by alternating muscular articulations and synarthrial unions, strong serrated processes common on brachials. Theca ornamented by spines, ridges, wings, and flanges. *L.Cret.-U.Cret.*

Roveacrinus DOUGLAS, 1908, p. 358 [*R. alatus*; OD] [= *Drepanocrinus* JAEKEL, 1918, p. 72]. Theca with small semicircular arm facets and 5 undivided radial ridges extending from proximal portion of arm facets to aboral pole, distal part of

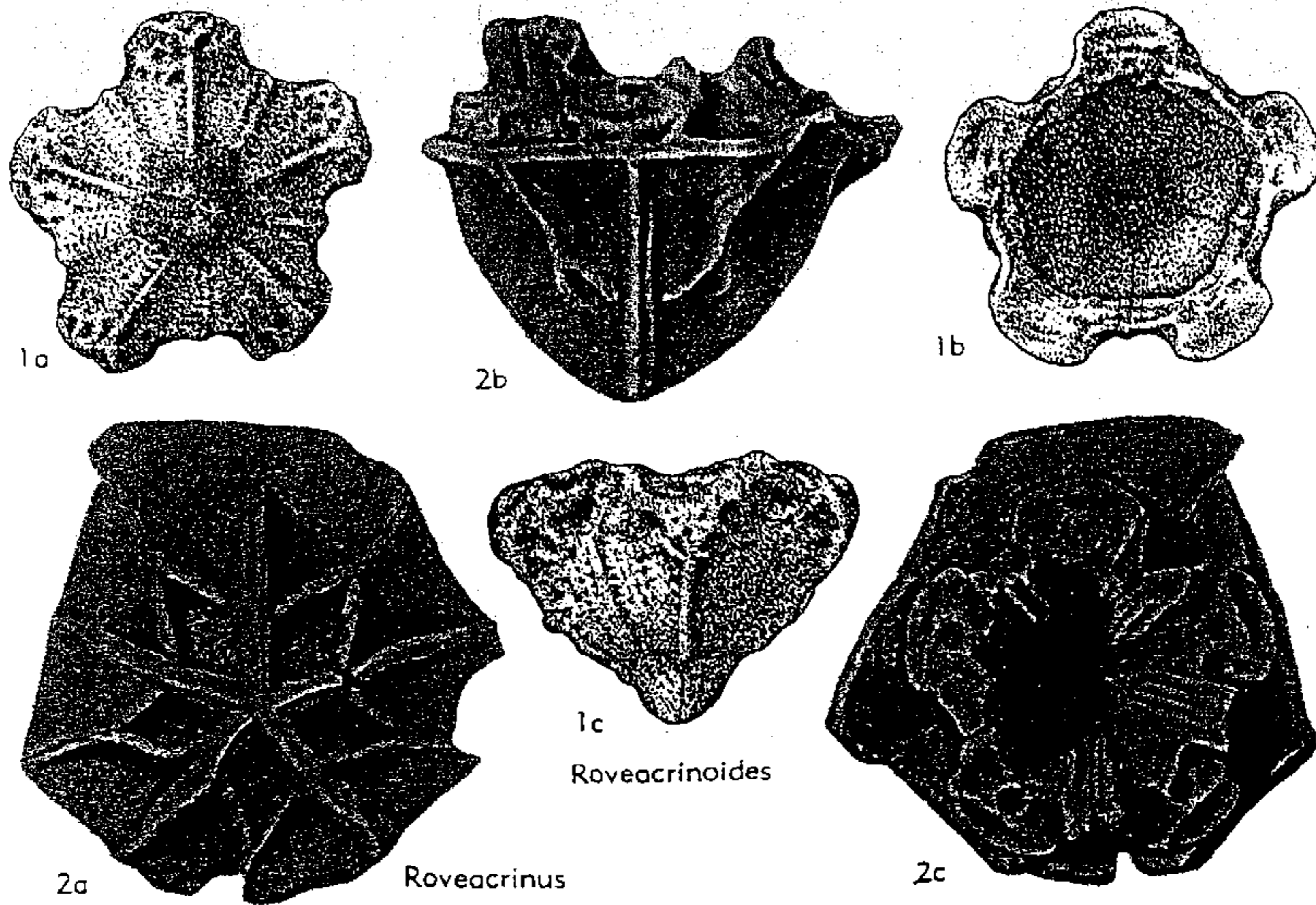


FIG. 612. Roveacrinidae (Roveacrininae) (p. T921-T922).

radial ridges may bear spines, wings, or flanges. *L.Cret.(Alb.)-U.Cret.(Cenoman.)*, USA (Texas); *U. Cret. (Cenoman.-Coniac.)*, Eu. (Eng.-Ger.-France); *U.Cret.(Turon.)*, Eu.(Boh.).—FIG. 612,2. *R. signatus* PECK, *U.Cret.(Grayson F.)*, Texas; 2a-c, dorsal, lat., and ventral views of holotype,  $\times 18$  (Peck, 1943).

*Discocrinus* PECK, 1943, p. 474 [*\*D. catastomus*; OD]. Cylindrical theca with large arm facets located on outer sides of radials and almost parallel to dorsoventral axis; dorsal cavity open at base. *L.Cret.(Alb.)*, USA (Texas)-*U.Cret.(Cenoman.)*, Eu.(Eng.).—FIG. 611,1. *\*D. catastomus*, *L.Cret.(Ft. Worth Ls.)*, Texas; 1a,b, ventral and lat. views of holotype,  $\times 18$  (Peck, 1943).

*Orthogonocrinus* PECK, 1943, p. 464 [*\*O. apertus*; OD]. Theca with well-developed arm facets occupying most of distal surface and parts of sides of radials, facets making almost right angle turn at transverse ridge. Arms unknown. *L.Cret.(Alb.)-U.Cret.(Cenoman.)*, USA (Texas); *U.Cret.(Cenoman.-Coniac.)*, Eu.(Eng.-France-Ger.); *U. Cret.(Turon.)*, Eu.(Boh.).—FIG. 613,1. *\*O. apertus*, *L.Cret.(Duck Creek F.)*, Texas; 1a,b, lat. and ventral views of holotype,  $\times 18$ ; 1c, detail of arm facet,  $\times 25$ ; 1d,e, lat. and interior of 3 radials showing internal structure, both  $\times 18$  (Peck, 1943).

*Pocilocrinus* PECK, 1943, p. 471 [*\*P. dispandus*; OD]. Like *Roveacrinus* but radial ridges bifurcate

at midheight of theca or below and each branch connects with outside proximal portion of arm facets. *L.Cret.(Alb.)-U.Cret.(Cenoman.)*, USA (Texas).—FIG. 611,3a-c. *\*P. dispandus*, *L.Cret.(Ft. Worth Ls.)*; 3a, lat. view of paratype with horizontal flanges broken,  $\times 18$ ; 3b,c, dorsal and ventral views of paratypes,  $\times 18$  (Peck, 1943).—FIG. 611,3d. *P. porcatus* PECK, *L.Cret.(Duck Creek F.)*; showing dorsal side of partition between cavities,  $\times 18$  (Peck, 1943).

*Plotocrinus* PECK, 1943, p. 469 [*\*P. hemisphericus*; OD]. Theca hemispherical with large arm facets and radial ornamentation consisting of either simple vertical ridges or simple ridges flanked along their distal half by additional ridges. Spines, wings or horizontal flanges not developed. *L.Cret.(Alb.)*, USA (Texas).—FIG. 611,2. *\*P. hemisphericus*, *Duck Creek F.*; 2a,b, lat. and ventral views of holotype; 2c-f, basal view, brachials 1,2, and interior view of 2 radials, all  $\times 18$  (Peck, 1943).

*Roveacrinoides* RASMUSSEN, 1971, p. 287 [*\*R. nudus*; OD]. Like *Roveacrinus* but dorsal cavity enclosed by basals not overgrown by radials. *U. Cret.*, Eu.(Eng.).—FIG. 612,1. *\*R. nudus*, *Turon.*; 1a-c, dorsal, ventral, and lat. views of holotype,  $\times 18$  (Rasmussen, 1971).

*Styracocrinus* PECK, 1955, p. 1022 [*\*Drepanocrinus peracutus* PECK, 1943; OD]. Theca small, elongate conical; radial facets triangular or semicircular in shape, sloping outward-downward at angle from



horizontal slightly greater outside traverse ridge than inside. Second primibrachs axillary, long and slender with narrow median ridge and thin lateral flanges. *L.Cret.(Alb.)-U.Cret.(Cenoman.)*, USA(Texas); *U.Cret.(Cenoman.)*, Eu.(Eng.).—FIG. 613,2. \**S. peracutus* (PECK); 2a-c, *L.Cret.*, Texas; 2a, paratype with first primibrachs attached,  $\times 20$ ; 2b, ext. of first primibrach of paratype showing synarthrial union surface,  $\times 50$ ; 2c, lat. view of first primibrach of paratype,  $\times 50$  (Peck, n; Univ. Missouri, Columbia, E-22-3); 2d, *Cenoman.*, Eu., theca with brachials,  $\times 15$  (Rasmussen, 1961).

Subfamily SOMPHOCRININAE Peck,  
new subfamily

Theca and arms similar to Roveacrininae. Radials resting on long or short spinelike projection comprising dorsal spine, which probably represents fused basals. *M.Trias.-U.Trias.*

According to Dr. H. KOZUR (written commun., 1973), these crinoids are excellent guide fossils in the Ladinian and Carnian of southern Europe.

*Somphocrinus* PECK, 1948, p. 82 [\**S. mexicanus*; OD]. Radials joined to dorsal spine along small triangular surfaces and in contact with each other only at distal lateral borders; spines conical to cylindrical with flaring distal ends. *U.Trias.(Carn.)*, Mexico.—FIG. 614,1. \**S. mexicanus*; 1a, drawing showing PECK's interpretation of theca and arms, enl.; 1b, side view of dorsal spine of holotype,  $\times 10$ ; 1c, reconstruction of arm,  $\times 5$ ; 1d-f, radial, first and second primibrachs,  $\times 10$  (Peck, 1948).

*Osteocrinus* KRISTAN-TOLLMAN, 1970, p. 784 [\**Rhabdotites rectus* FRIZZELL & EXLINE, 1956, p. 66; OD]. Smaller than *Somphocrinus* and radials joined laterally along their entire length. Arm facets strongly bent at transverse ridge, almost vertical dorsal ligament fossae and ligament pits on sides of radials; central canal, interarticular ligament fossae and muscular fossae on ventral surface of radials. Interarticular ligament fossae and muscular fossae divided centrally by narrow ridge sloping toward interior of theca and carrying a fairly deep furrow. Brachials round, long and slender, with swollen ends. *M.Trias.(U.Ladin.)-U.Trias.(L.Carn.)*, Eu.(Italy-Aus.-Rumania-Turkey)-Asia(Nepal)-Indon.(Timor).—FIG. 614, 4a-c. \**O. rectus rectus* (FRIZZELL & EXLINE), *U.Ladin.* (Cassiano beds), S. Alps (Italy); 4a,b, ext. and int. of first primibrach,  $\times 41$ ,  $\times 40$ ; 4c, ext. of secundibrach,  $\times 33$ ; 4d, lat. view of radial pentagon,  $\times 22$ ; 4e, lat. view of dorsal spine,  $\times 29$  (Kristan-Tollman, 1970).—FIG. 614,4f,g. *O. spinosus* (KRISTAN-TOLLMAN), *U.Ladin.* (Seelandschichten), S. Alps (Italy); 4f,g, int.

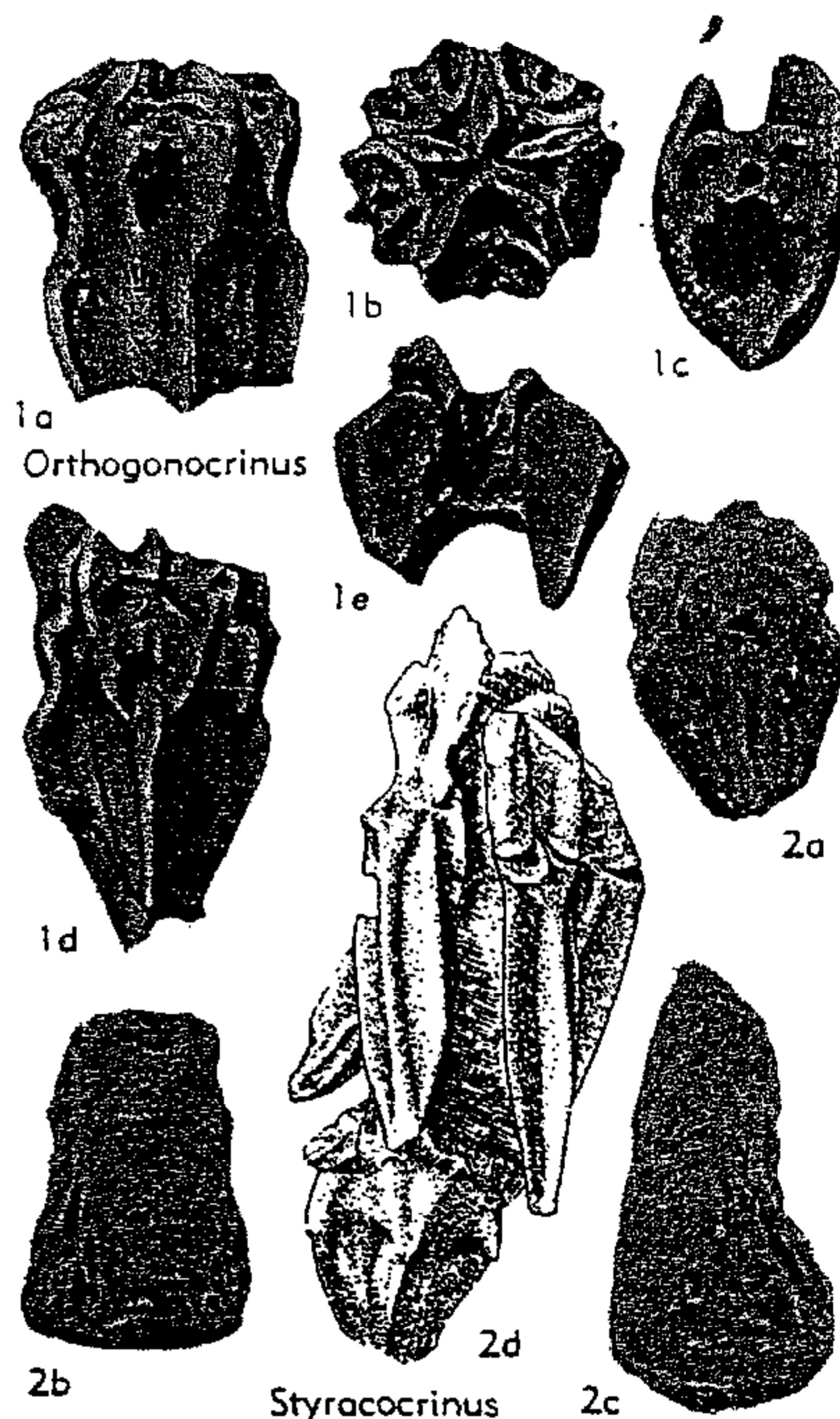


FIG. 613. Roveacrinidae (Roveacrininae) (p. T922-T923).

and ventral views of radial,  $\times 32$  (Kristan-Tollman, 1970).—FIG. 614,4h. *O. rimosus* KRISTAN-TOLLMAN, *L.Carn.* (Halobien-schiefer), N. Alps (Aus.); lat. view of holotype showing short dorsal spine,  $\times 37$  (Kristan-Tollman, 1970).

