PALEOZOIC HEXACTINELLID SPONGES

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Class HEXACTINELLIDA Schmidt, 1870

[*nom. transl.* MINCHIN, 1900, p. 111, *ex* order Hexactinellida CARTER, 1875, p. 131, *nom. correct. pro* "Gruppe" Hexactinellidae SCHMIDT, 1870, p. 13]

Sponges with siliceous spicules that are orthotriaxial hexactines or related forms with fewer than six rays, and with soft parts of adults comprising an internal, choanocytal membrane suspended within networks of syncytial filaments (trabeculae) with water-filled interspaces. Diverticula of choanocytal membrane form flagellated chambers, which may either face a paragastral surface directly (as in sycons or rhagons) or have leuconoid arrangements to folding of primary chamber layer. Circulation wholly intertrabecular, or in part through subdermal or subgastral lacunae, or inhalant or exhalant canals that arise by special local enlargement of intertrabecular spaces. Outermost trabeculae modified on both sides of wall to form finely porous surface membranes that cover subdermal or subgastral ends of canals unless secondary perforations develop. Megascleres typically with a three-fold division into dermal and gastral series (dermalia, gastralia) that support surface membranes, and a parenchymal skeleton that supports choanosome; some also with further hypodermal or hypogastral megascleres (hypodermalia, hypogastralia) that may have a relationship to those of parenchymal skeleton; or, with special protruded megascleres (prostalia) of hypodermal or parenchymal origin. Parenchymal skeleton one of two types: (a) lyssacine, with megascleres in forms from hexactine to rhabdodiactine, of a single type or two or more different types, and all loose unless rigidly united by a secondary development of fusion; or (b) dictyonine, with megascleres (dictyonalia) that are typically all hexactines, and are united to form a rigid framework as part of their normal development. Attachment by encrusting basal parts or by imbedded prostalia. Common microscleres of two living subclasses are microholactines and amphidiscs in Amphidiscophora, hexasters without amphidiscs in Hexasterophora; additional sceptrules in one order of Hexasterophora (Hexactinosa); hemidiscs in fossil (Carboniferous, Cretaceous) Amphidiscophora; paraclavules in some Paleozoic forms (Dictyospongiidae) of uncertain subclass. [Taxon initially termed "Gruppe" (group) (SCHMIDT, 1870, p. 13) but subsequently ranked as an order in the same publication (1870, p. 83) and in the same year by KENT (1870). Initial form "Hexactinellidae" has been used as a family name, attributed to SCHMIDT by DE LAUBENFELS (1936, 1955), but had no generic basis and no possible connection with *Hexactinella* CARTER, 1885, published 15 years later. Translation from order to subclass was by TOPSENT (1892, p. 24).

The taxon Hexactinellida SCHMIDT is preferred to the alternative Hyalospongiae CLAUS used by DE LAUBENFELS (ascribed to VOSMAER; 1882, 1883, 1885, 1887) because (a) SCHMIDT's diagnosis states the character of the spicules correctly; whereas (b) characters cited by CLAUS (euplectellid type of skeletal framework, beardlike roots, nonexistent siliceo-fibrous skeleton) define no group of sponges at any level. The Hyalospongiae of CLAUS also included lithistid Demospongea, supposed with dictyonine Hexactinellida to have skeletons composed of siliceous fibers. The Hyalospongea of DE LAUBENFELS (1955, not 1936) included the Heteractinellida (as Heteractinida), herein regarded as a separate class of sponges, in which spicules are of unknown composition and were possibly calcareous.] *Lower Cambrian–Holocene.*

Subclass AMPHIDISCOPHORA Schulze, 1887

[*nom. transl.* Reid, 1958a, p. xliii, *ex* Amphidiscophora Schulze, 1887a, p. 178; *emend.,* Schrammen, 1924a, p. 18]

Hexactinellida with microholactine and amphidisc or hemidisc microscleres, to which other birotulates (staurodiscs, hexadiscs) may be added, but without any form of hexaster. All known genera lyssacine and having no fusion of spicules in any part of body; modern genera all with large, pentactinal hypodermalia and with monactinal basalia.

[This taxon was originally (Schulze, 1887a) a tribe Amphidiscophora of the suborder Lyssacina Zittel, with the class Hexactinellida treated as an order of Porifera. It was then raised to suborder status when Schulze (1899, p. 93) abandoned Zittel's taxa. Subclass status here corresponds with class status of the Hexactinellida. The subclass is known chiefly from modern examples of one order (Amphidiscosa Schrammen), in which birotulates are typically amphidiscs and never hemidiscs. The latter were first known as loose microscleres of Late Cretaceous age (Schrammen, 1924a, p. 21), but have been found with associated megascleres in a Carboniferous genus, *Microhemidiscia* Kling & Rief. The first certain genus (*Uralonema* Librovich) is Carboniferous (Mississippian); but the subclass may be older, because patterns of megaspiculation that approach those of modern pheronematids occur in unplaced forms back to the Ordovician (*Brachiospongia* Marsh). The Reticulosa (=Protospongioidea Finks; Cambrian–Permian) may belong here if their paraclavule microscleres are related to amphidiscs and hemidiscs.] *Lower Cambrian–Holocene.*

Order AMPHIDISCOSA Schrammen, 1924

[*nom. transl. et corr.* Reid, 1958a, p. xliii, *ex* tribus Amphidiscaria Schrammen, 1924a, p. 18]

Birotulate microscleres are characteristically amphidiscs with equal umbels and never hemidiscs; modern forms always with pentactinal hypodermalia and monactinal basalia, and usually with pentactinal autodermalia and autogastralia in which unpaired ray is distal and pinular; some with staurodiscs or hexadiscs as rare variants of normal amphidiscs.

[Common features of the megaspiculation of modern forms point to an origin from a source with these features already developed. Three largely modern families (Pheronematidae, Monoraphididae, Hyalonematidae) are distinguished mainly by differences in their parenchymal megascleres. The oldest known amphidiscs are early Pennsylvanian, occurring in *Uralonema* Librovich, 1929, which is possibly an early hyalonematid, even though it lacks some of the characteristic megascleres. Still earlier genera are included here, however, because they resemble *Uralonema* in having differentiated hypodermalia, a thick, parenchymal layer of nonparallel hexactines organized around skeletal canals, and a stout root tuft with some spicules having quadridentate, anchorate terminations, where preserved.] *Lower Cambrian–Holocene.*

Family HYALONEMATIDAE Gray, 1857

[*nom. correct.* Schulze, 1887a, p. 178, *pro* Hyalonemadae Gray, 1857, p. 278]

Parenchymal principalia mainly or all rhabdodiactines, although pentactines or hexactines may also occur; basalia typically with four or more terminal teeth and arranged to form an anchor rope (hence vernacular name glass-rope sponges), often spirally twisted in adults, with proximal, imbedded part forming axial columella through body; some with prostal rhabdodiactines, with distal ray smooth or pinular; acanthophores in basal parts; sceptres absent. *Cretaceous (Turonian)–Holocene.*

Hyalonema Gray, 1832, p. 59 [**H. sieboldi;* M]. Some species thick-walled cup with columellar prominence in paragaster floor; osculum covered by sieve plate; other species without a spongocoel and may have mushroomlike shape; anchor rope typically compact and spirally twisted; no prostalia. [The Cretaceous occurrence in northwestern Germany (Mehl & Hauschke, 1995) is the only Mesozoic record of the genus. A doubtful Tertiary record is

based on loose amphidiscs.] *Cretaceous (Turonian)–Holocene:* Germany, *Turonian;* New Zealand, *?middle Eocene;* cosmopolitan, *Holocene.*——Fig. 200,*2. H. cretacea* Mehl & Hauschke, lower Campanian, Coesfeld-Holtwick area, Münsterland, Germany; side view of holotype, WMNM P 14.900, ×1 (Mehl & Hauschke, 1995; courtesy of *Geologie und Paläontologie des Westfalen*).

Family PATTERSONIIDAE Miller, 1889

[Pattersoniidae Miller, November 1889, p. 153]

Sponges without cloaca or osculum but with skeletal canals of two sizes (epirhyses and possible aporhyses) and a stout, root tuft in which some spicules end in quadridentate anchors; parenchymal spicules hexactines in nonparallel orientation with differentiated, hypodermal pentactines or hexactines. [Oldest whole sponges are Trentonian, but earlier, isolated, massive root tufts are included in stratigraphic range.] *Middle Ordovician–Upper Ordovician.*

Pattersonia Miller, 1882, p. 42 [**P. difficilis* Miller, 1882, p. 43; OD] [=?*Strobilospongia* Beecher, April 1889, p. 14 (type, *S. tuberosa* Beecher, April 1889, p. 26, OD); ?*Chirospongia* Miller, November 1889, p. 156 (type, *C. wenti* Miller, November 1889, p. 157, OD)]. Sponge body a conical, lobate mass, narrowest at top with lobes pendent so resembles a fir or spruce tree (or a pine cone); very thick root tuft emerging at base and extending a considerable distance below body; in many individuals lobate body diverging basally to reveal root tuft in axial region for a considerable distance toward apex; some individuals have two root tufts and seemingly represent two bodies fused side by side; root tuft consisting of parallel, smooth, spicule rays (possible rhabdodiactines) of unknown but great length; root tuft occupying much of interior and may have gentle twisting or curvature; surfaces of lobes bearing pores of two sizes, larger ones continuing into body wall as radial tubes of same diameter and may be epirhyses or diarhyses. [No body spicules are visible on the calcified cotypes of *Pattersonia difficilis* or on the silicified holotype of *Chirospongia wenti.* Beecher (1889, p. 26) stated that cruciform ends of large, hexactinellid spicules can be seen on some parts of the surface of *Strebilospongia tuberosa,* and resemble those of *Brachiospongia.* He further said, "Smaller dermal spicules and traces of a spicular mesh can likewise be detected." Examination of the types leave little doubt that the three genera are identical; furthermore, the silicified types of *Strobilospongia* and *Chirospongia* are from the same locality. *Chirospongia faberi* is not congeneric with the type of its genus, and has spicular structures reminiscent of the receptaculitid *Leptopoterion.* Near-topotype root tufts, probably of *Pattersonia,* that have been prepared out with acid are composed of fine rhabdodiactines with a minority of clemes that have quadrianchorate ends.] *Middle Ordovician–Upper Ordovician:* USA (Kentucky, Ohio).——Fig. 200,*1a. *P. difficilis,* Corryville Formation, Maysvillian, Cincinnati, Ohio; side view of holotype showing lobate form, USNM 46565, ×1 (Rauff, 1893).——Fig. 200,*1b–c. P. ulrichi* Rauff, Corryville Formation, Maysvillian, Cincinnati, Ohio; *b,* side view of lobate to digitate holotype, ×1; *c,* photomicrograph of skeletal net of irregularly oriented hexactines, USNM 46566, ×71 (Rauff, 1893).

?Chirospongia Miller, November 1889, p. 156 [**C. wenti;* OD]. From same locality and having same preservation as senior *Strobilospongia* Beecher, 1889 (April). The calcified, Cincinnatian, senior genus *Pattersonia* Miller, 1882, is identical in all other respects. The Cincinnatian *C. faberi* is not congeneric. *Upper Ordovician:* USA (Kentucky).

?Strobilospongia Beecher, 1889 (April), p. 14 [**S. tuberosa* Beecher, 1889, p. 26; OD]. Sole genus in family for which body spicules have been described. [In external form, pores, parietal gaps, and root tuft, it is identical to the senior calcified *Pattersonia* Miller, 1882, and to the junior, topotypic, and likewise silicified *Chirospongia* Miller, 1889 (November).] *Upper Ordovician:* USA (Kentucky).

Family PELICASPONGIIDAE Rigby, 1970

[Pelicaspongiidae Rigby, 1970a, p. 11] [=Keriogastrospongiidae Wu, 1989, p. 767]

Thick-walled, vasiform sponges with circular, parietal openings or well-defined canal system; skeleton with specialized gastral or dermal layer, or both, of large simple hypodermal and hypogastral hexactines whose gastral or tangential rays appear unoriented with reference to one another but whose proximal and distal rays are arranged approximately normal to surface; interior spicules unoriented, smaller hexactines and related forms. *Lower Ordovician (Tremadocian)–Triassic (Carnian).*

Pelicaspongia Rigby, 1970a, p. 12 [**P. sterea;* OD]. Thick-walled and bowl-shaped with flat base and rounded sides; hypogastralia are hexactines of larger size than interior spicules and have a variably shortened, distal ray; on one isolated near-pentactine the proximal ray very stout and contracts abruptly short of crossing; hypodermalia seem to be similar but poorly preserved; paratangential rays of both in nonparallel orientation; parenchymalia simple hexactines in nonparallel orientation and somewhat larger and more closely spaced about numerous, large, cylindrical skeletal canals that open on both dermal and gastral surfaces, and unclear whether

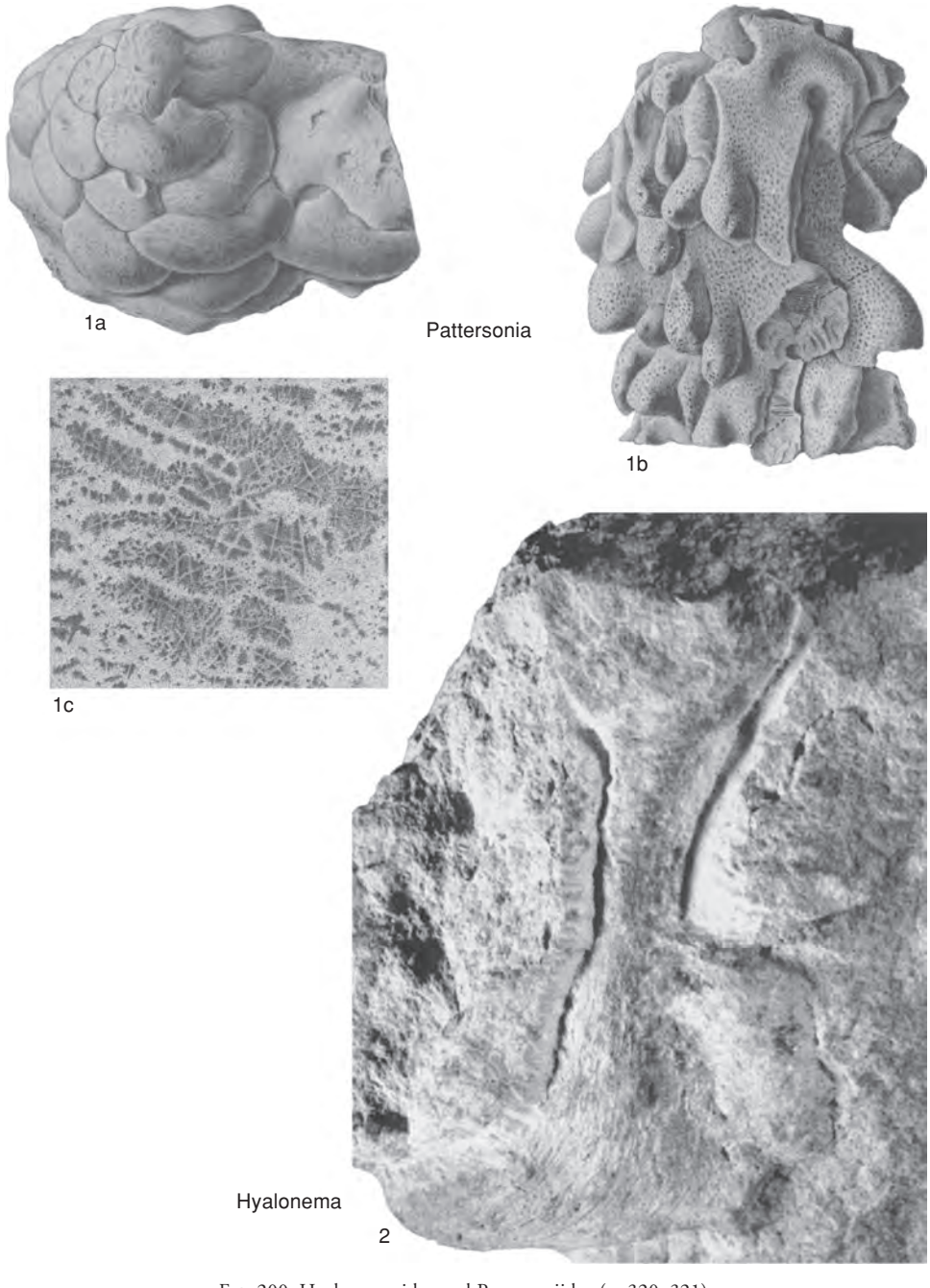


FIG. 200. Hyalonematidae and Pattersoniidae (p. 320–321).

they are epirhyses and aporhyses or parietal gaps; long, coarse spicule fragments, adherent to base of sponge, may represent root-tuft rhabdodiactines. *Devonian (Frasnian):* Canada (Alberta).——FIG. 201,*2a–c. *P. sterea,* Mount Hawk Formation, Front Range; *a,* view down into broad, bowl-shaped spongocoel with prominent parietal gaps and smaller canals filled with light gray matrix in sur-

rounding thick walls; *b,* side view of bowl-shaped holotype with light gray matrix filling parietal gaps, ×0.5; *c,* etched surface of spongocoel with irregularly oriented, siliceous hexactines of various sizes, GSC 24501, ×3 (Rigby, 1970a).

