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KEY FOR CLASSIFICATION OF CYSTOIDS

BY  
ROBERT V. KESLING

FROM THE  
EDWARD PULTENEY WRIGHT MEMORIAL VOLUME



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# CONTRIBUTIONS FROM THE MUSEUM OF PALEONTOLOGY

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## KEY FOR CLASSIFICATION OF CYSTOIDS

BY  
ROBERT V. KESLING

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## INTRODUCTION

**I**N THE COURSE of writing the section on Cystoidea for the *Treatise on Invertebrate Paleontology*, it was necessary for me to examine taxonomy critically, to compare genera in minute detail, and to institute changes in classification which would make the taxa mutually exclusive. Information was garnered from textbooks, monographs on Pelmatozoa, previous treatises, familial and generic descriptions and emendations, and articles on cystoid morphology; and observations were made of numerous type specimens and undescribed specimens. From analysis and winnowing of this data, a tentative key was prepared.

Copies of the key were circulated to cystoid workers in various parts of the world. In correspondence, pertinent and significant suggestions on classification were received from Professor Gerhard Regnéll, Paleontologisk-Geologiska Institutionen, Lunds Universitet, Sweden; from Professor G. Ubaghs, Laboratoire de Paléontologie, Université de Liège, Belgium; and from Professor R. F. Hecker, Paleontologiskii Institut, Akademia Nauk, Moscow, U.S.S.R. For their generous advice, my sincere appreciation is extended to each of these authorities. Their comments were weighed carefully and produced some marked improvements to the key.

The key is presented here as a unit. Detailed descriptions of orders, superfamilies, families, subfamilies, and genera will be published with pertinent parts of the key in the forthcoming *Treatise on Invertebrate Paleontology, Volume 5*. It seems desirable, in the meantime, to make available to students of Cystoidea this consistent and integrated key for classification. To promote clearer understanding of morphological terms, a short glossary precedes the key.

This presentation has some shortcomings, most of which can be removed only by study of better-preserved specimens and by discovery of additional kinds of cystoids. Although the key emphasizes essential characteristics of cystoid taxa, it does not comprise complete descriptions. Certain genera that I regard as highly questionable have been omitted; some may criticize the omission of these genera, whereas others may hold that some of the genera which I included should be placed in synonymy. Undoubtedly, parts of the key do not accurately reflect genetic relationships; this particularly applies to the families Sphaeronitidae and Aristocystitidae, in which genera have been poorly delineated. Cystoid taxonomy is at present a fertile field for investigation. Nevertheless, it appears that the general classification of cystoids is now established, even though future refinements can be expected.

## GLOSSARY OF TERMS

aboral. Located away from mouth; in the direction away from mouth.

"adambulacral." Pertaining to brachiole-bearing plates which regularly alternate in paired vertical rows in Dactylocystidae and Protocrinidae.

adoral. Located toward mouth; in the direction toward mouth.

ambulacral. 1. Referring to zone in which an ambulacrum is present, as contrasted with *interambulacral*. 2. Referring to an ambulacrum or to ambulacra collectively, as in *ambulacral system*.

ambulacral covering plates. Tiny plates biserially arranged and covering ambulacral groove, in some forms readily dislodged and rarely preserved.

ambulacral flooring plates. Plates of ambulacrum biserially arranged, containing ambulacral groove, and attached to underlying thecal plates. Plates of two sizes, one long and one short, arranged biserially whereby long and short plates alternate in each row and a long plate is aligned with a short plate on opposite side of ambulacrum.

ambulacral groove. Groove through which food was conveyed from brachioles to mouth, covered by ambulacral covering plates; in some cystoids lying within ambulacral flooring plates as a zigzag trough (*e.g.*, Glyptocystitida), but in others lying directly in surface layer of thecal plates (*e.g.*, Glyptosphaeritida) or concealed by "tegmens" (*e.g.*, Caryocrinidae).

ambulacrum. Structure in which food was conveyed, invariably on surface of theca, exothecal but never erect. Five ambulacra in many cystoids, but number may be reduced to two. Length of ambulacra varies greatly, from very short conduits where brachioles are clustered near mouth (*e.g.*, Aristocystitidae) to medium where brachioles are limited to crown of theca (*e.g.*, Cheirocrinidae), to very long, in some extending