*Ossicrinus* KRISTAN-TOLLMAN, 1970, p. 788 [\**O. reticulatus*; OD]. Smaller than *Osteocrinus* and arm facets lack ventral ridge and groove; muscular fossae small and on distal edge of radial. Brachials triangular in cross section, and deeply grooved on interior. *M.Trias.(U.Ladin.)*, Eu.(Italy, S.Alps).—FIG. 614,3. \**O. reticulatus*, Cassiano beds; 3a,b, summit and lat. views of holotype,  $\times 67$ ,  $\times 64$  (Kristan-Tollman, 1970).

*Poculicrinus* MOSTLER, 1972, p. 720 [\**P. glaber*; OD]. Dorsal spine cup shaped. Radials quadrangular and expanding distally. Arms unknown. *U.Trias.(Carn.)*, Eu.(Aus.).—FIG. 614,2a. \**P. glaber*, Salzkammergut; dorsal spine,  $\times 20$  (Mostler, 1972).—FIG. 614,2b. *P. globosus* MOSTLER; dorsal spine with attached radials,  $\times 20$  (Mostler, 1972).

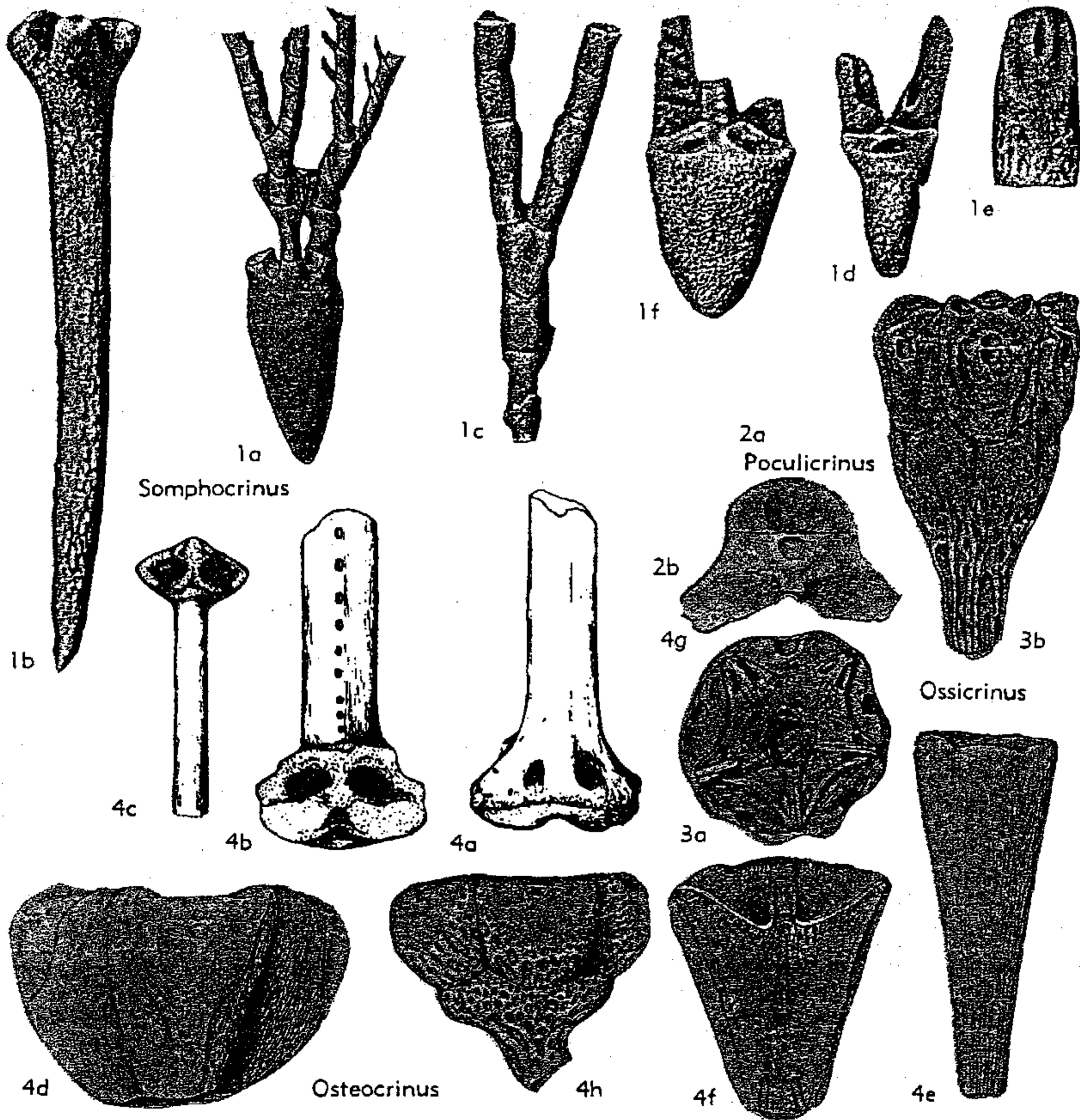


FIG. 614. Roveacrinidae (Somphocrininae) (p. T923).

**Family SACCOCOMIDAE**  
d'Orbigny, 1852

[Saccocomidae d'ORBIGNY, 1852, p. 137]

Stemless Articulata with theca composed of five large radials, five very small basals, and minute centrale surrounding large, undivided cavity. Arms very slender or absent. No cirri. (RASMUSSEN, 1961, p. 389.) *U. Jur.-Cret.*

**Subfamily SACCOCOMINAE** d'Orbigny, 1852

[*nom. transl.* BACHMAYER, 1958, p. 43 (ex Saccocomidae d'ORBIGNY, 1852, p. 137)]

Theca with large radials, small basals, and nonperforated centrale; oral cover present at least in some species; thecal plates very thin. Arms, if present, slender, articulated to a very small articular face at upper edge of radials. (RASMUSSEN, 1961, p. 389.) *U. Jur.-Cret.*

Saccocoma AGASSIZ, 1836, p. 193 [*\*Comatula pectinata filiformis* GOLDFUSS, 1831, p. 205 (= *Euryale bajeri* KOENIG, 1825, p. 2); SD JAEKEL, 1918, p. 92] [= *Saccoma* JAEKEL, 1918, p. 92; *Lombardia* BRÖNNIMANN, 1955, p. 43]. Radials and small centrale enclosing large spheroidal cavity, each

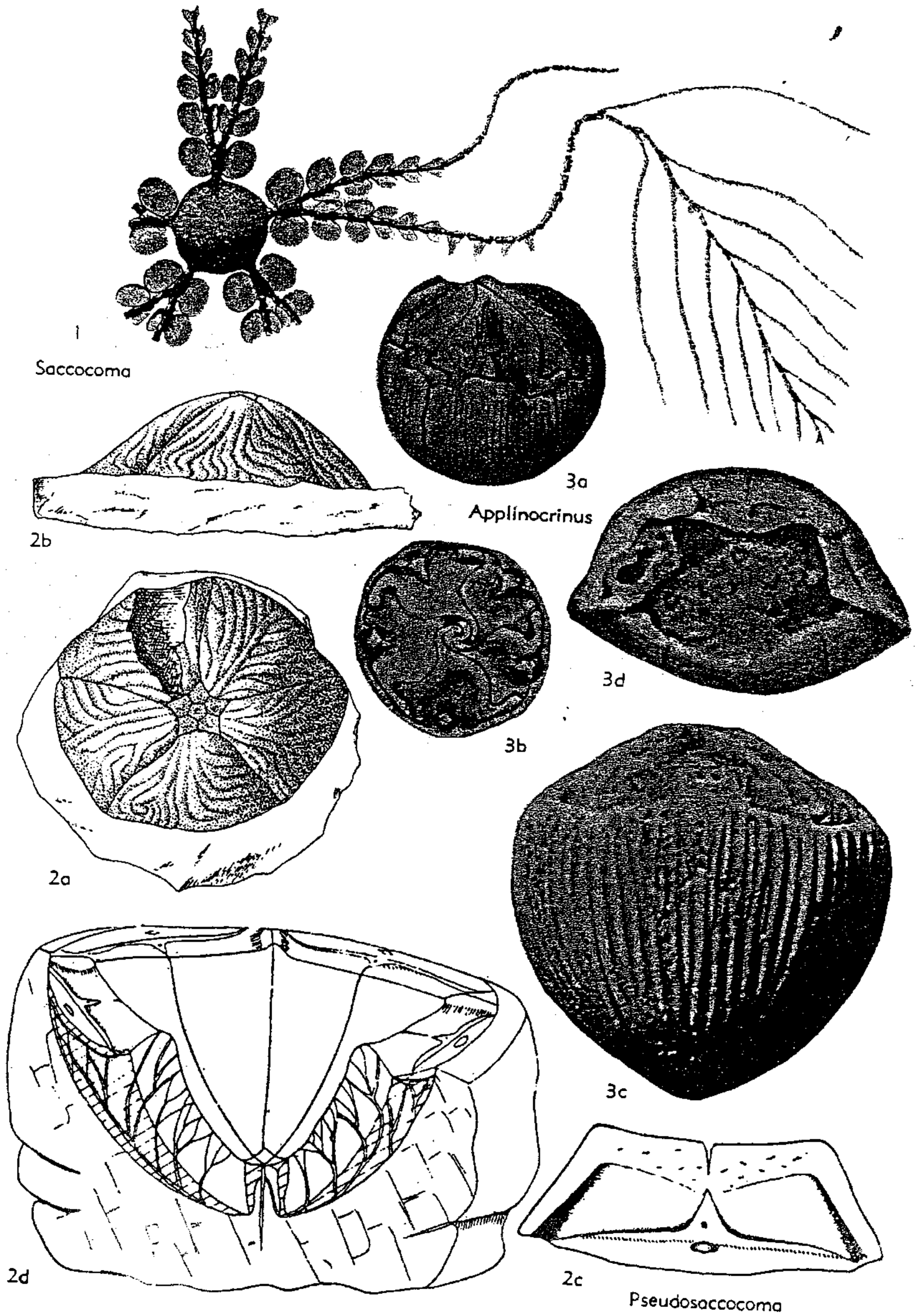


FIG. 61. Saccocomidac (Saccocominae) (1,3); (Pseudosaccominae) (2) (p. T924, T926).



joint faces toward unknown basal circlet. [Originally referred to Cyrtocrinida, but when indication for a basal circlet was found, JAEKEL (1907, p. 291) transferred the genus to Millericrinida. The extremely high, cylindrical radial circlet is similar to recent *Naumachocrinus* among Bourgueticrinida (Porphyrocrinidae). The only columnal recorded from the same locality may well belong to *Eugeniocrinites*, which was also present. We have no certain indication of the possible affinity with Millericrinidae or Porphyrocrinidae.] *M. Jur.* (Callov.)—*U. Jur.* (Oxford.), *Eu.* (France-Port.).—FIG. 616, 2. \**D. aberrans*, *M. Jur.*, Port.; 2a, b, lower face of radial circlet and lat. view,  $\times 4.8$  (de Loriol, 1891a).

## REJECTED NAMES

*Alceto* LEACH, 1815 [\**A. horrida*; SD A. H. CLARK, 1908c, p. 449]. According to CLARK (1908c), genus name, previously used for several recent and fossil comatulids, was based on *A. horrida*, which he considered unidentifiable. This is accepted here. Name was subsequently introduced as a junior homonym by LAMOUREUX, 1821, for a bryozoan. [See also p. T890.]

*Asteriatites* VON SCHLOTHEIM, 1813, p. 68, 99, 109. Name unavailable (*Code*, Art. 20), introduced by VON SCHLOTHEIM in the combination *A. pennatus* (pro KNORR, 1768, v. 2, pt. 2, pl. 51, = *Pterocoma pennata*), *A. filiformis* (pro KNORR, 1755, v. 1, pl. 11, fig. 2-7, 9, = *Saccocoma filiformis*), *A. rosaceus* (pro KNORR, 1755, pl. 11, fig. 8, = *Saccocoma filiformis*), *A. eremita* (*nom. nud.* = *Asteriacites ophiurus* VON SCHLOTHEIM, 1820, p. 325, an indeterminable ophiuroid), *A. spinosus* (*nom. nud.*), *A. pentagonatus* (*nom. nud.*), and probably as a misprint *Osteratites siderolites* (pro MONFORT, 1808, p. 150, = *Siderolites calcitrapoides*). LOEBLICH & TAPPAN (1964, in *Treatise*, Part C, p. C796) incorrectly claimed *Asteriacites ophiurus* VON SCHLOTHEIM, 1820, to be type species by subsequent monotypy. SPENCER & WRIGHT (1966, in *Treatise*, Part U, p. U103) considered *Asteratites* (= *Asteriacites*) a dubious synonym of *Saccocoma*.

*Astropodium* LHWYD, 1699. Pre-Linnean name used by LHWYD for various crinoid columnals, also recorded in BERTRAND, 1763 (publication rejected by ICZN for nomenclatorial purposes), in KNORR & WALCH, 1769, and in URE, 1793, but not as a proper genus name. DEFRANCE (1819, p. 467-468), adopted this name from German authors (presumably KNORR & WALCH) and used it in the combination "*astropode elegante*" or "*astropodium elegans*" for a species of *Apiocrinites*. He

is here considered to have established a new species *A. elegans* in combination with a genus name not available (*Code*, Art. 17). [= *Astropoda* DE BLAINVILLE, 1830, p. 239 (*nom. null.*).]