Arakespongia Rigby, Chamberlain, & Black, 1970, p. 827 [**A. mega* Rigby, Chamberlain, & Black, 1970, p. 828; OD]. Thick-walled bowl to goblet shaped, with flat-bottomed to short, stalklike base; numerous large, radial, cylindrical epirhyses and aporhyses (or possible parietal gaps); smaller, more irregular and anastomosing, skeletal canals connecting with them, canals mainly radial near gastral surface but mainly concentric near dermal surface; hypodermalia are larger pentactines with reflexed, paratangential rays bearing a few tubercles on their distal surfaces; apparently no hypogastralia; parenchymal spicules including hexactines of several sizes, irregularly curved or bent rhabdodiactines, some of which are strongylelike and outline skeletal canals; relatively large oxyhexasters (with four-branched rays) occurring near dermal surface, rays bearing an ornament of spiral ridges resembling spicules of *Spiractinella* Hinde; all parenchymal and hypodermal spicules have nonparallel orientation; long rhabdodiactines with quadrianchorate terminations occurring in basal part of sponge and may be basalia. *Carboniferous (Lower Pennsylvanian):* USA (Oklahoma).——Fig. 202*a–c. *A. mega,* Wapanuka Limestone, Ouachita Mountains; *a,* side view of holotype with stalked base and smooth, bow-shaped profile; *b,* vertical cut and etched section with light and dark gray matrix filling parietal gaps in both basal area and walls; *c,* view down into spongocoel of large, bowl-shaped holotype, BYU 1596, ×0.5 (Rigby, Chamberlain, & Black, 1970).

Ascospongiella García-Bellido Capdevila & Rigby, 2004, p. 445 [**A. capdevila;* OD]. Sack-shaped, moderately thick-walled pelicaspongiid with broad and deep spongocoel; walls perforated by straight, radial, closely spaced, parietal gaps or coarse canals that are cross connected by smaller canals with relatively uniform diameters; all canals separated by thin walls composed of irregularly oriented hexactines of several sizes; distinct, gastral layer of enlarged and irregularly oriented hexactines locally developed but not uniformly present; differentiated dermal layer absent. *Carboniferous (upper Bashkirian):* Spain.——Fig. 203*a–c. *A. capdevila,* San Emiliano Formation, Villafeliz Léon, northwestern Spain; *a,* longitudinal section of large holotype with wide, open spongocoel and thick walls; *arched light lines,* saw marks, ×0.5; *b,* dermal surface of paratype with oscular area and round ostia filled with light matrix, ×0.4; *c,* detail of various sizes of hexactines in dermal layer, ×8 (García-Bellido Capdevila & Rigby, 2004).

Asturiaspongia García-Bellido Capdevila & Rigby, 2004, p. 441 [**A. aqualiforma;* OD]. Bowl-shaped, thin-walled pelicaspongiid with walls perforated by common, interconnected, tubular canals of at least three sizes, all irregularly distributed, separated by relatively thin, skeletal tracts of small, irregularly oriented hexactines of several sizes; distinct dermal layer of small hexactines with four rays tangential to dermal surface. *Lower Devonian (Emsian):* Spain.——Fig. 204,*3a–b. *A. aqualiforma,* Aguión Formation, Arno, Asturias, northern Spain; *a,* side view of bowl-shaped holotype with large inhalant ostia in dermal layer, MNCN-I-3565a, ×1; *b,* tangential section of wall of paratype, on left, showing canals in wall, and transverse section of bowl-shaped paratype, on right, with large spongocoel filled with light matrix, MNCN-I-3565b, ×1 (García-Bellido Capdevila & Rigby, 2004).

Bayviewia Reimann, 1945b, p. 48 [**B. echinata;* OD]. Subglobular with osculum; surface bearing tufts of prostalia (possible rhabdodiactines); body spicules hexactines but poorly known. [This genus is included here with considerable doubt, mainly because of its resemblance to the sympatric *Calicispongia*.] *Middle Devonian:* USA (New York).——Fig. 204,*4. *B. echinata,* Wanakah Shale, Bayview; side view of holotype with rows of small clumps of prostalia, BMS E16566, ×1 (Reimann, 1945b; courtesy of Buffalo Museum of Science).

Calicispongia Reimann, 1945b, p. 48 [**C. airiness;* OD]. Bowl shaped with rounded rim; hypogastral hexactines (those on upper surface) larger than rest; several layers of parenchymal hexactines; all spicules in nonparallel orientation; the paratype (Reimann, 1945b, pl. 9,*3*) appearing to bear circular openings of possible aporhyses on gastral surface. [This genus resembles *Pelicaspongia*.] *Middle Devonian:* USA (New York).——Fig. 201,*3a–c. *C. airiness,* Wanakah Shale, Bayview; *a,* view of holotype from above showing broad, shallow spongocoel and thick walls with low nodes on saucer-shaped sponge; ×1; *b,* view of rounded base of holotype, BMS E14107, ×1; *c,* view from above showing exhalant ostia in gastral surface of broad, saucer-shaped paratype, BMS E16565, ×2 (Reimann, 1945b).

Cavospongiella Rigby, 1986b, p. 38 [**C. confossa;* OD]. Moderately thin-walled, cup- to bowl-shaped brachiosponges with gently convex sides curving inwardly toward osculum; two sizes of circular to polygonal, parietal gaps make up over two-thirds of wall; skeleton of irregularly oriented, smooth hexactines of various sizes; dermal layer present but not thick nor well defined, composed of enlarged hexactines. *Devonian (Famennian):* Western Australia.——Fig. 205,*2a–b. *C. confossa,* Virgin Hills Formation, Lawford Range; *a,* view of flattened holotype from above showing thin walls and large, parietal gaps filled with dark matrix, ×1; *b,* side view with rounded profile showing large, parietal gaps and ostia of smaller canals, in intervening areas, filled with dark matrix, GSWA F7226, ×1 (Rigby, 1986b).

Estrellaspongia García-Bellido Capdevila & Rigby, 2004, p. 443 [**E. irregulara;* OD]. Globose pelicaspongiid with small, shallow spongocoel; thick walls perforated by irregular, branched,

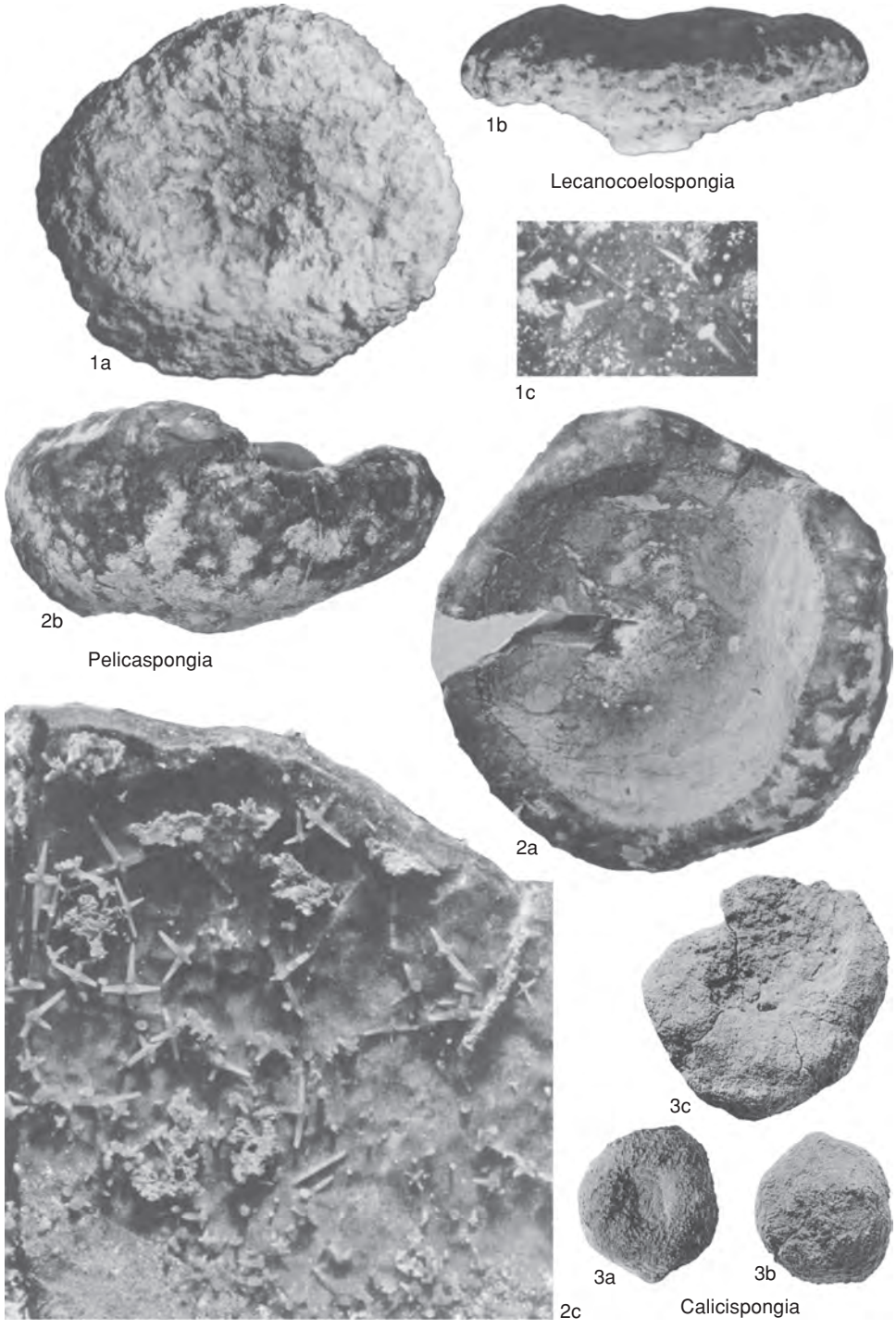


FIG. 201. Pelicaspongiidae (p. 321–329).

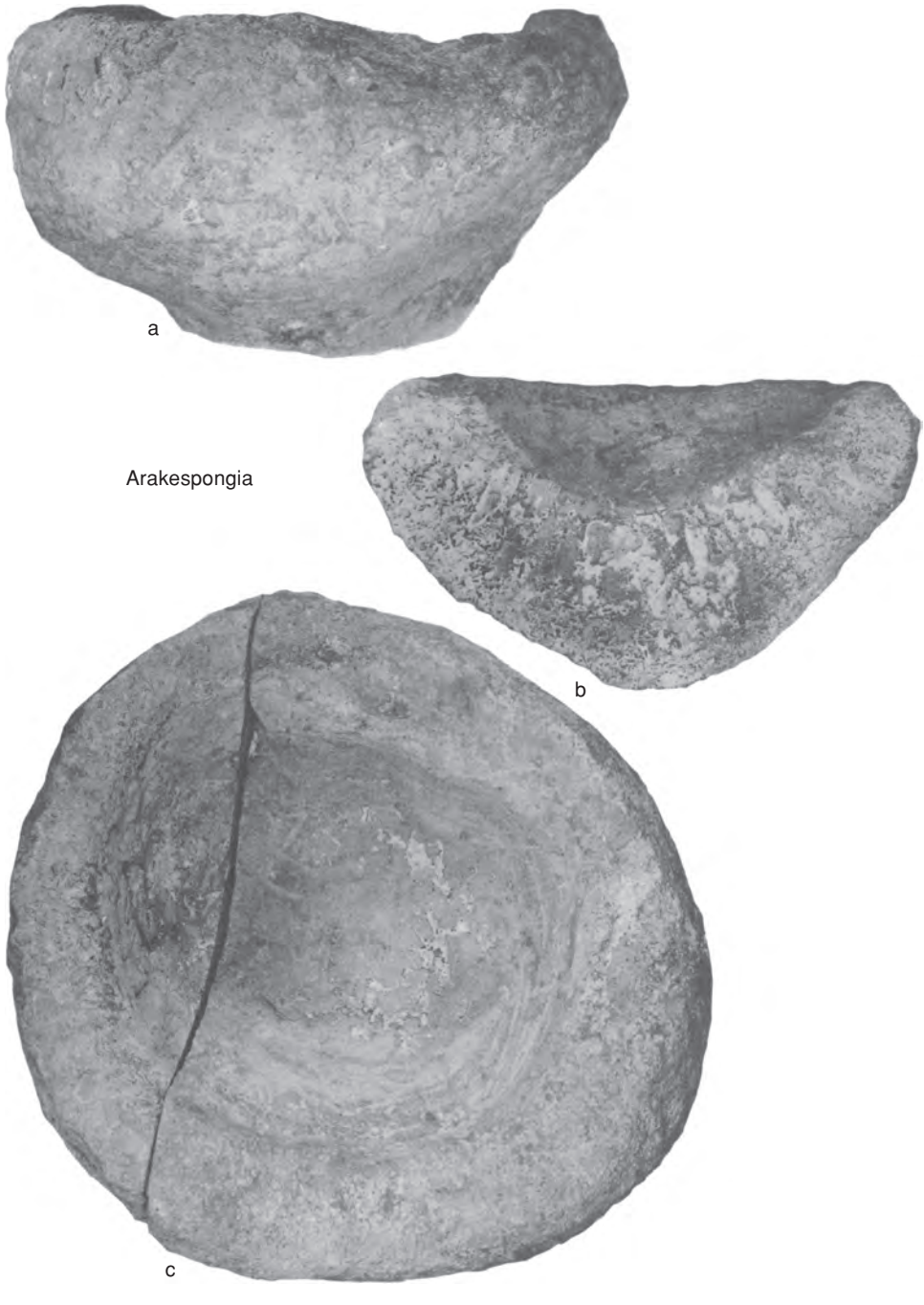


FIG. 202. Pelicaspongiidae (p. 323).

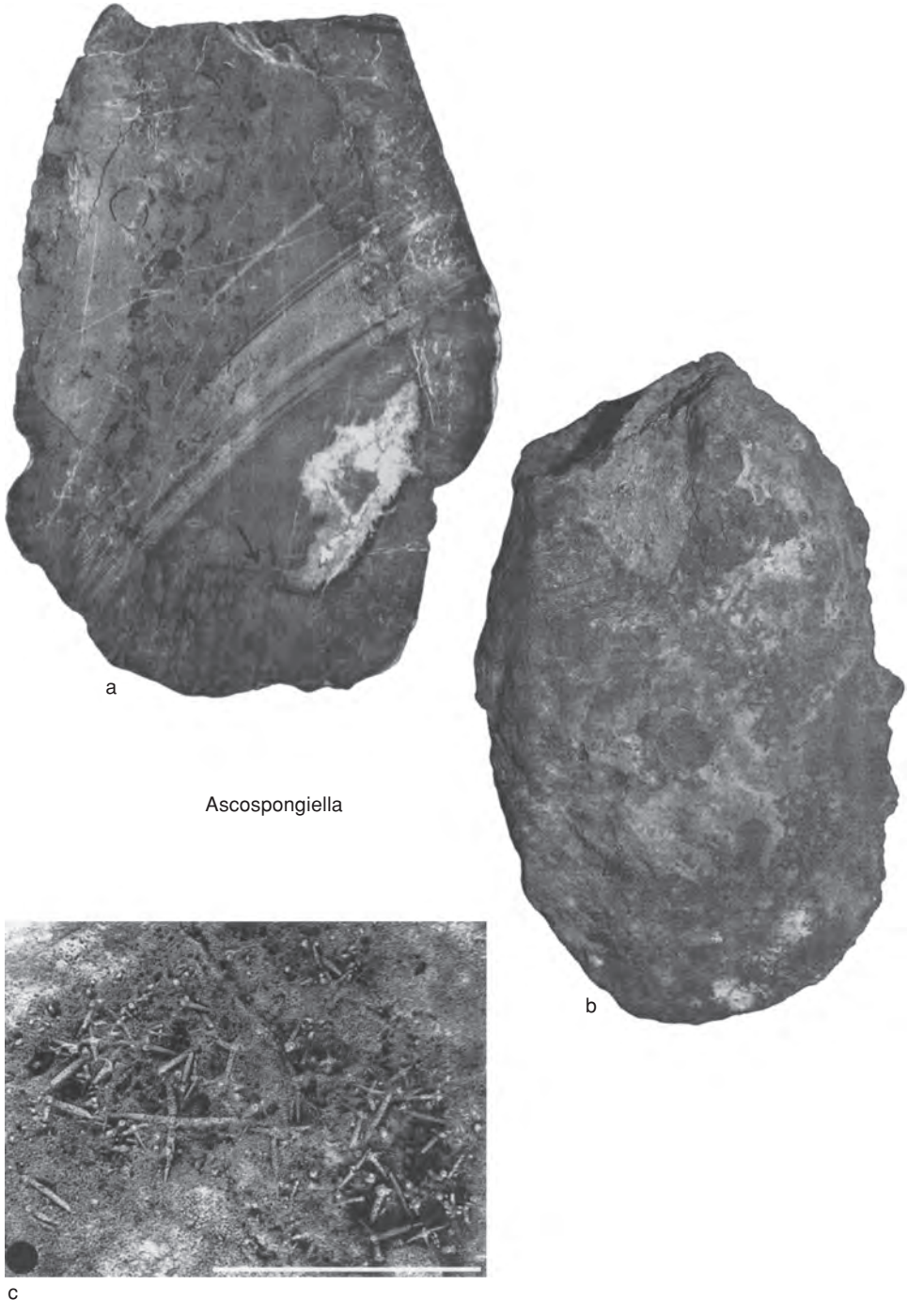


FIG. 203. Pelicaspongiidae (p. 323).

