# PART G

# BRYOZOA

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# INTRODUCTION

The phylum Bryozoa comprises a puzzling group of minute invertebrates, some of which grow into colonies of considerable size. They are widely distributed at all depths and latitudes in the modern seas and are equally well represented as fossils in the stratified rocks.

The Bryozoa, popularly known by the paradoxical term "moss animals," long have been noticed by many strollers along some seashores where their delicate plantlike colonies are washed ashore after every storm. A common sort consists of broad incrustations upon seaweeds. Such specimens attracted early European students, who found that they were composed of a multitude of separate individuals generally less than 1 mm. long. These observers at first interpreted the organisms as plants, but later placed them in a halfway group, "zoophytes," presumed to be part animal and part plant. Then the coral-like appearance of some calcareous Bryozoa gave origin to another term, "corallines," but when it was discovered that each unit of the colony consists of an animal with complete alimentary canal, totally unlike the corals or any other group, there was more general agreement as to their nature. Still, for some time their exact systematic position among the animals remained in doubt, and they were shifted from class to class.

## POLYZOA VERSUS BRYOZOA

In 1830 J. V. Thompson published in Ireland his observations "On Polyzoa, a New Animal Discovered as an Inhabitant of some Zoophites" (Zool. Researches, no. 5, p. 89-102, pl. 1-111). A few months later, 1831, C. G. Ehrenberg published in Germany a paper *(Symbolae Physicae, seu Icones et Descriptiones Animalium Evertebratorum, 1828-1831)* in which this group of animals, termed Phytozoa Polypi, was separated under the name Bryozoa, from Greek signifying "moss animals."

Although Polyzoa are judged by many zoologists to have been defined inadequately by Thompson, most English naturalists have preferred this term, which has priority of publication. Continental and American students, on the other hand, with few exceptions have adopted the designation Bryozoa.

As early as 1880, Waters pointed out that Thompson's use of Polyzoa referred to the associated animals (zooids) without differentiating them clearly as a major assemblage within the animal kingdom, whereas

Ehrenrerg definitely separated the Bryozoa as a group. Discussions by Stebbing, Herdman, Harmer, Waters, and others, favoring one or other of these terms, are contrasted in the Proceedings of the Linnean Society of London for 1910-1911. A review of the Polyzoa-versus-Bryozoa question, prepared about 1947 by S. F. Harmer at request of the Zoological Society of London, was entirely inconclusive.

Since priority is not recognized as a controlling factor in nomenclature of divisions of the organic world higher than genera, the proper name of this phylum must be agreed to depend on use by a majority of students or by ruling of some authoritative body of zoologists. Preponderance of usage among zoologists, reinforced by nearly unanimous recommendation of American and several European paleontologists consulted, has led to adoption of Bryozoa in the *Treatise*.

## DEVELOPMENT OF BRYOZOAN STUDIES

Such familiar bryozoan terms of today as *Retepora* and *Frondipora* appear for the first time in the Historia Naturale "Classification" of Imperato, 1599. In 1755, John Ellis, English businessman interested in natural history, published his "Essay on Corallines" with plates illustrating bryozoans; in this work he resolved the controversial subject of relationships of the zoophytes by establishing their animal nature. Pallas, in 1766, described *Eschare spongites,* which is the widespread bryozoan, *Stylopoma spongites,* of modern seas. Linné in the Tenth Edition (1758) of his "Systema Naturae" gave binominal status to the Ellis species and taxonomic studies of succeeding years.

Notwithstanding great development of studies on the Bryozoa in past and present, investigation of these animals always has been limited to a comparatively few specialists who have been unable to overcome popular belief that the bryozoans present too difficult problems for any but persons willing to spend a lifetime of research upon them. This belief has been strengthened by the fact that most published works are highly technical in nature and usually deal with special aspects of the subject.

For a considerable time the Bryozoa were grouped with Brachiopoda and Ascidia, in the phylum called Molluscoidea, but the Ascidia long have been removed from this assemblage and the Brachiopoda are now classed definitely in a phylum of their own. Finally, of the 2 very unequal main divisions of Bryozoa recognized today, Entoprocta and Ectoprocta, the former is now judged by some zoologists to be classifiable as an independent phylum, and by others to belong with the Bryozoa. If the Entoprocta are removed from the phylum Bryozoa, no need remains to employ the term Ectoprocta.

In the early days of bryozoology in Europe both fossil and Recent species were most often collected and studied as an avocation by people in various walks of life. Outstanding in England were the Rev. Thomas Hincks and Canon Alfred M. Norman among the clergy; John Ellis, just mentioned, and A. W. Waters in the business world; and in France, there was Ferdinand Canu, who taught physics and meteorology in the Paris schools. Distinguished among the specialists who followed the subject as a part of their profession was the British Museum group comprising George Busk in the earlier days, and later J. W. Gregory, Sir Sidney Harmer, W. D. Lang, Anna Hastings, and others who consistently maintained a high level of careful, well-illustrated work. Through the efforts of Gregory, Lang, and Brydone in England, Ehrhard Voigt in Germany, and G. M. R. Levinsen in Denmark, careful surface zonal collecting in the Chalk and other Mesozoic deposits has shown the Bryozoa to be so restricted in stratigraphic range and so widespread in geographic distribution that they form excellent guide fossils. In North America their value is recognized by many oil companies with research staffs engaged in determining their subsurface distribution.

Since the 60-year span of the writer's interest in bryozoans embraces the period during which chief advances in knowledge of the North American fossil species occurred, it seems appropriate to explain how he came to spend so much time in their taxonomic study. Early boyhood experiences in collecting and wondering about the twig-like delicately marked stones found so abundantly around his home region of Cincinnati excited his curiosity. At this time various amateur and professional geologists, members of the Cincinnati Society of Natural History, were active in studies of the Upper Ordovician fossils of that region. Among these, some of whom became internationally known, were S. A. MILLER, U. P. JAMES and son J. F. JAMES, EDWARD ORTON, the Rev. HENRY HERZER, G. W. HARPER, E. W. CLAYPOLE, A. F. FOERSTE, C. B. DYER, C. L. FABER, J. M. NICKLES, CARL ROMINGER, CHARLES SCHUCHERT, and E. O. ULRICH. Gaining acquaintance with these enthusiasts brought invitations to field excursions and at length permission to browse in the Society's library, where a volume "Synonymic Catalogue of Recent Marine Bryozoa" by the English student Miss E. C. JELLY (1889) aroused the ambition to prepare a similar compilation of American fossil bryozoans. While in high school, he was invited to serve as part-time assistant to E. O. ULRICH, who lived on a somewhat precarious income derived largely from sale of fossil collections and bryozoan thin sections prepared for various universities and museums. In this fortunate opportunity he succeeded CHARLES SCHUCHERT, who had just completed the lithographic illustrations for ULRICH's bryozoan and other reports published in Illinois (1890) and Minnesota (1893) and who had now left for work on his own specialty, the brachiopods, with JAMES HALL at Albany. Learning that J. M. NICKLES was undertaking to catalog the American fossil Bryozoa, agreement to combine efforts led to completion of the NICKLES & BASSLER "Synopsis of American Fossil Bryozoa" (U.S. Geol. Survey Bull. 173, 1900).

In 1901, the writer became assistant to CHARLES SCHUCHERT, then curator of invertebrate fossils at the U.S. National Museum, and almost coincidently, ULRICH and NICKLES moved to Washington as members of the U.S. Geological Survey. Then followed some years in processing for the Museum considerable Paleozoic collections which included many bryozoans. A study of the beautifully preserved Ordovician bryozoans of the European Baltic provinces, based on collections obtained by SCHUCHERT, appeared in 1911 (3). Unusually ample collections of Recent bryozoans from Philippine and southwestern Pacific localities representing more than 300 dredging stations resulted from the U.S. Bureau of Fisheries "Albatross" expedition in 1908-1909 through the activities of PAUL BARTSCH of the Museum staff. Similarly, "Albatross" material from some hundreds of Atlantic Coast and Gulf of Mexico dredgings provided still more Recent bryozoans for investigation. From field work in the Atlantic and Gulf Coastal Plains directed by T. WAYLAND VAUGHAN for the U.S. Geological Survey came a multitude of Tertiary bryozoans. The collection of these faunas, begun in 1907, had reached such proportions in 1913 that the Smithsonian Institution and U.S. Geological Survey commissioned FERDINAND CANU to join the writer in investigating them. CANU, recognized as an outstanding specialist on post-Paleozoic Bryozoa, was assigned senior status in this joint labor, which had to be carried on by shipment of specimens and manuscript to and fro across the Atlantic in perilous war times. The collaboration resulted in reports on North American Early Tertiary Bryozoa in 1920 (24) and North American Later Tertiary and Quaternary Bryozoa in 1923 (26), volumes which included the description and illustration of many other genera and their type species beside those represented in the fossil collections. A personal meeting with CANU was deferred until 1926; this and a later very pleasurable meeting in 1931 gave opportunity for planning continuation of joint researches, but CANU's lamented death in 1932 intervened. Work on a world catalog of bryozoan genera and families for the "Fossilium Catalogus" (Part 67, Bryozoa) was then concluded and published in 1935. Now this contribution to the *Treatise* is an endeavor to lighten the taxonomic studies of present and future students. In its preparation the author realizes his great indebtedness to all the persons mentioned, all of whom, save naturally a few of earliest date, he had the honor and pleasure of knowing personally. He is also very grateful for the support of the several institutions which authorized the various projects.

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# MORPHOLOGICAL CHARACTERS

The Bryozoa are small, composite, almost exclusively marine invertebrates, which develop from a free-swimming larva that becomes sedentary, attaching itself to some foreign object; initial fixation is established by a small chitinous disk **(protoecium)**, from which the primary individual **(ancestrula)** develops. By repeated budding from the ancestrula, a colony **(zoarium)** of varied shape and size is produced according to the nature of the species. Budding occurs in various ways (terminal, lateral, dorsal, frontal, stolonate) but it is an interesting fact that, excepting the ancestrula, all individual bryozoan animals **(zooids)** of the same colony, possibly amounting to thousands, are derived directly or indirectly from the single initial zooid that started the colony.

## INDIVIDUAL ANIMAL

Each individual zooid is composed of a double-walled membranous or calcareous sac **(zooecium)** and its contained soft parts **(polypide)** consisting of the visceral mass and food-gathering tentacles. The freely suspended alimentary canal is U-shaped, and, accordingly, the mouth and anus open close to each other. The canal is divisible into 3 distinct regions—esophagus, stomach, and intestine. A heart and vascular system are wanting, but numerous leucocytes float in the body cavity. A nervous ganglion between the mouth and anus sends delicate nerve filaments to the tentacles and esophagus. The upper part of the polypide is generally flexible and can be invaginated through the action of numerous longitudinal and transverse muscles traversing the fluid-filled visceral cavity. Both sexes generally are combined in the same zooid, and, furthermore, the same zooecium may be inhabited at various times by different polypides, which successively degenerate. The reproductive organs are developed in various parts of the body cavity, although spermatozoa commonly occur in the lower region and ova in the upper. The ova may be developed in a special receptacle **(marsupium)**, in an inflation of the zoarial surface **(gonocyst)**, or in a modified zooecium **(gonoecium)** set aside for reproductive purposes. The general term **ovicell** (ooecium) is applicable to all of these structures.

The mouth is surrounded by the lophophore, which bears a crown of slender hollow, ciliated tentacles arranged in a circle or horseshoe shape. Microscopic organisms, such as diatoms and radiolarians, are gathered for food. The 2 large divisions under which the Bryozoa are usually classed (Entoprocta, Ectoprocta) are based upon position of the anal opening, which in most is situated outside the row of tentacles (Ectoprocta); rarely it is placed within this row (Entoprocta).

This description of bryozoan anatomy applies, with certain exceptions, to all divisions of the phylum, and, in general, within each division the individual zooids conform to a single definite type of structure. Modifications in structure are more evident in the protective covering or skeleton of the animal, the zooecium, than in its soft parts,

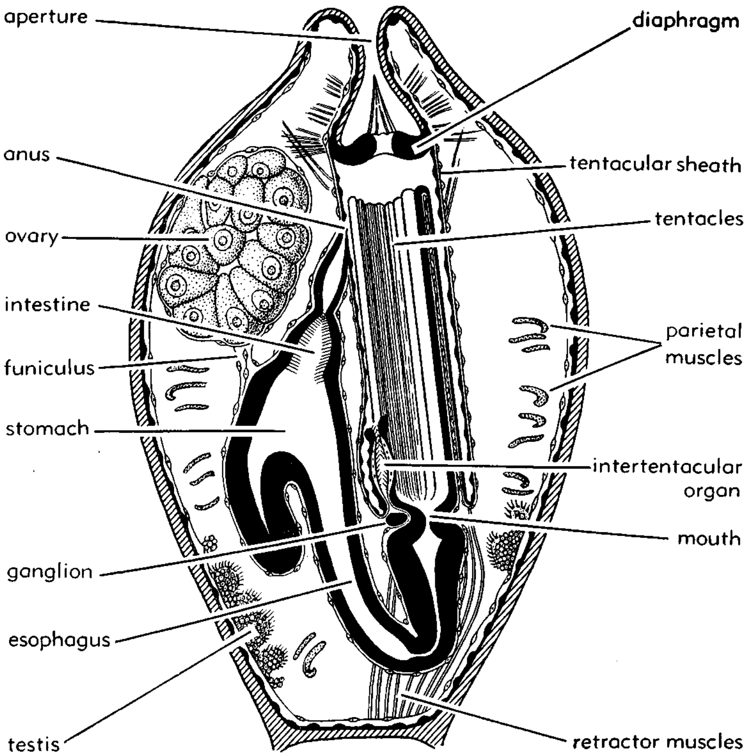


FIG. 1. Anatomy of a single bryozoan zooid (*Alcyonidium albidum* AIDER, of the order Ctenostomata) with polypide retracted; much enlarged *(after Prouho)*.

the polypide. The accompanying diagram of the anatomy of a single zooid (Fig. 1) with retracted polypide illustrates this general structure. The mouth leads into the ciliated pharynx, and this into the esophagus, followed by the stomach, which in turn passes into the intestine, and this through the rectum communicates with the exterior by the anus. When retracted, the tentacles lie in a cavity (tentacular sheath), which opens to the exterior by the **orifice.** The extended polypide is withdrawn into the zooecium by the contraction of retractor muscles attached to the tentacular crown. Among Bryozoa with flexible zooecia, contraction of the body walls by parietal muscles produces protrusion of the polypide, but the means for protrusion are more complicated in forms having rigid calcareous zooecial walls.

A considerable amount of polymorphism occurs in this phylum, and different names have been applied to the various types of individual skeletal structures—**autozooecia** to ordinary zooecia, **gonozooecia** to modified reproductive ones, **kenozooecia** to accessory individuals, and **heterozooecia** to those modified for other functions of the colony. The heterozooecia are reduced members of the colony attached to a zooecium; they include **avicularia** and **vibracula.** The avicularia of some bryozoans have a bird's-head form; the vibracula are bristle-like. The jaws of the avicularia open and close with a snapping motion, which has given rise to the probably erroneous idea that they are organs of defense. The structure of these 2 types of heterozooecia is described in more detail in the consideration of cheilostomatous Bryozoa. Both the avicularia and vibracula are chitinous and thus incapable of preservation in the fossil state, but their former presence is indicated by the porelike excavations in which they lodged.

## COLONIES

The colonies **(zoaria)** which the combined zooids form, present a great variety of shape and structure, although the form is mostly constant in individual species. Commonly the zoaria grow over shells, stones, or other bodies, forming delicate incrustations of exquisite pattern. By the superposition of many such incrustations, lamellate, hemispherical, globular, nodular, or irregular masses may result, and some of these are conspicuously large. Again, the zoaria may arise in broad fronds, branching stems, or bifoliate leaves; some of them form open-meshed lacework of the most regular and beautiful patterns. Although often described as free, only the upper branches actually are free, for most bryozoans are attached basally or by other parts of their surface to extraneous objects; they may be moored to the bottom by rootlike appendages. Thin discoid, apparently free zoaria result from growth about a sand grain, shell fragment, or some destructible object which has disappeared. In many species belonging to quite different families, the zoarium is regularly jointed so as to provide mobility.

The Bryozoa resemble certain corals (Tabulata) and hydrozoans in their external configuration but differ from them radically in the presence of a distinct body cavity, closed alimentary canal, nervous system, and delicate respiratory tentacles surrounding the mouth. A true coenenchyma, such as found in the coelenterates, is not seen in any bryozoan; accordingly, coenenchymal gemmation is unknown, but somewhat similar vesicular tissue may occupy the interzooecial spaces. Such tissue occurs commonly in Paleozoic bryozoans such as the Fistuliporidae and in the expanded base of the Fenestellidae; as elsewhere, the main purpose of such vesicles seems to be that of furnishing support for the zoarium.

## MORPHOLOGICAL TERMS APPLIED TO BRYOZOANS

Descriptive literature on Recent and fossil Bryozoa is encumbered by a multiplicity of morphological terms to such extent that understanding of these animals by nonspecialists is impeded greatly and unnecessarily. Morphological nomenclature is even burdensome to the specialist; he must become acquainted with the meaning of diverse terms in order to use the literature, but in his own writing he can well afford to dispense with a majority of them.

The following alphabetically arranged glossary of bryozoan terms has been prepared with the double purpose of (1) aiding students to find readily a definition of terms unfamiliar to them and (2) indicating judgment as to importance of the terms. For the latter purpose, classification of terms in 3 categories is indicated typographically: (a) boldface capitalized words (as **ACANTHOPORE**) are assigned rank as most generally accepted and useful; (b) boldface uncapitalized words (as **anter**) are terms considered secondary, either because they are rather commonly used synonyms of preferred terms, or because their application is restricted to a minor fraction of the bryozoans; and (c) italicized words in the list (as *oecium*) are terms judged to have a minimum usefulness, most of them being suited for discard. An asterisk (*) indicates that the term with which it is associated, although used in the literature, has historical interest only.

## GLOSSARY OF MORPHOLOGICAL TERMS

*A-zooecium.* Skeleton of normal egg-producing zooid in zoarium with dimorphic zooecia, as in *Steginoporella* (syn., zooecium) (*see* B-zooecium).

*aborted zooecium.* Skeleton of zooid arrested in development; with others forms "packing material" between normal zooecia in some zoaria.

**ACANTHOPORE.** Cylindrical tube adjoining zooecial walls and parallel to them in growth, formed of cone-in-cone layers with narrow central tubule which may be crossed by minute diaphragms; position commonly marked surficially by projecting spines, mostly at angles between zooecia in Paleozoic species (syn., spiniform tubule) (*see* megacanthopore, micracanthopore).

**acanthostegous.** Type of ovicell in some cheilostomes (Anasca) consisting of marsupial space between cover membrane (ectocyst) of zooecium and 2 overlying series of concurrent spines.

**accessory cell (or tube).** Small chamber or tubular space; inclusive term for firmatopores, nematopores, tergopores, dactylethrae, and cancelli (syn., kenozooecium, interstitial cell).

*acropetalous.* Term applied to spines developed upward from base of zoarium.

**adeoniform.** Shaped like the lobate bilamellar zoaria in the cheilostome family Adeonidae.

**adnate.** Growing with one side adherent to a foreign object.

**adventitious.** Developed sporadically, not in the usual place (as in some avicularia).

*alveolus* (pl., *alveoli*). Small cavity or pit between zooecia; chiefly in the cyclostome family Lichenoporidae.

**anastomosing.** Uniting irregularly to form a network; applied to branches that diverge and rejoin (syn., inosculating).

*ancestroecium.* Skeletal cover (zooecium) of the ancestrula.

**ANCESTRULA.** First-formed zooid of a colony, derived by metamorphosis of a free-swimming larva.

*antenniform.* Shaped like insect antenna; jointed, with each segment widening distally.

**anter.** Part of operculum on distal side of cardelles in cheilostomes, serving for closure of the portion of the orifice called porta, through which the polypide is protruded and withdrawn.

*anterior.* Direction or side toward which growth proceeds (syn., distal, forward). Ambiguously and objectionably, this term has been used by some authors to denote the side of a zoarium bearing apertures (*see* posterior).

*apertural bar.* Fused pair of costae next proximal to aperture of cribrimorph cheilostomes.

**APERTURE.** Outermost opening of zooecium; in cryptostomes, mouth of the vestibule, and in cheilostomes, the opening occupied by an uncalcified frontal membrane. Among cheilostomes having a calcified frontal wall and peristomie, the aperture is synonymous with the terms peristomice and secondary orifice, employed by some authors; but among cheilostomes having a mostly uncalcified frontal membrane, the area occupied by this membrane has been termed aperture. Loosely used in literature, the term aperture is best defined as here indicated and thus may not be confused with orifice.

*appendicular organs.* Collective term for avicularia and vibracula (syn., heterozooecia).

*area.* Flat or concave frontal membrane bordered by gymnocyst, in cheilostomes (syn., frontal area).

*areola.* Same as areole.

**areolar pore.** One of a series of openings arranged around the frontal margin of cheilostomes (syn., areola, areole, lateral punctation).

**AREOLE.** Marginal pore on frontal wall in some cheilostomes (Ascophora) connecting endocyst with ectocyst (syn., areola, areolar pore, lateral punctation).

**ASCOPORE.** Median small opening in the frontal wall of some cheilostomes (Ascophora) leading to the compensatrix, located proximally with reference to the aperture (syn., fenestrula, micropore).

*ascus.* Hydrostatic organ in some cheilostomes (Ascophora) (syn., compensatrix).

**astogeny.** Life history (ontogeny) of a colony (asty).

*asty.* Colony; zoarium.

**autocystid.* Cyclostomatous zooecium of normal size.

**autopore.** Tube or chamber forming skeleton of one of the main zooids in a colony (syn., zooecium, autozooecium, orthoecium).

*autozooecium.* Skeleton of normal zooid (syn., zooecium, autopore, orthoecium).

**autozooid.** One of the normal individuals composing a colony (syn., zooid).

**AVICULARIUM** (pl., **AVICULARIA**). Specialized cheilostome zooid with reduced polypide but strong muscles which operate a mandible-like operculum; it comprises one type of heterozooid and may be vicarious (in series with normal zooids) or adventitious (attached to some part of the frontal wall of a zooecium). In describing the composite skeletons of cheilostomes, avicularium is used commonly in sense exactly equivalent to the rarely used term aviculoecium.

*aviculoecium.* Skeletal parts of an avicularium.

**axis.** Solid calcareous support of a colony, as in *Archimedes*, formed of laminated tissue.

*B-zooecium.* Enlarged aviculoecium with acute mandible comprising one of the dimorphic zooecial types in some cheilostomes, as *Steginoporella* (*see* A-zooecium).

**back.** Side of zoarium opposite that bearing zooecial apertures (syn., dorsal, reverse, noncelluliferous) (*see* front).

*basal mark.* Curved line on underside of hyperstomial ovicell.

*basal plate.* Expanded calcareous structure serving for attachment of a colony.

**basal surface.** Underside of an incrusting or freely growing colony.

*beak.* Pointed operculum of an avicularium (syn., mandible).

**bifoliate.** Consisting of 2 layers of zooecia growing back to back with a double-walled median lamina (mesotheca) between them (syn., bilamellar).

**bilamellar.** Same as bifoliate.

*blastozooid.* Individual produced as a bud.

*blind zooecium.* Chamber of a zooid closed by a deposit of calcite (syn., kenozooecium).

**brood chamber.** Enlarged ovicell covering several zooecia, as in some cyclostomes.

**brown body.** Colored organic tissue in zooecium resulting from disintegration of polypide.

**bryozooid.** Individual animal of a bryozoan colony, including its skeleton (zooecium) and soft parts (polypide) (syn., zooid, polyzooid).

*cadre.* Raised frontal edge of side walls in some cheilostomes (Anasca) (syn., mural rim).

*calcified zooecium.* Chamber of zooid thickened by calcite deposits after death of individual, generally with opening reduced to a small central pore (syn., blind zooecium).

**cancellus** (pl. **cancelli**). Cylindrical interzooecial tube lacking polypide, closed by finely perforate calcareous lamella with many spines on interior; typically developed in some cyclostomes (Lichenoporidae).

*capitulum.* Large rounded cluster of zooecial apertures in some cyclostomes.

**cardelle.** Denticle for hingement of the operculum in cheilostomes (syn., condyle).

**carina.** Median ridge on front side of branches, chiefly in cryptostomes (syn., keel).

**cell.** Zooecial chamber or tube (syn., zooecium, autozooecium, autopore, etc.); loosely used term without special signification.

*cellariiform.* Like the cheilostome *Cellaria,* with zoarium composed of slender jointed cylindrical segments bearing apertures on all sides.

*celleporiform.* Like the cheilostome *Cellepora,* with zoarium formed of zooecia heaped irregularly in multilamellar masses of variable shape.

**celluliferous.** Side of zoarium bearing zooecial apertures (syn., front, obverse) (*see* noncelluliferous).

*cistern cell.* Avicularium-like structure observed in some cyclostomes, as *Entalophora.*

*clithridiate.* Keyhole-shaped, like apertures of some cheilostomes, as Celleporidae.

**coenelasma.** Basal lamina of zoarium from which zooecia arise (syn., epitheca, epizoarium).

*coenenchyme.* Generally vesicular calcareous tissue between zooecia in some cyclostomes and cryptostomes (syn., coenosteum); this term is commonly employed in description of corals but not for bryozoans.

*coenoecium.* Composite skeleton of a bryozoan colony (syn., zooarium).

**coenosteum.** Vesicular or dense calcareous tissue between zooecia of some cyclostomes and cryptostomes, especially in the mature region (syn., coenenchyme).

**common bud.** In Cyclostomata, the protoecium grows into a cylindrical tube with mouth closed by an uncalcified terminal membrane which by the growth of an oblique calcareous septum is divided into 2 parts. The smaller part becomes the common bud, and the larger the first zooecium. Further growth repeats the process with development of a new septum and so on until a zoarium is formed with the common bud portion composed of chitinous fibrous substance extending throughout. First recognized only in Cyclostomata, occurrence of the common bud now is reported by some students in Cryptostomata and Trepostomata.

**communication pore.** Opening in zooecial wall that serves as passageway for soft tissue connecting adjacent polypides in some zoaria (*see* dietella, septule).

**compensation sac.** Same as compensatrix.

**COMPENSATRIX.** Membranous sac beneath the frontal wall of many cheilostomes (Ascophora) for regulating hydrostatic pressure within the zooecium and thus providing for movement of the polypide outward and inward; a water passageway for this organ is located at or near the proximal edge of the aperture in a sinus or tubular opening (ascopore) (syn., compensation sac, zooecial hypostege).

**condyle.** Rounded protuberance or denticle for hingement of the operculum; a pair of these oppositely placed in the orifice is common in cheilostomes (syn., cardelle).

**costa.** Radially disposed rib or ridge forming part of frontal shield that arches over frontal membrane in cribrimorph cheilostomes; between them are areolar pores (syn., costula, costule).

*costula.* Same as costule.

**costule.** Same as costa but somewhat smaller and commonly spiniform (syn., costula).

**cribrimorph.** Characterized by radiating costae or costules on the frontal wall, as in Cribrilinidae.

**cryptocyst.** Shelflike calcareous lamina beneath frontal membrane extending inward from the proximal mural rim in some cheilostomes (Anasca); the space between cryptocyst and frontal membrane serves as hydrostatic chamber (hypostege) in these bryozoans.

*cyphonautes.* Pelagic larval form in some cheilostomes, as *Membranipora, Electra,* etc.

*cystid.* Zooecium in cyclostomes, or space between polypide and frontal wall.

**CYSIIPHRAGM.** Convexly curved calcareous lamina extending from zooecial wall part way across tube, commonly arranged in vertical series forming subhemispherical vesicles; they occur chiefly in trepostomes.

**dactylethra** (pl., **dactylethrae**). Short kenozooecium consisting of club-shaped tubule without polypide, closed at outer extremity by a finely perforate calcareous lamella.

*decussating.* Intersecting at acute angle in form of the letter X.

*descending lamina.* Part of ovicell frontal wall turned downward into the peristome.

**DIAPHRAGM.** Transverse calcareous platform extending across zooecial tube or mesopore; common in most trepostomes, many cyclostomes, and some cryptostomes (syn., tabula, tabulium; *see* cystiphragm, hemiphragm, heterophragm).

**dichotomous.** Dividing in 2 branches.

**dietella** (pl. **dietellae**). Small enclosed space near base of distal parts of zooecial wall containing communication pores traversed by mesenchymatous fibers (syn., pore chamber).

**dissepiment.** Generally noncelluliferous crossbar connecting branches of fenestrate zoaria.

**DISTAL.** Direction of growth away from the ancestrula (syn., anterior, forward) (*see* proximal).
**dorsal.** Side of zooecium opposite that having the frontal wall and aperture, or side of zoarium opposite that bearing apertures (syn., back, reverse).
*double-valved ooecium.* Ovicell consisting of 2 arched vessels.
**ECTOCYST.** Thin chitinous outermost layer covering zooecium or entire zoarium (syn., frontal membrane, outer membrane, epitheca of some authors).
*ectooecium.* External wall of ovicell, commonly calcareous.
*eleocellarium.* Avicularium-like heterozooecium with long paddle-shaped openings, as in some cyclostomes (Eleidae).
*embryonary.* Chamber containing embryos during their development (syn., embryophore).
*embryonic fission.* Division of primary embryo in ovicell giving rise to many larvae, as in cyclostomes.
*embryophore.* Same as embryonary.
**endocyst.** Thin membrane lining interior of zooecium and enclosing polypide; it gives rise to the ectocyst and mesenchyme with its derivatives.
**endooecium.** Inner calcareous wall of ovicell (syn., entooecium).
**endotoichal.** Type of ovicell in some cheilostomes consisting of hollow formed by resorption of thick calcareous frontal wall and provided with independent opening outward (syn., entotoichal).
**endozooecial.** Type of ovicell in some cheilostomes consisting of endooecium formed by the distal wall of the zooecium and on the opposite side of ectooecium formed by covering membrane, which impinges deeply on the interior of the next distal zooecium (syn., entozooecial).
**entooecium.* Same as endooecium.
**entotoichal.* Same as endotoichal.
**entozooecial.* Same as endozooecial.
*epheboecium.* Mature zooecium.
*epistome.* Protective lip overhanging mouth.
*epitheca.* Basal lamina of zoarium from which zooecia arise (syn., coenelasma, epizoarium); also used by some authors for outer chitinous membrane (syn., ectocyst, frontal membrane, outer membrane).
*epizoarium.* Same as coenelasma.
**eschariform.** Like *Eschara,* with free bilamellar zoarium.
**exsert.** Thrust out, protruded.
**facet.** Calcareous lamella serving for closure of zooecial aperture in some cyclostomes; may be centrally perforate.
*fenestra.* Uncalcified area of ectooecium or frontal wall of zooecium in some cheilostomes. Also used for open spaces (meshes) in reticulate zoaria of cheilostomes such as Reteporidae, Petraliidae, etc.
*fenestrula.* Same as ascopore.
**FENESTRULE.** Open space in reticulate zoarium enclosed by branches and connecting crossbars or by anastomosing branches; characteristic of some cryptostomes (Fenestellidae) and trepostomes (Phylloporinidae).
**firmatopore.** Type of kenozooecium consisting of slender proximally directed tubule on dorsal side of zoarium in some cyclostomes.
*fissiparity.* Reproduction by division, as among cyclostomes in which the primary embryo by fission gives rise to many larvae.
**flagellum** (pl., **flagella**). Modified operculum (mandible) of a vibraculum, generally provided with a terminal hairlike bristle (seta).
*floatoblast.* Floating statoblast of a fresh-water bryozoan.
**forward.** Direction toward growing edge of zooecium or zoarium, away from ancestrula (syn., anterior, distal).
**front.** Side of unilamellar or reticulate zoarium that bears zooecial apertures (syn., obverse, celluliferous) (*see* back, dorsal, reverse).
**FRONTAL.** Pertaining to the exposed side of zooecial chambers which bears the aperture, used chiefly for cheilostomes (syn., ventral; in terminology of some authors, front).
*frontal area.* Space covered by frontal membrane.
*frontal membrane.* Uncalcified part of body wall in some cheilostomes (Anasca) on side of zooecium bearing the aperture; may be exposed or covered over by a frontal shield.
**frontal shield.** Calcareous cover of fused spines above the frontal membrane, the space between (hypostege) functioning as a hydrostatic organ; characteristic of cribrimorph types of anascan cheilostomes (syn., pericyst).
**frontal wall.** Calcareous cover on external side of the compensatrix in some cheilostomes (Ascophora).
*funiculus.* Double strand of cells connecting alimentary canal with zooecial wall.
**gemmation.** Reproduction of zooids by division (budding) or junction of previously formed individuals. Several types of gemmation are recognized: (1) axial, zooids produced along zoarial axis; (2) biparietal, tubes of new zooids adjoined to 2 others as seen in longitudinal section; (3) dorsal, zooids produced from dorsal side of zoarium; (4) intrazooecial, zooids introduced from zooecia without order or definite plan; (5) juxtaposed, zooids with tubes parallel, open at their extremities; (6) oriented, zooids uniformly directed from one or both sides of a lamella; (7) peripheral, zooids produced by bifurcation in all directions; (8) triparietal, new zooids adjoin 3 others.
**génése.* Cell containing female reproductive elements only (syn., gonoecium, gonozooecium).
**gerontoecium.* Very old (senile) zooecium.
*gonocyst.* Compound ovicell appearing as inflated part of zoarial surface.
*gonoecium.* Same as gonozooecium.
**gonozooecium.** Zooecium modified to serve as ovicell (syn., gonoecium).

**gonozooid.** Individual bryozooid modified for reproduction.

**GYMNOCYST.** Peripheral calcified portion of frontal membrane in some cheilostomes, developed especially in proximal region, not covered by membranous ectocyst; marginal spines, if present, invariably are produced from the inner border of the gymnocyst.

*hemescharan.* Like *Hemeschara,* with erect unilamellar zoarium having apertures confined to one side.

**hemiphragm.** Shelflike platform in zooecial tube joined to walls on one side, extending only part way across tube; it may occur in any part of the tube (syn., semidiaphragm).

**hemiseptum** (pl., **hemisepta**). Like hemiphragm but confined to near-apertural parts of zooecial tube and only 1 or 2 in a single tube; these are designated as superior hemiseptum (on proximal wall of tube) and inferior hemiseptum (on distal wall of tube); characteristic of many cryptostomes.

*heteromorphic.* Aberrant forms of zooecia.

**heterophragm.** Similar to hemiphragm but composed of laminated tissue continuous with zooecial walls and forming strongly arched inward projection; not superposed in series like cystiphragms.

**HETEROZOOECIUM** (pl., **HETEROZOOECIA**). Modified zooecium lacking polypide or with only a vestige of one but provided with muscles for movement of modified operculum (mandible); aviculoecium and vibraculoecium are different types of heterozooecia.

**heterozooid.** Individual animal which secretes a heterozooecium; avicularium and vibraculum are different types of heterozooids.

*hippoporine.* Like the cheilostome *Hippoporina,* characterized by horseshoe-shaped operculum.

**hyperstomial.** Type of external ovicell in cheilostomes, resting on or indenting distal wall of associated zooecium.

**HYPOSTEGE.** Space between frontal membrane (ectocyst) and overlying frontal shield (pericyst) in some cheilostomes (Anasca), functioning as hydrostatic organ.

*idmoneiform.* Signifying erect arborescent zoarial form; descriptive term commonly applied to cyclostomes (actually not like *Idmonea,* which is adnate).

**IMMATURE REGION.** Basal or internal part of zoarium characterized by thinness of zooecial walls and relative sparseness or absence of transverse structures (diaphragms, cystiphragms, hemiphragms) in them, as well as by absence of kenozooecial structures (mesopores, acanthopores); typically developed in trepostomes, cryptostomes, and some cyclostomes.

**immersed avicularium.** Small kenozooid on frontal wall of zooecium in some cheilostomes.

**incrusting.** Attached along one side to a foreign body.

**inferior hemiseptum.** Shelf projecting part way into zooecial tube from distal side not far from aperture; typical of some cryptostomes.

*inosculating.* Same as anastomosing.

**internode.** Segment of jointed zoarium between surfaces of articulation.

**interspace.** Part of zoarium between adjacent zooecia or their apertures.

*interstitial cell.* Kenozooecium (syn., accessory cell).

*intertentacular organ.* Flask-shaped tubular structure between 2 tentacles providing passageway for extrusion of ova.

*introvert.* Drawn in or turned in, as tentacles and thin distal cuticle of polypide when retracted into zooecial interior.

**keel.** Median ridge on front side of branches, chiefly in cryptostomes (syn., carina).

**KENOZOOECIUM** (pl., **KENOZOOECIA**). Modified zooecium without polypide or operculum and generally no aperture or muscles; types of kenozooecia common in some cyclostomes include firmatopores, nematopores, tergopores, dactylethrae, and cancelli (syn., accessory cell, interstitial cell).

**kenozooid.** Individual animal which secretes a kenozooecium.

*labellum.* Free tongue of descending lamina of ovicell (syn., labrum).

*labial pore.* Median or submedian small opening in proximal wall of peristome in some cheilostomes (Reteporidae), formed by coalescence of labial sinus denticles.

*labial sinus.* Median or submedian slit in proximal wall of peristome in some cheilostomes (Reteporidae).

*labium.* Descending liplike fold of upper margin of ovicell aperture.

*labrum.* Same as labellum.

**lacuna.** Gap or pore commonly consisting of simple slit between adjacent costae or costules in some cheilostomes (cribrimorph Anasca); distinct from areoles, which are pores serving for transfer of food.

*lageniform.* Like *Lagena* (foraminifer), bottle- or flask-shaped.

*lanceolate.* Spear-shaped, tapering to point at apex and commonly also at base.

*lateral punctation.* Same as areole and areolar pore.

*lateral sinus.* Indentation on side of median carina of ovicell in some cheilostomes, as *Iodictyum.*

*lateral slit.* Linear indentation on side of labellum or in base of lateral sinus.

*lepralioid.* Like *Lepralia,* incrusting; referring to cheilostomes.

*locella.* Small free space into which ovicell may open.

**LONGITUDINAL.** Parallel to zooecial tube, as longitudinal thin section (syn., vertical).

**LOPHOPHORE.** Circular or horseshoe-shaped ridge around mouth of polypide bearing ciliated tentacles (syn., tentacular crown).

*lucida.* Clear area in chitinous membrane such as operculum or mandible.
*lumen.* Clear line or pore on midline of costule, as in cribrimorph Anasca.
**LUNARIUM** (pl., **LUNARIA**). Hoodlike overarching projection of peristome on proximal side of zooecial tube, somewhat thickened and more strongly curved than other parts of tube, and in some perforated by 1 to 6 minute longitudinal tubules with diaphragms; common in cyclostomes and some cryptostomes.
*lunulitiform.* Like *Lunulites,* with free turbinate conical zoarium.
*lyrula.* Same as lyrule.
**lyrule.** Median, commonly anvil-shaped tooth on proximal edge of orifice, located below the mucro; common in some cheilostomes (syn., lyrula).
**MACULA** (pl., **MACULAE**). Cluster of kenozooecia (commonly mesopores) or smaller-than-average zooecia, surficially marked by flat or slightly depressed areas and generally bordered by zooecia somewhat larger than average in size; regularly spaced with others on zoarial surface (*see* monticule). This term was formerly used also for irregular cavities in walls of post-Paleozoic cyclostomes.
**MANDIBLE.** Small triangular or rounded articulated part of an avicularium, mostly chitinous but calcified in some; an incessantly moving structure homologous with zooecial operculum (syn., beak).
*marginal denticle.* One of the minute teeth projecting into the peristomie of some cheilostomes (Reteporidae).
**marginal spine.** Sharp-pointed projection, other than oral spine, in a series surrounding the aperture; characterizes some cheilostomes.
*marginal tooth.* Prolongation of orifice edge, one of several, in some cheilostomes (Reteporidae).
*marginate.* Bordered, as in the secondary fold around base of ovicell.
*marsupium* (pl., *marsupia*). Receptacle joined to zooecium for containment of ova during development to embryos.
**MATURE REGION.** External part of zoarium characterized by thick zooecial walls, relative abundance of diaphragms, and common occurrence of kenozooecial structures (mesopores, acanthopores), vesicular coenosteum between zooecia, or dense interzooecial stereome; characteristic of trepostomes, cryptostomes, and some cyclostomes.
*median lamina.* Same as mesotheca.
*median process.* Flanged structure formed by prolongation of parts of zooecial tube in some cheilostomes.
*median tubule.* Small pore in mesotheca of some bifoliate zoaria.
**megacanthopore.** Conspicuously large acanthopore, commonly located at distal border of zooecium in some cryptostomes (*see* acanthopore, micracanthopore).
*membranaceous.* Same as membranous.
**membranimorph.** Like simple incrusting cheilostomes such as the anascan Membraniporidae (syn., membranipore, membraniporiform).
*membranipore.* Same as membranimorph.
*membraniporiform.* Same as membranimorph.
**membranous.** Covered with membrane, not preservable (syn., membranaceous).
**mesenchymatous.** Referring to endocyst-derived tissue such as that traversing tremopores.
*mesenchyme.* Tissue derived from endocyst.
**MESOPORE.** Kenozooecium of generally polygonal tubular form, smaller than zooecia adjoining it and containing more numerous diaphragms (syn., accessory cell, interstitial cell).
**MESOTHECA.** Double laminae of bifoliate zoarium produced by back-to-back growth of 2 unilamellar series of zooecia.
**micracanthopore.** Small (normal) acanthopore associated with much enlarged ones (megacanthopores); common in cryptostomes and some trepostomes (*see* acanthopore).
*micropore.* Same as ascopore.
*monila.* Beadlike expansion in wall of some trepostomes (Stenoporidae).
**moniliform.** Beaded, alternately expanded and constricted so as to resemble string of beads.
**MONTICULE.** Clusters of kenozooecia and associated enlarged zooecia regularly spaced as in maculae but projecting as prominences on zoarial surface (syn., tubercle); common in some trepostomes.
**monticuliporoid.** Like *Monticulipora,* a typical massive stony trepostome.
**mucro.** Rounded or spinelike projection at proximal edge of peristome in some cheilostomes (Ascophora), located on proximal side of lyrule (syn., mucron).
**mucron.* Same as mucro.
**multilamellar.** Type of growth in which successive zooecial layers grow over and cover older ones (syn., multilaminar).
*multilaminar.* Same as multilamellar.
**multiporous.** Type of communication openings in zooecial walls for passage of mesenchymatous fibers (*see* rosette plate, septule).
*munitiform.* Signifying large rounded avicularium with wide aperture, typically developed on distal side of fenestrule in some reticulate cheilostomes (Reteporidae).
**mural rim.** Raised edge of zooecial side walls on frontal side in some anascan cheilostomes, commonly spine-bearing (syn., cadre).
**nanoid.* Same as nanozooid.
*nanozooid.* Dwarfed zooecium containing reduced polypide with only a single tentacle, occurring in some cyclostomes; ?type of kenozooecium (syn., nanoid).
**neanoecium.* Partly developed (adolescent) zooecium).
**nematopore.** Very slender tubular kenozooecium opening on dorsal side of zoarium with axis of

tube directed obliquely upward (distally) (syn., accessory cell, interstitial cell).

**nervus.** Longitudinal threadlike structure on front or back side of zoarium in some cyclostomes (Horneridae).

**node.** Place of articulation in jointed zoarium, as in some cryptostomes, cyclostomes, and cheilostomes; or junction of stolons in ctenostomes.

**noncelluliferous.** Side of unilamellar or reticulate zoarium lacking zooecial apertures (syn., back, reverse) (*see* nonporiferous).

*nonporiferous.* Without pores, covered by epitheca; also in unilamellar and most reticulate zoaria, refers to back (reverse) side which lacks apertures (syn., noncelluliferous).

*obverse.* Side of unilamellar or reticulate zoarium bearing zooecial apertures (syn., front, celluliferous) (*see* reverse).

*occlusor lamina.* One of pair of calcareous plates which with side wall of zooecium forms cavity for attachment of muscle that closes operculum, in some cheilostomes.

**oeciopore.** Aperture of ovicell, serving for escape of larvae.

**oeciostome.** Peristome surrounding oeciopore in cyclostomes.

**oecium.* Same as zooecium.

*ogival.* Gothic-arched form of distal-lateral walls of zooecium in some cheilostomes.

**OLOCYST.** Innermost smooth layer of 3 thin calcified layers forming frontal wall of zooecia and ovicells in some cheilostomes (Ascophora) (*see* pleurocyst, tremocyst).

*onychocellarium.* Modified generally asymmetrical avicularium in which mandible has lateral membranous winglike expansions; occurs in some cheilostomes (Onychocellidae).

*ooecium.* Same as ovicell.

**OPERCULUM** (pl., **OPERCULA**). Small chitinous or calcareous lamina articulating on condyles (cardelles) projecting from edge of orifice; in closed position its distal part (anter) covers the zooecial orifice and its proximal part (poster) closes the opening (vanna) to the compensatrix; typically developed in cheilostomes.

*opesiula.* Same as opesiule.

*opesiular indentation.* Same as opesiule.

**opesiule.** One of the small grooves in cryptocyst for passage of depressor muscles attached to ectocyst (frontal membrane) in some anascan cheilostomes.

**OPESIUM** (pl., **OPESIA**). Large opening generally equal to entire frontal area of zooecium, bordered by cryptocyst and covered by frontal membrane; characterizes many anascan cheilostomes.

**oral avicularium.** One definitely associated with the zooecial aperture in some cheilostomes, located on its proximal edge (suboral) or at the side (lateral-oral).

**oral shelf.** Flattened rim at lateral and distal borders of orifice on which the operculum or mandible rests.

**oral spine.** Calcareous projection at distal margin or sides of orifice, generally jointed at base.

**ORIFICE.** Primary opening of the zooecium for extrusion of polypide, in cheilostomes covered by operculum.

*orthoecium.* Normal zooecium (syn., autozooecium, autopore).

*outer membrane.* Same as ectocyst.

**OVICELL.** General term for any structure serving to contain bryozoan larvae during their development (syn., ooecium) (*see* gonocyst, gonoecium, gonozooecium, hyperstomial, endotoichal, endozooecial, vestibular).

*parietal pore.* Perforation in distal wall of zooecium of some cheilostomes serving as passageway for mesenchymatous fibers connecting polypides (syn., communication pore) (*see* dietella).

**pedicellate.** Elevated on stalk or pedicel, generally referring to avicularia (syn., pedunculate).

*pedunculate.* Same as pedicellate.

**pelma** (pl., **pelmata**). Opening in costa or costula of some cheilostomes (cribrimorph Anasca); primary pelma located nearest to edge of frontal shield and secondary pelma next to primary on inward side.

**pelmatidium** (pl., **pelmatidia**). Small opening in costa or costula of some cheilostomes (cribrimorph Anasca).

**pericyst.** Calcified frontal wall above ectocyst in some cheilostomes (Anasca), generally formed of fused marginal spines (syn., frontal shield).

**perigastric cavity.** Space between polypide and inner wall (endocyst) of zooecium.

*peripore.* Salient collar surrounding large pores in pericyst.

**PERISTOME.** Rim surrounding orifice in cheilostomes, many cyclostomes, and some trepostomes, or surrounding aperture in many cryptostomes (*see* peristomie, peristomice).

**peristomial ooecium.** Single-layered ovicell comprising expansion of peristomie in some cheilostomes (syn., vestibular ovicell).

*peristomiale.* Upper swollen part of zooecial tube in some ascophoran cheilostomes (Tubucellariidae), corresponding to peristomie.

**peristomice.** Opening at outer extremity of the peristomie in some cheilostomes (syn., aperture, secondary orifice).

**PERISTOMIE.** Tubelike extension of the peristome outward from the operculum-bearing orifice in some cheilostomes; homologous, if not synonymous, with the vestibule of cryptostomes.

**pinnate.** Feather-like, with lateral (generally oblique) branches on each side of a midrib.

*petraliiform.* Like *Petralia,* consisting of unilamellar zooecial colony attached by rootlets.

**pleurocyst.** Calcareous frontal layer covering olocyst in some cheilostomes, generally granulated and forming costules between areoles.

*polyembryony.* Production of many larvae from a single ovum or embryo.

**polymorphic.** Having several distinct forms of cells, tubes, or chambers consisting of zooecia, kenozooecia, heterozooecia, and ovicells.

**POLYPIDE.** Collective term for soft parts of zooid, freely movable within zooecium.

*polypidian convexity.* Incomplete tube protecting tentacular sheath of polypide in some cheilostomes (Onychocellidae).

*polypidian tube.* Distal prolongation of median opening in descending lamina of cryptocyst in some cheilostomes (Steginoporellidae) for passage of tentacles.

*polyzoarium.* Same as zoarium (syn., polyzoary).

*polyzoary.* Same as polyzoarium.

*polyzooid.* Individual animal of bryozoan colony, comprising polypide and zooecium (syn., zooid, bryozooid).

*pore chamber.* Small enclosed space near base of distal parts of zooecial walls containing communication pores traversed by mesenchymatous fibers (syn., dietella).

*poriferous.* Bearing apertures; in unilamellar and most reticulate zoaria refers to front (obverse) side (syn., celluliferous) (*see* nonporiferous).

**porta.** Part of orifice in cheilostomes on distal side of cardelles, serving as passageway for polypide during its extrusion and retraction; it is closed by part of the operculum termed anter.

**poster.** Part of operculum in cheilostomes on proximal side of cardelles, serving for closure of the vanna (part of orifice opening into compensatrix).

*posterior.* Direction or side toward beginning of growth in the ancestrula (syn., proximal); also used by some authors to denote the side of a zoarium lacking apertures (syn., proximal) (*see* anterior).

*post-oral shelf.* Thickened proximal and lateral margins of cryptocyst in some cheilostomes (Steginoporellidae).

*primary aperture.* Original opening of zooecium closed by operculum (syn., orifice).

*primary peristome.* Fold of olocyst around orifice in some cheilostomes.

*primary zooid.* Same as ancestrula.

*primoserial.* Zooecium at proximal end of a new series.

*proancestrula.* Primary zooid of colony at initial stage of attachment.

*protoecium.* Minute chitino-calcareous discoid embryonic shell at base of ancestrula in cyclostomes (*see* proancestrula).

**PROXIMAL.** Direction toward origin of growth (syn., posterior) (*see* distal).

*pseudopore.* Perforation in zooecial walls of some cyclostomes.

*pseudorimule.* Peristomial canal in some cheilostomes, regulating flow of water from peristomie into compensatrix (*see* rimule).

*pseudoseptum.* Longitudinal ridge on proximal side of interior of lunarium-bearing zooecial tube, formed by inward projection of either lateral extremity of the lunarium.

*pseudospiramen.* Asymmetrically placed notch at edge of poster in some cheilostomes (Celleporidae).

*pseudostolon.* Short slender extension of zooecial tube in some fresh-water bryozoans.

**quincuncial.** Characterized by arrangement consisting of 4 objects symmetrically placed around a fifth.

*rachis.* Axial structure of some sort.

**radicle.** Rootlike structure formed by kenozooecia serving for zoarial attachment.

*radicular fiber.* Equivalent to minute radicle.

*recumbent.* Type of ovicell in some cheilostomes (Phylactelliporidae) which reclines against the distal zooecial wall.

*repent.* Same as reptant.

**reptant.** Creeping, prostrate.

*reteporidan pore.* Opening (spiramen) into compensatrix in Reteporidae.

**reteporiform.** Referring to reticulate zoaria as in the cheilostome Reteporidae.

*reticulocellarium.* An onychocellarium or avicularium with perforations beneath the opesium.

*reverse.* Back of unilamellar or reticulate zoarium, lacking zooecial apertures (syn., back, dorsal, noncelluliferous, nonporiferous).

*rhamna.* Linear median crest on gymnocyst in some cheilostomes.

**rimule.** Fissure or small cleft at proximal edge of orifice in some cheilostomes, serving as opening to the compensatrix (syn., rimule spiramen, sinus) (*see* vanna).

*rimule spiramen.* Same as rimule.

**rosette plate.** Subcircular porous area in distal part of zooecial wall for passage of mesenchymatous fibers between adjacent zooids (*see* multiporous, septule).

**rostrate.** Beaked, mounted on a beak, as an avicularium.

*rostrum.* Suboral protuberance on frontal wall of some cheilostomes (Celleporidae); also distal part of avicularium occupied by a mandible.

**schizoporellid.** Characterized by a median sinus at proximal margin of the orifice, as in Schizoporellidae.

*sclerenchyme.* Generally dense calcareous tissue (syn., stereom).

*sclerite.* Thickened line of chitin or calcite on operculum or mandible.

*scutum.* Commonly large flabellate spine overhanging aperture.

*secondary aperture.* Opening at outer extremity of peristomie in some cheilostomes or vestibule in cryptostomes (syn., secondary orifice, aperture).

*secondary orifice.* Same as secondary aperture (syn., aperture).

**semidiaphragm.** Transverse calcareous platform extending part way across zooecial tube (syn., hemiphragm) (*see* hemiphragm, hemiseptum, heterophragm).

*septal ridge*. Linear elevation outlining young zooecium in Reteporidae.

**SEPTULE.** Single (uniporous) or grouped (multiporous) perforations in distal part of zooecial wall for passage of mesenchymatous fibers connecting adjacent zooids (syn., septulum) (*see* rosette plate).

*septulum*. Same as septule.

*septum*. Membranous cross wall between zooids in stolon or elsewhere.

*sessoblast*. Sessile reproductive body formed by fresh-water bryozoans.

**seta** (pl., **setae**). Chitinous terminal bristle on flagellum of a vibraculum; also, one of the hairlike processes surrounding delicate structures of some zooids.

*shield*. Broad elevated area surrounding some zooecial apertures.

**sinus.** Slit at proximal edge of orifice in some ascophoran cheilostomes (syn., rimule).

*spicule*. Small spine without internal canal.

**spine.** Small hollow elongate projection, distally closed or open (*see* marginal spine, oral spine).

**spiniform tubule*. Same as acanthopore.

*spiracle*. Same as spiramen.

**SPIRAMEN.** Median pore in frontal wall on proximal side of orifice in some ascophoran cheilostomes, serving as passage to the compensatrix (syn., spiracle).

*statoblast*. Hard-shelled reproductive body formed by fresh-water bryozoans.

**STEREOM.** Generally dense calcareous tissue (syn., sclerenchyme).

*stigma*. Linear or trifoliate fissure in frontal wall of ovicell in some cheilostomes (Reteporidae).

**STOLON.** Slender creeping tube consisting of kenozooecia, from which zooids with zooecia may develop; characterize ctenostomes.

**sulcus** (pl., **sulci**). Longitudinal groove between nervi on front or back of some cyclostomes (*Hornera*), with elongate pores (vacuoles) at base.

*tabula*. Same as diaphragm (syn., tabulium).

**tabulate.** Bearing tabulae (diaphragms).

*tabulium*. Rarely used equivalent of tabula.

**TANGENTIAL.** Referring to sections cut parallel to surface of zoarium.

**TENTACLE.** Ciliate flexible appendage of lophophore used in gathering food.

**tentacle sheath.** Delicate introverted membrane enclosing tentacles when polypide is retracted.

*tentacular crown*. Same as lophophore.

**tergopore.** Type of accessory tube (kenozooecium) on dorsal side of zoarium, as wide as polypide tubes but with polygonal aperture; characterize some cyclostomes.

*termen*. Marginal rim of frontal wall surrounding opesium in some cheilostomes (Membraniporidae).

*thyrostome*. Opening of zooecium through which tentacles and mouth of polypide may be extended (syn., orifice).

*tower zooecium*. Abnormal erect short tube (kenozooecium) rising from opesium in some cheilostomes (Membraniporidae).