*Leiocrinus* D'ORBIGNY, 1850, p. 180, non SPRINGER, 1902, p. 95 [\**Eugeniocrinites essensis* F. A. ROEMER, 1840, p. 26; M]. Based on strongly corroded, cylindrical columnals commonly with radiating marginal crenulae or a marginal furrow. According to RASMUSSEN (1961, p. 155), genus indeterminable, although probably belongs to Millericrinida or Cyrtocrinida. Found in Cenomanian conglomerate, but may well be of Jurassic origin. *Eu.* (Ger.).

*Pachyantodon* JAEKEL, 1891, p. 628 [\**P. beyrichi*; M]. Indeterminable crinoid, interpreted by JAEKEL as arms of a comatulid with 5 arms proximally divided in 10 short and stout branches. Brachials extremely low and wide, strongly wedge shaped. Presumed cirri stout, with short, wedge-shaped segments. Type based on impression in boulder of flint of presumed Late Cretaceous age from North Germany.

*Picteticrinus* ETALLON, 1857, p. 282 [\**P. parasiticus*; M]. A *nomen nudum* (non *Picteticrinus* DE LORIOI & PELLAT, 1875, p. 297, which is a junior homonym) (p. T853).

*Symphytocrinus*. Name unavailable, attached by KOENIG to four figured but undescribed species in his unpublished second part of "*Icones Fossilium Sectilis*" (1825). Quoted by AGASSIZ, 1836, as a synonym of *Apiocrinus* and of *Eugeniocrinus*. DE LORIOI (1878, p. 62) identified *S. caryophyllum* as a copy of VON SCHLOTHEIM's figure of *Eugeniocrinites cariophilites*, and BATHER (1900a) recorded the name as a synonym of *Eugeniocrinus*.

## NAMES NOT BASED ON CRINOIDS

*Gasterometra* GISLÉN, 1925, p. 30 [\**G. polycirra*; M]. Originally referred to Palaeantedonidae, but demonstrated by NIELSEN (1943, p. 61) to be dorsal plate of asteroid *Staturanderaster*.

*Pogocrinus* GAGNEBIN, 1930, p. 219 [\**P. raafensis*; M] [= *Pogocrinus* GAGNEBIN, 1930, p. 219, *nom. null.*]. Unidentified fossil from Middle Triassic of Switzerland, interpreted as arms of a crinoid. Herein rejected from echinoderms.

*Rhabdocrinus*. Misprint by ETHERIDGE, 1882, p. 179, for the echinoid *Rhabdocidaris*.

*Trigonocrinus* BATHER, 1889, p. 149 [\**T. liratus*; M]. A fossil described as the cup of a crinoid referred to Eugeniocrinitidae from the Upper Jurassic (Oxford.) of Germany. Herein interpreted as the tube of a serpulid.

## UNASSIGNED TAXA

During final revision in galley proof stage it was discovered that the following names were omitted from the text:

## CAMERATA

- Astrocrinites AUSTIN, 1843, p. 206 (*non* CONRAD, 1841).  
Doliocrinites SHUMARD, 1866, p. 366 (*pro Doliocrinites* TROOST in HALL, 1858).

## INADUNATA

- Apiocrinites HISINGER, 1828, p. 217 (*non* MILLER, 1821, *Articulata*) [= *Enallocrinus* D'ORBIGNY, 1850].  
Cosmocrinus JAEKEL, 1898, p. 31, *U.Dev.*, N.Am.-Eu.(Ger.).  
Cryptocrinites VON BUCH, 1840, p. 36.  
Cryptocrinus VON BUCH, 1840, p. 60.  
Cryptocrinus GEINITZ, 1846, p. 557.  
Decadactylocrinus WACHSMUTH & SPRINGER, 1886, p. 313.  
Dicirrocrinus SCHMIDT, 1934, p. 88. *L.Dev.*, Eu.(Ger.).  
Dimorphicrinus D'ORBIGNY, 1850, p. 155.  
Graphyocrinus TIEN, 1926, p. 40 (*nom. null.*, *pro Graphyocrinus* DE KONINCK & LE HON, 1854).  
Paralageniocrinus WANNER, 1949.  
Thuringocrinus JAEKEL, 1918, p. 61 [\**T. saalfeldianus*]. *U.Dev.*, Eu.(Ger.).

## FLEXIBILIA

- Asutaracrinus YAKOVLEV, 1956, p. 71.

## NOMINA NUDA

- Ascocrinus TROMELIN & LEBESCONTE, 1876, pl. D.  
Bicilocrinus IVANOV, 1926, p. 176.

- Decadactylocrinites OWEN in SHUMARD, 1866, p. 376.

## UNRECOGNIZABLE GENERA

- Ascocrinus JAEKEL, 1918, p. 54 (*non* BARRANDE, 1887, *cystoid*). *M.Dev.*, Eu.(Boh.).  
Bichirocrinus JAEKEL, 1918, p. 88 (no species named). *Sil.-Dev.*, N.Am., Eu.  
Calocrinites STEININGER, 1849, p. 21 (?= *Cupressocrinites*).  
Calocrinus BATHER, 1900, p. 202 (*nom. van.*, *pro Calocrinites* STEININGER, 1849).  
Chelocrinites GEINITZ, 1846, p. 540 (*nom. van.*, *pro Chelocrinus* VON MEYER, 1837).  
Chelocrinus VON MEYER, 1837, p. 260 (according to BATHER, 1900, p. 181, = *Encrinus* SCHULZE, 1760).  
Cothocrinites PHILIPPI, 1876 [= *Cothocrinus* ZITTEL, 1879 (*nom. van.*)].  
Dichirocrinus JAEKEL, 1918, p. 88 (no species assigned).  
Glyptaster VINASSA DE REGNY, 1942 (?*non* HALL, 1852).  
Heliocrinites EICHWALD, 1840, p. 189.  
Heliocrinus EICHWALD, 1859, p. 629 (*nom. van.*, *pro Heliocrinites*).  
Heliocrinus QUENSTEDT, 1876.  
Microcrinus BOLKHOVIMINOVA & MARKOV, 1926, p. 40 (*non* EMMONS, 1858) (no type species).  
Pentamerocrinus JAEKEL, 1918, p. 79. *M.Ord.*, USSR (Leningrad area).  
Peripterocrinus WANNER, 1916, p. 360 (*nom. subst. pro Thalassocrinus* WANNER, 1916, *non* CLARK, 1911).  
Polytrema RAFINESQUE, 1819, p. 429.  
Tetractocrinus JAEKEL, 1918, p. 25. *Ord.*, USSR (Leningrad area).  
Thalassocrinus WANNER, 1916, p. 311 [= *Peripterocrinus* WANNER, 1916].

## DISSOCIATED CRINOID SKELETAL ELEMENTS

By RUSSELL M. JEFFORDS

[Exxon Production Research Company]

Disarticulated parts of crinoids, decidedly common in the fossil record, have been recognized, classified, and named by many paleontologists as a minor but significant part of their studies on these fossils. Throughout the gradual development of knowledge on crinoids, paleontologists have proposed and named many genera and species for such dissociated elements, particularly the columnals and holdfasts, even though primary attention was on investigations of the cups and crowns (MOORE & JEFFORDS, 1968). Increasing appreciation of

the abundance and distinctive attributes of dissociated columnals and other skeletal elements in many Ordovician to Holocene marine sedimentary sections, however, has led to repeated attempts at classification and naming these potentially important biostratigraphic indicators. Artificial schemes to classify and name crinoid skeletal elements, chiefly the columnals, were proposed by MOORE (1939b), MOORE & LAUDON (1944), VYALOV (1953a,b, 1969), YELTY-SHEVA (1956, 1959, 1965a), and TERMIER & TERMIER (1974). MOORE, for example, ap-

plied latinized binomina (called Divisions and Groups) to a wide variety of dissociated elements but stipulated that the nomenclature was not intended to be governed by the *International Code of Zoological Nomenclature*. VYALOV and YELTY SHEVA formulated different comprehensive but arbitrary and artificial (and largely hypothetical) form groups, bearing latinized names, on the basis of geometric features of columns. As introduced and subsequently applied by Soviet specialists, these form groups of YELTY SHEVA were applied to many newly proposed species in the sense of collective groups without designation of type species. Considerable nomenclatural uncertainty and confusion accompanied the interchange of the terms form group and genus, the seeming availability under the *Code* of some extensively used genus-group names because of original fixation of type species by monotypy, and the citation and treatment of unavailable manuscript names in successive publications (MOORE & JEFFORDS, 1969). More recently, however, attention has been focused on proposing or recognizing taxa of columnals (families, genera, species) based on their distinctive morphological characteristics and interpreted affinities. Thus, some species-group taxa are assigned to genera previously proposed for crinoid cups or crowns or are recognized as previously unnamed genera.

Disarticulated skeletal remains of crinoids have distinctive morphological features affording a basis by which many may be classified in groups defined as representing different zoological taxa (MOORE, JEFFORDS, & MILLER, 1968). Each skeletal part constitutes a record, albeit differing in completeness, of a crinoid animal from which it was derived. Disarticulated remains, therefore, differ only qualitatively in completeness from crowns; all represent once-living animals. A considerable majority, but not all, fossil skeletal elements have individual distinctness such as to permit reliable identification. The abundance and variety of crinoid parts, especially columnals, make them immediately useful for purposes of biostratigraphy and studies of paleoecology after they have been adequately described, illustrated, classified, and named.

Studies on dissociated parts of crinoidal stems are concerned largely with the nature of their 1) transverse and longitudinal shapes, 2) intercolumnal surfaces of articulation (articula), 3) sideward-directed exterior surfaces (latera), 4) transverse outlines and longitudinal profiles of the axial canal, 5) lateral appendages (cirri), if present, and 6) arrangement in sequence. Dissociated parts of crinoid crowns can be treated similarly using comparable analysis of morphological features.

Classification of fossil crinoids based on their dissociated stem and crown parts is approached most advantageously by distributing some of these genus-group taxa in the established classification of crinoids either as representatives of previously described taxa or as newly proposed taxa. Many incompletely known crinoids, however, cannot be placed reliably in such a classification until more complete articulated remains are discovered. Some highly distinctive parts of crinoids (e.g., holdfasts of *Ancyrocrinus bulbosus*, stem parts of *Myelodactylus*) can be identified reliably with previously described species or only with genera. Others can be assigned only doubtfully to such taxa or are desirably distinguished as genera and species lacking recognized affinity with previously proposed crinoid taxa based on cups or crowns. Additionally, fragmentary remains that are too poorly preserved or too generalized in morphological features do not merit systematic treatment.

Inasmuch as analysis of the tremendous number of distinctive dissociated parts of fossil crinoids presently is only in an initial phase with the vast majority of taxa remaining to be discovered, substantial uncertainty exists as to classification of genera defined solely on the basis of columnals or other skeletal elements. Thus, here the genera are not so classified even though studies by YELTY SHEVA (1957), STUKALINA (1964, 1966, 1968a,b), MOORE & JEFFORDS (1968), DUBATOLOVA (1971), and others do illustrate the practicality of such a hierarchical classification.

[For description of the morphology of dissociated crinoid skeletal elements, especially of the stem, see Part T(1), p. T63-T93.]

SUBCLASS AND ORDER  
UNCERTAIN

TAXA PROPOSED FOR  
CRINOIDS BASED SOLELY ON  
DISARTICULATED SKELETAL  
ELEMENTS

[Unavailable taxa are marked by a dagger (†). These are hypothetical terms (e.g., VYALOV, 1953a,b, 1969; YELTYSHEVA, 1956, 1959), were not proposed for taxonomic use (e.g., MOORE, 1939b), or lack availability under the *Code* for other reasons (e.g., *nom. nud.*.)]

GROUP TAXA PROPOSED FOR  
DISARTICULATED SKELETAL ELEMENTS,  
RANKING ABOVE FAMILY-GROUP

- †Acanthostegae MOORE, 1939b. Terminals (as main group).  
 †Aglapolygona MOORE, 1939b. Polygonal ossicles (as main group).  
 Angulata STUKALINA, 1967. Columnals (as order).  
 †Anobases MOORE, 1939b. Apical plates (as subdivision).  
 †Anocyclotypi MOORE, 1939b. Apicals (as main group).  
 †Anopentagonotypi MOORE, 1939b. Apicals (as main group).  
 Asegmentata STUKALINA, 1966. Columnals (as group).  
 †Catobases MOORE, 1939b. Apicals (as subdivision).  
 †Catocyclotypi MOORE, 1939b. Apicals (as main group).  
 †Caulinaria VYALOV, 1953a. Columnals.  
 †Centrocordalia VYALOV, 1953a. Columnals (as order).  
 †Centrocordata VYALOV, 1969. Columnals (as order).  
 †Crinarthra MOORE, 1939b. Facetals (? as division).  
 †Crinobases MOORE, 1939b. Apicals, basals, infra-basals (as division).  
 †Crinopolygona MOORE, 1939b. Polygonal ossicles (as division).  
 †Crinoptera MOORE, 1939b. Free arms and pinnules (as division).  
 †Crinostegae MOORE, 1939b. Terminals (as division).  
 †Crinostyli MOORE, 1939b. Columnals (as division).  
 Cyclici MOORE & JEFFORDS, 1968. Columnals (as group).  
 †Cyclostyli MOORE, 1939b. Columnals (as main group).  
 Cyclotremata YELTYSHEVA, 1956. Columnals (as group).  
 †Diarthroptera MOORE, 1939b. Pinnates (as main group).  
 †Ellipsostyli MOORE, 1939b. Columnals (as main group).  
 Ellipsotremata YELTYSHEVA, 1956. Columnals (as group).  
 Elliptici MOORE & JEFFORDS, 1968. Columnals (as group).  
 †Excentrocaulacea VYALOV, 1969. Columnals (as suborder).  
 †Excentrocordata VYALOV, 1969. Columnals (as order).  
 †Exobases MOORE, 1939b. Apicals (as subdivision).  
 †Exocyclotypi MOORE, 1939b. Apicals (as main group).  
 †Exopentagonotypi MOORE, 1939b. Apicals (as main group).  
 †Fatinocaulacea VYALOV, 1953a. Columnals (as suborder).  
 Hexagonotremata YELTYSHEVA, 1956. Columnals (as group).  
 †Liocrinarthra MOORE, 1939b. Facetals (as subdivision).  
 †Liopolygona MOORE, 1939b. Polygonal ossicles (as main group).  
 †Lophocrinarthra MOORE, 1939b. Facetals (as subdivision).  
 †Micrarthroptera MOORE, 1939b. Pinnules (as main group).  
 †Monocordalia VYALOV, 1953a. Columnals (as suborder).  
 †Pentacaulacea VYALOV, 1953a. Columnals (as suborder).  
 †Pentacordata VYALOV, 1953a. Columnals (as order).  
 †Pentagonostyli MOORE, 1939b. Columnals (as main group).  
 Pentagonotremata YELTYSHEVA, 1956. Columnals (as group).  
 Pentamerata STUKALINA, 1966. Columnals (as group).  
 Pentameri MOORE & JEFFORDS, 1968. Columnals (as group).  
 †Pentaricaulacea VYALOV, 1969. Columnals (as suborder; spelled Pentaraulacea).  
 †Planocaulacea VYALOV, 1953a. Columnals (as suborder).  
 †Platylopharthra MOORE, 1939b. Facetals (as main group).  
 †Polycordalia VYALOV, 1953a. Columnals (as superorder).  
 Quadrilaterata STUKALINA, 1966. Columnals (as group).  
 †Quadrati TERMIER & TERMIER, 1974. Columnals (unspecified rank).  
 †Somphostegae MOORE, 1939b. Terminals (as main group).  
 †Stenolopharthra MOORE, 1939b. Facetals (as main group).  
 Strialata STUKALINA, 1967. Columnals (as order).  
 †Tetracaulacea VYALOV, 1969. Columnals (as suborder).  
 †Tetracordata VYALOV, 1953a. Columnals (as order).  
 †Tetraricaulacea VYALOV, 1969. Columnals (as



suborder).