- to base (*e.g.*, Callocystitidae). Each ambulacrum consisting of ambulacral groove enclosed by ambulacral covering plates, and in some forms of ambulacral flooring plates. Ambulacrum applies to all branches of main conduit.
- anal pyramid. Valvular structure of triangular plates in periproct serving to close anus.
- anus. Exit of alimentary canal or gut, including tissues as well as anal pyramid.
- auxiliary plate. One of tiny plates bordering anal pyramid and forming ring around inner edge of periproct, present in many cystoids of Glyptocystitida.
- B.* See basal.
- basal. 1 (n.). Plate in aboral circllet, especially one of the 4 plates in this circllet in Glyptocystitida and Hemicosmitida, designated as *B1*, *B2*, etc., plural *BB*. 2 (adj.). Referring to aboral part of theca.
- base. Aboral part of theca, by some authors restricted to columnar facet but by others expanded to include thecal plates of *BB* or other aboral circllets.
- BB.* See basal.
- brachiole. One of erect structures by which food is gathered and transmitted to ambulacra. Brachioles reduced to two large tapering structures in Pleurocystitidae, but numerous in most Glyptocystitida, especially Callocystitidae, and abundant in Mesocystidae, with as many as 1000 in *Mesocystis*. Each brachiole composed of biserial plates and unbranched. Dorsal plates in two rows forming brachiole groove, ventral plates in two rows roofing over groove; both sets of plates biserially arranged. Of all cystoids, only *Caryocrinites* having arms with pinnules instead of brachioles.
- brachiole facet. Indentation to which brachiole was attached, commonly subcircular. Brachiole facets on thecal plates in cystoids lacking ambulacral flooring plates (*e.g.*, Glyptosphaeritida), otherwise shared by two flooring plates (*e.g.*, Glyptocystitida).
- circllet. Plates forming ring around theca, or which in classic type of Glyptocystitida form such a ring. Thus circllets of *BB*, *ILL*, *LL*, *RR*, and *OO* are present in glyptocystitidans. Circllet is *complete* if it extends all the way around theca and *interrupted* if a plate of another circllet intervenes in such manner as to separate two plates adjacent in circllet.
- column. Stemlike structure attached to aboral end of most cystoids, fairly rigid in *Caryocrinites* but in most other forms having proximal section

- flared and flexible. Column presumably used for anchoring cystoid; distal end known to be variously modified in some species.
- complete. *See* circlet.
- compound. *See* tangential pore canal.
- conjunct. *See* pectinirhomb.
- covering plate. *See* ambulacral covering plate *and* peristomial covering plate.
- crown. Oral region, especially applied to cystoids having sharp boundary between steep lateral sides and blunt, flat, or gently convex oral region (*e.g.*, *Cheirocrinus*), in which theca is adorally truncate, with flat-lying *OO* forming lidlike cap atop steep *RR*.
- demirhomb. Kind of pectinirhomb in which pores are arranged in a chevron, formed when successive pores developed on only one side of first pore. Rare except in Glyptocystitidae, Cheirocrinidae, and Cystoblastidae.
- dichopore. Structure in pore rhomb, originally proposed for complete unit of two terminal openings and their connection, but sometimes applied to only terminal pore or slit in pectinirhomb. Dichopores differ in superfamilies of the Rhombifera, but each kind extends from one thecal plate to another.
- dipopore. Structure penetrating a thecal plate and confined in most cases to a single plate. Classic example as figured in texts consists of Y-shaped branching canal or tube with two openings at outer end, but canals which do not branch or which branch irregularly also included in dipopores by some workers.
- disjunct. *See* pectinirhomb.
- divided. As applied to ambulacra, signifying that ambulacral groove (exclusive of lateral branches) bifurcates, with each branch complete with flooring and covering plates; taxonomically significant in Callocystitidae.
- epithea. Outermost thin calcareous layer of thecal plates, especially noted in Caryocystitida, in which it covers tangential pore canals so that pore rhombs are apparent only in specimens having epithea weathered off.
- flooring plate. *See* ambulacral flooring plate.
- food groove. *See* ambulacral groove.
- gonopore. Small opening in posterior region, usually close to mouth, penetrating thecal plates. Gonopore not detected in all cystoids.
- half-rhomb. That part of pore rhomb lying within one thecal plate.
- height. Distance between oral and aboral ends.
- hydropore. Opening or openings through thecal plates in posterior region in vicinity of mouth, variously developed as slit, group of irregular

slits, or sieve. In most cystoids, hydropore lies between gonopore and mouth, yet in some it is offset to one side, in which case it is not farther from mouth than is gonopore.

*IL*. See infralateral.

*ILL*. See infralateral.

infralateral. One of cirlet of 5 plates in Glyptocystitida lying adoral to *BB* and aboral to *LL*, designated as *IL1*, *IL2*, etc., plural *ILL*.

interambulacral. Referring to zone between ambulacra, especially to thecal plates found there.

intercalation. In Glyptocystitida, arrangement of thecal plates wherein those of one cirlet extend into zone of another cirlet, separating plates or parts of plates. Extending plates sometimes said to be "inserted" into other cirlet.

interrupted. See cirlet.

*L*. See lateral (1).

lateral. 1 (n). One of cirlet of 5 plates in Glyptocystitida lying between *ILL* and *RR*, thus about equatorial in many cystoids; designated as *L1*, *L2*, etc., plural *LL*. 2 (adj.). Located on side of theca, as contrasted with oral and aboral areas.

lateral branches. Short grooves from brachioles to main ambulacral groove, roofed by tiny biserial covering plates; in Glyptocystitida lying upon flooring plates.

*LL*. See lateral (1).

marginal plate. See auxiliary plate.

mouth. Aperture at oral pole through which food entered body from ambulacra, covered by peristomial covering plates similar to and continuous with those of ambulacra.

multidisjunct. See pectinirhomb.

*O*. See oral (1).