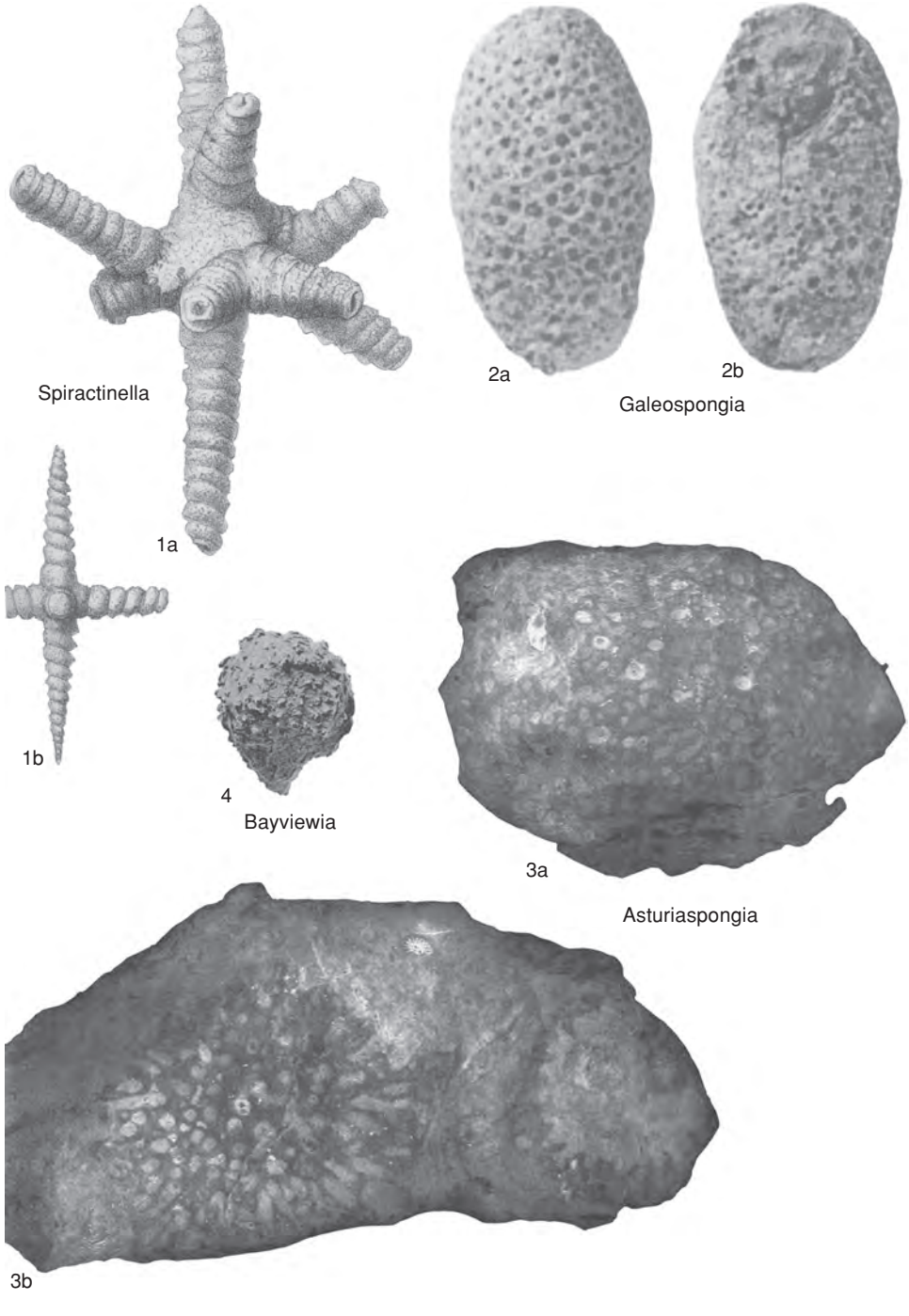


FIG. 204. Pelicaspongiidae (p. 323–336).

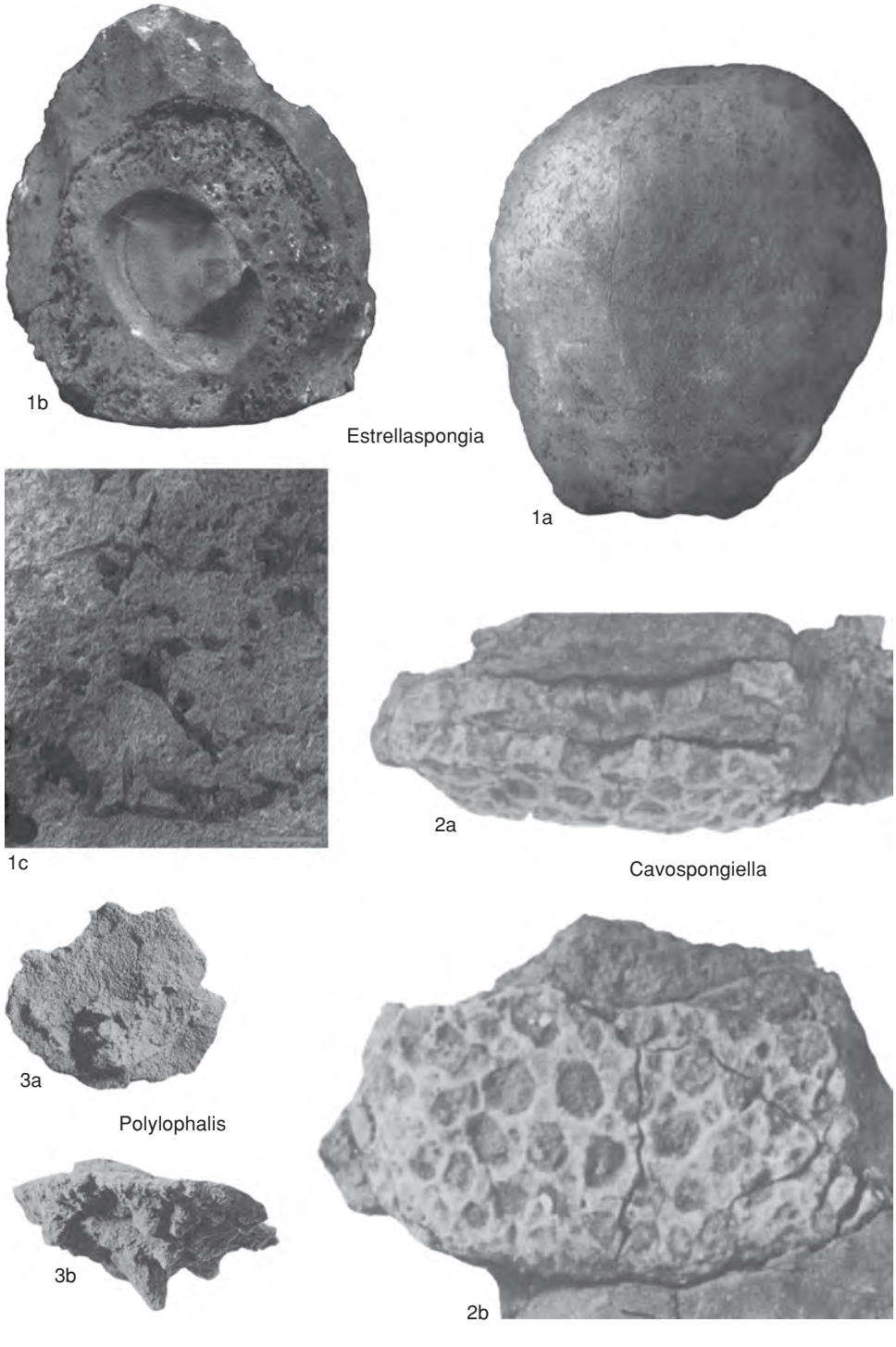


FIG. 205. Pelicaspongiidae (p. 323–333).

moderately coarse, inhalant canals that converge to coarse, irregular, exhalant canals in wall interior; endosomal skeleton of irregularly oriented and spaced, small hexactines; distinct, dermal layer composed of irregularly spaced, enlarged hexactines whose dermal rays are irregularly oriented. *Carboniferous (Visean):* Spain.——Fig. 205,*1a–c. *E. irregulara,* Sierra del Castillo Unit, Asbian-Brigantian, upper Visean, Sierra de la Estrella, Córdoba, southern Spain; *a,* side view of globose holotype with osculum at top, 98SSEC-1, ×0.5; *b,* weathered transverse section through paratype with sinuous canal system, spongocoel partially filled with matrix, 98SSEC-2, ×0.5; *c,* obliquely eroded, irregularly oriented, large, dark hexactines in dermal layer of holotype, 98SSEC-1, ×2 (García-Bellido Capdevila & Rigby, 2004).

Galeospongia Rigby, 1986b, p. 39 [**G. pleraducta;* OD]. Conicocylindrical or prolate spheroidal to sack-shaped sponges with contracted, oscular margin and rounded base, with thin walls and deep, simple spongocoel; circular, parietal gaps make up most of wall, spaced less than their diameter apart and notably larger on one side than other; skeletal net poorly preserved of irregularly oriented, small hexactines and possibly other spicules. *Devonian (Frasnian–Famennian):* Western Australia.——Fig. 204,*2a–b. *G. pleraducta,* Virgin Hills Formation, Lawford Range; *a,* side view showing elliptical shape and coarse, inhalant ostia; *b,* opposite side view showing matrix-filled osculum at top, GSWA F7239, ×1 (Rigby, 1986b).

Hadrophragmos García-Bellido Capdevila & Rigby, 2004, p. 443 [**H. soleniscus;* OD]. Bowl-shaped to globose pelicaspongiid with thick walls perforated by coarse, parietal gaps that are normal to dermal and gastral surfaces of wall; skeleton composed of small hexactines that are irregularly spaced and oriented; walls without differentiated dermal and gastral layers of enlarged spicules. *Carboniferous (upper Bashkirian):* Spain.——Fig. 206,*1a–c. *H. soleniscus,* San Emiliano Formation, Villafeliz, Léon, northeastern Spain; *a,* polished vertical section of holotype, with shallow upper spongocoel and coarse parietal gaps filled with matrix, 99VI4-9B, ×2.0; *b,* detail of polished section of holotype showing wide parietal gaps cross connected by small, irregular canals, ×3.0; *c,* thin section with irregularly oriented hexactines and with long-rayed hexactines in upper right, associated with dark, rimmed microborings, ×9 (García-Bellido Capdevila & Rigby, 2004).

Keriogastrospongia Wu, 1989, p. 767 [**K. phialoides;* OD]. Bowl-shaped lyssacine sponges with shallow spongocoel marked by concentric rings of coarse ostia of subradial, exhalant canals; walls thick and composed of irregularly oriented and spaced hexactines and hexactine-based spicules of several sizes in generally fine-textured skeleton, except for dermal layer of somewhat coarser, more consistently oriented, hexactines of general brachiospongiid appearance. *Triassic (Carnian):* China (Sichuan).——Fig. 207,*2a–b. *K. phialoides,* Hanwang Formation, Hanwang; *a,* view from above of broad spongocoel in figured specimen with thick walls and coarse, exhalant ostia, S-1096, ×1; *b,* photomicrograph of longitudinal section with coarse, irregularly oriented hexactines, light matrix on right filling exhalant canal and dark rings in upper left are sections through *Terebella*-like worms that occupy some canals, IGASB R6-23(073), ×10 (Rigby, Wu, & Fan, 1998).

Larispongia Carrera, 1998, p. 206 [**L. magdalenae* Carrera, 1998, p. 207; OD]. Bowl-shaped, thick-walled hexactinellid with broad, simple spongocoel and closely spaced, parietal openings; gaps separated by thin parietes; dermal and gastral layers of enlarged (first-order), irregularly oriented hexactines; interior of skeleton of smaller, second- and third-order, irregularly oriented hexactines; dermal and gastral hexactines with four rays parallel to surface and proximal and distal rays at right angles to surface; most spicules with regular form and fine-textured appearance. [*Twenhofelella* lacks a differentiated gastral layer and the dermal layer is of pentactines; and *Vaurealispongia* lacks a differentiated dermal layer. *Pelicaspongia* has both dermal and gastral layers of enlarged hexactines, but it has thick parietes with spicules that have considerable variety in morphology and dimensions, in contrast to more uniform hexactines in *Larispongia*.] *Ordovician (Tremadocian):* Argentina.——Fig. 207,*3a–b. *L. magdalenae,* Las Vicuñas Formation, Puna region of Salta Province; *a,* vertical view of entire specimen showing open spongocoel and part of exterior, ×1.7; *b,* photomicrograph of exterior of holotype with enlarged, dermal hexactines around parietal openings with spongocoel at bottom, Cegh-Unc 17365, ×5 (Carrera, 1998).

Lecanocoelospongia Wu, 1989, p. 769 [**L. brachystypos;* OD]. Broadly obconical to open, mushroom-shaped sponges with short stalk; slightly concave to flat, upper gastral surface of thick wall with honeycomb-like spacing of coarse oscula; nodose, lower, dermal surface with smaller, inhalant ostia; skeleton mainly of stout, irregularly oriented and spaced hexactines and long monactines, with occasional small, secondary oxeas. [Genus tentatively included in family for development of coarsely spiculed dermal or gastral layers unknown.] *Triassic (Carnian):* China (Sichuan).——Fig. 201,*1a–c. *L. brachystypos,* Hanwang Formation, upper member, Jiangyou County; *a,* view onto upper, gastral surface with shallow spongocoel and irregular, coarse, exhalant ostia of holotype; *b,* side view showing general form and short, lower stalk of holotype, ×1; *c,* photomicrograph showing ray junctions of robust hexactines and transverse sections of other rays in skeleton of holotype, ×10 (Wu, 1989).

Liscombispongia Rigby & Webby, 1988, p. 84 [**L. nodosa;* OD]. Thin walled, cuplike, with distinctly knobby exterior; canal system diplorhysal with both incurrent and excurrent canals ending blindly in midwall; skeleton of three layers: outer, dermal layer knobby of small to large, irregularly oriented,

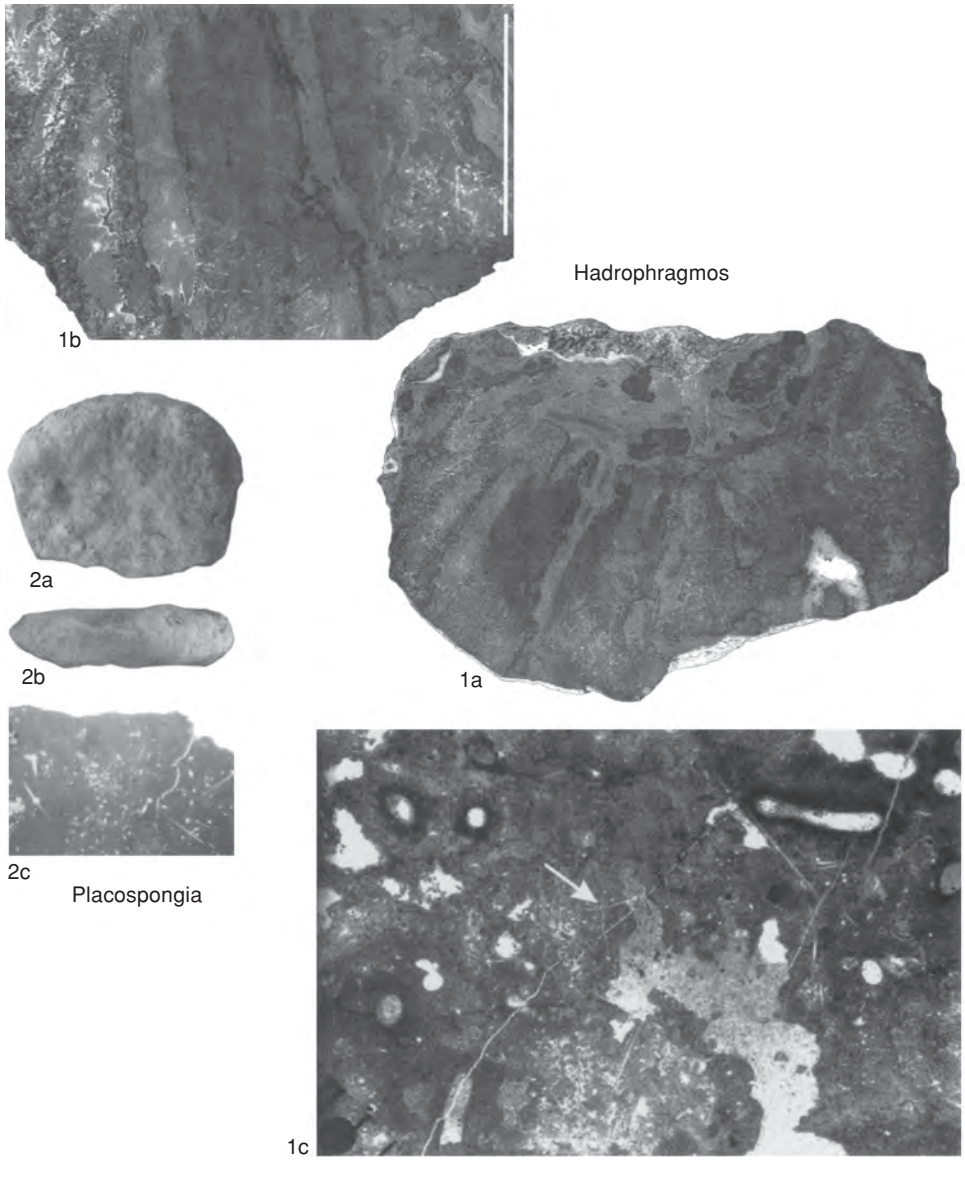


FIG. 206. Pelicaspongiidae (p. 329–333).

normal hexactines; middle layer of straps of subparallel, long, monaxial or rhabdodiactine spicules that occur between tracts of irregular hexactines; gastral layer of ropy tracts of long-rayed rhabdodiactines or other reduced derivatives of hexactines. *Upper Ordovician:* Australia (New South Wales).——FIG. 208*a–e. *L. nodosa,* Malongulli Formation, Cliefden Caves area; *a,* view from above of thick-walled, somewhat collapsed, cup-shaped holotype with irregular, nodose exterior and interior; *b,* side view of exterior with widely spaced, incurrent ostia in nodose, dermal layer, ×1; *c,* photomicrograph of coarse, outer part of dermal layer, with finer spicules that line canals and occur in bottoms of grooves, between nodes; *d,* photomicrograph of gastral surface with characteristic, somewhat bundled, long-rayed, fine spicules; *e,* photomicrograph of part of endosomal layer where dermal layer has been removed, with straps of bundled, long-rayed, possible rhabdodiactines associated with normal, small hexactines, tracts of spicules lining incurrent canals in outer part of wall,