Tetragonotremata YELTYSHEVA, 1956. Columnals (as group).

†Triaricaulacea VYALOV, 1969. Columnals (as suborder).

†Triarthroptera MOORE, 1939b. Pinnates (as main group).

†Tricordata VYALOV, 1953a. Columnals (as order).

Trigonotremata YELTYSHEVA, 1956. Columnals (as group).

Varii MOORE & JEFFORDS, 1968. Columnals (as group).

#### FAMILY-GROUP TAXA BASED ON DISARTICULATED SKELETAL ELEMENTS

- †Acantharthroptera MOORE, 1939b. Pinnates (as group).
- Anthinocrinidae STUKALINA, 1961 (ex YELTYSHEVA & SIZOVA). Columnals.
- Apertocrinidae STUKALINA, 1968a. Columnals.
- Aporretocrinidae DUBATOLOVA, 1971. Columnals.
- Arenariocrinidae YELTYSHEVA & SIZOVA in DUBATOLOVA & YELTYSHEVA, 1969. Columnals.
- †Asteroaulidae VYALOV, 1953a. Columnals.
- †Aulosomphostegae MOORE, 1939b. Terminals (as group).
- Babanocrinidae STUKALINA, 1969. Columnals.
- †Bourguetiaulidae VYALOV, 1953a. Columnals.
- †Bunaglaopolygona MOORE, 1939b. Polygonal ossicles (as group).
- †Bunarthra MOORE, 1939b. Facetals (as group).
- Bystrowicrinidae YELTYSHEVA & STUKALINA, 1963. Columnals.
- †Canthocaulidae VYALOV, 1953a. Columnals.
- Catagraphiocrinidae STUKALINA, 1968b. Columnals.
- †Coenarthroptera MOORE, 1939b. Pinnates (as group).
- Crossotocrinidae DUBATOLOVA, 1971. Columnals.
- †Cupressocaulidae VYALOV, 1953a. Columnals.
- Cyclocharacidae MOORE & JEFFORDS, 1968. Columnals.
- †Cyclocyclopa MOORE, 1939b. Columnals (as group).
- Cyclomischidae MOORE & JEFFORDS, 1968. Columnals.
- Cyclopagodidae MOORE & JEFFORDS, 1968. Columnals.
- †Cyclopentagonopae MOORE, 1939b. Columnals (as group).
- Cyclostylidae YELTYSHEVA, 1956. Columnals (as subgroup).
- Decacrinidae YELTYSHEVA, 1957. Columnals.
- †Decicaulidae VYALOV, 1953a. Columnals.
- †Dianobases MOORE, 1939b. Apicals (as group).
- Dianthicoelomatidae MOORE & JEFFORDS, 1968. Columnals.
- †Dwortsowaecrinidae MOORE & JEFFORDS, 1969. Columnals.
- †Ellipsellipsopae MOORE & JEFFORDS, 1968. Columnals (as group).
- Ellipostylidae YELTYSHEVA, 1956. Columnals.
- Encrinidae DUJARVIS & MOORE, 1932 (ex Encriniens,

ICZN Op. 636). Columnals.

†Engoniarthra MOORE, 1939b. Facetals (as group).

Euracidae MOORE & JEFFORDS, 1968. Columnals.

Exacsioidiscidae MOORE & JEFFORDS, 1968. Columnals.

†Excentrocaulidae VYALOV, 1969. Columnals.

Facetocrinidae STUKALINA, 1968b. Columnals.

†Fatinocaulidae VYALOV, 1969. Columnals.

Floricyclidae MOORE & JEFFORDS, 1968. Columnals.

Flucticharacidae MOORE & JEFFORDS, 1968. Columnals.

†Gisacanthostegae MOORE, 1939b. Terminals (as group).

†Granocaulidae VYALOV, 1953a. Columnals.

Haplotetocrinidae DUBATOLOVA, 1971. Columnals.

†Henanobases MOORE, 1939b. Apicals (as group).

Hexagonostylidae YELTYSHEVA, 1956. Columnals.

†Hiatocrinidae STUKALINA, 1969. Columnals.

†Hoplarthra MOORE, 1939b. Facetals (as group).

†Isotrianobases MOORE, 1939b. Apicals (as group).

Kstutocrinidae SHEVCHENKO, 1966. Columnals.

Leptocarphiidae MOORE & JEFFORDS, 1968. Columnals.

†Lophaglaopolygona MOORE, 1939b. Polygonal ossicles (as group).

†Macrocrinarthra MOORE, 1939b. Facetals (as group).

Malovicrinidae STUKALINA, 1968b. Columnals.

†Notocrinidae STUKALINA, 1969. Columnals.

†Ornocaulidae VYALOV, 1953a. Columnals.

Particrinidae STUKALINA, 1968b. Columnals.

†Pentacaulidae VYALOV, 1969. Columnals.

Pentacauliscidae MOORE & JEFFORDS, 1968. Columnals.

†Pentagonocyclopa MOORE, 1939b. Columnals (as group).

Pentagonostylidae YELTYSHEVA, 1956. Columnals (as subgroup).

Pentamerostelidae MOORE & JEFFORDS, 1968. Columnals.

†Pentanobases MOORE, 1939b. Apicals (as group).

†Pentanobathra MOORE, 1939b. Apicals (as group).

†Pentaricaulidae VYALOV, 1953a. Columnals.

†Pentecatobases MOORE, 1939b. Apicals (as group).

†Pentexobases MOORE, 1939b. Apicals (as group).

†Pentexobathra MOORE, 1939b. Apicals (as group).

†Planocaulidae VYALOV, 1953a. Columnals.

†Ramosocrinidae STUKALINA, 1969. Columnals.

†Rotacaulidae VYALOV, 1953a. Columnals.

Salaiocrinidae DUBATOLOVA, 1971. Columnals.

†Schedaglaopolygona MOORE, 1939b. Polygonal ossicles (as group).

Schyschcatocrinidae DUBATOLOVA, 1971. Columnals.

†Sculpticaulidae VYALOV, 1953a. Columnals.

†Solicaulidae VYALOV, 1953a. Columnals.

†Sphenarthroptera MOORE, 1939b. Pinnates (as group).

†Squamocaulidae VYALOV, 1969. Columnals.

†Stellacaulidae VYALOV, 1953a. Columnals.

Stenocrinidae DUBATOLOVA, 1971. Columnals.

†Tetracaulidae VYALOV, 1969. Columnals.

- Tetracrinidae DUBATOLOVA, 1971. Columnals.  
 †Tetragonoptera MOORE, 1939b. Pinnates (as group).  
 Tetragonostylidae YELTYSHEVA, 1956. Columnals (as subgroup).  
 †Tetranobases MOORE, 1939b. Apicals (as group).  
 Tetraptocrinidae DUBATOLOVA, 1971. Columnals.  
 †Trapezoptera MOORE, 1939b. Pinnates (as group).  
 †Trianobases MOORE, 1939b. Apicals (as group).  
 †Triaricaulidae VYALOV, 1953a. Columnals.  
 †Triexobases MOORE, 1939b. Apicals (as group).  
 Trigonostylidae YELTYSHEVA, 1956. Columnals (as subgroup).  
 Trilobocrinidae DUBATOLOVA, 1971. Columnals.
- AVAILABLE GENUS-GROUP TAXA  
 BASED SOLELY ON DISARTICULATED  
 SKELETAL ELEMENTS
- Adelocrinus PHILLIPS, 1841 [\**A. hystrix*; M]. Columnal. *Dev.*, G.Brit.  
 Algasocrinus STUKALINA & TUYUTYAN, 1970 [\**A. obtusus*; OD]. Columnal. *M.Ord.-U.Ord.*, USSR (Kazakh.).  
 Ampholenium MOORE & JEFFORDS, 1968 [\**A. apolegma*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Ky.).  
 Amsdenanteris MOORE & JEFFORDS, 1968 [\**A. tennesseensis*; OD]. Columnal. *Sil.(Niag.)*, USA (Tenn.).  
 Amurocrinus DUBATOLOVA, 1971 [\**Pentagonocyclicus imatschensis* YELTYSHEVA & DUBATOLOVA, 1961; OD]. *M.Dev.*, USSR (Altai, Far East).  
 Ancyrocrinus HALL, 1862 [\**A. bulbosus*]. Holdfast. *M.Dev.*, USA (N.Y.).  
 Anthinocrinus STUKALINA, 1961 (ex YELTYSHEVA & SIZOVA) [\**A. ludlowicus*; M] [= *Anthinocrinus* SIZOVA, 1960 (nom. nud.)]. Columnal. *U.Sil.-L.Carb.*, USSR (Kazakh.-C.Asia).  
 Apertocrinus STUKALINA, 1968a [\**A. apertus* YELTYSHEVA & STUKALINA in STUKALINA, 1968a; OD] [= *Apertocrinus* STUKALINA, 1965c, 1966, 1967 (nom. nud.)]. Columnal. *M.Ord.-L.Sil.*, USSR (Kazakh.).  
 Apiastrum MOORE & JEFFORDS, 1968 [\**A. candidum*; OD]. Columnal. *L.Dev.*, USA (Tenn.).  
 Aporetocrinus DUBATOLOVA, 1971 [\**Entrochus ligatus* QUENSTEDT, 1876; OD]. Columnal. *Dev.*, USSR (Salair).  
 Arenariocrinus YELTYSHEVA & SIZOVA in DUBATOLOVA & YELTYSHEVA, 1969 [\**Pentagonocyclicus arenarius* YELTYSHEVA & SHEVCHENKO, 1960; OD]. Columnal. *L.Carb.*, USSR (Armenia).  
 Aspidocrinus HALL, 1858 [\**A. scutelliformis* HALL, 1859; SD S. A. MILLER, 1889]. Holdfast. *L.Dev.*, USA (N.Y.).  
 Asteroocrinus MÜNSTER, 1839 [\**A. murchisoni*; M] [= *Asteroocrinites* ROEMER, 1852 (nom. van.)]. *Ord.-Dev.*, USSR (Est.), Eu. (Ger.).  
 Asteromischus MOORE & JEFFORDS, 1968 [\**A. stellatus*; OD]. Columnal. *U.Miss.(Chester.)*, USA (Ill.).  
 Astroporites LAMBE, 1896 [\**A. ottawaensis*; M]. Holdfast. *Ord.*, Can.-USA (Ky.).  
 Avicantus MOORE & JEFFORDS, 1968 [\**A. dunbari*; OD]. Columnal. *L.Dev.*, USA (Tenn.).  
 Babanicrinus STUKALINA, 1969 [\**B. tuberosus*; OD] [= *Babanicrinus* STUKALINA, 1967 (nom. nud.)]. *Ord.*, USSR.  
 Bakanasocrinus STUKALINA & TUYUTYAN, 1970 [\**B. clavatus* STUKALINA in STUKALINA & TUYUTYAN, 1970; OD]. Columnal. *U.Ord.*, USSR (Kazakh.).  
 Baryschr MOORE & JEFFORDS, 1968 [\**B. anosus*; OD]. Columnal. *M.Penn.(Atokan)*, USA (Okla.).  
 Bazaricrinus STUKALINA, 1968a [\**B. bazarensis*; OD]. Columnal. *Sil.(Wenlock.)-L.Dev.*, USSR (Kazakh.).  
 Beccrinus DUBATOLOVA, 1975 [\**B. amplus*; OD]. Columnal. *Dev.*, USSR (C.Asia, Kuznetsk).  
 Bicostulocrinus DUBATOLOVA & YELTYSHEVA, 1969 [\**Cyclocyclicus circumvallatus* YELTYSHEVA in DUBATOLOVA & SHAO, 1959; OD]. Columnal. *Dev.-Carb.*, USSR (Amur area-Kuzbas-Kazakh.-Armenia); *L.Carb.(Tournais.)-Perm.*, China (Hunan-Kwangtung).  
 Blothronagma MOORE & JEFFORDS, 1968 [\**B. cinctutum*; OD]. Columnal. *M.Penn.(Atokan)*, USA (Okla.).  
 Bornium DE GREGORIO, 1930 [\**B. vetustum*; M]. Columnal. *Perm.*, Sicily.  
 Bystrowicrinus YELTYSHEVA in YELTYSHEVA & STUKALINA, 1963 [\**Pentagonopentagonalis quinquelobatus* YELTYSHEVA, 1955b; OD]. Columnal. *M.Ord.-L.Sil.*, USSR (C.Sib.-Taymyr).  
 Callocrinus DUBATOLOVA, 1971 [\**Pentagonocyclicus granatus* DUBATOLOVA, 1964; OD]. Columnal. *L.Dev.*, USSR (Salair, Kuznetsk).  
 Catagraphiocrinus STUKALINA, 1968a [\**Pentagonopentagonalis quindecimlobatus* YELTYSHEVA & STUKALINA, 1963; OD]. Columnal. *U.Ord.-L.Sil.*, USSR (Taymyr).  
 Catholicorhachis MOORE & JEFFORDS, 1968 [\**C. multifaria*; OD]. Columnal. *M.Penn.(Desmoines.)*, USA (Texas).  
 Cionerisma MOORE & JEFFORDS, 1968 [\**C. exile*; OD]. Columnal. *Sil.(Niag.)*, USA (Ind.).  
 Clematidiscus MOORE & JEFFORDS, 1968 [\**C. denotatus*; OD]. Columnal. *M.Dev.(Erian)*, USA (N.Y.).  
 Conspeciocrinus STUKALINA, 1969 [\**C. conspectus*; OD]. Columnal. *U.Ord.*, USSR.  
 Cotylocrinus DUBATOLOVA, 1971 [\**Pentagonocyclicus insignis* DUBATOLOVA, 1964; OD]. Columnal. *L.Dev.*, USSR (Salair).  
 Craptocrinus DUBATOLOVA, 1971 [\**Pentagonocyclicus inconditus* DUBATOLOVA, 1964; OD]. Columnal. *M.Dev.*, USSR (Salair).  
 Crenatames MOORE & JEFFORDS, 1968 [\**C. amicalis*; OD]. Columnal. *M.Dev.(Erian)*, USA (N.Y.)-USSR (Salair).  
 Crossotocrinus DUBATOLOVA, 1971 [\**Pentagonocyclicus cortinatus* DUBATOLOVA, 1968; OD]. Columnal. *Dev.*, USSR (Salair).