**trabecula.** Branch separating fenestrules in reticulate cheilostomes (Reteporidae).

**TRANSVERSE.** Generally refers to sections of zoaria cut at right angles to the direction of colony growth.

**TREMOCYST.** Perforate calcareous layer of frontal wall overlying pleurocyst or olocyst in some ascophoran cheilostomes.

*tremogastre*. Zooecium with tremopores.

**tremopore.** Large perforation in tremocyst; may be continuous with tubule in olocyst.

*trochosphere*. Form of larva with bilaterally symmetrical ovoid body and round mouth, characteristic of Entoprocta.

*trypa*. Central pore in frontal wall of some cheilostomes (Microporellidae) corresponding to sinus (syn., ascopore).

*tubula*. Slender tremopore tube arising from small pore, piercing subjacent olocyst.

*umbo*. Prominence on frontal wall on proximal side of aperture in some cheilostomes.

*unguiculate*. Claw-shaped, talon-like.

**uniporous.** Type of septule having relatively large communication pore (*see* multiporous, rosette plate).

**vacuole.** Slender tube (kenozooecium) approximately normal to front or back zoarial surface, separated from neighboring similar tubes by stereom; characteristic of some cyclostomes (Horneridae) where commonly they occur at base of sulci.

**vanna.** Part of zooecial orifice on proximal side of cardelles, functioning as opening to compensatrix; it is closed by part of the operculum termed poster.

*vertical section*. Same as longitudinal section.

**vesicular tissue.** Superposed irregular arched small lamellae forming cystose filling of interzooecial spaces, commonly filled partly or entirely near zoarial surface by stereom; characterizes many cryptostomes and some cyclostomes (syn., coenosteum).

*vestibular arch*. Calcareous lamella on superior part of tentacular sheath.

*vestibular ovicell*. Same as peristomial ooecium.

**VESTIBULE.** Circular or oval shaft extending inward from zooecial aperture of cryptostomes, limited at base by hemisepta or by passage from mature to immature part of zooecial tube, this inner limit being interpreted as equivalent to the orifice of cheilostomes.

**vibex** (pl., **vibices**). Salient line on front and back of trabeculae in reticulate cheilostomes (Reteporidae).

*vibracularium*. Small kenozooecium without polypide but provided with muscles for movement of vibraculum.

*vibraculoecium.* Skeletal structure of vibraculum.

**VIBRACULUM** (pl., **VIBRACULA**). Highly modified chitinous or calcareous avicularian heterozooid with mandible replaced by bristle-like seta movable in various directions for purposes of stabilization.

**vicarious.** Referring to avicularia that occupy places of zooecia and thus occur between zooecia.

**vincularian.** Referring to unjointed rodlike zoaria with zooecial apertures on all sides.

**ZOARIUM** (pl., **ZOARIA**). Assemblage of many zooids comprising an entire bryozoan colony, formed by repeated gemmation from a single initial zooid (ancestrula); form generally fairly constant for each species (syn., asty, polyzoarium, polyzoary, coenoecium). The term zoarium is used also for the collective skeletal parts of a colony.

*zooecial hypostege.* Same as compensatrix.

*zooeciule.* Immature zooecium or kenozooecium occurring sporadically among normal zooecia, generally in cyclostomes.

**ZOOECIUM** (pl., **ZOOECIA**). Chitinous double-walled sac, chamber, or tube containing the soft parts (polypide) of the bryozooid (syn., autopore, autozooecium, oecium, cell).

**ZOOID.** Single bryozoan animal, consisting of soft parts (polypide) and skeleton (zooecium) (syn., autozooid).

*zoophyte.* Early name for bryozoan, considered half plant, half animal.

# TECHNIQUES

The relationship between the polypide and its protecting zooecial cover is such that the study of Recent Bryozoa embraces 2 distinct processes. The first, dealing with the anatomy of the fleshy polypide, is interpreted by well-known histological methods, while the second usually involves determination by thin sections or otherwise of the calcareous or chitinous zooecial structures. Although much important work on bryozoan anatomy has been accomplished, this is still a favorable field for research. The second process must be discussed more at length because the identifications of many fossil forms are based so largely on the nature of minute wall structure. Thin sections are a prime necessity, particularly for study of the Paleozoic stony Bryozoa—Trepostomata, Cryptostomata, and the Ceramoporoidea division of the Cyclostomata. In the more delicate Cyclostomata and even in the Cheilostomata, where zooecial surface characters are important, such sections are needed frequently.

## PREPARATION FOR STUDY

Bryozoa are uncommon in most sandstone strata, but beginning with the Lower Ordovician there is scarcely a limestone formation, especially if it has shale alternations, in which they are not more or less abundant. Generally the specimens are calcareous, but some are silicified, with the internal structure obliterated, which prevents successful sectioning. In certain strata their substance has been dissolved away, leaving a perfect mold in the matrix from which gutta-percha or rubber impressions will usually give a satisfactory idea of the surface characters.

The best specimens usually occur in the shales between or just above or below limestone layers. The smaller forms may be obtained free by carefully washing the shales and separating the specimens from the debris. Some kinds of shales or clay will wash away better if first allowed to become thoroughly dry or even baked. Others do better after thorough soaking or boiling in water.

The surface characters may be obscured by an indurated clayey matrix which can be removed by the use of caustic potash (KOH) in stick form. The deliquescence of small pieces of this substance, which needs to be handled gingerly with unprotected hands, laid upon the fossil softens and loosens the clay, which is then readily washed off. Some workers accomplish the same result by placing specimens in a saturated solution of Glauber's salts, which, in crystallizing, likewise softens the clay. To prevent further action of the small amount of caustic potash still remaining, the specimen must be carefully neutralized by washing and soaking in water containing very dilute hydrochloric acid.

Today the increased use of a 3-percent hydrochloric acid solution in etching solid fossiliferous limestones has resulted in the recovery of many specimens otherwise buried in solid rock. This process was carried on over half a century ago on a large scale particularly in releasing the many beautiful corals as well as most fragile Bryozoa from the massive Middle Devonian limestones at the Falls of the Ohio. Now it has again become a quite common practice, and many specimens of delicately formed fossils have been revealed. The process requires that the chunk of rock be painted with a plastic such as ambroid to hold the fossils together as solution progresses, leaving an uncoated space for the escape of bubbles. To spray sandstone the use of the Duco-spraying machine and acetone as a solvent if necessary, is recommended. All fossiliferous limestones will not yield silicified specimens by etching, but some release their treasures even in nature in a few years under ordinary surface weathering, especially if a light cover of ordinary clay soil be spread over the rock outcrops occasionally. The Mississippian limestones of Tennessee and nearby states with their classic crinoid localities are noteworthy examples. Horny fossils, including phosphatic and chitinous varieties, will yield to etching when a 10-percent acetic acid solution is employed as the solvent.

Bryozoa in the Recent seas are collected in quantity by dredging, particularly in areas with a shelly bottom, although a thorough search of seaweeds and shells cast upon the beach or of piling and other structures exposed at low tide often will reveal them in considerable numbers. A prolific source of Bryozoa for the student is the common oyster and clam of eastern markets. Most of the specimens secured in these ways are dead, that is, they contain no living polypides, but their study follows the methods indicated for fossil forms. Specimens retaining the polypide may be preserved in alcohol or formaldehyde for some time before the animal matter is destroyed. After decalcifying and embedding in paraffin, thin sections of such specimens may be cut with the microtome, as usual for tissues. If removal of the animal matter is desired in order to study the zooecia unobscured, boiling in Javelle water, as described under "Work on Post-Paleozoic Bryozoans," is necessary.

### Thin Sections

The preparation of satisfactory thin sections is not difficult, but care and experience are required to produce uniformly good results. Lacking a diamond saw or other machine for cutting rock sections, one may obtain excellent results by the following old-fashioned method. The materials required are a piece of fine-grained solid sandstone, 8 or 10 inches wide, several inches thick, and 18 or 20 inches long; a water hone an inch thick and 4 or 5 inches long; and a block of wood about 2 inches wide, 4 or 5 inches long, and an inch thick to hold the glass slide. In place of the sandstone, a carborundum slab about an inch thick, 8 inches wide, and 18 inches long, obtainable from the Carborundum Company at Niagara Falls, is very durable and more efficient. Such slabs come in coarse, medium, and fine grades, so that it is advantageous to have a set of all 3 at hand. The wooden block should have its upper edges rounded to fit the hand, and the lower side should be excavated in a manner suited to hold an ordinary glass slip. A carborundum hone of considerable fineness is quite useful, but the best results in final thinning come from a hone of carefully selected lithographic limestone.

The following procedure for sectioning specimens large enough to be handled without difficulty was followed by most students in early days. With a pair of wire nippers, a fragment illustrating the desired structure is cut from the specimen and rubbed upon the sandstone until the surface is perfectly flat. This surface is then smoothed upon the hone and the preparation cemented upon a glass slip with Canada balsam. Proper heating of the glass slip to harden the balsam is an important part of the process, for if allowed to boil too long on a hot plate or over a lamp it will be brittle when cold and the fragment tends to spring off the slide; if heating is too short, the section when thinned will granulate. After heating and subsequent cooling, the balsam should be tested for hardness, the correct degree being intermediate between brittleness and the point where the fingernail can make an impression upon it. If too soft, the slip must be sufficiently reheated; but if too hard it is better to remove the fragment, clean it by smoothing it off again on the hone, and then remount. When proper hardness of the balsam is obtained, the glass slip is placed in the excavation of the wooden block dipped into water to secure adhesion. Then, after rubbing away all superfluous material on the sandstone or carborundum slab until the section is quite thin, one removes the slide from the block and completes further thinning upon the hone by hand.

In this process, the glass slip becomes scratched and unsightly; for a permanent mount, the entire slip may be rubbed to give a ground-glass appearance, or the thin section may be transferred to a clean slip and covered in the usual way for permanent preservation. The transfer is accomplished by first cleaning off all old balsam with alcohol, then adding a drop of fresh balsam, heating, and when the thin section has become loosened, sliding it onto a clean glass slip with a sharp-pointed instrument. Bubbles may be eliminated by pressure upon the cover glass while the balsam is liquid. Unlike petrologists, most bryozoologists use 1x3-inch slides because they provide greater label space. Canada balsam sticks of the required hardness are useful timesavers. They are prepared by filling with properly hardened balsam tinfoil cylinders made with the help of a lead pencil.

Today most students employ 3 pieces of plate glass about 1x3 feet in dimension, 1 for each of the 3 grades of carborundum employed; No. 320 is generally used for the coarsest, No. 600 for medium, and No. 1000 for final finishing. Fingers placed on top of the slide give sufficient pressure to direct the thinning. Specimens too small to be cut with the wire nippers may be prepared for sectioning held by the fingers, or they may be mounted on a slide in balsam only partially hardened by heating. Remelting the balsam and turning over the specimens with a sharp-pointed instrument, one may complete the sections in the manner described above. In place of Canada balsam, a thermoplastic compound such as Lakeside cement, prepared by the Lakeside Chemical Company of Chicago, is one of several equally good preparations for the purpose.

The above methods apply particularly to solid, ramose, or massive Bryozoa, furnishing the best method to show certain peculiar structural features, particularly those of the inner immature zone and the outer peripheral mature area, where the zooecia develop accessory features, such as acanthopores, mesopores, and diaphragms. Two sections are needed always, a longitudinal one parallel to direction of growth, and a tangential one parallel to the surface and close enough to it to show the mature structure. Two tangential sections generally are required for bifoliate zoaria, one near the surface and the other just above the median lamina. A third section, called transverse, cut at right angles to the longitudinal, is very useful in studying stemlike forms, especially in order to show median pores in the mesotheca. Serial sections have been prepared separately to show structural changes as growth proceeds, but this arduous task is unnecessary, since a single slightly oblique tangential section can be prepared to intersect higher and lower levels of the zooecial tubes, instead of crossing them in the same zone. Thus, extreme youthful to old-age conditions may appear in the same slide. A longer life is insured for the completed section if the cover glass is ringed with asphaltum or some similar cement. Slides in the U.S. National Museum collection so treated more than 75 years ago are still as good as new.

### Use of X-rays

The Bryozoa lend themselves to study under the application of X-rays as shown by J. J. Trillat & Roger (1947) and Roger & Buge (1947). Extensions of their work, eliminating the need of so much thin sectioning, will undoubtedly result in much saved time.

## WORK ON POST-PALEOZOIC BRYOZOANS

Specimens of Bryozoa of Mesozoic and Cenozoic (particularly Recent) age are generally so fragile that preparation of thin sections may require hardening of zoarial fragments by preliminary boiling in Canada balsam. Thin sections of the walls, particularly the outward-facing frontal, are needed to reveal the nature of the 3 layers (olocyst, tremocyst, pleurocyst) and similar features. Then, so-called opaque sections may be needed to reveal characters of the zoarial and zooecial interior. The frontal must be abraded away to show the occurrence of various internal structures (dietellae, septules, and others). This abrasion is effected by mounting the fossil, frontal side up, on a slide in hardened balsam and rubbing the surface gently on a hone until the internal structures become visible. Similar opaque sections designed to reveal structures on the inner side of the frontal may be made by mounting the fragment with outer face down and rubbing away the exposed side until outlines of the primitive aperture, ovicell, and other features are revealed clearly. Opaque sections passing lengthwise through the zoarium may be necessary to determine the nature of the ovicell. Such preparations require much care, because the fragments must be mounted on edge and abrasion must follow definite rows of zooecia. A specimen can be trimmed with small wire nippers to exactly the right form, whereupon by mounting in hardened balsam between 2 small bits of wood (fragments of a match serve excellently) to hold it on edge, one can make the necessary abrasion. Lastly, actual dissection of both fossil and Recent specimens with a fine needle under the microscope often is necessary.

Careful washing of the specimens with a camel's-hair brush and (after thoroughly drying) tinting them pink with a light solution of red ink or some stain will bring out characters more clearly than can be observed on the original material. This not only aids in ready separation of species but is a help in preparing illustrations, for the tint forms a background well adapted to photography, even if the specimen subsequently is coated with a light blue film of ammonium chloride. Brushing or soaking with water will remove the tint readily when desired. The modern bryozoans lend themselves to this method, for their glassy surfaces make it difficult to observe characters which appear plainly on the tinted surface. Delicate Paleozoic forms, too, especially fragile silicified specimens of white or yellow color, can be studied better after staining.

*Use of Javelle water.*—The chitinous covering membrane and other obscuring surface tissues of Recent species may be removed by boiling in Javelle water, whereupon the specimen assumes the aspect of fossils from which, naturally, all the chitinous and fleshy parts have disappeared. Javelle water, usually obtainable from any druggist, can be prepared readily by dissolving one pound of washing soda in a quart of cold water and adding to this ¼ pound of bleaching soda (calcium hypochlorite). After filtering, the solution should be kept in a tightly closed bottle. Preparation of bryozoans by boiling in this solution is a slow process which has the advantage that specimens are not destroyed.

*Calcination.*—MARY D. ROGICK (1945) has published instructions for students of Recent Bryozoa on calcining calcareous specimens by burning away the organic material which obscures the surface. Chitinous structure also is destroyed by calcination with a simple blowpipe, Bunsen burner, or alcohol lamp; a spoon to hold small specimens in place is the only additional equipment necessary for this process. Calcining must stop while the structural zooecial pattern is still evident without showing any crumbling. Then, in form closely similar to fossils, the specimens can be moved with a suitable instrument or brush and mounted on a slide in balsam or glue. For comparison, an uncalcined fragment of the same species or specimen should be mounted next to the preparation.

*Mounting chitinous appendages.* — The preparation of opercula, mandibles of avicularia, and other chitinous appendages of modern Cheilostomata, so important in taxonomic study of this group under the microscope, is not only in order but is recommended as a pleasant diversion. Methods for the separation of these appendages from the zoarial surface and mounting them properly have been described by various authors, but most of them are complicated and time-consuming. Today, such preparations are made simply by scraping the surface of a few zooecia from the zoarium with a scalpel and gently crushing the material thus obtained in a drop of water on a slide. The appendages, being flexible, seldom are damaged in the process; so after spreading the material in the water and allowing it to dry, one adds Canada balsam and a cover glass as usual to complete the mount.

## PHOTOGRAPHS AND DRAWINGS

The illustration of bryozoans has importance both as a technique in study and for use in publications. Because of the microscopic dimensions of zooecia, their structural features and arrangement in a zoarium cannot be compared readily with corresponding characters of numerous specimens by the unaided eye, nor can specimens generally be examined simultaneously with a microscope. Enlargements made by photography or by drawings are almost indispensable; these furnish materials for study, and selected illustrations may be used in publication. Commonly, 2 types of illustrations are needed: some showing surface characters of the zoarium, and others recording features revealed by thin sections. Both may be prepared with a suitable setup for low-power photomicrography or manually with aid of a camera lucida or use of a micrometer eyepiece. Thin sections may be projected directly on bromide paper by placing the section in a photographic enlarger such as is widely used in making prints from 35-mm. negatives. The slide takes the place of the negative, and very useful record at selected standard magnification (controlled by setting of the enlarger) can be obtained easily and rapidly.

With various highly developed, expensive cameras for photography of microscopic objects, illustrations are not difficult to prepare. If need be, a simple boxlike camera with a bellows length of less than a foot attached to an upright stand, allowing movement of both camera and bellows, may be used, like the one which has served the writer for the past half century in preparing negatives with magnifications up to 100 diameters; use of suitable microscopic objectives and close stopping down of the diaphragm are aids.

*Whitening.*—The zoaria of many Recent Bryozoa are semitransparent or so glasslike that only with difficulty can their various zooecial features be studied and photographed. Fortunately, their structures may be brought out in great perfection and clearness by gently whitening the surface with the fumes of ammonium chloride through sublimation. A simple apparatus for this purpose is illustrated in figure 2. By

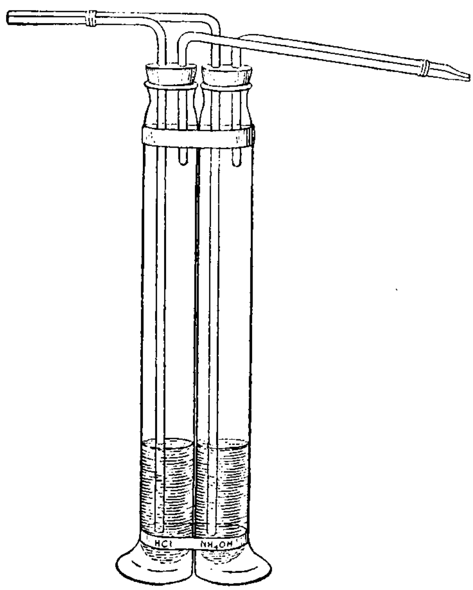


FIG. 2. Apparatus for whitening fossils with ammonium chloride sublimate (131).

blowing through the mouthpiece, one may bring the fumes of hydrochloric acid (HCl) and ammonia ($NH_4OH$) to unite at the outlets of the tubes, and the white sublimate of ammonium chloride will be deposited upon any object held near the outlets. The density of this sublimate can be controlled so that the object may be coated with a uniform, thin film, varying in color according to its thickness, from a light blue to an ivory white, whereby all the details of structure are reproduced perfectly for study under the microscope without exhibiting any crystalline structure of the ammonium chloride. By this process, the minute sculpturing of structures scarcely visible on the corneous or transparent calcareous colony is brought out in clear relief. This whitening process is a great aid in preliminary study, but it is almost indispensable for illustration of Recent bryozoans by photography. Fossils lend themselves equally well to this method of study and illustration. The sublimate may be removed by simply blowing the breath upon the object so coated. Small quantities only of acid and ammonia should be used, so that the bottles can be emptied and cleaned frequently, as the reagents not only absorb moisture but lose their strength in several days of use. It is a pity that several important research works of recent years have lost value by furnishing poor photographs made without use of the sublimation process.

The bottles need not be long, and density of the sublimate can be modified by narrowing the ammonium outlet, which reduces the strong ammonium fumes, objectionable to some. Poor results occur from blowing too hard or too long or in a damp atmosphere, in which case the ammonium chloride piles up in curdy masses, evident in illustrations found even in some modern treatises. Good strong solutions (95 percent) of both acid and ammonia are required, but cotton plugs strapped to the ends of the tubes after use will preserve their strength for several days and give relief from continual bottle cleaning. The use of these strong chemicals can be avoided by heating a plug of ammonium chloride powder in a piece of glass tubing to supply the fumes, but this is inconvenient for several obvious reasons. Puffing, instead of continuous blowing, gives the best results. Warming the specimen before whitening aids in case of damp weather.

In recent years, whitening by use of magnesium ribbon has given fair results; when the ribbon is burned, an ivory white sublimate is formed, not quite so suitable for photography. A small strip held firmly with forceps is lighted and the specimen carefully manipulated in the resulting fumes.

# CLASSIFICATION

A tabular summary of main divisions of the Bryozoa showing distribution of recognized subordinal, familial, generic, and subgeneric units, is introduced here for convenience in surveying the whole assemblage. This is followed by an outline of classification giving names of suprageneric units, with abbreviated characterizations of higher-than-family categories. The names and taxonomic relationships of main parts of the phylum have been established for periods ranging from 70 to 100 years, but designations of taxonomic rank adopted in the *Treatise*, particularly in omitting such categories as "group" and "tribe," variously used by many authors, include some departures from older classifications. The number of genera and subgenera in each unit are given in parentheses; for example, "(8)" signifies 8 genera, and "(1219;46)" indicates 1219 genera and 46 subgenera.

### *Suprageneric Divisions of Bryozoans*

Entoprocta *(subphylum)*, without skeleton, mouth and anus enclosed within circle of tentacles (8). *Rec.*
- Loxosomatidae *(family)* (3). *Rec.*
- Pedicellinidae (5). *Rec.*

Ectoprocta *(subphylum)*, mostly with calcareous skeleton but some chitinous, anus not enclosed by tentacles (1219;46). *?U.Cam., Ord.-Rec.*
- Gymnolaemata *(class)*, circular row of tentacles around mouth (1210;46). *?U.Cam., Ord.-Rec.*
  - Ctenostomata *(order)*, comblike processes at mouth (43). *Ord.-Rec.*
    - Carnosa *(suborder)*, zooids in direct line, laterally budded from ancestrula (7). *Rec.*
      - Alcyonidiidae *(family)* (4). *Rec.*
      - Flustrellidridae (3). *Rec.*
    - Paludicellea, zooids stolon-like proximally (8). *Rec.*
      - Victorellidae (3). *Rec.*
      - Arachnidiidae (3). *Rec.*
      - Nolellidae (2). *Rec.*
    - Vesicularina, zooids produced from thick free stolon (8). *Rec.*
      - Vesiculariidae (8). *Rec.*
    - Stolonifera, zooids generally paired along thin creeping stolon (20). *Ord.-Rec.*
      - Walkeriidae (2). *Rec.*
      - Mimosellidae (3). *Rec.*
      - Buskiidae (1). *Rec.*
      - Triticellidae (1). *Rec.*
      - Ropalonariidae (1). *Ord.-Perm.*
      - Vinellidae (5). *Ord.-Cret.*
      - Ascodictyidae (3). *Sil.-Perm.*
      - Terebriporidae (2). *Tert.-Rec.*
      - Penetrantiidae (1). *Rec.*
      - Immergentiidae (1). *Rec.*
  - Cyclostomata *(order)*, calcareous tubular zooecia with circular apertures, no operculum (303; 29). *?U.Cam., Ord.-Rec.*
    - Articulata *(suborder)*, zoaria mostly jointed (9). *Sil.-Rec.*
      - Crisiidae (8). *Cret.-Rec.*
      - Phaceloporidae (1). *Sil.-Dev.*
    - Tubuliporina, zoaria very rarely jointed, zooecial walls not cancellate (122;7). *Ord.-Rec.*

Cyclostomata, Tubuliporina *(continued)*
Diastoporidae (29). *Ord-Rec.*
Tubuliporidae (25). *Dev.-Rec.*
Multisparsidae (2). *Jur.*
Oncousoeciidae (6). *Jur.-Rec.*
Terviidae (4). *Tert.-Rec.*
Entalophoridae (17). *Jur.-Rec.*
Diaperoeciidae (9). *Jur.-Rec.*
Plagioeciidae (12). *Jur.-Rec.*
Hastingsiidae (1). *Rec.*
Frondiporidae (7). *Jur.-Rec.*
Theonoidae (10;7). *Jur.-Rec.*
Cancellata, zoaria not jointed, zooecial walls cancellate (44). *Jur.-Rec.*
Horneridae (2). *Eoc.-Rec.*
Cytididae (21). *Jur.-Rec.*
Petaloporidae (18). *Cret., ?Rec.*
Pseudidmoneidae (1). *Rec.*
Calvetiidae (1). *Rec.*
Stegohorneridae (1). *Rec.*
Cerioporina, zoaria unjointed somewhat resembling trepostomes, zooecial walls minutely porous (43). *Trias.-Rec.*
Heteroporidae (23). *Trias.-Rec.*
Corymboporidae (3). *Cret.-Rec.*
Tretocycloeciidae (7). *Cret.-Rec.*
Cavidae (6). *Jur.-Cret.*
Leiosoeciidae (4). *Jur.-Eoc.*
Rectangulata, zoarium unjointed, with coelomic spaces (alveoli) between zooids (13;12). *Cret.-Rec.*
Lichenoporidae (13;12). *Cret.-Rec.*
Dactylethrata, zoarium unjointed, zooecia separated by dactylethrae (4). *Cret.*
Clausiidae (4). *Cret.*
Salpingina, zoarium unjointed, avicularia present (13). *Jur.-Cret.*
Eleidae (9). *Jur.-Cret.*
Semiceidae (3). *Cret.*
Lobosoeciidae (1). *Cret.*
Hederelloidea, zooecia laterally budded from preceding one (6;5). *Sil.-Penn.*
Reptariidae (6;5). *Sil.-Penn.*
Ceramoporoidea, zooecial walls laminated granulose, with mural pores (49;5). *?U.Cam., Ord.-Perm.*
Ceramoporidae (14). *?U.Cam.. Ord.-Dev.*
Fistuliporidae (22). *Ord.-Perm.*
Hexagonellidae (10). *Dev.-Perm.*
Goniocladiidae (3;5). *Miss.-Perm.*
Trepostomata *(order)*, zooecial tubes with distinct immature and mature regions, aperture terminal (105). *Ord.-Perm., ?Trias.*
Amalgamata *(suborder)*, zooecial walls coalesced (70). *Ord.-Perm.*
Monticuliporidae (13). *Ord.-Dev.*
Heterotrypidae (11). *Ord.-Dev.*
Atactotoechidae (2). *Dev.*
Batostomellidae (10). *Ord.-Dev.*
Stenoporidae (27). *Sil.-Perm.*
Constellariidae (7). *Ord.-Sil.*
Integrata *(suborder)*, zooecial walls not coalesced (35). *Ord.-Perm., ?Trias.*
Amplexoporidae (5). *Ord.-Dev.*
Halloporidae (5). *Ord.-Dev.*
Trematoporidae (14). *Ord.-Dev.*
Phylloporinidae (11). *Ord.-Perm.*

Cryptostomata *(order)*, like Trepostomata but immature region short, aperture at bottom of vestibule (127). *Ord.-Perm.*
Fenestellidae (30). *Ord.-Perm.*
Acanthocladiidae (14). *Sil.-Perm.*
Arthrostylidae (11). *Ord.-Dev.*
Rhabdomesidae (29). *Sil.-Perm.*
Ptilodictyidae (7). *Ord.-Dev.*
Stictoporidae (7). *Ord.-Miss.*
Rhinidictyidae (11). *Ord.-Carb.*
Sulcoreteporidae (8). *Sil.-Perm.*
Rhinoporidae (4). *Sil.*
Cycloporidae (3). *Miss.*
Actinotrypidae (1). *Miss.-Perm.*
Worthenoporidae (1). *Miss.*
Palescharidae (1). *Ord.-Dev.*
Cheilostomata *(order)*, zooecial orifice closed by movable operculum (632;17). *?M.Jur., Cret.-Rec.*
Anasca *(suborder)*, no zooecial hydrostatic system (327;2). *?M.Jur., Cret.-Rec.*
Inovicellata *(division)* (1). *Eoc.-Rec.*
Aeteidae (1). *Eoc.-Rec.*
Scrupariina (6). *Cret.-Rec.*
Scrupariidae (5). *Cret.-Rec.*
Labiostomellidae (1). *Rec.*
Malacostega (90;2). *Cret.-Rec.*
Membraniporidae (18). *Cret.-Rec.*
Electridae (9). *Cret.-Rec.*
Flustridae (7). *Rec.*
Hincksinidae (12). *Cret.-Rec.*
Calloporidae (35;2). *Cret.-Rec.*
Chaperiidae (2). *Oligo.-Rec.*
Hiantoporidae (3). *Cret.-Rec.*
Arachnopusiidae (4). *Eoc.-Rec.*
Coilostega *(division)* (63). *?M.Jur., Cret.-Rec.*
Onychocellidae (11). *?M.Jur., Cret.-Rec.*
Microporidae (17). *Cret.-Rec.*
Lunulitidae (2). *Cret.-Rec.*
Calpensiidae (7). *Cret.-Rec.*
Steginoporellidae (4). *Eoc.-Rec.*
Thalamoporellidae (6). *Cret.-Rec.*
Aspidostomatidae (8). *Cret.-Rec.*
Setosellidae (3). *Cret.-Rec.*
Cothurnicellidae (2). *Rec.*
Alysidiidae (3). *Tert.-Rec.*
Pseudostega *(division)* (19). *Cret.-Rec.*
Cellariidae (13). *Cret.-Rec.*
Membranicellariidae (4). *Cret.-Rec.*
Coscinopleuridae (2). *Cret.-Eoc.*
Cellularina *(division)* (53). *Eoc.-Rec.*
Farciminariidae (7). *Eoc.-Rec.*
Bugulidae (14). *Rec.*
Bicellariellidae (10). *Rec.*
Beaniidae (4). *Rec.*
Scrupocellariidae (16). *Eoc.-Rec.*
Epistomiidae (2). *Rec.*
Cribrimorpha *(division)* (95). *Cret.-Rec.*
Cribrilinidae (21). *Cret.-Rec.*
Myagroporidae (1). *Cret.*
Otoporidae (3). *Cret.*
Ctenoporidae (1). *Cret.*
Thoracoporidae (1). *Cret.*
Taractoporidae (1). *Cret.*
Lagynoporidae (5). *Cret.*
Calpidoporidae (3). *Cret.*
Disheloporidae (2). *Cret.*

Rhacheoporidae (5). *Cret.*
Andrioporidae (22). *Cret.-Eoc.*
Pelmatoporidae (30). *Cret.-Rec.*
Francoporinae (2). *Cret.*
Opisthornithoporinae (1). *Cret.*
Kelestominae (3). *Cret.- Rec.*
Pelmatoporinae (7). *Cret.-Mio.*
Tricephaloporinae (5). *Cret.-Rec.*
Diacanthoporinae (1). *Cret.*
Castanoporinae (10). *Cret.-Eoc.*
Pnictoporinae (1). *Cret.*
Ascophora *(suborder)*, with zooecial hydrostatic system (305;15). *Cret.-Rec.*
Porinidae (7). *Cret.-Eoc.*
Cyclicoporidae (7). *Eoc.-Rec.*
Hippothoidae (8). *Cret.-Rec.*
Euthyroididae (1). *Rec.*
Umbonulidae (2). *Eoc.-Rec.*
Petraliidae (11). *Eoc.-Rec.*
Gigantoporidae (13). *Cret.-Rec.*
Stomachetosellidae (12). *Eoc.-Rec.*
Schizoporellidae (20;2). *Cret.-Rec.*
Hippoporinidae (21). *Cret.-Rec.*
Exochellidae (6). *Cret.-Rec.*
Microporellidae (4;4). *Mio.-Rec.*
Eurystomellidae (1). *Pleisto.-Rec.*
Mucronellidae (23;2). *Cret.-Rec.*
Tubucellariidae (5). *Eoc.-Rec.*
Reteporidae (21). *Cret.-Rec.*
Adeonidae (18;4). *Eoc.-Rec.*
Cheiloporinidae (14). *Cret.-Rec.*
Parmulariidae (3). *Cret.-Rec.*
Phylactelliporidae (7). *Cret.-Rec.*
Phylactellidae (10). *Cret.-Rec.*
Crepidacanthidae (4). *Cret.-Rec.*
Celleporidae (14). *Cret.-Rec.*
Pasytheidae (3). *Eoc.-Rec.*
Catenicellidae (14;3). *Tert.-Rec.*
Savignyellidae (5). *Rec.*
Sclerodomidae (3). *Rec.*
Onchoporidae (5). *Rec.*
Euthyridellidae (4). *Rec.*
Bifaxariidae (1). *Rec.*
Bitectiporidae (1). *Tert.*
Nephroporidae (1). *Cret.*
Platyglenidae (1). *Cret.*
Prostomariidae (1). *Tert.*
Mamilloporidae (10). *Eoc.-Rec.*
Orbituliporidae (10). *Cret.-Rec.*
Conescharellinidae (5). *Tert.-Rec.*
Fusicellariidae (1). *Cret.*
Myriozoidae (2). *Mio.-Rec.*
Lekythoporidae (6). *Tert.-Rec.*
Phylactolaemata *(class)*, fresh-water bryozoans with tentacles arranged in horseshoe-shaped manner around mouth, which has overhanging lip (9). *Cret.-Rec.*

*Summary of Classification of Bryozoa*

| | Suborders | Families | Genera | Sub-genera |
|---|---|---|---|---|
| Ctenostomata | 4 | 16 | 43 | — |
| Cyclostomata | 9 | 34 | 303 | 29 |
| Trepostomata | 2 | 10 | 105 | — |
| Cryptostomata | — | 13 | 127 | — |
| Cheilostomata | 2 | 82 | 632 | 17 |
| Gymnolaemata | 17 | 155 | 1210 | 46 |
| Phylactolaemata | — | 1 | 9 | — |
| Ectoprocta | 17 | 156 | 1219 | 46 |
| Entoprocta | — | 2 | 8 | — |
| Total | 17 | 158 | 1227 | 46 |

# DISTRIBUTION

North America, undoubtedly the most favored continent for reading Paleozoic history, is equally favored for the study of fossil bryozoans, as many of its marine limestones and shales abound in their remains. The Eurasian land mass presents many Paleozoic outcrops but they are more or less disconnected, and the fossils are not so well known. In Asia, the Salt Range of India has yielded Permian Bryozoa, while in Europe the Ural Mountains region, areas in Great Britain, and the Baltic provinces expose most of the Paleozoic strata with such fossils. Approximately 4 times as many species have been described from the North American Paleozoic as from all the rest of the world.

Ordovician formations above the Canadian abound in stony Bryozoa (Trepostomata, Cryptostomata) (Fig. 3*A*), although representatives of the Cyclostomata and a few species of Ctenostomata may be found. In the Silurian, bryozoans are not so common, Cryptostomata being developed more than Trepostomata. In the Devonian and Carboniferous, the Trepostomata became much reduced in numbers and finally disappeared, while the Cryptostomata developed a wealth of species, especially of the lacelike *Fenestella* (Fig. 3*B*) and its allies. The Ctenostomata remain as sparsely represented as before, but the Cyclostomata increased in number by development of the great family Fistuliporidae.

Beginning with the Mesozoic, a decided change occurs in these fossils. The Cryptostomata and Trepostomata apparently disappeared, the Ctenostomata became exceedingly rare, but the Cyclostomata developed many species, with zoaria quite similar to those of Paleozoic Trepostomata. These remained the predominating type until Late

Cretaceous time, when the Cheilostomata, which appeared first in the Jurassic, expanded greatly in numbers. D'ORBIGNY alone has described not less than 537 species of Upper Cretaceous Cyclostomata and 300 Cheilostomata, although many are synonyms. This unusual profusion in the Mesozoic is known mainly in European strata, for in North America and elsewhere these rocks so far have yielded comparatively few Bryozoa (Fig. 4*A*).

Both North America and Europe are noted for their Cenozoic bryozoan faunas. The Atlantic and Gulf coastal plains of North America and the northern and southern slopes of the Alps, as well as numerous other scattered European areas, are rich in Cheilostomata and Cyclostomata, the former predominating. Southern Australian Tertiary strata likewise afford bryozoans in abundance.

In the Recent seas, the Cheilostomata flourish in the highest stage of their perfection and beauty in numerous species described from all the oceans from tide level down to great depths. The voyages of the British "Challenger" and the American "Albatross" resulted in finding many new species which have since been greatly augmented by various other expeditions and the activity of local students. The seaweeds tossed up so abundantly along certain coasts afford fertile collecting places in the holdfasts of their branches, for they contain many incrusting and delicate branching forms of Cheilostomata and Cyclostomata (Fig. 4*B*).

Information concerning stratigraphic and geographic distribution of bryozoans is indexed in following paragraphs by citation of the authors and dates of more important publications. Space does not allow publication of complete references; for these one must consult monographic works or various standard bibliographies. For sake of brevity, an apostrophe (') is used to indicate the first 2 numerals of all dates between 1850 and 1950, others being given in full.

The oldest fossil reported to be a bryozoan is a supposed trepostome in Lower Cambrian rocks of western England. From Upper Cambrian strata of western Canada another presumed bryozoan, described under the name *Archaeotrypa,* is tentatively classed as a ceramoporoid cyclostome, but it may be a tabulate coral. These Cambrian records of the occurrence of bryozoans are dubious. Also, an abundant ctenostome described as *Heteronema priscum,* from Upper Cambrian sandstone of the Baltic region (13), is now considered to come from basal Ordovician beds; the fossil has been renamed *Marcusodictyon priscum.*

Higher formations in Estonia, which are assigned to Middle Ordovician, contain 18 additional genera, including 4 cyclostomes, 11 trepostomes, and 3 cryptostomes. Thus, all main types of Bryozoa, except cheilostomes, appear very early in the Paleozoic succession. The oldest discovered cheilostomes are described from Middle Jurassic (Bajocian) rocks of northwestern France.

## *Stratigraphically Arranged Summary of Publications on Bryozoans*

### Cambrian

L.CAM.: *Eng. (Shrops.),* COBBOLD, '31 (trep.).

U.CAM.: *Can.(B.C.),* FRITZ, '47 (?cycl.—*Archaeotrypa*).

### Ordovician

L.ORD.: *U.S.(Ark.),* U.S.Natl.Mus.coll. (trep.—*Nicholsonella*); *U.S.(Mo.),* CULLISON, '38 (cycl.—*Crepipora*).——*Est.,* Zone A2 (basal Ord.), BASSLER, '11 (cten.—*Marcusodictyon*).——*Wales,* L. ARENIG, LEWIS, '26 (cycl.—*Bolopora*).

M.ORD.(CHAZYAN): *NE. N. Am. (N.Y.-Vt.-Ont.-Que.),* HALL, 1847; BILL., '59; SEELY, '06; TWENHOFEL, '38.

M.ORD.(BLKRIV.): *U.S.(Appalach.),* BASSLER, '11, '19, 1952; BUTTS, '40-41; ULR., '82.——*U.S. (Tenn.),* BASSLER, '32; CORYELL, '21; SAFFORD, '51, '69; ULR., '82, '90, '93, '03; WILSON, '49.——*U.S. (Miss.V.),* LOEBLICH, '42; SHROCK & RAASCH, '37; ULR., '82, '90, '93, '96.——*NE.N.Am.(N.Y.-Ont.),* FOORD, '83; HALL, 1847; ULR., '82, '90, '93; WILSON, '21.——*Est.,* Zone B2 (Walchow), EICHW., 1829, 1832, 1840, '60; DYBOWSKI; '77, BASSLER, '11 (cycl.—*Fistulipora;* 2 crypt.—*Stictoporella, Arthroclema;* 6 trep.—*Nicholsonella, Dianulites, Esthoniopora, Hemiphragma, Dittopora, Diplotrypa*); Zone B3 (Kunda), BASSLER, '11 (3 cycl.—*Anolotichia, Mitoclema, Coscinotrypa;* crypt.—*Phyllodictya;* 11 trep. incl.—*Stigmatella, Leioclema, Orbipora, Batostoma, Hallopora*).

M.ORD.(TRENTON): *U.S.(Miss.V.),* BASSLER, '03, '06, '11, '32; BRADLEY, '30; BUTTS, '40-41; NICH., '81; NICKLES, '05; ULR., '82-83, '86, '90, '93; ULR.-B., '04; WILSON, '49.—— *N.E.N.Am.(N.Y.-Vt.-Ont.-Que.),* AMI, '92, '95; BASSLER, '11; BILL., '62; CALEY, '36, '43; FOORD, '83; HALL, 1847, 1850, '51; MATHER, '17; NICH., '75, '79, '81; PARKS, '28; RUEDEMANN, '01, '13; SPROULE, '36; ULR., '90, '93; WHITEAVES, '97; WILSON, '21.

M.ORD.(UNDIFF.): *Can.(Que.),* FRITZ, '41.——

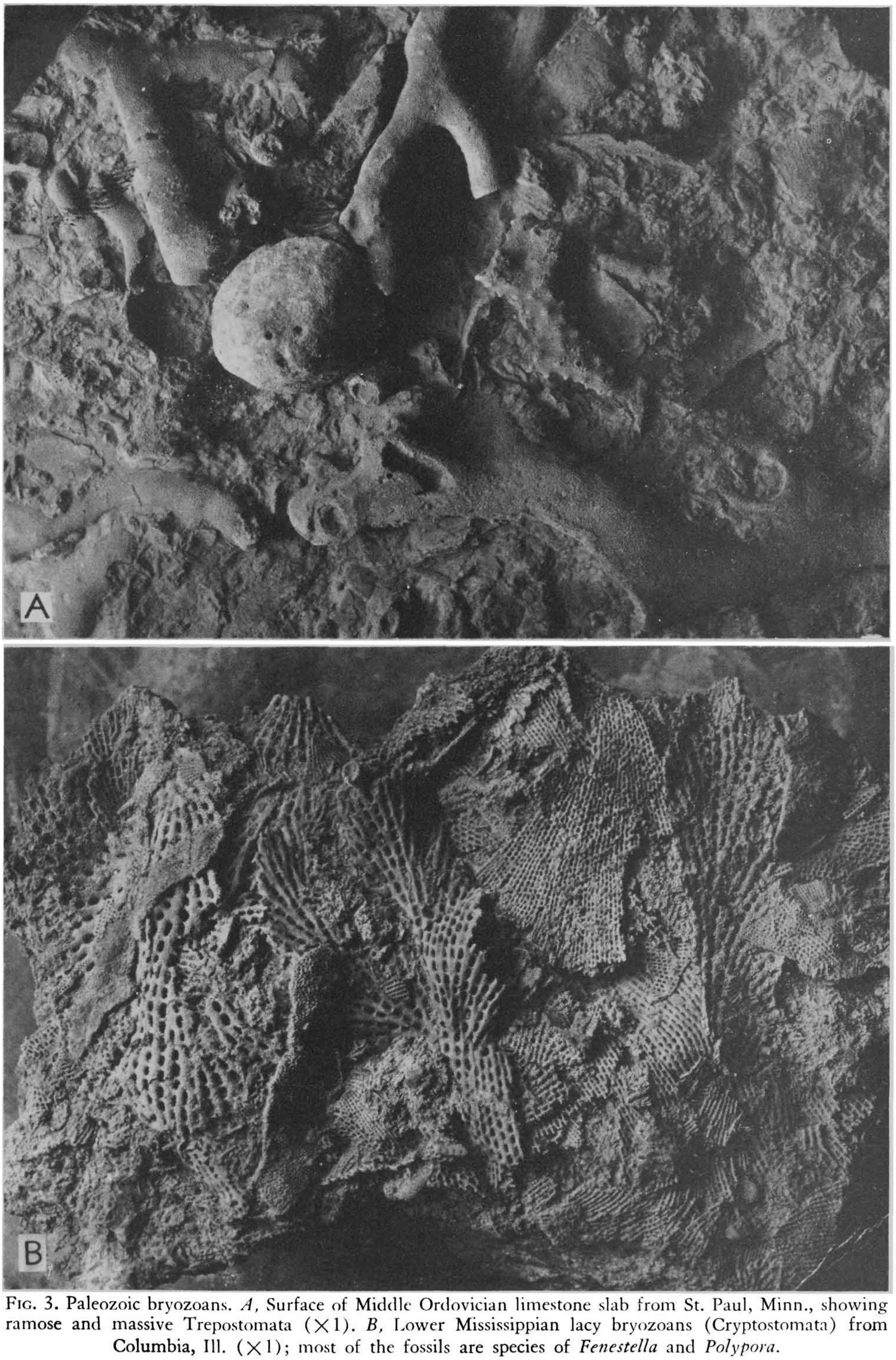

FIG. 3. Paleozoic bryozoans. *A*, Surface of Middle Ordovician limestone slab from St. Paul, Minn., showing ramose and massive Trepostomata (×1). *B*, Lower Mississippian lacy bryozoans (Cryptostomata) from Columbia, Ill. (×1); most of the fossils are species of *Fenestella* and *Polypora*.

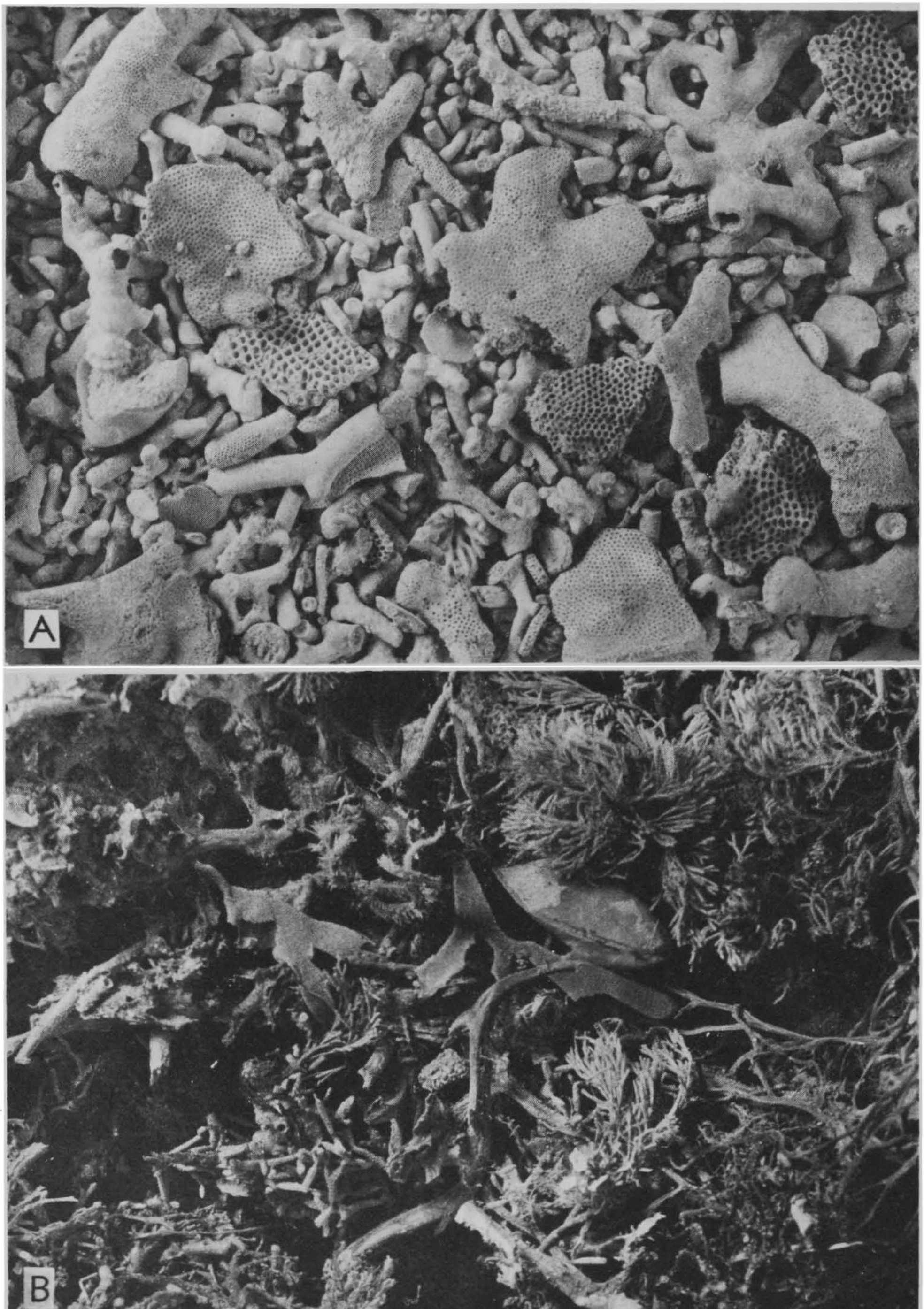


FIG. 4. Mesozoic and Cenozoic bryozoans. *A,* Fragments of solid branching Cyclostomata and sheetlike Cheilostomata from Upper Cretaceous (Maastrichtian) chalky limestone near Maastricht, Holland (×1). *B,* Delicate branching Cheilostomata of Recent age from the Pacific Coast in California (×1).

*Scot.*, NICH., '81; NICH.-E., '77; REED, '26.——*Baltic*, BASSLER, '11; BEKKER, '21; DYBOWSKI, '77; EICHW., '56, '60; ÖPIK, '27; TOOTS, 1952.

U.ORD.(EDEN.): *U.S.(OhioV.)*, BASSLER, '03, '04, '06, '11, '13; CUMINGS, '08; CUMINGS-G., '13; JAMES, '75, '78-84, '93-'96; NICH., '74-74, '79, '81; NICKLES, '05; ULR., '70, '80-84, '90, '93; WALCOTT, '79.

U.ORD. (EDEN.-MAYSV.): *NE.N.Am.(N.Y.-Ont.)*, ARMSTRONG, '45; CALEY, '40; DYER, '25; FRITZ, '26; PARKS & DYER, '22; RUEDEMANN, '25.

U.ORD.(MAYSV.): *U.S.(OhioV.)*, BASSLER, '03, '06, '13, '32; BOULE, '06; CUMINGS, '04, '12; CUMINGS-G., '13, '15; M.EDW.-H., '51, '54; HALL, 1847; JAMES, '78-84, '93-96; JAMES & JAMES, '87-88; MILLER & DYER, '75, '78; NICH., '74-75, '79, '81; NICKLES, '05; D'ORB., 1850; ULR., '79, '82-83, '90, '93, '03; ULR.-B., '04; WILSON, '49.——*U.S.(Appalach.)*, BASSLER, '11; BUTTS, '40-41.——*Can.(Ont.)*, CALEY, '40; FRITZ, '26; PARKS & DYER, '22.

U.ORD.(RICHMOND.): *U.S.(OhioV.)*, BASSLER, '03, '06, '13; CUMINGS, '08, '12; CUMINGS-G., '13; JAMES, '78, '82; NICH., '73-75, '79, '81; NICKLES, '02, '05; ROM., '60, '66; ULR., '78-79, '82, '89-90; ULR.-B., '04; WHITF., '78.——*U.S. (Miss. V.)*, BASSLER, '03, '11, '13, '32; HUSSEY, '26; NICH., '75; ROM., '60, '66; ULR., '88, '90, '93; ULR.-B., '04; WHITF., '78, '82.——*Can.(Man.)*, NICH., '74-75; OK., '43; ROM., '60; ULR., '80, '89; WHITEAVES, '95.——*Can.(Ont.-Que.)*, BASSLER, '29; BILL., '66; DYER, '25; FOERSTE, '25; FRITZ, '26; ULR., '90.——*N.Am.(Arct.)*, OAKLEY, '38; ROY, '41; TROEDSSON, '29.

U.ORD.(UNDIFF.): *Eng.*, MCCOY, 1850.—*Fr.*, DREYFUSS, '48; PRANTL, '39-41.——*Balt.*, BASSLER, '11; DYBOWSKI, '77; WIMAN, '02.——*Italy*, NEKH., '26; VINASSA, '10, '15, '41.

ORD.(UNDIFF.): *Can.(Arct.)*, TEICHERT, '37.——*Arg.*, KEYSER, '25; RUSCONI, '48.——*Czech.*, BOUCEK, '28; KETTNER, '13; PERNER, '09; POČTA, '02; POUBA, '48; PRANTL, '39.——*Italy*, VINASSA, '42.——*Asia*, GORTANI, '34; OZAKI, '33; REED, '35; YABE-H., '20.——*Austral.*, CROCKFORD, '43.

**Silurian**

L.SIL.: *Can.(Que.)*, BASSLER, '27-28; BILL., '66.——*Ont.-N.Y.*, HALL, '52; HALL-W., '75; NICH. & HINDE, '74-75, '79.——*U.S.(Ohio-Miss.V.)*, CULBERTSON, '26; FOERSTE, '87, '89, '95; SAVAGE, '27; ULR., '90.

M.SIL.(CLINT.): *Can.(Que.)*, BASSLER, '27; BILL., '66; VINE, '81-82, '84.——*U.S.(N.Y.)*, BASSLER, '06; GRABAU, '91, '01; HALL, '52; RINGUEBERG, '86; ULR.-B., '04.——*U.S.(OhioV.)*, BASSLER, '06; HALL, '52.

M.SIL.(CLIFT.): *U.S.(OhioV.)*, BASSLER, '06; HALL, '52, '76, '79, '82-83; ROM., '66; ULR.-B., '04.——*U.S.(Appalach.)*, BASSLER, '39.

M.SIL.(LOCKPORT.): *NE.N.Am.*, CLAYPOLE, '80; GRUBBS, '39; NICH., '75; ROEMER, '60, '62.

M.SIL.(UNDIFF.): *Eng.*, M.EDW.-H., '51; FOORD, '84; GOLDF., 1831; LONSD., 1839; NICH.-F., '85; SHRUBSOLE, '80; VINE, '81-82, '84-85, '87.——*Balt.*, BASSLER, '39; HENNIG, '05-06, '08; ULR., '90; ULR.-B., '04; VINE, '81, '84.

U.SIL. (TONOL.): *U.S.(Appalach.-N.Y.)*, BASSLER, '23, '39.

U.SIL.(KEYS.): *U.S.(Appalach.-N.Y.)*, BASSLER, '23, '39; BUTTS, '40-41; ULR.-B. '13.

SIL.(UNDIFF.): *Can.*, TEICHERT, '37; WHITEAVES, '01, '05.——*Greenl.*, POULSEN, '34.——*Eire*, Portlock, 1834.——*Wales*, LEWIS, '33.——Isle Man, LEWIS, '34——*Fr.*, PRANTL, '40, '43.——*Czech.*, BASSLER, '35, '39; POČTA, '94, '02; PRANTL, '32, '34-39.——*Pol.*, PRENIK, '24.——*Asia*, NEKH., '33, '36.——*Austral.*, CHAPMAN, '03; CROCKFORD, '41-42.

**Devonian**

L.DEV.(HELD.): *U.S.(Appalach.-N.Y.)*, BASSLER, '39; HALL, '74, '80-83; HALL-S., '87; ULR.-B., '18.——*U.S.(Tenn.)*, BASSLER, '39; HALL-S., '87.

L.DEV.(DEERPARK.): *U.S.(N.Y.)*, BASSLER, '39; BILL., '74; CLARKE, '00.——*U.S.(Mo.)*, TANSEY, '24.——*Can.(Que.)*, BASSLER, '39; BILL., '74; CLARKE, '07; FRITZ, '38-40, '41, '44.

L. DEV. (ONESQUETH.): *N.Y.-Ont.*, BASSLER, '39; HALL, '83, '86; HALL-S., '87; NICH., '74; ROM., '92; ULR., '86, '90, '96.

L.DEV.(UNDIFF.): *Belg.*, ASSELBERGHS, '46; MAILLIEUX, '36; SALÉE, '19.——*Ger.*, DAHMER, '46.