*OO*. See oral (1).

orad. Toward mouth.

oral. 1 (n.). One of circumoral cirlet of 5 plates in Glyptocystitida, designated as *O1*, *O2*, etc., plural *OO*; *O1* containing hydropore and gonopore, normally tripartite. 2 (adj.). Located toward, near, or at mouth.

oral projection. Protuberance of oral end or pole; in *Echinospaerites* set off by constriction, whereby theca has phialine lip at mouth.

ornamentation. Surface features of thecal plates, such as ridges, granules, tubercles, nodes, and spines.

pectinirhomb. Type of pore rhomb found in Glyptocystitida, in which units or dichopores terminate in perforations through thecal plates,

- either as round pores or, more commonly, slits. If slits from one plate are continuous with those of the other, pectinirhomb is *conjunct*; if slits of one plate are separated from those of the other by a slit-free area, pectinirhomb is *disjunct*; and if each dichopore has line of slits in each plate instead of one terminal slit, pectinirhomb is *multidisjunct* (rare).
- periproct. Major thecal opening containing anal pyramid and, in many species, additional plates. Extreme development attained in Pleurocystitidae, in which periproct nearly fills one side of compressed theca. In many Callocystitidae, periproct is filled by small anal pyramid and surrounding ring of auxiliary plates.
- peristome. Structures associated with mouth, especially peristomial covering plates.
- peristomial covering plate. Any of small plates covering mouth and continuous with ambulacral covering plates, which they resemble.
- plate. Any calcareous secretion, normally nearly flat, in cystoids; by some applied only to thecal units, but by others used for ambulacral and columnar structural units.
- pore. General term for perforation in thecal plate. Properly, pore applies to openings of perforations and pore canal to the perforation, but usage has been confused on this distinction.
- pore canal. Perforation in thecal plate.
- pore rhomb. Group of perforations in thecal plates, of which each end of one perforation lies in one of 2 adjacent plates. Ends may be exposed (*e.g.*, Glyptocystitida) or covered by epitheca (*e.g.*, Hemicosmitida), and canal from one opening to other may pass through stereotheca (*e.g.*, Caryocystitida) or under it (*e.g.*, Glyptocystitida and Hemicosmitida).
- pore slit. Form of pore in pectinirhomb. *See* dichopore.
- R.* *See* radial (1).
- radial. 1 (n.). One of cirlet of 5 plates in Glyptocystitida lying adoral to *LL* and aboral to *OO*, designated as *R1*, *R2*, etc., plural *RR*. Most ambulacra extend to or over corresponding radial. 2 (adj.). Used by some authors as synonym of ambulacral to signify zone in which an ambulacrum is present.
- rhomb. *See* pore rhomb.
- RR.* *See* radial (1).
- sculpture. Ornamentation of thecal plates, especially strongly developed ornamentation.
- simple. *See* tangential pore canal.
- slit. *See* pore slit.



- stem. *See* column.
- stereom. Calcareous material of cystoid, in particular that comprising thecal plates.
- stereotheca. Inner layer of thecal plate, thicker than epitheca, containing tangential pore canals in Caryocystitida.
- subepithecal. Lying below epitheca, used in reference to location of tangential pore canals.
- suture. Boundary line marking junction between two plates, or area of contact between adjacent plates.
- tangential pore canal. Subepithecal pore canal in Caryocystitida which runs parallel to surface of thecal plates and connects two pore canals normal to inner surface of different plates; each tangential pore canal extends through stereotheca of two adjacent plates. If two pores normal to surface and leading to interior of theca are connected by only one tangential pore canal, that canal is *simple*; but if the two are connected by more than one, tangential pore canals are *compound*.
- "tegmen." Structure in *Caryocrinites* and related genera which covers mouth and ambulacral grooves as plated roof; not homologous to tegmen of crinoid.
- theca. Enclosure of plates in which body of cystoid was housed.
- thecal plate. One of plates comprising theca.

## KEY

## Class CYSTOIDEA von Buch, 1846

## KEY TO ORDERS, SUPERFAMILIES, FAMILIES, AND SUBFAMILIES

1. Thecal pores developed as rhombs, with units, or dichopores, extending across sutures ..... Order RHOMBIFERA .... 2
  - Thecal pores developed as units normally contained within plates, commonly as diplopores, rarely extending across sutures ..... Order DIPLOPORITA .... 14
2. Theca composed of 4 *BB*, 5 *ILL*, 5 *RR*, and 5 *OO* (with rare exceptions); rhombs as distinct pectinirhombs on particular sutures, outer surface with well-exposed slits ..... Superfamily GLYPTOCYSTITIDA .... 3
  - Theca composed of 4 *BB*, 6 to 10 *ILL*, 8 or more *LL*, and several *RR*; rhombs with inner side of strong folds or laminae perpendicular to sutures, outer side of pores (covered by epitheca in unweathered specimens) each surrounded by a rim (or divided into two or more smaller pores) Superfamily HEMICOSMITIDA .... 10
  - Theca composed of numerous, irregularly arranged plates; pore rhombs on all sides of thecal plates, pores inclined and not connected by inside or outside calcareous tubes ..... Superfamily POLYCOSMITIDA .... 12
  - Theca composed of numerous, irregularly arranged plates; pores connected by outer, covered tubes ..... Superfamily CARYOCYSTITIDA .... 13
3. Periproct large, containing numerous plates ..... 4
  - Periproct small, anal pyramid surrounded by not more than one circlet of auxiliary plates ..... 6