- Cyclocaudex MOORE & JEFFORDS, 1968 [\**C. typicus*; OD]. Columnal. *L.Miss.(Osag.)-U.Penn.(Virgil.)*, USA (Kans.-Ky.-Texas).
- Cyclocaudiculus MOORE & JEFFORDS, 1968 [\**C. regularis*; OD]. Columnal. *U.Penn.(Virgil.)*, USA (Texas).
- Cyclocharax MOORE & JEFFORDS, 1968 [\**C. fasciatus*; OD]. Columnal. *Sil.(Niag.)*, USA (Ind.).
- Cyclocion MOORE & JEFFORDS, 1968 [\**C. distinctus*; OD]. Columnal. *U.Miss.(Chester.)*, USA (Ill.).
- Cyclocrista MOORE & JEFFORDS, 1968 [\**C. lineolata*; OD]. Columnal. *U.Penn.(Virgil.)-Perm.(Wolfcamp.)*, USA (Texas).
- Cyclocyclicus YELTYSHEVA, 1955b [\**C. tenuis*; M] [ICZN appeal pending for status as collective group, MOORE & JEFFORDS, 1969]. Columnal. *Ord.-Perm.*, USSR-China.
- Cyclomischus MOORE & JEFFORDS, 1968 [\**C. shelbyensis*; OD]. Columnal. *Sil.(Niag.)*, USA (Ind.).
- Cyclomonile MOORE & JEFFORDS, 1968 [\**C. monile*; OD]. Columnal. *M.Ord.(Trenton.)*, USA (Tenn.).
- Cylopagoda MOORE & JEFFORDS, 1968 [\**C. alternata*; OD]. *U.Ord.(Cincinnati.)*, USA (Ohio).
- Cyclopentagonalis YELTYSHEVA, 1964 [\**C. balticus*; M] [= *Cyclopentagonalis* YELTYSHEVA, 1956—ICZN appeal pending for status as collective group, MOORE & JEFFORDS, 1969]. Columnal. *L.Ord.-M.Ord.*, USSR (Est.-Leningrad).
- Cycloscapus MOORE & JEFFORDS, 1968 [\**C. laevis*; OD]. Columnal. *M.Penn.(Desmoines.)*, USA (Texas).
- Cyclostelechus MOORE & JEFFORDS, 1968 [\**C. turritus*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Iowa).
- Cymatocrinus DUBATOLOVA, 1971 [\**C. undulaticostatus*; OD]. Columnal. *M.Dev.*, USSR (Salair).
- Cystocrinus ROEMER, 1860 [\**C. tennesseensis*; M] [= *Cystocrinus* DELAGE & HEROUARD, 1903 (*nom. null.*)]. Columnal. *Sil.(Niag.)*, USA (Tenn.).
- Decacrinus YELTYSHEVA, 1957 [\**D. pennatus*; OD] [= *Decarcinus* LEVITAKIY *et al.*, 1968 (*nom. null.*)]. Columnal. *L.Ord.-M.Dev.*, USSR (Far East, Altai).
- Dentiferocrinus STUKALINA, 1968a [\**Pentagonopentagonalis dentiferus* YELTYSHEVA, 1960; OD] [= *Dentiferocrinus* STUKALINA, 1967 (*nom. nud.*)]. Columnal. *M.Ord.-L.Sil.*, USSR (Sib.platf.).
- Desidiamphtidia MOORE & JEFFORDS, 1968 [\**D. frondea*; OD]. Columnal. *M.Dev.(Erian)*, USA (N.Y.).
- Dianthicoeloma MOORE & JEFFORDS, 1968 [\**D. insuetum*; OD]. Columnal. *L.Ord.-U.Ord.*, USA (Ohio), USSR (Leningrad-Taymyr), Eu. (Yugo.).
- Dierocalipter MOORE & JEFFORDS, 1968 [\**D. doter*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Ky.).
- Dilanteris MOORE & JEFFORDS, 1968 [\**D. trestes*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Ky.).
- Dulanocrinus STUKALINA & TUYUTYAN, 1970 [\**D. wiktasensis*; OD]. Columnal. *U.Ord.*, USSR (Kazakh.).
- Dwortsowaecrinus STUKALINA in STUKALINA & TUYUTYAN, 1967 [\**Tetragonotetragonalis quadrihamatus* YELTYSHEVA in YELTYSHEVA & STUKALINA, 1963; OD] [= *Dwortsowaecrinus* STUKALINA, 1966 (*nom. nud.*); *Dworzowicrinus* STUKALINA, 1965b (*nom. nud.*)]. Columnal. *U.Ord.-L.Sil.*, USSR (Baltic-Tuva-Arctic).
- Egiasarowicrinus SHEVCHENKO, 1971 [\**Pentagonocyclicus egiasarowi* YELTYSHEVA, 1960; OD]. Columnal. *Sil.*, USSR.
- Elytroclon MOORE & JEFFORDS, 1968 [\**E. elimatus*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Ky.).
- Entrochus HOFER, 1760 (ICZN appeal pending for status as collective group, MOORE & JEFFORDS, 1969).
- Euloncherostigma MOORE & JEFFORDS, 1968 [\**E. impunitum*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Ky.).
- Eurax MOORE & JEFFORDS, 1968 [\**E. ethas*; OD]. Columnal. *Sil.(Niag.)-L.Dev.*, USA (Ind.-Tenn.)-USSR (Salair).
- Exaesiocrinus MOORE & JEFFORDS, 1968 [\**E. acutus*; OD]. Columnal. *Sil.(Niag.)-M.Dev.(Erian)*, USA (Ind.-N.Y.).
- Exedrodiscus MOORE & JEFFORDS, 1968 [\**E. excussus*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Ky.).
- Fabalium MOORE & JEFFORDS, 1968 [\**F. fabale*; OD]. Columnal. *Sil.(Niag.)*, USA (Tenn.).
- Facetocrinus STUKALINA, 1968a [\**Pentagonopentagonalis facetus* STUKALINA, 1961; OD] [= *Facetocrinus* STUKALINA, 1967 (*nom. nud.*)]. Columnal. *U.Sil.(Ludlov.)-M.Dev.(Givet.)*, USSR (Kazakh.).
- Fascicrinus STUKALINA, 1968a [\**F. flabellatus* YELTYSHEVA & STUKALINA, 1963; OD]. Columnal. *Ord.(Caradoc.)*, USSR (Kazakh.).
- Fibracrinus STUKALINA & TUYUTYAN, 1970 [\**F. fibratus*; OD]. Columnal. *Ord.*, USSR (Kazakh.).
- Flexicrinus STUKALINA & TUYUTYAN, 1970 [\**F. flexus*; OD]. Columnal. *U.Ord.*, USSR (Kazakh.).
- Floricyclus MOORE & JEFFORDS, 1968 [\**F. hebes*; OD]. Columnal. *L.Miss.(Osag.)-U.Penn.(Virgil.)*, USA (Colo.-Kans.-Ky.-Texas).
- Floripila MOORE & JEFFORDS, 1968 [\**F. florealis*; OD]. Columnal. *M.Dev.(Erian)*, USA (N.Y.).
- Flucticharax MOORE & JEFFORDS, 1968 [\**F. undatus*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Ky.).
- Glyphidocrinus DUBATOLOVA, 1971 [\**Pentagonocyclicus singularis* DUBATOLOVA, 1964; OD]. Columnal. *U.Dev.*, USSR (Kuznetsk).
- Goniocion MOORE & JEFFORDS, 1968 [\**G. gonimus*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Iowa).
- Goniostathmus MOORE & JEFFORDS, 1968 [\**G. annexus*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Iowa).
- Grammocrinus EICHWALD, 1860 [\**Cyathocrinus lineatus* EICHWALD, 1856; SD ?BASSLER, 1938]. Columnal. *Ord.*, USSR.
- Graphosterigma MOORE & JEFFORDS, 1968 [\**G. scriptum*; OD]. Columnal. *L.Miss.(Osag.)*, USA

- (Ind.-Ky.).  
 Gregariocrinus STUKALINA, 1968a [*\*Pentagonocyclicus forus* STUKALINA, 1961; OD] [=*Gregariocrinus* STUKALINA, 1966 (*nom. nud.*)]. Columnal. *U.Sil.*, USSR (Kazakh.).  
 Gurjevskocrinus DUBATOLOVA, 1971 [*\*G. punctulatus*; OD]. Columnal. *L.Dev.*, USSR (Salair).  
 Haplotetocrinus DUBATOLOVA, 1971 [*\*Pentagonocyclicus expoliatus* DUBATOLOVA, 1964; OD]. Columnal. *L.Dev.*, USSR (Salair).  
 Hattinatheris MOORE & JEFFORDS, 1968 [*\*H. indianensis*; OD]. Columnal. *Sil.(Niag.)*, USA (Ind.-Tenn.).  
 Heterostaurus MOORE & JEFFORDS, 1968 [*\*H. belknapensis*; OD]. Columnal. *U.Penn.(Virgil.)*, USA (Texas).  
 Heterosteochus MOORE & JEFFORDS, 1968 [*\*H. texanus*; OD]. Columnal. *U.Penn.(Virgil.)-Perm.(Wolfcamp.)*, USA (Texas).  
 Hyperexochus MOORE & JEFFORDS, 1968 [*\*H. immodicus*; OD]. Columnal. *L.Dev.*, USA (Tenn.).  
 Idromocrinus DE GREGORIO, 1930 [*\*I. genistus*; M]. Columnal. *U.Perm.*, Sicily.  
 Ilematerisma MOORE & JEFFORDS, 1968 [*\*I. enamma*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Ky.).  
 Jonkerocrinus WANNER, 1924 [*\*J. spinosus*; M]. Anal sac. *U.Perm.*, Timor (Basleo).  
 Kasachstanocrinus SHEVCHENKO, 1966, *ex* YELTYSHEVA & SIZOVA [*\*K. asperum* (*not K. pentamerus, nom. nud.*); M]. Columnal. *L.Dev.-L.Carb.*, USSR (Kazakh.-Tien Shan).  
 Klunnikowicrinus SHEVCHENKO, 1971 [*\*Pentagonopentagonalis klunnikowi* SHEVCHENKO, 1964; OD]. Columnal. *Sil.*, USSR.  
 Kstutocrinus SHEVCHENKO, 1966 [*\*K. sublatus*; OD]. Columnal. *L.Dev.*, USSR (Tien Shan).  
 Kuzbassocrinus YELTYSHEVA, 1957 [*\*K. bystrowi*; OD] [=? *Melocrinites* GOLDFUSS, 1831]. Columnal. *L.Dev.-M.Dev.*, USSR (Kazakh.-Salair-Altai-Far East)-C.Eu.  
 Lamprosterigma MOORE & JEFFORDS, 1968 [*\*L. mirificum*; OD]. Columnal. *M.Penn.(Desmoines.)*, USA (Kans.-Texas).  
 Laudonomphalus MOORE & JEFFORDS, 1968 [*\*L. regularis*; OD]. Columnal. *M.Dev.*, USA (Mich.-N.Y.), USSR (Kuznetsk).  
 Leptocarphium MOORE & JEFFORDS, 1968 [*\*L. gracile*; OD]. Columnal. *M.Penn.(Desmoines.)*, USA (Texas).  
 Lescus DE GREGORIO, 1930 [*\*L. palazzensis*; M]. Columnal. *U.Perm.*, Sicily.  
 Lichenocrinus HALL, 1866 [*\*L. dyeri*]. Holdfast. *Ord.-Sil.*, USA (Ind.-Ohio).  
 Lissocrinus DUBATOLOVA, 1971 [*\*Pentagonocyclicus glaber* YELTYSHEVA *in* YELTYSHEVA & DUBATOLOVA, 1961; OD]. Columnal. *L.Dev.*, USSR (Salair).  
 Lomalegnum MOORE & JEFFORDS, 1968 [*\*L. horridum*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Iowa).  
 Malovicrinus STUKALINA, 1968 [*\*M. fragosus* YELTYSHEVA & STUKALINA, 1968b; OD] [= *Malovicrinus* STUKALINA, 1967 (*nom. nud.*)]. Columnal. *M.Ord.-U.Ord.*, USSR (Kazakh.).  
 Medineocrinus STUKALINA, 1965a [*\*Pentagonopentagonalis vitreus* STUKALINA, 1961; OD]. Columnal. *U.Sil.*, USSR (Kazakh.).  
 Mediocrinus STUKALINA, 1965a [*\*M. medius* YELTYSHEVA *in* STUKALINA, 1965a; OD]. Columnal. *U.Sil.-Dev.*, USSR (Kazakh.-Salair).  
 Moorecanteris MILLER *in* MOORE & JEFFORDS, 1968 [*\*M. waylandensis*; OD]. Columnal. *U.Penn.(Virgil.)*, USA (Texas).  
 Musivocrinus TERMIER & TERMIER, 1958 [*\*M. arnouldi*; M] [= *Musivocrinus* TERMIER & TERMIER, 1949 (*nom. nud.*)]. Columnal. *Perm., Afr.* (Tunisia).  
 Northrosterigma MOORE & JEFFORDS, 1968 [*\*N. merum*; OD]. Columnal. *U.Penn.(Virgil.)*, USA (Texas).  
 Obuticrinus YELTYSHEVA & STUKALINA, 1963 [*\*Pentagonopentagonalis bilobatus* YELTYSHEVA, 1960; OD]. Columnal. *Sil.*, USSR (Novaya Zemlya-Siber.platf.-Tadzhik.-Taymyr).  
 Orocrinus SIEVERTS-DORECK, 1951 [*\*O. hercynicus*; OD]. Columnal. *L.Carb., Eu.* (Ger.).  
 Pachycrinites EICHWALD, 1840 [*\*P. compressus*; SD ? BASSLER, 1938] [= *Pachycrinus* EICHWALD, 1860 (*nom. vet.*)]. Columnal. *L.Carb.*, USSR.  
 Pachyocrinus BILLINGS, 1859 [*\*P. crassibasalis*; M]. Base of cup only. *Ord.*, N.Am. (Can.).  
 Palermocrinus JAEKEL, 1918 [*\*P. jaekeli* GISLÉN, 1924; SM]. Columnal. *U.Perm.*, Sicily.  
 Pandocrinus STUKALINA, 1965a [*\*P. pandus*; OD]. Columnal. *U.Sil.-L.Dev.*, USSR (Kazakh.-Salair), Eu. (Czech.), USA (N.Y.-Tenn.).  
 Particrinus STUKALINA, 1968a [*\*Pentagonocyclicus partitus* YELTYSHEVA, 1960; OD] [= *Particrinus* STUKALINA, 1967 (*nom. nud.*)]. Columnal. *U.Ord.*, USSR (Taymyr).  
 Pennatocrinus STUKALINA, 1968b [*\*P. subpennatus* YELTYSHEVA *in* STUKALINA, 1968b; OD]. Columnal. *U.Sil.-L.Dev.*, USSR (Kazakh.).  
 Pentacauliscus MOORE & JEFFORDS, 1968 [*\*P. nodosus*; OD]. Columnal. *L.Dev.(Helderberg.)*, USA (Tenn.).  
 Pentagonocyclicus YELTYSHEVA & SHEVCHENKO, 1960 (*ex* YELTYSHEVA, 1955) [*\*P. haldaranensis*; M] [*Pentagonocyclicus* YELTYSHEVA, 1955a—ICZN appeal pending for status as collective group, MOORE & JEFFORDS, 1969]. Columnal. *L.Carb.*, USSR.  
 Pentagonopentagonalis YELTYSHEVA, 1955b [Unavailable (no fixation of type species); ICZN appeal pending for status as collective group, MOORE & JEFFORDS, 1969]. Columnal. *Ord.-Sil.*, USSR (widespread).  
 Pentagonostaurus MOORE & JEFFORDS, 1968 [*\*P. leptus*; OD]. Columnal. *U.Miss.(Chester.)*, USA (Ill.).  
 Pentagonostipes MOORE & JEFFORDS, 1968 [*\*P. petaloides*; OD]. Columnal. *M.Dev.(Erian)*, USA (N.Y.).  
 Pentamerostela MOORE & JEFFORDS, 1968 [*\*P. delicatula*; OD]. Columnal. *L.Miss.(Osag.)*, USA