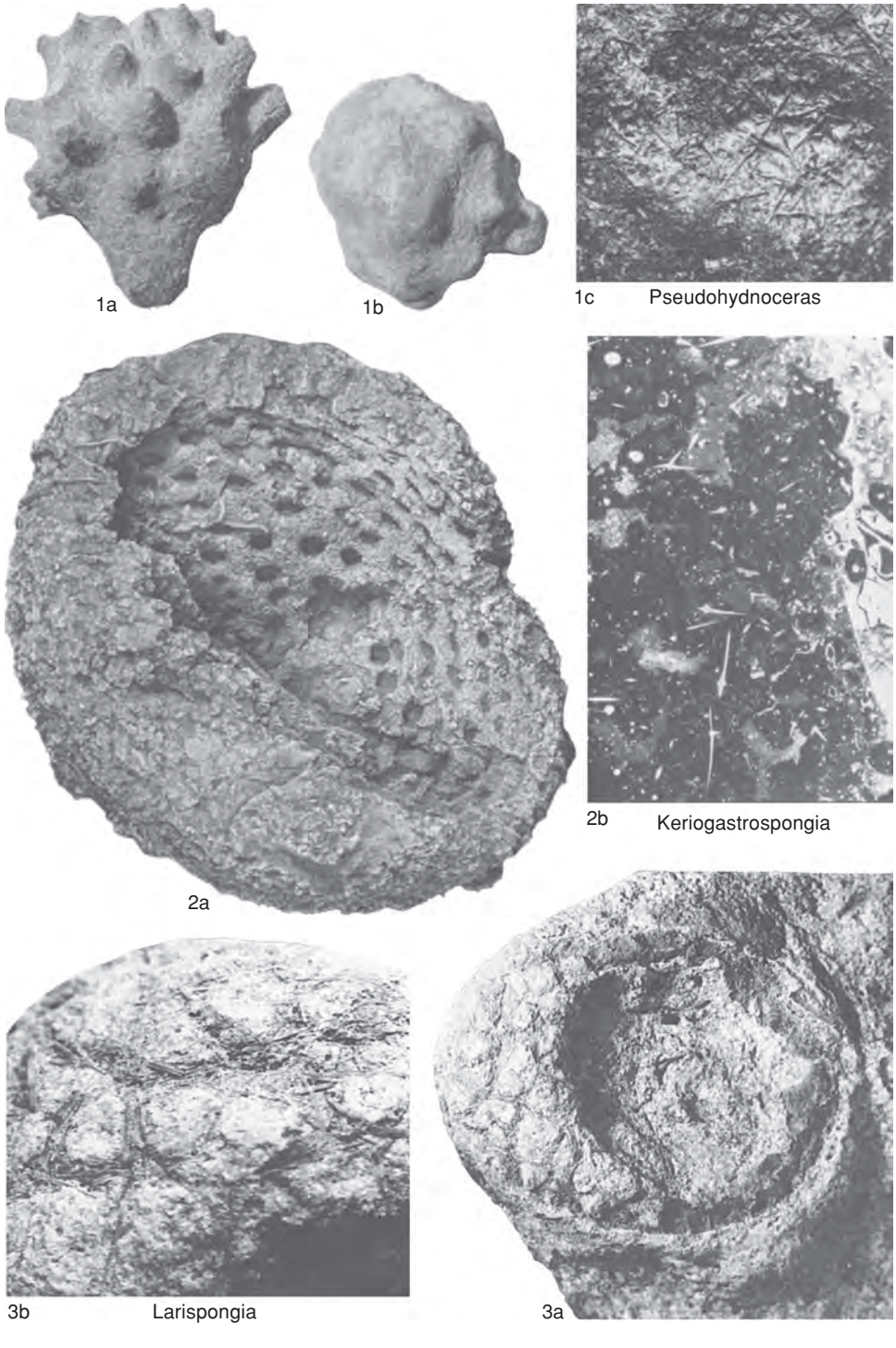


FIG. 207. Pelicaspongiidae (p. 329–333).

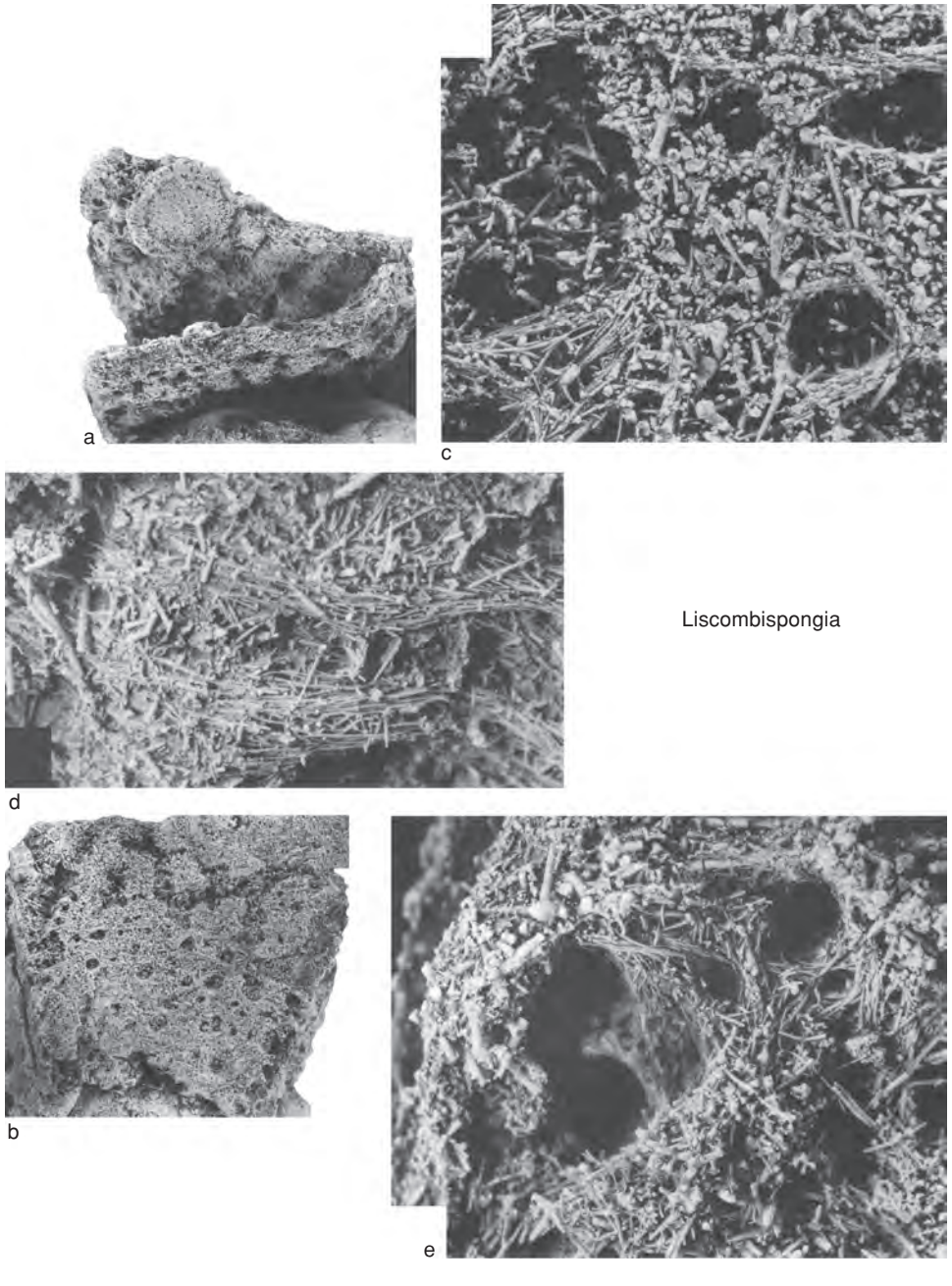


FIG. 208. Pelicaspongiidae (p. 329–332).

AMu. F66904, ×8 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Lysactinella GIRTY, 1895, p. 267 [**L. gebhardi* GIRTY, 1895, p. 269; SD DE LAUBENFELS, 1955, p. 94]. Small, spheroidal sponge without cloaca, canals, or root tuft; interior filled with closely packed, separate, nonaligned, smooth, possible hexactines and derivatives, with larger, dermal spicules near periphery having a suppressed distal ray; inter-ray angles, seen only in section on single, complete sponge;

frequently nonrectangular, and sometimes with five rays in one plane. [Such spicules suggest, together with the lack of a cloaca, that it might be a heteractinid, although such irregularities are also common in lyssacines. Isolated irregular, smooth hexactines, pentactines, and stauractines of somewhat smaller size, however, occur in the associated sediment, as do larger ones that are distinctively strongly spinose and were assigned to a second species, *L. perelegans* Girty, 1895, p. 270. It is possible that the whole specimen is a juvenile and the larger, spinose spicules are from adults of the same species (smaller spicules have some nonspinose rays). If the genus is to be recognized it must be based on the whole specimen, which is here designated the lectotype. The genus is assigned here with considerable doubt; however, the larger dermalia are characteristic of the family.] *Devonian (Lochkovian):* USA (New York).——Fig. 209,*3a–d. *L. gebhardi,* shaly limestone, Gedinnian, Lower Helderberg Group, Indian Ladder, Albany County; *a–c,* various hexactine-based spicules from type specimen; *d,* representative spicule from type specimen with five rays in one plane, ×25 (Girty, 1895).

Placospongia Wu, 1989, p. 770 [**P. annulicarina;* OD]. Round to elliptical or rectangular or fan-shaped, flat plates, in which margin may turn up slightly and plate may be slightly concave; upper, gastral surface may be marked by low, radiate ridges and with exhalant ostia that range from obscure and shallow to prominent and deep; lower, dermal surface with small tubercles and shallow, inhalant ostia; megascleres of skeleton mainly coarse monactines and scattered hexactines, with associated small oxeas. [Genus tentatively included in the family for development of coarse, dermal or gastral layer unknown.] *Triassic (Carnian):* China (Sichuan).——Fig. 206,*2a–c. *P. annulicarina,* Hanwang Formation, upper member, Mianzhu County; *a,* gastral surface of platelike holotype with faint impressions of exhalant ostia; *b,* side view of holotype with rounded margins, ×1; *c,* photomicrograph of relatively fine spicules of holotype, including some small hexactines, ×10 (Wu, 1989).

Polylophalis Reimann, 1945b, p. 45 [**P. bayviewensis* Reimann, 1945b, p. 46; OD]. Sponge broadly conical with flat, upper surface bearing a shallow, central depression; lower surface bearing conical tufts of (possible rhabdodiactine) prostalia; upper surface bearing rhabdodiactine prostalia directed toward central depression; internal, skeletal canals present; hexactines not preserved on type species, according to author, but present in *P. clivulatus* from same locality; numerous micromonaxon impressions said to occur in the adherent matrix of one specimen; microscopic (200 μm) hollow, possibly organic, spheres said to occur in some specimens were interpreted by author as possible gemmules. *Middle Devonian:* USA (New York).——Fig. 205,*3a–b. *P. bayviewensis,* Wanakah Shale, Bayview; *a,* view of funnel-like holotype from above with prostalia radiating from central area, ×1; *b,* view from side with pointed base and smaller, pointed tufts of basalia below expanded, upper part of sponge, BMS E15576, ×1 (Reimann, 1945b).

Prenehydnoceras Hurcewicz & Czarniecki, 1986, p. 339 [**P. trachys;* OD]. Small, conical, with narrow, rounded base and somewhat contracted, rounded summit; no osculum; moderately thick-walled with broad cloaca; exterior bearing rounded protuberances in obscure, longitudinal and transverse rows; skeletal net of parallel hexactines in loose, cubic mesh, with pentactines and short rhabdodiactines at surface; sinuous canals interrupting skeletal net and opening as pores (possibly exhalant), being concentrated at summit and also on protuberances. *Carboniferous (Visean):* Poland.——Fig. 209,*2a–i. *P. trachys,* Carboniferous limestone of Galezice, Holy Cross Mountains; *a,* wider side view of holotype, black line is trace of section; *b,* vertical section showing broad spongocoel filled with bioclasts, ×1; *c,* fragment showing skeletal structure, ×100; *d–i,* spicules of endosomal skeleton drawn from thin section; *d,* regular hexactines; *e,* axial hexactines with one or two longer rays; *f,* large hexactines; *g,* pentacts; *h,* oxeas; *i,* strongyle, scale bars, 0.1 mm, AI-68/19 (Hurcewicz & Czarniecki, 1986; courtesy of Polish Geological Society, Krakow).

Pseudohydnoceras Reimann, 1935, p. 13 [**P. erraticum;* OD]. Vasiform with stalklike base and large, rounded nodes on subglobose, upper part; osculum not known in type species; closely spaced, parallel, large, cylindrical epirhyses and aporhyses penetrating thick, sponge wall; possible rhabdodiactine pleuralia and basalia present; only a few hexactines preserved. *Middle Devonian–Upper Devonian (Frasnian):* USA (New York), *Middle Devonian;* Poland, *Frasnian.*——Fig. 207,*1a. *P. erraticum,* Ludlowville Shale, Hamiltonian, Erie County, New York; side view of lobate lectotype, NYSM, ×0.8 (Reimann, 1935; courtesy of Buffalo Museum of Science).——Fig. 207,*1b–c. P. obscurum* Reimann, Ludlowville Shale, Hamiltonian, Erie County, New York; *b,* side view of globose holotype with low nodes, ×0.66; *c,* photomicrograph of surface of holotype with numerous hexactine-based spicules, BMS, ×5 (Reimann, 1935; courtesy of Buffalo Museum of Science).

Spiractinella Hinde, 1887b, p. 74 [**Holasterella wrighti* Carter, 1880a, p. 209; OD]. Known only from isolated, smallish hexactines that bear spiral ridges on each of the rays; many rays bifurcate or trifurcate terminally; associated, smaller, smooth spicules have trifurcate (and possibly quadrifurcate) terminations and resemble hexasters. [The genus is included here because of the resemblance to the oxyhexaster spicules of *Arakespongia.* Reid (personal communication, early 1970s) considers these spicules of *Spiractinella* to be pseudohexasters of demosponge origin. Although the formal description of the genus was published in Hinde, 1888, p. 164, the name was first mentioned in Hinde, 1887b, p. 74, accompanied by a reference to plate 8, figure 1 of the same volume, where the type

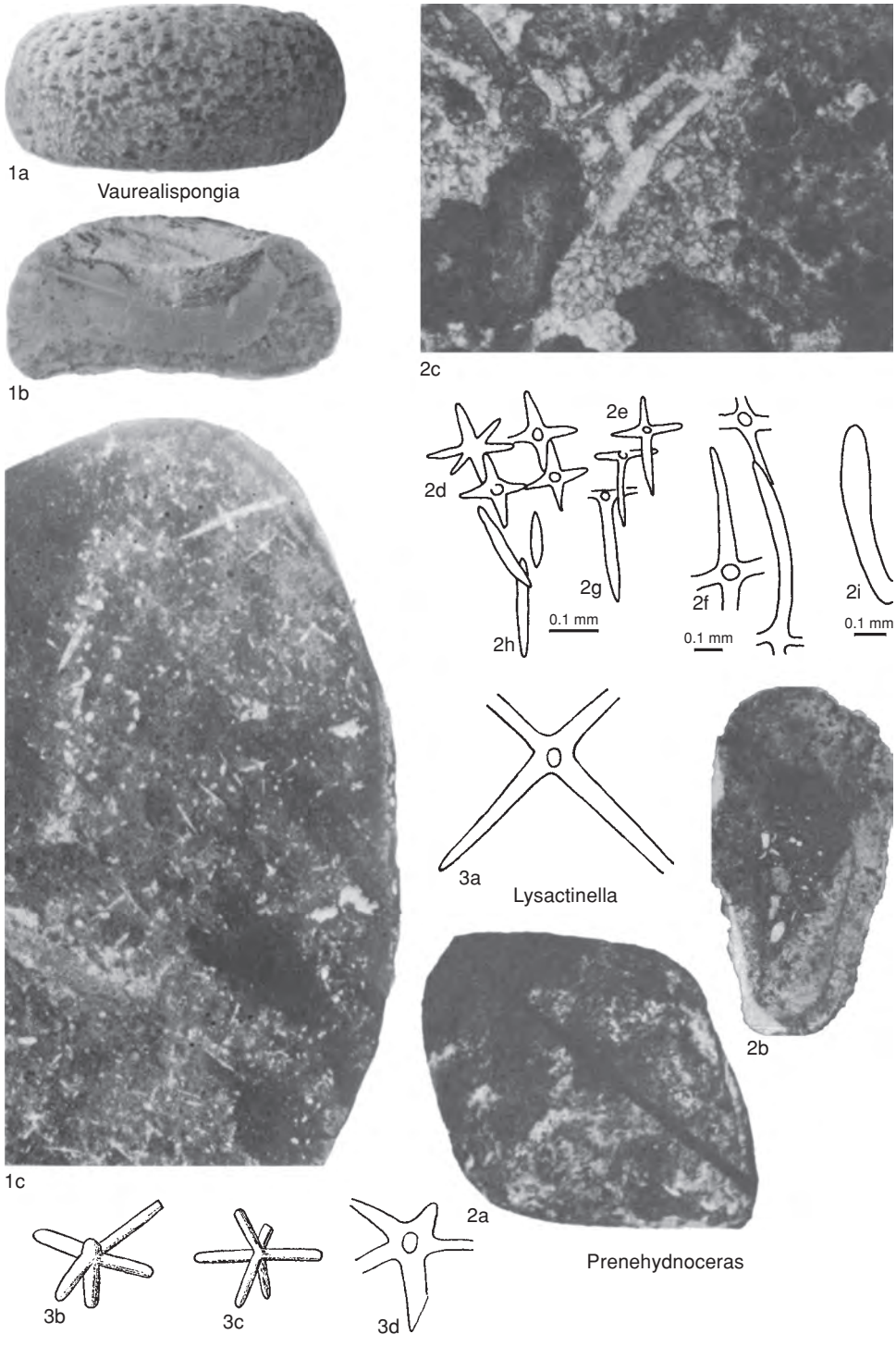


FIG. 209. Pelicaspongiidae (p. 332–338).