4. Theca strongly compressed, periproct comprising most of one side of theca, 3 rhombs or less ..... Family Pleurocystitidae .... 30  
Theca ovate, periproct much smaller than one side of theca, numerous rhombs .. 5
5. Ambulacra short, limited to crown of theca, brachioles relatively few ..... Family Cheirocrinidae .... 21  
Ambulacra long, extending down over theca, brachioles numerous ..... Family Glyptocystitidae .... 18
6. Theca shaped like a pentremite or bud, with marked pentameral symmetry; ambulacra very large, tapering, tongue-shaped; rhombs numerous ..... Family Cystoblastidae .... 19  
Theca ovate, spindle-shaped, globular, or biconvex, but not pentremite-shaped; ambulacra not broad and tongue-shaped; rhombs not very numerous, in many reduced to 3 ..... 7
7. Ambulacra short, restricted to crown of theca ..... 8  
Ambulacra long, extending down over theca; periproct never produced ..... Family Callocystitidae .... 9
8. Theca with shape of quadrate spindle; *ILL* and *LL* comprising sides of theca, *RR* and *OO* alternating small plates in circllet at crown; 3 long vertical rhombs on *LL* set directly above 3 long rhombs on *ILL*; periproct small ..... Family Rhombiferidae .... 20  
Theca ovate to subglobular; *RR* large; periproct typically produced ..... Family Echinoencrinitidae .... 23
9. Theca ovate or globular; 4 or 5 divided ambulacra; brachioles small, widely spaced; *LL* intercalated deeply into *IL* circllet, as many as 3 *LL* in contact with *BB* ..... Subfamily Callocystitinae .... 32  
Theca ovate or biconvex; 2 to 4 undivided, strongly protuberant ambulacra; brachioles very numerous, closely spaced; plate circllets variously modified by shape of theca ..... Subfamily Staurocystinae .... 43  
Theca ovate; 4 or 5 undivided (except in *Strobilocystites*) ambulacra, not protuberant; brachioles relatively widely spaced; *ILL* forming closed circllet .... Subfamily Apiocystitinae .... 34
10. Ten *ILL* in circllet above *BB* ..... Family Heterocystitidae .... 50  
No more than 6 *ILL* in circllet above *BB* ..... 11
11. Brachioles few, clustered at top with very short ambulacral grooves; periproct lateral ..... Family Hemicosmitidae .... 44  
Brachioles at lateral borders of covering plates (so-called "tegmen"), which form roof over ambulacral grooves; periproct at upper border of theca ..... Family Caryocrinitidae .... 46
12. Pores not arranged in rows ..... Family Polycosmitidae .... 51  
Pores in radial rows ..... Family Stichocystidae .... 52
13. Theca ovate or elongate; 30 to about 120 plates, tending to be in circllets, alternating; epitheca seldom preserved ..... Family Caryocystitidae .... 53  
Theca bullet-shaped or spheroidal; 200 to more than 800 tiny, irregularly polygonal plates; epitheca preserved in many specimens as smooth, concentrically striped layer ..... Family Echinospaeritidae .... 56
14. Theca ovate, saclike, pear-shaped, or globular; ambulacra radial, extending over theca, with alternating lateral branches (single or in groups) to brachioles; most forms stemmed, few becoming free as adults; diplopores restricted to ambulacral plates or spread out over rest of theca .. Superfamily GLYPTOSPHAERITIDA .... 15

- Theca ovate to conical, with one or the other end expanded in some; ambulacra with brachioles concentrated near mouth, not extending over theca; most attached by base of theca; pores irregularly distributed over theca ..... Superfamily SPHAERONITIDA .... 16
- Theca bud-shaped or bullet-shaped with nearly flat base; ambulacra straight, pentamerally arranged, distally resting on *RR*; stemmed; diplopores only on interambulacral plates ..... Superfamily ASTEROBLASTIDA .... 17
15. Theca apple-shaped; stem short; ambulacral grooves long, twisted or zigzag with few irregularly alternating brachioles, ends may branch to several brachioles; pores in many forms radially disposed, in some concentrated in upper parts of plates ..... Family Glyptosphaeritidae .... 57
- Theca saclike, bullet-shaped, or ovate; stemmed as young, may be free as adult; ambulacral grooves very long, slightly zigzag with regularly alternating branches leading to brachioles, may extend to aboral end; pores distributed over ambulacral and interambulacral plates ..... Family Protocrinidae .... 60
- Theca ovate to pear-shaped; stemmed or free; ambulacra long, straight, brachioles at ends of short, very regularly alternating branches, so that those of each ambulacrum are arranged in two straight rows; brachiole-bearing plates ("adambulacrals") regularly alternating, bearing diplopores; interambulacral plates irregular, without diplopores ..... Family Dactylocystidae .... 58
- Theca shaped like inverted pear; no special columnar section known; ambulacra spiral, branches (if present) from only one (aboral) side; brachioles unknown; diplopores distributed over theca ..... Family Gomphocystitidae .... 63
16. Ambulacral grooves distinctly branched immediately from peristome; numerous brachioles in each ray ..... Family Sphaeronitidae .... 64
- No extensions of any kind known in food grooves; at most, one brachiole in each ray, may be reduced to two, no brachioles or attachment known for some forms ..... Family Aristocystitidae .... 73
17. Theca bud-shaped; ambulacra broad, leaflike; brachioles relatively few; 4 *BB*, 6 *ILL*, other plates in circlets, and several additional intervening plates ..... Family Asteroblastidae .... 82
- Theca bullet-shaped, base obtuse, nearly flat; ambulacra very narrow, long, straight; numerous brachioles; plates small, exceptionally numerous ..... Family Mesocystidae .... 84