M.DEV.(UNDIFF.): *U.S.(N.Y.)*, BASSLER, '39; GRABAU, '99-00; HALL, '81, '83-84, '91; HALL-S., '87; NICH., '74; ROLLE, '51.——*U.S.(Mich.)*, BASSLER, '39; DEISS, '32; DUNCAN, '39; MCNAIR, '32, '37; NICH., '74; ROM., '66; ULR., '90; WINCHELL, '66.——*U.S.(Ohio)*, BAKER, '42; BASSLER, '39; MCNAIR, '37, '43; STEWART, '27.——*U.S.(Mo.)*, BRANSON, '22.——*U.S.(Wis.)*, BASSLER, '11, '39; ULR., '90.——*Can.(Ont.)*, BASSLER, '11, '39; FRITZ, '30; HALL, '84; HALL-S., '87; NICH., '74-75; NICH.-E., '77; ROM., '66; WHITEAVES, '98.——*Colom.*, MCNAIR, '40.——*Sib.*, SCHOENMANN, '27.——*Mongol.*, NEKH., '26.——*Austral.*, BASSLER, '39; CROCKFORD, '41-42.

U.DEV.(UNDIFF.): *U.S.(N.Y.)* MCNAIR, '43.——*U.S.(Ill.-Iowa)*, BASSLER, '39; FENTON-F., '24; HALL-W., '73; PROUT, '66; ROM., '66; ULR., '90; WHITE, '76.——*U.S.(Mo.)*, BRANSON, '22.——*U.S. (N.Mex.)*, BASSLER, '39; FRITZ, '44.——*Can.*, NICH., '75; WHITEAVES, '91.

DEV.(UNDIFF.): *Eng.*, ETH.-F., '84; PHILLIPS, 1841; WHIDBOURNE, '95.——*Fr.*, DOLLFUSS, '88; FRECH, '85, '86; LEMAITRE, '33; NICH.-F., '85; OEHLERT, '88; DE VERNEUIL & HAIME, '52.——*Ger.*, FRECH, '85, '96; GOLDF., 1827; NICH., '79; NICH.-F., '85; QUENST., '81; ROLLE, '51; SCHLÜTER, '85; SOLLE, '37, 1950, 1952; TOOTS, 1951.——*Portugal*, DE ANDRAHE, '45.——*Czech.*, KETTNER, '19; POČTA, '94; PRANTL, '28-29, '32, '33, '35, '37-39, '42.——*Pol.*, GÜRICH, '96.——*Italy*, GORTANI, '11.——*Asia*, KRASNOPAYEVA, '35; NEKH., '26, '40; REED, '22.——*N.Z.*, ALLAN, '35; SHIRLEY, '38.

**Mississippian (Lower Carboniferous)**

L.MISS.(KIND.): *U.S.(Iowa)*, ULR., '90.

L.MISS.(OSAG.): *U.S.(Miss.V.)*, BASSLER, '32; GIRTY, '15; KEYES, '94; MEEK-W., '65, '68; PROUT, '58, '60; ROM., '66; ULR., '88, '90; WELLER, '09; WINCHELL, '63.

U.MISS.(MERAMEC.): *U.S.(Miss.V.)*, BASSLER, '39; CUMINGS, '05-06; GIRTY, '11; HALL, '57; PROUT, '58, '60; ROM., '66; ULR., '84, '88, '90; WELLER, '08, '20.——*U.S.(Appalach.)*, BUTTS, '41.

U.MISS.(CHEST.): *U.S.(Miss.V.)*, BASSLER, '39, '41; BUTTS, '41; EASTON, '42-43; GIRTY, '10; HAAS, '46; MCFARLAN, '42; PROUT, '58-60; ULR., '84, '90; WELLER, '20.——*U.S.(Ariz.)*, HERNON, '35.

MISS.(L.CARB.)(UNDIFF.): *U.S.*, CONDRA-E., '44; SIMPSON, '94; ULR.-B., '04.——*Can.(N.Scot.)*, BELL, '29; DAWSON, '78.——*Can.(B.C.)*, FRITZ, '42.——*Bol.*, D'ORB., 1842.——*Eng.*, LEE, '12; MUNRO, '12; PHILLIPS, 1836, 1841; SHRUBSOLE, '79, '81; VINE, '77-79, '81, '88, '90; YOUNG, '81, '83; Y.-Y., '74-75, '80, '83, '88-89.——*Eire*, MCCOY, 1844.——*Belg.*, DEKON., 1842-44, '71; KAISIN, '42. ——*Ger.*, NEKH., '32.——*Russ.*, NIKIF., '27, '33; STUCK., '01, '07; TOLMACHOFF, '31.——*Sib.*, NEKH., '26; TOLMACHOFF, '24, '36.——*Turkestan*, NIKIF., '26, '33.——*Mal.*, OAKLEY, '48.——*Austral.*, CHAPMAN, '20; CROCKFORD, '47, '49; DEKON., '76, '98.

### Pennsylvanian (Upper Carboniferous)

L.PENN.: *U.S.(Ark.-Okla.)*, CORYELL, '24; HARLTON, '33; MATHER, '15.

M.PENN.: *U.S.(OhioV.)*, FOERSTE, '87; MEEK, '75; MORNINGSTAR, '22; ULR., '90.——*U.S.(Ill.)*, FOERSTE, '87; MEEK, '72; ULR., '90; ULR.-B. '04; WHITE, '78; WORTHEN, '75.——*U.S.(Mo.-Kans.-Okla.)*, BEEDE & ROGERS, '01; CONDRA, '02; GIRTY, '15; WARTHIN, '30.——*U.S.(Tex.)*, PLUMMER & MOORE, '21.

U.PENN.: *U.S.(Mo.-Kan.-Okla.)*, BEEDE & ROGERS, '01; CONDRA, '02; CONDRA-E., '44; ELIAS, '37; MOORE-D., '44; ROGERS, '00; SAYRE, '30.——*U.S. (Tex.)*, MOORE, '29-30; PLUMMER & MOORE, '21.

PENN. (U. CARB.) (UNDIFF.): *U.S. (N.Mex.-Utah)*, CONDRA-E., '44; PROUT, '58.——*Can.(B.C.)*, WARREN, '27.——*Arct. (Ellesm.)*, TSCHERNYSCHEV & STEPANOW, '16.——*Peru*, CHRONIC, '49.——*Arg.*, REED, '27.——*Balk.*, PRANTL, '34, '39.——*Russ.*, FREDERIKS, '15, '20; SHULGA, '33, '36.——*Sib.*, NEKH., '35.——*Austral.*, CROCKFORD, '47. '49.

### Carboniferous (Undifferentiated)

CARB.: *Aus.*, DEKON., '73; HERITSCH, '30-31; JOHNSEN, '06.——*Russ.*, BOLKHOWITZ & MARKOFF, '26; FREDERIKS, '32; KEYSERLING, 1846; LEE, '09; LUDWIG, '61-62; NIKIF., '33, '38; TOOTS, 1951.——*Turk.*, NIKIF., '34.——*Mongol.*, NEKH., '35.——*India*, DEKON., '63.——*Austral.*, NICH.-E., '86.

### Permian

PERMOCARB.: *Bol.-Peru*, BASSLER, '36; CHRONIC, '49; MEYER, '14; D'ORB., 1842.——*Iran*, DOUGLAS, 1836.——KASHMIR, DIENER, '99.

L.PERM.: *U.S.(Nebr.-Kans.-Okla.)*, CONDRA, '02; ELIAS, '37; MEEK, '72; MOORE-D., '44; ROGERS, '00.——*Russ.*, NIKIF., '38-39; SHULGA, '33, '36, '39, '41, '49; STUCK., '95; TRIZNA, '39.——*Arct. (Spitz.-N.Zem.)*, NIKIF., '36; TOULA, '75.

U.PERM.: *U.S.(Okla.-Tex.)*, GIRTY, '08; MOORE, '39; MOORE-D., '44; PROUT, '58.——*U.S.(Ariz.)*, CONDRA-E., '44-45.——*Can.(B.C.)*, FRITZ, '32, '46.

PERM.(UNDIFF.): *Col.*, ROYO & GOMEZ, '45.——*Eng.*, KING, 1850.——*Ger.*, GEINITZ, '61, '66; KORN, '30.——*Aus.*, JOHNSEN, '06.——*Italy*, GREGORIO, '30.——*Russ.*, LIKHAREV, '25; NIKIF., '38-39; SHULGA, '41; STUCK., '95; TRIZNA, '39; YAKOVLEV, '45.——*Turk.*, METZ, '39; NIKIF., '33.——*Tibet*, MERLA, '34; METZ, '46; NIKIF., '33.——*China*, GIRTY, '08; GRABAU, '31; MINATO, '43; REED, '27, '33; YABE-S., '42; YOH, '32.——*Japan*, OZAWA, '25.——*Indochina*, COLANI, '19; MANSUY, '13-14, '20.——*India*, DEKON., '63; REED, '25, '31; WAAG. & PICHL, '85; WAAG.-W., '86.——*E.Indies (Timor)*, BASSLER, '29.——*Austral.-Tasm.*, BRETNALL, '26; CROCKFORD, '41, '43-46; ETH., '91-92, '21; HOSKING, '31; HUMMELL, '15; LONSD., 1845.

### Triassic

TRIAS.(UNDIFF.): *Arg.*, RUSCONI, '48.——*Italy*, GREGORIO, '30.——*Rumania*, KÜHN, '36.——*Hung.* PAPP, '00; VINASSA, '11.——*Russ.*, NEKH., '49.——*N.Z.*, WILCKENS, '27.

### Jurassic

M.JUR.: *Eng.-Fr.*, BRAUNS, '79; CANU, '98, '13; CANU-B., '22, '29; FRIREN, '92; GREGORY, '96; HAIME, '54; LAMX., 1821; LANG, '04; MICH., 1840-46; D'ORB., '51-52; VINE, '82-93; WALFORD, '84, '87, '89, '94.

JUR.(UNDIFF.): *U.S.(Tex.)*, ALBRITTON, '38; CRAGIN, '05.——*Fr.*, CANU, '13; HAIME, '54; ORIEUX, '40; SAUVAGE, '89.——*Belg.*, JOLY, '36.——*Ger.*, GOLDF., 1825-33; KOCH & DUNKER, 1837; KÜHN, '35, '39; ROEMER, 1836; WOLFER, '13.——*Balk.*, PRANTL, '38.——*Pol.*, REUSS, '67.——*Switz.*, PETERHANS, '27.——*Eur.*, CANU-B., '22, '26, '29.

### Cretaceous

L.CRET. (NEOCOM.): *Fr.*, CORROY, '25.——*Switz.*, BASCHONG, '21; CANU, '02; CANU-B., '26; GREGORY, '99, '09; DELORIOL, '63, '68; D'ORB., '51-54.——*Ger.*, GREGORY, '09; KOCH & DUNKER, 1837; ROEMER, 1840; VOIGT, '24, '30.——*Russ.*, BAILEY, '48; GREGORY, '09.

L.CRET.(APT.): *Eng.*, CANU-B., '26; GREGORY, '09; KEEPING, '83; PITT, '49; VINE, '89.——*Fr.*, GREGORY, '09; D'ORB., '54.

L.CRET.(ALB.): *Eng.*, GREGORY, '09; VINE, '85.——*Fr.*, D'ORB., '54.

U.CRET.(CENOM.): *Fr.*, CANU, '97, '00; CANU-B., '22; GREGORY, '09; LECOINTRE, '12; D'ORB., '51; PERGENS, '89.——*Ger.*, GOLDF., 1827; GREGORY, '99, '09; REUSS, '72; SIMONOWITSCH, '71; VOIGT, '42.——*Czech.*, GREGORY, '99, '09; NOVAK, '77; POČTA, '92; PRANTL, '38; REUSS, 1846.——*Tunisia*, CANU, '03.

U.CRET.(TURON.): *Eng.*, BRYDONE, '18; GREGORY, '99, '09; LANG, '16.——*Fr.*, CANU, '97; D'ORB., '51-54; PERGENS, '92.——*Ger.*, REUSS, '74; VOIGT, '24.——*Czech.*, NOVAK, '77; PRANTL, '38——*Tunisia*, PERON, '93.

U.CRET.(CONI.): *Eng.*, BRYDONE, '17, '30; GREGORY, '09; LANG, '16; LEV., '12; THOMAS, '39.——*Fr.*, ALLEGRE, '36; FILLIOZAT, '07-08; GREGORY, '99, '09; LANG, '16; LEV., '12; D'ORB., '51-54; PERGENS, '93.

U.CRET.(SANTON.): *Eng.*, BRYDONE, '16-17, '29; GREGORY, '09; LANG, '16; D'ORB., '51-54; THOMAS, '35.——*Fr.*, CANU, '00; GREGORY, '99, '09.————*Ger.*, VOIGT, '24.——*Egypt*, CANU, '04.

U.CRET.(CAMP.): *Eng.*, BRYDONE, '06, '09-18, '29-'30, '36; GREGORY, '99, '09; LANG, '16, '18, '21-22. ——*Fr.*, GREGORY, '09; LANG, '21; D'ORB., '53.——

*Ger.*, BEISSEL, '65; GOLDF., 1827-33; GREGORY, '99; HAG., 1839-40, 1846; LANG, '16, '21-22; LEV., '25; MARSSON, '87; PERGENS, '93; VOIGT, '23-24, '29-30. ——*Swed.*, GREGORY, '99, '09; HENNIG, '92, '94; VOIGT, '30.

U.CRET.(MAASTR.): *Holl.*, GOLDF., 1826-33; GREGORY, '99; HAG., '51; HAMM, '81; MEUNIER & PERGENS, '85; PERGENS, '94; QUENST., '81; UBAGHS, '58, '65; VOIGT, '30.——*Belg.*, GREGORY, '09; PERGENS, '87.——*Fr.*, CANU, '20; CANU-B., '22; GILLARD, '40, '42.——*Ger.*, VOIGT, 1951.——*Sp.*, BARROSA, '44.

U.CRET.(DAN.): *Denm.*, BERTHELSEN, '48; LEV., '25; PERGENS & MEUNIER, '86; VOIGT, '23, '30.——*Swed.*, GREGORY, '99, '09; HENNIG, '92; VOIGT, '30.——*Ger.*, VOIGT, '25, '28.——*Aus.*, KÜHN, '30.

U.CRET.(UNDIFF.): *U.S.(Tenn.)*, CANU-B., '26.——*U.S.(Colo.)*, WHITE, '83.——*Arg.*, CANU, '11.——*Eng.*, BRYDONE, '06-18, '29-30, '36, '42; VINE, '84-95, '98.——*Fr.*, JULLIEN, '86; D'ORB., '51-54.——*Ger.*, SCHONFELDER, '33.——*Italy*, SEGUENZA, '82. ——*N. Afr.*, ZUFFARDI-COMMERCI, '27.——*S. Afr.*, LANG, '08.

CRET.(UNDIFF.): *Can.(Georges Bank)*, BASSLER, '36. ——*Braz.*, WHITE, '87.——*Eng.*, CASTER, '32.——*N.Afr.*, ALLEGRE, '33.——*S.Afr.*, LANG, '06.——*Madag.*, CANU, '22.——*India*, CHIPLONKER, '39; STOLICZKA, '42.

**Paleocene**

PALEOC.(MONT.): *Belg.*, CANU, '00, '07; MEUNIER & PERGENS, '86.

PALEOC.(MIDWAY.): *U.S.(GulfMex.)*, CANU-B., '20.

**Eocene**

L.EOC.(LED.): *Belg.-Fr.*, CANU-B., '29; DARTEVILLE, '33, '39; MEUNIER & PERGENS, '86.

L.EOC.(WILCOX.): *U.S.(N.J.)*, CANU-B., '33; GABB-H., '60, '62; LONSD., 1845; VOIGT, '42.——*U.S. (Md.-Va.)*, CANU-B., '20; ULR., '01.——*U.S.(Gulf Mex.)*, CANU-B., '20.

M.EOC.(LUT.): *Eng.*, BUSK, '66; DAVIS, '34; GREGORY, '93; VINE, '89, '91.——*Fr.*, BUGE, '46; BUGE & BALAVOINE, '01; CANU, '07-08, '10, '13, '18.——*Ger.*, BEUTLER, '08; KOSCHINSKY, '85.——*Sp.*, FAURA & CANU, '17.——*Tunisia*, CANU, '04.

M.EOC.(CLAIB.): *U.S.(N.Car.-S.Car.)*, CANU-B., '20; GABB-H., '62; LONSD., 1845.——*U.S.(GulfMex.)*, CANU-B., '20; GABB-H., '62; GREGORIO, '90; LEA, 1833.

U.EOC.(BARTON.): *Fr.*, CANU, '07, '10-12; CANU & CAILLOT, '32; MORELLET, '48.——*Ger.*, REUSS, '64. ——*Pol.*, PAZDRO, '29; PERGENS, '89.——*Hung.*, PERGENS, '96.——*Italy*, CANU-B., '20; GOTTARDI, '86; REUSS, 1847, '68-69; WATERS, '91-92, '19.

U.EOC.(JACKSON.): *U.S.(N.Car.-S.Car.-Ga.)*, CANU-B., '20.——*U.S.(GulfMex.)*, CANU-B., '20; MCQUIRT, '41.

EOC.(UNDIFF.): *Afr.*, CIPOLLA, '34; PFENDER, '34; ZUFFARDI-COMMERCI, '48.——*N.Z.*, UTTLEY, '49.

**Oligocene**

L.OLIGO.: *Belg.*, CANU-B., '31.——*Ger.*, FRANCKE, '39; REUSS, '67; STOLICZKA, '62.——*U.S.(Gulf-Mex.)*, CANU-B., '20.

M.OLIGO.: *Ger.*, REUSS, '65; *Fr.*, CANU, '14, '17; REUSS, '69.——*U.S.(GulfMex.)*, CANU-B., '20.

U.OLIGO.: *Ger.*, GORGAS, '41; REUSS, '58, '64.——*Aus.*, STACH, '36.——*U.S.(GulfMex.)*, CANU-B., '20; MCQUIRT, '41.——*C.Am.(C.Z.)*, CANU-B., '19. ——*W.Indies*, CANU-B., '19, '23.

OLIGO.(UNDIFF.); *Pol.*, REUSS '67.——*Arg.*, CANU, '08.——*N.Z.*, BROWN, '48, 1952; UTTLEY, '48.

**Miocene**

L.MIO.(AQUIT.-BURDIG.): *Fr.*, CANU, '06-07, '09, '13, '16-17; DUV., '21, '24; VIG., '49.——*Sp.*, FAURA & CANU, '16.——*Italy*, CANU, '13.——*U.S.(Fla.)*, CANU-B., '23.——*W.Indies*, CANU-B., '19, '23.——*W.Indies*, CANU-B., '19, '23.——*C.Am.*, CANU-B., '19.

M.MIO.(HELV.): *Fr.*, BALAVOINE, '48; BUGE, '48; CANU, '09, '17; CANU-L., '25, '27-28, '30, '33-34; DUV., '20-21, '24; VIG., '49.——*Italy*, CANU, '13. ——*Egypt*, CANU, '04, '12.——*Crete*, KÜHN, '36. ——*U.S.(Md.-Va.)*, CANU-B., '23; ULR.-B., '04. ——*Austral.*, CANU-B., '35; MACGILL., '95; MAPLE., '98-04, '08, '10, '12-13, '18; STACH, '32-37; T-WOODS, '76.——*N.Z.*, BROWN, '48, 1952; STOLICZKA, '64; T-WOODS, '80; UTTLEY, '49; WATERS, '87.

U.MIO.(TORT.): *Fr.*, CANU, '13.——*Aus.-Hung.*, REUSS, '47-48, '74.——*Czech.*, CANU, '13.——*U.S. (Va.-N.Car.-S.Car.-Fla.)*, CANU-B., '23; GABB-H., '62; LONSD. 1845.

MIO.(UNDIFF.): *Fr.*, CANU, '07-10, '20; PERGENS, '87, '91.——*Italy*, SCOTTI, '36.——*Aus.*, KÜHN, '25. ——*Yugo.*, PERGENS, '87.——*Russ.*, NICOLAESCU, '32; PERGENS, '89; REUSS, '69; SAULA-BOCCE, '43; SINZOW, '92.——*Libya*, PANZERA, '32.——*Kenya*, THOMAS, '30.——*Canaryl.*, DARTEVILLE, '37.——*Iran*, DARTEVILLE, '45.——*Japan*, SAKAKURA, '36. ——*U.S.(La.)*, MCQUIRT, '41.——*C.Am.*, GABB-H., '62.——*Colom.*, TOLMACHOFF, '34.——*Arg.*, CANU, '04, '08; CONTE, '49.

**Pliocene**

PLIO. (UNDIFF.): *Eng.*, BUSK, '59.——*Holl.-Belg.*, CANU, '20; LAGAAIJ, 1952.——*Fr.*, CANU, '13.——*Sp.*, BARROSA, '45; FAURA & CANU, '16.——*Italy*, CIPOLLA, '21; MANZONI, '69, '75; NAMIAS, '90-91; NEVIANI, '95, '98; WATERS, '78.——*Cyprus-Rhodes*, MANZONI, '77; PERGENS, '87; REED, '35.——*N.Afr.*, BUGE, '47; CANU, '13.——*U.S.(S.C.-Fla.)*, CANU-B., '23; TUOMEY & HOLMES, '57.——*C.Am.*, CANU-B., '28.——*Arg.*, CANU, '08.——*Japan*, SAKAKURA, '35.——*Austral.*, STACH, '35.——*N.Z.*, BROWN, 1952; UTTLEY, '49.

**Tertiary (Undifferentiated)**

TERT.: *Ger.*, REUSS, '51; ROEMER, '63.——*Italy*, CIPOLLA, '26; GIOLI, '89; MANZONI, '69-71; NEVIANI, '00, '05; SEGUENZA, '79.——*Sp.*, BARROSA, '49.——*Hung.*, KARÖSSY, '40.——*Russ.*, MOKRINSKII, '15-16.——*Greece*, MITZOPOULOS, '40.——*N.Afr.*, CANU, '04; CIPOLLA, '26, '29, '33.——*Tasm.*, T.WOODS, '77.——*Antarct.*, WILCKENS, '24.

**Pleistocene**

PLEISTO.: *Italy*, CANU, '20; CIPOLLA, '24-25; NEVIANI, '91, '95-96.——*Can.(Que.)*, DAWSON, '59.——*U.S.(Atl.Coast)*, CANU-B., '23.——*C.Am.*, CANU-B., '23.—— *U.S.(Calif.)*, CANU-B., '23; GABB-H., '62.——*Arg.*, CANU, '08.——*Japan*, SAKAKURA, '35, '38.——*Antarct.*, HENNIG, '11.

**Recent**

ARCT.: ABRIKOSOV, '45; BIDENKAP, '00, '05; BORG, '26; HINCKS, '80; KLUGE, '06, '29; LEV., '16; NORGAARD, '96-97, '00, '03-06, '18, '23; NORMAN, '03, '05; OSBURN, '19, '28, '30; RIDLEY, '81; SMITT, '66, '77-78; WATERS, '00, '04.

N.ATL.(WEST): CANU-B., '28; HINCKS, '88-89, '92; HUTCHINS, '45; LEIDY, '55; MARCUS, '41; OSBURN, '10, '12-14, '27, '32-33, '40, '44, '47; ROGICK & CROASDALE, '49; SMITT, '72-73.

N.ATL.(EAST): BARROSA, '12, '15; BORG, '26; BUSK, '58-60, '81, '84, '86; CALVET, '28, '31; CANU-B., '25, '28; COUCH, 1844; HARMER, '91, '33; HASSALL, 1840-41; HINCKS, '60, '62, '77; JOHNSON, 1847; JULLIEN, '82; JULLIEN & CALVET, '03; LANDSBOROUGH, '52; LEV., '94, '09; LOPPENS, '06, '48; MARCUS, '19, '26, '40; MOORE, '37; NOBRE, '04, '37: NORDGAARD, '24-25; NORMAN, '09; ORTMANN, '94; OSBURN, '26; PERGENS, '89; SILÉN, '43, '46-47; WATERS, '99, '18.

S.ATL.: BORG, '44; BUSK, '84, '86; CANU-B., '28; HASENBANK, '32; JULLIEN, '91; MARCUS, '37-39, '41-42, '49; D'ORB., 1839; RIDLEY, '81; WATERS, '05.

MEDIT.: ANTIPA, '41; AUDOUIN, 1826; BARROSA, '15-35, '49; CALVET, '02, '27; CANU, '04, '12; CANU-B., '25, '28, '30; FRIEDEL, '18; HELLER, '67; HINCKS, '86-88; NEVIANI, '39; PERGENS, '89; SAVIGNY, 1809; WATERS, '79, '90, '97, '10, '18, '22-23, '25.

S.AFR.COAST: BUSK, '52, '54, '84, '86; HINCKS, '80, '91; LEV., '09; MARCUS, '22; O'DONOGHUE, '24; O'DONOGHUE & DEWATTEVILLE, '35, '37, '40.

INDIANO.: BUSK, '86; CANU-B., '29; HARMER, '15, '24, '26, '34; HASENBANK, '32; HINCKS, '84, '87; KIRKPATRICK, '88; MARCUS, '21-22; ROBERTSON, '21; THORNELEY, '05; WATERS, '13-14.

ANTARCT.: BORG, '26, '44; BUSK, '79, '86, '88; CALVET, '09; HARMER, '34; HASENBANK, '32; HASTINGS, '43; KLUGE, '01-03, '23; LIVINGSTONE, '11-14, '28; THORNELEY, '24; WATERS, '98, '04.

SW.PAC.: BORG, '44, BRETNALL, '22; BUSK, '84, '86; CANU-B., '29; HARMER, '26; HASENBANK, '32; HASTINGS, '32; HINCKS, '81, '83-85, '91, '93; HUTTON, '73, '80, '96; KIRKPATRICK, '90; LEV., '09; MACGILL., '79-91; MAPLE., '05, '09; MARCUS, '22; SILÉN, '46; UTTLEY, '49; WATERS, '89, '06, '21; WILSON, '80.

S.PAC.: BUSK, '84; CANU-B., '29-30; HARMER, '23; HASTINGS, '30; LEV., '09; MARCUS, '21; OSBURN, 1950, 1952; WATERS, '89.

N.PAC.: BORG, '33; BUCHNER, '24; BUSK, '84; CANU-B., '27-29; HARMER, '26; HINCKS, '82, '84; MAPLE., '08-09; MATAWARI, '48; O'DONOGHUE & O'DONOGHUE, '23, '25-26; OKADA, '17-21, '23, 28-29, '33-34; OKADA & MATAWARI, '35; D'ORB., 1839, 1846; ORTMANN, '80, '90; OSBURN, 1950, 1952;ROBERTSON, '00, '04-06, '08, '10; SAKAKURA, '35; SILÉN, '24, '41-42, '47; YANAGI & OKADA, '18.

# SYSTEMATIC DESCRIPTIONS

## Phylum BRYOZOA Ehrenberg, 1831

[=Polyzoa J. V. THOMPSON, 1830]

Minute, almost exclusively marine colonial animals, comprising a very few forms without hard parts, some with a membranous covering partly chitinous, and a vast majority with a calcareous skeleton. The body contains a U-shaped alimentary canal with mouth and anus, the mouth being surrounded by slender ciliated tentacles which function in gathering food. Reproduction of individuals within the variously shaped colonies is by budding, but fertilized ova produced by some members of the colony are ultimately liberated as free-swimming larvae, which later become attached and initiate growth of new colonies. *?U.Cam., Ord.-Rec.*

## Subphylum ENTOPROCTA Nitsche, 1869

[=Calyssozoa A. H. CLARK, 1921; Kamptozoa CORI, 1927]

Soft-bodied animals without hard parts and lacking a body cavity; a ring of tentacles borne on a fleshy ridge (lophophore) encloses both mouth and anus, the tentacles being folded into a vestibule closed by a sphincter when they are retracted. *Rec.*

The comparatively few species assigned to this assemblage are interpreted either to represent the most primitive expression of the Bryozoa or to be referable to an independent phylum less highly organized than the bryozoans. In the Entoprocta, the tentacles of the naked stalked polypide are folded or rolled inward during retraction, coming to rest in a vestibule closed by a circular muscle; they are not pulled downward by withdrawing the lophophore which supports them (Fig. 5). The body wall is not strengthened by chitin or calcium carbonate, and no open space (coelome) occurs between it and the alimentary canal. Excretory and reproductive organs are present, with ducts leading to the vestibule.

Individuals formed by budding are characterized by extreme isolation from one another, and in this respect they differ from almost all other bryozoans, among which neighboring members of the colony normally are in close contact. In the typically entoproctous genus *Loxosoma,* no colony is formed even though new individuals develop by budding from old ones, for each zooid breaks away when it has matured, and leads an independent existence. Other genera of the Entoprocta exhibit a colonial mode of growth in which a threadlike duct (stolon) at intervals emits a cylindrical stalk that expands terminally as the body of a zooid. Best-known genera include *Loxosoma* KEFERSTEIN, 1863; *Urnatella* LEIDY, 1851; and *Pedicellina* M. SARS, 1839 (Fig. 5). They are confined to fresh waters. No representatives of the Entoprocta are known as fossils.

## Subphylum ECTOPROCTA Nitsche, 1869

Lophophore circular or horseshoe-shaped, surrounding mouth but not the anus; tentacles retractile into an inwardly folded delicate sheath (introvert) formed by part of the body wall. Fluid-filled body cavity surrounding the alimentary canal contains reproductive organs. Body wall membranous or calcareous. Exclusively colonial and almost entirely marine. *?U.Cam., Ord.-Rec.*

## Class GYMNOLAEMATA Allman, 1856

Lophophore circular, without a lip (epistome) overhanging the mouth; body cavities not connected and body wall not muscular. *?U.Cam., Ord.-Rec.*

This division, bearing a name which signifies "naked [unprotected] throat," contains an overwhelming majority of all known bryozoans, fossil and Recent. Almost exclusively they are marine. Some have a membranous or chitinous zooecial covering around the polypides, but most have a calcareous skeleton.

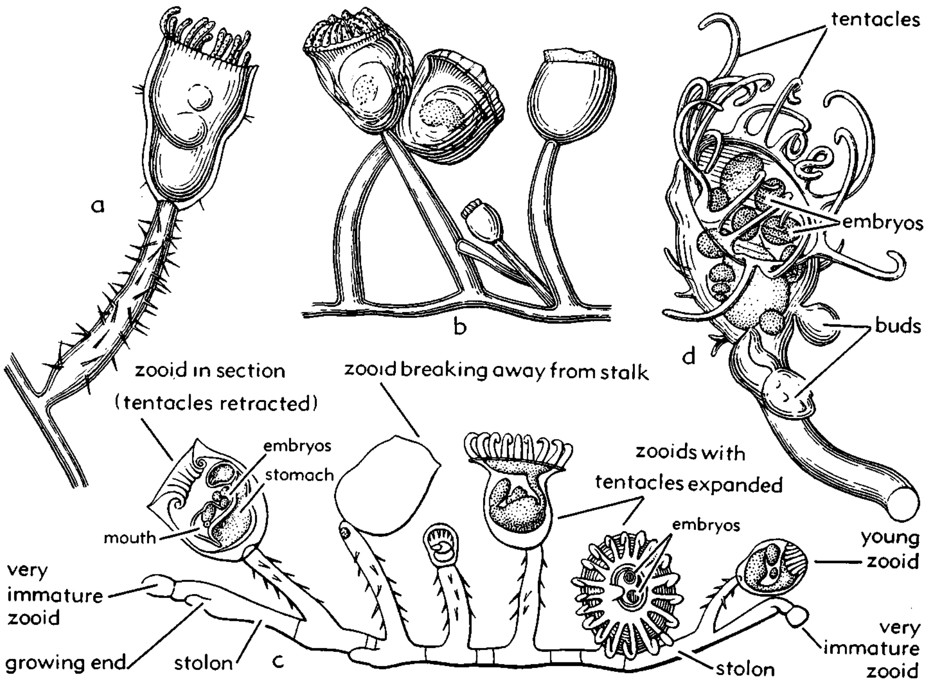


FIG. 5. Morphological features of Entoprocta.
*a-c, Pedicellina cernua* PALLAS, Rec., NE.Atl. *a,* Zooid with spinose stalk (peduncle), polypide with extended tentacles; flexuous stolon at lower left (×36). *b,* Zooids in various growth stages, ×20. *c,* Colony showing growing end of stolons, embryos, and young to mature zooids, ×22 (167).
*d, Loxosoma cerriferum* HARMER, Rec., E.Ind., female zooid showing embryo within circle of tentacles and various stages of buds, enlarged (164).

## Order CTENOSTOMATA Busk, 1852

[=Cheiloctenostomata SILEN, 1942 *(partim)*]

Zooids developed by budding from a slender tubular stolon, generally isolated. Zooecia membranous, with terminal aperture closed by a flexible fold of the body wall bearing a comblike row of setae. Specialized reproductive individuals (gonozooids) occur in some families. *Ord.-Rec.*

Zooids of the Ctenostomata resemble the Entoprocta in being isolated from one another and developed by budding from internodes of a distinct tubular stolon or stem. They may unite laterally to form sheets, but in both types of zoarium the body wall of the zooids is uncalcified and generally quite soft. The threadlike stolon gives off cylindrical stalks, each of which dilates at its end into the body of the zooid. In all known living ctenostomes, the zooecia are membranous, being little capable of preservation as fossils. In some, however, the stolon becomes partially calcified and thus may be preserved in rocks. Also, some Ctenostomata are able (possibly by chemical solution) to excavate a place for themselves in substance of the shell or other host which they incrust, and the size and shape of such excavations may serve for identification of fossil species.

The Ctenostomata are typically marine, but a few genera live in estuaries, for which reason and others, they have been judged to be progenitors of the exclusively fresh-water class Phylactolaemata.

Illustration of the anatomy of zooids of a

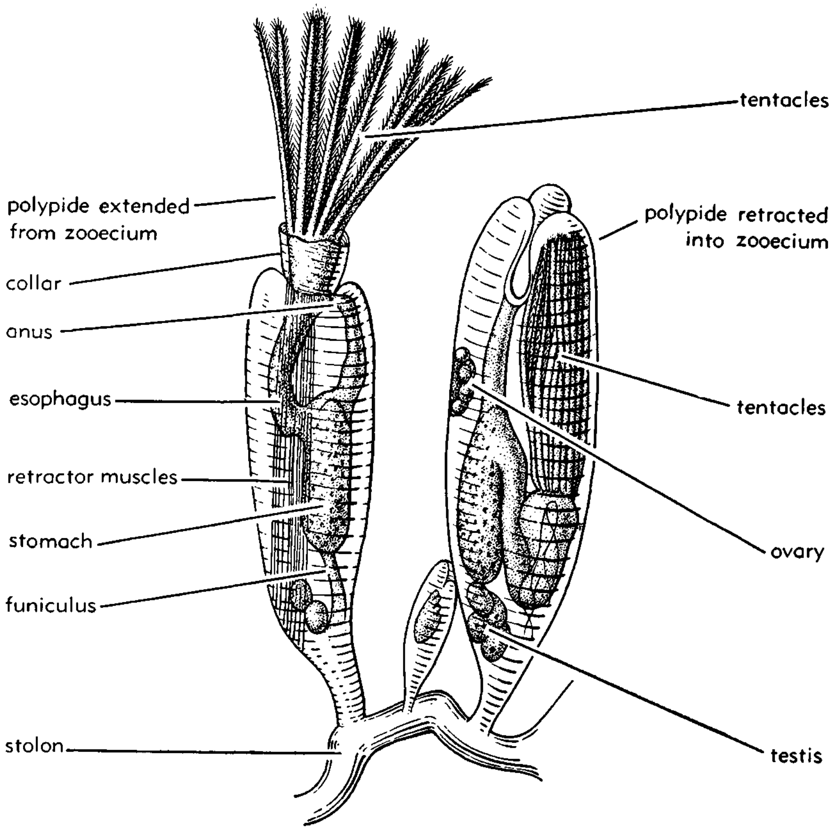


FIG. 6. Morphological features of a typical ctenostome (*Farrella repens* FARRE, Rec., E.Atl.) showing adult zooids and a young one growing from a stolon, the tentacles of one individual extended and in another retracted *(after van Beneden)*.

Recent ctenostome (Fig. 6) makes evident the similarity in structure of these bryozoans to representatives of other orders. The pinnately arranged stolons of *Ropalonaria* (Ord.-Perm.), indicated by excavations in shells or corals, are perhaps the most common Paleozoic fossils belonging to this group, although the chainlike *Allonema* (Sil.-Penn.) and radially arranged bulbous vesicles of *Eliasopora* (Sil.-Miss.) often are found. The threadlike species are interesting because (excepting the doubtful *Archaeotrypa* from Upper Cambrian rocks) the oldest known bryozoan is a ctenostome of this type, named *Marcusodictyon priscum;* it occurs in lowermost Ordovician strata of Estonia. Many of the known Paleozoic Ctenostomata formerly were regarded as trilobite eggs, sponge borings, or foraminifers (39,116). Possibly the slightly calcified zoaria of all known Paleozoic ctenostomes represent creeping bases which supported the zooids.

Mesozoic and Tertiary ctenostomes seem to be rare, for little has been published about them. The few recorded forms are most like *Ropalonaria.*

In Recent seas, some ctenostome species are very abundant as individuals and widely distributed (70,75). *Alcyonidium* and related genera grow as soft incrustations or build masses 6 inches high, and in these the zooecia are closely united. In *Bowerbankia,* erect branches of the zoarium bear tufts of zooecia at regular intervals; in *Amathia,* the branches have a spiral arrangement.

The classification of Recent Ctenostomata adopted here is that which prevailed before SILÉN (1942) published studies in which he combined the ctenostomes with cheilostomes as Cheiloctenostomata. In view of the great time interval between Early Ordovician, when the oldest known ctenostome appeared and middle Mesozoic, when the first cheilostomes became established, close relationship between these divisions of the Bryozoa seems improbable.

## Suborder CARNOSA Gray, 1841

[=Halcyonellea HINCKS, 1880]

Aperture at distal extremity of box-shaped zooid closed by circular folds of the body wall; collar present. Zooids budding laterally from ancestrula in direct line with each other. *Rec.*

### Family ALCYONIDIIDAE Johnston, 1849

**Alcyonidium** LAMX.. 1821 [**Alcyonium gelatinosum* LINNÉ, 1766][=*Halodactylus* FARRE, 1837]. Zoarium a gelatinous crust or with fleshy cylindrical expansions. Zooecia in contact. *Rec.*——FIG. 7, 7. **A. gelatinosum* (LINNÉ), Atl.; *7a,* ×1; *7b,* ×20, edge view of zooecia; *7c,* zooecia, ×40 (167).

**Benedinipora** PERGENS, 1888; **Clavopora** BUSK, 1874; **Lobiancopora** PERGENS, 1888.

### Family FLUSTRELLIDRIDAE Bassler, nov.

[=emend. Flustrellidae Hincks, 1880]

**Flustrellidra** BASSLER, nov. [*pro Flustrella* GRAY, 1848 (*non* EHR., 1839, *nec* D'ORB., 1852)] [**Flustra hispida* FABRICIUS, 1780]. Movable lip acts as an operculum. *Rec.,* N.Atl.

**Elzerina** LAMX., 1816; **Pherusa** LAMX., 1821.

## Suborder PALUDICELLEA Allman, 1856

Zooids with proximal ends prolonged and narrow, stolon-like. *Rec.*

### Family VICTORELLIDAE Hincks, 1880

**Paludicella** GERVAIS, 1836; **Pottsiella** HARMER, 1915; **Victorella** SAVILLE-KENT, 1870.

### Family ARACHNIDIIDAE Hincks, 1880

**Arachnidium** HINCKS, 1877 [**A. hippothoides*]. Creeping or stolonate network of zooecia connected by slender fibers with zooecia arising at crossings. *Rec.* ——FIG. 7,*3.* **A. hippothoides,* Irish Sea; ×25 (167).

**Arachnoidea** MOORE, 1903; **Platypolozoon** ANNANDALE, 1912.

### Family NOLELLIDAE Harmer, 1915

[emend. Cylindroeciidae HINCKS, 1880]

**Nolella** GOSSE, 1855 [**N. stipata*] [=*Cylindroecium* HINCKS, 1880]. Incrusting, basal part with spinose dilatations with tall zooecia. *Rec.*——FIG. 7,*4. N. dilatata* (HINCKS) (type of *Cylindroecium*), NE.Atl.; *4a,* basal part with spines, ×25; *4b,* zooecia arising from base, ×25 (167).

**Anguinella** VAN BENEDEN, 1845.

## Suborder VESICULARINA Johnston, 1847

Zooids developed from erect free thick stolon. *Rec.*

## Family VESICULARIIDAE Hincks, 1880

**Vesicularia** J. V. THOMPSON, 1830 [**Sertularia spinosa* LINNÉ, 1766]. Zoarium repent or erect, rooted by a fibrous base. *Rec.*——FIG. 7,2. **V. spinosa* (LINNÉ), NE.Atl.; tip of branch, zooecia stripped away, ×25 (167).

**Avenella** DALYELL, 1847 [**A. fusca*]. Tubular repent stolon with erect solitary zooecia, 20 to 24

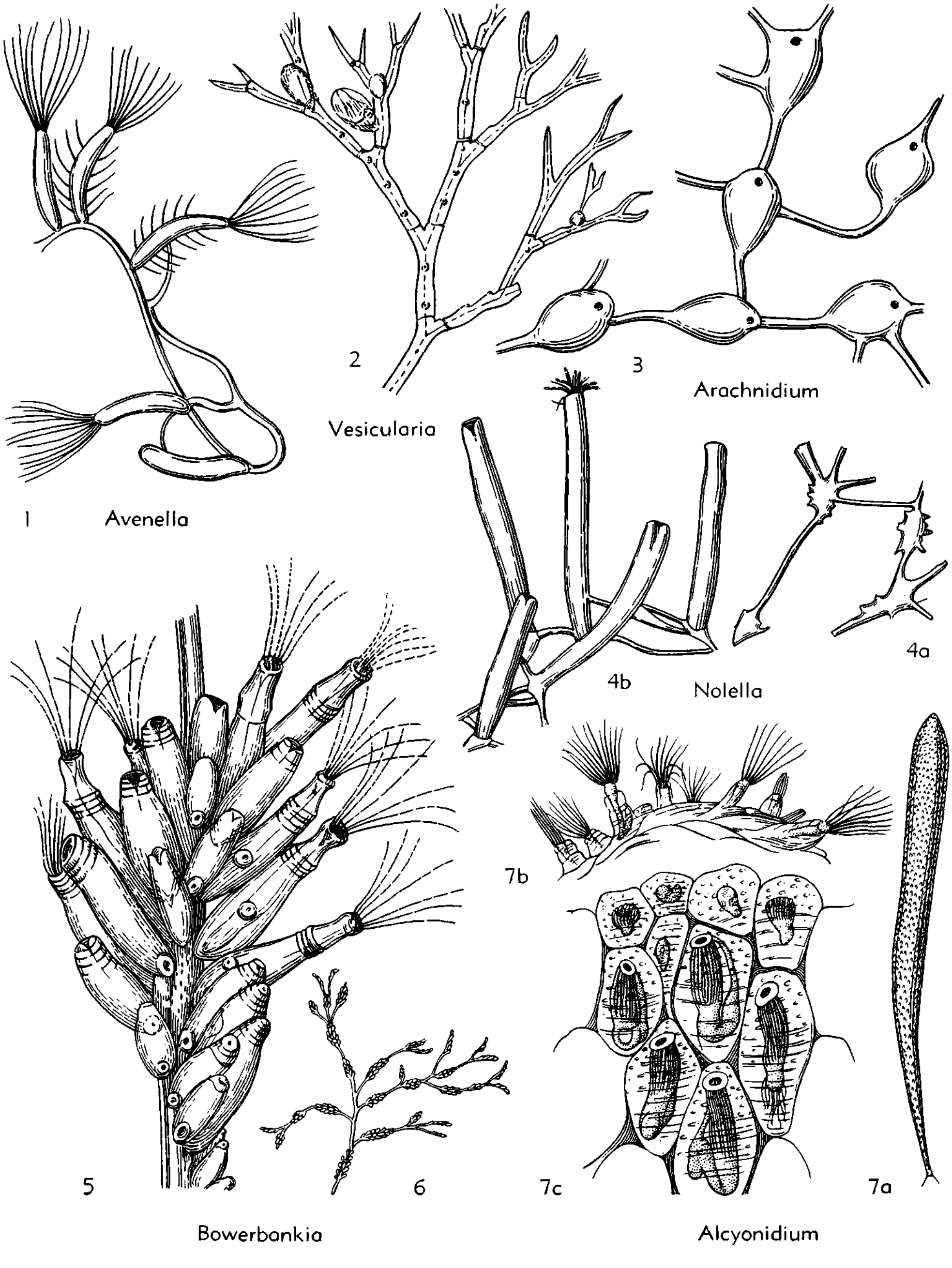


FIG. 7. Alcyonidiidae, Arachnidiidae, Nolellidae, Vesiculariidae (p. G33-G35).

tentacles in a circle. *Rec.*——FIG. 7,*1*. **A. fusca,* NE.Atl.; ×25 (167).

**Bowerbankia** FARRE, 1887 [**Sertularia imbricata* ADAMS, 1800]. Zoarium repent or erect. Zooecia oval, disjunct, clustered, subspirally arranged. *Rec.*——FIG. 7,*5*. *B. pustulosa* ELLIS-S., Atl.; polypide expanded, ×25 (167).——FIG. 7,*6*. **B. imbricata* (ADAMS), Atl.; ×1 (167).

**Amathia** LAMX., 1812; **Cryptopolyzoon** DENDY, 1889; **Hislopia** CARTER, 1858; **Norodoniana** JULLIEN, 1880; **Zoobotryoon** EHR., 1831.

## Suborder STOLONIFERA Ehlers, 1876

Zoarium formed by lateral budding from delicate creeping stolon which expands at intervals, zooids generally arising in pairs; zooecial apertures closed with collar as in Carnosa. *Ord.-Rec.*

### Family WALKERIIDAE Bassler, nov.

[=emend. Valkeriidae HINCKS, 1880] (*Rec.*)

**Walkeria** FLEMING, 1823 [**Sertularia uva* LINNÉ, 1766] [=*Valkeria* FLEMING, 1828]. Zoarium erect with ovate, clustered zooecia, contracted below, deciduous. *Rec.*——FIG. 8,5. **W. uva* (LINNÉ), Atl.; ×15 (167).

**Monastesia** JULLIEN, 1888.

### Family MIMOSELLIDAE Hincks, 1851

(*Rec.*)

**Mimosella** HINCKS, 1851; **Hypophorella** EHLERS, 1876.

**Farrella** EHR., 1838 [*pro Lagenella* FARRE, 1837 (*non* EHR., 1835)] [**Lagenella repens* FARRE, 1837] [=*Laguncula* VAN BENEDEN, 1845]. Zoarium repent. Zooecia elliptical, scattered, with bilabiate aperture. *Rec.*——FIG. 8,*1*. **F. repens* (FARRE), Atl.; ×25 (167).

### Family BUSKIIDAE Hincks, 1880

(*Rec.*)

**Buskia** ALDER, 1857.

### Family TRITICELLIDAE Sars, 1874

(*Rec.*)

**Triticella** DALYELL, 1848.

### Family ROPALONARIIDAE Bassler, nov.

[=emend. Rhopalonariidae NICKLES-B., 1900]

Zoarium of fusiform internodes or cells connected by delicate tubular stolons pinnately arranged and becoming partly embedded by excavating surface of host. Zooecia unknown, probably deciduous and developed by budding from a subcentrally located pore in the internodes (1). *Ord.-Perm.*

**Ropalonaria** ULR., 1879 [**R. venosa*] [=*Rhopalonaria* MILLER, 1889] Represented by clublike excavations in host, species distinguished chiefly by variations in stolon dimensions. *Ord.-Perm.*——FIG. 8,*4*. **R. venosa*, U.Ord.(Richmond.), Ohio; *4a*, incrusting *Streptelasma*, ×1; *4b*, ×25 (222).

### Family VINELLIDAE Ulrich & Bassler, 1904

Creeping base of single delicate tubular threads, locally segregated or proceeding from more or less definite centers. Pores in single row on stolon but numerous on internodes of segmented forms; zooecia unknown, probably deciduous (1). *Ord.-Cret.*

**Vinella** ULR., 1890 [**V. repens*]. Delicate tubular stolons radially arranged with single row of small pores. *Ord.-Cret.*——FIG. 8,2. **V. repens*, M.Ord. (Blkriv.), Minn.; *2a*, on brachiopod, ×1; *2b*, ×25 (222).——FIG. 8,*3*. *V. radiata* ULR.-B., U.Ord.(Maysv.), Ohio; ×1 (222).

**Allonema** ULR.-B., 1904 [**A. botelloides*]. Parasitic base comprising strings of sausage-like bulbous vesicles (internodes) with minutely punctate surface; porelike depression near end of vesicle probably marks point where erect zooid was attached. *Sil.-Penn.*——FIG. 8,*6*. **A. botelloides*, Sil., Gotl.; *6a,b*, ×10; *6c*, ×25 (223).

**Condranema** BASSLER, 1952 [*pro Heteronema* ULR.-B., 1904 (*non* DUJARDIN, 1841, *nec* KELLER, 1889)] [**Heteronema capillare* ULR.-B., 1904]. Simple or locally jointed, delicate creeping stolons without apparent order; pores in single row. *Ord.-Perm.*——FIG. 8,*8*. **C. capillare* (ULR.-B.), Sil., Gotl.; ×10 (223).

**Marcusodictyon** BASSLER, 1952 [**Heteronema priscum* BASSLER, 1911]. Like *Condranema* but stolons unite to form generally 6-sided polygons. *Ord.*——FIG. 8,*7*. **M. priscum* (BASSLER), L.Ord., Est.; *7a*, on brachiopod, ×10; *7b*, one colony growing over another, ×25 (131).

**Vinelloidea** CANU, 1913 [**V. crussolensis*]. Like *Vinella* but stolons twisted, not regularly arranged. *Jur.*——FIG. 8,*9*. **V. crussolensis*, U.Jur. (Oxf.), Fr.; ×10 (136).

### Family ASCODICTYIDAE Miller, 1889

[as Ascodictyonidae]

Parasitic threadlike branching stolons with bulbous pyriform minutely punctate vesicles isolated or in stelliform clusters; zooecia unknown (1). *Sil.-Perm.*

**Ascodictyon** NICH.-E., 1877 [**A. fusiforme*]. Elongate pyriform vesicles with connecting threads little developed. *Sil.-Perm.*——FIG. 9,*3*. **A. fusiforme*, M.Dev., Mich.; ×10 (223).

**Bascomella** MORNINGSTAR, 1922 [**B. gigantea*]. Large ovoid to fusiform irregularly arranged vesicles connected by narrow tubular stolons, both embedded in host, generally preserved as internal molds. *Penn.-Perm.*——FIG. 9,*5*. **B. gigantea*, Penn., Ohio; ×10 (194).

**Eliasopora** BASSLER, 1952 [**Ascodictyon stellatum* NICH.-E., 1877]. Like *Ascodictyon* but vesicles oval, grouped in radiating clusters, connected at intervals by stolons. *Sil.-Miss.*——FIG. 9,*2*. **E. stellata* (NICH.-E.), Dev., N.Y.; ×25 (223).——FIG. 9,*1*. *E. siluriensis* (VINE), Sil., N.Y.; ×10 (223).

## Family TEREBRIPORIDAE d'Orbigny, 1847

Zoarium a network of small canals perforating superficial enamel of shells. Zooe-

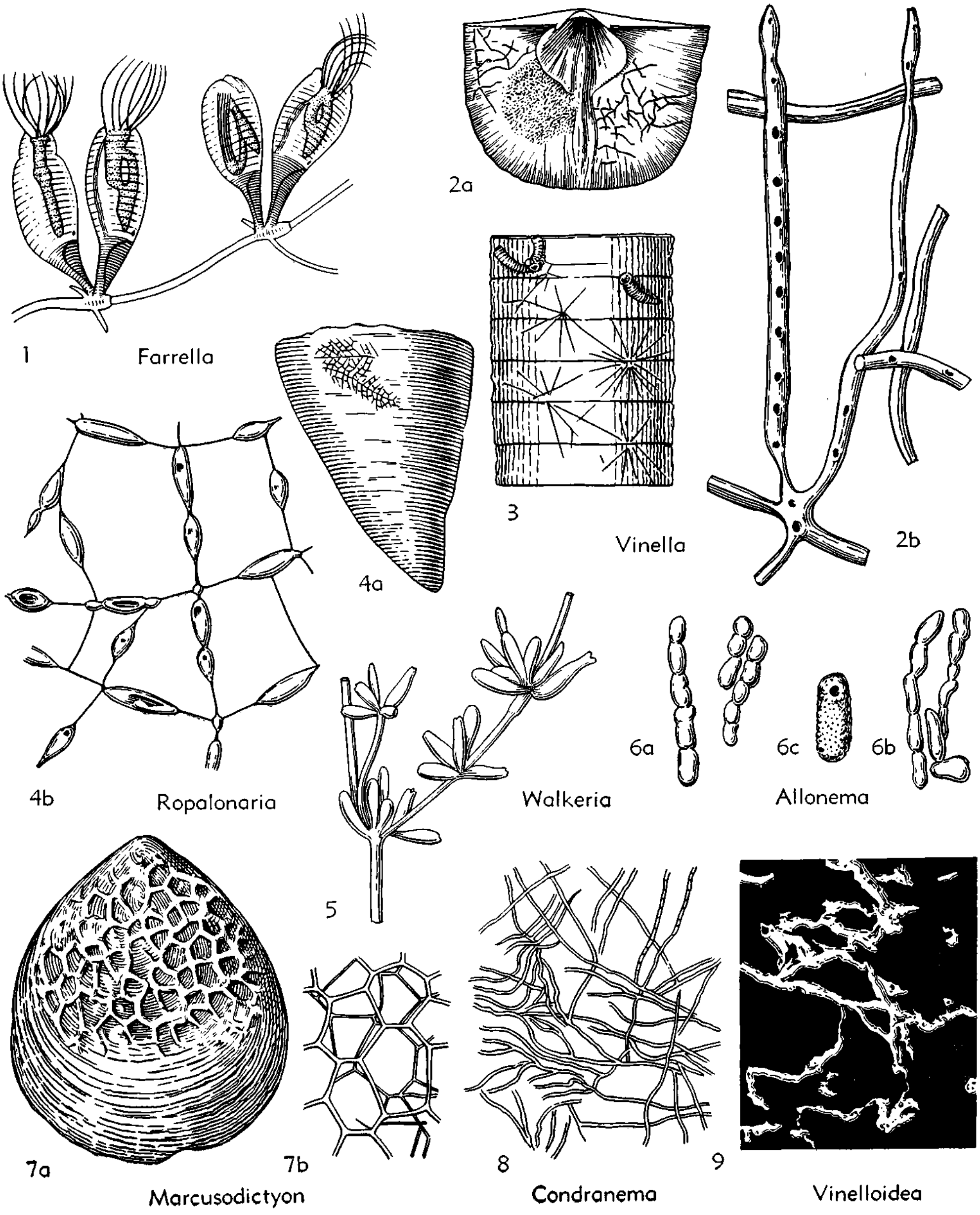


FIG. 8. Walkeriidae, Mimosellidae, Ropalonariidae, Vinellidae (p. G35).