FIG. 210. Pelicaspongiidae (p. 336).

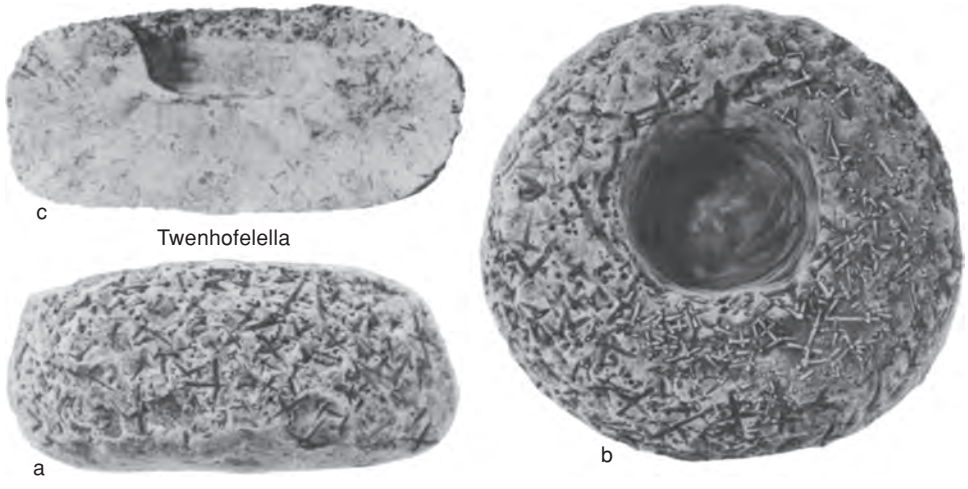


FIG. 211. Pelicaspongiidae (p. 336).

species is named, and the spicules illustrated and briefly described; this constitutes an "indication" as required by the *Code* (ICZN, 1999). *Carboniferous (Visean):* Ireland.——FIG. 204,*1a–b. *S. wrightii* (CARTER), Lower Carboniferous limestone, Sligo; *a,* large, hexactine spicule with spiral sculpture and bifurcated, transverse rays; *b,* smaller hexactine with typical spiral sculpture, ×40 (Hinde, 1887b).

Stiodermiella RIGBY & CLEMENT, 1995, p. 224 [**S. amanita;* OD]. Stalked, mushroomlike, or inverted, cup-shaped sponge with stalk, if present, of normal-appearing hexactines, but upwardly expanded cap with dense, gastral armor of spicules with expanded ray junctions, or centra, which may be papillose and combine to produce dense cortex; internal spicules in nonparallel arrangement; cortex if present covers canals. *Devonian (Lochkovian):* USA (Tennessee).——FIG. 210*a–c. *S. amanita,* Ross Formation, Benton County; *a,* arched upper surface of massive, mushroomlike holotype where distal rays of spicules are side by side, USNM 463603; *b,* base with massive stalk and overhanging upper part of sponge, irregular hexactines developed in center and more regular hexactines in upper left, USNM 464606, ×2; *c,* photomicrograph of paratype with grossly enlarged spicules typical of upper part of sponge with some regular, smaller hexactines between, USNM 463604, ×20 (Rigby & Clement, 1995).——FIG. 210*d. S. tetragona* RIGBY & CLEMENT, Ross Formation, Benton County; holotype with swollen papillae that are petalloid appearing on terminations of distal rays of dermal hexactines in armored, dermal layer, USNM 463608, ×20 (Rigby & Clement, 1995).

Twenhofelella RIGBY, 1974, p. 1347 [**Hyalostelia anticostiana* TWENHOFEL, 1928, p. 103; OD]. Bowl-shaped, smooth, unribbed, small sponge with large, central spongocoel and thick walls perforated with radially arranged, circular, parietal gaps curved from outer surface to spongocoel except in basal part where they begin within wall; skeleton of irregularly oriented, variously sized, smooth-rayed hexactines; dermalia enlarged hexactines and possible pentactines with four rays tangential to surface but in nonparallel orientation; gastralia not developed. *Silurian (Wenlock)–Devonian (Lockhovian):* Canada (Quebec, Anticosti Island), *Wenlock–Ludlow;* USA (Indiana), *Wenlock;* USA (Tennessee), *Lochkovian.*——FIG. 211*a–c. *T. anticostiana* (TWENHOFEL), Jupiter Formation, Niagaran, Anticosti Island, Canada; *a,* side view of exterior showing irregular arrangement of dermal hexactines in holotype, ×1; *b,* view down onto oscular margin with enlarged hexactines of dermal layer of wall around cylindrical spongocoel, ×1; *c,* vertical section showing shallow spongocoel and light gray matrix in parietal gaps and canals of wall, YPM 10404, ×1 (Rigby, 1974; courtesy of *Canadian Journal of Earth Sciences*).

Vaurealispongia RIGBY, 1974, p. 1343 [**V. perforata* RIGBY, 1974, p. 1346; OD]. Bowl shaped to vasiform with large, central, simple spongocoel and moderately thick walls of irregularly oriented, smooth-rayed hexactines and related spicules, with largest enlarged, interleaved hexactines of gastral layer; wall perforated by numerous, dominantly radially arranged, irregular to circular, tubular, parietal gaps and smaller, circular canals that may bifurcate or anastomose in interior and interconnect with one another. *Ordovician–Silurian:* Canada (Quebec, Anticosti); USA (Indiana), *Wenlock.*——FIG. 209,*1a–c. *V. perforata,* Vaureal Formation, Ashgill, Anticosti Island, Canada; *a,* side view of holotype showing dimpled surface produced by large, parietal gaps; *b,* vertical section showing thick wall around part of matrix-filled spongocoel, ×1; *c,*

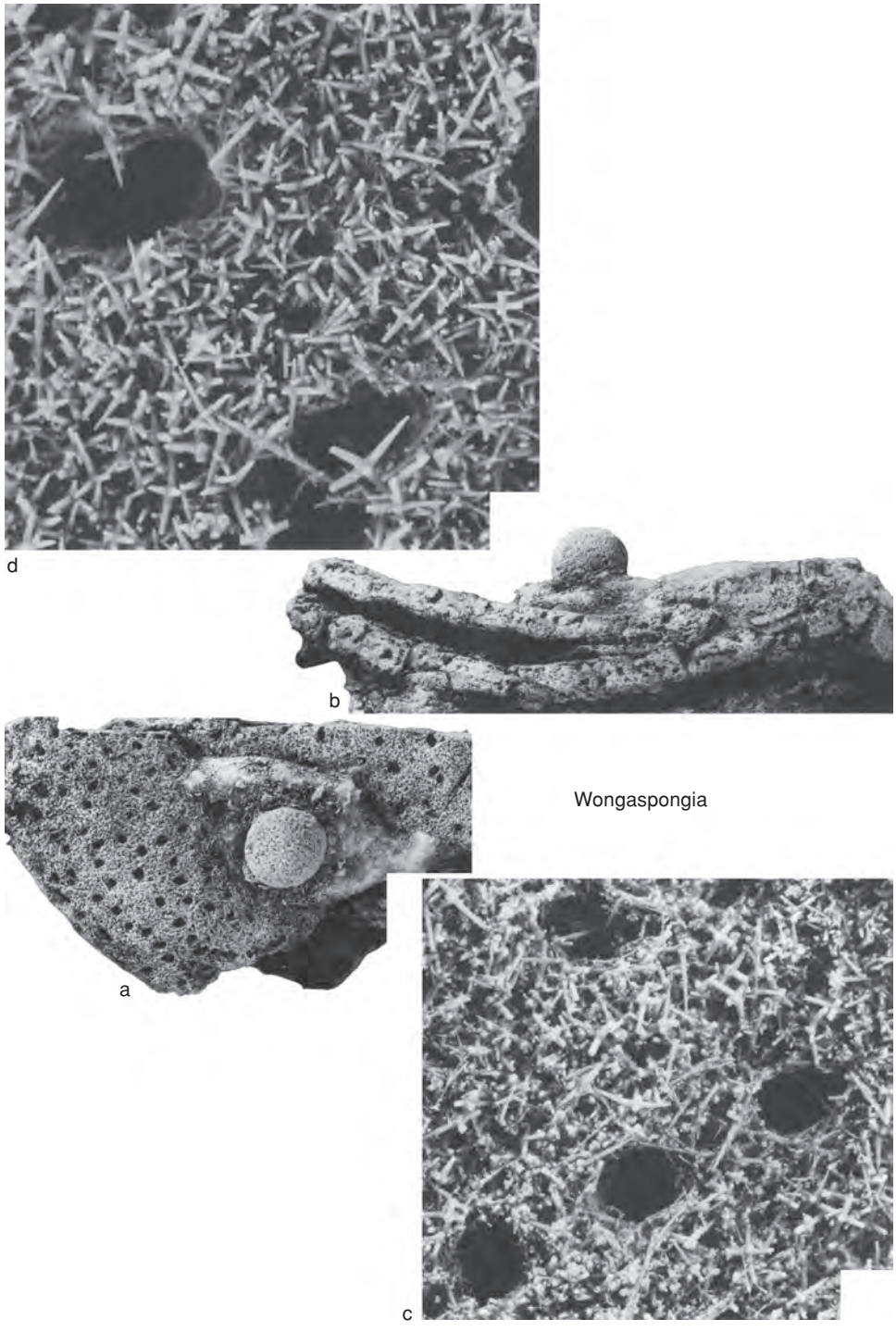


FIG. 212. Pelicaspongiidae (p. 338).

photomicrograph of cellulose, acetate peel of vertical section of upper, oscular rim showing matrix-filled, parietal gaps and skeleton with irregularly oriented and spaced hexactines and with enlarged hexactines as gastral layer on left, GSC 38402, ×10 (Rigby, 1974; courtesy of *Canadian Journal of Earth Sciences*).

Wongaspongia Rigby & Webby, 1988, p. 79 [**W. minor* Rigby & Webby, 1988, p. 80; OD]. Open conical to bowl-shaped sponges with smooth, moderately thin walls with diplorhysal canal system; larger, circular to polygonal, epirhysal openings on exterior spaced irregularly but generally more than their diameter apart; large, subcircular, aporhysal openings on gastral surface spaced less than their diameter apart; epirhyses communicating with vertical canals within body wall, or else end blindly halfway through wall; aporhyses and epirhyses alternating more or less quincuncially; walls of two layers; dermal layer of coarse, armoring, irregularly oriented hexactines and less common pentactines; main skeleton of irregularly oriented hexactines and bundles of thinner rhabdodiactines, or hexactines with two long rays parallel to bundle; bundles mostly parallel to sponge surface and outlining canals. *Upper Ordovician:* Australia (New South Wales).——Fig. 212*a–d.* **W. minor,* Malongulli Formation, Cliefden Caves area; *a,* side view of collapsed, thin-walled holotype with smooth exterior perforated by incurrent canals that extend through wall, gastral surface showing in upper right, beyond broken margin above small, spherical *Hindia,* with excurrent openings slightly larger than incurrent ones, ×1; *b,* view from above of collapsed sponge where dark groove is spongocoel, round, midwall canals showing in both walls below small, spherical *Hindia,* ×1; *c,* photomicrograph of dermal surface showing irregularly oriented and spaced, coarse hexactines in outer part of sponge and somewhat finer hexactines in interior in tracts between incurrent openings, AMu. F66897, ×8; *d,* photomicrograph of dermal layer and outer part of endosome of paratype perforated by incurrent canals and composed of irregularly spaced and oriented hexactines, AMu. F66898, ×10 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Family STIODERMATIDAE Finks, 1960

[Stiodermatidae Finks, 1960, p. 130]

Thin-walled, vasiform sponges with root tuft (at least some spicules of which bear quadridentate, anchorate terminations where preserved); enlarged, hypodermal pentactines or subhexactines, often with swollen, distal and paratangential rays; similar hypogastralia may be present; parenchymal hexactines nonparallel; large, circular parietal gaps or epirhyses and aporhyses; amphidiscs found in or associated with most genera. *Lower Cambrian–Permian.*

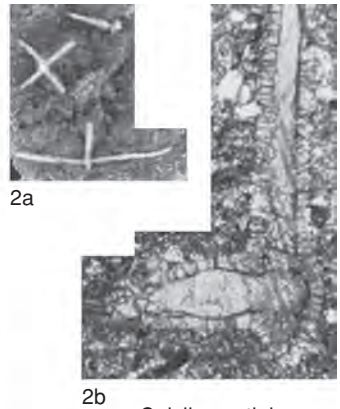
Stioderma Finks, 1960, p. 132 [**S. coscinum* Finks, 1960, p. 133; OD]. Sponge goblet shaped, relatively thin walled, with stalklike base from which emerges a long, stout, root tuft; body wall pierced by numerous large, circular, possible parietal gaps, not covered by preserved skeleton and much broader than longest rays of hypodermalia; hypodermalia and possible autodermalia fused in adult sponge into rigid skeleton that curves over oscular rim and extends a short distance down into cloaca; hypodermalia large hexactines in which distal ray is enlarged into spheroidal knob and paratangential rays are variably swollen and not reflexed; possible autodermalia smaller, similarly knobbed hexactines more or less radially disposed about distal knob of hypodermalia and external to their paratangential rays, which are in nonparallel orientation; parenchymalia simple hexactines, some spinose, in nonparallel orientation; specialized gastralia and hypogastralia apparently not present except for some short, straight, smooth, oxeote rhabdodiactines irregularly oriented parallel to gastral surface; terminations of long, smooth, root-tuft spicules not preserved but a broken spicule with a quadrianchorate termination found in association with isolated, hypodermal spicules. *Carboniferous (?Mississippian), Carboniferous (Pennsylvanian)–Permian:* USA (Texas, Arkansas, ?Illinois), Spain, ?Scotland, *?Mississippian, Pennsylvanian–Permian*; China, *Moscovian.*——Fig. 213,*1a–b.* **S. coscinum,* Victorio Peak Limestone, Leonardian, Sierra Diablo, Texas; *a,* holotype as natural sagittal section showing upper, cup-shaped part of sponge above stalk and prominent, basal, root tuft, ×0.5; *b,* photomicrograph of outer surface of holotype with coarse, parietal gaps and fine, skeletal pores between distal knobs of dermalia, USNM 127666, ×5 (Finks, 1960; courtesy of The American Museum of Natural History).

Acanthactinella Hinde, 1888, p. 167 [**Holasterella bennei* Hinde, 1884a, p. 153; OD]. Isolated hexactines with stout rays that bifurcate or trifurcate terminally or branch irregularly; also pentactines with a stout, tapering, unbranched, possible proximal ray. [They are placed here because of a distinct similarity to *Rhakistella* Weller, 1930, but the trifurcate branching of some spicules suggests demosponge affinities, and it is not clear that all these are hexactinellid or from the same genus of sponges.] *Carboniferous (Visean):* United Kingdom (Scotland).——Fig. 213,*4a–c.* **A. bennei* (Hinde), Lower Limestone series, Ayrshire; *a,* isolated hexactine with bifurcated rays in type suite; *b,* large hexactine with trifurcated rays; *c,* large spicule with bifurcated rays, ×10 (Hinde, 1887b).

Astroconia Sollas, 1881, p. 254 [**A. granti;* OD]. Large, isolated, hexactine-based spicules include common, normal, smooth-rayed hexiradiates, ones

1a

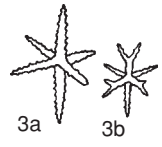
Stioderma



2a

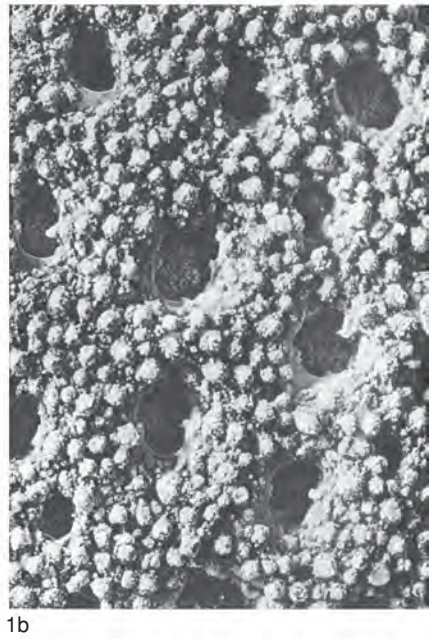
2b

Calcihexactinia

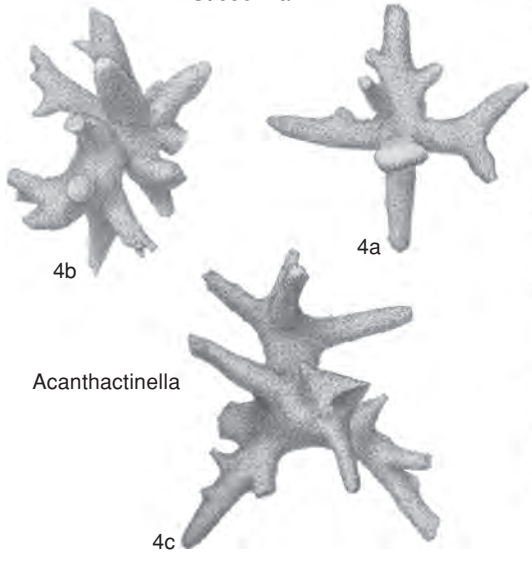


3a 3b

Rhakistella



1b



4b

4a

Acanthactinella

4c

FIG. 213. Stiodermatidae (p. 338–344).

with spinose rays, ones with large, downwardly directed, bifid spines over more normal reflexed rays. [Nature of the complete sponge is unknown and position in the family is tentative.] *Silurian:* Canada, England.——Fig. 214,*3a–d. *A. granti,* isolated, large spicules of sponge, Niagara, possibly Lockport, Limestone, lower Silurian, Ontario, Canada; *a,* normal hexactine, ×20; *b,* hexactine with spinose rays, ×50; *c,* hexactine with bifid spines; *d,* anchorate hexactine with reflexed rays, ×20 (Sollas, 1881).