## KEY TO GENERA

Order RHOMBIFERA Zittel, 1879

Superfamily GLYPTOCYSTITIDA Bather, 1899

Family Glyptocystitidae Bather, 1899

18. One genus known ..... *Glyptocystites* Billings, 1854

Family Cystoblastidae Jaekel, 1899

19. Only 1 pair of *RR* without intervening *L*; only demirhombs on *RR*, with no more than 2 half-rhombs on any *R* ..... *Cystoblastus* von Volborth, 1867
- At least 2 pairs of *RR* without intervening *L*; *RR* with demirhombs and full rhombs, with 3 half-rhombs on at least one *R* ..... *Hesperocystis* Sinclair, 1945

## Family Rhombiferidae Kesling, 1962

20. One genus known ..... *Rhombifera* Barrande, 1867

## Family Cheirocrinidae Jaekel, 1899

21. Pectinirhombs developed as conjunct rhombs, at least on base. *Leptocystis* Jaekel, 1899  
 Pectinirhombs developed as disjunct or multidisjunct rhombs ..... 22
22. Theca ornamented only by ridges radiating from centers to sides of plates, forming large network of triangles ..... *Cheirocrinus* Eichwald, 1856  
 Theca ornamented by both large radiating ridges from centers to sides of plates and parallel lateral ridges, forming concentric triangles with the former; lateral ridges may be interrupted by growth lines to make reticulate sculpture .....  
 ..... *Homocystites* Barrande, 1887

## Family Echinoencrinitidae Bather, 1899

23. Circllet of *RR* interrupted by adoral projection of *L5*, with *R4* very small or absent; of *ILL*, only *IL4* bordering periproct ..... *Glaphrocystis* Jaekel, 1899  
 Circllet of *RR* not interrupted by any *L*; both *IL4* and *IL5* bordering periproct .. 24
24. Four *RR* only, no *R5* ..... *Proctocystis* Regnéll, 1945  
 Five *RR* ..... 25
25. Theca sharply pointed by elongate, adorally attenuated *RR*; *L3* in contact with *B3*, interrupting *IL* circllet between *IL2* and *IL3* ..... *Erinocystis* Jaekel, 1899  
 Theca not sharply pointed, *RR* not attenuated; *IL* circllet complete ..... 26
26. Pectinirhomb *B2/IL1*; *BB* strongly indented to form quadrate depression for junction with column; periproct rather strongly protuberant ..... 27  
 No *B2/IL1* pectinirhomb; *BB* only slightly indented if at all; periproct not strongly protuberant ..... 28
27. Extra pectinirhomb on *L3/R3* ..... *Eutretocystis* Phleger, 1935  
 No extra pectinirhomb ..... *Echinoencrinites* von Meyer, 1826
28. More than 3 pectinirhombs; periproct bordered by 5 plates (*IL4, IL5, L1, L4, L5*) ..... *Scoliocystis* Jaekel, 1899  
 Two or 3 pectinirhombs, *B2/IL2* and *L4/R3* invariably present, *L1/R5* in most; periproct bordered by less than 5 plates, never by *L1* ..... 29
29. Brachioles clustered near peristome; theca subovate, no part compressed .....  
 ..... *Prunocystites* Forbes, 1848  
 Brachioles in two groups, at opposite ends of long curved ambulacral groove across top of theca (mouth in center); theca subovate aborally, compressed in *R3-L1* direction adorally ..... *Schizocystis* Jaekel, 1895

## Family Pleurocystitidae Neumayr, 1889

30. No trace of pore rhombs, at least externally ..... *Amecystis* Ulrich and Kirk, 1921  
 One to 3 pore rhombs, distinct, slits well-defined ..... 31
31. Two or 3 rhombs (*L1/L2* and *L3/L4* invariably present, *B2/IL2* in most); anal pyramid at corner of periproct, in so-called "rectal lobe" .....  
 ..... *Pleurocystites* Billings, 1854  
 Only 1 rhomb (*L3/L4*); anal pyramid subcentral in periproct .....  
 ..... *Regulaecystis* Dehm, 1932

## Family Callocystitidae Bernard, 1895

## Subfamily Callocystitinae Bernard, 1895

32. Two *RR* (*R1* and *R4*) very small or absent; *L2* nearly or quite reaching *B2*; *L4* not forming suture with *B4*, subtrapezoidal, 4-sided ... *Sphaerocystites* Hall, 1859  
All *RR* present; *L2* distinctly separated from *B2*; *L4* in contact with *B4*, 5-sided... 33
33. Theca ovate to ellipsoidal; pectinirhombs rather long, with numerous slits .....  
..... *Callocystites* Hall, 1852  
Theca depressed globular; pectinirhombs small, with few slits .....  
..... *Coelocystis* Schuchert, 1903