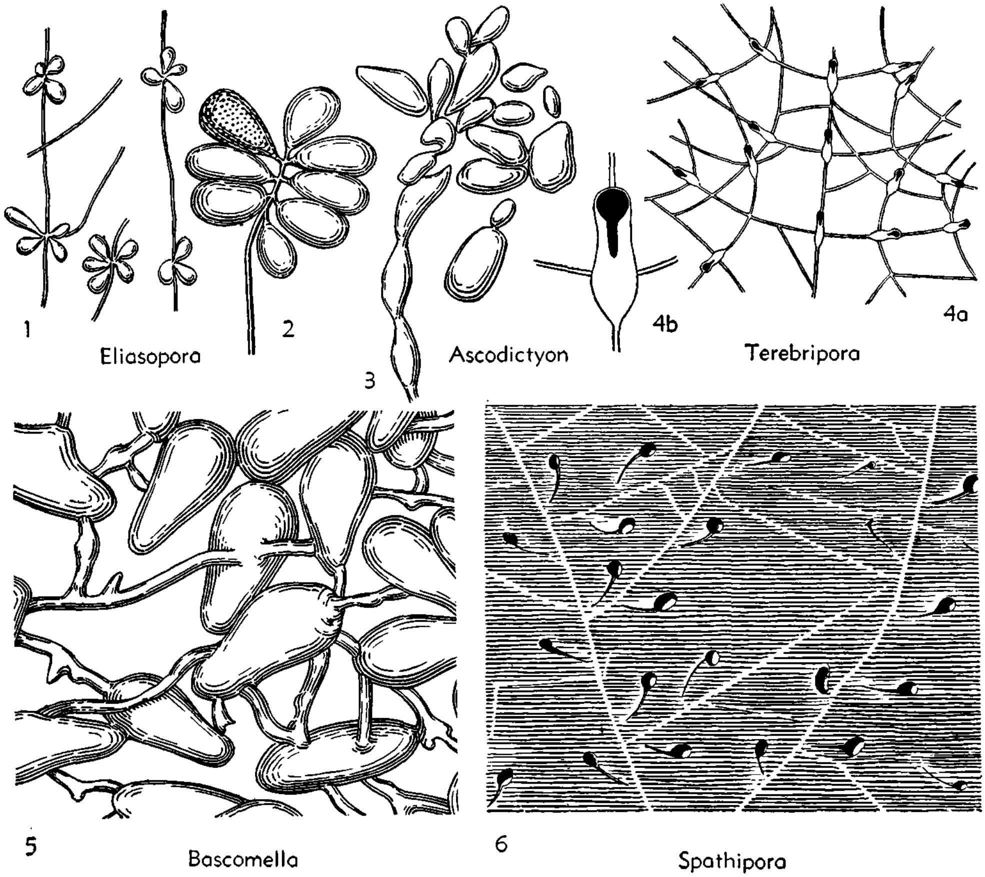


FIG. 9. Ascodictyidae, Terebriporidae (p. G35-G37).

cial apertures with rimule, not operculated; no gonozooid. *Tert.-Rec.*

**Terebripora** D'ORB., 1842 [**T. ramosa*]. Primary stolons joined to zooecia by secondary ones. *Jur.-Rec.*——FIG. 9,*4*. **T. ramosa,* Rec., Atl.; *4a*, ×25; *4b*, ×50 (137).

**Spathipora** FISCHER, 1866 [**S. sertum*]. Zoaria lack secondary stolons. Zooids thin, elongate, fusiform, with long peduncle attached to stolons and arranged alternately. *Mio-Rec.*——FIG. 9,*6*. **S. sertum*. Mio.(Helv.), Fr.; ×25 (137).

## Family PENETRANTIIDAE Silén, 1946

**Penetrantia** SILÉN, 1946 [**P. densa*]. Primary stolons perforating host, connected to zooids by short secondary stolons entering near distal end. Zooids operculated, gonozooid present. *Rec.*

## Family IMMERGENTIIDAE Silén, 1946

**Immergentia** SILÉN, 1946 [**I. californica*]. Perforating zoaria without secondary stolons. *Rec.*

# Order CYCLOSTOMATA Busk, 1852

[=Centrifugines D'ORB., 1852; Stenolaemata BORG, 1926 (*partim*); Stenostoma MARCUS, 1936 (*partim*)]

Zooecia consisting of simple calcareous tubes, generally without transverse partitions (diaphragms), with plain, rounded, uncontracted aperture, not closed by an operculum; walls thin, minutely porous (with pseudopores), lacking the more complicated structures developed in Cheilostomata and Trepostomata. Reproduction in an ovicell, consisting of an enlarged single zooecium (gonoecium) with special opening (oeciopore) terminated externally by a peristome-like rim (oeciostome), or an inflation of the zoarial surface (gonocyst) covering several apertures. Appendicular organs wanting. The zoarium assumes many different forms of growth, from delicate jointed threadlike branches to solid masses 10 or more centimeters in diameter, commonly variable in a genus but fairly constant in a species. *Ord.-Rec.*

## CLASSIFICATION

Prior to 1900, the families and genera of Cyclostomata were based almost entirely on zoarial growth form and zooecial arrangement, resulting in proposal of several complicated artificial classifications, as noted in a review by GREGORY (1909), whose classification in general is still held, in spite of radical changes by others. BORG (9,11), from studies on Recent bryozoans without notice of fossil forms, has proposed a new order (Stenolaemata) for a combination of the Cyclostomata and Trepostomata. GREGORY (63) inadvisedly referred the Heteroporidae and Cerioporidae to the Trepostomata, overlooking the presence of ovicells, porous walls with pseudopores, and other features that are distinctly cyclostomatous characters.

The distinction between families of Cyclostomata, like other orders of bryozoans, is or should be based on their larval forms, each family being characterized by a special kind of larva. The known larvae of the Cyclostomata are very similar to each other and difficult to discriminate, but fortunately they show differences in evolution of the embryos in ovicells of very different size, form, and position. The first tube of a zoarium is the **ancestrula,** with its lower part comprising a dilated blister-like expansion, called the protoecium, in which the histolysis of the fixed larva and its replacement by the first normal polypide living in the ancestrula occurs. In the Cyclostomata, the aperture invariably is more or less circular, the operculum and cardelles are wanting, leaving the ovicell as the single remaining essential character shown by the zooecia.

The value of the ovicell in classification of the Cyclostomata is therefore of utmost importance, but, unfortunately, its study formerly was much neglected. Some species of Cyclostomata possibly did not develop ovicells, but the majority of them, after some search, undoubtedly will reveal specimens showing this organ. Indeed, one of the most interesting features in the study of the Cyclostomata is the search for ovicelled specimens among the many described species where now no ovicell is known. A beginning toward a natural classification of the Cyclostomata was made by CANU early in the century, and in 1920 CANU & BASSLER amplified this subject. The student is referred to their work for more details and references to other researches on the group.

## MORPHOLOGICAL FEATURES

In spite of general simplicity of organization, the Cyclostomata exhibit various features which can be used in connection with the ovicell for classification. For example, in many Cyclostomata accessory tubes **(kenozooecia** are developed either on the frontal or the dorsal side of the zoarium. These tubes are closed or open special sorts of zooecia which appear to lack a polypide. Thin sections of the zoarium frequently are necessary to determine the nature of such accessory tubes. The dorsal side of many branching forms is occupied in some species by short tubes called **nematopores,** which appear at the surface as threadlike structures and in thin sections as narrow upwardly directed tubes. Somewhat similar tubes on the dorsal side grow in the opposite direction, that is, toward the zoarial base. Certain Cyclostomata exhibit pores on the dorsal side which are as large as polypide tubes but distinguished by their polygonal orifice. These are termed **tergopores.** Somewhat similar pores on the frontal side, but covered by calcareous closures, are known as **dactylethrae;** another curious development on the frontal side is cylindrical tubes **(cancelli)** closed by a finely perforated lamella and garnished in the interior with numerous spinules. Still other forms of tubes in this order are ramifications of the polypidian tubes, termed **vacuoles and mesopores.** The physiologic function of these various accessory tubes is unknown, but they are constant in their development and are therefore of value in classification.

The method of division **(gemmation)** of the zooecial tubes in the Cyclostomata also is quite important. In one method (peripheral), the tubes bifurcate at all heights and in all directions. In another (oriented), gemmation occurs in a definite manner on a single or on 2 sides of a basal lamella or of an axial zone. Thin sections are indispensable in the study of this order.

The study of many Cyclostomata, particularly those forming solid calcareous zoaria, requires thin sections. The preparation of such sections is discussed in this article under "Technique."

In addition to the ovicells and other features just mentioned, the size of the apertures and distances between them are important in specific identifications. Probably the simplest and most trustworthy method of identifying closely allied species is by preparation of uniformly magnified photographs of the zoarial surface. The magnification of 12 and 25 diameters for the Cyclostomata has been found most useful and is recommended for comparative purposes. Polyembryony occurs wherein many larvae result from the budding of a single embryo.

### DISTRIBUTION

The Cyclostomata are first known in the Lower Ordovician and continue until the end of the Paleozoic era, fairly well de-

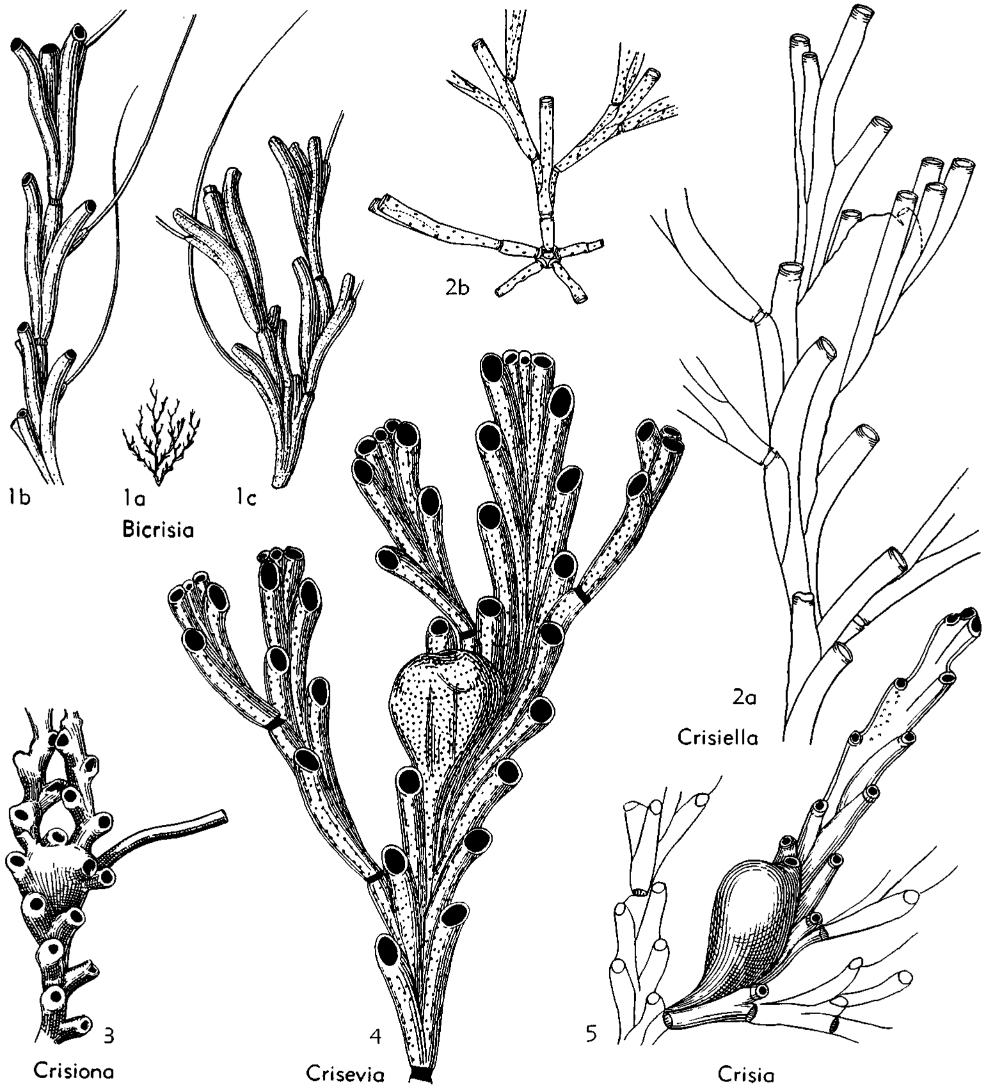


Fig. 10. Crisiidae (p. G40).

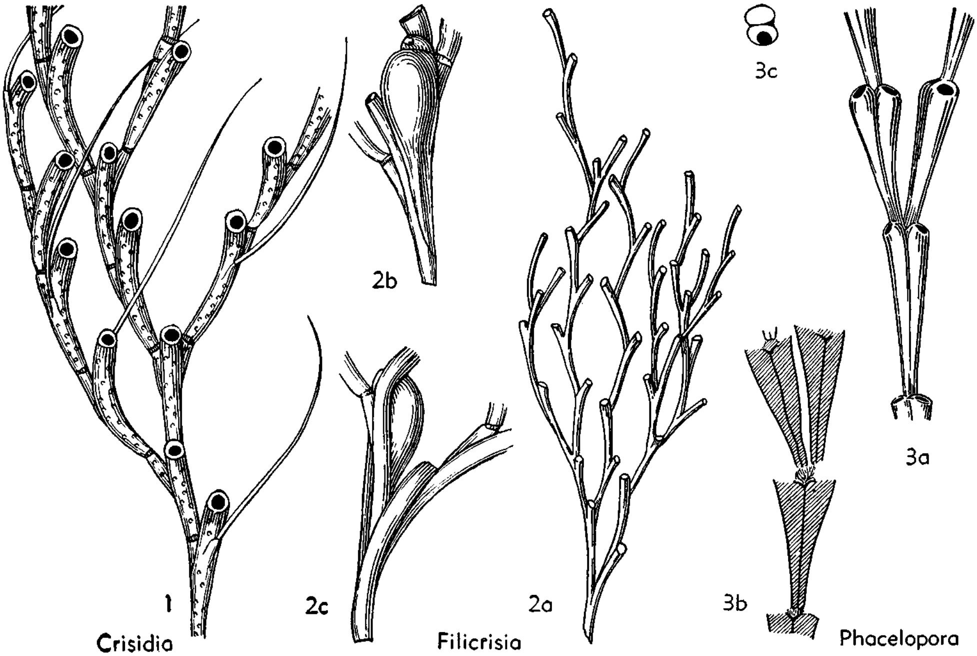


FIG. 11. Crisiidae, Phaceloporidae (p. G40, G41).

veloped in numbers but of less importance than the 2 strictly Paleozoic orders, Trepostomata and Cryptostomata. In the early and middle Mesozoic, they constitute the predominating order, but in the Cretaceous, the Cheilostomata assume first place and continue so until the present. The Paleozoic forms have been described by ULRICH and other workers mentioned under the Trepostomata. The Mesozoic species have been the subject of numerous publications, among which may be mentioned those by GREGORY (63) and D'ORBIGNY. The Cenozoic Cyclostomata likewise have received much attention (13,24,75).

## Suborder ARTICULATA Busk, 1859

[=Radicata BUSK, 1858; Camptostega BORG, 1926]

Zoaria mostly articulated, with rhizoids; erect primary zooid separated by joint from primary disk. Zooecia tubular, with calcareous walls; vestibular sphincter present; ovicell (where known) dilated in middle part (9). *Sil.-Rec.*

### Family CRISIIDAE Johnston, 1847

Zoaria erect, richly branched, mostly articulated, joints corneous. Zooecia tubular, in single or double series, opening on one side only; ovicell symmetrical, sacciform, isolated, paralleling zooecial axis, with terminal large oeciopore (24). *Cret.-Rec.*

**Crisia** LAMX., 1812 [**Sertularia eburnea* LINNÉ, 1758] [=*Lafoea* LAMX., 1821]. Biserial, 3 or more zooecia in sterile segments, 5 or more in fertile. *Eoc.-Rec.*——FIG. 10,*5*. **C. eburnea* (LINNÉ), Rec., Atl.-Eur.; zoarium with ovicell, ×25 (202).

**Bicrisia** D'ORB., 1853 [**Crisidia edwardsiana* D'ORB., 1839]. Sterile segments of 2 zooecia and fertile of 3 to 5; gonozooids on dorsal side, free for much of length. *Rec.*——FIG. 10,*1*. **B. edwardsiana* (D'ORB.), Patag.; *1a*, zoarium, ×1; *1b,c*, front, back, ×25 (202).

**Crisevia** MARCUS, 1937 [**C. pseudosolena*]. Rec.——FIG. 10,*4*. **C. pseudosolena*, Braz.; ×25 (185).

**Crisidia** M.EDW., 1838 [*Falcaria* OKEN, 1815 (*non* HARWORTH, 1809)] [**Sertularia cornuta* LINNÉ, 1758]. Uniserial, one zooecium to a segment and gonozooid only member of its internode.——FIG. 11,*1*. **C. cornuta* (LINNÉ), Rec., Atl.; ×25 (202).

**Crisiella** BORG, 1924 [**Crisia producta* SMITT, 1864]. Sterile segments of 3 to 7 zooecia, fertile commonly with more than 20. *Rec.*——FIG. 10,*2*. **C. producta* (Smitt), Atl.; *2a*, fertile internode, ×25; *2b*, part with primary disc, ×25 (137).

**Crisiona** CANU-B., 1928 [**C. baculifera*]. Zoarium not articulated. Ovicell a triangular sac with flat area on one exterior face. *Cret.-Rec.*——FIG. 10,*3*. **C. baculifera*, Rec., Hawaii; ×25 (137).

**Filicrisia** d'Orb., 1853 [**Crisia geniculata* M.Edw., 1838]. Sterile segments with 1 to 3 zooecia, fertile with 3 to 5, most internodes with single one, ovicell adherent full length. *Rec.*——Fig. 11,*2*. **F. geniculata* (M.Edw.), E.Atl.; *2a,* branch without ovicell, ×25; *2b,c,* ovicell, front and back, ×50 (202).

**Unicrisia** d'Orb., 1853 [**U. compressa*]. Uniserial; ?jointed. *Cret.(Senon.),* Fr.

## Family PHACELOPORIDAE Miller, 1889

Zoarium erect, articulated; each segment a short cone-shaped bundle of 2 or more equal conical parallel zooecia with subterminal end slightly contracted; apertures circular. Ovicell unknown (114). *Sil.-Dev.*

**Phacelopora** Ulr., in Miller, 1889 [**P. pertenuis* Ulr., 1890].——Fig. 11,*3*. **P. pertenuis* Ulr., Sil.(U.Medin.), Ill.; *3a,* segments; *3b,* long. sec.; *3c,* distal end of segment; all ×25 (222).

# Suborder TUBULOPORINA Milne-Edwards, 1838

[Parallelata Waters, 1887; Tubulata Gregory, 1896; Acamptostega Borg, 1926]

Zoaria ramose, sheetlike, to massive, erect or incrusting. Zooecia tubular, apertures circular; ovicells mostly comprise expanded zooecia with special orifice (oeciopore). Numerous larvae budded from single embryo (polyembryony) (11). *Ord.-Rec.*

## Family DIASTOPORIDAE Gregory, 1899

Zoaria incrusting linear series or expansions, erect bifoliate sheets, solid or hollow stems, jointed segments, or small masses. Zooecia simple open tubes; ovicells unknown (24). *Ord.-Rec.*

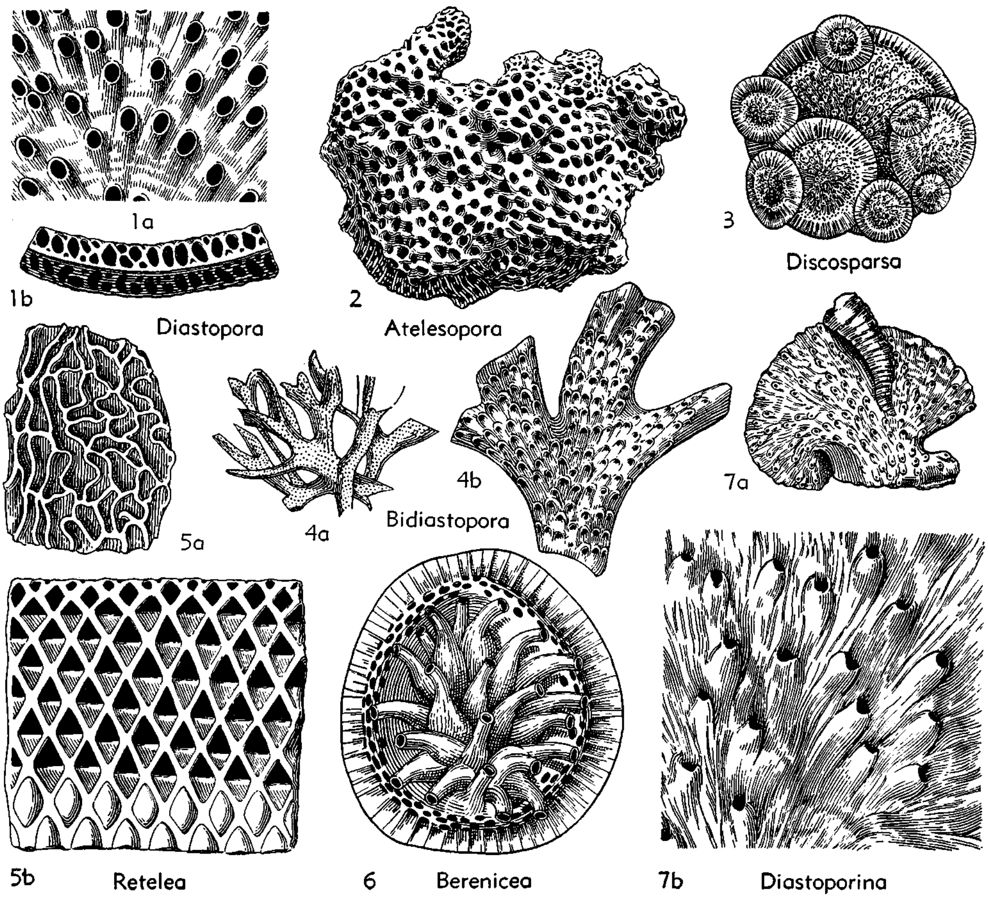


Fig. 12. Diastoporidae (p. G42, G43).

**Diastopora** LAMX., 1821 [**D. foliacea*]. Erect, bifoliate. *Jur.-Rec.*——FIG. 12,*1*. **D. foliacea*, Jur. (Bath.), Fr.; *1a,b*, surface and edge, ×10 (202).

**Atelesopora** CANU-B., 1923 [**A. reptans*]. Incrusting salient masses of expanded tubes without peristomes. *Tert.*——FIG. 12,*2*. **A. reptans*, Mio., S.Car.; ×10 (131).

**Berenicea** LAMX., 1821 [**B. prominens*]. Thin unilamellar, subcircular incrusting sheets without ovicells. *Ord.-Rec.*——FIG. 12,*6*. **B. prominens*, Rec., Medit.; ×25 (202).

**Bidiastopora** D'ORB., 1849 [**Diastopora cervicornis* MICH., 1846]. Like *Diastopora* but zoaria many-branched stems. *Jur.-Cret.*——FIG. 12,*4*. **B. cervicornis* (MICH.), Jur.(Bath.), Fr.; *4a* ×1; *4b*, ×5 (189).

**Cellulipora** D'ORB., 1849 [**C. ornata* D'ORB., 1851]. Massive, composed of lamina-bounded angular groups of zooecia packed together. *U.Cret.*——FIG. 13,*2*. **C. ornata* D'ORB., Cenom., Fr.; *2a*, ×1; *2b*, surface, ×2 (202).

**Clinopora** MARSSON, 1887 [**Entalophora lineata* BEISSEL, 1868]. Narrow, erect, cylindrical branches, surface longitudinally striate. *U.Cret.*——FIG. 13,*5*. **C. lineata* (BEISSEL), Camp., Ger.; *5a*, branch, ×10; *5b*, transv. sec., ×10 (186).

**Corynotrypa** BASSLER, 1911 [**Hippothoa delicatula* JAMES, 1878]. Like *Stomatopora* but proximal part of zooecium constricted for union with preceding one. *Ord.-Cret.*——FIG. 13,*7*. **C. delicatula* (JAMES), Ord.(Eden.), Ohio; ×25 (131). ——FIG. 13,*8*. *C. curta*, Ord.(Richmond.), Wis.;

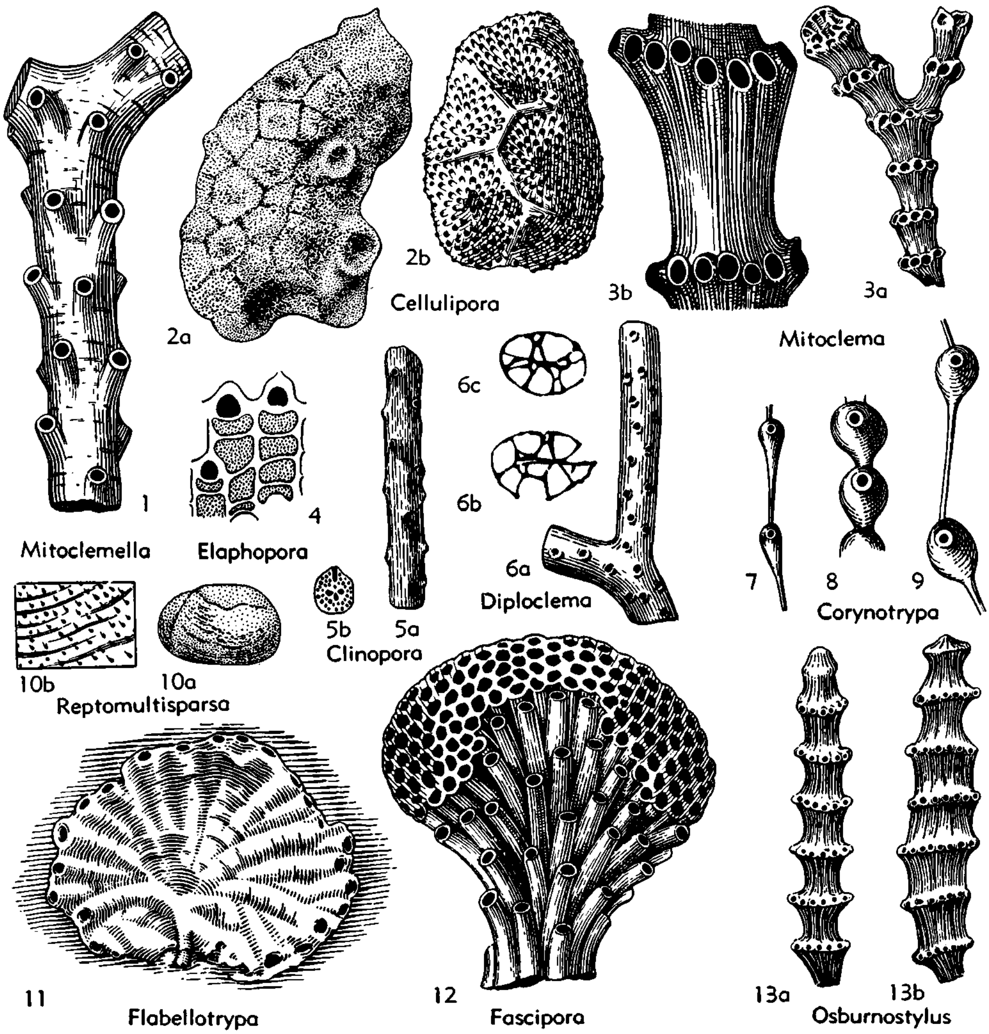


FIG. 13. Diastoporidae (p. G42, G43).

×25(131).——Fig. 13,*9*. *C. abrupta,* Ord.(Richmond.), Ill.; ×25 (131).

**Diastoporina** Ulr., 1890 [**D. flabellata*]. Bifoliate flabelliform zoarium with prostrate immersed subtubular zooecia. *Ord.*——Fig. 12,*7*. **D. flabellata,* Trenton., Minn.; *7a,* frond with attached annelid, ×5; *7b,* surface, ×25 (222).

**Diploclema** Ulr., 1889 [**D. trentonense* Ulr., 1890]. Like *Mitoclema* but zooecia diverge from mesotheca. *Ord.-Sil.*——Fig. 13,*6*. **D. trentonense* Ulr., Ord.(Trenton.), N.Y.; *6a,* branch, ×10; *6b,c,* transv. secs., ×25 (222).

**Discosparsa** d'Orb., 1852 [**D. simplex*]. Small cupuliform attached zoaria. Zooecia radially arranged on upper surface in various growth stages. *Cret.*——Fig. 12,*3*. *D. marginata* d'Orb., Coni., Fr.; ×5 (202).

**Elaphopora** Lang, 1926 [**E. cervina*]. Erect flattened bifurcating stems. Short tubular zooecia with surface crossed by transverse partitions. *Jur.*——Fig. 13,*4*. **E. cervina,* Portl., Eng.; ×25 (175).

**Fascipora** d'Orb., 1853 [**Diastopora pavonina* Mich., 1845] [=*Fasciporina* d'Orb., 1853]. Erect bundles of zooecia with flat upper margin. *U.Cret.*——Fig. 13,*12*. **F. pavonina* (Mich.), Cenom., Fr.; ×10 (202).

**Flabellotrypa** Bassler, 1952 [**F. rugulosa*]. Like *Sagenella* but zooecia open only along outer edges of zoarium. *Sil.-Dev.*——Fig. 13,*11*. **F. rugulosa,* Dev.(Held.), Tenn.; ×15 (131).

**Kukersella** Toots, 1952 [**K. bassleri*]. Like *Mitoclema* but tubes in immature region bear many diaphragms. *Ord.* Kuckers, Est.

**Mitoclema** Ulr., 1882 [**M. cinctosum*]. Narrow erect cylindrical branches. Long tubular zooecia, apertures in transverse parallel rows. *Ord.-Sil.*——Fig. 13,*3*. **M. cinctosum,* Ord. (Blkriv.), Tenn.; *3a,* ×10; *3b,* ×25 (*3a,* 131; *3b,* 222).

**Mitoclemella** Bassler, 1952 [**Mitoclema mundulum* Ulr., 1890]. Like *Mitoclema* but apertures in steeply ascending spirals. *Ord.*——Fig. 13,*1*. **M. mundula* (Ulr.), Trenton., Minn.; ×25 (222).

**Osburnostylus** Bassler, 1952 [**O. typicalis* Bassler, 1951]. Like *Mitoclema* but zoarium of jointed segments about 4 mm. long. *Ord.*——Fig. 13,*13*. **O. typicalis* Bassler, Blkriv., Va.; *13a,b,* ×10 (131).

**Reptomultisparsa** d'Orb., 1853 [**Diastopora microstoma* Mich., 1846] [=*Semimultisparsa* d'Orb., 1853]. Like *Berenicea* but multilamellate. *Jur.-Cret.*——Fig. 13,*10*. **R. microstoma* (Mich.), Jur.(Bath.), Fr.; *10a,* zoarium, ×1; *10b,* surface, ×5 (189).

**Retelea** d'Orb., 1853 [**R. pulchella*]. Possibly same as *Reticulipora. U.Cret.*——Fig. 12,*5*. **R. pulchella,* Senon., Fr.; *5a,* zoarium, ×1; *5b,* surface, ×25 (202).

**Reticulipora** d'Orb., 1849 [**Apsendesia dianthus* Mich., 1847] [=*Holostoma* Lonsd., 1850 (*non* Nitsche, 1816)] Reticulate bifoliate zoarium with apertures on edges of branches. *Jur.-Cret.*——Fig. 14,*9*. **R. dianthus* (Mich.), Jur.(Bath.), Fr.; *9a,b,* side and upper edge, ×10 (202).

**Rhipidopora** Marsson, 1887 [**R. flabellum*]. Cylindrical stem ending above in a lamellar expansion without apertures. *U.Cret.*——Fig. 14,*5*. **R. flabellum,* Camp., Ger.; ×10 (186).

**Rosacilla** Roemer, 1840 [**R. flabelliformis*]. Possibly same as *Berenicea. Cret.,* Ger.

**Sagenella** Hall, 1851 [**S. membranacea* (=*Diastopora consimilis* Lonsd., 1839)] [=*Diastoporella* Vine, 1883 (obj.)]. Incrusting multiserial expansions with surface of tubes marked by strong transverse wrinkles. *Sil.*——Fig. 14,*3*. **S. consimilis* (Lonsd.), Clint., N.Y.; *3a,* ×10; *3b,* ×25 (*3a,* 132; *3b,* 131).

**Semifascipora** d'Orb., 1853 [**S. variabilis*]. Cupuliform with apertures on a series of ridges radiating from the axial tube. *U.Cret.*——Fig. 14,*10*. **S. variabilis,* Maastr., Fr.; ×10 (202).

**Siphoniotyphlus** Lonsd., 1850 [**S. plumatus*] [=*Lanceopora* Reuss, 1874 (*non* d'Orb., 1852); *Epidictyon* Marsson, 1887]. Compressed, narrow, bifoliate branches with zooecia marked by fine longitudinal lines. *Cret.*——Fig. 14,*8*. **S. plumatus,* Eng.; ×10 (158).

**Spiropora** Lamx., 1821 [**S. elegans*] [=*Cricopora* Blainv., 1834 (obj.)]. Ramose, erect, with apertures in parallel, well-separated uniserial verticels. *Jur.-Rec.*——Fig. 14,*7*. **S. elegans,* Jur.(Bath.), *7a,b,* ×10 (158).

**Stomatopora** Bronn, 1825 [*pro Alecto* Lamx., 1821 (*non* Leach, 1814)] [**Alecto dichotoma* Lamx., 1821]. Adnate zoaria of uniserial subtubular zooecia branching at characteristic angles to form indefinite polygons. Ovicells not observed in typical uniserial species but reported (11) in triserial portion of a Recent form. *Ord.-Rec.*——Fig. 14,*1*. **S. dichotoma* (Lamx.), Jur.(Bath.), Fr.; ×10 (174).——Fig. 14,*2*. *S. parvipora* Canu-B., Eoc. (Jackson), Miss.; protoecium with adjacent zooecia, ×25 (131).

**Tubigerina** Canu, 1911 [**T. clavata*]. Incrusting flabellate, with several rows of apertures in transverse fascicles. *Cret.-Rec.*——Fig. 14,*4*. **T. clavata,* Cret.-Eoc. (Rocanean), Arg.; ×10 (136).

**Voigtopora** Bassler, 1952 [**Alecto calypso* d'Orb., 1850]. Like *Stomatopora* but zooecia broad, elliptical, slightly constricted at base and marked by transverse lines. *U.Cret.*——Fig. 14,*6*. **V. calypso* (d'Orb.), Senon., Fr.; ×25 (131).

## Family TUBULIPORIDAE Johnston, 1838

[=Idmoneidae Busk, 1859; Crisinellidae Miller, 1889]

Typically adnate with salient tubes joined in broad fascicles but commonly narrow, erect, dichotomously dividing branches bearing circular zooecial apertures in transverse rows on both sides of the frontal medial line. Basal (dorsal) side smooth or marked by layers of some form of tubular pores (kenozooecia). Ovicell generally on frontal crest with longer axis parallel to the zooecial one and formed after calcification of tubes on which it rests (24). *Dev.-Rec.*

**Tubulipora** Lamarck, 1816 [*T. *transversa* (=*Millepora liliacea* Pallas, 1766)] [=*Obelia* Lamx., 1821 (*non* Peron & Lesueur, 1810); *Criserpia* M.Edw., 1838; *Phalangella* Gray, 1848 (*non* Hamm, 1881)]. Incrusting pyriform to

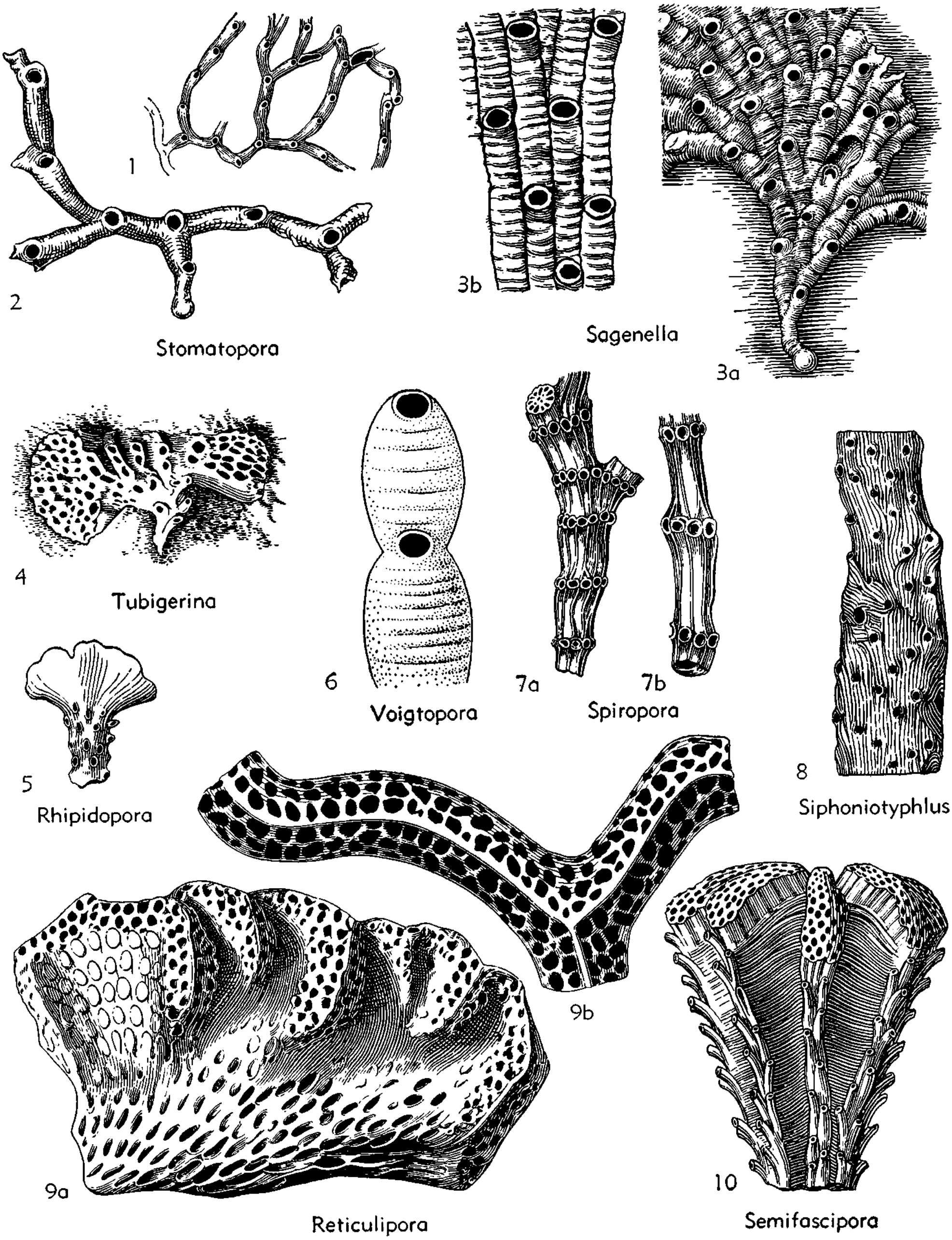


Fig. 14. Diastoporidae (p. G43).

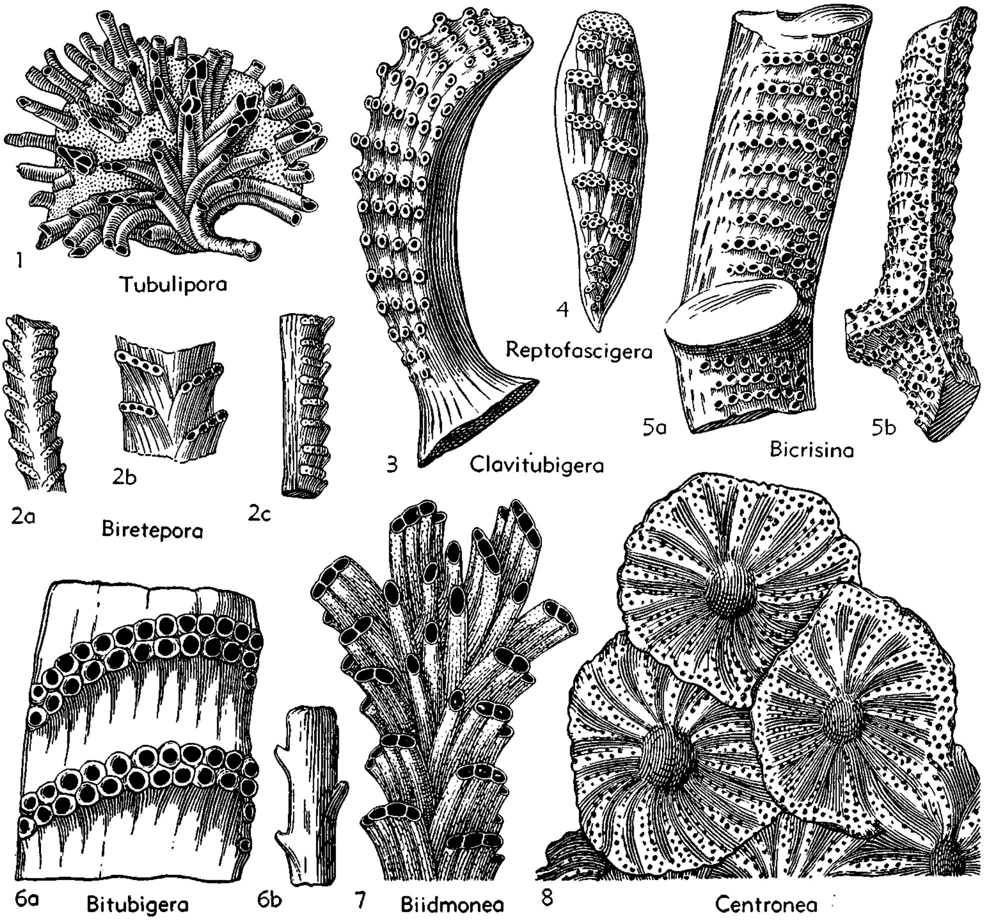


FIG. 15. Tubuliporidae (p. G44-G48).

flabelliform, becoming partly erect with zooecia in obliquely transverse fascicles. Ovicell irregular, spread out between several fascicles. Oeciostome much smaller than zooecial orifice. *Eoc.-Rec.*——FIG. 15,*1*. **T. liliacea* (PALLAS), Rec., Medit.; ovicell-bearing zoarium, ×10 (137).

**Bicrisina** D'ORB., 1853 [**Reticulipora cultrata* D'ORB., 1853]. Like *Crisisina* but ovicell not known. *Cret.*——FIG. 15,*5*. **B. cultrata* (D'ORB.), Maastr., Fr.; *5a,b*, front, side, ×10 (202).

**Biidmonea** CALVET, 1903 [**B. fayalensis*]. Narrow branches with zooecial arrangement as in *Tubulipora;* ovicell not known. *Rec.*——FIG. 15,*7*. **B. fayalensis*, Azores; ×10 (135).

**Biretepora** D'ORB., 1849 [**Retepora disticha* GOLDF., 1831]. Possibly *Crisisina* but ovicell unknown. *U.Cret.*——FIG. 15,*2*. **B. disticha* (GOLDF.), Maastr., Holl.; *2a,b*, front, ×5, ×10; *2c*, side, ×5 (160).

**Bitubigera** D'ORB., 1853 [**Idmonea biseriata* PHILLIPI, 1844]. Like *Crisisina* but zooecia in biserial rows; ovicell not known. *Oligo.*——FIG. 15,*6*. **B. biseriata* (PHILLIPI), Ger.; *6a*, front, ×25; *6b*, back, ×15 (186).

**Centronea** CANU-B., 1920 [**Multitubigera micropora* REUSS, 1869]. Like *Platonea* but zoarium orbicular, ovicell median. *Eoc.*——FIG. 15,*8*. **C. micropora* (REUSS), Priabon., Italy; compound zoarium, ×5 (137).

**Clavicava** D'ORB., 1854 [**C. compressa*] [=*Claviclava* GREGORY, 1909]. Like *Crisisina*. *L.Cret.*——17,*1*. **C. compressa*, Neocom., Fr.; ×10 (202).

**Clavitubigera** D'ORB., 1853 [**C. convexa*]. Possibly *Crisisina;* ovicell unknown. *U.Cret.*——FIG. 15,*3*. **C. convexa*, Senon., Fr.; side, ×10 (202).

**Crisinella** HALL, 1883 [**Crisina? scrobiculata* HALL, 1883]. Like *Crisisina* but ovicell unknown. *Dev.*——FIG. 16,*1*. **C. scrobiculata* (HALL), M.Dev. (Onond.), N.Y.; *1a,b*, back, front, ×20 (162).

**Crisisina** D'ORB., 1850 [**C. cenomana*] [=*Coelo-*

*phyma* HAG., 1851]. Like *Idmonea* but erect, with smooth back and celluliferous front bearing ovicell on edges of median crest. *Cret.-Rec.*——FIG. 16,*3*. *C. laevis* (HAG.), Cret.(Maastr.), Holl.; *3a,b,* front, back, with ovicells, ×5 (186).——FIG. 16,*4*. **C. cenomana,* Cret.(Cenom.), Fr.; *4a,b,* front, back, ×10 (202).

**Erkosonea** CANU-B., 1920 [**E. semota*]. Like *Crisisina* but back bears club-shaped distally directed tubes closed by a lamella (dactylethra-type of kenozooecia). *Eoc.*——FIG. 16,*2*. **E. semota,* Jackson., Miss.; *2a,* back, showing dactylethrae; *2b,* normal front; *2c,* front with broken ovicell; *2d,* long. sec., dactylethrae at right, ×20 (137).

**Idmidronea** CANU-B., 1920 [**Idmonea maxillaris* LONSD., 1845]. Like *Crisisina* but back bears proximally directed tubes (firmatopore-type of kenozooecia). *Eoc.*——FIG. 16,*7*. *I. culter* CANU-B.,

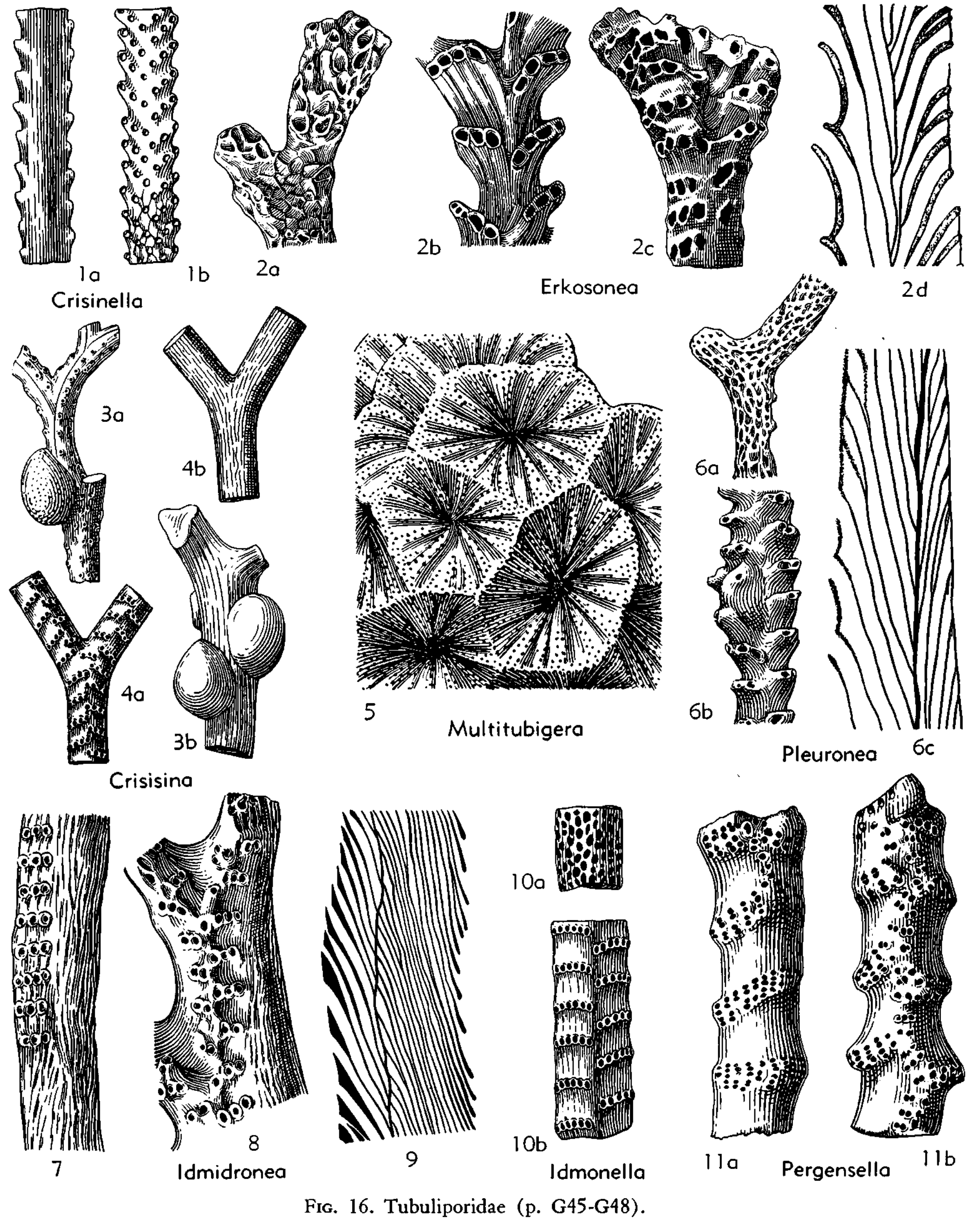


FIG. 16. Tubuliporidae (p. G45-G48).

Claib., N.Car.; side, ×10 (131).——FIG. 16,*8*. *I. rosacea* CANU-B., Claib., N.Car.; front, ×10 (131). ——FIG. 16,*9*. *I. coronopus* (DEFRANCE), Fr.; long. sec., ×10 (137).

**Idmonea** LAMX., 1821 [**I. triquetra*] [=*Reptotubigera* D'ORB., 1853]. Incrusting, simple or branched stems with ridges bordered by thin flat selvage and apertures in transverse alternate series. Ovicell on zoarial median crest pierced by zooecia. *Jur.*——FIG. 17,*9*. **I. triquetra*, Bath., Fr.; *9a*, attached zoarium, ×1; *9b*, front, ×25 (161).

**Idmonella** LEV., 1925 [**I. insignis*]. Like *Crisisina* but with mesopore-like kenozooecia on back. *U. Cret.*——FIG. 16,*10*. **I. insignis*, Camp., Ger.; *10a,b*, back, front, ×10 (186).

**Mesonea** CANU-B., 1920 [**Retepora radians* LA-

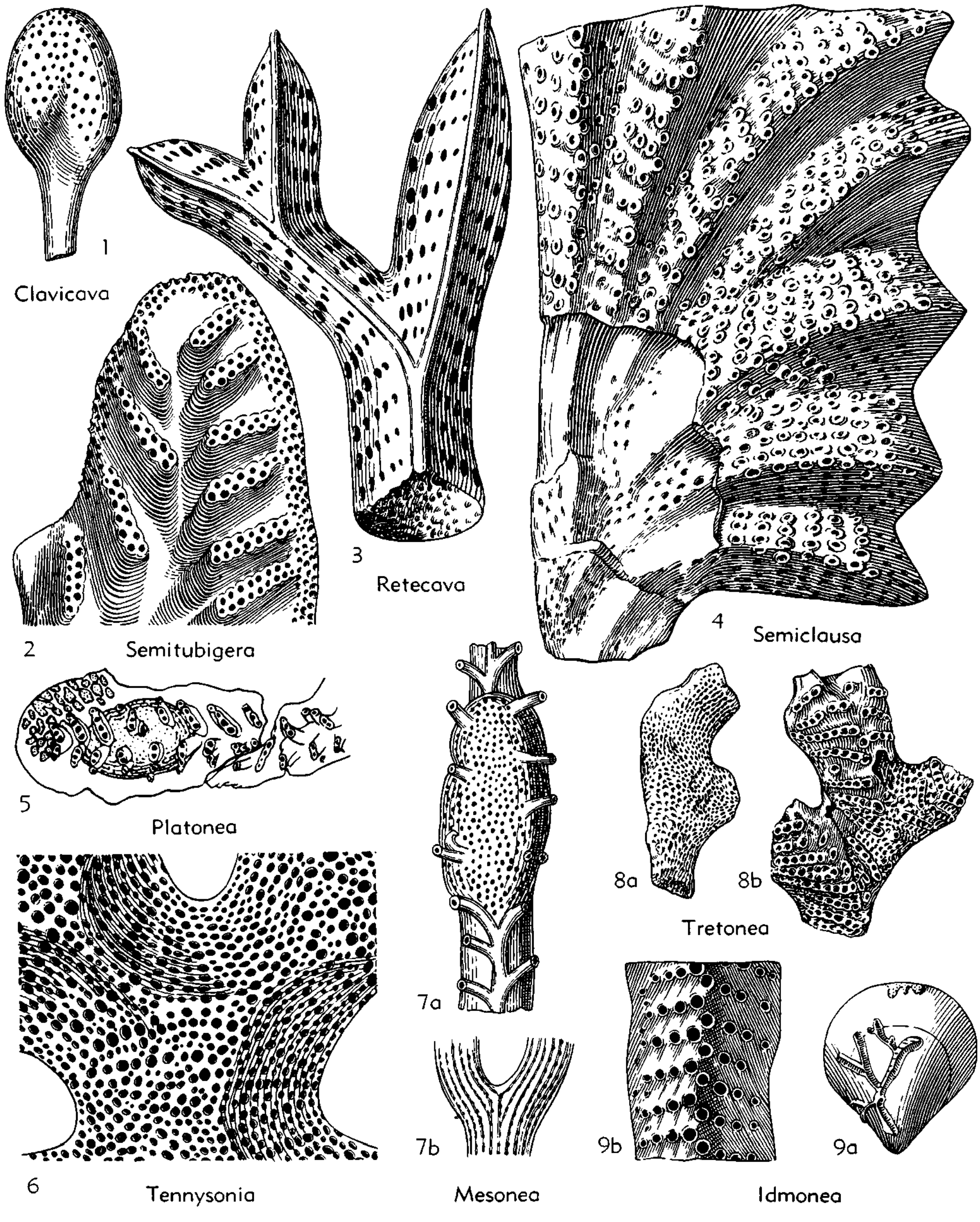


FIG. 17. Tubuliporidae (p. G45-G48).

MARCK, 1816]. Like *Crisisina* but back with tergopore-type kenozooecia and broad porous ovicell on front. *Eoc.-Rec.*——FIG. 17,*7*. **M. radians* (LAMARCK), Rec., Austral.; *7a,* front with ovicell, ×25; *7b,* back, ×10 (*7a,* 230; *7b,* 137).

**Multitubigera** D'ORB., 1853 [**M. gregaria*]. Like *Centronea* but ovicell unknown. *U.Cret.*——FIG. 16,*5*. **M. gregaria,* Maastr., Fr.; front, ×5 (202).

**Pergensella** GREGORY, 1899 [**Idmonea geniculata* HAG., 1851]. Like *Crisisina* but with apertures in lateral series of 3 to 8 rows and a median series of 3 to 4 rows. *U.Cret.*——FIG. 16,*11*. **P. geniculata* (HAG.), Maastr., Holl.; *11a,b,* side, front, ×5 (186).

**Platonea** CANU-B., 1920 [**Reptotubigera philippsae* HARMER, 1915]. Incrusting like *Idmonea* but with ovicell spread out between the fascicles occupying the full zoarial width. *Oligo.-Rec.*——FIG. 17,*5*. **P. philippsae* (HARMER), Rec., Pac.; front with ovicell, ×15 (137).

**Pleuronea** CANU-B., 1920 [**Idmonea fenestrata* BUSK, 1859]. Like *Mesonea* but ovicell on sides and back with large imperfectly oriented tergopore-type kenozooecia. *Eoc.-Plio.*——FIG. 16,*6*. **P. fenestrata* (BUSK), Plio.(Crag), Eng.; *6a,b,* back, front, ×10; *6c,* long. sec., tergopores at right, ×25 (137).