- (Ky.).
- Pentariidica* MOORE & JEFFORDS, 1968 [\**P. rothi*; OD]. Columnal. *M.Penn.-U.Penn.(Desmoines-Virgil.)*, USA (Colo.-Texas).
- Peribolocrinus* DUBATOLOVA, 1971 [\**Cyclocyclicus proximus* DUBATOLOVA, 1964; OD]. Columnal. *L.Dev.*, USSR (Salair).
- Petalerisma* MOORE & JEFFORDS, 1968 [\**P. eriense*; OD]. Columnal. *M.Dev.(Erian)*, USA (N.Y.).
- Phialocrinus* EICHWALD, 1856 [\**P. impressus*; M]. Columnal. *Ord.*, USSR.
- Phragmoporella* REZAK, 1959 [\**P. monilis*; OD]. Proposed as dasycladacean alga, interpreted as columnal by WOOD, 1965. *Sil.*, USA (Utah).
- Platycion* MOORE & JEFFORDS, 1968 [\**P. mingusensis*; OD]. Columnal. *M.Penn.(Desmoines.)*, USA (Texas).
- Platyclonus* MOORE & JEFFORDS, 1968 [\**P. dispar*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Ky.).
- Platyparallelus* MOORE & JEFFORDS, 1968 [\**P. parilis*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Ky.).
- Platyplateium* MOORE & JEFFORDS, 1968 [\**P. texanum*; OD]. Columnal. *L.Miss.(Osag.)-M.Penn.(Desmoines.)*, USA (Ky.-Texas).
- Platystela* MOORE & JEFFORDS, 1968 [\**P. proiecta*; OD]. Columnal. *M.Dev.(Erian)*, USA (N.Y.).
- Plummeranteris* MOORE & JEFFORDS, 1968 [\**P. sansaba*; OD]. Columnal. *M.Penn.(Atokan)*, USA (Texas).
- Plusacrinus* YELTYSHEVA, 1957 [\**P. flabellum*; OD]. Columnal. *M.Dev.*, USSR (Est.-Leningrad).
- Podoliocrinus* YELTYSHEVA, 1957 [\**P. nikiforovae*; OD]. Columnal. *U.Sil.(Ludlov.)*, USSR (Tien Shan).
- Podolithus* SARDESON, 1908 [\**P. schizocrinus*; OD]. Holdfast. *Ord.*, USA (Minn.).
- Polycerus* FISCHER DE WALDHEIM, 1811 [\**P. stoloniferus*; M]. Pentagonal plates. ?*Carb.*, USSR.
- Polyporocrinus* DUBATOLOVA, 1971 [\**P. octoforbilis*; OD]. *M.Dev.*, USSR (Salair).
- Polyptychella* JAEKEL, 1918, p. 27 [\**P. esthona*; OD]. *M.Dev.*, USSR (Est.).
- Porcunicrinus* YELTYSHEVA in YELTYSHEVA & SIZOVA, 1971 [\**P. coronarius* YELTYSHEVA; OD]. Columnal. *U.Dev.(p. Ashgill.)* (Porkunian Stage), USSR (Est.). [The age of this genus was erroneously given as Early Silurian (Llandoveryan) by its author.]
- Preptocrinus* MOORE & JEFFORDS, 1968 [\**P. rugosus*; OD]. Columnal. *M.Penn.-U.Penn.(Desmoines-Virgil.)*, USA (Texas).
- Rambulicrinus* STUKALINA, 1968a [\**Pentagonopentagonalis* YELTYSHEVA, 1955b; OD]. Columnal. *M.Dev.*, USSR (Siber.platf.-Tayr).
- Rhyssocrinus* MOORE & JEFFORDS, 1968 [\**R. cristata*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Iowa).
- Salaxocrinus* DUBATOLOVA, 1971 [\**Pentagonocyclicus* YELTYSHEVA, 1964; OD]. Columnal. *L.Dev.*, USSR (NE.Sib.).
- Scelidiopternix* MOORE & JEFFORDS, 1968 [\**S. norops*; OD]. Columnal. *Sil.(Niag.)*, USA (Ind.).
- Schyschcatocrinus* DUBATOLOVA, 1971 [\**Pentagonocyclicus astericus* SHEVCHENKO, 1966; OD]. Columnal. *Sil.-Dev.*, USSR (Salair-Tiep Shan-Kuznetsk).
- Scillus* DE GREGORIO, 1930 [\**S. pauper*]. Columnal. *U.Perm.*, Sicily.
- Sidericrinus* STUKALINA, 1968a [\**S. depressus*; OD] [= *Sidericrinus* STUKALINA, 1966 (*nom. nud.*)]. Columnal. *M.Dev.-U.Dev.*, USSR (Kazakh.).
- Sokolovicrinus* YELTYSHEVA, 1968 [\**S. dnestrowensis*; OD]. Columnal. *L.Dev.-Sil.*, USSR (Est.).
- Sphenocrinus* EICHWALD, 1856 [\**S. obtusus*; M]. Columnals. *Ord.*, USSR.
- Squameocrinus* STUKALINA, 1968a [\**Pentagonopentagonalis privus* YELTYSHEVA, 1964; OD] [= *Squameocrinus* STUKALINA, 1965c, 1967 (*nom. nud.*)]. Columnal. *L.Dev.*, USSR (Est.-Kazakh.).
- Stegocrinus* SIEVERTS-DORECK, 1962 [\**S. dohmi*; OD]. *M.Dev.*, Eu. (Ger.).
- Stenocrinus* DUBATOLOVA, 1971 [\**S. bifurcatus*; OD]. Columnal. *M.Dev.*, USSR (Salair-Kuznetsk).
- Stiberostaurus* MOORE & JEFFORDS, 1968 [\**S. aestimatus*; OD]. Columnal. *L.Miss.(Osag.)*, USA (Ky.).
- Tebagacrinus* TERMIER & TERMIER, 1958 [\**Coenocrinus solignaci* VALETTE, 1934; OD] [= *Coenocrinus* VALETTE, 1934, *non* FORBES, 1852]. Columnal. *Perm.*, N.Afr. (Tunisia).
- Tessarocrinus* DUBATOLOVA, 1971 [\**Tetragonocyclicus fimbriatus* DUBATOLOVA, 1964; OD]. Columnal. *L.Dev.*, USSR (Salair).
- Teratocrinus* WANNER, 1924 [\**T. spathulifer*; OD]. *U.Perm.*, Indon. (Timor).
- Tetragonocrinus* YELTYSHEVA, 1964a [\**Goniaster pygmaeus* EICHWALD, 1861; OD]. *Ord.(Arenig-Caradoc.)*, USSR (Baltic, Kazakh.).
- Tetragonocyclicus* DUBATOLOVA, 1964 (*ex* YELTYSHEVA, 1956) (ICZN appeal pending for status as collective group, MOORE & JEFFORDS, 1969). Columnal. *L.Dev.-M.Dev.*, USSR.
- Tetragonotetragonalis* YELTYSHEVA in YELTYSHEVA & STUKALINA, 1963 [\**T. quadrihamatus* YELTYSHEVA; M] (ICZN appeal pending for status as collective group, MOORE & JEFFORDS, 1969; = *Tetragonotetragonalis* YELTYSHEVA, 1956 (*nom. vet.*)). Columnal. *U.Dev.*, ?*Dev.*, USSR (Salair).
- Tetralobocrinus* DUBATOLOVA, 1971 [\**Tetragonocyclicus perplexus* DUBATOLOVA, 1964; OD]. Columnal. *L.Dev.*, USSR (Salair).
- Tetraptocrinus* DUBATOLOVA, 1971 [\**Tetragonocyclicus permirus* DUBATOLOVA, 1964; OD]. Columnal. *L.Dev.*, USSR (Salair).
- Tetrastaurus* DUBATOLOVA, 1971 [\**Tetragonotetragonalis nudus* DUBATOLOVA, 1964; OD]. Columnal. *M.Dev.*, USSR (Salair).
- Tetraxonocrinus* DUBATOLOVA, 1971 [\**Tetragonocyclicus indefinitus* DUBATOLOVA, 1967; OD]. Columnal. *M.Dev.*, USSR (NE.Sib.).

- Tjeccrinus DUBATOLOVA, 1975 [\**T. crassijugatus*; OD]. *M.Dev.-U.Dev.*, USSR(C.Asia-C.Dev.Field).
- Tomeocrinus DUBATOLOVA, 1971 [\**Pentagonocyclicus observabilis* DUBATOLOVA, 1964; OD]. Columnal. *U.Dev.*, USSR(Kuznetsk).
- Trigonocyclicus YELTYSHEVA in YELTYSHEVA & STUKALINA, 1963 [\**T. vajgatschensis*; M] [ICZN appeal pending for status as collective group, MOORE & JEFFORDS, 1969; =*Trigonocyclicus* YELTYSHEVA, 1956 (*nom. vet.*)]. Columnal. *M.Ord.-L.Dev.*, USSR.
- Trigonotrigonalis DUBATOLOVA & SHAO, 1959 (*ex* YELTYSHEVA, 1956) [\**T. asymmetricus*; M] [ICZN appeal pending for status as collective group, MOORE & JEFFORDS, 1969; =*Trigonotrigonalis* YELTYSHEVA, 1956 (*nom. vet.*)]. Columnal. *L.Carb. (Viséan)*, China(Hunan), USSR(Kazakh).
- Trilobocrinus DUBATOLOVA, 1971 [\**Trigonocyclicus acceptus* DUBATOLOVA, 1964; OD]. Columnal. *L.Dev.*, USSR(Salair).
- Trochita HOFER, 1760 (ICZN appeal pending for status as collective group, MOORE & JEFFORDS, 1969). Columnal.
- Trochites BERTRAND, 1763 (ICZN appeal pending for status as collective group, MOORE & JEFFORDS, 1969).
- Tschironocrinus STUKALINA, 1973 [\**T. tschironensis*; OD]. USSR. (Not seed.)
- Unilineatocrinus DUBATOLOVA & YELTYSHEVA, 1969 [\**U. unilineatus* YELTYSHEVA & DUBATOLOVA; OD]. Columnal. *L.Carb.(Tournais.)*, USSR(Armenia).
- Verticillopora REZAK, 1959 [\**V. annulata*; OD]. Proposed as dasycladacean alga, interpreted as columnal by WOOD, 1965. *M.Sil.*, USA(Calif.-Nev.-Utah).
- Wanakastaurus MOORE & JEFFORDS, 1968 [\**W. delicatus*; OD]. Columnal. *M.Dev.(Erian)*, USA(N.Y.).
- Xenobasis FABER, 1929 [\**X. williamsi*; M]. *U.Ord.*, USA(Ohio).
- Zeravschanocrinus SHEVCHENKO, 1966 [\**Z. barbatus*; OD] [=*Zeravschanocrinus* SHEVCHENKO, 1966 (*nom. null.*)]. Columnal. *L.Dev.*, USSR(Tien Shan).