## Subfamily Apiocystitinae Jaekel, 1899

34. Five ambulacra; more than 3 pectinirhombs, with 2 half-rhombs on *R3* ..... 35  
Four ambulacra; only 3 pectinirhombs, with only 1 half-rhomb on *R3* ..... 36
35. Five pectinirhombs; *IL4* and *IL5* elongate vertically; *RR* interrupted by *L5*; no globular projections on thecal plates ..... *Lepadocystis* Carpenter, 1891  
Four pectinirhombs; *IL4* and *IL5* not elongate; *RR* in complete circlet; major thecal plates with globular projections ..... *Brockocystis* Foerste, 1914
36. *LL* and *RR* in complete circlets ..... 37  
*LL* and *RR* intercalated, one or both circlets interrupted ..... 39
37. Periproct bordered by 4 plates, including *L4* ..... *Lovenicystis* Regnéll, 1945  
Periproct bordered by 3 plates, not by *L4* ..... 38
38. Pectinirhombs short, with few slits; ambulacra long, nearly reaching column ....  
..... *Apiocystites* Forbes, 1848  
Pectinirhombs long, with numerous slits; ambulacra rarely extending below *LL*  
..... *Lepocrinites* Conrad, 1840
39. Periproct enclosed mainly by *L5* ..... *Lipsanocystis* Ehlers and Leighly, 1922  
Periproct bordered by 3 plates, not by *L4* ..... 40  
Periproct bordered by 4 plates, including *L4* ..... 41
40. Pectinirhombs small, with few slits; *L1*, *L2*, and *L3* diamond-shaped, scarcely in contact, if at all; *ILL* much larger than *LL* ..... *Halicystis* Jaekel, 1899  
Pectinirhombs large, long, with numerous slits; *L1*, *L2*, and *L3* large, with sutures between; *ILL* not much larger than *LL* ..... *Lepocrinites* Conrad, 1840
41. Hydropore with two separate openings; anal pyramid very small, with aboral bordering plates very large and elongate; ambulacra divided in most mature specimens ..... *Strobilocystites* White, 1876  
Hydropore with only one opening; anal pyramid relatively large, with bordering plates (if present) subequal; ambulacra undivided in normal specimens ..... 42
42. Pectinirhombs long, with nearly equal halves; anal pyramid with marginal ring of plates; hydropore elongate ..... *Tetracystis* Schuchert, 1904  
Pectinirhombs short, with half-rhombs on *IL2*, *L1*, and *L4* reduced to small circular openings with tubular rims; anal pyramid lacking marginal ring; hydropore large, subcircular ..... *Jaekelocystis* Schuchert, 1903

## Subfamily Staurocystinae Jaekel, 1899

43. Theca subovate; 4 ambulacra ..... *Staurocystis* Jaekel, 1896  
Theca biconvex, lenslike; 2 ambulacra forming thick peripheral rim .....  
..... *Pseudocrinites* Pearce, 1842

## Superfamily HEMICOSMITIDA Jaekel, 1918

## Family Hemicosmitidae Jaekel, 1918

44. Eight *LL*; periproct between two *LL*, not in contact with any *IL*; theca spindle-shaped, tapering at both ends ..... *Corylocrinus* von Koenen, 1886  
 Nine *LL*; periproct normally bordered by two *ILL* and one *L* plate; theca subovate 45
45. Pores in fairly regular, radiating rows; 3 large brachioles, set close to top of theca; in many species, *ILL* and *LL* with central nodes; in some, nodes accentuated on 3 *LL* aligned with brachioles ..... *Hemicosmites* von Buch, 1840  
 Pores rather irregular; 3 brachioles set on 3 large processes on *LL*, near border of theca; plates strongly tumid or "swollen," no nodes or ridges .....  
 ..... *Tricosmites* Jaekel, 1918

## Family Caryocritidae Bernard, 1895

46. Plates very tumid or "swollen," without ridges; pores mostly obscure .....  
 ..... *Stribalocystites* Miller, 1891  
 Plates not tumid, bearing ridges; pores distinct ..... 47
47. Pores in areas between ridges, not arranged in rows .... *Ptychocosmites* Jaekel, 1918  
 Pores in rows along sides of ridges ..... 48
48. *LL* not regularly arranged with respect to *ILL*, of several shapes .....  
 ..... *Juglandocrinus* von Koenen, 1886  
*LL* regularly arranged with respect to *ILL*, 6 nearly identical, with their lower apices between *ILL* ("radial" positions of some authors) and 2 of different shape set atop *ILL* ("interradial" positions) ..... 49
49. Three large and three smaller brachiole facets alternating; *LL* elongate, nearly or quite pentagonal ..... *Oocystis* Dreyfuss, 1939  
 Several brachiole facets at ends of three branching ambulacra; *LL* partly covered by "tegmen," not elongate, more nearly hexagonal than pentagonal .....  
 ..... *Caryocritites* Say, 1825