**Reptofascigera** D'ORB., 1853 [**R. alternata*]. Like *Bitubigera* but adnate zooecia in biserial rows. *U.Cret.*——FIG. 15,*4*. **R. alternata,* Santon., Fr.; ×10 (202).

**Retecava** D'ORB., 1854 [**Retepora clathrata* GOLDF., 1827] [=*Spiridmonea* HENNIG, 1894]. Erect laterally compressed branches with rod of rudimentary zooecia at back. *Cret.*——FIG. 17,*3*. **R. clathrata* (GOLDF.), L.Cret.(Valang.), Switz.; front, ×10 (202).

**Semiclausa** D'ORB., 1853 [**S. alternata*]. Compound zoarium with apertures on pinnate ridges. *U.Cret.*——FIG. 17,*4*. **S. alternata,* Maastr., Holl.; front, ×5 (202).

**Semitubigera** D'ORB., 1853 [**S. lamellosa*]. Adnate lamina with zooecia in biserial rows. *Cret.-Eoc.*——FIG. 17,*2*. **S. lamellosa,* Maastr., Fr.; front, ×10 (202).

**Tennysonia** BUSK, 1867 [**T. stellata*]. Erect branching stalks with straight uniserial lines of apertures separated by several rows of mesopores on front; back smooth. *Cret.-Rec.*——FIG. 17,*6*. **T. stellata,* Rec., S.Afr.; front, ×5 (137).

**Tretonea** CANU-B., 1920 [**T. levis*]. Like *Tennysonia* but both sides bear mesopore-like kenozooecia and front has lobate ovicell. *Eoc.*——FIG. 17,*8*. **T. levis,* Jackson., Ga.; *8a,b,* back, front, ×10 (137).

### Family MULTISPARSIDAE Bassler, 1935

[=emend. Macroeciidae CANU, 1918]

Incrusting or erect bifoliate zoaria characterized by greatly enlarged, elongate ovicells paralleling the tube axis and displacing the short broad zooecia (24). *Jur.*

**Multisparsa** D'ORB., 1853 [**Bidiastopora luceana* D'ORB., 1850] [=*Macroecia* CANU, 1928]. Bifoliate, dichotomously branched. Ovicell broadly elliptical, with large transverse oeciostome. *Jur.*——FIG. 18,*3*. **M. luceana* (D'ORB.), M.Jur.(Bath.), Fr.; *3a,* zoarium, ×1; *3b,* surface, ×25 (*3a,* 202; *3b,* 136).

**Atractosoecia** CANU-B., 1922 [**Berenicea edwardsi* CANU, 1913]. Incrusting; ovicell a long fusiform sac with terminal rounded oeciostome. *Jur.*——FIG. 18,*6*. **A. edwardsi* (CANU), M.Jur.(Bath.), Fr.; surface with ovicell, ×10 (137).

### Family ONCOUSOECIIDAE Canu, 1918

Incrusting, lobate or narrow erect zoaria, with dilated isolated ovicell paralleling axis of tubes developed at the same time; tubes not disarranged (24). *Jur.-Rec.*

**Oncousoecia** CANU, 1918 [**Tubulipora lobulata* HASSALL, 1841]. Incrusting to erect. Ovicell a dilation of entire visible part of zooecium, with large oeciopore. *Cret.-Rec.*——FIG. 18,*1*. **O. lobulata* (HASSELL), Rec., Atl.; surface with ovicell, ×25 (137).

**Dacryopora** TERQUEM, 1855 [**Berenicea archiaci* HAIME, 1854]. Like *Oncousoecia* but ovicell doubtful. *Jur.* Ger.

**Filisparsa** D'ORB., 1853 [**F. neocomiensis*] [=*Phormonotos* MARSSON, 1887]. Erect, narrow dichotomous branches with irregularly placed zooecial apertures on front; back smooth. *Cret.-Rec.*——FIG. 18,*7*. **F. neocomiensis,* L.Cret.(Neocom.), Fr.; *7a,b,* front, back, ×10 (202).——FIG. 18,*8*. *F. crassa* D'ORB., L.Cret.(Neocom.), Fr.; *8a,b,* back, front, ×25 (202).

**Leptopora** D'ORB., 1849 (*non* WINCHELL, 1863) [**L. elegans*]. Like *Proboscina* but ovicell unknown. *U.Cret.*——FIG. 18,*2*. **L. elegans,* Cenom., Fr.; ×10 (202).

**Penciletta** GRAY, 1848 [**Tubipora penecillata* FABRICIUS, 1780]. Like *Proboscina,* ovicell unknown. *Rec.,* Atl.

**Proboscina** AUDOUIN, 1826 (*non* RONDANI, 1856) [**P. boryi*] [=*Phalangella* HAMM, 1881 (*non* GRAY, 1848); *Peristomoecia* CANU-B., 1920]. Incrusting. Single zooecium enlarged to form ovicell. *?Ord., Jur.-Rec.*——FIG. 18,*5*. **P. boryi,* Rec., Red Sea; zoarium with ovicell (?inaccurate, BORG, 1944), ×10 (130).——FIG. 18,*4*. *P. divergens* WATERS, Rec., Atl.; *4a,b,* specimens with ovicells, ×10, ×25 (230).

### Family TERVIIDAE Canu & Bassler, 1920

Zoaria with ovicell (gonozooecium) typically on noncelluliferous back, with its

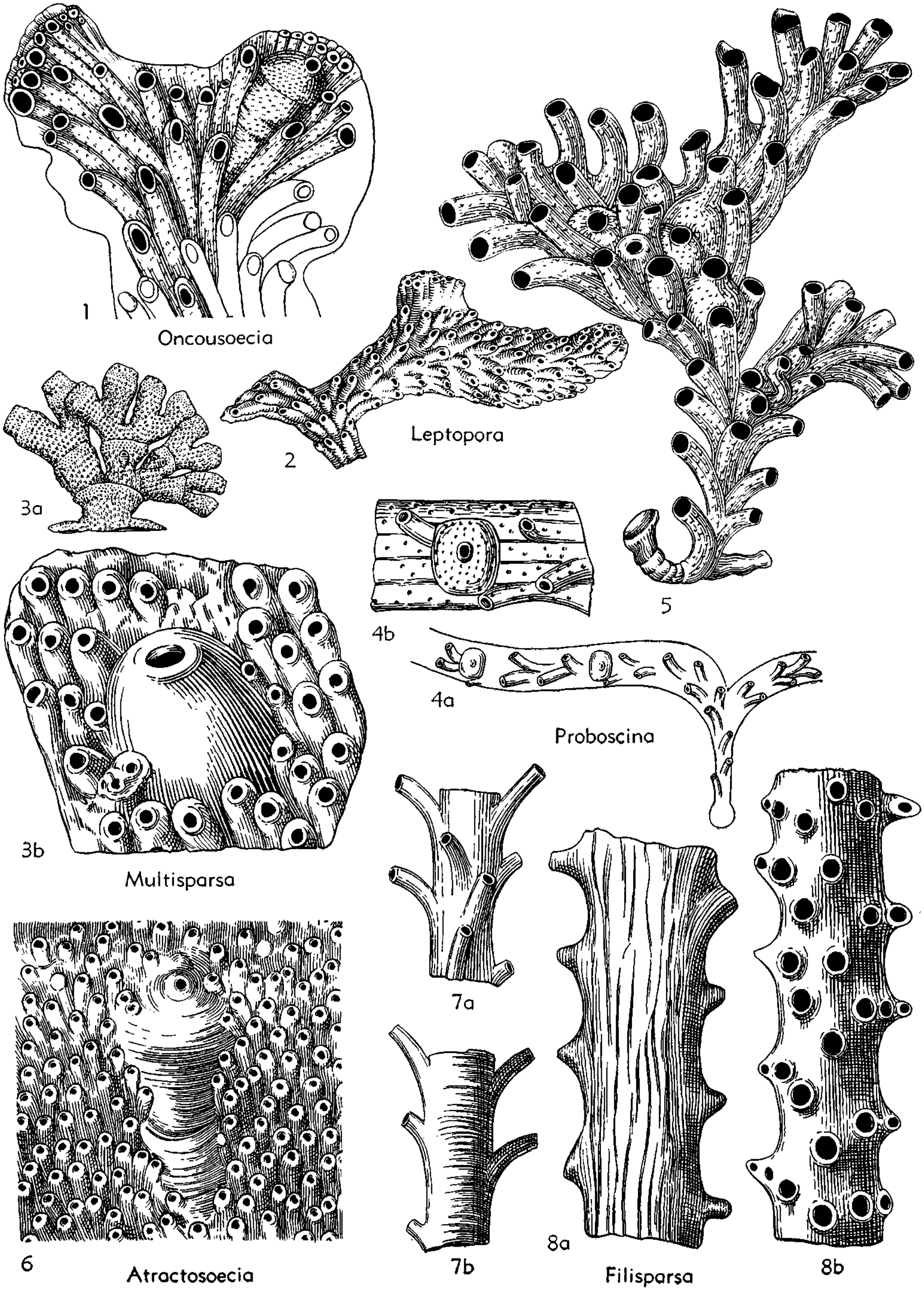


FIG. 18. Multisparsidae, Oncousoeciidae (p. G48).

longitudinal axis paralleling that of zooecia formed after their calcification. Oeciostome terminal, directed distally, placed at a bifurcation so as to open on frontal side (24). *Tert.-Rec.*

**Tervia** JULLIEN, 1882 [**T. solida*]. Erect branches with long ovicell and zooecial tubes visible on back. *Eoc.-Rec.*——FIG. 19,*2*. **T. solida*, Rec., E.Atl.; *2a,b*, back, front, ×10 (137).——FIG. 19,*3*. *T. jellyae* HARMER, Rec., Queensl.; *3a,b*, front, back, with ovicell, ×10 (164).

**Lagonoecia** CANU-B., 1920 [**L. lamellifera*]. Like *Tervia* but with symmetrical globular ovicell attached to edge of back. *Eoc.*——FIG. 19,*4*. **L. lamellifera*, Wilcox., Ala.; front with ovicell, ×10 (137).

**Nevianopora** BORG, 1944 [**Idmonea milneana* D'ORB., 1839]. Apertures in uninterrupted transverse series with ovicell on middle median of front just below bifurcation. *Rec.*, S.Atl.

**Prosthenoecia** CANU, 1918 [**Reptotubigera lateralis* D'ORB., 1853]. Zoarium short, idmoneiform, with much elongated ovicell and large terminal oeciostome on celluliferous side. *Eoc.*——FIG. 19,*1*. **P. lateralis* (D'ORB.), Lut., Fr.; *1a,b*, specimen with ovicell, front and side, ×10 (137).

## Family ENTALOPHORIDAE Reuss, 1869

[=Mecynoeciidae CANU, 1918]

Erect, slender, solid cylindrical stems or bifoliate convoluted fronds with apertures opening on all sides. Ovicells developed parallel with zooecial length, formed before them, thus disarranging their position; oeciostome anterior, small nonterminal (24, 25). *Jur.-Rec.*

**Entalophora** LAMX., 1821 [**E. cellarioides*] [=*Intricaria* DEFRANCE, 1822; *Mecynoecia* CANU, 1918]. Zoarium slender, cylindrical, ramose. Symmetrical ovicell with transverse oeciostome. (Many forms belonging here but not showing ovicell have been erroneously named.) *Jur.-Rec.*——FIG. 19,*8*. **E. cellarioides*, Jur.(Bath.), Fr.; *8a*, branch, ×25; *8b*, surface with ovicell, ×15 (*8a*, 202; *8b*, 131).

**Anguisia** JULLIEN, 1882 [**A. verrucosa*]. Slender bifurcating branches. Zooecia verrucose, uniserial; ovicell at bifurcations. *Rec.*——FIG. 19,*6*. **A. verrucosa*, Medit.; *6a,b*, ×25 (169).

**Bientalophora** BORG, 1944 [**Pustulopora regularis* MACGILL., 1883]. Like *Entalophora* but kenozooids form network through which zooecia protrude. *Rec.*, Austral.

**Bisidmonea** D'ORB., 1853 [**B. antiqua* (=*Spiropora tetragona* LAMX., 1821)]. Tetragonal branches with ovicells at angled edges; zooecia partly closed by facets, leaving small orbicular aperture. *Jur.*——FIG. 19,*7*. **B. tetragona* (LAMX.), M.Jur. (Bath.), Fr.; *7a*, long. sec., ×10; *7b*, fragment with ovicell, ×10; *7c,d*, transv. sec., surface, ×25 (*7a,b*, 202; *7c,d*, 137).

**Brachysoecia** CANU-B., 1922 [**B. convexa*]. Like *Microecia* but stems cylindrical with zooecia partly closed by facets; ovicell very short, with transverse oeciostome. *U.Cret.*——FIG. 20,*4*, **B. convexa*, Cenom., Fr.; *4a*, distal part of branch, ×10; *4b*, surface with ovicell, ×25; *4c*, long. sec., ×10 (137).

**Cardioecia** CANU-B., 1922 [**Bidiastopora neocomiensis* D'ORB., 1853]. Slender bifoliate branches with heart-shaped ovicells. *L.Cret.*——FIG. 19,*5*. **C. neocomiensis* (D'ORB.), Valang., Switz.; *5a*, distal part of zoarium; *5b*, surface with ovicells; *5c*, long. sec.; all ×10 (*5a*, 202; *5b,c*, 137).

**Cisternifera** WALFORD, 1894 [**C. inconstans*]. Like *Entalophora* but with so-called cistern cells (?avicularia); supraoral ovicells reported. *Jur.*——FIG. 20,*5*. **C. inconstans*, Lias., Eng.; ×10 (229).

**Clavisparsa** D'ORB., 1853 [**C. clavata*]. Zoarium club-shaped, ?with ovicell; may be *Entalophora*. *U.Cret.*——FIG. 20,*11*. **C. clavata*, Santon., Fr.; ×10 (202).

**Clypeina** MICH., 1844 [**C. marginoporella*]. Like *Umbrellina* but with hollow top (?young stage). *Cret.-Eoc.*, Fr.

**Exochoecia** CANU-B., 1920 [**E. rugosa*]. Bifoliate, surface reticulate; ovicell large, restricted to edge of zoarium. *Oligo.*——FIG. 20,*12*. **E. rugosa*, Vicksb., Ala.; *12a*, fragment with ovicells, ×10; *12b*, surface, ×25 (137).

**Mesenteripora** BLAINV., 1830 [**M. michelini*] [=*Trigonoecia* CANU-B., 1922 (obj.)]. Erect bifoliate convoluted fronds with apertures on both sides; ovicell wrinkled, pyriform. *Jur.*——FIG. 20,*8*. **M. michelini*, M.Jur.(Bath.), Fr.; *8a*, zoarium, ×1; *8b*, surface with ovicells, ×10 (*8a*, 202; *8b*, 137).

**Microecia** CANU, 1918 [**Berenicea sarniensis* NORMAN, 1864]. Typically incrusting; ovicell very small, not salient and spread between a few tubes. *Cret.-Rec.*——FIG. 20,*9*. **M. sarniensis* (NORMAN), Rec., E.Atl.; ×10 (200).——FIG. 20,*10*, *M. flabellata* CANU-B., Eoc.(Claib.), N.Car.; surface with ovicell, ×25 (137).

**Nematifera** CANU-B., 1922 [**Elea reticulata* D'ORB., 1853]. Like *Mesenteripora* but zooecia with facets, short, bordered exteriorly by salient thread. *L.Cret.*——FIG. 20,*3*. **N. reticulata* (D'ORB.), Valang., Switz.; *3a*, fragment, ×10; *3b*, surface, ×25; *3c*, long. sec., ×10 (*3a*, 202; *3b,c*, 137).

**Pergensia** WALFORD, 1894 [**P. nidulata*]. Like *Entalophora* but with hollow central tubes and globose ovicell (peristomial) enveloping end of aperture. *Jur.*——FIG. 20,*1*. **P. nidulata*, Eng.; *1a*, zoarium, ×10; *1b*, median long. sec., ×10 (229).

**Peripora** D'ORB., 1850 [**P. ligeriensis* (*Pustulopora pseudospiralis* MICH., 1845)]. Cylindrical stems with zooecial apertures in 2 or more spirals. *U. Cret.*——FIG. 20,2. **P. pseudospiralis* (MICH.), Cenom., Fr.; ×10 (202).

**Pustulopora** BLAINV., 1834 [**Ceriopora pustulosa* GOLDF., 1827] [=*Stigmatopora* HAMM, 1881 (*non* KAUP, 1853); *Hammia* GREGORY, 1899 (obj.)]. Thick solid branches with apertures on spiral ridges. *Cret.*——FIG. 20,7. **P. pustulosa* (GOLDF.), Maastr., Holl.; ×5 (157).

**Umbrellina** REUSS, 1872 [**U. stelzneri*]. Zoarium peg-shaped, with apertures on broad flat-topped summit. *U.Cret.*——FIG. 20,6. **U. stelzneri*,

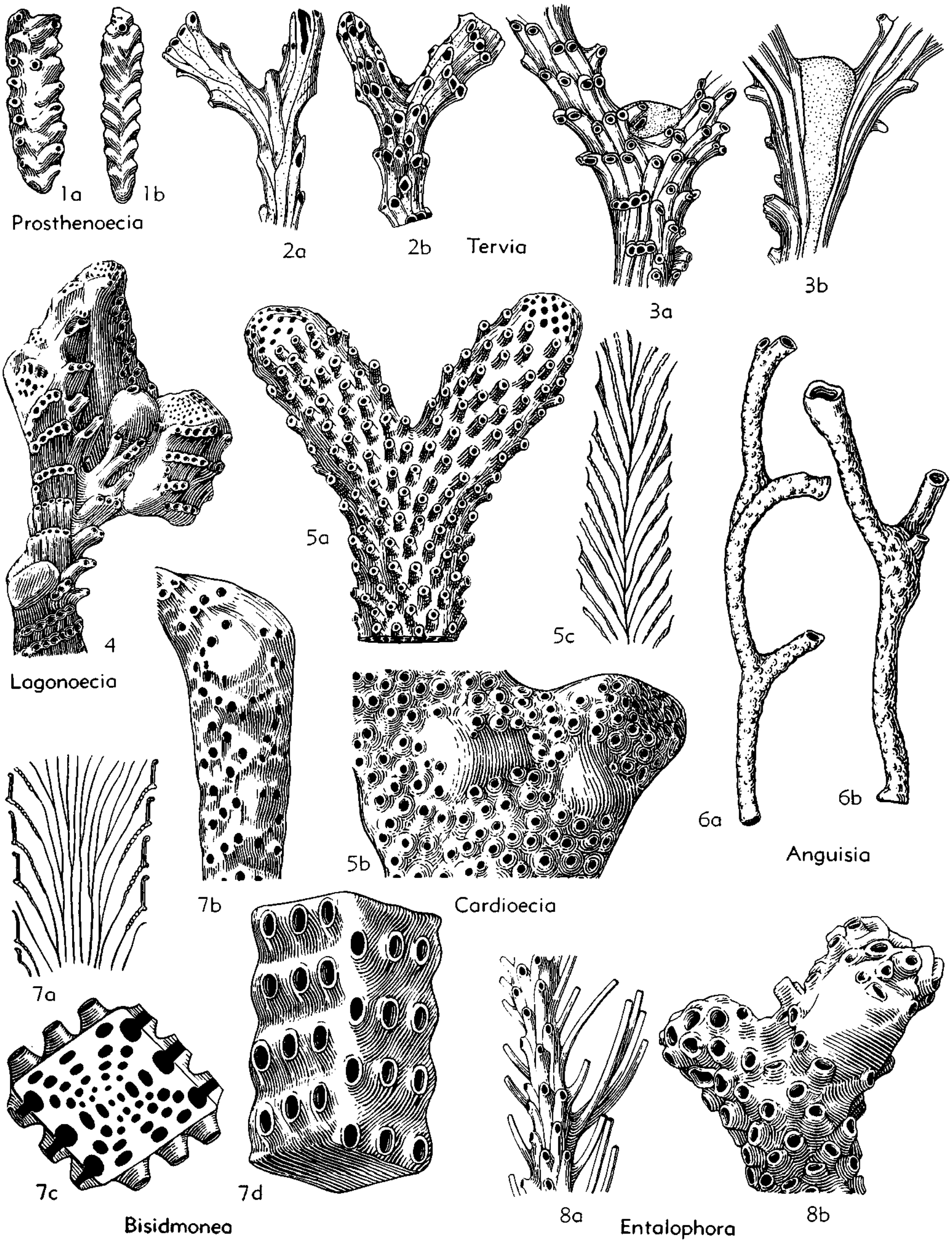


FIG. 19. Terviidae, Entalophoridae (p. G50).

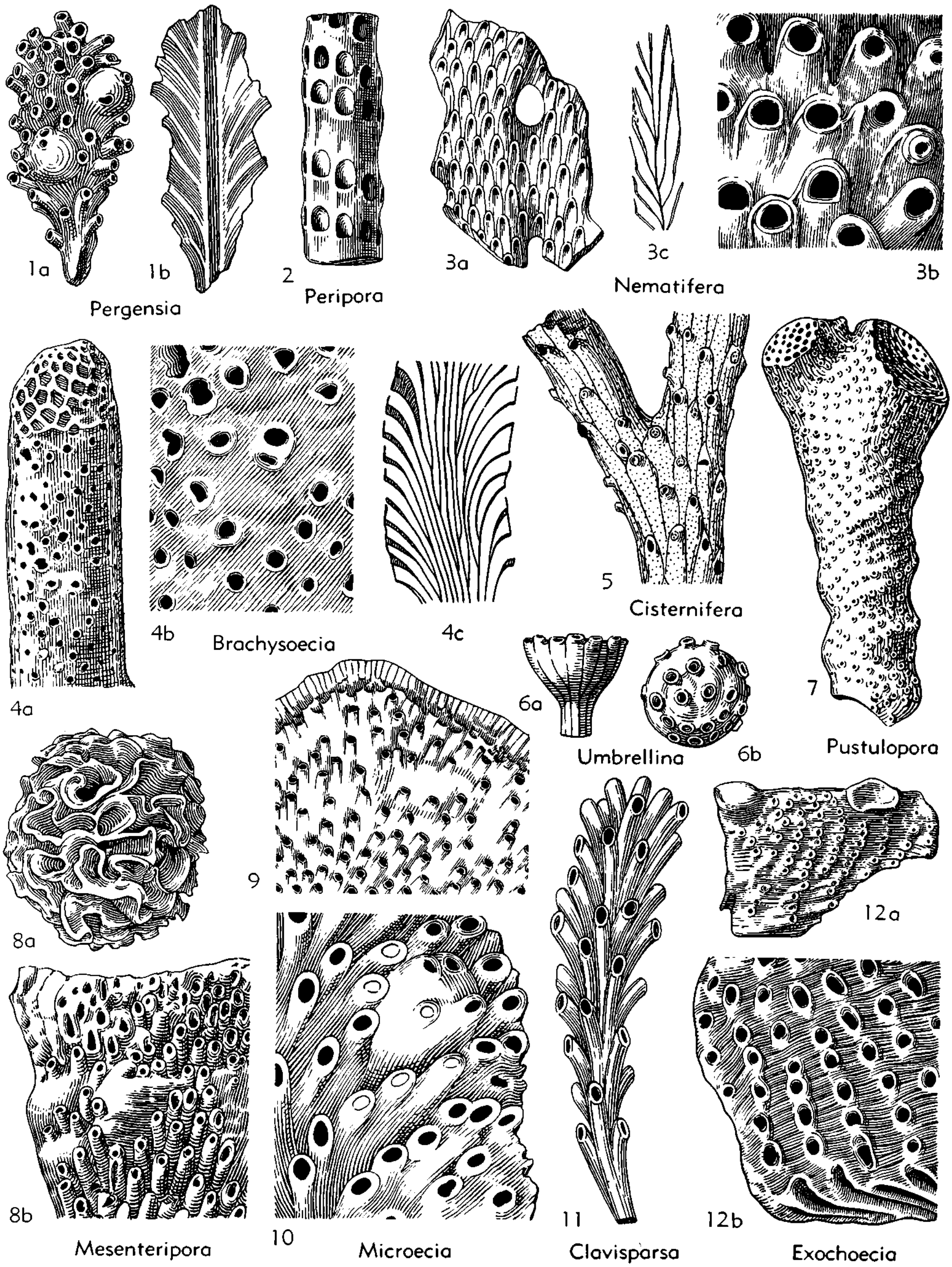


FIG. 20. Entalophoridae (p. G50, G51).

Cenom., Ger.; *6a,b,* side, top, ×10 (210).

### Family DIAPEROECIIDAE Canu, 1918

Zoaria incrusting, ramose, orbicular, tubular, or jointed, with globular ovicell formed after calcification of zooecial tubes, which without disarrangement project through it (24,25). *Jur.-Rec.*

**Diaperoecia** CANU, 1918 [**Pustulopora intricaria* BUSK, 1876]. Incrusting or ramose. Oeciostome transversely elliptical, adjacent to a zooecial aperture. No adventitious tubes. *Cret.-Rec.*——FIG. 21,*1*. **D. intricaria* (BUSK), Rec., Austral.; part of zoarium with ovicell, ×10 (164).

**Crisulipora** ROBERTSON, 1910 [**C. occidentalis*]. Erect zoarium of flexible joints as in Crisiidae but ovicell comprises an internodal inflation perforated by zooecia, not a single expanded zooecium. *Oligo.-Rec.*——FIG. 21,*5*. **C. occidentalis,* Rec., Calif.; part of zoarium with ovicell, ×10 (211).

**Desmediaperoecia** CANU-B., 1920 [**Tubulipora campicheana* WATERS, 1887]. Like *Diaperoecia* but tubes arranged in small fascicles which penetrate ovicell. *Tert.*——FIG. 21,*9*. **D. campicheana* (WATERS), N.Z.; part of zoarium with ovicell, ×10 (137).

**Diplosolen** CANU, 1918 [*pro Diplopora* JULLIEN, 1886 (*non* MACGILL., 1881, *nec* GÜMBEL, 1866)] [**Tubulipora obelia* JOHNSTON, 1838]. Like *Diaperoecia* but with adventitious tubules (nano-

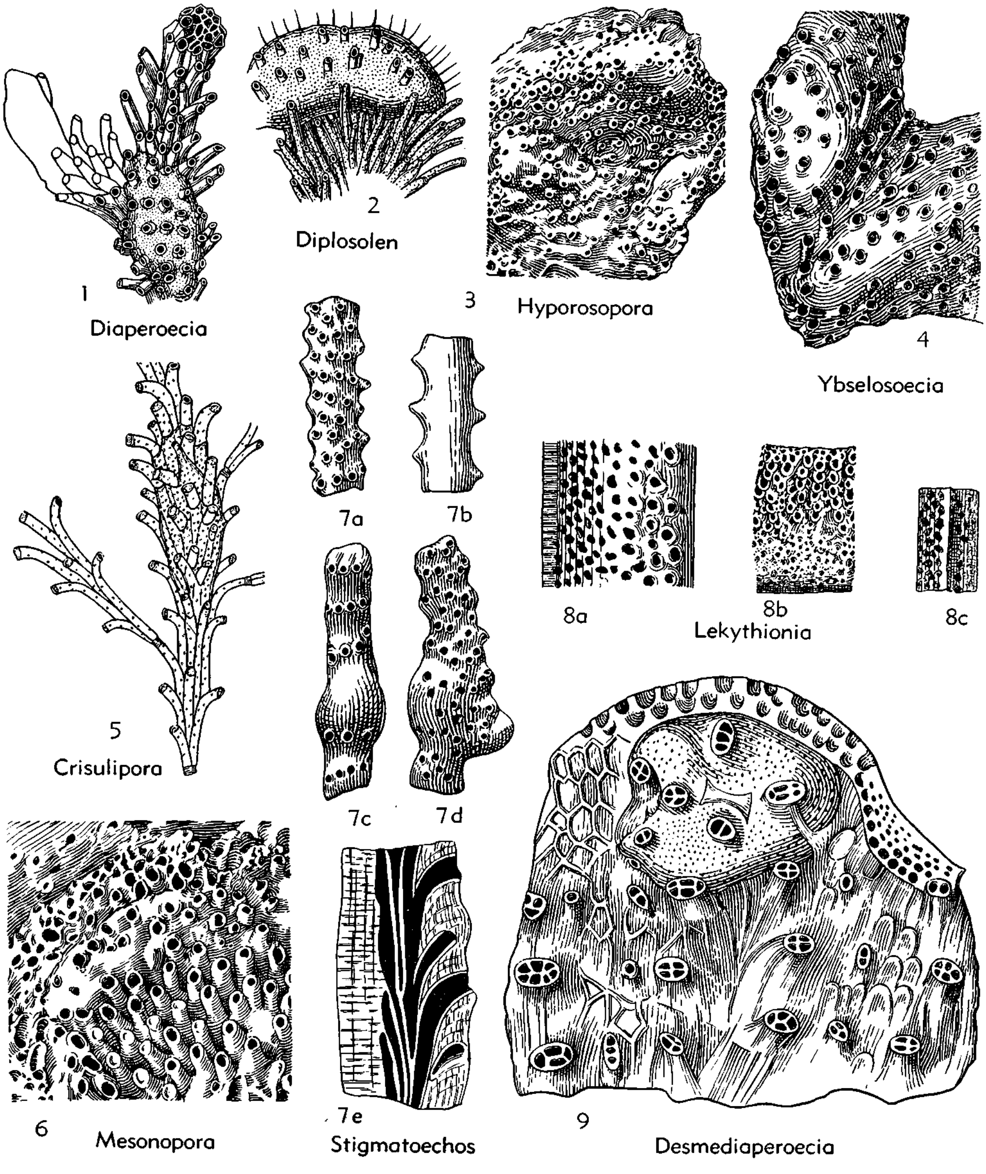


FIG. 21. Diaperoeciidae (p. G53, G54).

zooids) among the zooecia. *Cret.-Rec.*——FIG. 21,*2*. **D. obelia* (JOHNSTON), Rec., Atl.; part of zoarium with ovicell, ×10 (230).

**Hyporosopora** CANU-B., 1929 [**H. typica*]. Like *Diaperoecia* but with transverse ovicell and no central oeciostome. *Jur.*——FIG. 21,*3*. **H. typica*, M.Jur.(Bath.), Fr.; part of zoarium with 3 ovicells, ×10 (137).

**Lekythionia** CANU-B., 1920 [**Reticulipora dichotoma* GABB-H., 1862]. Erect, bifoliate expansions with adventitious tubes and bottle-shaped oeciostome. *Eoc.*——FIG. 21,*8*. **L. dichotoma* (GABB-H.), Wilcox., N.J.; *8a-c*, front, surface, side, ×10 (137).

**Mesonopora** CANU-B., 1929 [**M. typica*]. Oeciostome a small short tube in ovicell center. *Jur.*——FIG. 21,*6*. **M. typica*, M.Jur.(Bath.), Fr.; ×10 (137).

**Stigmatoechos** MARSSON, 1887 [**S. punctatus*]. Flat narrow stems, smooth on one side, apertures and large ovicell traversed by them on other. *Cret.*——FIG. 21,*7*. **S. punctatus*, Camp., Ger.; *7a,b*, front, back, ×10; *7c,d*, fragments with ovicells, ×10; *7e*, long. sec., ×25 (*7a,b,e*, 186; *7c,d*, 137).

**Ybselosoecia** CANU-L., 1933 [**Pustulopora palmata* BUSK, 1859]. Erect slender branches. Oeciostome at distal extremity of ovicell. *Tert.-Rec.*——FIG. 21,*4*. *Y. *palmata* (BUSK), Plio., Eng.; part of zoarium with ovicells, ×10 (136).

## Family PLAGIOECIIDAE Canu, 1918

Zoaria incrusting, cylindrical or bifoliate, hollow or solid erect stems. Ovicell smooth, formed before calcification of zooecial tubes which are thus disarranged; longer ovicell axis at right angle to that of zooecia; oeciostome small. Adventitious tubes absent (24, 25). *Jur.-Rec.*

**Plagioecia** CANU, 1918 [**Tubulipora patina* LAMARCK, 1816]. Incrusting or free, zooecial tubes radiating from centers of growth; ovicell a long transverse sac near zoarial margin. *Jur.-Cret.*——FIG. 22,*8*. **P. patina* (LAMARCK), Rec., Atl.; zoarium with transverse ovicell, ×10 (137).

**Cavaria** HAG., 1851 [**C. pustulosa*]. Cylindrical stems with hollow axial tube crossed by diaphragms. Ovicell globular, transverse. *U.Cret.*——FIG. 22,*6*. **C. pustulosa*, Maastr., Holl.; *6a,b*, fragments, with ovicell in *6a*, ×10; *6c,d*, secs., transv., long., ×10 (*6a,c,d*, 186; *6b*, 137).

**Desmatelesia** CANU-L., 1933 [**Tubulipora coerulea* CANU-B., 1929]. Like *Desmeplagioecia* but no pores between fascicles; ovicell perforated by both tubes and fascicles. *Mio.-Rec.*——FIG. 22,*12*. **D. coerulea* (CANU-B.), Rec., SW.Pac.; ×10 (131).

**Desmeplagioecia** CANU-B., 1920 [**Diastopora lineata* MACGILL., 1885]. Like *Plagioecia* but with zooecia grouped in fascicles. *Cret.-Rec.*——FIG. 22,*9*. **D. lineata* (MACGILL.), Rec., SW.Pac.; ×10 (164).

**Laterotubigera** D'ORB., 1853 [**L. cenomana*]. Possibly *Notoplagioecia;* ovicell not known. *U.Cret.*——FIG. 22,*10*. **L. cenomana*, Cenom., Fr.; ×5 (202).

**Liripora** MACGILL., 1887 [**Diastopora fasciculata* MACGILL., 1885]. Incrusting, flabellate; ovicell not known. *Cret.-Rec.*——FIG. 22,*2*. **L. fasciculata* (MACGILL.), Rec., SW.Pac.; ×25 (181).

**Notoplagioecia** CANU-B., 1922 [**N. farringdonensis*]. Free cylindrical stems with irregularly convex ovicell replacing many tubes. *L.Cret.*——FIG. 22,*7*. **M. farringdonensis*, Apt., Eng.; *7a*, fragment with broken ovicell; *7b*, long. sec.; *7c*, distal part of zoarium; all ×10 (137).

**Reticrisina** GREGORY, 1899 [**Reticulipora obliqua* D'ORB., 1859]. Laterally much compressed reticulated branches with ovicell as in *Plagioecia*. *Cret.*——FIG. 22,*4*. **R. obliqua* (D'ORB.), Coni., Fr.; *4a*, side, ×10; *4b*, front, ×5 (202).

**Semilaterotubigera** D'ORB., 1853 [**S. annulata*]. Like *Notoplagioecia;* ovicell not known. *U.Cret.*——FIG. 22,*11*. **S. annulata*, Coni., Fr.; *11a*, ×1; *11b*, surface, ×10; *11c*, transv. sec., ×10 (202).

**Stathmepora** CANU-B., 1922 [**S. flabellata*]. Bifoliate flabellate fronds with tubes in rectilinear fascicles. *Cret.-Pleisto.*——FIG. 22,*5*. **S. flabellata*, Pleisto., Calif.; zoarium with ovicell, ×10 (137).

**Terebellaria** LAMX., 1821 [**T. ramosissima*]. Erect branches with successive colonies at their end, and with zones of apertures separated by interzones of dactylethrae; ovicell transversely convex. *Jur.*——FIG. 22,*1*. **T. ramosissima*, M.Jur.(Bath.), Fr.; *1a*, surface with ovicells; *1b*, distal part of zoarium; *1c*, long. sec.; all ×10 (*1a,c*, 202; *1b*, 131).

**Tubigera** D'ORB., 1853 [**T. antiqua* (=*Retepora disticha* GOLDF., 1827)]. Slender erect branches with apertures in parallel rows; ovicell not known. *U.Cret.*——FIG. 22,*3*. **T. disticha* (GOLDF.), Maastr., Fr.; ×10 (202).

## Family HASTINGSIIDAE Borg, 1944

Zoaria erect, irregular, with zooecia single or in fascicles opening generally on front. Gonozooids in the axils, kenozooecia on basal side rare. *Rec.*

**Hastingsia** BORG, 1944 [**H. irregularis*]. *Rec.*, Antarct.

## Family FRONDIPORIDAE Busk, 1875
[=Fascigeridae D'ORB., 1853]

Zoaria ramose, incrusting, or massive. Zooecial tubes cylindrical, equal in diameter throughout, bundled; ovicell globular, located between fascicles and traversed by iso-

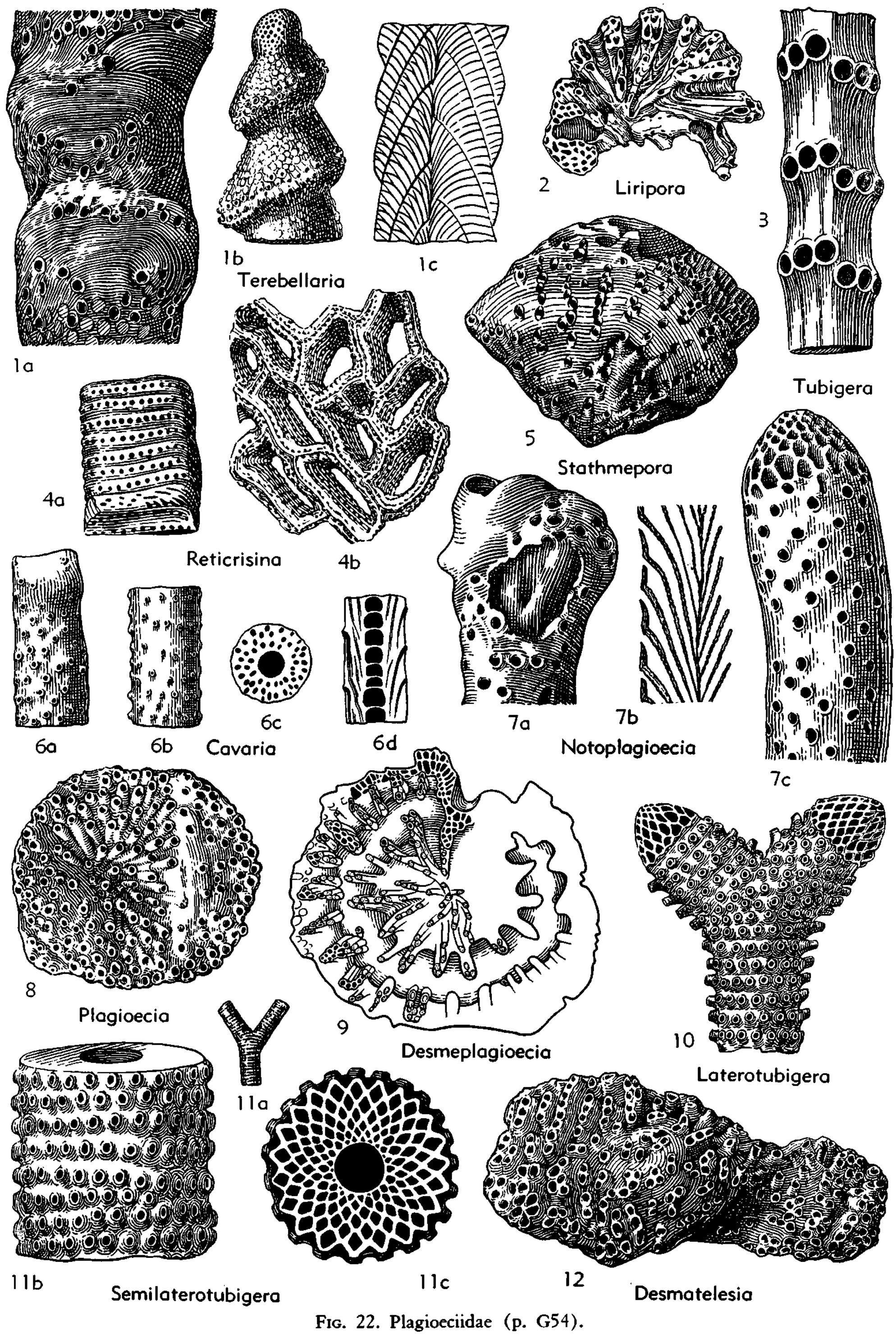


FIG. 22. Plagioeciidae (p. G54).

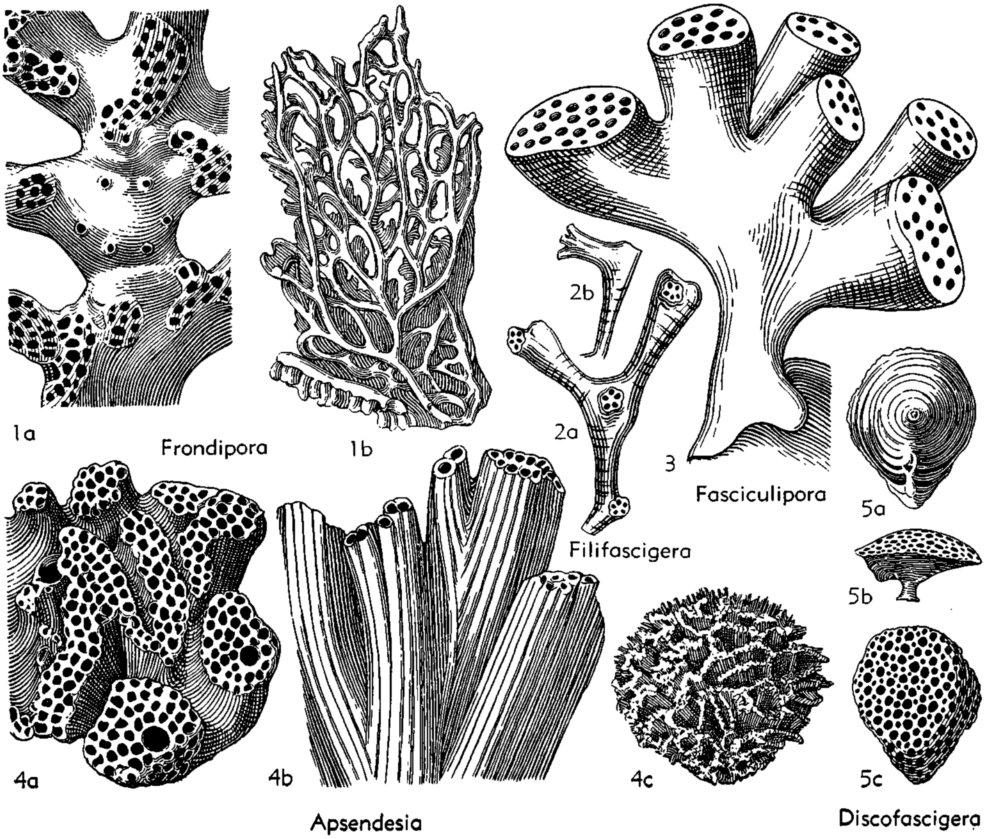


FIG. 23. Frondiporidae (p. G56).

lated tubes (Fascigeridae invalid because type genus lacking) (24). *Jur.-Rec.*

**Frondipora** LINK, 1807 [**Millepora reticulata* LINNÉ, 1758] [=*Krusensterna* TILESIUS & LAMX., 1821; *Rhyzopora* D'ORB., 1849 (obj.)]. Erect, slender many-branched stems with apertures bunched on front. *Eoc.-Rec.*——FIG. 23,*1*. **F. reticulata* (LINNÉ), Rec., Medit.; *1a,* front with ovicell, ×10; *1b,* zoarium, ×1 (*1a,* 137; *1b,* 134).

**Apsendesia** LAMX., 1821 [**A. cristata*] [=*Pelagia* LAMX., 1821 (*non* PERON, 1803); *Defrancia* BRONN, 1825]. Massive, developing from a small cup-shaped disc. Zooecia in irregularly sinuous fascicles with apertures terminal. *Jur.-Cret.*——FIG. 23,*4*. **A. cristata,* M.Jur.(Bath.), Fr.; *4a,b,* fascicles in end and side views, ×10; *4c,* zoarium, ×1 (137).

**Discofascigera** D'ORB., 1853 [**D. ligeriensis*]. Small discoid bundle of short zooecia. *Cret.-Mio.*——FIG. 23,*5*. **D. ligeriensis,* Cret.(Santon.), Fr.; *5a-c,* back, side, front, ×10 (202).

**Fasciculipora** D'ORB., 1846 [**F. ramosa*]. Like *Frondipora* but fascicles long, opening at end of branches. Ovicell an elongate tube with apertures at bifurcations. *Jur.-Rec.*——FIG. 23,*3*. **F. ramosa,* Rec., S.Atl.; ×10 (134).

**Filifascigera** D'ORB., 1853 [**Tubulipora megaera* LONSD., 1845] [=*Seriefascigera* HAMM, 1881]. Narrow incrusting zoaria with tubes grouped in salient fascicles opening at intervals in clusters. *Cret.-Rec.*——FIG. 23,*2*. **F. megaera* (LONSD.), Eoc.(Wilcox.), N.J.; *2a,b,* front, edge, ×10 (222).

**Meandropora** D'ORB., 1849 [*pro Fascicularia* M. EDW., 1830]. Zoarium massive, zooecia in irregularly anastomosing fascicles which project on surface as tortuous ridges. *Plio.,* Eng.

**Paraquataia** RUSCONI, 1948 [**P. tellechea*]. *?Ord.,* Arg.

## Family THEONOIDAE Busk, 1859

[=Actinoporidae VIG., 1949]

Zoaria typically erect fronds, but also cylindrical stems, adnate discs, and incrusting sheets. Zooecia comprise simple short open tubes with apertures in crowded bands, either along raised ridges or at edges of fronds. Ovicells incompletely known (63, 102). *Jur.-Rec.*

**Theonoa** LAMX., 1821 [**T. clathrata*] [=*Tilesia* LAMX., 1821; *Phyllofrancia* MARSSON, 1887]. Erect fronds or massive, with apertures in multiserial raised bands diverging from base to upper edge. Ovicell not known. *Jur.-Cret.*——FIG. 24,*1*. *T. grandis* MARSSON, Cret.(Camp.), Ger.; zoarium, ×10 (186).——FIG. 24,*2*. **T. clathrata*, M.Jur. (Bath.), Fr.; surface, ×2 (202).

**Actinopora** D'ORB., 1853 [**A. regularis* (=*Ceriopora stellata* KOCH & DUNKER, 1837)] [=*Repto-*

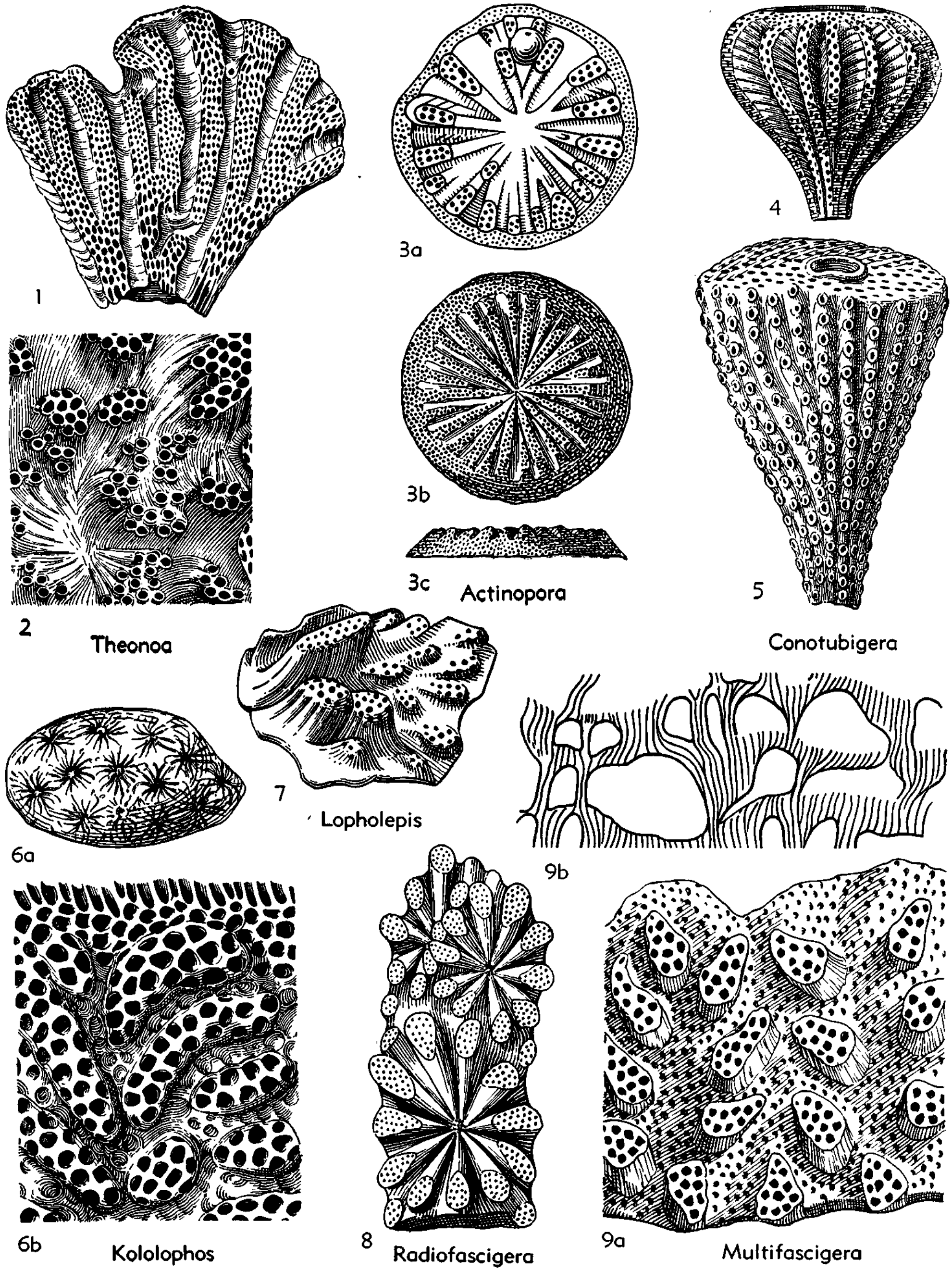


FIG. 24. Theonoidae (p. G57, G58).

*pora* DE LORIOL, 1868]. Flat adnate disc with apertures opening in one or more rows on ridges radiating from central depression. Ovicell a small ovoid capsule with terminal oeciostome interrupting an intermediate fascicle. *Cret.-Rec.*

**A. (Actinopora).** Origin of radiating ridges central; apertures biserial on each ridge. *Cret.-Rec.*——FIG. 24,*3*. **A. stellata* (KOCH & DUNKER), Cret.(Neocom.), Ger.; *3a,* zoarium with ovicell, ×5; *3b,c,* summit and edge views, ×5 (202).

**A. (Discotubigera)** D'ORB., 1853 [**Defrancia michelini* HAG., 1851]. Like *A. (Actinopora)* but apertures triserial. *Cret.,* Holl.

**A. (Radiotubigera)** D'ORB., 1853 [**R. organisms*]. Like *A. (Actinopora)* but apertures uniserial. *Cret.,* Fr.

**A. (Unitubigera)** D'ORB., 1853 [**U. discus*]. Resembles *A. (Radiotubigera). Cret.,* Switz.

**A. (Pavotubigera)** D'ORB., 1853 [**P. flabellata*]. Like *A. (Actinopora)* but origin of ridges eccentric. *Cret.,* Fr.

**Conotubigera** D'ORB., 1853 [**C. irregularis*]. Zoarium erect cylindrical, obconical, or clavate, with apertures on vertical ridges. *Cret.,* Eur.

**C. (Conotubigera).** Apertures uniserially arranged. *Cret.*——FIG. 24,*5*. **C. (C.) irregularis,* U.Cret. (Maastr.), Fr.; ×10 (202).

**C. (Serietubigera)** D'ORB., 1853 [**S. francquana*]. Like *C. (Conotubigera)* but apertures biserial. *Cret.,* Eur.——FIG. 24,*4*. **C. (S.) francquana,* U.Cret.(Maastr.), Fr.; ×10 (202).

**Kololophos** GREGORY, 1896 [**Constellaria terquemi* HAIME, 1854]. Incrusting sheets with zooecia in numerous interrupted radial groups. *M.Jur.*——FIG. 24,*6*. **K. terquemi* (HAIME), Baj., Fr.; *6a,* zoarium, ×1; *6b,* surface, ×10 (161).

**?Locularia** HAMM, 1881 [**L. semipatina*]. Zoarium divided into compartments by vertical partitions. *U.Cret.,* Holl.

**Lopholepsis** HAG., 1851 [**L. radians*]. Broad incrustations with crowded apertures at end of erect bundles of zooecia. *U.Cret.*——FIG. 24,*7*. **L. radians,* Maastr., Holl.; ×10 (160).

**Multifascigera** D'ORB., 1853 [**M. campicheana*] [=*Meandrocavea* D'ORB., 1853]. Massive, superposed lamellae, each formed of subcolonies with *Actinopora* growth form. *Cret.*——FIG. 24,*9*. **M. campicheana,* L.Cret.(Valang.), Switz.; *9a,* surface, ×10; *9b,* long. sec., ×5 (*9a,* 202; *9b,* 137).

**?Patenaria** HAMM, 1881 [**P. depressa*]. (?Cytisidae VOIGT, 1953). *U.Cret.,* Holl.

**Radiofascigera** D'ORB., 1853 [**R. ramosa*]. Subcylindrical branches composed of numerous confluent, radially arranged zooecial clusters; ovicell as in *Actinopora. Cret.-Rec.*——FIG. 24,*8*. **R. ramosa,* L.Cret.(Valang.), Switz.; ×5 (202).

**Seguenziella** NEVIANI, 1900 [**Patinella manzonii* SEGUENZA, 1879]. Like *Actinopora* but ovicell unknown. *Tert.(Plio.),* Italy.

## Suborder CANCELLATA Gregory, 1896

[Pachystega BORG, 1926]

Zoaria chiefly subcylindrical ramose, but a few forms discoid; walls cancellate (traversed by tubules classed as cancelli, mesopores, vacuoles, nematopores). *Jur.-Rec.*

This group of cyclostome bryozoans was differentiated initially on the basis of structural characters observed in the Horneridae and Petaloporidae; subsequently, GREGORY (1909) added the family which he named Desmeporidae (=Cytididae). Passageways penetrating the zoarial walls are of various sorts. Cancelli, first employed (BUSK) for structures now termed mesopores, are defined (GREGORY, 1896) as closed tubes or irregular spaces between zooecia. Mesopores are minute nontabulate tubes parallel to zooecia which open on the zoarial surface adjacent to the zooecial apertures. Vacuoles are small, obliquely disposed, recurved tubules opening on any part of the zoarium, generally along the floor of longitudinal furrows (sulci); they may be abundant on the back of zoaria where zooecial apertures are lacking. Nematopores are distally directed threadlike perforations, which generally are abundant along the back of zoaria, opening on this surface.

### Family HORNERIDAE Gregory, 1899

Zoaria ramose, erect, attached by expanded base. Zooecia with lamellose or squamose walls traversed by vacuoles which open on all sides of zoarium; zooecial apertures confined to front. Ovicell large, sac-shaped, symmetrically placed on back of zoarium, with lateral oeciostome (24,63). *Eoc.-Rec.*

**Hornera** LAMX., 1821 [**H. frondiculata*] [=*Retihornera* KIRCHENPAUER, 1869]. Vacuoles opening at base on longitudinal sulci both on front and back. *Eoc.-Rec.*——FIG. 25,*1*. **H. frondiculata,* Rec., Medit.; *1a,* zoarium, ×1; *1b,c,* back, front; *1d,* ovicell; *1e,* long. sec.; *1b-e,* ×25 (*1a,e,* 137; *1b,c,* 135; *1d,* 230).