UNAVAILABLE GENUS-GROUP TAXA  
BASED SOLELY ON DISARTICULATED  
SKELETAL ELEMENTS

- †Acantharthropterum MOORE, 1939b. Pinnates. *Nom. vet.*
- †Acutobrachiola TERMIER & TERMIER, 1974. Brachiole. *Nom. vet.*
- †Altaecrinus STUKALINA, 1966. Columnal. *Nom. nud.*
- †Arcobrachiola TERMIER & TERMIER, 1974. Brachiole. *Nom. vet.*
- †Asperocrinus STUKALINA in LEVITAKIY *et al.*, 1968. Columnal. *Nom. nud.*
- †Aulosomphostega MOORE, 1939b. Terminals. *Nom. vet.*
- †Basotheca TERMIER & TERMIER, 1974. Basal part of cup. *Nom. vet.*
- †Bunaglaopolygonum MOORE, 1939b. Polygonal oscicles. *Nom. vet.*
- †Bunarthrum MOORE, 1939b. Facetals. *Nom. vet.*
- †Camarocrinus HALL, 1879 [\**C. stellatus*; SD S. A. MILLER, 1889] [=*Scyphocrinites* ZENKER, 1833]. Holdfast.
- †Chingizocrinus STUKALINA, 1968b. Columnal. *Nom. nud.*
- †Coenarthropterum MOORE, 1939b. Pinnates. *Nom. vet.*
- †Costatocrinus STUKALINA, 1966; STUKALINA in LEVITAKIY *et al.*, 1968. Columnal. *Nom. nud.*
- †Cuboidocrinus STUKALINA, 1967; TUYUTYAN, 1972. Columnal. *Nom. nud.*
- †Cyclocyclopa MOORE, 1939b. Columnal. *Nom. vet.*
- †Cycloellipticus YELTYSHEVA, 1956. Columnal. *Nom. vet.*
- †Cyclohexagonalis YELTYSHEVA, 1956. Columnal. *Nom. vet.*
- †Cyclopentagonopa MOORE, 1939b. Columnal. *Nom. vet.*
- †Cyclotetragonalis YELTYSHEVA, 1956. Columnal. *Nom. vet.*
- †Cyclotrigonalis YELTYSHEVA, 1956. Columnal. *Nom. vet.*
- †Dianobasis MOORE, 1939b. Apicals. *Nom. vet.*
- †Ellipsellipsopa MOORE, 1939a. Columnal. *Nom. vet.*
- †Ellipsocyclicus YELTYSHEVA, 1956. Columnal. *Nom. vet.*
- †Ellipsoellipticus YELTYSHEVA, 1956. Columnal. *Nom. vet.*
- †Ellipsohexagonalis YELTYSHEVA, 1956. Columnal. *Nom. vet.*
- †Ellipsopentagonalis YELTYSHEVA, 1956. Columnal. *Nom. vet.*
- †Ellipsotetragonalis YELTYSHEVA, 1956. Columnal. *Nom. vet.*
- †Ellipsotrigonalis YELTYSHEVA, 1956. Columnal. *Nom. vet.*
- †Engoniarthrum MOORE, 1939b. Facetals. *Nom. vet.*
- †Epalxyocrinus SIZOVA, 1960. Columnal. *Nom. nud.*
- †Fasciculocrinus STUKALINA, 1967. Columnal. *Nom. nud.*
- †Formaliocrinus STUKALINA, 1969. Columnal. *Nom. nud.*
- †Gisacanthostega MOORE, 1939b. Terminals. *Nom. vet.*
- †Henanobasis MOORE, 1939b. Apicals. *Nom. vet.*
- †Hexagonocyclicus YELTYSHEVA, 1956. Columnal. *Nom. vet.*
- †Hexagonoellipticus YELTYSHEVA, 1956. Columnal. *Nom. vet.*
- †Hexagonohexagonalis YELTYSHEVA, 1956. Columnal. *Nom. vet.*
- †Hexagonopentagonalis YELTYSHEVA, 1956. Columnal. *Nom. vet.*

- †Hexagonotetragonalis YELTYSHEVA, 1956. Columnnal. *Nom. vet.*
- †Hexagonotrigonalis YELTYSHEVA, 1956. Columnnal. *Nom. vet.*
- †Hiatocrinus STUKALINA, 1969. Columnnal. *Nom. nud.*
- †Hoplarthrum MOORE, 1939b. Facetals. *Nom. vet.*
- †Isotrianobasis MOORE, 1939b. Apicals. *Nom. vet.*
- †Lacunocolumnea TERMIER & TERMIER, 1974. Columnnal. *Nom. vet.*
- †Latibrachiola TERMIER & TERMIER, 1974. Brachioles. *Nom. vet.*
- †Limbatoocrinus STUKALINA, 1967. Columnnal. *Nom. nud.*
- †Lobatocrinus STUKALINA, 1969. Columnnals. *Nom. nud.*
- †Lophaglaopolygonum MOORE, 1939b. Polygonal ossicles. *Nom. vet.*
- †Macrocrinarthrum MOORE, 1939b. Facetals. *Nom. vet.*
- †Nimioocrinus STUKALINA in LEVITAKIY *et al.*, 1968. Columnnal. *Nom. nud.*
- †Notocrinus STUKALINA, 1969. Columnnal. *Nom. nud.*
- †Pentagonocyclopa MOORE, 1939b. Columnnal. *Nom. vet.*
- †Pentagonoellipticus YELTYSHEVA, 1956. Columnnal. *Nom. vet.*
- †Pentagonotetragonalis YELTYSHEVA, 1956. Columnnal. *Nom. vet.*
- †Pentagonotrigonalis YELTYSHEVA, 1956. Columnnal. *Nom. vet.*
- †Pentanobasis MOORE, 1939b. Apicals. *Nom. vet.*
- †Pentanobathrum MOORE, 1939b. Apicals. *Nom. vet.*
- †Pentecatobasis MOORE, 1939b. Apicals. *Nom. vet.*
- †Pentexobasis MOORE, 1939b. Apicals. *Nom. vet.*
- †Pentexobathrum MOORE, 1939b. Apicals. *Nom. vet.*
- †Planocrinus STUKALINA, 1966. Columnnal. *Nom. nud.*
- †Radiobrachiola TERMIER & TERMIER, 1974. Brachioles. *Nom. vet.*
- †Ramosocrinus STUKALINA, 1969. Columnnals. *Nom. nud.*
- †Retibrachiola TERMIER & TERMIER, 1974. Brachioles. *Nom. vet.*
- †Schedaglaopolygonum MOORE, 1939b. Polygonal ossicles. *Nom. vet.*
- †Siluroocrinus STUKALINA, 1969. Columnnals. *Nom. nud.*
- †Sphenarthropterum MOORE, 1939b. Pinnates. *Nom. vet.*
- †Spinocrinus STUKALINA, 1966, 1968b. Columnnals. *Nom. nud.*
- †Syndetocrinus STUKALINA in LEVITAKIY *et al.*, 1968. Columnnals. *Nom. nud.*
- †Tantalocrinus STUKALINA in LEVITAKIY *et al.*, 1968. Columnnal. *Nom. nud.*
- †Tetragonocyclicus YELTYSHEVA, 1956. Columnnal. *Nom. vet.*
- †Tetragonoellipticus YELTYSHEVA, 1956. Columnnal. *Nom. vet.*
- †Tetragonoheptagonalis YELTYSHEVA, 1956. Columnnal. *Nom. vet.*
- †Tetragonopentagonalis YELTYSHEVA, 1956. Columnnal. *Nom. vet.*
- †Tetragonopterum MOORE, 1939b. Pinnates. *Nom. vet.*
- †Tetragonotrigonalis YELTYSHEVA, 1956. Columnnal. *Nom. vet.*
- †Tetranobasis MOORE, 1939b. Apicals. *Nom. vet.*
- †Tolenicrinus STUKALINA, 1966, in LEVITAKIY *et al.*, 1968. Columnnal. *Nom. nud.*
- †Trapezopterum MOORE, 1939b. Pinnates. *Nom. vet.*
- †Trianobasis MOORE, 1939b. Apicals. *Nom. vet.*
- †Triexobasis MOORE, 1939b. Apicals. *Nom. vet.*
- †Trigonocrinus STUKALINA, 1969. Columnnal. *Nom. nud.*
- †Trigonoellipticus YELTYSHEVA, 1956. Columnnal. *Nom. vet.*
- †Trigonoheptagonalis YELTYSHEVA, 1956. Columnnal. *Nom. vet.*
- †Trigonopentagonalis YELTYSHEVA, 1956. Columnnal. *Nom. vet.*
- †Trigonotetragonalis YELTYSHEVA, 1956. Columnnal. *Nom. vet.*

PRESENTLY UNRECOGNIZABLE  
GENUS-GROUP TAXA BASED SOLELY ON  
DISARTICULATED SKELETAL ELEMENTS

- Autunia RUSCONI, 1955. Columnnal. *Paleoz.*
- Ascarum DE GREGORIO, 1930 [\**A. montanum*; M].  
?Columnnal. *U. Perm.*, Sicily.
- Cladostoma RAFINESQUE, 1819.
- Concretum DE GREGORIO, 1930 [\**C. perplexum*; M].  
?Columnnal. *U. Perm.*, Sicily.
- Cophinus MURCHISON, 1839 [\**C. dubius*; M]. Im-  
pression of columnnal. *Sil. (Ludlov.)*, Eu. (Eng.).
- Crisantum DE GREGORIO, 1930 [\**C. stvensoni*; M].  
?Columnnal. *U. Perm.*, Sicily.
- Cystoidosaccus FABER, 1929, p. 481. *U. Ord.*, USA  
(Ind.).
- Encrinites GUETTARD, 1761 (*non* DAVILA & ROMÉ  
DE L'ISLE, 1769) (ICZN appeal pending for status  
as collective group, MOORE & JEFFORDS, 1969).  
*Paleoz.-Mesoz.*
- Entrochi (of authors).
- Entrochites TRIVIS, 1767 (ICZN appeal pending for  
status as collective group, MOORE & JEFFORDS,  
1969).
- Imperatoria DE GREGORIO, 1930 [\**I. marconii*; M].  
Doubtful biologic assignment. *U. Perm.*, Sicily.
- Mestyrites RAFINESQUE, 1819.
- Mirmus DE GREGORIO, 1930 [\**M. ruptus*; M]. Un-  
recognizable. *U. Perm.*, Sicily.
- Pentagonites RAFINESQUE, 1819. Pentagonal colum-  
nals (3 species named but not described).
- Salagastiana RUSCONI, 1951 [\**S. simetrica*; M]  
[= ?*Ottawacrinus* BILLINGS, 1887]. Columnnal. *U.*  
*Cam.*, ?*Ord.*, S. Am. (Arg.).

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[Because the statements published in the paper in the American Geologist, April-December, 1890, clearly indicate publication subsequent to 1889 (MILLER's *North American Geology and Paleontology* containing provisional outline of families, p. 214-215), definitive first publication is evidently that in the American Geologist, p. 275-286, 340-357.

MILLER's paper in the Indiana 16th annual Report, p. 302-326, is identical with paper in the American Geologist and patently printed subsequent to December, 1890. This part of the Indiana 16th Report indicated as 1889 should be indicated as actually 1891. Pages noted in margin of the Indiana version are those of the American Geologist reference, which are taken to have precedence as definitive first references.—R. C. MOORE.]

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## ADDENDUM TO SUBPHYLUM HOMALOZOA

### CTENOCYSTOIDS

BY JAMES SPRINKLE and R. A. ROBISON

[University of Texas at Austin and University of Kansas]

The following account of the Class Ctenocystoidea (ROBISON & SPRINKLE, 1969) supplements coverage of the subphylum Homalozoa in *Treatise Part S* (1967).

#### Class CTENOCYSTOIDEA Robison & Sprinkle, 1969

[Ctenocystoidea ROBISON & SPRINKLE, 1969, p. 1512]

Small, flattened echinoderms bearing a double-layered marginal frame surrounding two flexibly plated central areas; ovoid theca shows near perfect bilateral symmetry with mouth and anus at opposite body poles; no aulacophore, stele, or arm appendages present; seven marginal plates in each layer of frame alternate across knife-edge contact; dorsal centrals tiny and polygonal, ventral centrals tiny oval- or spear-shaped plates in aligned rows; grill-like array of 18 to 20 blade-shaped ctenoid plates attached to dorsal anterior of theca and apparently covering central mouth and two lateral food grooves; anal pyramid between layers of marginal frame at rear of theca. *M. Cam.* (*Glossopleura Assemblage-zone*).

Ctenocystoids are now known to occur in the Spence Tongue of the Lead Bell Shale at eight localities in northern Utah and southeastern Idaho. Nearly 1,000 specimens of the single described genus and species have been found at these localities in association with several trilobite genera of the *Glossopleura Assemblage-zone*, the eocrinoids *Gogia granulosa*, *G. palmeri*, *G. n. sp.*, an undescribed stylophoran, inarticulate brachiopods, hyolithids, sponges, and rare annelids. Some beds in the Spence Tongue are packed with complete ctenocystoids jumbled together in all orientations; one example of this type of preservation is shown in Figure 617. Disarticulated ctenocystoid plates are also found in some beds,

but complete specimens are usually more common.

Because of their flattened thecal shape, differentiation into marginal frame and enclosed central areas, and lack of radial symmetry, ctenocystoids belong in the echinoderm subphylum Homalozoa ("carpoids"). However, they differ from the other three homalozoan classes in several important respects. They are the only group that completely lacks appendages such as aulacophore, stele, or arms. Ctenocystoids are smaller, more bilaterally symmetrical, and better streamlined than other homalozoans, probably implying a more active mode of life. Other differences include the double-layered marginal frame and the grill-like array of ctenoid plates along the anterior thecal margin.

UBAGHS (1971) has suggested that ctenocystoids are most closely related to members of the homalozoan class Stylophora. Ctenocystoids and cornute stylophorans like *Phyllocystis* (U. Cam.-L. Ord.) both have well-developed bilateral symmetry, mouth and anus at opposite body poles, a marginal frame strongly differentiated from two tiny-plated central areas, and no tail-like peduncular appendage. However, ctenocystoids lack the typical stylophoran aulacophore appendage attached to the anterior end of the theca over the mouth, and instead have a grill-like array of ctenoid plates covering two lateral ambulacra along the anterior margin. If this inferred relationship between ctenocystoids and stylophorans is correct, then the marginal ctenoid grill may be homologous to all or part of the erect stylophoran aulacophore, even though these structures differ greatly in appearance and in their method of food gathering. It is interesting to note that ctenocystoids occur in the Spence Tongue



F. ... several representative specimens of *Ctenocystis utahensis*  
R. ... Tongue, Lead Bell Shale (lower Middle Cambrian,  
... X3.5 (Sprinkle & Robison, n, USNM 163253).