## Family Heterocystitidae Jaekel, 1918

50. One genus known ..... *Heterocystites* Hall, 1851

## Superfamily POLYCOSMITIDA Jaekel, 1918

## Family Polycosmitidae Jaekel, 1918

51. One genus known ..... *Polycosmites* Jaekel, 1918

## Family Stichocystidae Jaekel, 1918

52. One genus known ..... *Stichocystis* Jaekel, 1918

## Superfamily CARYOCYSTITIDA Jaekel, 1918

## Family Caryocystitidae Jaekel, 1918

53. Theca subovate; peristome and periproct protuberant from opposing sides of top of theca, both directed upward ..... *Orocystites* Barrande, 1887  
 Theca elongate; periproct not protuberant, not on top of theca, and not directed upward ..... 54
54. Theca claviform, tapering aborally to small stemlike base; periproct only one-fourth the height from oral pole ..... *Ulrichocystis* Bassler, 1950

- Theca not claviform, its greatest diameter near mid-height or below; periproct about one-third to one-half the height from oral pole ..... 55
55. Height of theca more than twice greatest diameter; theca tapering toward each end, with greatest diameter median; tangential pore canals compound, several connecting each pair of pores; sculpturing of thecal plates not very prominent ..... *Caryocystites* von Buch, 1846
- Height of theca scarcely exceeding twice the greatest diameter, even in more attenuated specimens; theca pear-shaped, aborally more rotund and tapering orad; tangential pore canals simple, one canal connecting each pair of pores; sculpturing of plates by folds and ridges ..... *Heliocrinites* Eichwald, 1840

## Family Echinospaeritidae Neumayr, 1889

56. Theca typically subspheroidal, in few species pear-shaped, with aboral projection formed of one or two circlets of plates but not stemlike; one form with plates subequal, many hexagonal, and another form with polymorphous plates; 2 to 5 ambulacra short but distinct, set upon oral projection ..... *Echinospaerites* Wahlenberg, 1818
- Theca pear-shaped, tapering to remarkably prolonged, thin, stemlike section of alternating rows of tiny hexagonal plates; most other plates small (200 to 800) but few larger plates interspersed, very few plates hexagonal; 2 or 3 brachioles springing more or less directly from oral projection with little or no development of intervening ambulacra ..... *Arachnocystites* Neumayr, 1889

## Order DIPLOPORITA Müller, 1854

## Superfamily GLYPTOSPHAERITIDA Bernard, 1895

## Family Glyptosphaeritidae Bernard, 1895

57. One genus known ..... *Glyptosphaerites* Müller, 1854

## Family Dactylocystidae Jaekel, 1899

58. Theca pear-shaped, gradually tapering toward broad column; ambulacra unequal in length ..... *Revalocystis* Jaekel, 1918
- Theca ovate or ellipsoidal, distinctly set off from column; ambulacra equal in length 59
59. Each ambulacral area of two long, vertical rows of alternating large irregular-shaped plates, each plate with one large and several small brachiole facets with diplopores between ambulacral extensions; each interambulacral area with one vertical row of irregular-shaped plates ..... *Estonocystis* Jaekel, 1918
- Each ambulacral area of two long, vertical rows of alternating small, transversely elongate plates, each plate with one brachiole facet, bearing diplopores; each interambulacral area filled with irregular plates not arranged in a vertical row and some larger than the ambulacral plates, entire area depressed ..... *Dactylocystis* Jaekel, 1918

## Family Protocrinitidae Bather, 1899

60. Theca composed of several hundred tiny plates; 4 *BB* much larger than adjacent plates, imperforate, conspicuous; column present in adult ..... 61
- Theca composed of less than 200 plates; no special *BB*, at least in adult specimens; column not developed or not retained in adult ..... 62

61. Theca elongate; ambulacra terminating on platforms of special flooring plates set upon large thecal plates possibly qualifying as *RR* .....  
*Eumorphocystis* Branson and Peck, 1940  
 Theca ovate, rotund; ambulacra not extending to raised structures, no thecal plates differentiated as *RR* ..... *Regnellcystis* Bassler, 1950
62. Theca saclike; ambulacra zigzag; theca attached by broad base, typically concave; few diplopores, not more than 4 to a plate and mostly 1 or 2 to a plate ....  
*Fungocystites* Barrande, 1887  
 Theca ovate to spherical; ambulacra nearly straight or slightly curved, not zigzag, with short alternating lateral branches to brachioles; theca attached by column when young, free when adult; numerous diplopores, several to each plate ..  
*Protocrinites* Eichwald, 1840

## Family Gomphocystitidae Miller, 1889

63. Thecal plates along ambulacra regularly arranged in alternating pattern ("adambulacrals") ..... *Gomphocystites* Hall, 1865  
 Theca plates along curved ambulacra irregular, without pattern .....  
*Pyrocystites* Barrande, 1887