**Crassohornera** WATERS, 1887 [**C. waipukurensis*]. Like *Hornera* but sulci lacking on front. *Tert.*——FIG. 25,*2*. *C. arbuscula* REUSS, Eoc. (Barton.), Italy; *2a,b,* front, back with ovicell, ×10 (230).

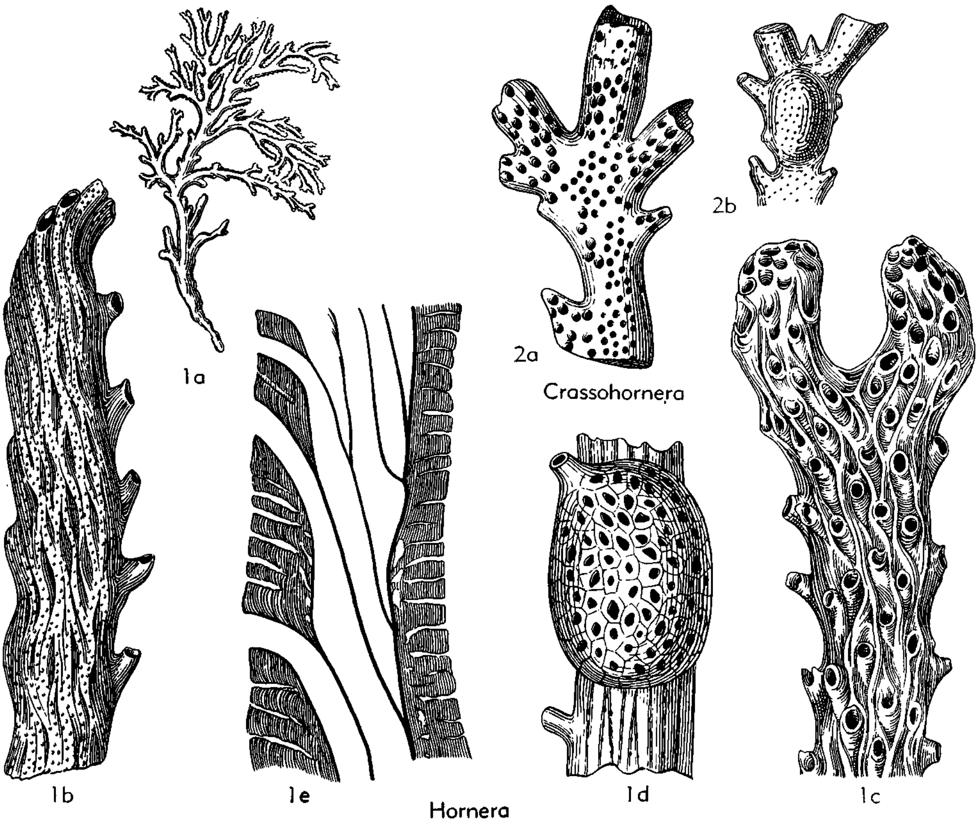


FIG. 25. Horneridae (p. G58).

## Family CYTIDIDAE d'Orbigny, 1854

[as Cytisidae] [=Desmeporidae GREGORY, 1909]

Zoaria mostly erect, ramose, but some are frondose or discoidal. Zooecia long, tubular, commonly in bundles with apertures grouped in fascicles on sides or surface. Ovicell globular, paralleling zooecial axis and formed after consolidation of subjacent peristomes. Nematopores (upwardly directed threadlike tubes, kenozooecia) generally on back (25). *Jur.-Rec.*

**Cytis** D'ORB., 1854 [**C. lanceolata*]. An erect square stem with apertures in raised groups along longitudinal projecting crests on all sides of zoarium. *U.Cret.*——FIG. 26,*1*. **C. lanceolata,* Coni., Fr.; ×10 (202).

**Bicavea** D'ORB., 1853 [**Fasciculipora urnula* D'ORB., 1850] [=*Multicrisina* D'ORB., 1853]. Vase-shaped or knoblike, with radial fascicles of zooecia on upper surface; ovicell not known. *U.Cret.*——FIG. 26,*2*. **B. urnula* (D'ORB.), Maastr., Fr.; ×10 (202).

**Chartecytis** CANU-B., 1926 [**C. compressa*]. Erect compressed fronds. Zooecia thick-walled with elongate lozenge-shaped apertures lacking peristome. Elliptical ovicell near bifurcations. *L.Cret.* ——FIG. 26,*3*. **C. compressa,* Valang., Switz.; *3a,* zoarium, ×1; *3b,* broken ovicell, ×10; *3c,* surface, ×25 (137).

**Cyrtopora** HAG., 1851 [**C. elegans*]. Solid cylindrical stems with fascicles of 3 to 6 zooecial tubes opening on all sides. No nematopores. *U.Cret.*——FIG. 26,*6*. **C. elegans,* Maastr., Holl.; *6a,* zoarium, ×1; *6b,c,* surface, transv. sec., ×10 (202).

**Desmepora** LONSD., 1850 [**Idmonea semicylindrica* ROEMER, 1840] [=*Semicytis* D'ORB., 1854]. Like *Osculipora* but has widened noncylindrical tubes. Vacuoles and nematopores all around zoarium. *Cret.*——FIG. 27,*1*. **D. semicylindrica* (ROEMER), Camp., Ger.; *1a,b,* front, side with ovicell, ×10; *1c,* fragment, ×1; *1d,* long. sec., ×10 (137).

**Diplodesmopora** CANU-B., 1922 [**D. opposita*]. Erect, slender stems. Zooecia in 2 rows of tubes to a fascicle with transversely arranged apertures confined to front. Ovicell smooth, globular, at edge of zoarium. Nematopores abundant along

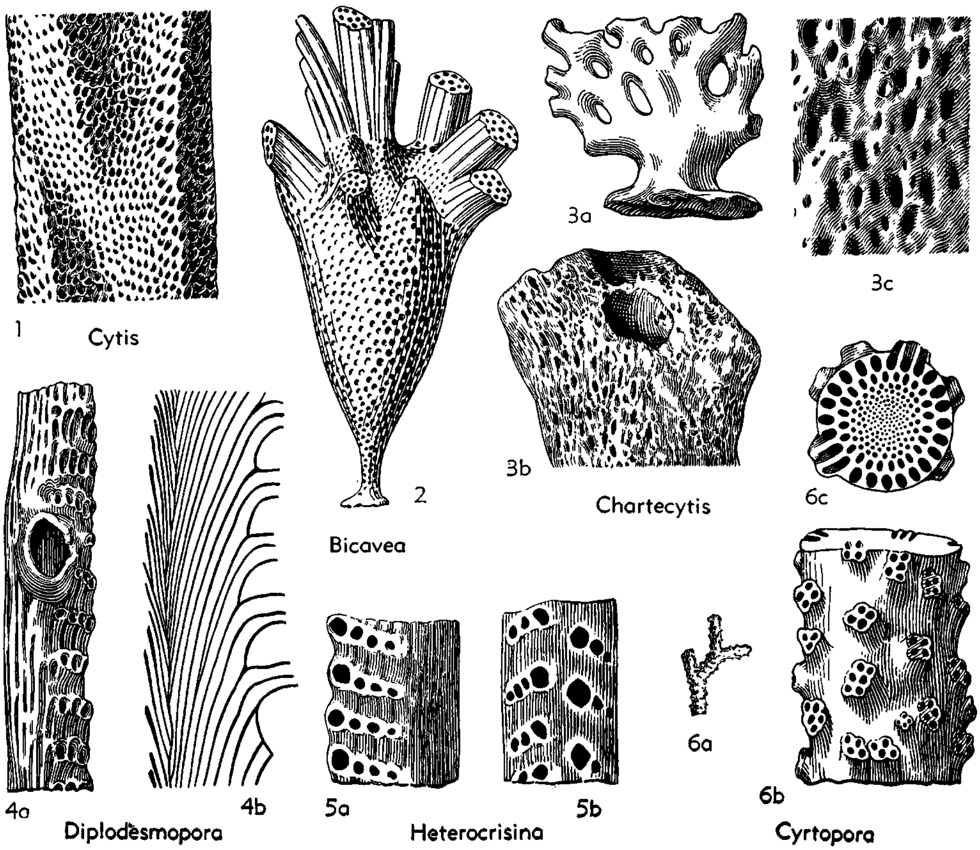


FIG. 26. Cytididae (p. G59, G60).

back. *Cret.*——FIG. 26,*4*. **D. opposita*, Coni., Fr.; *4a*, edge with ovicell, ×10; *4b*, long. sec., ×10 (137).

**Discocytis** D'ORB., 1854 [**Pelagia eudesi* MICH., 1844]. Cupuliform, with cup-shaped head; grouped radiating zooecia form ridges on summit. Ovicells large, ovoid, near periphery on back. Base a thick layer of nematopores. *U.Cret.*——FIG. 27,*3*. **D. eudesi* (MICH.), Cenom., Fr.; *3a*, back, showing ovicells and openings of nematopores, ×5; *3b*, front, ×5; *3c*, zoarium, ×1 (*3a,b*, 202; *3c*, 137).

**Echinocava** D'ORB., 1854 [*pro Echinopora* D'ORB., 1849 (*non* LAMARCK, 1816)] [**Ceriopora raulini* MICH., 1841] Solid, ramose, with fascicles extending above surface as spines or blunt projections. *Cret.*——FIG. 27,*4*. **E. raulini* (MICH.), Alb., Belg.; *4a,b*, ×1, ×10 (202).

**Heterocrisina** GABB-H., 1860 [**H. abbottii*]. Like *Diplodesmopora* but with a single row of tubes to fascicle. *Eoc.*——FIG. 26,*5*. **H. abbottii*, Wilcox., N.J.; *5a,b*, edge, front, ×10 (154).

**Homoeosolen** LONSD., 1850 [**H. ramulosus*]. Like *Truncatulipora* but no nematopores. *Cret.*——FIG. 27,*2*. **H. ramulosus*, Eng.; *2a-c*, front, back, front with ovicell, ×10 (137).

**Hypocytis** ORTMANN, 1890 [**H. asteriscus*]. Like *Supercytis* but apertures open at end of bundle only on lower side. *Rec.*, Japan.

**Osculipora** D'ORB., 1849 [**Retepora truncata* GOLDF., 1827]. Differs from *Desmepora* in lacking vacuoles and nematopores on front. *U.Cret.*——FIG. 29,*2*. **O. truncata* (GOLDF.), Maastr., Holl.; *2a,b*, edge, back, ×10; *2c*, front, ×5 (137).——FIG. 29,*3*. *O. repens* HAG., Maastr., Fr.; front with ovicell, ×10 (137).

**Plethopora** HAG., 1851 [**P. verrucosa*] [=*Pledopora* HAG., 1850 *(nom.nud.)*; *Polyphyma* HAMM, 1881. Zoarium short, ramose; cylindrical tubes grouped in salient orbicular bundles. Nematopores present. *U.Cret.*——FIG. 28,*1*. **P. verrucosa*, Maastr., Holl.; *1a*, zoarium, ×5; *1b*, surface, ×10 (160).

**Plethoporella** CANU-B., 1922 [**Monticulipora ramulosa* D'ORB., 1850]. Structure like ramose *Ceriopora* but has large smooth ovicells. *U.Cret.*——FIG. 28,*2*. **P. ramulosa* (D'ORB.), Maastr., Fr.; *2a*, surface, ×5; *2b*, ovicell, ×10; *2c*, zoarium,

×1; *2d,* long. sec., ×5 (*2a,b,d,* 137; *2c,* 202).

**Retenoa** Gregory, 1909 [**Frondipora campicheana* d'Orb., 1853]. Erect stems. Zooecia with lozenge-shaped apertures on one side only; smooth convex ovicell on back. *L.Cret.*——Fig. 28,*4.* **R. campicheana* (d'Orb.), Valang., Switz.; *4a-c,* edge with ovicell, long. sec., front, ×10 (137).

**Semicytella** Bassler, 1934 [*pro Semicytis* Canu-B., 1922 (*non* d'Orb., 1854)] [**Semicytis disparilis* d'Orb., 1854]. Like *Truncatulipora* but mesopores occur between apertures along branchlets (pinnules). *Cret.*——Fig. 28,*5.* **S. disparilis* (d'Orb.), Coni., Fr.; *5a,* zoarium, ×1; *5b,c,* front, back, ×10 (202).

**Stephanodesma** Hamm, 1881 [**S. bifurcata*]. Zoarium goblet-shaped. *U.Cret.(Maastr.),* Holl.

**Supercytis** d'Orb., 1854 [**S. digitata*]. Like *Homoeosolen* but attached by short stalk; branches

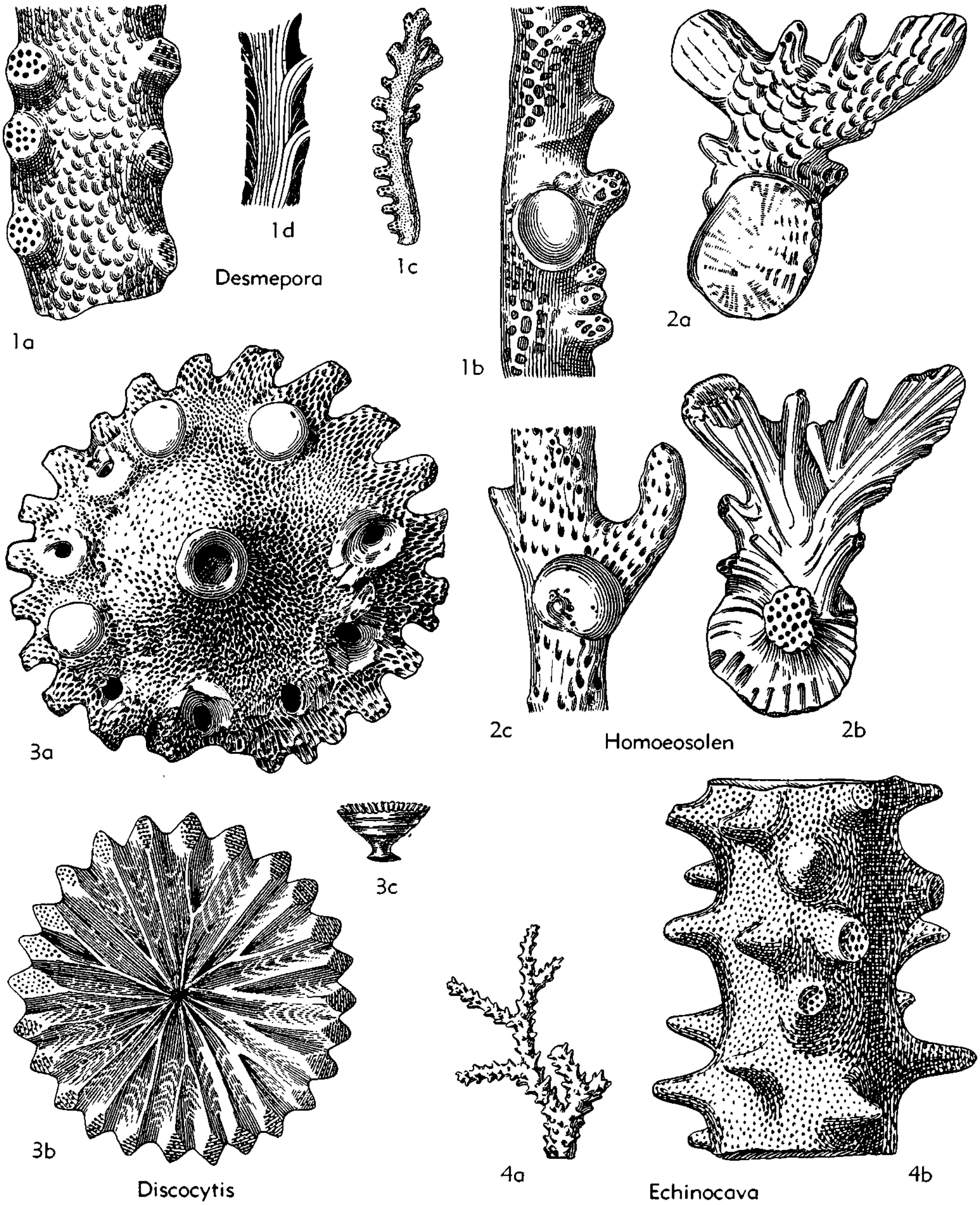


Fig. 27. Cytididae (p. G59, G60).

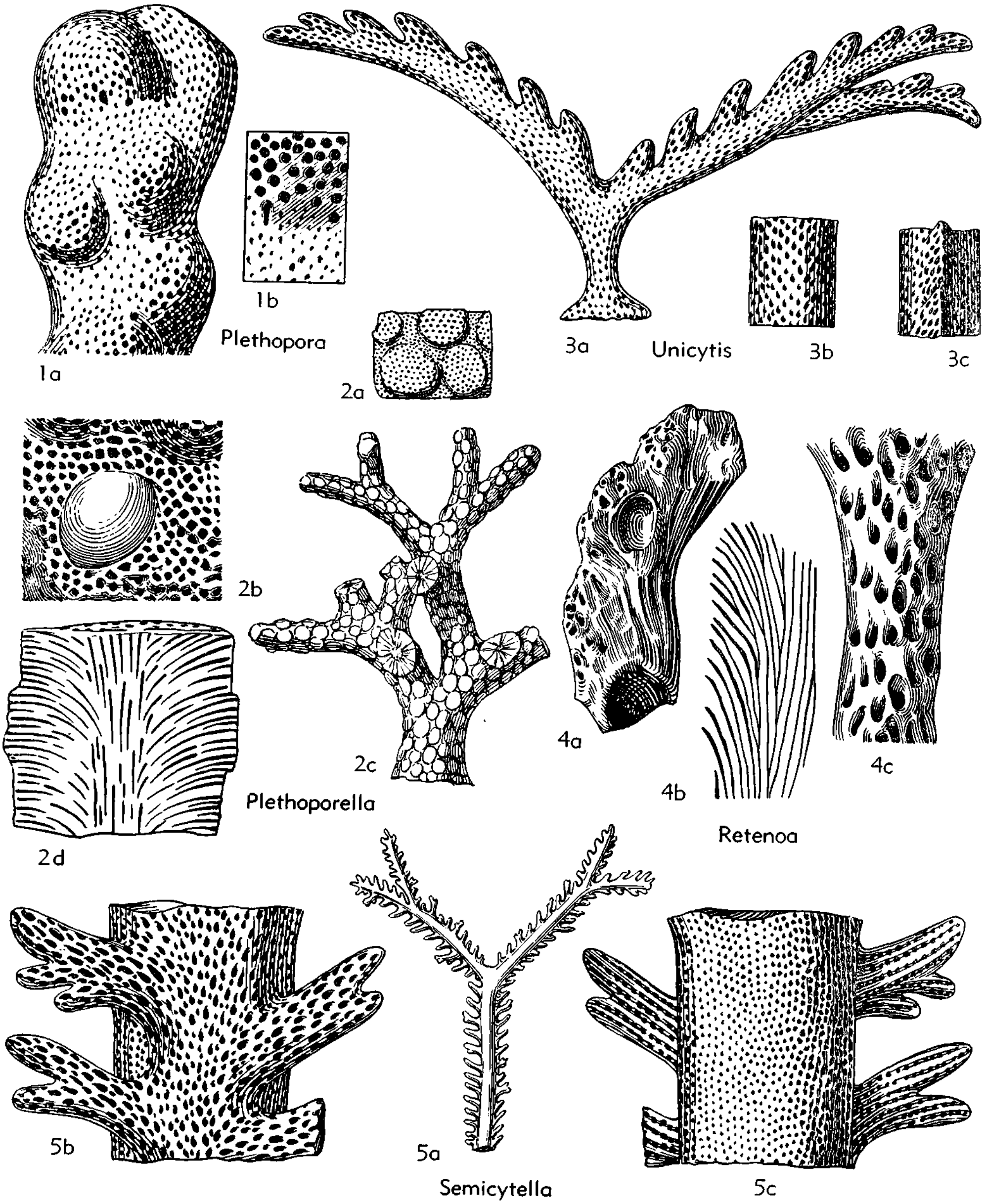


FIG. 28. Cytididae (p. G60-G62).

diverge subhorizontally. *Cret.*——FIG. 29,*4*. **S. digitata*, Maastr., Fr.; *4a*, front with ovicell, ×10; *4b,c*, back, side, ×5 (202).

**Tetrapora** QUENST., 1858 [**T. suevica*]. *Jur.*, Ger.

**Truncatulipora** BASSLER, *nom. nov.* [*pro Truncatula* HAG., 1851 (ref. 65, p. 34) (*non* LEACH, 1847)] [**Truncatula filix* HAG., 1851]. Like *Homoeosolen* but ovicells dorsally placed between pinnules; apertures elongate, oblique; nematopores present. *U.Cret.*——FIG. 29,*1*. **T. filix* (HAG.), Maastr., Holl.; *1a,b*, front, ×5; *1c*, back, ×5; *1d*, ovicell, ×10 (*1a-c*, 160; *1d*, 137).

**Unicytis** D'ORB., 1854 [**U. falcata*]. Like *Truncatulipora* but with pinnules formed of 2 alternate bundles. *U.Cret.*——FIG. 28,*3*. **U. falcata*, Senon., Fr.; *3a*, zoarium, ×5; *3b,c*, back, front, ×10 (202).

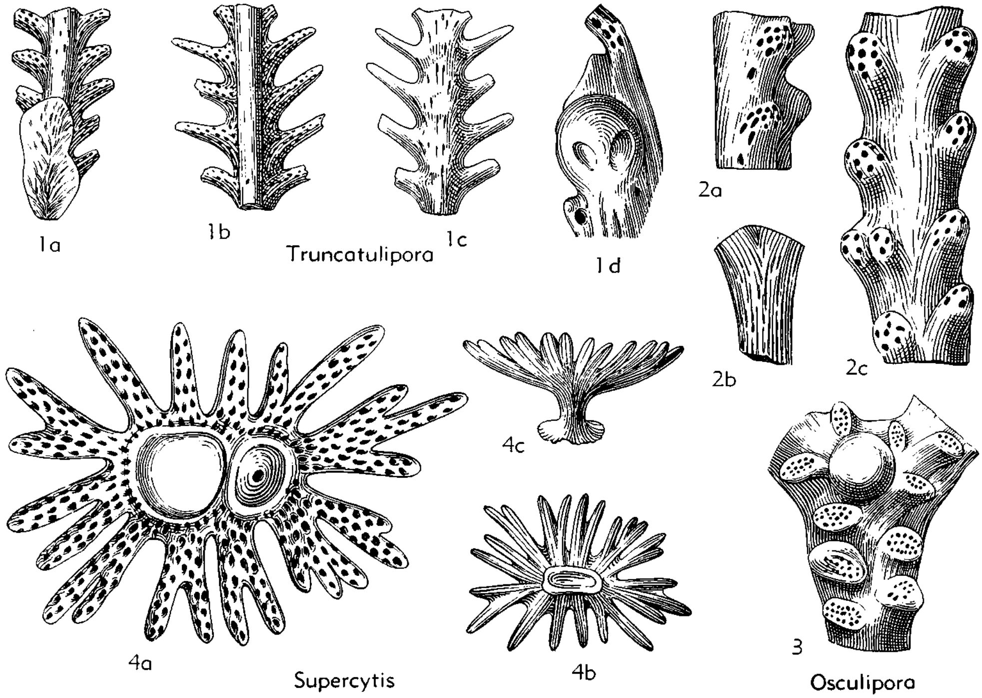


FIG 29. Cytididae (p. G60-G62).

## Family PETALOPORIDAE Gregory, 1899

[=Ascosoeciidae CANU, 1919; Crisinidae BORG, 1944]

Zoaria erect, dendroid. Zooecia opening on all sides of branches or only one; walls perforated by the zooecial tubes; oeciostome commonly median (25,63). *Cret., ?Rec.*

**Petalopora** LONSD., 1850 [**Chrysaora pulchella* ROEMER, 1840] [=*Cavea* (obj.), *Clavicavea, Reptocavea* D'ORB., 1853; *Parascosoecia* CANU, 1919]. Slender cylindrical branches with zooecia opening on all sides and numerous mesopores longitudinally arranged. Ovicell large, elongate, perforated by zooecia. *Cret.*——FIG. 30,*1*. *P. costata* D'ORB., Fr.; *1a*, surface, ×25; *1b*, ovicell, ×10; *1c,d*, secs., long., transv., ×25 (*1a,c,d*, 202; *1b*, 137).

**Atagma** LONSD., 1850 [**Ceriopora papularia* MICH. (=*A. lonsdalei* GREGORY, 1899]. Ramose, with the axial bundle covered by several lamellae and mesopores in circular broad-banded series *.Cret.*

**?Bivestis** HAMM, 1881 [**B. macropora*]. Ramose with central branch covered by another layer of zooecia; may be *Multizonopora*. (?Eleidae VOIGT, 1953). *U.Cret.(Maastr.)*, Belg.

**Cavarinella** MARSSON, 1887 [**Cavaria ramosa* HAG., 1851]. Like *Petalopora* but with axial cavity divided into compartments by partitions. *U.Cret.* ——FIG. 30,*2*. **C. ramosa* (HAG.), Maastr., Holl.; *2a,b*, secs., long., transv., ×10; *2c*, surface, ×10 (160).

**Choristopetalum** LONSD., 1849 [**C. impar*]. Allied to *Petalopora*. *L.Cret.(Apt.)*, Eng.

**Coelocochlea** HAG., 1851 [**C. torquata*]. Hollow stems with angular, spirally arranged ridges and numerous minute mesopores. *U.Cret.*——FIG. 30,*3*. **C. torquata*, Maastr., Holl.; ×10 (160).

**Crisina** D'ORB., 1853 [**C. normaniana*]. Like *Reteporidea* but salient unsymmetrical ovicell covers zoarial width, zooecial tubes short, club-shaped, with thick dilated walls; no frontal mesopores but back is smooth, perforated by scattered vacuoles. *Cret.-Rec.*

**Filicrisina** D'ORB., 1853 [**F. retiformis*] [=*Phormopora* MARSSON, 1887]. Slender cylindrical dichotomous branches with laterally placed ovicell and apertures in quincunx arrangement on front; back with lozenge-shaped dactylethrae pierced by salient tubules. *Cret.*——FIG. 30,*5*. *F. verticillata* D'ORB., Santon., Fr.; *5a,b*, back, front, ×15 (202).

**Grammanotosoecia** CANU-B., 1922 [**G. contorta*]. Zoarium bifoliate. Zooecial tubes long, cylindrical, without peristome; ovicell orbicular. Mesopores numerous. *Cret.*——FIG. 30,*6*. **G. contorta* Santon., Fr.; *6a*, surface, ×10; *6b*, ovicell, ×10 (137).

**Grammascosoecia** CANU-B., 1922 [**Ceriopora dichotoma* GOLDF., 1827]. Bifoliate; tubes short,

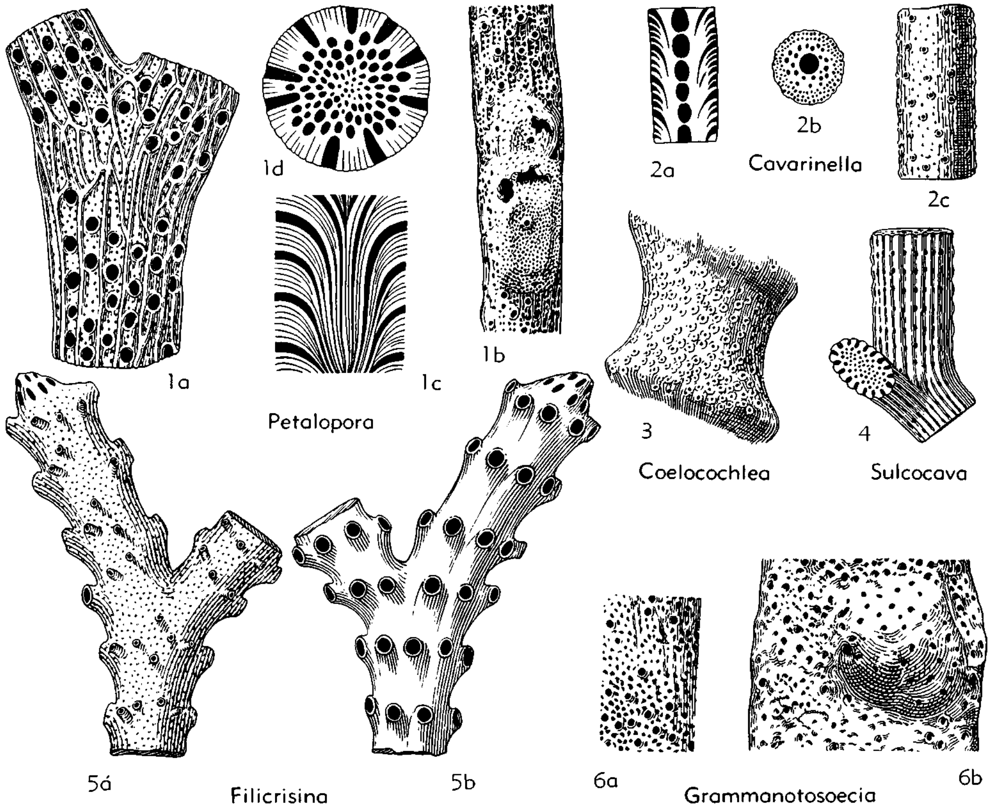


FIG. 30. Petaloporidae (p. G63, G64).

with gemmation on mesotheca only developed in older growth stages. *Cret., ?Rec.*——FIG. 31,*2*. **G. dichotoma* (GOLDF.), Maastr., Holl.; *2a-c,* secs., tang., transv., long., ×15 (137).

**Hemicellaria** D'ORB., 1850 [**H. ramosa*] [=*Semicellaria* D'ORB., 1853 (obj.)]. Small, solid, ramose. Zooecial apertures somewhat irregular. Mesopores deep, numerous; back with much lamellar tissue bearing vacuoles. *Cret.*——FIG. 31,*4*. **H. ramosa,* Maastr., Fr.; *4a,b,* front, transv. sec., ×10; *4c,* zoarium, ×1 (202).

**Laterocavea** D'ORB., 1853 [**L. dutempleana*]. Slender-branched, compressed fronds with cylindrical zooecia and many mesopores arranged around a central line. Edges of fronds formed of mesopores only and bearing ovicell. *L.Cret.*——FIG. 31,*1*. **L. dutempleana,* Apt., Fr.-Eng.; *1a,* front, ×25; *1b,c,* long. sec., edge, ×10 (137).

**Multicavea** D'ORB., 1853 [**M. magnifica*] [=*Ascosoecia* CANU, 1919]. Like *Petalopora* but peristomes arranged in radial rows. *Cret.*——FIG. 31,*6*. **M. magnifica,* Maastr., Fr.; *6a,* surface, ×10; *6b,* ovicell, ×10 (*6a,* 202; *6b,* 137).

**Multizonopora** D'ORB., 1853 [**Heteropora ramosa* ROEMER, 1850 (=*H. arborea* KOCH & DUNKER, 1827)] [=*Zonatula* HAMM, 1881]. Like *Petalopora* but composed of many superimposed laminae. *L.Cret.*——FIG. 31,*3*. **M. arborea* (KOCH & DUNKER), Neocom., Ger.-Fr.; *3a,* zoarium, ×1; *3b,* surface, ×10 (202).

**Reteporidea** D'ORB., 1849 [**Retepora lichenoides* GOLDF., 1827] [=*Crisidmonea* MARSSON, 1887; *Polyascosoecia* CANU-B., 1920]. Zoarium free, arborescent, front with divergent mesopores, back with proximally bent vacuoles (25). *U.Cret.,* Eur.

**Siphodictyum** LONSD., 1849 [**S. gracile*] [=*Filicavea* D'ORB., 1853]. Like *Laterocavea* but adventitious pores are vacuoles, not mesopores; ovicell unknown. *L.Cret.,* Eng.

**Sparsicavea** D'ORB., 1853 [**S. carantina*]. Like *Petalopora* but radiating ridges on surface connect zooecia separated by irregularly distributed mesopores between ridges. *U.Cret.*——FIG. 31,*5*. **S. carantina,* Turon., Fr.; ×25 (202).

**Sulcocava** D'ORB., 1854 [**S. cristata*] [=*Laterocava* D'ORB., 1854]. Slender bifoliate branching stems covered partly by thin lamellar tissue; mesopores absent but represented by tear-shaped pores in sulci. Ovicell spread out over broad side of zoarium. *U.Cret.*——FIG. 30,*4*. **S. cristata,* Santon., Fr.; ×10 (202).

## Family PSEUDIDMONEIDAE Borg, 1944

Zoaria erect, ramose. Zooecial apertures on frontal side in transverse or oblique series; gonozooecium simple, unlobed, its middle and distal points located on basal part of zoarium (11). *Rec.*

**Pseudidmonea** Borg, 1944 [**Idmonea fissurata* Busk, 1886]. S.Atl.

## Family CALVETIIDAE Borg, 1944

Zoaria erect, cylindrical. Zooecial apertures open all around; ovicells located only at bifurcations (11). *Rec.*

**Calvetia** Borg, 1944 [**C. dissimilis*]. S.Atl.

## Family STEGOHORNERIDAE Borg, 1944

Gonozooids in axil or with middle (inflated) and distal portions on basal side of stem, gymnocyst partly calcified (11). *Rec.*

**Stegohornera** Borg, 1944 [**Hornera violacea* Sars, 1835]. Atl.

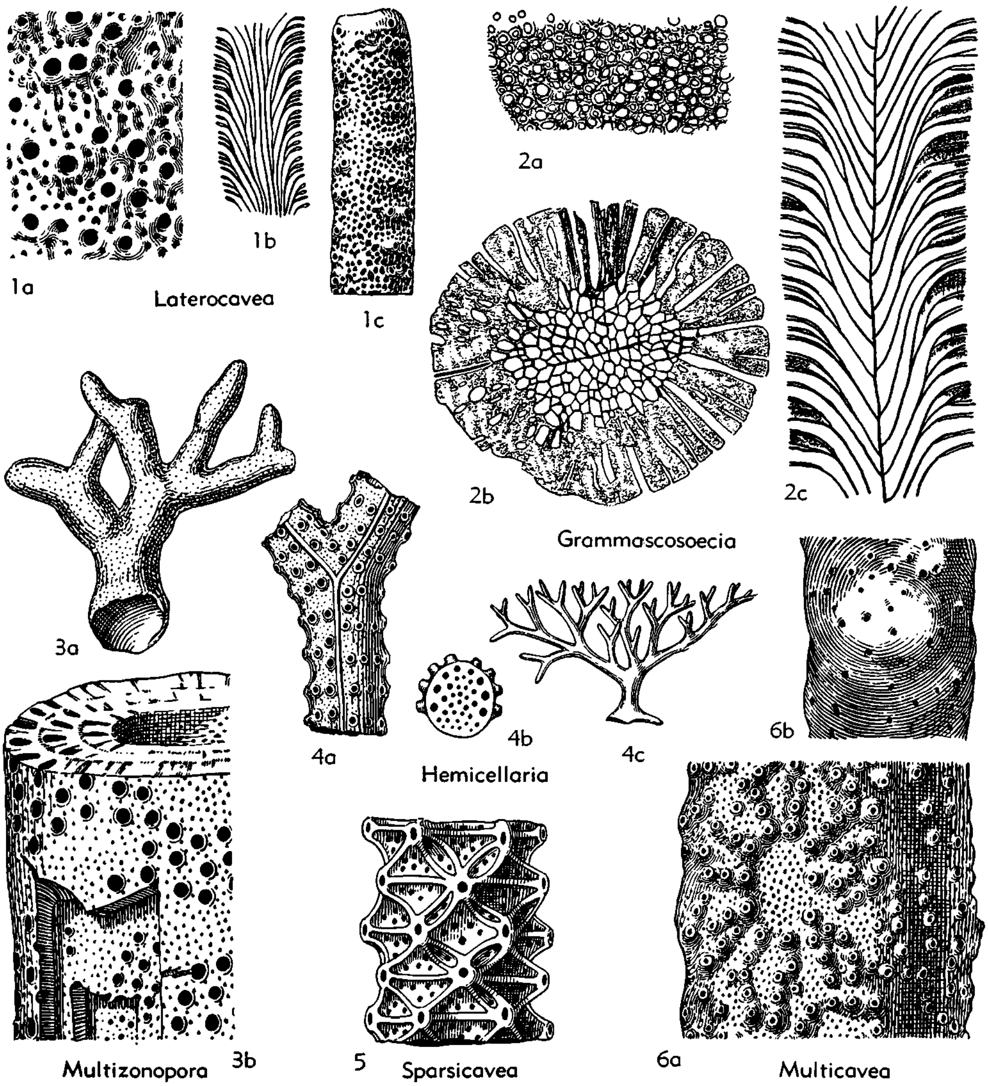


Fig. 31. Petaloporidae (p. G63, G64).

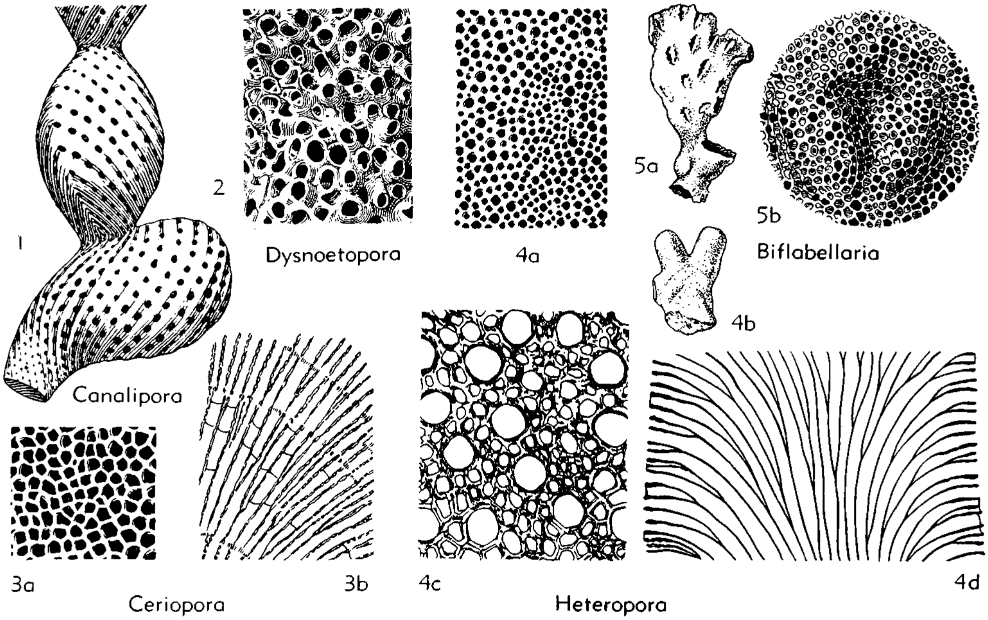


FIG. 32. Heteroporidae (p. G66, G67).

## Suborder CERIOPORINA Hagenow, 1851

[=Heteroporina BORG, 1933]

Zoaria generally thick, solid or hollow branches, or dense variously shaped lamellar masses, composed of adjoined simple, prismatic or cylindrical zooecial tubes with horizontal diaphragms; mesopores common. Superficially resemble Trepostomata but differ in having typical cyclostomatous vesicular walls and ovicells developed at right angles to the zooecial axis; regularly spaced monticules, such as occur in trepostomes, are not developed. *Trias.-Rec.*

### Family HETEROPORIDAE Waters, 1880

[=Cerioporidae HENNIG, 1894; Canuellidae, BORG, 1944]

Zoaria varied in form but all exhibiting minutely porous or vesicular wall structure denoting pseudopores; longitudinal thin sections show that the vesicles (variable in size) are formed by contraction of the membranous ectocyst in front of the pseudopores (24,63). *Trias.-Rec.*

*Ceriopora* and allied genera without mesopores were formerly classified as Cerioporidae but the presence or absence of mesopores in the Cyclostomata is not a diagnostic family character. Since ovicells remain undiscovered in the type species of *Heteropora,* the Heteroporidae should be maintained for the numerous genera without known ovicells and the Tretocycloeciidae for those with brood chambers. Naturally, future discoveries may furnish bases for changing this arrangement.

**Heteropora** BLAINV., 1830 [**Ceriopora cryptopora* GOLDF., 1827] [=*Thalamopora* HAG., 1846 (*non* MICH., 1844); *Nodicrescis* D'ORB., 1854]. Zoaria erect, arborescent with smooth surface. Zooecial tubes long, cylindrical to prismatic, separated by many thin-walled angular mesopores. Ovicell reported by VOIGT (1953). *Trias.-Rec.*——FIG. 32,4. **H. cryptopora* (GOLDF.), Maastr., Holl.; *4a,* surface, ×10; *4b,* zoarium, ×1; *4c,d,* secs., ×25, ×10 (137).

**Acanthopora** D'ORB., 1849 (*non* Y.-Y., 1876) [**Chrysaora spinosa* MICH., 1843]. Like *Neuropora* but the thickened peristome borders bear small conical points. *Jur.-Cret.*——FIG. 34,4. **A. spinosa* (MICH.), Jur.(Bath.), Fr.; *4a,* surface, ×25; *4b,* zoarium, ×1 (202).

**Biflabellaria** PERGENS, 1894 [**B. apathyi*]. Zoarium flabelliform, bifoliate, with numerous pyriform depressions (maculae) occupied only by mesopores. Zooecia dimorphic. *Cret.*——FIG. 32,5. **B. apathyi,* Maastr., Holl.; *5a,* zoarium, ×1; *5b,* surface, ×10 (202).

**Borgiola** STRAND, 1933 [**Canuella rugosa* BORG, 1933] [=*Canuella* BORG, 1933 (*non* SCOTT, 1893)]. Erect, branching, with irregular elevated areas separated by depressions. *Rec.*, Japan.

**Canalipora** HAG., 1850 [**Ceriopora articulata* HAG., 1839] [=*Cabalipora* DE MORGAN, 1882; *Tuberculipora* PERGENS & MEUNIER, 1887]. Zoaria globular, apertures quincuncially arranged, with curved ridges between rows. *U.Cret.*——FIG. 32,*1*. **C. articulata* (HAG.), Camp., Ger.; ×10 (160).

**Ceriopora** GOLDF., 1827 [**C. micropora*] [=*Semimulticava, Reptonodicava* D'ORB., 1854]. Like *Heteropora* but without mesopores; zooecia with few to many horizontal diaphragms. [Discovery of a *Corymbopora*-like ovicell in *C. tumulifera* CANU-B. (BALAVOINE, 1950) with aid of X-rays does not require reference of the Cerioporidae to the Corymboporidae because the ovicell of the type species (*Ceriopora micropora*) must still be validated.] *Trias.-Mio.*——FIG. 32,*3*. **C. micropora*, Cret.(Maastr.), Holl.; *3a,b*, secs., ×10 (*3a*, 202; *3b*, 137).

**Cerioporella** LEV., 1925 [**Ceriopora gutta* VOIGT, 1924]. Small globular zoaria with branches composed of mesopores on which new colonies are built. *U.Cret.* (*Dan.*), Ger.-Denm.

**Defranciopora** HAMM, 1881 [**Defrancia cochloidea* HAG., 1851]. Several superposed saucer-shaped subcolonies. *Cret.*——FIG. 33,*1*. **D. cochloidea* (HAG.), Maastr., Holl.; *1a*, top, ×10; *1b*, side, ×5 (202).

**Densipora** MACGILL., 1881 [**D. corrugata*]. Incrusting; zooecia with blunt processes aligned with mesopores between strong ridges; ovicell not known. *Rec.*, SW.Pac.

**Dysnoetopora** CANU-B., 1926 [**D. celleporoides*]. Zoaria solid, ramose. Zooecia club-shaped, some with salient orbicular peristomes, some irregularly polygonal, undeveloped, and some elongated into form of avicularia with teeth. *Cret.*——FIG. 32,*2*. **D. celleporoides*, Ripley, Tenn.; ×10 (137).

**Filicava** D'ORB., 1854 [**F. triangularis*]. Erect, triangular branches with zooecia outlined by 3 narrow nonporiferous ridges. *U.Cret.*——FIG. 33,*5*. **F.*

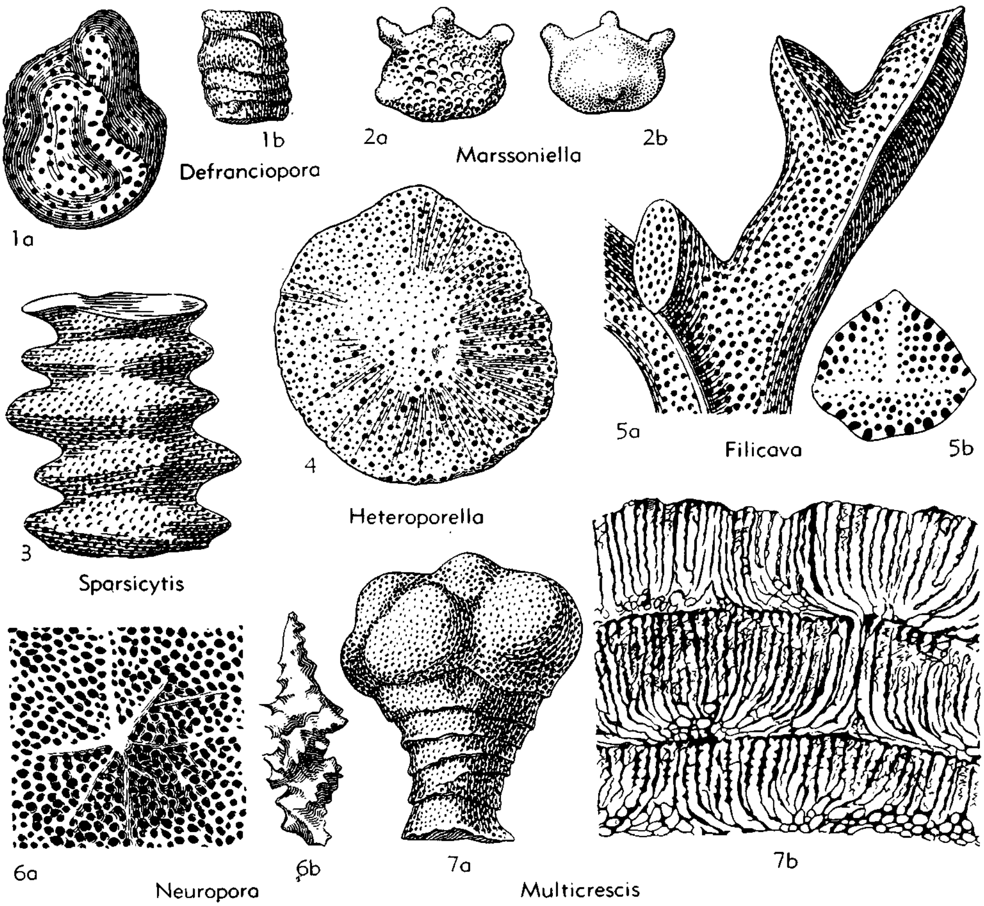


FIG. 33. Heteroporidae (p. G67-G69).

*triangularis,* Maastr., Fr.; *5a, 5b,* side, top, ×10 (202).

**Globulipora** Peron, 1893 [**G. africana*]. Globular cellular bodies, internal structures not defined (?calcareous alga). *U.Cret.,* Tunis.

**Heteroporella** Busk, 1859 [**H. radiata*]. Discoid, adnate zoarium with polygonal zooecia and many mesopores radially arranged. *Cret.-Plio.*——Fig. 33,*4*. **H. radiata,* Plio.(Crag), Eng.; ×10 (134).

**Marssoniella** Lev., 1925 [**M. reticulata*]. Top-shaped stalked colonies with zooecial apertures only on upper surface, mesopores elsewhere. *U. Cret.*——Fig. 33,*2*. **M. reticulata,* Dan., Denm.; *2a,b,* front, back, ×10 (177).

**Multicrescis** d'Orb., 1854 [**M. variabilis*] Zoarium massive or branched, composed of superposed thin layers of zooecia; apertures bearing nodose spines or visors. *Cret.-Mio.*——Fig. 33,*7*. **M. variabilis,* Cret.(Cenom.), Fr.; *7a,* side, ×5; *7b,* long. sec., ×10 (202).

**Neofungella** Borg, 1933 [**Heteropora claviformis* Waters, 1904] Simple, capitate zoarium with short peduncle; ovicell unknown. *Rec.,* Antarct.

**Neuropora** Bronn, 1825 [*pro Chrysaora* Lamx., 1821 (*non* Peron, 1809)] [**Chrysaora spinosa* Lamx., 1821]. Zoarium claviform or arborescent, surface traversed by irregular veinules of solidified tubes, radiating from special center. Zooecia polygonal, apertures with short visors. *Jur.-Cret.*——Fig. 33,*6*. **N. spinosa* (Lamx.), M.Jur.(Bath.), Fr.; *6a,* surface, ×10; *6b,* zoarium, ×1 (202).

**Neuroporella** Hennig, 1894 [**N. ignabergensis*]. Like *Neuropora* but formed of incrusting uni- or multilamellar masses. *U.Cret.,* Swed.

**Ramia** Gregorio, 1930 [**Ceriopora elegantula* Gregorio, 1930]. *Trias.,* Sicily.

**Reptomulticava** d'Orb., 1854 [**Alveolites (Micropora) heteropora* Roemer, 1839] [=*Semicava* d'Orb., 1854; *Reptocea* Keeping, 1883 (*non* d'Orb., 1854)]. Like *Ceriopora* but zoaria multilamellar, branched, or massive; zooecia short, expanding rapidly. *Cret.-Mio.*——Fig. 34,*1*. **R. heteropora* (Roemer), Cret.(Neocom.), Ger.; *1a,* long. sec., ×10; *1b,* zoarium, ×1; *1c,* surface, ×10 (137).

**Seminodicrescis** d'Orb., 1854 [**S. nodosa*]. Erect hollow branches with nodosities of zooecia and mesopores. *Cret.*——Fig. 34,*2*. **S. nodosa,* Apt., Fr.; *2a,* surface, ×10; *2b,* zoarium attached to shell, ×1 (*2a,* 202; *2b,* 137).

**Sparsicytis** Filliozat, 1907 [**Plethopora (Monticulipora) cervicornis* d'Orb., 1854]. Ramose;

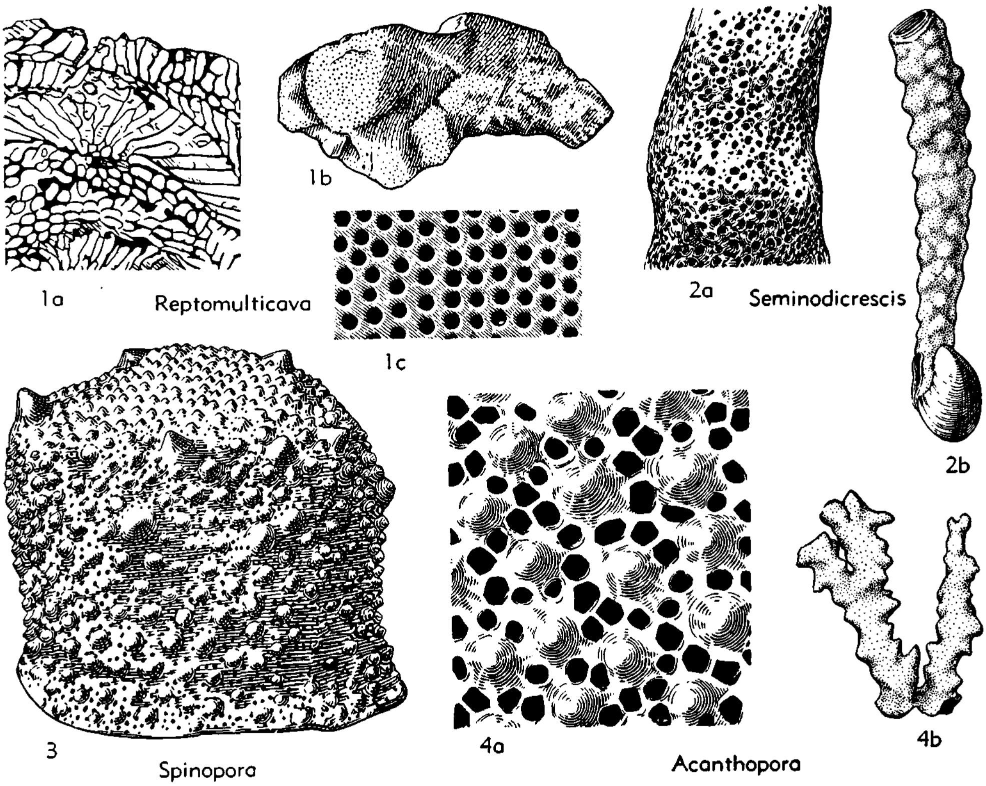


Fig. 34. Heteroporidae (p. G66-G70).

zooecial apertures opening on horizontally elongated prominences separated by areas of mesopores. *Cret.*——Fig. 33,*3*. **S. cervicornis* (d'Orb.), Coni., Fr.; ×5 (202).

**Spinopora** Blainv., 1830 [**Ceriopora mitra* Goldf., 1827]. Like *Neuropora* but surface bears very salient, smooth tuberosities without veinules; zooecial tubes with internal spines. *U.Cret.*——

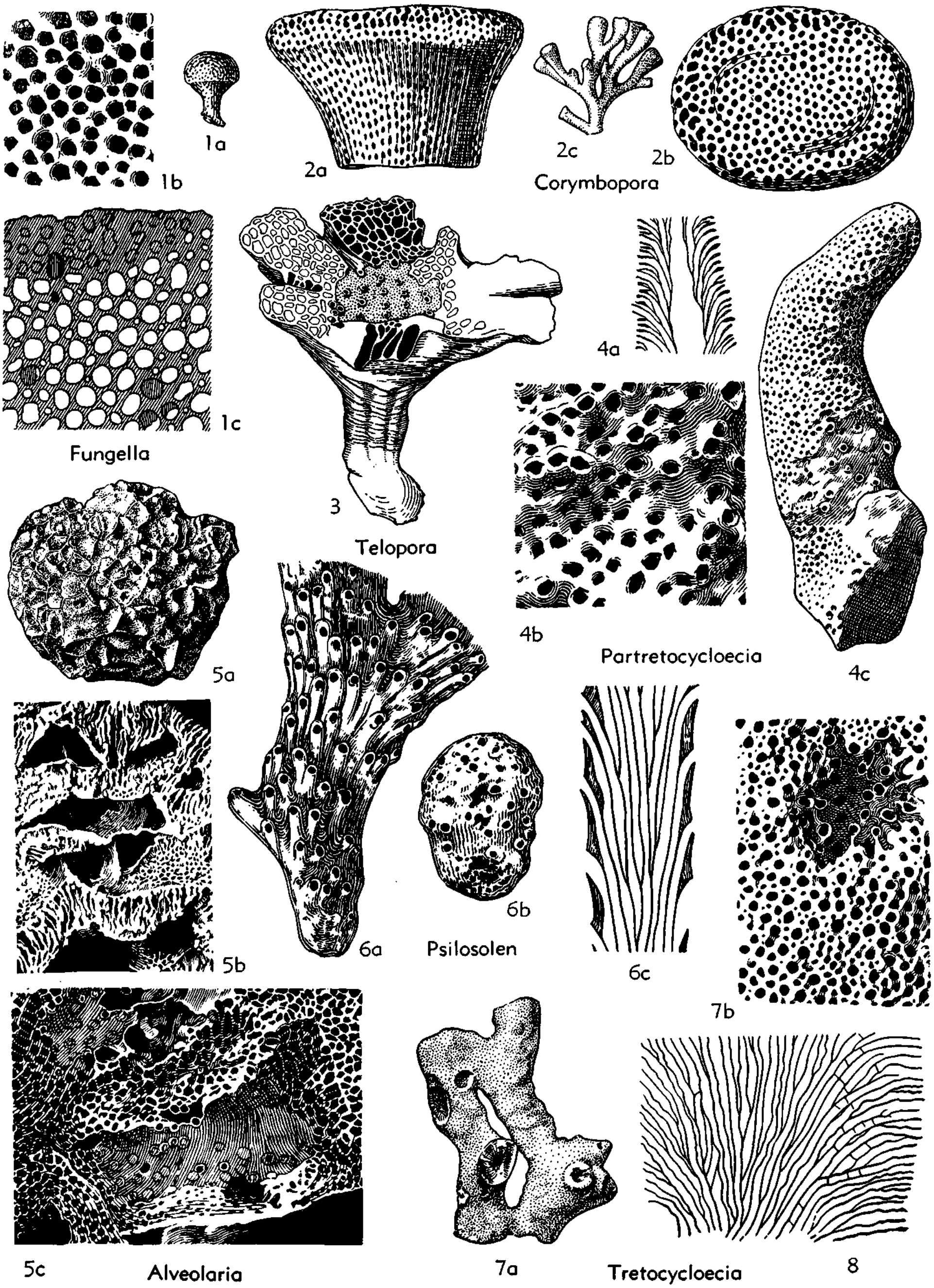


Fig. 35. Corymboporidae, Tretocycloeciidae (p. G70).