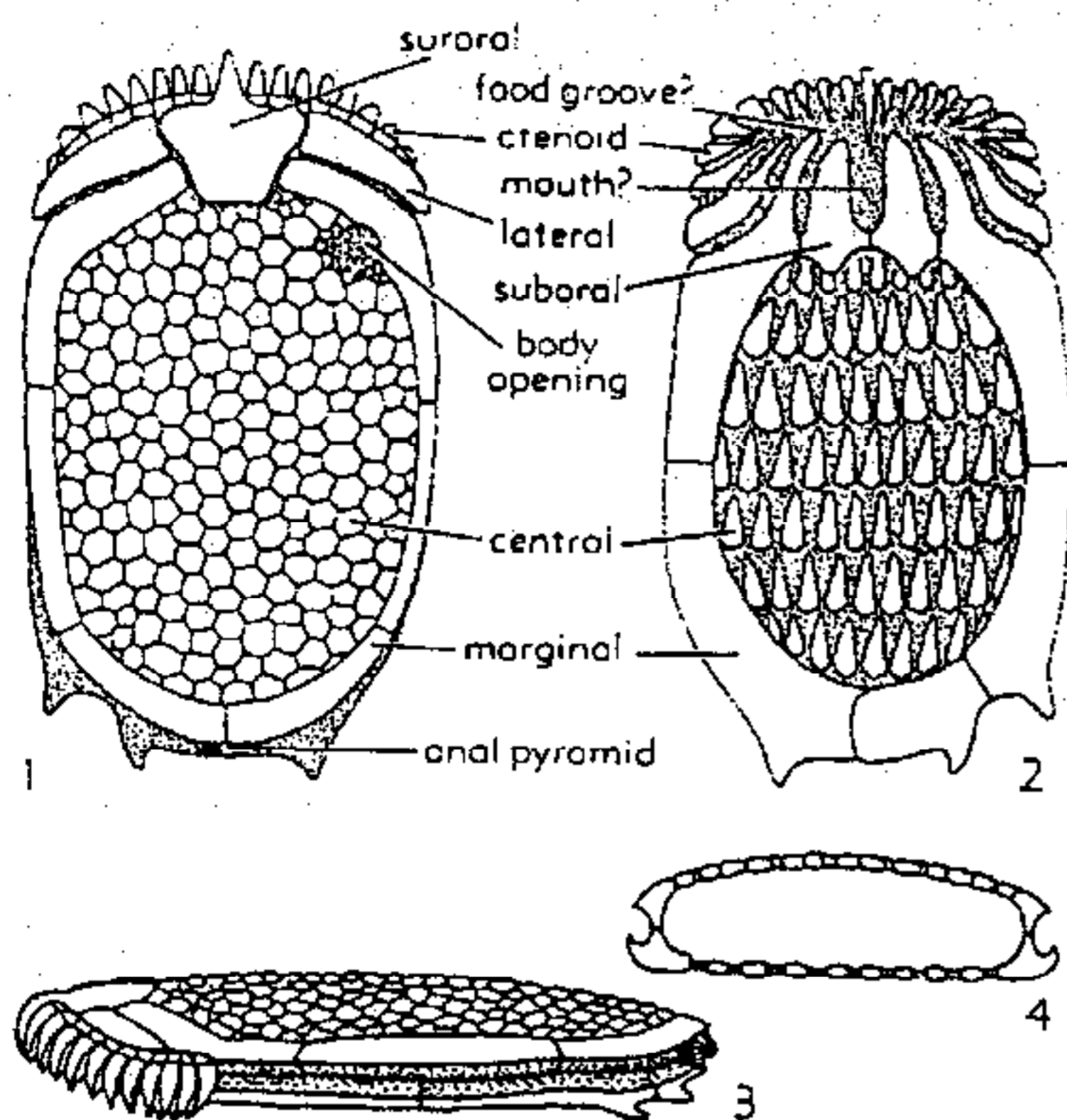


FIG. 618. Morphological features of Ctenocystoidea, based on *Ctenocystis utahensis* ROBISON & SPRINKLE, Middle Cambrian, Utah.—1-4, dorsal, ventral, side, and cross-sectional views of reconstructed specimen,  $\times 5$  (1,2, after Robison & Sprinkle, 1969, by permission of R. A. Robison and James Sprinkle, and *Science*, v. 166, p. 1512-1514, 19 December, 1969, copyright 1969 by American Association for the Advancement of Science; 3,4, Sprinkle & Robison, n).

with a rare cornute stylophoran similar to *Phyllocystis*; these two forms now are among the earliest known homalozoans in the fossil record (early Middle Cambrian).

Although an average ctenocystoid is only about 6 mm. long and 4 mm. wide, at least 210 plates are present in four major body regions: the marginal frame, the anterior food-gathering ctenoid grill, and the two central areas. The marginal frame is composed of 14 medium-sized, mostly elongate, curved plates. These marginals are arranged in two series of seven plates each on the dorsal (superior) and ventral (inferior) surfaces, joined together along a knife-edge hinge line (see Fig. 618,3,4) that extends around the lateral and posterior margins of the theca. The anterior-most plate on the dorsal side, called the suroral, has a distinctive trapezoidal shape and a large central tooth-like process (Fig. 619,1a,c,e), resembling the other ctenoids on this margin. This suroral process fits into a groove between two symmetrically arranged small frame plates, called suborals, on the ventral surface (Fig. 619,1a). The

mouth was probably located at the center of the anterior margin below the suroral and just above and between the two suborals.

The anterior margin of the theca bears a grill-like array of 18 to 20 ctenoid plates articulated either with the suroral, with two wedge-shaped plates called laterals lying beside it, or with the edges of the two other anterior supermarginals (Fig. 619,1c). These ctenoid plates intermesh ventrally with two suborals or projections from the two anterior infermarginals (Fig. 619,1a). Each ctenoid is a curved, tooth- or blade-shaped plate ranging from 0.5 to 1.2 mm. long, increasing in size from the center of the anterior margin beneath the suroral toward both sides. New ctenoid plates may have been added beneath the suroral, because one well-preserved specimen (Fig. 619,1a) shows a tiny plate inserted here. If true, the number of ctenoids probably increased during thecal growth to an observed maximum of 20.

Several specimens have the ctenoid plates slightly open, revealing two shallow grooves running along the anterior margin (Fig. 619,1d). These probably represent short ambulacral food grooves leading to the central mouth. The larger lateral ctenoids close off the ends of these grooves from the rest of the thecal margin, which also bears a shallow groove but without any kind of cover plates (Fig. 618,3).

Within the marginal frame on the dorsal and ventral thecal surface are central areas covered with flexible membranes bearing tiny plates (centrals). The dorsal central area is slightly domed and somewhat larger than the nearly flat ventral one (see Fig. 618,1,2,4), probably because the ventral marginals are wider and flat. The dorsal central areas contains approximately 100 to 110 tiny polygonal centrals (Fig. 619,1c), whereas the ventral area contains 50 to 60 tiny elongate oval or spear-shaped centrals that do not appear to be tightly sutured, but partially arranged in rows (Fig. 619,1f). The ventral centrals appear to be about twice as large as the dorsal centrals (0.5-0.6 mm. long vs. 0.2-0.3 mm. long and wide).

Two of the posterior infermarginals apparently overlap along a slanting suture (Fig. 619,1d) instead of directly abutting.

This probably allowed the anal pyramid, which is a small cone-shaped structure with about 15 tiny plates located here in an elliptical area between the frame layers (Fig. 619,1b), to protrude for venting or pumping. At least two posterior infermarginals have short spines extending back from the theca (Fig. 619,1c).

A small groove or sulcus extends down the inner surface of the right anterior supermarginal (Fig. 619,1e), perhaps representing another body opening, such as a hydropore or gonopore.

Ctenocystoids show a high degree of bilateral symmetry, deviating from this primarily in the slightly off-center arrangement of the posterior infermarginals and their spines (Fig. 618,2). This strongly developed symmetry along with their small size, streamlined airfoil shape, and mouth and anus at opposite body poles all point to an active mobile (probably swimming) mode of life. Using their flexible central areas and hinged marginals in a bellows-like manner, ctenocystoids could have drawn sea water into a cloaca-like structure just inside the posterior anal pyramid, extended the pyramid, and jetted this water back out, propelling the animal forward for a short distance along or above the sea bottom. The elongate ventral centrals and the posterior infermarginal spines would have prevented lateral drift of the animal during movements of this type. UBAGHS (1968) has proposed a similar type of movement for stylophorans but ctenocystoids were probably more mobile because of their smaller size, better symmetry, and lack of appendages.

The feeding apparatus of ctenocystoids does not seem to be comparable to food-gathering structures found in any other homalozoan class. The ctenoid plates may possibly represent greatly modified ambulacral cover plates that have become reduced to only one series of enlarged, blade-shaped plates articulated dorsally. The arrangement and articulation of ctenoid (and lateral) plates suggest that they were probably used for digging or sifting through fine-particulate material, implying that ctenocystoids were most likely detritus-feeders living on the surface or in the top few mm. of sediment. Mucus secretion,

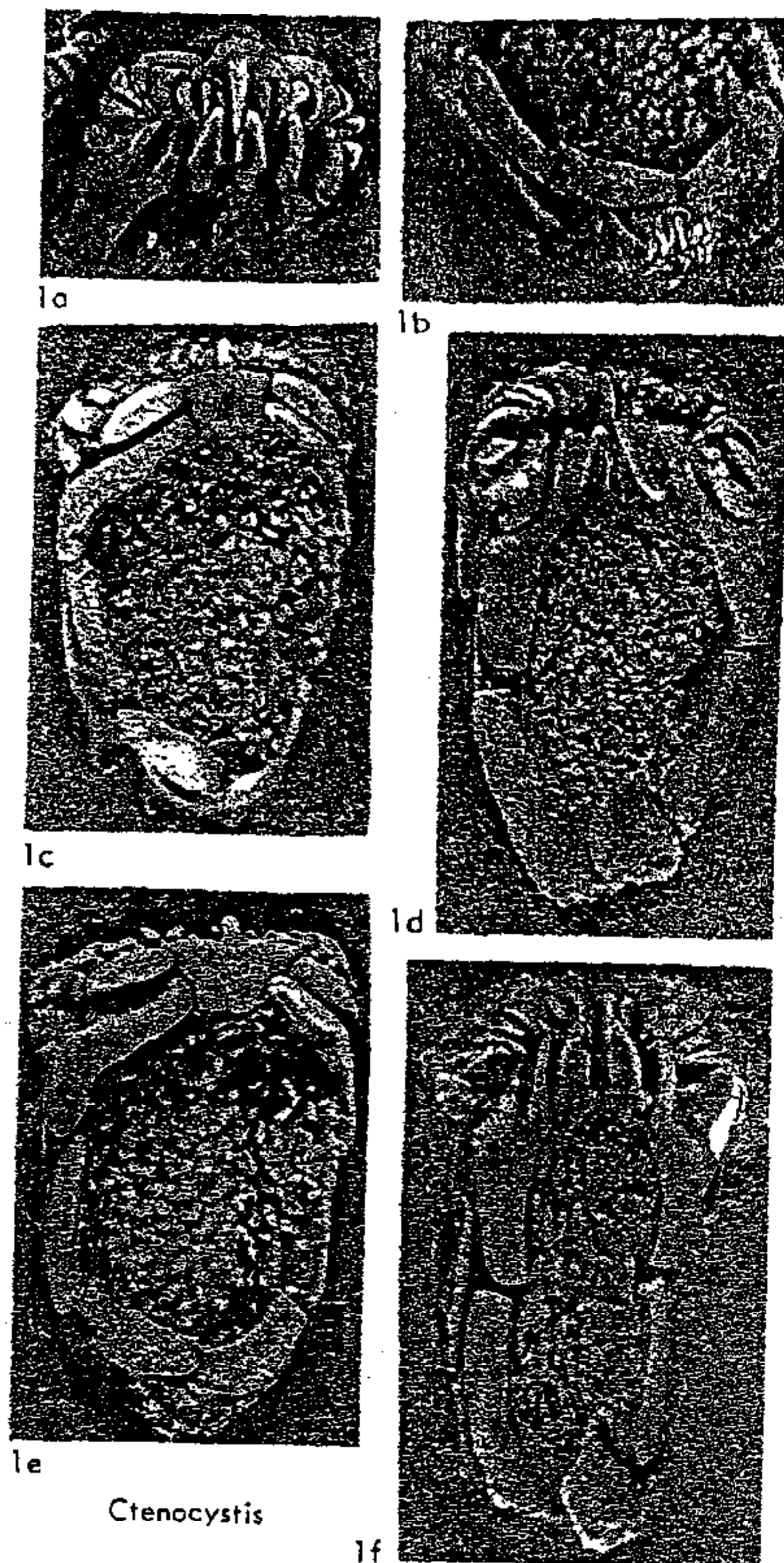


FIG. 619. Ctenocystidae (photos by courtesy of R. A. Robison and James Sprinkle, from *Science*, v. 166, p. 1512-1514, 19 December, 1969, copyright 1969 by American Association for the Advancement of Science) (p. T1001).

ciliary currents, or both would have aided in collecting microscopic food particles from the fine detrital sediment and transporting them to the central mouth. No evidence for ambulacral tube feet has been observed.

#### Family CTENOCYSTIDAE Sprinkle & Robison, new family

Characters of class. *M. Cam.* (*Glossopleura Assemblage-zone*).

*Ctenocystis* ROBISON & SPRINKLE, 1969, p. 1513 [*C. utahensis*; OD]. Theca small, flattened, ovoid, nearly bilaterally symmetrical; marginal

frame double-layered, each layer consisting of seven plates that alternate across a hinge line; central areas flexibly plated with tiny polygonal plates dorsally and rows of tiny oval or spear-shaped plates ventrally; anterior grill of blade-shaped ctenoid plates apparently covers central mouth and two lateral food grooves; anal pyramid between marginal layers at opposite thecal pole; posterior infermarginals bear short spines; third opening present on edge of right anterior supermarginal. *M. Cam. (Glossopleura Assemblage-zone)*, USA (Utah-Idaho).—FIG. 619, 1. *C. utahensis*, Utah; *1a*, ant. view showing well-preserved ctenoid series,  $\times 6$ ; *1b*, post. view with anal pyramid between marginal layers,  $\times 6$ ; *1c, e*, dorsal views of two specimens (*1c* is holotype); note shape of suroral and posterior spines,  $\times 6$ ; *1d, f*, ventral views showing suborals and spear-shaped centrals,  $\times 6$  (from Robison & Sprinkle, 1969; courtesy

R. A. Robison and James Sprinkle, and *Science*, v. 166, p. 1512-1514, 19 December, 1969, copyright 1969 by American Association for the Advancement of Science).

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