## Superfamily SPHAERONITIDA Neumayr, 1889

## Family Sphaeronitidae Neumayr, 1889

64. Anal pyramid adjacent to orals (plates covering peristome) on summit of theca, modified so that one side fits against posterior oral plate; gonopore displaced to left of periproct-peristome junction ..... *Sphaeronites* Hisinger, 1828  
 Anal pyramid not adjacent to orals, but may be high on theca; gonopore (if present) directly between periproct and peristome or only slightly offset ..... 65
65. All or nearly all branches of each ambulacrum confined to one adoral plate (at most, one may extend beyond) ..... 66  
 Some branches of each ambulacrum extending beyond adoral plate ..... 72
66. Relatively few thecal plates (less than 50) ..... 67  
 Numerous thecal plates (more than 50, some with several hundred) ..... 69
67. Theca tapering to small aboral area; plates highly irregular; peristome apparently raised above general level of theca ..... *Allocystites* Miller, 1889  
 Theca ovate to spherical; plates rather regular; peristome not elevated ..... 68
68. Theca with 3 to 5 circlets of plates; diplopores not very numerous, large, mostly limited to adoral half of theca ..... *Eucystis* Angelin, 1878  
 Theca with 2 circlets of plates, lower of 7 and upper of 5; diplopores numerous, distributed over theca ..... *Haplosphaeronis* Jaekel, 1926
69. Thecal plates vermiculate, with diplopores in troughs or grooves; spherical theca said to have column ..... *Carpocystites* Oehlert, 1887  
 Thecal plates not highly ornamented, with simple depressions for diplopores; column unknown ..... 70
70. Theca with shape of kettle, resting on broad circular base; numerous brachioles at or near periphery of star formed by ambulacral branches; strong circumoral symmetry ..... *Tholocystis* Chauvel, 1941  
 Theca ovoid to saclike; brachioles connected to mouth by short ambulacral branches; circumoral symmetry weak (if present) ..... 71



71. Each ambulacrum primarily divided in two, with further divisions leading to 7 or 8 brachiole facets, nearly in a row and equally spaced from center of mouth; thecal plates thick ..... *Codiacystis* Jaekel, 1899  
 Each ambulacrum at end of straight suture between 2 of the 5 peristomial covering plates, subdivided into 5 to 7 short branches with clockwise curvature, brachiole facets not aligned in a row; theca weakly calcified .....  
 ..... *Archegocystis* Jaekel, 1899
72. Ambulacra somewhat irregular, not strongly developed; no definite number of brachioles ..... *Proteocystites* Barrande, 1887  
 Ambulacra very regular, well developed; definite number of brachioles, 5 facets at corners of mouth and 5 others at periphery of adoral part of theca .....  
 ..... *Bulbocystis* Ružička, 1939

## Family Aristocystitidae Neumayr, 1889

73. Theca in form of very elongate cone, commonly more than 30 cm high and attaining 40 cm; provided with aboral terminal tubercle and composed of about 2000 small plates, some ornamented ..... *Calix* Rouault, 1851  
 Theca not in form of elongate cone, seldom exceeding 8 cm and most forms smaller; no aboral tubercle, theca with only few hundred plates at most ..... 74
74. Adult theca with plates of two drastically different sizes, large primary plates and small intercalated secondary or accessory plates ..... 75  
 Adult theca with subequal plates ..... 76
75. All plates polygonal ..... *Holocystites* Hall, 1864  
 Primary plates oval, secondary plates rounded or subpolygonal .....  
 ..... *Amphoracystis* Haeckel, 1896
76. Mouth sinuous, bordered on one side by large crescentic plate .....  
 ..... *Campylostoma* Dreyfuss, 1939  
 Mouth not sinuous, more than one plate on either side ..... 77
77. Theca shaped like flared cone or bell, aboral part exceptionally thick .....  
 ..... *Pachycalix* Chauvel, 1936  
 Theca more or less ovate, not exceptionally thick ..... 78
78. Subepithecal channels or pore canals connecting pores in shape of horseshoe ....  
 ..... *Hippocystis* Bather, 1919  
 Subepithecal channels or pore canals (if present) not in shape of horseshoe ..... 79
79. Normally 2 brachioles, set at ends of elongate mouth or oral slit, 3 known (anomalous?) ..... *Aristocystites* Barrande, 1887  
 Normally 4 brachioles ..... 80
80. Thecal perforations large, not developed as dipopores, some continuing from one plate to another ..... *Pseudaristocystis* Sun, 1936  
 Thecal perforations small, developed as dipopores, very few if any continuing from one plate to another ..... 81
81. Mouth narrow and elongate, with short ambulacral grooves diverging from each end; brachiole facets set as at corners of oblong ..... *Sinocystis* Reed, 1917  
 Mouth large and nearly square, with ambulacral grooves scarcely more than extensions of corners of mouth; brachiole facets set as at corners of square ....  
 ..... *Trematocystis* Jaekel, 1899

## Superfamily ASTEROBLASTIDA Bather, 1900

## Family Asteroblastidae Bather, 1900

82. In each interambulacrum, diplopore-bearing area between ambulacra composed of one large, subrhombic suboral plate (so-called "subdeltoid"); 4 plates in vertical row in each interambulacrum except that with periproct, here called *O*, suboral, *L*, and *IL* ..... *Asteroblastus* Eichwald, 1862  
 In each interambulacrum, diplopore-bearing area between ambulacra composed of several small plates, no large suboral plate ..... 83
83. On aboral side of theca, each interambulacrum (except that with periproct) composed of *IL* and *L*, with few small accessory plates .... *Asterocystis* Haeckel, 1896  
 On aboral side of theca, each interambulacrum composed of small plates in 4 to 6 rows ..... *Metasterocystis* Jaekel, 1918

## Family Mesocystidae Bather, 1899

84. One genus known ..... *Mesocystis* Bather, 1899