FIG. 34,*3*. **S. mitra* (GOLDF.), Cenom., Ger.; ×5 (137).

## Family CORYMBOPORIDAE Smitt, 1866

Zoaria erect, club-shaped or bushy, with distal ends expanded, larger young zooecia at top, sides marked by numerous pores comprising remnants of old zooecia. Ovicell perpendicular to zooecial axis, restricted to top (64). *Cret.-Rec.*

**Corymbopora** MICH., 1846 [**C. menardi*] [=*Corymbosa* D'ORB., 1853 (obj.)]. Tips of branches flat or curved, occupied by ovicell which resembles a branched trench when broken. *U. Cret.-Rec.*——FIG. 35,*2*. **C. menardi,* Cret. (Cenom.), Fr.; *2a,b,* ×10, side, top, ×10; *2c,* zoarium, ×1 (202).

**Dartevillea** BORG, 1944 [**D. cylindrica*]. Cylindrical peduncle arising from a disc with ovicell at top. *Rec.,* S.Atl.

**Fungella** HAG., 1851 [**F. dujardini*]. Club-shaped zoarium with narrow peduncle; ovicell unknown. *Cret.*——FIG. 35,*1*. **F. dujardini,* Maastr., Holl.; *1a,* zoarium, ×1; *1b,c,* surface, tang. sec., ×10 (137).

## Family TRETOCYCLOECIIDAE Canu, 1919

Zoaria erect, arborescent, smooth. Zooecia cylindrical to polygonal (autozooecia), with vesicular walls bearing diaphragms and separated by numerous small mesopores (kenozooecia). No gonozooecia but a flat, smooth orbicular structure extending at right angles across a number of zooecial tubes and adjacent mesopores (in some) constitutes a zoarial brood chamber (24,25,26). *Cret.-Rec.*

**Tretocycloecia** CANU, 1910 [**Heteropora dichotoma* REUSS, 1847]. Zoarium arborescent. Brood chamber embracing several zooecia and mesopores which cross at right angles. *Cret.-Rec.*——FIG. 35,*7*. *T. tortilis* (LONSD.), Mio., Va.; *7a,* zoarium, ×1; *7b,* surface with broken ovicell, ×10 (137).——FIG. 35,*8*. **T. dichotoma* (REUSS), Mio. (Helv.), Fr.; long. sec., ×10 (137).

**Alveolaria** BUSK, 1859 [**A. semiovata*]. An aggregation of club-shaped bodies united by their basal lamellae, composed of cylindrical tubes without mesopores. Brood chamber irregular, not salient, placed at center of each subcolony. *Oligo.-Plio.*——FIG. 35,*5*. **A. semiovata,* Plio., Eng.-Holl.; *5a,* zoarium, ×1; *5b,* long. sec., ×5; *5c,* surface with ovicell, ×10 (137).

**Coscinoecia** CANU-L., 1934 [**C. radiata*]. Like *Tretocycloecia* but oeciostome larger than zooecial apertures. *Mio.,* Fr.

**Paratretocycloecia** BUGE & BALAVOINE, 1951 [**P. parisiensis*]. Like *Tretocycloecia* but with surface of brood chamber reticulate (possibly clusters of mesopores). *Eoc.(Lut.),* Fr.

**Partretocycloecia** CANU, 1919 [**Cavaria dumosa* ULR., 1901]. Hollow ramose branches to massive, with short club-shaped tubes accompanied by mesopores. Brood chamber perforated by a group of tubes, each with single mesopore. *Eoc.-Oligo.*——FIG. 35,*4*. **P. dumosa* (ULR.), Eoc.(Wilcox.), Md.; *4a,* long. sec., ×10; *4b,* surface, ×25; *4c,* branch, ×10 (137).

**Psilosolen** CANU-B., 1922 [**P. capitiferox*]. Free cylindrical branches with apertures on all sides and brood chamber covering their ends. *Pleisto.-Rec.*——FIG. 35,*6*. **P. capitiferox,* Pleisto., Calif.; *6a,* fragment, ×10; *6b,* terminal brood chamber, ×10; *6c,* long. sec., ×25 (137).

**Telopora** CANU-B., 1920 [**Supercytis watersi* HARMER, 1915] Brood chamber surmounting colony, spreading over its entire width. *Mio-Rec.*——FIG. 35,*3*. **T. watersi* (HARMER), Rec., E.Indies; ×10 (164).

## Family CAVIDAE d'Orbigny, 1854

[=Ceriocavidae CANU-B., 1922; Monticuliporidae BASSLER, 1935]

Zoaria solid cylindrical or bifoliate, resembling Trepostomata in growth form but different in developing ovicells and in having vesicular wall structure with pseudopores. Ovicell a long transverse, convex, symmetrical vesicle with a large median salient tubular oeciostome and having special walls developed above the peristomes so as to enclose a number of zooecial tubes (25). *Jur.-Cret.*

**Cava** D'ORB., 1854 [**Ceriopora dumetosa* MICH., 1846] [=*Grammecava* CANU-B., 1922 (obj.)]. Zoarium dichotomously branching, bifoliate; zooecial tubes short, without peristome, their recurved extremity much widened with vesicular walls and commonly closed by facets. *Jur.*——FIG. 36,*4*. **C. dumetosa* (MICH.), M.Jur.(Bath.), Fr.; *4a,* zoarium, ×1; *4b-d,* secs., ×10 (137).

**Ceriocava** D'ORB., 1849 [**Ceriopora pustulosa* MICH., 1826 (=*Millepora corymbosa* LAMX., 1821)] [=*Monticulipora* D'ORB., 1849 (obj.) (*non* D'ORB., 1850); *Nodicava* D'ORB., 1854]. Ramose solid stems; long zooecial tubes with diaphragms in the cylindrical part and vesicular walls in the outer, wider portion. Ovicell a transverse smooth vesicle. *Jur.-Cret.*——FIG. 36,*5*. **C. corymbosa* (LAMX.), M.Jur.(Bath.), Fr.; *5a,* surface with ovicell, ×10; *5b,c,* secs., long., transv., ×10; *5d,* zoarium, ×1 (*5a-c,* 137; *5d,* 202).

**Diplocava** Canu-B., 1926 [**D. incondita*]. Like *Ceriocava* but with dimorphic zooecia, groups of large open ones separated by zones of small ones with facets. Ovicell not known. *L.Cret.*——Fig. 36,*6*. **D. incondita,* Valang., Switz.; *6a,* long. sec., ×10; *6b,c,* zooecia without and with facets, ×25 (137).

**Haplooecia** Gregory, 1896 [**Millepora straminea* Phillips, 1829]. Like *Ceriocava* but terminal walls not vesicular, diaphragms and mesopores absent, facets constant, and apertures terminal, without peristome. Ovicell not known. *Jur.-Cret.*——Fig. 36,*3*. **H. straminea* (Phillips), M.Jur.(Bath.), Eng.; surface, ×25 (137).

**Ripisoecia** Canu-B., 1922 [**Millepora conifera* Lamx., 1821] [=*?Polytrema* Risso, 1826; *?Crescis, ?Reptomulticrescis* d'Orb., 1854]. Small club-shaped stems composed of long, cylindrical zooecial tubes with peristomes, mesopores closed by calcareous lamella. Ovicell a fan-shaped smooth vesicle, striated transversely. *Jur.*——Fig. 36,*1*. **R. conifera* (Lamx.), Bath., Fr.; *1a,* surface with ovicell, ×10; *1b,* zoaria, ×1; *1c,* long. sec., ×10 (*1a,c,* 137; *1b* (202).

**Zonopora** d'Orb., 1849 [**Ceriopora spiralis* Goldf., 1827; SD d'Orb., 1849] [=*Spiroclausa* d'Orb., 1853; *Spirofascigera* Hamm, 1881]. Slender screw-shaped zoarium with zooecia in spirally arranged

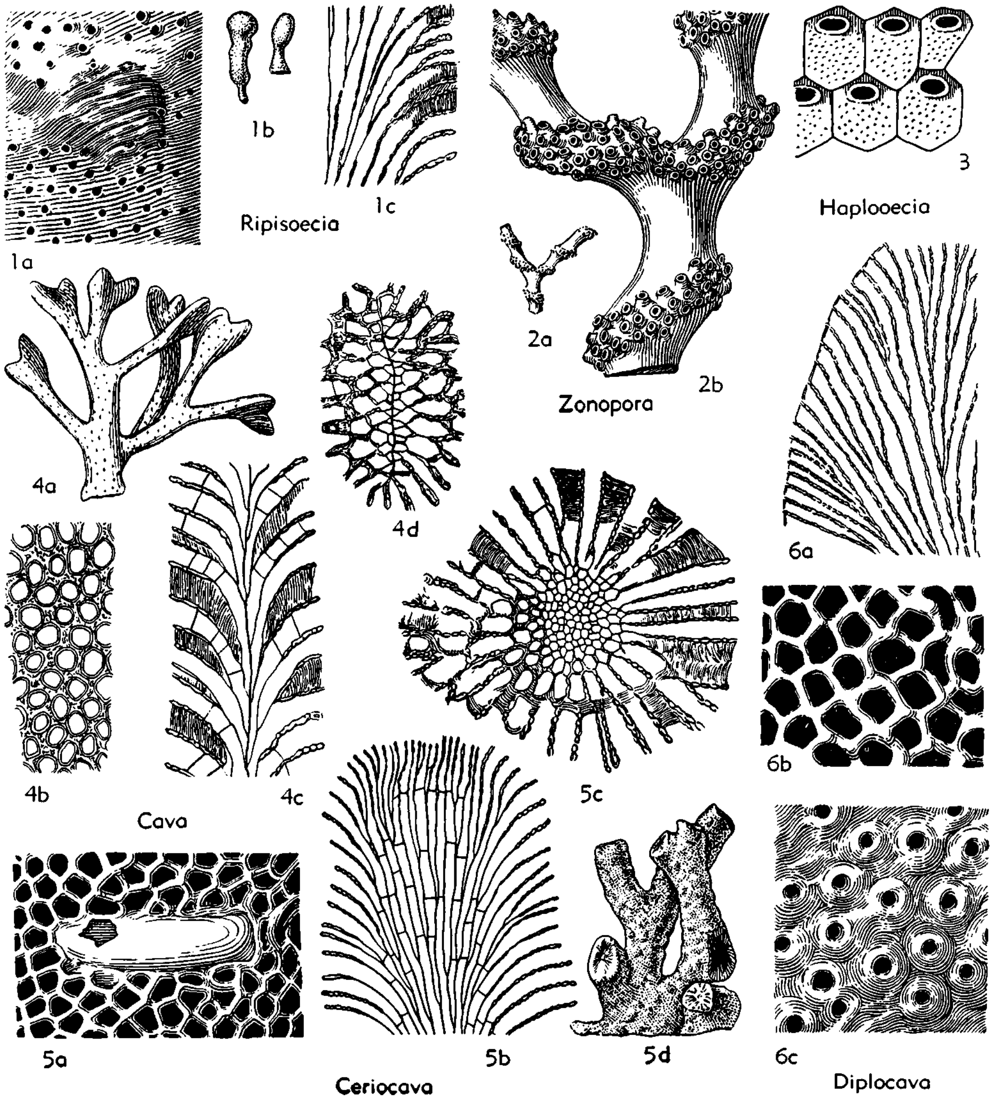


Fig. 36. Cavidae (p. G70-G72).

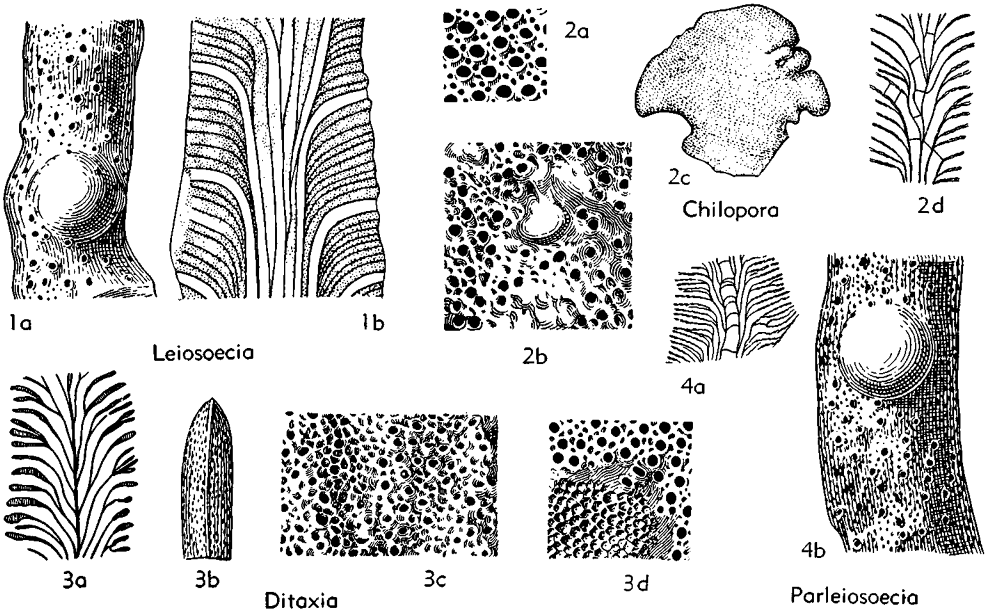


FIG. 37. Leiosoeciidae (p. G72).

bands separated by dactylethrae. Ovicell a smooth elongate sac located between spirals. *Cret.*——FIG. 36,*2*. **Z. spiralis* (GOLDF.), Maastr., Holl.; *2a,* zoarium, ×1; *2b,* side, ×5 (202).

## Family LEIOSOECIIDAE Canu & Bassler, 1920

Zoaria solid ramose, hollow, or bifoliate fronds with smooth orbicular ovicell placed above and obstructing a number of zooecial tubes but not perforated by them; numerous minute mesopores (24,25). *Jur.-Eoc.*

**Leiosoecia** CANU-B., 1920 [**Multicrescis parvicella* GABB-H., 1860]. Zoarium solid, ramose. Zooecia cylindrical, with vesicular walls separated by regular parietal mesopores. Ovicell large, smooth, convex. *Eoc.*——FIG. 37,*1*. **L. parvicella* (GABB-H.), Wilcox., N.J.; *1a,* fragment with ovicell, ×10; *1b,* long. sec., ×25 (137).

**Chilopora** HAIME, 1854 [**C. guernoni*]. Erect bifoliate fronds. Zooecial apertures with salient curved lip (lunarium) along their lower edge separated by numerous mesopores. Ovicell very small, smooth, convex. *Jur.-Cret.*——FIG. 37,*2*. **C. guernoni,* Jur.(Bath.), Fr.; *2a,b,* surface without and with ovicell, ×10; *2c,* zoarium, ×1; *2d,* long. sec., ×10 (137).

**Ditaxia** HAG., 1851 [**Ceriopora anomalopora* GOLDF., 1827] [=*Semimulticrescis, Semicrescis* D'ORB., 1854; *Polytaxia* HAMM, 1881 (obj.)]. Like *Chilopora* but has a larger ovicell, thick median lamella and thickened tube extremities. *Cret.*——FIG. 37,*3*. **D. anomalopora* (GOLDF.), Maastr., Holl.; *3a,* long. sec., ×10; *3b,* edge, ×5; *3c,d,* surface, ×10 (*3a,c,* 137; *3b,d,* 202).

**Parleiosoecia** CANU-B., 1920 [**P. jacksonica*]. Like *Leiosoecia* but tubes club-shaped, abruptly bent distally. Mesopores numerous, with vesicular walls. Central hollow with partitions. *Eoc.*——FIG. 37,*4*, **P. jacksonica,* Jackson., Ga.; *4a,* surface with ovicell, ×10; *4b,* long. sec. with central partition, ×10 (137).

# Suborder RECTANGULATA Waters, 1887

[=Calyptrostega BORG, 1926]

Zoarium developed from an expanded funnel-shaped common bud (BORG, 1944); basal wall adherent to substratum not separated by a joint from the primary disc. Special coelomic spaces (alveoli) between zooids and where covering a fertile zooecium form a zoarial brood chamber at right angles to terminal zooecial axis, with an oeciostome which may be larger than zooecial apertures. *Cret.-Rec.*

## Family LICHENOPORIDAE Smitt, 1866

[=Disporellidae BORG, 1944]

Zoarium wartlike, discoid, simple, or composite, adnate, with tubular zooecia opening on upper surface, arranged in more or less distinct series (fascicles) radiating from a free central area and separated by alveoli. Between the fascicles are adventitious tubes (so-called "cancelli") with spicules, closed by a finely perforated lamella (11,24,63). *Cret.-Rec.*

**Lichenopora** DEFRANCE, 1823 [**L. turbinata*]. Zoarium composed of mono- or multiserial fascicles with central depression on the upper surface from which rows of zooecia radiate. Ovicell a brood chamber located near zoarial center. *Cret.-Rec.*

**L. (Lichenopora)** Monoserial fascicles. *Cret.-Rec.*——FIG. 38,*1*. **L. turbinata,* M.Eoc., Fr.; ×10 (136).——FIG. 38,*2*. *L. radiata* AUDOUIN, Rec., Atl.; ×10 (167).——FIG. 38,*3*. *L. holdsworthi* BUSK, Rec., Ceylon; ×25 (230).

**L. (Bimulticavea)** D'ORB., 1853 [**B. variabilis*]. Compound, with massive superposed lamellar

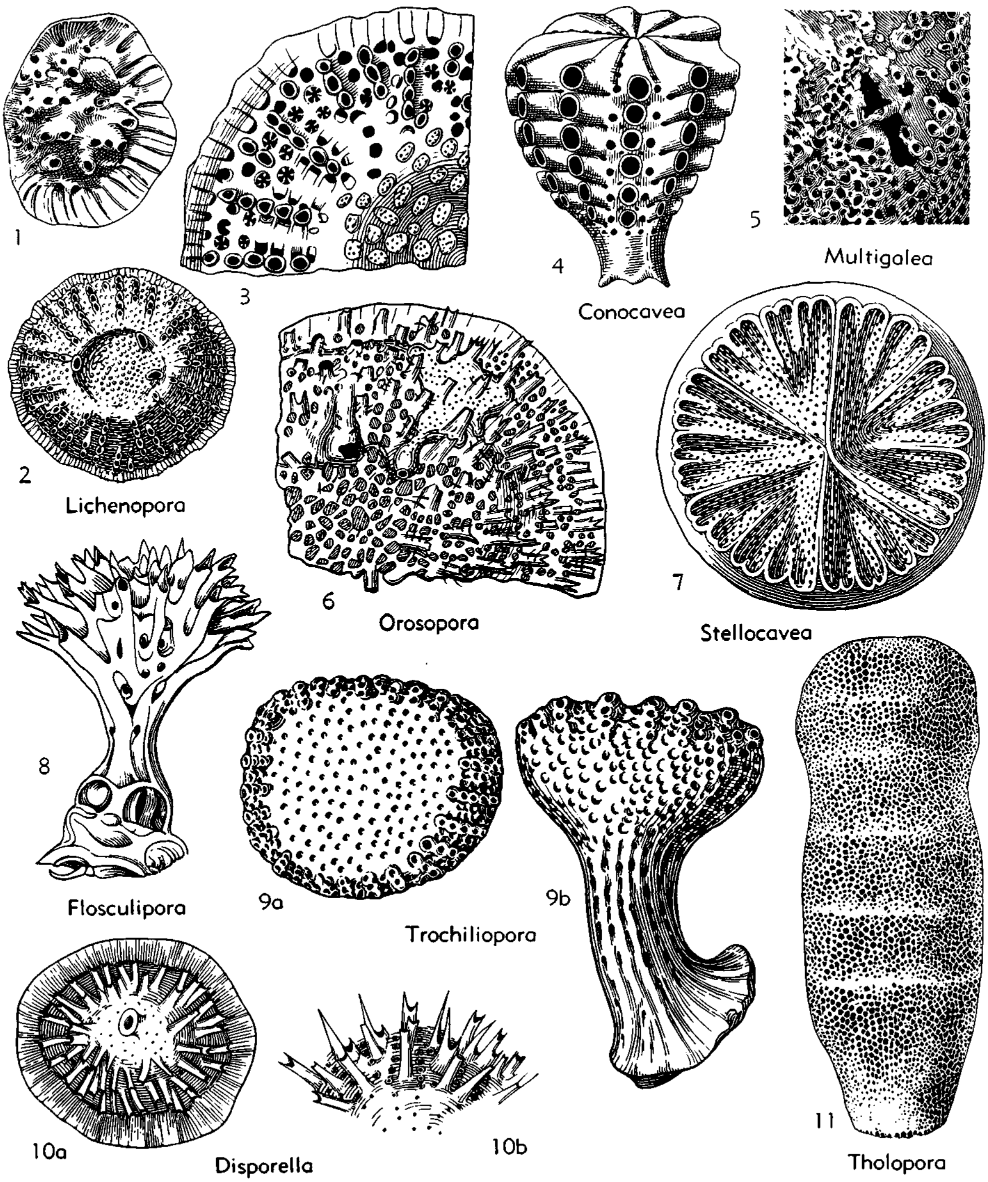


FIG. 38. Lichenoporidae (p. G73, G74).

zoarium. *U.Cret.(Maastr.)*, Fr.

**L. (Coronopora)** GRAY, 1848 [**Tubulipora truncata* FLEMING, 1828] [=*Coronopa* BUSK, 1860]. Apertures crowning an erect stem. *Rec.*, NE.Atl.

**L. (Discocavea)** D'ORB., 1853 [**D. irregularis*]. Apertures uniserial. *U.Cret.(Maastr.)*, Fr.

**L. (Domopora)** D'ORB., 1849 [**Ceriopora diadema* GOLDF., 1827]. Like *L. (Discocavea)* but with superposed colonies. *Cret.*, Ger.

**L. (Paricavea)** D'ORB., 1854 [**P. perforata*]. Like *L. (Discocavea)* but budded laterally. *U.Cret. (Maastr.)*, Fr.

**L. (Pyricavea)** D'ORB., 1853 [**P. francqana*]. Pyriform colonies connected by short cylindrical stems. *U.Cret.(Maastr.)*, Fr.

**L. (Radiocavea)** D'ORB., 1853 [**Tubulipora elegans* MICH., 1846]. Entirely incrusting. *U.Cret. (Cenom.)*, Fr.

**L. (Radiopora)** D'ORB., 1849 [**Ceriopora formosa* MICH., 1846]. Massive multilamellar zoarium with radially arranged uniserial zooecia separated by wide areas of adventitious tubes. *U.Cret. (Cenom.)*, Fr.

**L. (Semimulticavea)** D'ORB. [**Ceriopora landrioti* MICH., 1841]. Compound zoarium of confluent superposed growths of *L. (Discocavea)* type. *L.Cret.(Valang.)*, Switz.

**L. (Stellihagenowia)** BASSLER, *nom. nov.* [*pro Stellipora* HAG., 1851 (Bryo. Maastr. Kreide, p. 44) (*non* HALL, 1847)] [**Stellipora bosquetiana* HAG., 1851]. Resembles *L. (Radiopora)*. *U.Cret. (Maastr.)*, Holl.

**L. (Tecticavea)** D'ORB., 1854 [**T. boletiformis*]. Superposed colonies. *U.Cret.(Maastr.)*, Belg.

**L. (Unicavea)** D'ORB., 1853 [**U. vassiacensis*]. Short uniserial fascicles. *L.Cret.(Apt.)*, Fr.

**Actinotaxia** HAMM, 1881 [**A. magna*]. ?Like *Stellocavea* but compound (unfigured). *U.Cret*, Holl.

**Conocavea** CALVET, 1911 [**C. richardi*]. Zoarium conical, with lateral surface occupied by salient series of tubular zooecia separated by depressions with intermediate pores. *Rec.*——FIG. 38,*4*. **C. richardi*, Azores, ×10 (135).

**Cuvilliera** PFENDER, 1934 [**C. egyptiensis*]. Allied to *Lichenopora*. *Eoc.*, Egypt.

**Disporella** GRAY, 1848 [**D. hispida*] [=*Discoporella* BUSK, 1859 (obj.)]. Zoaria discoidal to oval, elongate or irregular because of secondary colonies, surrounded by a lamina. Zooecia arranged quincuncially or in clusters around a free central area occupied by alveoli, which are not closed unless brood chambers are plainly separated (11). *Rec.*——FIG. 38,*10*. **D. hispida*, Rec., E.Atl.; *10a*, colony with oeciostome, ×15; *10b*, tubes with visors, ×15 (137).

**Favosipora** MACGILL., 1885 [**F. rugosa* MACGILL., 1887]. Zoarium adherent, raised at intervals in irregular elevated rounded ridges with a distinct lamina. Zooecia large, unequal, closely packed. *Rec.*, SW.Pac.

**Flosculipora** MACGILL., 1887 [**F. pygmaea*]. Like *Lichenopora* but zoarium small, pedunculate, composed of smooth tubes with cancelli intervening towards the top. *Rec.*——FIG. 38,*8*. **F. pygmaea*, Rec., SW.Pac., ×10 (181).

**Multigalea** CANU-B., 1926 [**Reptomulticava canui* GREGORY, 1909]. Orbicular, irregularly superposed subcolonies with elongate, many-branched, star-shaped ovicell. Cancelli small, denticulate in interior zooecia with exterior triangular fragile visors. *L.Cret.*——FIG. 38,*5*. **M. canui* (GREGORY), Apt., Eng.; surface with ovicell, ×10 (137).

**Orosopora** CANU-B., 1920 [**Discoporella ciliata* BUSK, 1875]. Like *Lichenopora* but ovicell placed near zoarial margin, not at center. *Rec.*——FIG. 38,6. **D. ciliata* (BUSK), Rec., S.Atl., ×10 (230).

**?Radiocavaria** HAMM, 1881 [**R. fallax*]. Like *Cavaria* but with central tube, zooecia in stellate groups (?Petaloporidae VOIGT, 1953). *U.Cret.*, Holl.

**Stellocavea** D'ORB., 1853 [**S. francqana*] [=*Carinifer* HAMM, 1881; *Camerapora, Clausicamerapora, Curvacamerapora* MEUNIER & PERGENS, 1885]. Zoarium adnate, discoid, upper surface radially ridged, supported by lamina formed of upgrowth of under surface. Apertures generally biserial, opening along the ridges. *Cret.*——FIG. 38,*7*. **S. francqana*, Maastr., Holl.; ×10 (202).

**Tholopora** GREGORY, 1909 [**Ceriopora clavata* GOLDF., 1827]. Blunt cylindrical stems of superposed layers, center of each crowded with cancelli from which uniserial rows of apertures radiate with lines of cancelli between. *U.Cret.*——FIG. 38,*11*. **T. clavata* (GOLDF.), Cenom., Ger.; ×5 (157).

**Trochiliopora** GREGORY, 1909 [**T. humei*]. Constricted attached stem with cancelli surmounted by an expanded head with apertures in vertical series around the margin. *Cret.*——FIG. 38,9. **T. humei*, Santon., Eng.; *9a,b*, top, side, ×5 (158).

## Suborder DACTYLETHRATA Gregory, 1896

Zoaria adnate to erect, branching or multilamellar, with long cylindrical zooecia separated by dactylethrae (club-shaped polygonal tubes without polypides); mesopores, real cancelli, and avicularia absent. Ovicell unknown. *Cret.*

### Family CLAUSIDAE d'Orbigny, 1854

Dactylethrae short, frontal tubes closed by a finely perforated calcareous lamella, equal to zooecia in diameter (63). *Cret.*

**Clausa** D'ORB., [**Ceriopora heteropora* D'ORB., 1853]. [=*Claviclausa, Multiclausa* D'ORB., 1853]

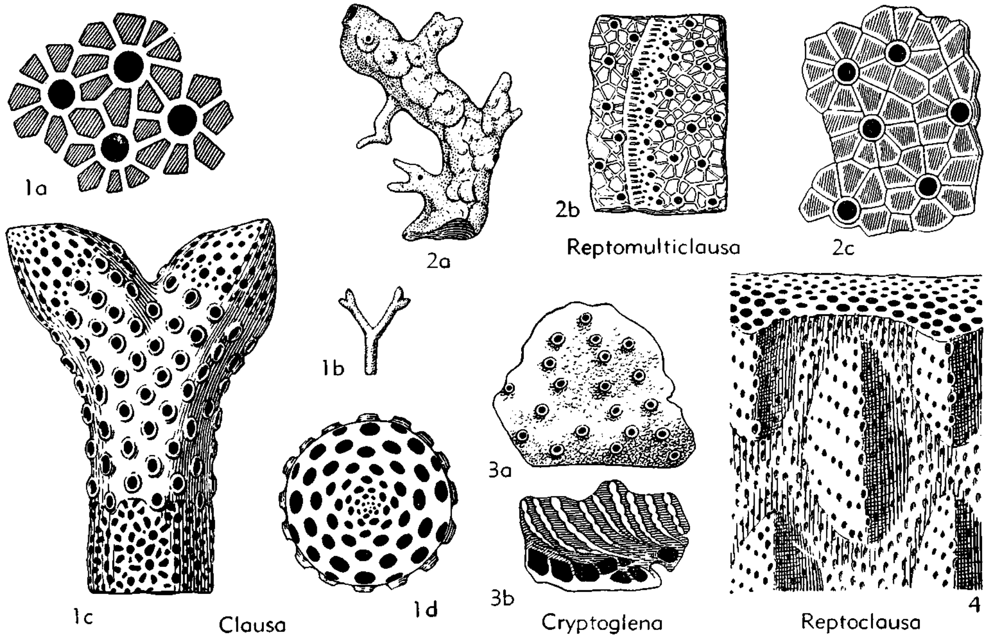


FIG. 39. Clausidae (p. G74, G75).

Stems formed of zooecia separated by dactylethrae. *Cret.*——FIG. 39,*1*. **Clausa heteropora* (D'ORB.), Cenom., Eur.; *1a,* worn surface showing dactylethrae, ×25; *1b,* zoarium, ×1; *1c,d,* distal extremity, transv. sec., ×10 (202).

**Cryptoglena** MARSSON, 1887 [**C. adspersa*]. Zoarium irregularly lobed, thick, unilaminar, with zooecia well separated by a single row of dactylethrae. *U.Cret.*——FIG. 39,*3*. **C. adspersa,* Camp., Ger.; *3a,b,* surface, edge, ×25 (186).

**Reptoclausa** D'ORB., 1853 [**R. neocomiensis*]. Incrusting, tubes grouped in idmoneiform fascicles with spaces between occupied by real zooecia and dactylethrae. *L.Cret.*——FIG. 39,*4*. **R. neocomiensis,* Valang., Switz.; surface, ×10 (202).

**Reptomulticlausa** D'ORB., 1853 [**R. papularia* (=*R. orbignyi* GREGORY, 1899)] [=*Clausimultelea, Semimulticlausa* D'ORB., 1853]. Zoarium adnate, massive, multilamellar. Dactylethrae abundant, widely separating the zooecia. *U.Cret.*——FIG. 39,*2*. **R. papularia,* Cenom., Fr.; *2a,* zoarium, 1; *2b,c,* surface, ×10, ×25 (202).

## Suborder SALPINGINA Hagenow, 1851

[=Stigmatoporina HAMM, 1881; Metopoporina MARSSON, 1887; Melicertitina PERGENS, 1890]

Zoaria with ovicells (gonocysts), tubular zooecia with facets, and other cyclostomatous characters, but also having avicularia (eleocellaria), generally a diagnostic feature of the Cheilostomata. *Jur.-Cret.*

### Family ELEIDAE d'Orbigny, 1852

[=Melicerititidae PERGENS, 1890]

Zoaria typically erect, slender, compressed stems. Zooecia long, tubular, with trumpet-shaped distal expansions, closed at the surface by perforated facet. Ovicell a large pyriform globular sac (gonocyst) with terminal oeciostome, formed on completely consolidated distal zooecia, its axis paralleling that of the tubes. Avicularia generally present as long spatulate openings, termed eleocellaria (25,63). *Jur.-Cret.*

**Elea** D'ORB., 1853 [**Bidiastopora lamellosa* D'ORB., 1850]. Slender compressed ramose stems; zooecia with short, hexagonal facet. Eleocellaria not known. *U.Cret.* ——FIG. 40,*1*. **E. lamellosa* (D'ORB.), Santon., Fr.; *1a,b,* surface, ×10, ×25; *1c,* fragment, ×1; *1d,* transv. sec., ×10 (202).

**Cyclocites** CANU-B., 1922 [**C. primogenitum*]. Like *Meliceritites* but facet-orifice circular, eleocellaria not known. *Jur.*——FIG. 40,*8*. **C. primogenitus,* Bath., Fr.; *8a,b,* surfaces with facets complete and destroyed, ×25, ×10; *8c,* surface with 2 ovicells, ×25 (137).

**Foricula** D'ORB., 1853 [**F. pyrenaica*]. Cylindrical solid stems, zooecia with long spatulate eleocellaria and walls pierced by small pores. *U.Cret.*——FIG. 40,*2*. **F. pyrenaica,* Cenom., Fr.; *2a,* fragment, ×1; *2b,c,* surface, transv. sec., ×10 (202).

**Meliceritella** LEV., 1925 [**Hornera steenstrupi* PERGENS & MEUNIER, 1886]. Slender stems with transverse rows of closed zooecia on back. *U.Cret.*——FIG. 40,*6*. **M. steenstrupi* (PERGENS & MEUNIER), Dan., Denm.; *6a,b,* front, back, ×25 (177).

**Meliceritites** ROEMER, 1840 [**Ceriopora gracilis* GOLDF., 1827][=*Escharites* ROEMER, 1840 (*non* SCHLOTH., 1820); *Vaginopora* HAG., 1846; *Chisma* LONSD., 1849; *Inversaria* HAG., 1851; *Multelea, Multinodelea, Nodelea* D'ORB., 1853]. Erect cylindrical, branching stems with tubes expanded at their extremity, lozenge-shaped facets with semicircular orifice and eleocellaria. Ovicell a heart-shaped gonocyst. *Cret.*——FIG. 40,*4*. **M. gracilis* (GOLDF.), Cenom., Ger.; *4a,* facets, ×25; *4b,* branched stem with ovicell, ×10 (137).——FIG. 40,*5*. *M. magnifica* D'ORB., Coni., Fr.; *5a,* ovicell, ×10; *5b,c,* secs., transv., long., ×10 (137).

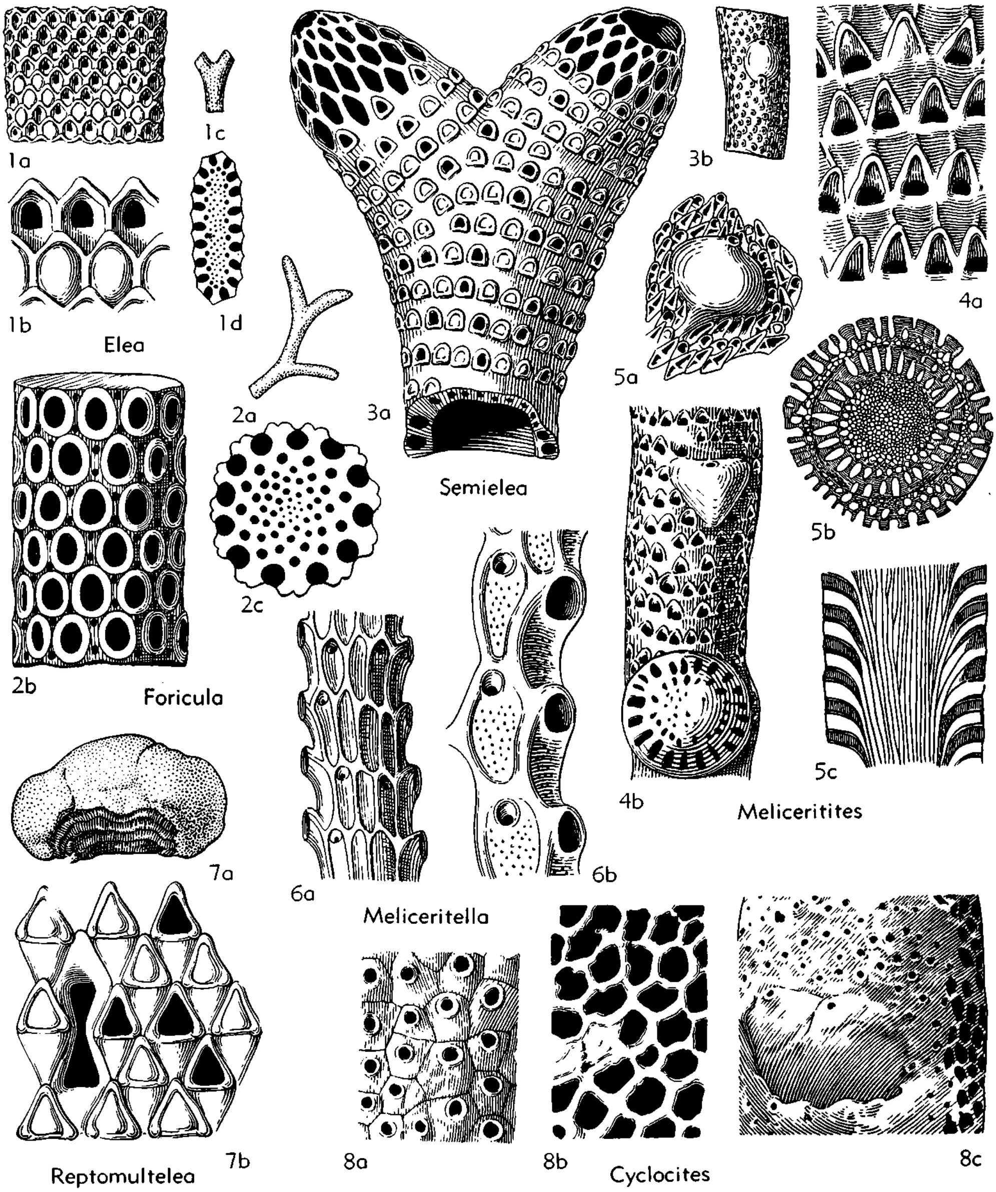


FIG. 40. Eleidae (p. G75-G77).

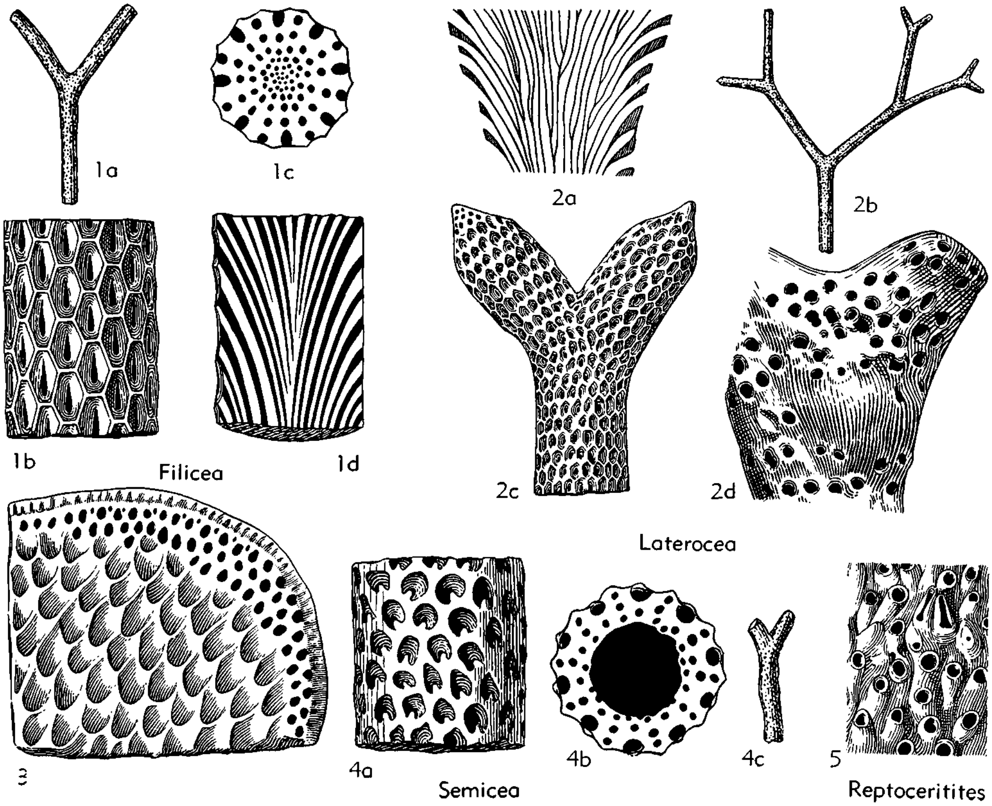


FIG. 41. Semiceidae (p. G77).

?**Pennipora** HAMM, 1881 [**P. beyrichii*]. Distinguished by feather-shaped arrangement of tubes and mesopores in longitudinal section (*fide* VOIGT, 1952). (?Heteroporidae VOIGT, 1953). *U.Cret. (Maastr.)*, Holl.

**Reptoceritites** GREGORY, 1899 [**R. rowei*]. Single adnate layer with eleocellaria and some closed zooecia. *Cret.*——FIG. 41,*5*. **R. rowei*, Eng.; ×10 (158).

**Reptomultelea** D'ORB., 1853 [**R. tuberosa*]. Like *Reptoceritites* but zoarium multilamellar. *Cret.*——FIG. 40,*7*. **R. tuberosa*, Cenom., Fr.; *7a*, zoarium, ×1; *7b*, surface with eleocellaria, ×10 (202).

**Semielea** D'ORB., 1853 [**S. vielbanci*] [=*Reptelea, Semimultelea* D'ORB., 1853]. Hollow cylindrical branches with apertures in transverse rows and well-developed heart-shaped ovicells. *Cret.*——FIG. 40,*3*. **S. vielbanci*, Senon., Fr.; *3a*, branch, ×25; *3b*, fragment with ovicell, ×10 (*3a*, 202; *3b*, 137).

## Family SEMICEIDAE Buge, 1952

[=emend. Ceidae D'ORB., 1854]

Zoaria as in Eleidae but zooecia consist of conical tubes with walls dilated distally, apertures funnel-shaped, lacking a peristome. Facets perforated by an orbicular aperture. Ovicell convex, somewhat embedded in the zooecia (25,102). *Cret.*

**Semicea** D'ORB., 1854 [*pro Cea* D'ORB., 1854 (*non* WALKER, 1837)] [**S. tubulosa*] [=*Reptocea* D'ORB., 1854; *Ceata* STRAND, 1928]. Hollow ramose zoarium with oral tongue well developed in aperture. *Cret.*——FIG. 41,*3*. *S. lamellosa* D'ORB., Fr.; surface, ×10 (202).——FIG. 41,*4*. **S. tubulosa*, Coni., Fr.; *4a*, surface, ×10; *4b*, transv. sec., ×10; *4c*, zoarium, ×1 (202).

**Filicea** D'ORB., 1854 [**F. regularis*] [=?*Cinctipora* HUTTON, 1873]. Solid cylindrical branches bearing zooecial orifices on all sides, with tubes radiating from an imaginary central axis. *U.Cret.*——FIG. 41,*1*. **F. regularis*, Maastr., Fr.; *1a*, zoarium, ×1; *1b*, surface, ×10; *1c,d*, secs., transv., long., ×10 (202).

**Laterocea** D'ORB., 1854 [**L. simplex*]. Like *Filicea* but tubes are cylindrical, dilated with thick walls at their extremity, tending to be arranged in transverse lines. Ovicell convex. *U.Cret.*——FIG. 41,*2*. **L. simplex*, Coni., Fr.; *2a*, long. sec., ×10; *2b*, zoarium, ×1; *2c*, surface, ×10; *2d*, fragment with ovicell, ×10 (*2a,d*, 137; *2b,c*, 202).

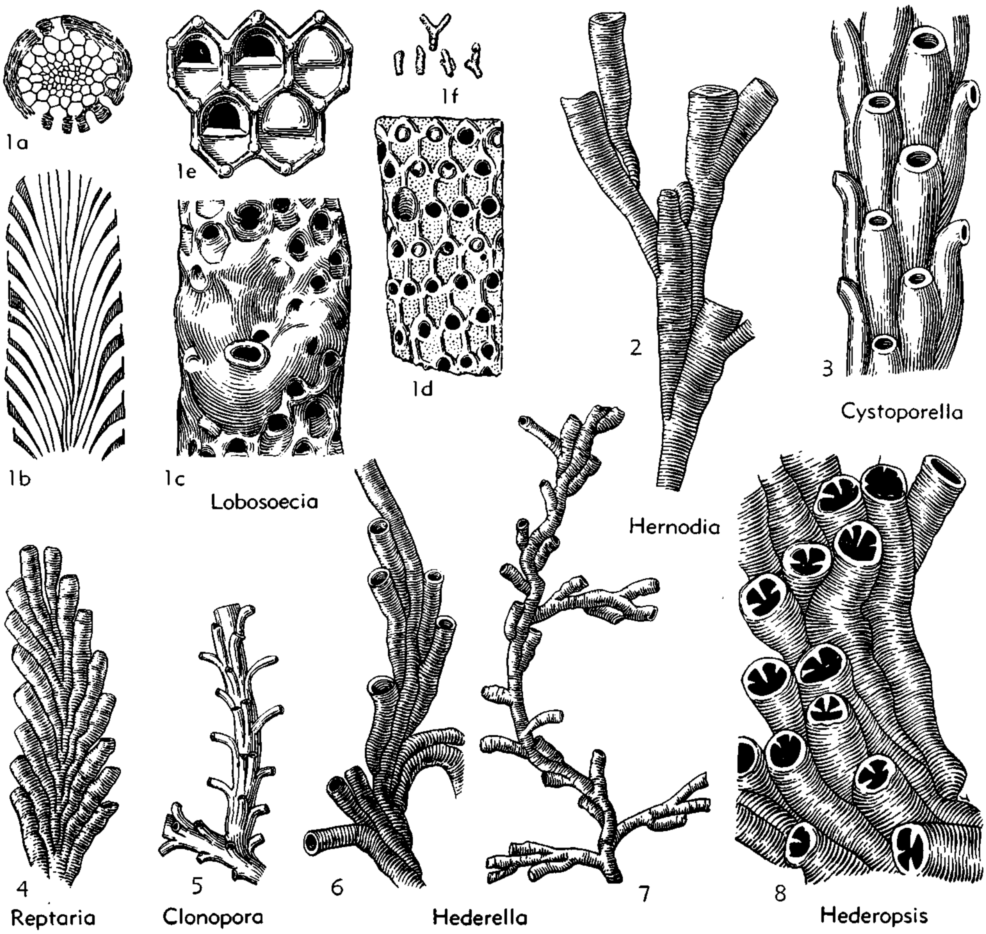


FIG. 42. Lobosoeciidae, Reptariidae (p. G78-G80).

### Family LOBOSOECIIDAE Canu & Bassler, 1922

Zoaria slender, cylindrical, solid, dichotomously dividing. Zooecial areas hexagonal with orbicular aperture. Ovicell lobed, convex, formed after consolidation of subjacent tubes; oeciostome central, with large crescent-shaped oeciopore larger than the apertures. Differs from Eleidae, which have similar zooecial areas, in the lobed ovicell and central, instead of terminal oeciostome (25). *Cret.*

**Lobosoecia** CANU-B., 1922 [**Pustulopora semiclausa* MICH., 1846]. *Cret.*——FIG. 42,*1*. **L. semiclausa* (MICH.), Cenom., Fr.; *1a,b,* secs., transv., long., ×10; *1c,* ovicell, ×25; *1d,e,* surface, ×25, ×50; *1f,* fragments, ×1 (*1a-c, f,* 137; *1d,e,* 202).

## Suborder HEDERELLOIDEA Bassler, 1939

Zoarium, derived from a bulbous ancestrula, incrusting, or rising into solid cylindrical narrow branches of tubular zooecia with perforated walls. Individual tubes budded from lateral wall of preceding zooecium, the ends of each separated by a terminal plate, probably perforated; apertures transversely elliptical, terminal, equalling the tube diameter. *Sil.-Penn.*

### Family REPTARIIDAE Simpson, 1897

Characters of the suborder (7; PRANTL, 1938; SOLLE, 1952). *Sil.-Penn.*

**Reptaria** ROLLE, 1851 [**R. stolonifera*] [=*Bryozoon*

BARRANDE, 1868; *Ptilionella* HALL, 1883]. Incrusting parallel-edged branches. Short adjacent zooecia of equal length arising alternately from basal portions of preceding ones and bending laterally outward in plane of their host. *Sil.-Dev.*——FIG. 42,*4*. **R. stolonifera*, Dev.(Hamilton), N.Y.; ×5 (131).

**Clonopora** HALL, 1883. [**C. semireducta*]. Erect, narrow, cylindrical branches. Elongate slender tubular zooecia, cohering in part of their length, then bending outward and becoming free; apertures terminal, not contracted, annular or spirally around branch. *L.Dev.*——FIG. 42,*5*. **C. semireducta*, Onond., Falls Ohio, Ind.-Ky.; ×5 (162).

**Cystoporella** BASSLER, *nom. nov.* [*pro Cystopora* HALL, 1883[1] (*non* POMEL, 1872)] [**Cystopora geniculata* HALL, 1883]. Like *Clonopora* but zooecial tubes flask-shaped terminally constricted. *L. Dev.*——FIG. 42,*3*. **C. geniculata* (HALL), Onond., Falls Ohio, Ind.-Ky.; ×10 (162).

[1]HALL, J. (1883) Trans. Albany Inst., vol. 10, p. 161.

**Hederella** HALL, 1883 [**Alecto canadensis* NICH., 1874] [=*Nicholsonia* DAVIS, 1885 (*non* WAAG.-W., 1886); *Thamnocoelum* POČTA, 1894]. Zoarium attached. Zooecia short, cylindrical, bending alternately right and left from a tubular axis, annulated and striated transversely; apertures terminal, transversely elliptical. A prolific genus (60 or more species). *Sil.-Penn.*

**H. (Hederella)**.——FIG. 42,*7*. *H. (H.) filiformis* (BILL.), Dev.(Hamilton), Ont.; ×4 (131).

**H. (Bassleria)** SOLLE, 1952 [**H. alpenensis* BASSLER, 1939]. Dev., Mich.

**H. (Rhenanerella)** SOLLE, 1952 [**H. applicata* SOLLE, 1937]. Dev., Ger.

**H. (Paralhederella)** SOLLE, 1952 [**H. parallela* BASSLER, 1939]. Dev., N.Y.——FIG. 42,*6*. **H. (P.) parallela* (BASSLER), Dev.(Hamilton), N.Y.; ×10 (162).

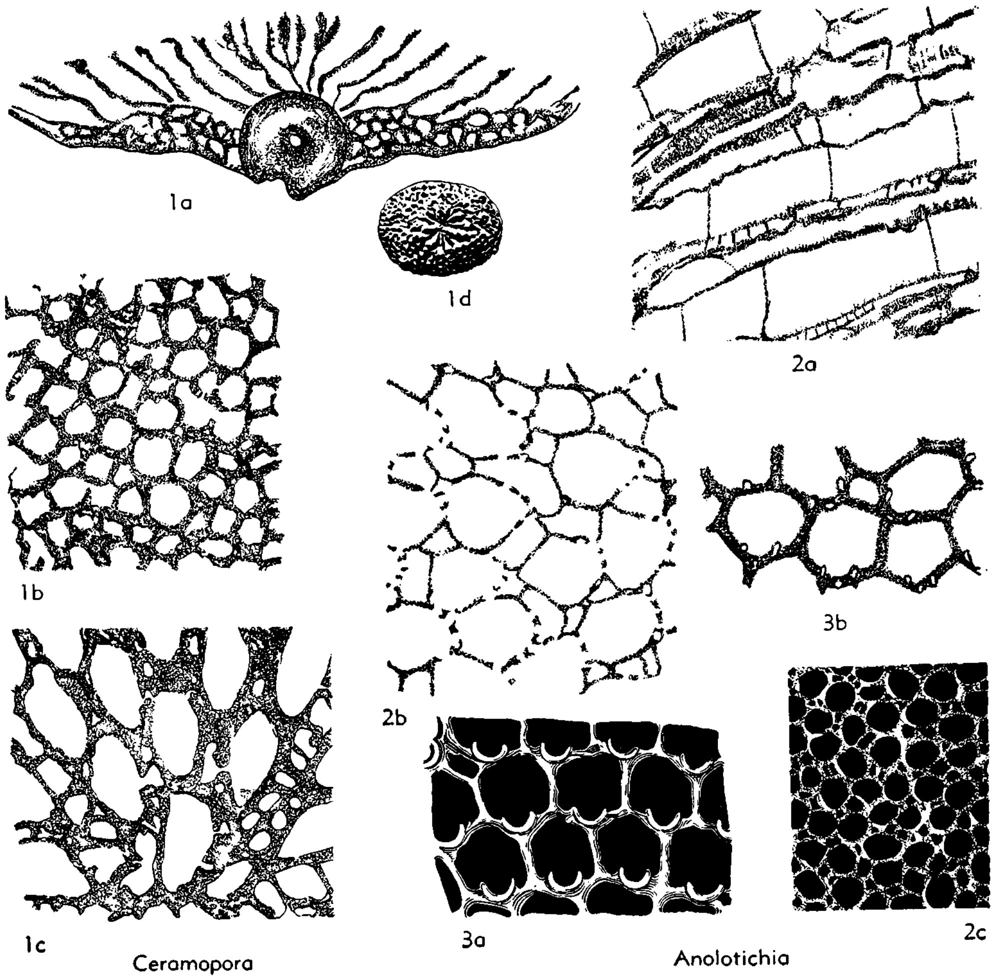


FIG. 43. Ceramoporidae (p. G81).

**H. (Magnederella)** Solle, 1952 [**H. magna* Hall, 1881]. Dev., N.Y.

**Hederopsis** Bassler, 1937 [**H. typicalis* Bassler, 1939]. Like *Hederella* but a basal part of tube has a well-defined longitudinal septum joined by 2 transverse partitions, outlining 2 rows of compartments. *Dev.*——Fig. 42,*8*. **H. typicalis* Bassler, Onond., Falls Ohio, Ind.-Ky.; ×5 (131).

**Hernodia** Hall, 1883 [**H. humifusa*]. Growth as in *Hederella* but zooecia elongate, club-shaped, each budding alternately at acute angle from midpart of preceding one. *Dev.*——Fig. 42,*2*. **H. humifusa,* Hamilton, N.Y.; ×5 (162).