Calcihexactinia Sdzuy, 1969, p. 139 [**C. franconica;* OD]. Isolated spicules, preserved as calcium carbonate with wide, axial canals, includes hexactines and pentactines with rays of uneven lengths; some spicules have a very long ray and others have reduced rays; no needles showing signs of overgrowths or fusion together. *Middle Cambrian:* Germany.——Fig. 213,*2a–b. *C. franconica,* Wildsteiner Schichten, Frankenwaldes; *a,* latex cast of three hexactines of type suite, SMF 26174, ×10; *b,* thin section of hexactine with wide, axial canals characteristic of genus, SMF 26173, ×60 (Sdzuy, 1969).

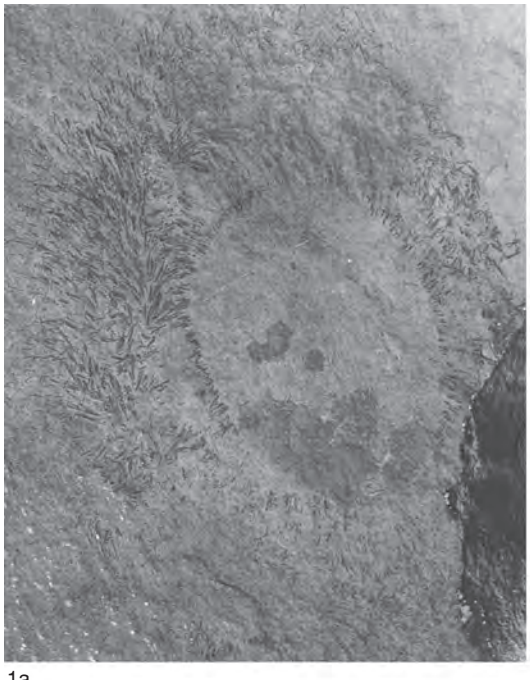
Divaricospongia Rigby & Maher, 1995, p. 1025 [**D. dilata;* OD]. Cylindrical to cuplike sponges with walls of hexactines and pentactines, spicules arranged in upwardly and outwardly plumose pattern diverging from surface of pinnation at midwall; spicules with swollen, proximal rays, but reduced or aborted distal and transverse rays; spicules of gastral layer with reduced, tangential rays; dermal part of wall with more nearly normal-appearing hexactines; paratangential or transverse rays not regularly oriented; skeletal structure not reticulate. *Silurian (Ludlow):* USA (Nevada).——Fig. 214,*1a–b. *D. dilata,* Roberts Mountains Formation, Snake Mountains; *a,* diagonally flattened, tubular to cup-shaped holotype with upwardly plumose, hexactine-based skeletal structure, ×2; *b,* photomicrograph showing upwardly divergent spicules in axial and gastral part of wall with moderately dense, gastral layer on right, USNM 480434, ×10 (Rigby & Maher, 1995).

Hyalostelia Zittel, 1878c, p. 185 [**Acanthospongia smithii* Young & Young, 1876, p. 38; OD]. Form of whole sponge unknown but probably thin walled and vasiform with a root tuft; hypodermalia stout pentactines or subhexactines in which distal ray is reduced to a short, but not strongly swollen knob, and in which paratangential rays are generally reflexed; small hexactines may lie distal to hypodermalia and parenchymal hexactines of varying size lie beneath; gastralia not known, all spicules smooth rayed and in nonparallel orientation; circular openings of about same diameter as length of hypodermal, paratangential rays outlined by skeletal net and may be either parietal gaps or inhalant or exhalant canals; compact groups of root-tuft spicules with quadrianchorate terminations attached to some specimens. [Isolated spicules like hypodermalia of *Stioderma* have been found in association with coherent, skeletal fragments of *Hyalostelia,* but not attached to them. Reid (1968b, p. 1,247) noted the occurrence of loose amphidiscs in a deposit (age not given) yielding juvenile *Hyalostelia* sp.] *?Ordovician, Devonian (Frasnian)–Carboniferous (Visean):* Australia (Northern Territory), *?Ordovician;* Poland, *Frasnian;* Scotland, *Visean.*——Fig. 214,*2a–c. *H. smithii* (Young & Young), Visean, Dalry, Ayrshire, Scotland; isolated spicules including, among others, sexiradiate spicules, ×12, anchoring or root tuft spicules, ×3, and polyactines with eight transverse rays, ×5 (Young & Young, 1877).

Irpaspongia Mehl & Mostler, 1993, p. 10 [**I. permica;* OD]. Known as yet only as isolated, hexactine-based spicules that attach to one another at ray tips by zygoses; middle parts of rays are spinose, but rays become more so on their broadened ends; spaces between spicules may be conspicuously rectangular. [*Irpaspongia* is the only known hexactinellid to create a skeletal structure by zygosis of ray tips, as in the lithistid demosponges.] *Permian (Artinskian):* USA (Texas).——Fig. 215,*1a–b. *I. permica,* Bone Spring Limestone, Guadalupe Mountains; isolated hexactines of holotype (syntype) suite, with spinose rays and articulating ray tips, GII ME/MO 730, ×40 (Mehl & Mostler, 1993).

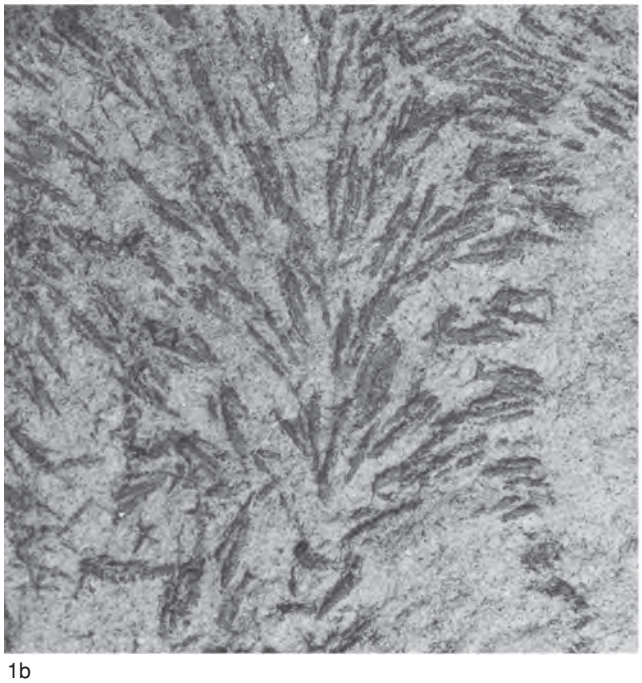
Itararella Kling & Reif, 1969, p. 1432 [**I. gracilis;* OD]. Sponge probably thin walled, vasiform, with root tuft; skeletal canals unknown; principal skeleton of simple, slender-rayed hexactines and pentactines, the latter at presumed dermal and gastral surfaces; no specialized hypodermalia or hypogastralia known; rhabdodiactines also present, some are smooth and others are clemate, occurring in bundles and bearing at one end an umbel with 9 to 12 teeth; amphidiscs with 7 to 8 (rarely 9) long, slender teeth occurring among spicules and showing bimodal size frequency, smaller including some with unequal-sized ends, larger including some with aborted teeth; spinose microhexactines also occur, as well as hexasters with quadrifurcate ray tips. *Carboniferous (Pennsylvanian):* Uruguay.——Fig. 216,*1a–c. *I. gracilis,* Itararé Formation, Rio Negro, Tacuarembó-Durazno; *a,* holotype thin section with anchorate diactines (*D*) in axial area, near bottom, and with amphidiscs (*A*) in central part, GPIT Po 1340/1, ×80; *b,* photomicrograph of amphidiscs at (*A*); *c,* anchorate ends of diactines in axial cluster, ×200 (Kling & Reif, 1969).

Protohyalostella Chapman, 1940, p. 103 [**P. mawsoni;* OD] [=*Protohyalostelia* Chapman, 1940, p. 104, *nom. null.*]. Cup- to vase-shaped sponges with double walls, separated approximately 2 mm, and each 3 to 4 mm thick, around a broad and deep spongocoel; spicules largely curved, fusiform microscleres, with scattered, large hexactines. [Pickett (1983, p. 98) noted that the type locality is probably in the Parara Limestone at Ten Mile

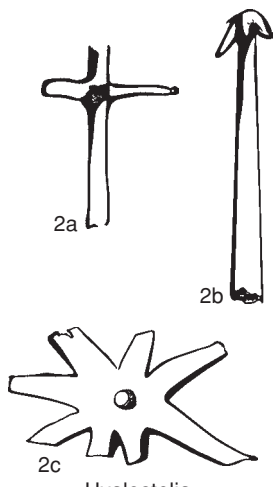


1a

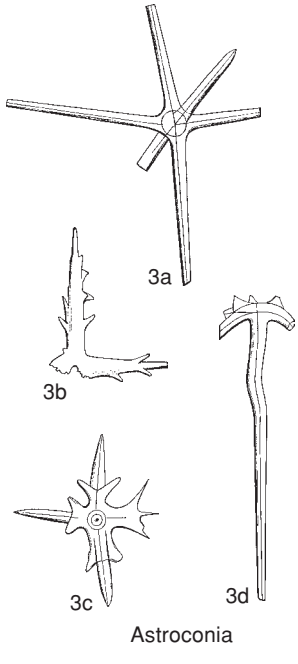
Divaricospongia



1b



Hyalostelia



Astroconia

FIG. 214. Stiodermatidae (p. 338–340).

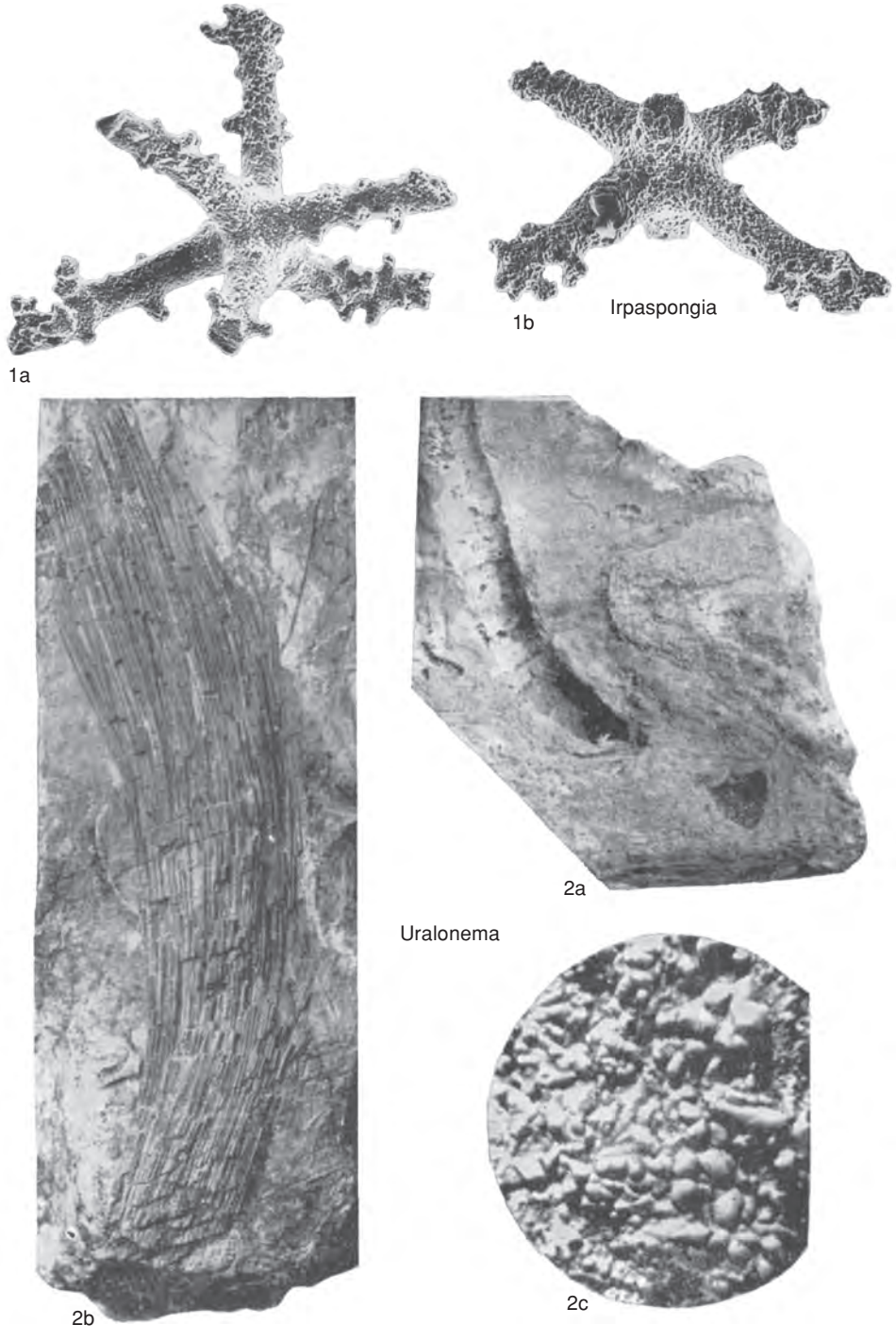


FIG. 215. Stiodermatidae (p. 340–344).

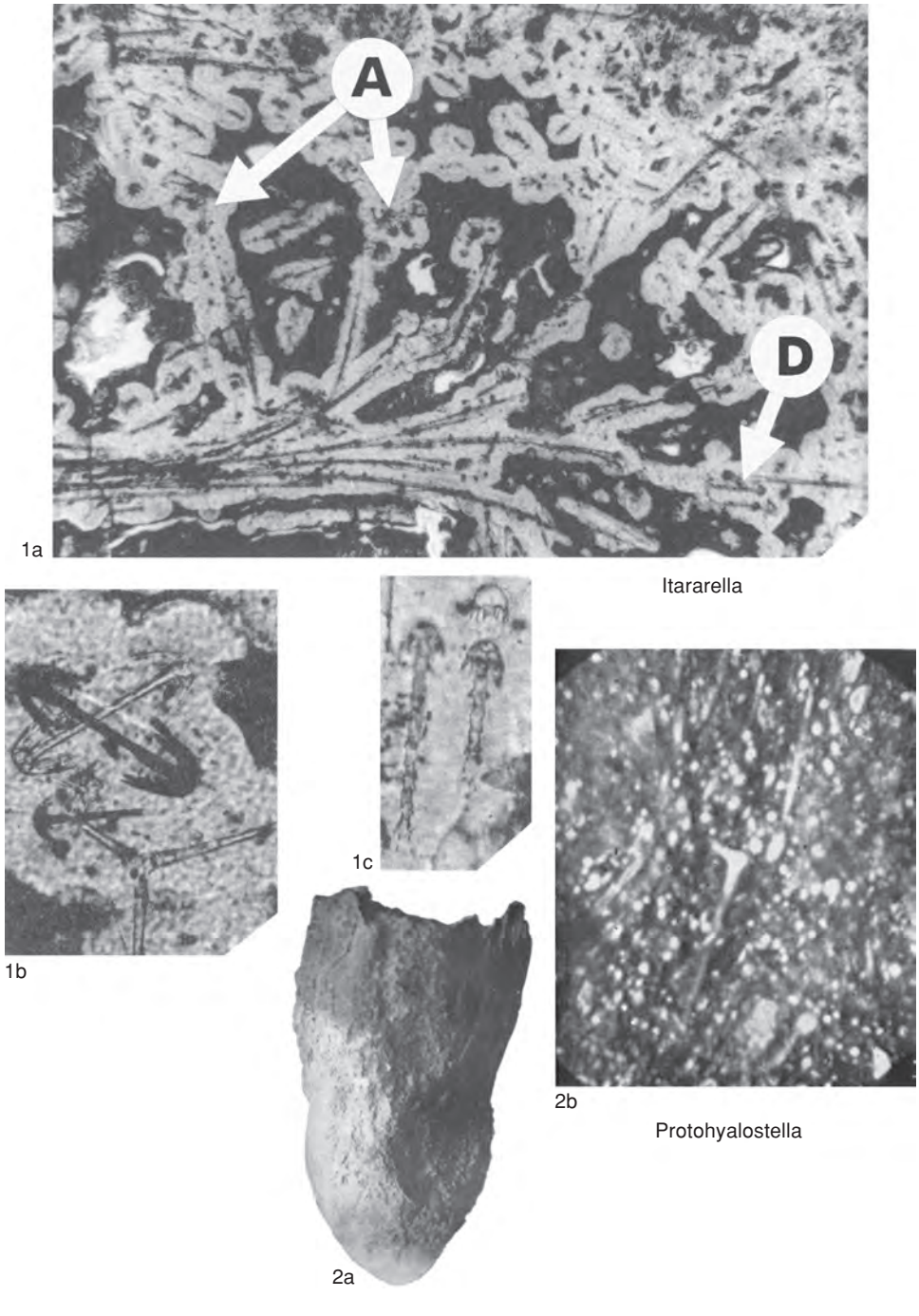


FIG. 216. Stiodermatidae (p. 340–344).

Creek in the Flinders Range. The type material has been lost, perhaps destroyed in a 1953 fire at the Bureau of Mineral Resources. Skeletal details and position in the family remain uncertain.] *Lower Cambrian:* Australia.——FIG. 216,*2a–b. *P. mawsoni,* Flinders Range, South Australia; *a,* side view of vase-shaped holotype with section through double-layered wall on right, ×0.5; *b,* section near base of reference sponge showing part of coarse hexactine and sections through rays of associated spicules, ×25 (Chapman, 1940).