## Suborder CERAMOPOROIDEA Bassler, 1913

Zoaria widely varied in shape, characterized by minutely porous structure of the zooecial walls formed of irregularly granulose laminated tissue; connection between tubes by mural communication pores. A feature typical of Trepostomata found in many ceramoporoids is divisibility of the zoarium into well-defined immature and mature zones. Ovicells are known in a few forms. *?Cam., Ord.-Perm.*

### Family CERAMOPORIDAE Ulrich, 1882

[=Ceramoporellidae Simpson, 1897]

Zoaria incrusting, ramose, massive, or bifoliate; maculae and monticules at regular intervals. Zooecia tubular, proximally

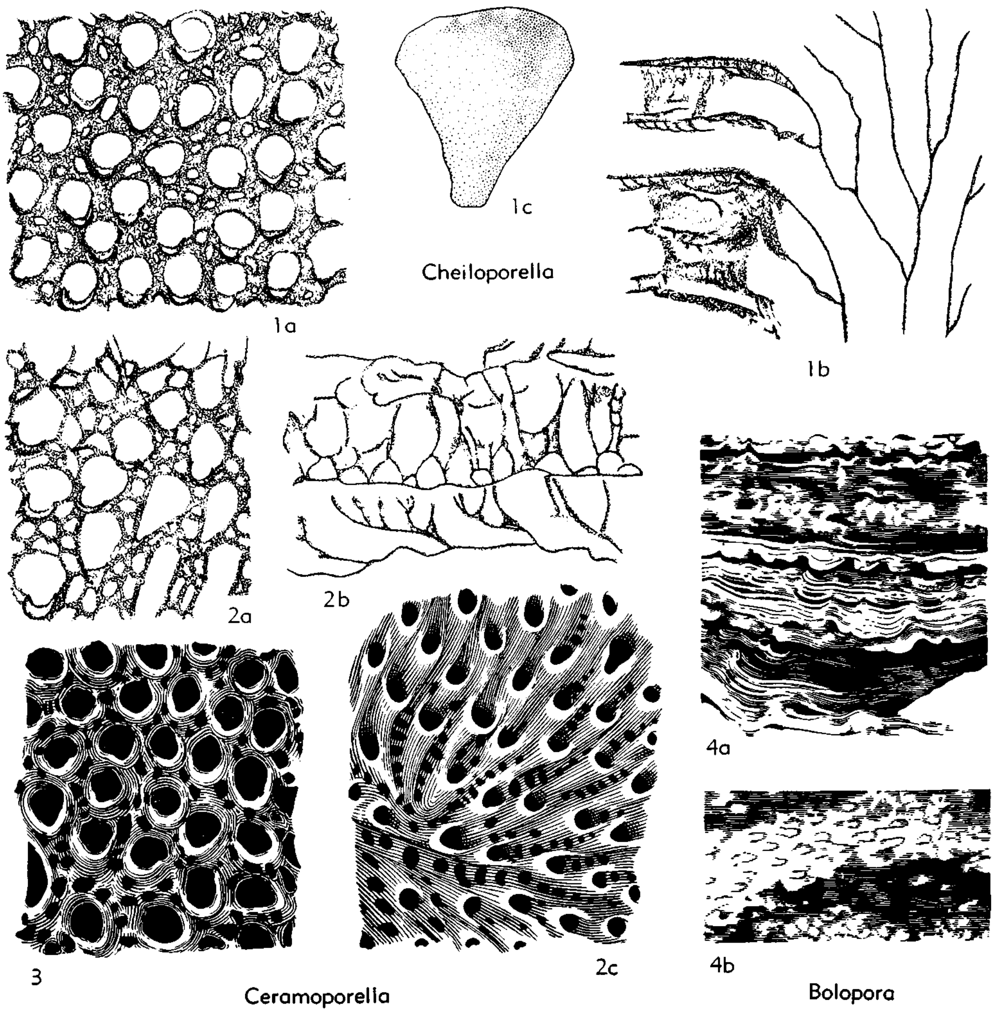


Fig. 44. Ceramoporidae (p. G81, G82).

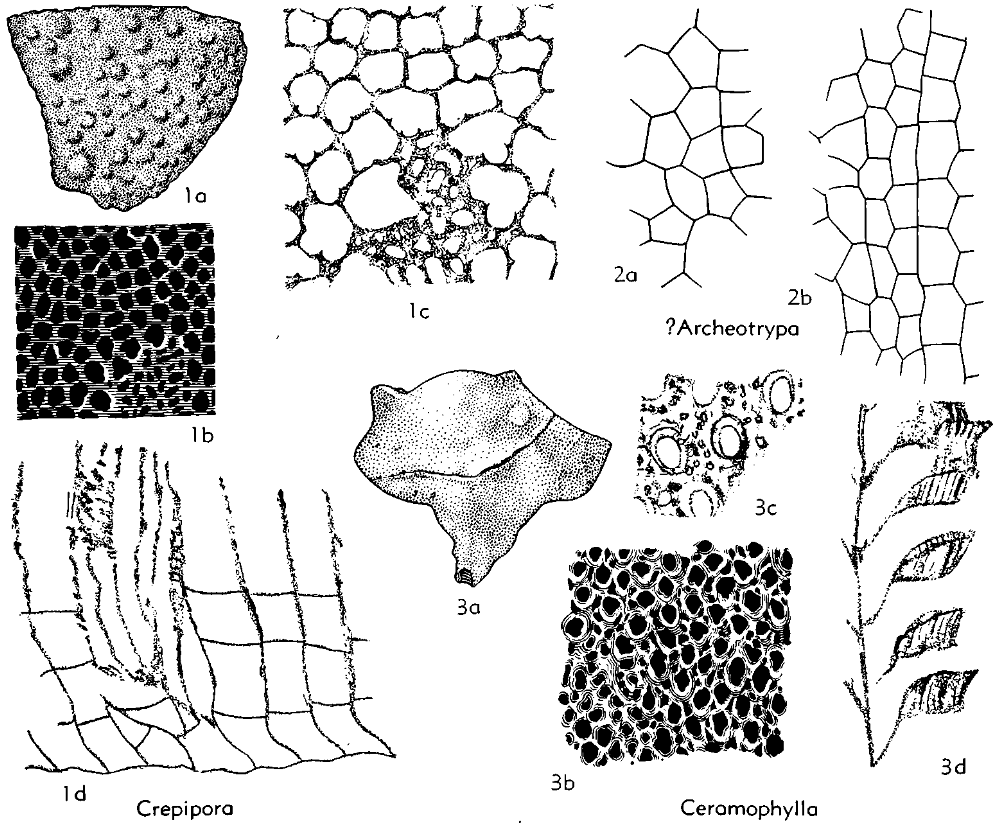


FIG. 45. Ceramoporidae (p. G81, G82).

prostrate, then extending obliquely or directly to the surface, commonly with a few diaphragms; apertures generally oblique, with part of proximal margin elevated as an overarching hood (lunarium). Mesopores more or less common (3,112,114,115; Nickles-B, 1900). *?Cam., Ord.-Dev.*

**Ceramopora** HALL, 1851 [**C. imbricata*]. Zoarium discoidal to massive. Zooecia large, irregular, with indefinite wall structure and large mural pores, radiating from depressed maculae; apertures oblique, with prominent but poorly defined lunaria. Mesopores large, irregular. *Ord.-Dev.*——FIG. 43,*1*, **C. imbricata,* Sil. (Clint.), N.Y.; *1a,* long. sec. of small zoarium attached to crinoid ossicle, ×10; *1b,c,* tang. secs., basal layer, and near periphery showing zooecia and mesopores, ×20; *1d,* zoarium, ×2 (131).

**Anolotichia** ULR., 1890 [**A. ponderosa*]. Incrusting, ramose, or massive. Zooecia long, subpolygonal, with remote diaphragms; lunarium elevated, traversed by 2 to 6 minute, vertical, closely tabulated tubules. Mesopores few. *Ord.-Sil.*——FIG. 43,*2*. **A. ponderosa,* Ord.(Richmond.), Ill.; *2a,b,* secs., long., tang., ×20; *2c,* surface, ×10 (222).——FIG. 43,*3*. *A. impolita* ULR., Blkriv., Minn.; *3a,b,* surface, tang. sec., ×20 (222).

?**Archaeotrypa** FRITZ, 1947 [**A. prima*]. Small flat poorly preserved zoarium with wall structure like *Crepipora* and ?lunaria but also resembling a small-celled tabulate coral such as *Lichenaria.* If bryozoan, the oldest known genus. *U.Cam.*——FIG. 45,*2*. **A. prima,* Front Range, Alba.; *2a,b,* secs., tang., long., ×10 (153).

**Bolopora** LEWIS, 1926 [**B. undosa*]. Doubtful, possibly a massive bryozoan or hydrocoralline. *L.Ord.*——FIG. 44,*4*. **B. undosa,* Arenig., N.Wales; *4a,* long. sec., ×25; *4b,* tang. sec., ×10 (178).

**Ceramophylla** ULR., 1893 [**C. frondosa*]. Like *Ceramoporella* but zoarium erect, bifoliate. *Ord.*——FIG. 45,*3*. **C. frondosa,* Blkriv., Minn.; *3a,* zoarium, ×1; *3b,* surface, ×10; *3c,d,* secs., ×20 (222).

**Ceramoporella** ULR., 1882 [**C. distincta* ULR., 1890] [=*Ceramporella* CUMINGS-G., 1913]. Incrusting, thin layers of short, tubular zooecia with prominent hoodlike lunaria and oval, oblique apertures encircled by abundant mesopores. *Ord.-Sil.*

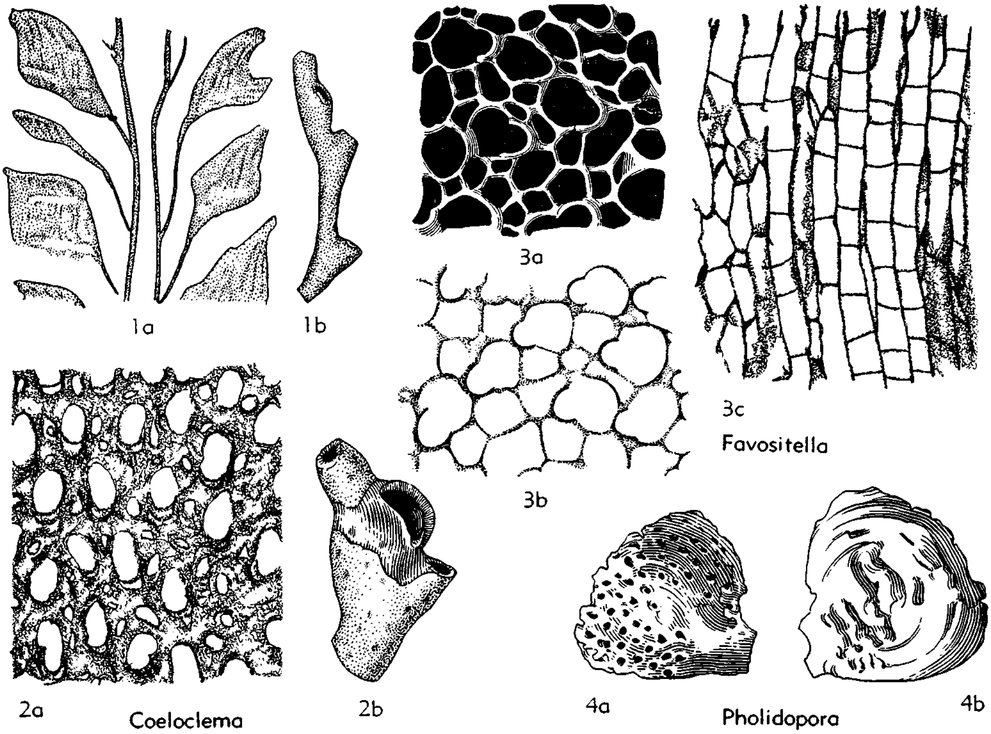


FIG. 46. Ceramoporidae (p. G82).

——FIG. 44,2. *C. distincta ULR., Eden., Ohio; 2a,b, secs., ×20; 2c, surface, ×20 (222).——FIG. 44,3. C. interporosa ULR., Trenton., Minn.; surface, ×20 (222).

**Cheiloporella** ULR., 1882 [**Fistulipora flabellata* ULR., 1879 (=*Ceramopora nicholsoni* JAMES, 1875)][=*Chiloporella* MILLER, 1889]. Erect flabellate fronds. Zooecial tubes long, with few diaphragms, walls much thickened by laminar tissues near surface; apertures ovate, with conspicuously elevated lunarium. Mesopores numerous small. *Ord.*——FIG. 44,1. **C. nicholsoni* (JAMES), Maysv., Ohio; *1a,b,* secs., tang., long., X20; *1c,* zoarium, ×1 (222).

**Coeloclema** ULR., 1882 [**Diamesopora vaupeli* ULR., 1890 (=*Ceramopora alternata* JAMES, 1878)]. Like *Ceramoporella* but zoarium of ramose hollow branches, lined internally with a striated and thicker walled epitheca. *Ord.-Sil.*——FIG. 46,1. **C. alternatum* (JAMES), Ord.(Eden.), Ohio; *1a,* long. sec., ×20; *1b,* zoarium, ×1; (222).——FIG. 46,2. *C. concentricum* (JAMES), Ord.(Eden.), Ohio; *2a,* tang. sec., ×20; *2b,* zoarium, ×1 (222).

**Crepipora** ULR., 1882 [**C. simulans* ULR., 1890]. Incrusting to massive, like *Ceramoporella* except that zooecia are long tubular, thin-walled, with diaphragms, lunaria erect; mesopores restricted to maculae. *Ord.-Sil.*——FIG. 45,1. **C. simulans* ULR., Ord.(Maysv.), Ohio; *1a,* zoarium, ×1; *1b,* surface, ×10; *1c,d,* secs., ×20 (222).

**Favositella** ETH.-F., 1884 (*non* MANSUY, 1912) [**Favosites interpuncta* QUENST., 1881] [=*Bythotrypa* ULR., 1893]. Zoarium massive. Zooecial tubes long, with thin diaphragms and ovicell-like (?brown body) structures; apertures nearly direct, with large well-raised lunarium. Mesopores numerous, forming loose vesicular tissue. *Ord.-Sil.*——FIG. 46,3. *F. laxata* (ULR.) (type of *Bythotrypa*), Ord.(Blkriv.), Minn.; *3a,* surface, ×20; *3b,* tang. sec., ×20; *3c,* long. sec., ×10 (222).

**Haplotrypa** BASSLER, 1936 [**H. typica*]. Incrusting to lamellate discoidal zoarium with ceramoporoid wall structure but lunaria, diaphragms and mesopores absent. *Sil.*——FIG. 47,3. **H. typica,* Clinton., Ind.; *3a,b,* secs., ×20 (131).

**Pholidopora** GRUBBS, 1939 [**P. concentrica*]. Zoarium thin lamellate with concentrically wrinkled epitheca; zooecia oblique, imbricating with strong lunaria and a few partial diaphragms. Maculae and mesopores absent. *Sil.*——FIG. 46,4. **P. concentrica,* Niag., Ill.; *4a,b,* zoarium, top, base, ×5 (159).

**Scenellopora** ULR., 1882 [**S. radiata*]. Pedunculate; macula surrounded by zooecia or an incrusting

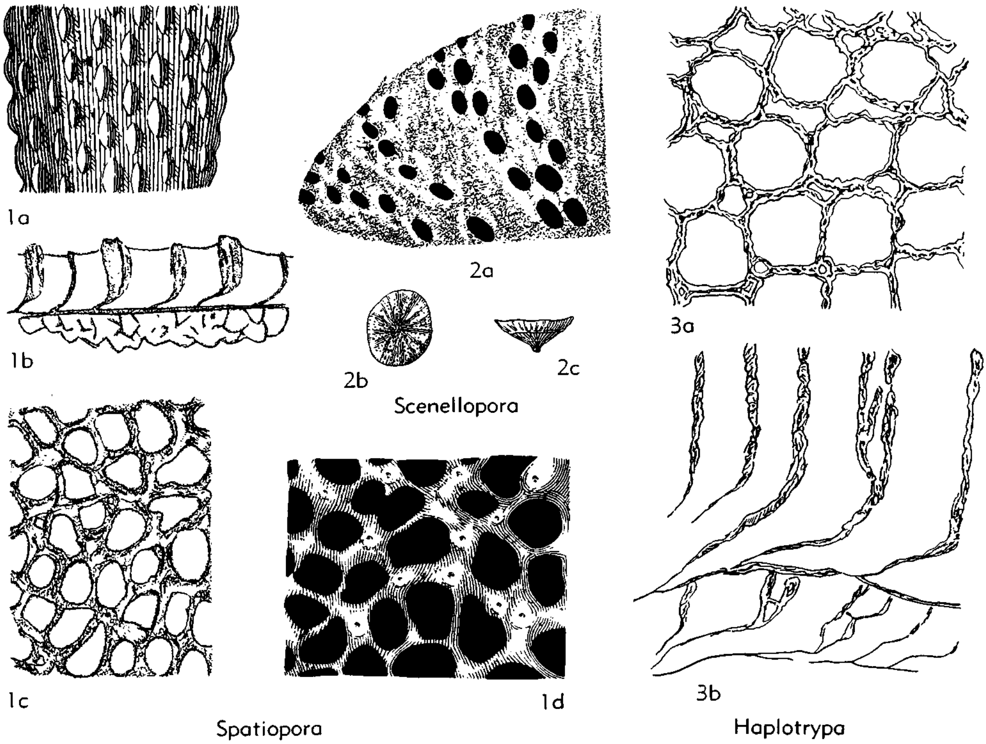


FIG. 47. Ceramoporidae (p. G82, G83).

group of maculae; epithecate base. *Ord.*——FIG. 47,*2*. **S. radiata*, Blkriv., Tenn.; *2a*, surface, ×10; *2b,c*, zoarium, ×1 (222).

**Spatiopora** ULR., 1882 [**S. aspera* ULR., 1883]. Thin crusts generally on orthoceroid shells composed of short, nearly direct thin-walled zooecia with ceramoporoid structure and blunt spines (acanthopores) at angles; mesopores and lunaria absent; elongated monticules common. *Ord.-Sil.* ——FIG. 47,*1*. **S. aspera* ULR., Ord.(Maysv.), Ohio; *1a*, surface, ×1; *1b,c*, secs., long., tang., ×20; *1d*, surface, ×20 (222).

## Family FISTULIPORIDAE Ulrich, 1882

[=Botrylloporidae MILLER, 1889; Chilotrypidae, Fistuliporinidae, Odontotrypidae, Selenoporidae SIMPSON, 1897; Cheilotrypidae MOORE-D., 1944]

Like Ceramoporidae in growth and general structure, lunaria, and maculae, but zooecial interspaces occupied by vesicles having convex walls on side toward zoarial surface. Ovicells in some genera (68,98,112, 114; NICKLES-B., 1900). *Ord.-Perm.*

This family name is employed on the basis of retention of *Fistulipora* as *nomen conservandum* (ICZN pend.).

**Fistulipora** MCCOY, 1850 [*nom. conserv.*, ICZN pend. (*non* RAF., 1831)] [**F. minor*] [=*Didymopora* ULR., 1882; *Cyclotrypa* MOORE-D., 1944 (*non* ULR., 1896)]. Zoaria lamellate, free or incrusting; ramose, or massive; commonly with regular maculae or monticules. Zooecia cylindrical, with straight diaphragms; apertures rounded, with lunaria moderately developed, not projecting into the tubes. *Sil.-Perm.*——FIG. 48,*1*. **F. minor*, L. Carb., Eng.; *1a*, tang. sec., MCCOY's type specimen, ×25; *1b,c*, secs., tang., long., ×20 (131).

**Botryllopora** NICH., 1874 [**B. socialis*]. Small, circular, incrusting, commonly joined laterally in a group with large vesicles along junction lines; surface marked by ridges radiating from disc centers (maculae), each ridge formed by double row of zooecial tubes with few diaphragms; apertures circular, without lunaria; depressed spaces between ridges with vesicles. *M.Dev.*——FIG. 48,*3*, **B. socialis*, Hamilton, N.Y.; *3a*, zoaria, ×1; *3b,c*, secs., long., tang., ×20 (222).

**Buskopora** ULR., 1886 [**B. dentata*] [=*Glossotrypa, Odontotrypa* HALL, 1886]. Zoarium thin lamellate. Zooecial tubes with diaphragms; prominent lunaria projecting as strong bidenticulate process. *L.Dev.*——FIG. 49,*2*. **B. dentata*, Onond., Falls Ohio, Ky.-Ind.; *2a,b*, surface, ×20, ×5 (*2a*, 222; *2b*, 162).

**Cheilotrypa** Ulr., 1884 [*C. hispida] [=*Chilotrypa* Miller, 1889]. Slender ramose fistuliporoids with expanding and contracting axial tube lined by epitheca. Vesicles filled by dense stereom near surface. *Sil.-Perm.*——Fig. 48,*2*. **C. hispida*, U.Miss.(Chest.), Ky.; *2a*, zoarium, ×1; *2b-d*, secs., long., transv., tang., ×20 (222).

**Cliotrypa** Ulr.-B., 1929 [*C. ramosa]. Slender, cylindrical, solid, smooth branches. Zooecial tubes with ovicell-like inflations; semidiaphragms projecting into mature region; lunaria distinct. *Miss.*——Fig. 48,*4*. **C. ramosa*, Osag., Ky.; *4a,b*, secs., ×20 (131).

**Coelocaulis** Hall-S., 1887 [**Callopora venusta* Hall, 1874]. Hollow, ramose stems. Zooecial apertures circular, surrounded by elevated peristomes; lunaria weak or absent. *Sil.-Dev.*——Fig. 50,*4*. **C. venusta* (Hall), L.Dev.(Held.), N.Y.; *4a*, fragment, ×10; *4b*, surface, ×20 (162).

**Cycloidotrypa** Chapman, 1920 [*C. australis]. Like *Cyclotrypa*. L.Carb., N.S.W.

**Cyclotrypa** Ulr., 1896 [**Fistulipora communis* Ulr., 1890]. Thick laminar to massive. Zooecial tubes with distant diaphragms; apertures circular, with peristomes, lunaria almost obsolete. *Sil.-Perm.*——Fig. 50,*5*. **C. communis* (Ulr.), Dev., Iowa; *5a,b*, secs., ×20 (222).

**Diphtheropora** DeKon., 1873 [*D. regularis] (=?*Eridopora*). Small incrusting patches with thin-walled oblique zooecia. *L.Carb.*, Belg.

**Duncanoclema** Bassler, 1952 [**Fistuliporella marylandica* Ulr.-B., 1913]. Solid twiglike stems with structure as in *Fistulipora* but lunaria pierced by 6 to 8 pores like those of *Anolotichia*. *L.Dev.*——Fig. 50,*1*. **D. marylandicum* (Ulr.-B.), Held., Md.; *1a,b*, secs., ×25; *1c*, fragment, ×1 (223).

**Dybowskiella** Waag.-W., 1886 [*pro Dybowskia* Waag.-W., 1885 (*non* Dall, 1879] [*D. grandis]

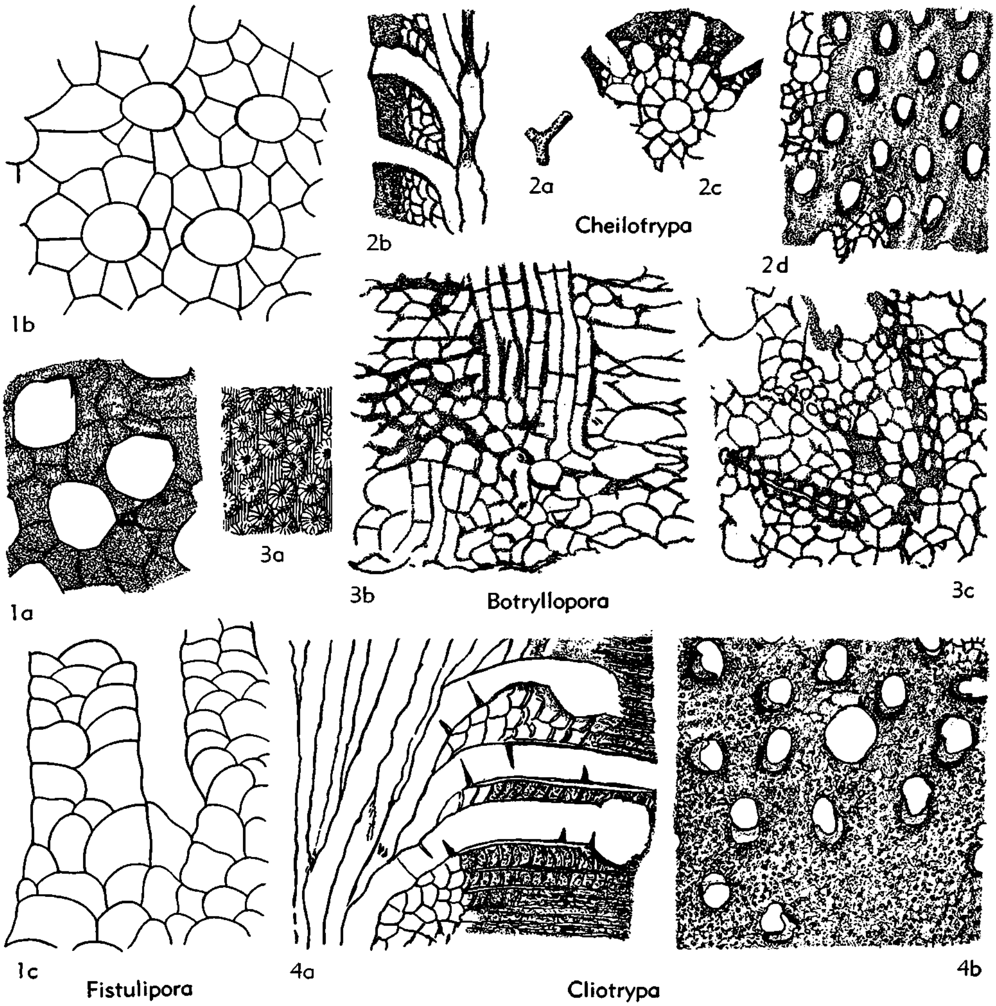


Fig. 48. Fistuliporidae (p. G83, G84).

[=*Triphyllotrypa* MOORE-D., 1944]. Zoaria solid or hollow thick branches or masses. Zooecia evenly spaced, especially characterized by strong lunaria with ends indenting the tubes like pseudosepta, giving them a trilobate cross section. *Perm.*——FIG. 49,*1*. **D. grandis,* SaltR., India; *1a,b,* secs., ×20 (228).

**Eridopora** ULR., 1882 [**E. macrostoma*] [=*Pileotrypa* HALL, 1886]. Thin, incrusting expansions with subtriangular to ovoid oblique apertures, very prominent overarching lunaria. *Dev.-Perm.*——FIG. 50,*3*. **E. macrostoma,* U.Miss.(Chest.), Ky.; *3a,* surface, ×20; *3b,c,* secs., ×20 (222).

**Favicella** HALL-S., 1887 [**Thallostigma inclusa* HALL, 1883] [=*Fistuliporidra* SIMPSON, 1897]. Thin lamellate expansions. Apertures circular, with peristome, situated in polygonal areas formed by coalescing angular ridges traversing the interspaces; lunaria weak or absent. *Dev.*——FIG. 50,*2*, **F. inclusa* (HALL), Hamilton, N.Y.; *2a,* long. sec., ×6, *2b,* surface, ×20 (162).

**Fistuliphragma** BASSLER, 1934 [**Fistulipora spinulifera* ROM., 1866]. Solid tuberculate branches. Zooecial tubes, with hemiphragms; lunaria poorly developed. *Dev.-Miss.*——FIG. 49,*3*. **F. spinulifera* (ROM.), M.Dev.(Traverse), Mich.; *3a,b,* secs., ×20; *3c,* zoarium, ×1 (222).

**Fistuliporella** SIMPSON, 1897 [**Lichenalia constricta* HALL, 1883]. Like *Fistulipora* but spine-like prolongations of interstitial walls appear as

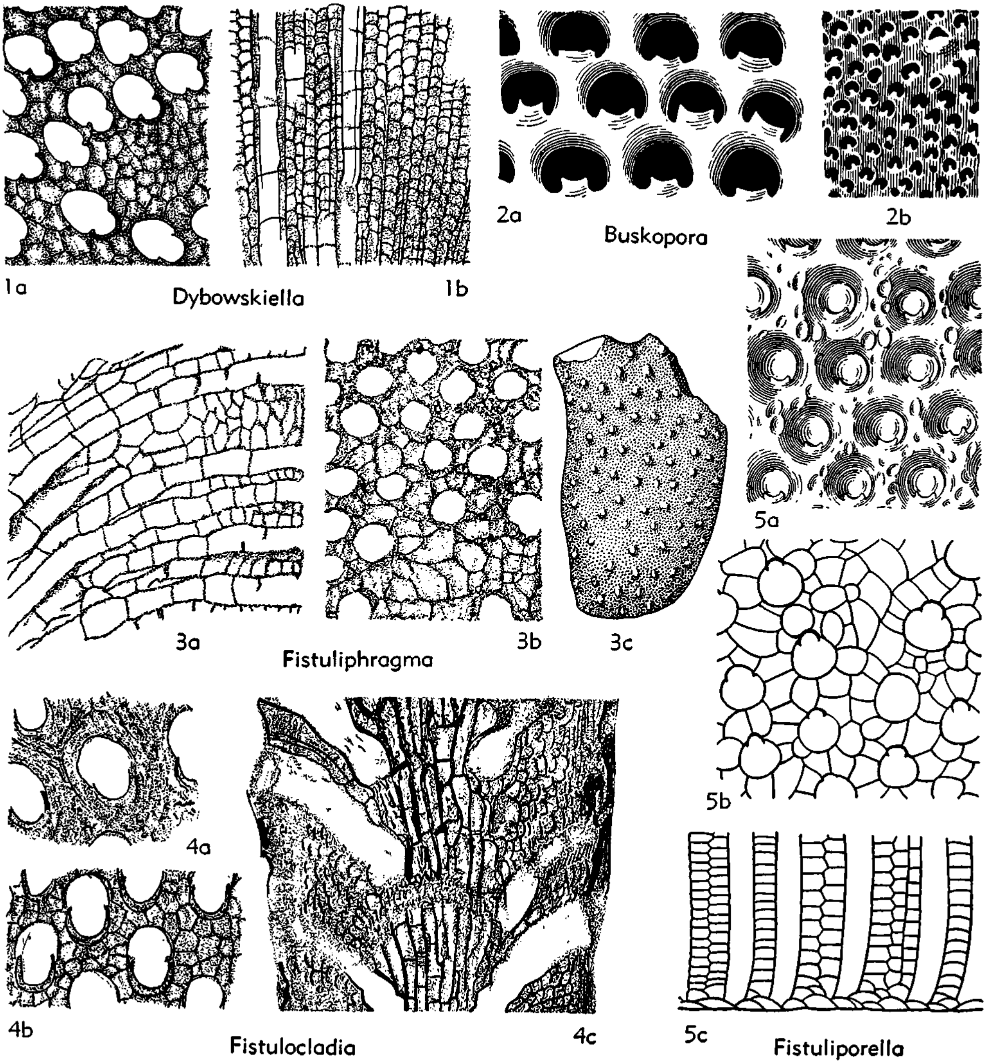


FIG. 49. Fistuliporidae (p. G83-G86).

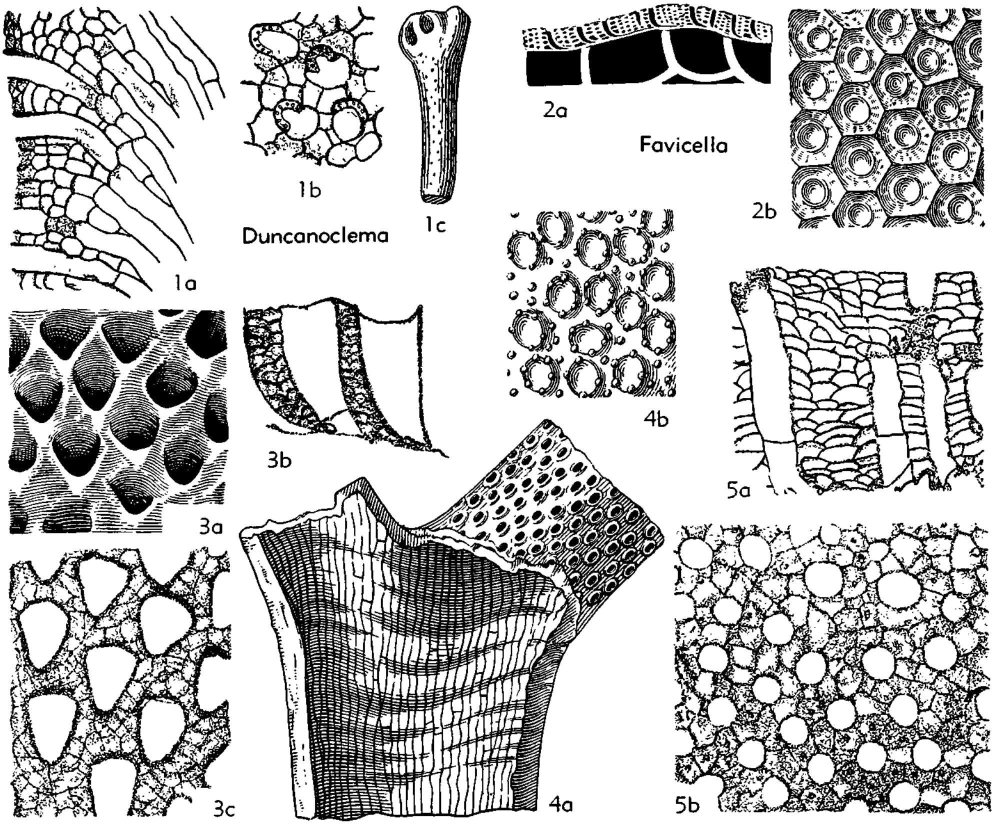


FIG. 50. Fistuliporidae (p. G84, G85).

granulations or spines on the surface. Lunaria sharply elevated. *Sil.-Dev.*——FIG. 49,*5*. **F. constricta* (HALL), Dev., N.Y.; *5a*, surface, ×20; *5b,c*, secs., ×20 (163).

**Fistulocladia** BASSLER, 1929 [**F. typicalis*]. Slender, solid, cylindrical, smooth branches with structure of *Fistulipora* but developing a central bundle of 5 or more narrow tabulate mesopore-like tubes and mature region with close vesicles thickened by laminated tissue. *Perm.*——FIG. 49,*4*. **F. typicalis*, Timor; *4a,b*, tang. secs., *4c*, long. sec., ×20 (131).

**Fistulotrypa** BASSLER, 1929 [**F. ramosa*]. Slender, solid branches. Zooecial tubes broad, in contact throughout immature zone but boxlike interzooecial structures of laminated tissue in very short mature zone. Lunaria weak. *Miss.-Perm.*——FIG. 51,*1*. **F. ramosa*, Perm., Timor; *1a,b*, secs., ×20 (131).

**Lichenotrypa** ULR., 1886 [**L. cavernosa* (=*Lichenalia longispina* HALL, 1883)]. First growth stages like *Fistulipora* but in mature zoaria acanthopores project as large spines and thin apertural walls leave numerous subangular openings between them. *Dev.*——FIG. 51,*2*. **L. longispina* (HALL), Onond., Falls Ohio, Ky.-Ind.; surface, ×10 (222).

**Pinacotrypa** ULR., 1889 [**Fistulipora elegans* ROM., 1866] [=*Fistulicella, Fistuliporina* SIMPSON, 1897]. Lamellate expansions. Zooecia with few diaphragms; lunaria weak; interspaces generally occupied by a single series of angular mesopores wider than the zooecia. *Dev.*——FIG. 51,*4*. **P. elegans* (ROM.), Hamilton, N.Y.; *4a,b*, secs., ×10 (223).

**Selenopora** HALL, 1886 [**Lichenalia circincta* HALL, 1883]. Like *Fistulipora* but lunaria strong, overarching, situated in polygonal vestibular areas formed by ridges traversing interspaces. *Dev.*——FIG. 51,*3*. **S. circincta* (HALL), Onond., Falls Ohio, Ky.-Ind.; surface, ×20 (162).

**Strotopora** ULR., 1889 [**S. foveolata* ULR., 1890]. Hollow branches with fistuliporoid structure bearing some large abruptly spreading cells (?broken ovicells). *Dev.-Miss.*——Fig. 51,*5*. **S. foveolata* Ulr., Miss.(Osag.), Iowa; surface, ×10 (222).

**Xenotrypa** Bassler, 1952 [**Fistulipora primaeva* Bassler, 1911]. Zoaria small, dome-shaped. Zooecia without diaphragms; lunaria weak. Vesicular interzooecial spaces traversed by large, thick, dense, granulose acanthopore-like tubes. *Ord.*——Fig. 51,*6*. **X. primaeva* (Bassler), Russ.; *6a,b*, secs., ×20 (131).

## Family HEXAGONELLIDAE Crockford, 1947

[as Hexagonellinae]

Zoaria bifoliate, with fistuliporoid structure; surface generally marked by solid noncelluliferous maculae and diverging narrow ridges. Zooecia tubular, rounded, proximally parallel to mesotheca, which has fine median tubules, distally bending outward but not at a right angle; lunaria poorly developed; complete diaphragms but no hemisepta. Interzooecial spaces with vesicular structure filled by dense tissue near surface but no vertical double plates between zooecia, as in Sulcoreteporidae (45,68,114). *Dev.-Perm.*

**Hexagonella** Waag.-W., 1886 [**H. ramosa*]. Zoarial surface divided into hexagonal areas by thin ridges of mesopore-like structures surrounding the maculae. Lunaria weak or absent. *Perm.*——Fig. 52,*1*. **H. ramosa*, SaltR., India; *1a*, zoarium, ×1; *1b*, surface, ×5; *1c,d*, secs., ×25 (*1a,c*, 131; *1b,d*, 228).

**Coscinotrypa** Hall-S., 1887 [*pro Coscinium* Keyserling, 1846 (*non* Endlicher, 1836)] [**Coscinium cribriforme* Prout, 1859]. Flattened bifoliate branches, inosculating at short distances forming a broad frond with circular to elliptical fenestrules. *Ord.-Perm.*——Fig. 52,*2*. **C. cribriformis* (Prout),

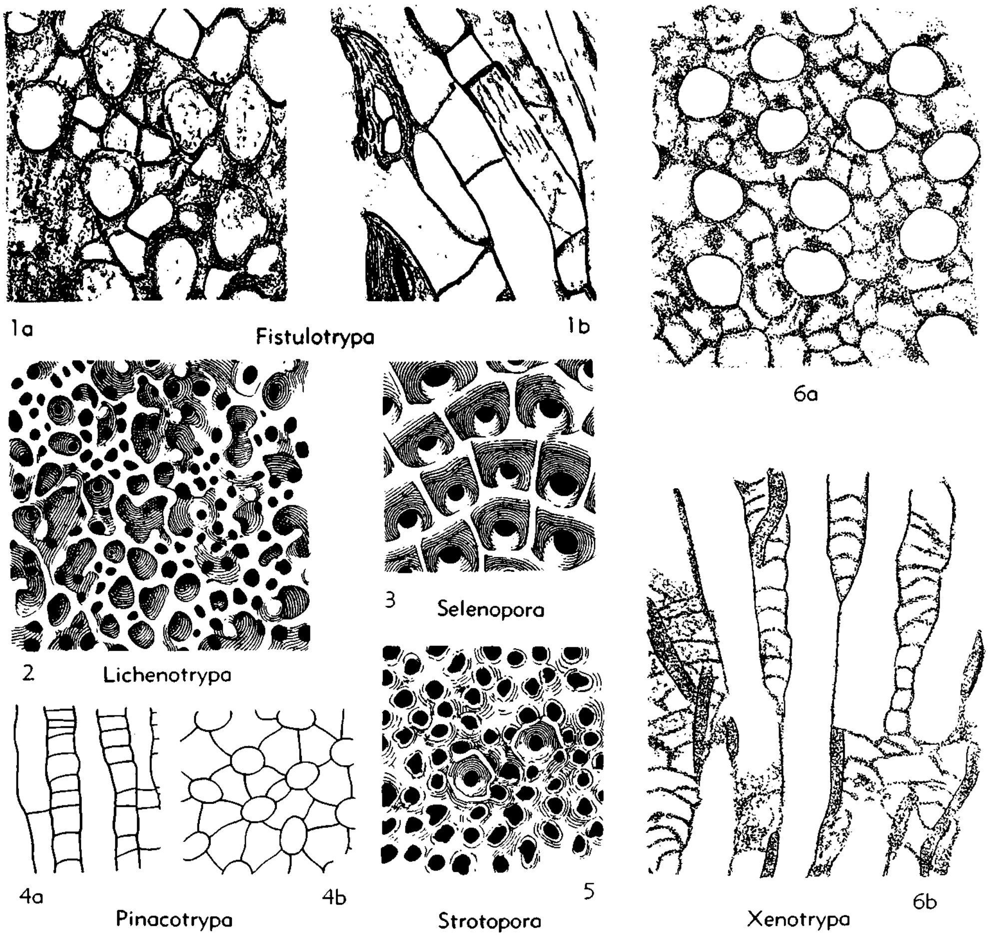


Fig. 51. Fistuliporidae (p. G86, G87).

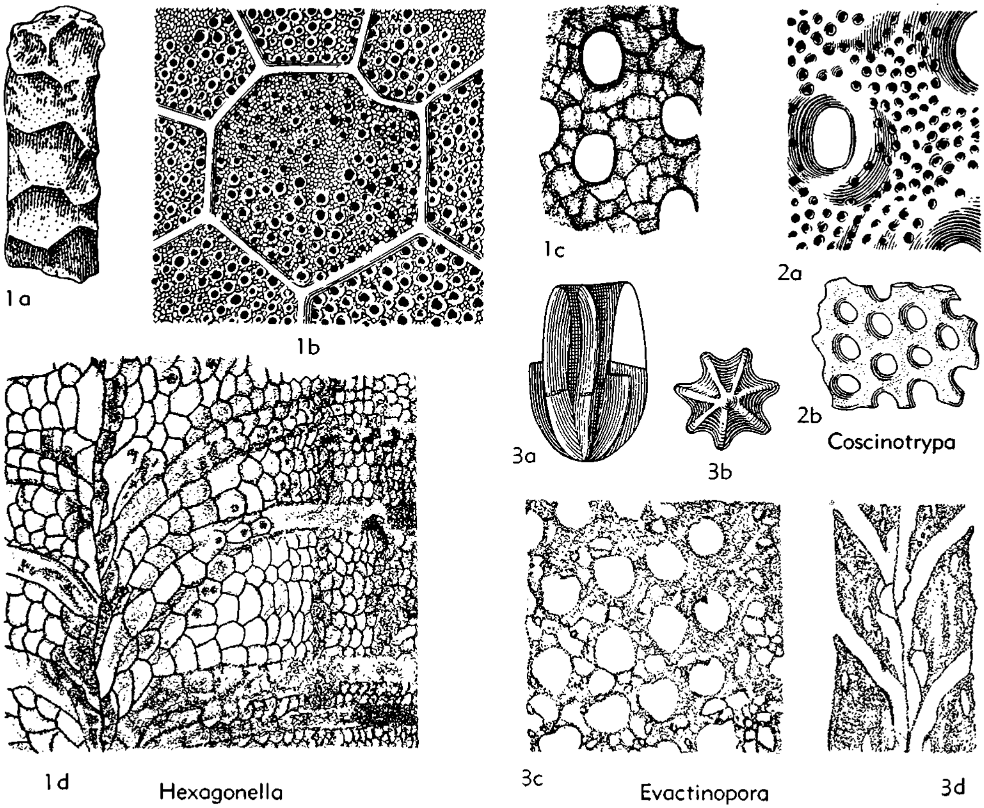


FIG. 52. Hexagonellidae (p. G87, G88).

Dev., Ky.; *2a,* surface, ×5; *2b,* fragment, ×1 (162).

**Evactinopora** MEEK-W., 1865 [**E. radiata*]. Zoaria composed of 3 or more vertical radiating bifoliate leaves arranged in a stellate or cruciform fashion. Internal structure as in *Hexagonella. Miss.*——FIG. 52,*3.* **E. radiata,* Osag., Mo.; *3a,b,* zoarium, side, top, ×1; *3c,d,* secs., ×20 (222).

**Fistulamina** CROCKFORD, 1947 [**F. inornata*]. Broad straplike bifoliate bifurcating branches with nonporiferous margins, surface without maculae. Apertures small, distinct, with lunaria. Vesicular structure replaced by dense tissue near surface. *L.Carb.,* N.S.W.

**Glyptopora** ULR., 1884 [**Coscinium plumosum* PROUT, 1860] [=*Glyptotrypa* MILLER, 1889]. Thin bifoliate expansions, surfaces traversed by salient ridges or unilaminate bases on which coalescing ridges of the upper surface are developed to form large leaves. Surface with prominent elongate, dimple-like maculae. *Miss.-Perm.* ——FIG. 53,*1.* **G. plumosa* (PROUT), Miss. (Warsaw), Ill.-Mo.; *1a,* surface, ×10; *1b,* zoarium, ×1 (222).

**Meekopora** ULR., 1889 [**Fistulipora? clausa* ULR., 1890]. Flat narrow bifurcating to broad bifoliate fronds. Apertures circular to oblique, lunarium present but not indenting the cavity. Maculae prominent; interzooecial vesicular structure well developed. *Sil.-Perm.*——FIG. 53,*2.* **M. clausa* (ULR.), Miss.(Chest.), Ky.; *2a,* zoarium, ×1; *2b,c,* secs., ×20 (222).

**Meekoporella** MOORE-D., 1944 [**M. dehiscens*]. Like *Meekopora* but growth in bifoliate sheets joined at angles of about 120° forming large polygonal inverted pyramidal chambers. *Penn.*—— FIG. 53,*3.* **M. dehiscens,* Kans.; side of chamber split along mesotheca (zooecial apertures not visible), ×1 (193).

**Phractopora** HALL, 1883 [**P. cristata*]. Like *Glyptopora* but junction angles celluliferous, thicker than any other part of the leaves. *Dev.-Miss.*——FIG. 53,*5.* **P. cristata,* Dev.(Onond.), Falls Ohio, Ky.-Ind.; *5a,* zoarium, ×1; *5b,* surface, ×5 (162).

**Prismopora** HALL, 1883 [**P. triquetra*]. Triangular bifurcating or trifurcating branches with zooecia arising from mesothecae, radiating from the center to the margins. *Dev.-Perm.*——FIG. 53,*4.* **P.*

*triquetra.* Dev.(Onond.), Falls Ohio, Ky.-Ind.; *4a,* zoarium, ×1; *4b,* transv. sec., ×5; *4c,* surface, ×20 (162).

**Scalaripora** Hall, 1883 [**S. scalariformis*]. Like *Prismopora* but faces of triangular branches crossed by salient transverse ridges. *M.Dev.*——Fig. 53,6. **S. scalariformis,* Onond., Falls Ohio, Ky.-Ind.; *6a,* zoarium, ×1; *6b,c,* side, end, ×5 (162).

## Family GONIOCLADIIDAE Nikiforova, 1938

Slender branched bifoliate fistuliporoids which differ from Hexagonellidae in bifurcation of the branches at right angles to the mesotheca and in their anastomosing or pinnate zoaria. Lack of hemisepta and vertical double plates between the zooecia distinguish them from sulcoreteporid Cryptostomata. Lunaria weak or absent (Shulga, 1933). *Miss.-Perm.*

**Goniocladia** Eth., 1876 [*pro Carinella* Eth., 1873 (*non* Johnston, 1833)] [**Carinella cellulifera* Eth., 1873]. Zoarium reticulate, composed of angular bifoliate branches with zooecia opening on both sides of the median lamina which bisects

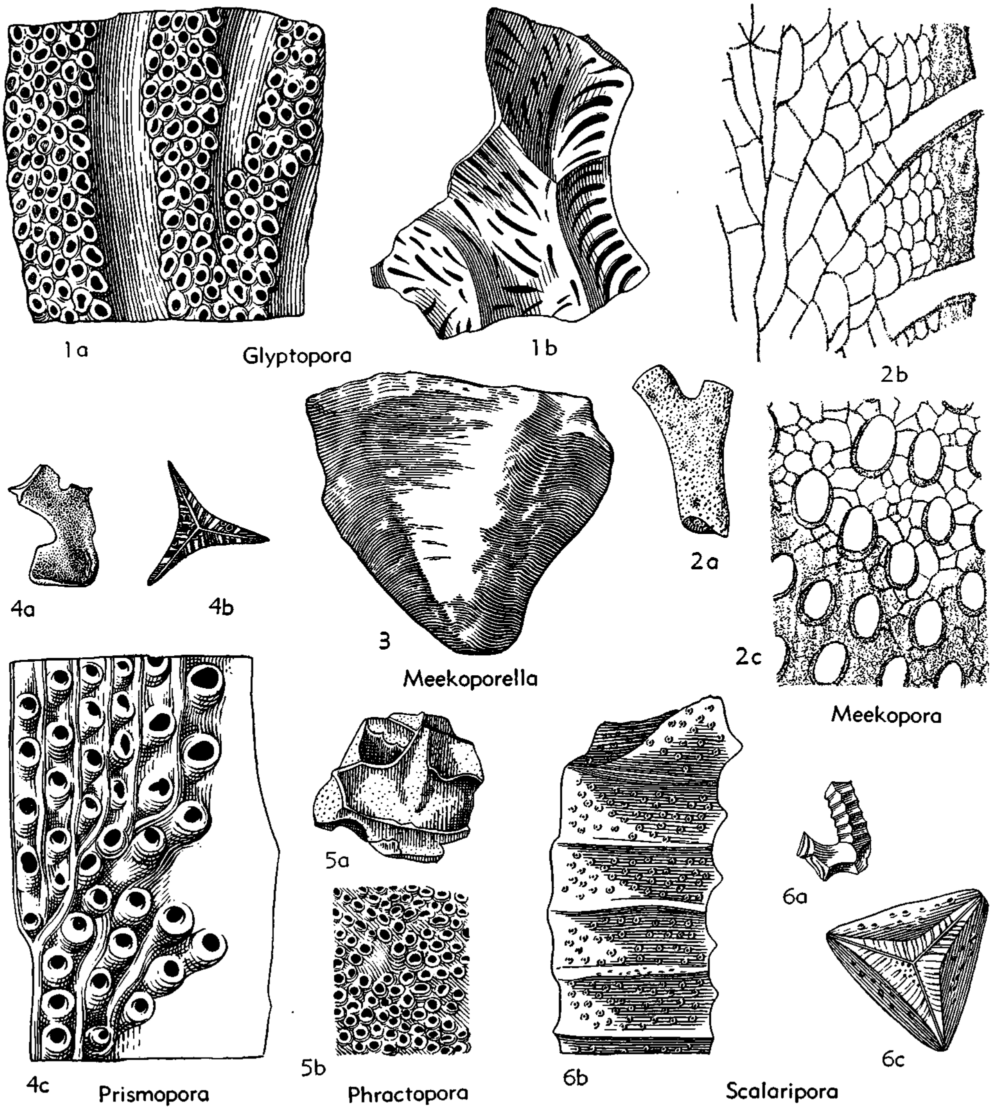


Fig. 53. Hexagonellidae (p. G88, G89).

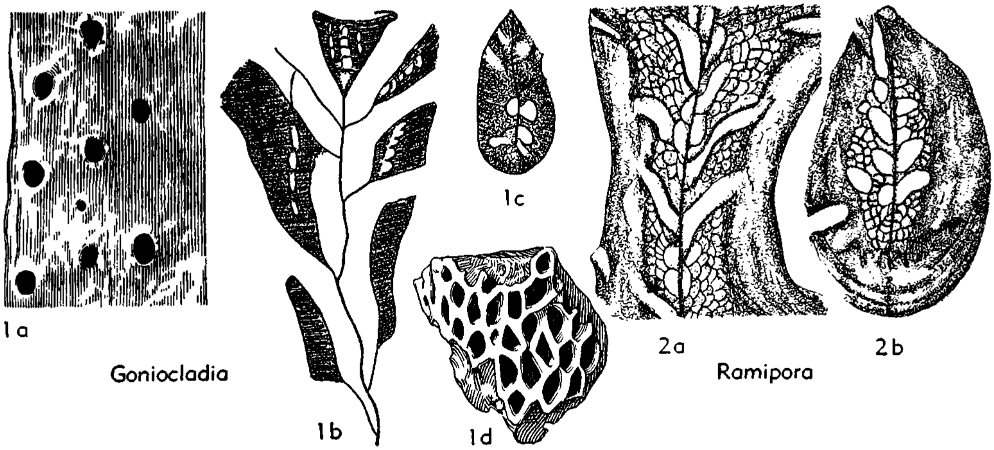


FIG. 54. Goniocladiidae (p. G89, G90).

the branch and projects as a keel on the front and a flat area on the back; fenestrules polygonal. *Miss.-Perm.*——FIG. 54,*1*. **G. cellulifera* (ETH.), Perm., Eng.; *1a*, surface, ×20; *1b*, long. sec., ×20; *1c*, transv. sec., ×10; *1d*, zoarium, ×1 (131).

**Ramipora** TOULA, 1875 [**R. hochstetteri*]. Like *Goniocladia* but zoarium dendroid, branches extended or short, ending bluntly. *Carb.-Permocarb.*, Spitz.

**R. (Ramipora)** Irregularly pinnate zoaria.

**R. (Ramiporidra)** NIKIF., 1938. *Permocarb.*——FIG. 54,*2*. **R. (R.) uralica* (STUCK.), *Permocarb.*, Russ.; *2a,b*, secs., ×10 (198).

**R. (Ramiporalia)** SHULGA, 1933 [**Ramiporalia dichotoma*]. *Carb.*, Russ.

**R. (Aetomacladia)** BRETNALL, 1926 [**A. ambrosioides*]. Zooecia in 3 or 4 rows on each side of mesotheca. *Carb.*, Austral.

**R. (Ramiporella)** SHULGA, 1933 [**Ramiporella asymmetrica*]. *Carb.*, Russ.

**Volgia** STUCK., 1905 [**Coscinium arborescens*] [=*Ramiporina* SHULGA, 1933]. Zoarium arborescent composed of primary branches giving off secondary branches in verticels and these bearing branches of third order. *Perm.*, Russ.

## Order TREPOSTOMATA Ulrich, 1882

[=Stenolaemata BORG, 1926 *(partim)*]

Zoaria mostly massive, lamellate, or stemlike, comprising typical so-called stony bryozoans. Zooecia consist of long calcareous tubes, generally intersected by many partitions (diaphragms), each tube being divisible into an immature region in the axial part of the zoarium characterized by thin walls, wide spacing of diaphragms, and contact with other zooecia on all sides, and a mature region near the zoarial surface characterized by thickened walls, close spacing of diaphragms, and intervention of special cells (mesopores, acanthopores) between zooecia. Monticules or maculae, comprising regularly spaced clusters of cells smaller or larger than average, commonly well defined on zoarial surface (1,5,6,7,8). *Ord.-Perm., ?Trias.*

### MORPHOLOGICAL FEATURES

This order seemingly is limited to the Paleozoic era, when it flourished in an abundance of species forming stony colonies and even coral-like reefs which contributed largely to the building of many formations. These colonies are invariably calcareous, consisting generally of solid masses which may attain considerable size (diameter and thickness exceeding 50 cm.), or branching growths composed of long, coherent, prismatic, or cylindrical tubes with terminal apertures. Each tube is composed of an inner axial **(immature)** region and an outer, peripheral **(mature)** region. This change in the character of the tubes, which is basis for the name of the order (*trepos*, change), is accompanied by development in the mature zone of additional features known as mesopores, acanthopores, cystiphragms, hemiphragms, and heterophragms, as well as more numerous diaphragms.