Rhakistella WELLER, 1930, p. 243 [**R. alba;* OD]. Isolated hexactines with spinose and sometimes bifurcate rays, associated with isolated, spheroidally swollen hexactines like hypodermalia of *Stioderma* (*Hyalostelia diabola* WELLER, 1930) and with isolated, quadrianchorate, probable basalia. [Inasmuch as these spinose hexactines resemble some of the parenchymalia of *Stioderma coscinum,* it is possible that *Rhakistella alba* and *Hyalostelia diabola* pertain to a single sponge belonging to *Stioderma.*] *Carboniferous (Pennsylvanian):* USA (Illinois, Indiana).——FIG. 213,*3a–b. *R. alba* WELLER, Spoon Formation, lower Pennsylvanian, Rock Island County, Illinois; *a,* isolated hexactine with spinose rays, cotype; *b,* isolated hexactine with some bifurcated rays, cotype, ×15 (Weller, 1930).

Rigbyella MOSTLER & MOSLEH-YAZDI, 1976, p. 19 [**R. ruttneri* MOSTLER & MOSLEH-YAZDI, 1976, p. 20; OD]. Isolated hexactines and pentactines with greatly swollen, long, possibly distal rays, with possible proximal and lateral rays commonly of unequal length and development that also may be greatly swollen; minor, short, supernumerary rays also may occur and may bifurcate or terminate as spines. [Spicules on which the type species and genus are based occur in the Mila Formation of Iran. Others that may be included in the genus were earlier reported from the Wilberns Formation of Texas (RIGBY, 1975).] *Middle Cambrian–Upper Cambrian:* Iran, USA (Texas).——FIG. 217,*1a–h. *R ruttneri; a,* holotype, swollen spicule, Mila Formation, Middle Cambrian, Elburz Mountains, Iran, ×100; *b–c,* additional swollen spicules of different shapes, Mila Formation, Middle Cambrian, Elburz Mountains, Iran, ×100 (Mostler & Mosleh-Yazdi, 1976); *d–g,* drawings of isolated spicules showing various degrees of enlargement of distal rays and development of tangential rays, Wilberns Formation, Upper Cambrian, Llano Uplift, Texas, ×20; *h,* reconstruction of possible spicule association in dermal pavement, Wilberns Formation, Upper Cambrian, Llano Uplift, Texas, ×20 (Rigby, 1975).

Thoracospongia MEHL, 1996, p. 34 [**T. follispiculata;* OD]. Hexactinellid sponges known only from isolated, follipinule spicules that have greatly swollen and longitudinally ribbed, distal rays, which probably formed an armored-appearing, outer layer, with more normal-appearing transverse rays tangential to dermal surface. [The genus is placed in the family with some question because of the similarity of the spicules to those in *Stioderma.*] *Middle Cambrian:* Australia (Queensland).——FIG. 217,*2a–c. **T. follispiculata,* Georgina Basin; *a,* holotype, isolated follipinule spicule, CPC 33671; *b,* spicule from paratype suite showing hexactine base, CPC 33674; *c,* reconstruction of skeleton of genotype showing possible relationships of various kinds of spicules, scale bar, 200 μm (Mehl, 1996).

Uralonema LIBROVICH, 1929, p. 13 [**U. karpinskii;* OD]. Thin-walled, vasiform with root tuft; hypodermalia hexactines with spheroidally swollen, distal ray and generally swollen remaining rays (sometimes including proximal); paratangential rays may be curved but apparently not reflexed; hypogastralia similar but less strongly swollen; parenchymalia simple, smooth hexactines of varying size down to microscopic, associated with short, smooth, sometimes slightly curved rhabdodiactines; all spicules in nonparallel orientations; numerous eight-toothed amphidiscs found among parenchymalia; microscopic hexactine spicules, described as pinuli in which distal ray is spheroidally swollen and apparently spinose, associated with dermal and gastral layers; isolated fragments of stout, root tuft associated with, but not found attached to, body fragments; isolated fragments of clemes and of rodlike spicules with quadrianchorate terminations also found; no parietal gaps or skeletal canals known from body fragments. *Carboniferous (Mississippian, ?Bashkirian):* Russia (Ural Mountains, western Qian Shan).——FIG. 215,*2a–c. *U. karpinskii,* Mississippian, Resh River, Ural Mountains, Russia; *a,* side view of flattened sponge; *b,* root tuft, ×1, *c,* part of dermal skeleton, ×8 (Rezvoi, Zhuravleva, & Koltun, 1962; courtesy of Russian Academy of Science).

Order RETICULOSA Reid, 1958

[Reticulosa REID, 1958a, p. xlv]

Amphidiscophora in which a dermal skeleton of parallel stauractines, pentactines, or hexactines form a major part of sponge skeleton, and in which microscleres include paraclavules. [The oldest specimens well preserved enough to be referred to a genus date from the Middle Cambrian, but isolated stauractines are known from Lower Cambrian sediments.] *Ediacaran–Holocene.*

Superfamily PROTOSPONGIOIDEA Hinde, 1887

[*nom. transl.* FINKS, 1960, p. 101, *ex* Protospongiidae HINDE, 1887b, p. 90]

Thin-walled Reticulosa in which a dermal layer, together with prostalia, forms entire skeleton. *Lower Cambrian–Jurassic.*

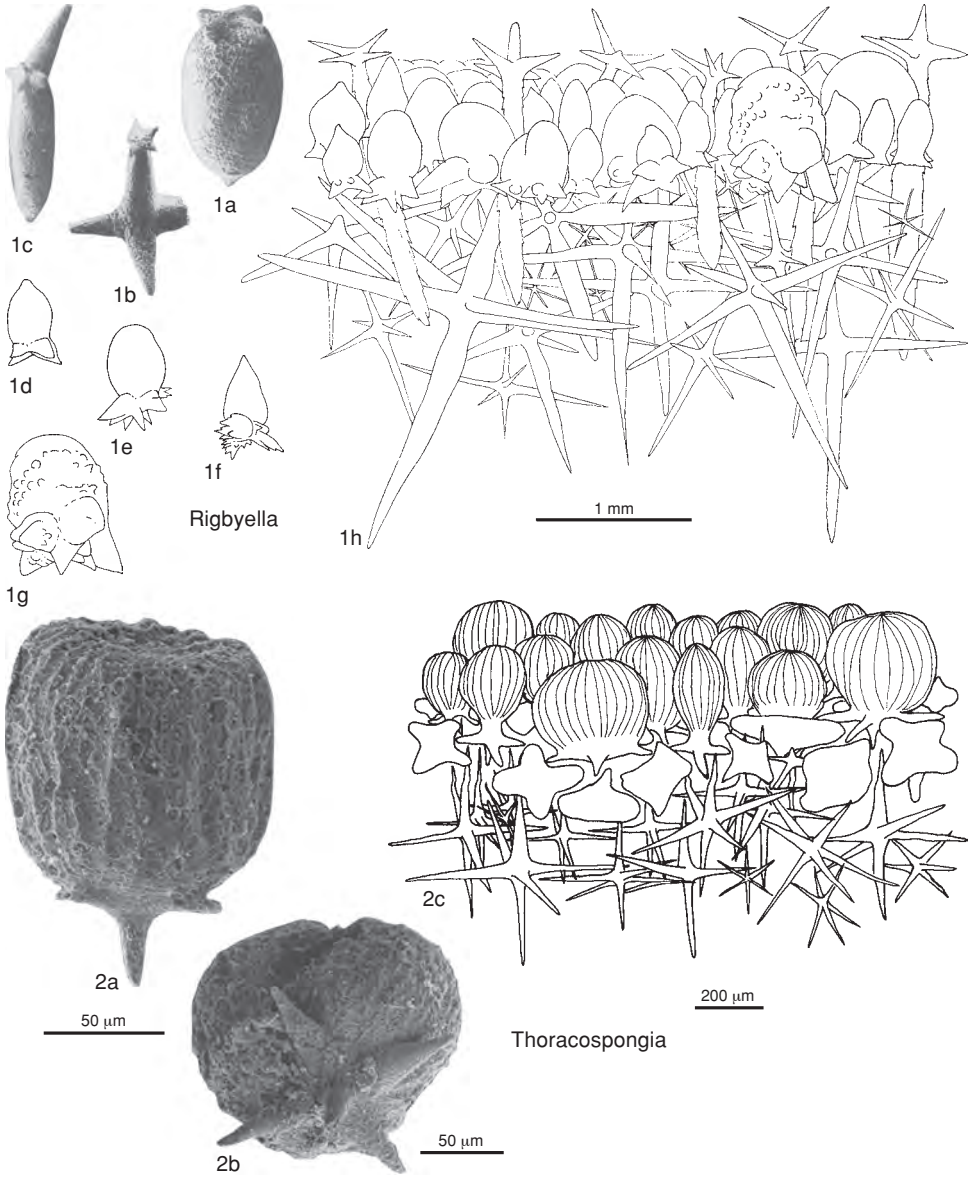


FIG. 217. Stiodermatidae (p. 344).

Family PROTOSPONGIIDAE Hinde, 1887

[Protospongiidae HINDE, 1887b, p. 90]

Vasiform or spheroidal; skeletal net essentially a single layer or thin, multiple layers of stauractines or pentactines, together with possible rhabdodiactines in some species; spicules typically in parallel arrangement, largest usually in quincuncial arrangement (but sometimes in overlapping, quadrate arrangement), smaller spicules in several orders of size subdividing quadrules thus formed into nonoverlapping, quadrate arrangement; spicules may be irregularly arranged in some genera, however; parietal gaps may be

present; prostalia (possible rhabdodiactines) may be strongly developed about osculum and may project from entire surface; basalia often developed. *Lower Cambrian–Jurassic.*

Protospongia Salter, 1864, p. 238 [**P. fenestrata;* M] [=*?Testiispongia* Rigby, 1983a, p. 262 (type, *T. venula,* OD)]. Large, ovoid or vasiform sponge with osculum; thin body wall composed of stauractines arranged parallel to principal dimensions of sponge with rays gently reflexed; largest stauractines in quincuncial arrangement overlapping slightly to form primary quadrules that are subdivided into as many as six or more orders of quadrules by smaller stauractines, each about half as large as preceding order, each smaller spicule lying beneath next larger; layer of nonparallel, small rhabdodiactines may underlie all the rest; rhabdodiactine prostalia may be present over entire body and may form a coronal fringe about osculum; small number of elongate, possible rhabdodiactines may form root tuft. *Lower Cambrian–Devonian (Givetian):* China (Anhui), *Lower Cambrian;* Wales, Ireland, Russia, USA (Utah, Idaho), Canada (British Columbia, Quebec), *Middle Cambrian;* Argentina, Australia, *Lower Ordovician;* Australia (Victoria), *Middle Ordovician;* Canada (British Columbia), *lower Silurian–middle Silurian;* Portugal, USA (?Nevada), *upper Silurian;* USA (Nevada), *Givetian.*——Fig. 218,*1a–c. *P. fenestrata,* Menevian strata, Middle Cambrian, St. David's, southern Wales, England; *a,* holotype fragment with spicule impressions, ×1; *b,* enlargement of spicules of type, BMNH, ×4 (Salter, 1864); *c,* drawing of holotype, ×5 (Hinde, 1884a).

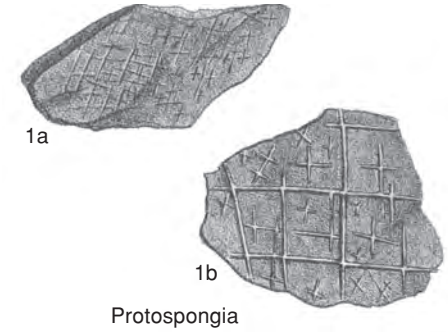
Acanthodictya Hinde in Dawson & Hinde, 1889, p. 47 [**A. hispida* Hinde in Dawson & Hinde, 1889, p. 48; M]. Cylindrical, small sponges; stauractines and possibly rhabdodiactines grouped into bundles parallel to longitudinal axis of sponge; bundles connected by single, horizontal spicules or spicule rays to form quadrules; entire lateral surface, as well as oscular rim, covered with densely bristling prostalia that may be greatly elongate, unpaired rays of pentactines; longitudinal strands prolonged to form root tuft. *Middle Cambrian:* Canada (Quebec).——Fig. 219,*3a–c. *A. hispida,* Metis Shale, Little Metis; *a,* holotype, flattened fragment of subcylindrical sponge with vertical and horizontal strands and with pronounced marginalia and prostalia; *b,* restoration of complete sponge based on several fragments, ×1; *c,* drawing of skeletal relationships of main body skeleton and projecting marginalia, ×5 (Dawson & Hinde, 1889).

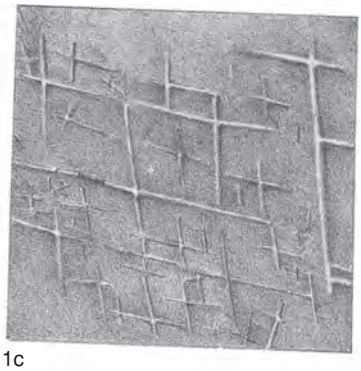
Actinodictya Hall, 1890b, p. 59 [**A. placenta* Hall, 1890b, p. 60; M]. Large, flattened, ovoid sponges with no indication of osculum or root tuft; surface crossed in all directions by interlaced, spicular bands with distinct irregularity but with some indication of rectangular reticulation; large, irregularly arranged stauractines, some more than half diameter of sponge, together with smaller intervening ones forming apparently single-layered, skeletal net. *Devonian (Givetian–Frasnian):* USA (Nevada), *Givetian;* USA (New York), *Frasnian.*——Fig. 220,*1. *A. placenta,* Chemung Group, Senecan, Cohocton, New York; holotype, two essentially complete sponges with rounded outlines showing differences in sizes of spicule elements and their orientations, UCC 13158A, ×0.5 (Hall & Clarke, 1899).

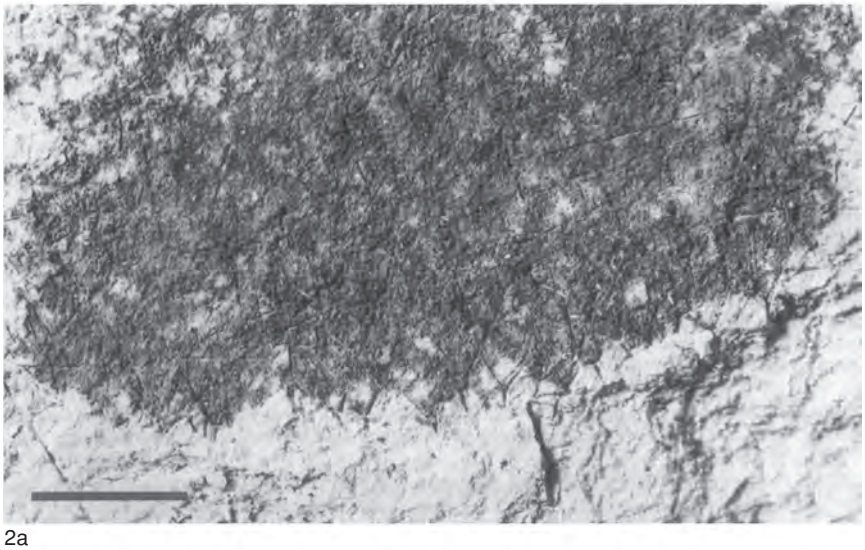
Ammonella Walther, 1904, p. 162 [**A. quadrata;* OD]. Thin-walled, cup- to bowl-shaped sponge without recognizable canal system in regular, quadratic, protospongiid, skeletal meshwork of stauractines of at least four orders, which may have thickened, small nodes at ray junctions; principal quadrate openings approximately 0.5 mm across, but may be larger where some needles are destroyed; curved, spicule fibers defining general shape of expanding sponge; root plate rather than root tuft locally preserved. [*Ammonella* has the skeletal structure of a protosponiid, but there is a major break in the record of the protosponges from the lower Paleozoic until the Jurassic. Keupp and Mehl (1994, 1995) concluded that the Jurassic form may be a result of convergent evolution rather than preservation of a Lazarus taxon. Consequently, the genus is included in the family with some question.] *Jurassic:* Germany, Italy.——Fig. 221,*2. *A. quadrata,* Solnhofen Plattenkalk, Pfalzpaint, Bavaria; flattened, thin-walled, bowl-shaped sponge with curved, upwardly divergent, spicule fibers in uniform, quadrate skeleton, ×1 (Keupp & Mehl, 1994).

Asthenospongia Rigby, King, & Gunther, 1981, p. 843 [**A. acantha* Rigby, King, & Gunther, 1981, p. 844; OD]. Thin-walled, open conical to conicocylindrical protosponge in which stauractines and hexactines of skeleton moderately to regularly oriented; right-angled rays of hexactine-based spicules mainly vertical and horizontal, although locally irregularly diagonal; crudely ordered spicules of at least four, and possibly six, orders subdividing net into rough quadrules; most distinctive spicules are large hexactines with rays commonly bent to produce variably oriented spicules and oriented with four rays tangential and one ray distal, producing long marginalia; large spicules placed two or three first-order quadrules apart, but in predictable diamond pattern; oscular and basal margins unknown; root tuft uncertain. *Lower Ordovician:* USA (Idaho).——Fig. 220,*2. *A. acantha,* Phi Kappa Formation, Trail Canyon, Rock Roll Canyon quadrangle; holotype with large hexactines near lower margin with rays extending beyond principal net, and with four orders of ranked hexactines somewhat irregularly and diagonally oriented in upper part, BYU 1711, ×4 (Rigby, King, & Gunther, 1981).

Diagoniella Rauff, 1894, p. 248 [**Protospongia coronata* Dawson & Hinde, 1889, p. 41; SD







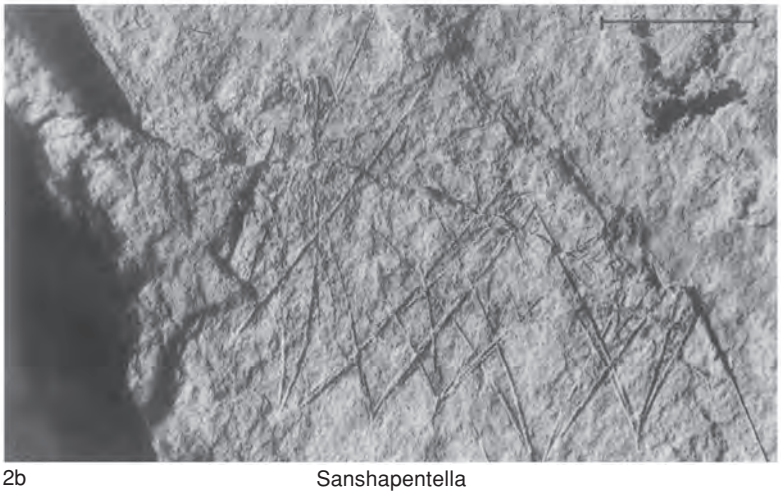
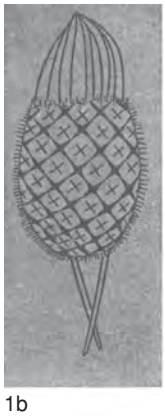
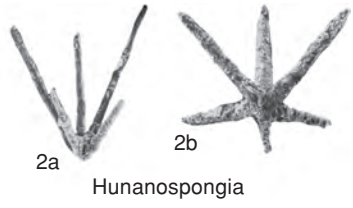


FIG. 218. Protospongiidae (p. 346–356).

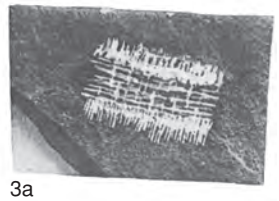


1b

1a Diagoniella

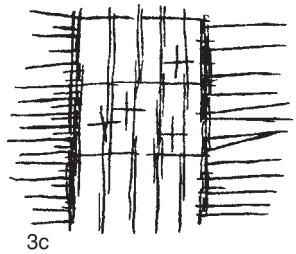


2a 2b Hunanospongia

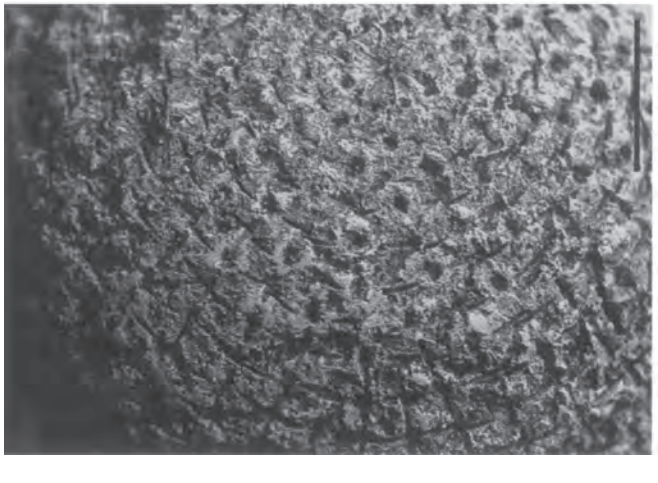


3a Acanthodictya

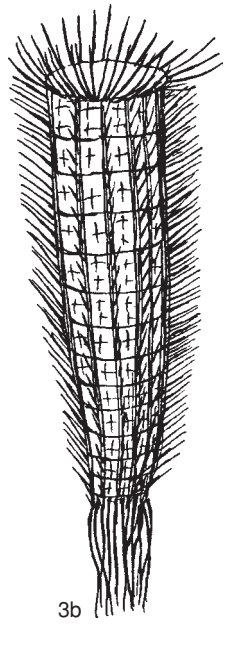
4a Iberospongia



3c

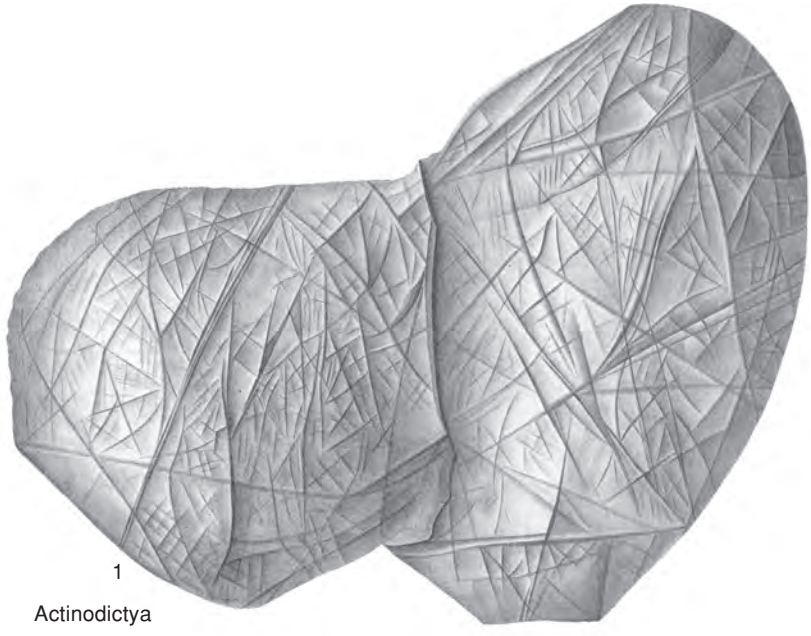


4b

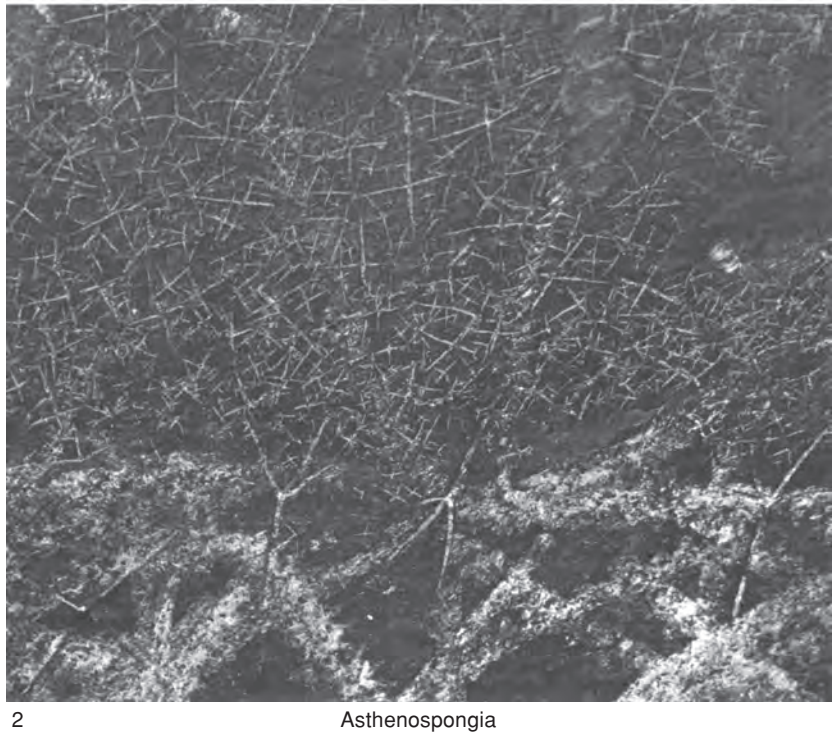


3b

Fig. 219. Protospongiidae (p. 346–351).



1
Actinodictya



2 Asthenospongia

FIG. 220. Protospongiidae (p. 346).

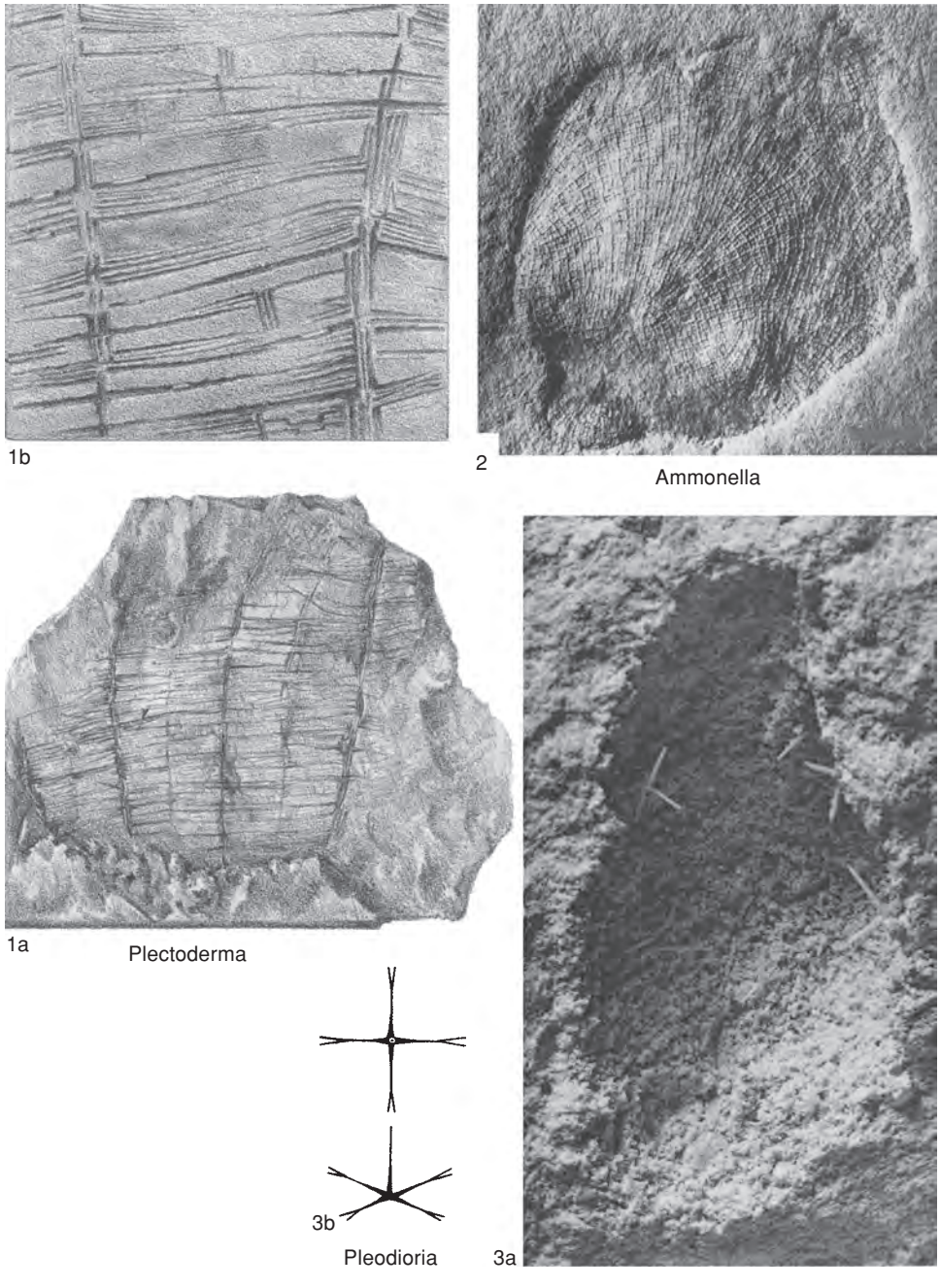


FIG. 221. Protospongiidae (p. 346–355).

WALCOTT, 1920, p. 310]. Ovoid or vasiform with broad osculum with or without strong prostalia (seemingly rhabdodiactines); principal spicules stauractines in parallel arrangement but diagonal to longitudinal axis of sponge; stauractines may be to five orders of size and may form smaller orders of quadrules in inner layer or layers; larger quadrately arranged in quincuncial arrangement; entire surface may be covered with short, rhabdodiactine prostalia perpendicular to surface; a few, long, stout basalia

present. *Lower Cambrian–Silurian (lower Llandovery–Wenlock):* China (Anhui), Canada (Quebec, British Columbia), USA (Utah, Nevada), Portugal.——Fig. 219,*1a–b. *D. coronata* (Dawson & Hinde), Metis Shale, Arenig, Little Metis Bay, Quebec, Canada; *a,* flattened holotype with white ink over spicules, including long prostalia and root tuft, PRM xx, ×1 (Dawson & Hinde, 1889); *b,* drawing from holotype showing skeletal relationships and diagonal, principal skeleton, ×1 (Rauff, 1893).

Gabelia Rigby & Murphy, 1983, p. 798 [**G. pedunculus* Rigby & Murphy, 1983, p. 799; OD]. Goblet-shaped, thin-walled, moderately large protosponge, with cylindrical, stemlike, lower stalk and egg-shaped, upper part; stem with hemispherical base; thin, upper, skeletal net of regularly oriented hexactines with essentially equidimensional rays, arranged in crude quadrules and up to five orders of decreasing spicule size; those in lower stalk with vertical rays markedly elongate in comparison to short, lateral rays; oscular margin unknown; walls unsculptured except for prostalia-like, distal rays of hexactines in net; spicules unbundled. *?Lower Cambrian, upper Silurian–Upper Devonian:* China (Anhui), *?Lower Cambrian;* USA (Nevada), *Upper Devonian;* Canada (British Columbia), *lower Silurian–middle Silurian;* USA (Nevada), ?Portugal, *upper Silurian.*——Fig. 222*a–c. *G. pedunculus,* unnamed Devonian shale, Upper Devonian, Roberts Mountains, Nevada; *a,* flattened holotype showing ovate upper part and cylindrical lower stem, all with skeleton of ranked hexactines, USNM 340059, ×1; *b,* generalized restoration, approximately natural size; *c,* photomicrograph of rounded base of stem with several orders of hexactines that have short, lateral rays and elongate, vertical ones, USNM 340059, ×10 (Rigby & Murphy, 1983).

Hexatractiella Mehl, 1996, p. 35 [**Diagoniella tubulara* Rigby & Harris, 1979, p. 970; OD]. Sponge body branched to subcylindrical, thin walled with deep, open spongocoel above rounded base without root tuft; prominent, uniformly separated, longitudinal bands of skeleton of greatly elongated, vertical tips of diagonally oriented hexactines; uniform skeleton between bands composed of four orders of diagonally oriented hexactines in ranked quadrules. *lower Silurian–upper Silurian:* Canada (British Columbia).——Fig. 223*a–b. *H. tubulara* (Rigby & Harris), unnamed Silurian siltstone, Llandovery–Wenlock, near Ware; *a,* side view of flattened holotype with two tubular branches on right and one on left, all with skeleton of diagonal stauractines and hexactines, ×1.5; *b,* photomicrograph showing diagonally oriented, larger stauractines and smaller hexactines in two flattened branches, GSC 60633, ×10 (Rigby & Harris, 1979).——Fig. 223*c. H. nevadensis* (Rigby & Stuart), Roberts Mountains Formation, upper Silurian, Independence Mountains, Nevada; restoration showing extended rays of diagonal hexactines that produce vertical, skeletal bands between bands of diagonal, smaller spicules, ×1 (Mehl, 1996).

Hunanospongia Qian & Ding in Ding & Qian, 1988, p. 47 [**H. delicata;* OD]. Shape of sponge body unknown but with small, hexactine-based pentactine to hexactine spicules with sharply to weakly reflexed rays; spicules occurring isolated or joined to form connected framework. [Somewhat similar spicules have been described from the Lower Cambrian of northern Hunan by Mehl and Erdtmann (1994) as *Sanshapentella,* but the spicules described by them are much larger, and most are without the vertical rays that are well developed in *Hunanospongia.*] *Lower Cambrian:* China.——Fig. 219,*2a–b. *H. delicata,* Yangjiaping Formation, Shimen County, Hunan; *a,* holotype hexactine with gently reflexed, lateral rays; *b,* pentactine with sharply reflexed rays, ×50 (Ding & Qian, 1988).

Iberospongia García-Bellido Capdevila & Rigby, 2004, p. 447 [**I. globulara;* OD]. Globular to subspherical, thin-walled sponge with single-layered, lyssacid skeleton of quadrately arranged hexactines that increase in size upwardly from invaginated base to maximum diameter of sponge at approximately midheight; first-order spicules with unfused, overlapping rays; second-order spicules present above midheight; upper part of skeleton converging toward oscular margin; coarse, basal root tuft present. *Lower Devonian (Emsian):* Spain.——Fig. 219,*4a–b. *I. globulara,* Abadia Formation, Cortés Member, upper Zlichovian, Polentinos, Palencia, northern Spain; *a,* holotype, oblique view of base and side showing general ovoid shape of sponge and hexactine-defined skeletal quadrules of skeleton, POL1-1, ×2; *b,* detail of basal region of holotype showing molds left by dissolved, regular, proximal and tangential rays of hexactines, ×4 (García-Bellido Capdevila & Rigby, 2004).

Kiwetinokia Walcott, 1920, p. 311 [**K. utahensis* Walcott, 1920, p. 313; OD]. The type species consists of scattered stauractines, tauactines, and two possible rhabdodiactines twisted together spirally. [*K. spiralis* Walcott and *K. metissica* (Dawson, 1889) consist of similar spicules with cablelike rods apparently of a half-dozen or so rhabdodiactines twisted together. Hinde (1893a) considered the cablelike spicules called *Hyalostelia metissica* by Dawson (1889) to be possibly the root tufts of co-occurring *Palaeosaccus,* an opinion subsequently concurred with by Dawson (1896, p. 108). *Kiwetinokia* could be considered a junior subjective synonym of *Palaeosaccus.*] *Middle Cambrian:* USA (Utah), Canada (Quebec), Argentina.——Fig. 224,*1a–b. *K. utahensis,* Marjum Limestone, House Range, Utah; *a,* photomicrograph of strew of stauractines in lectotype; *b,* rod formed of twisted diactine in lectotype fragment, USNM 66542, ×2 (Walcott, 1920).

Megastylia Ruedemann, 1934, p. 71 [**M. caliciformis;* OD]. Vase-shaped, small sponges with straight, upper margin of wide osculum and principal spicules larger than in *Protospongia,* but in a similar

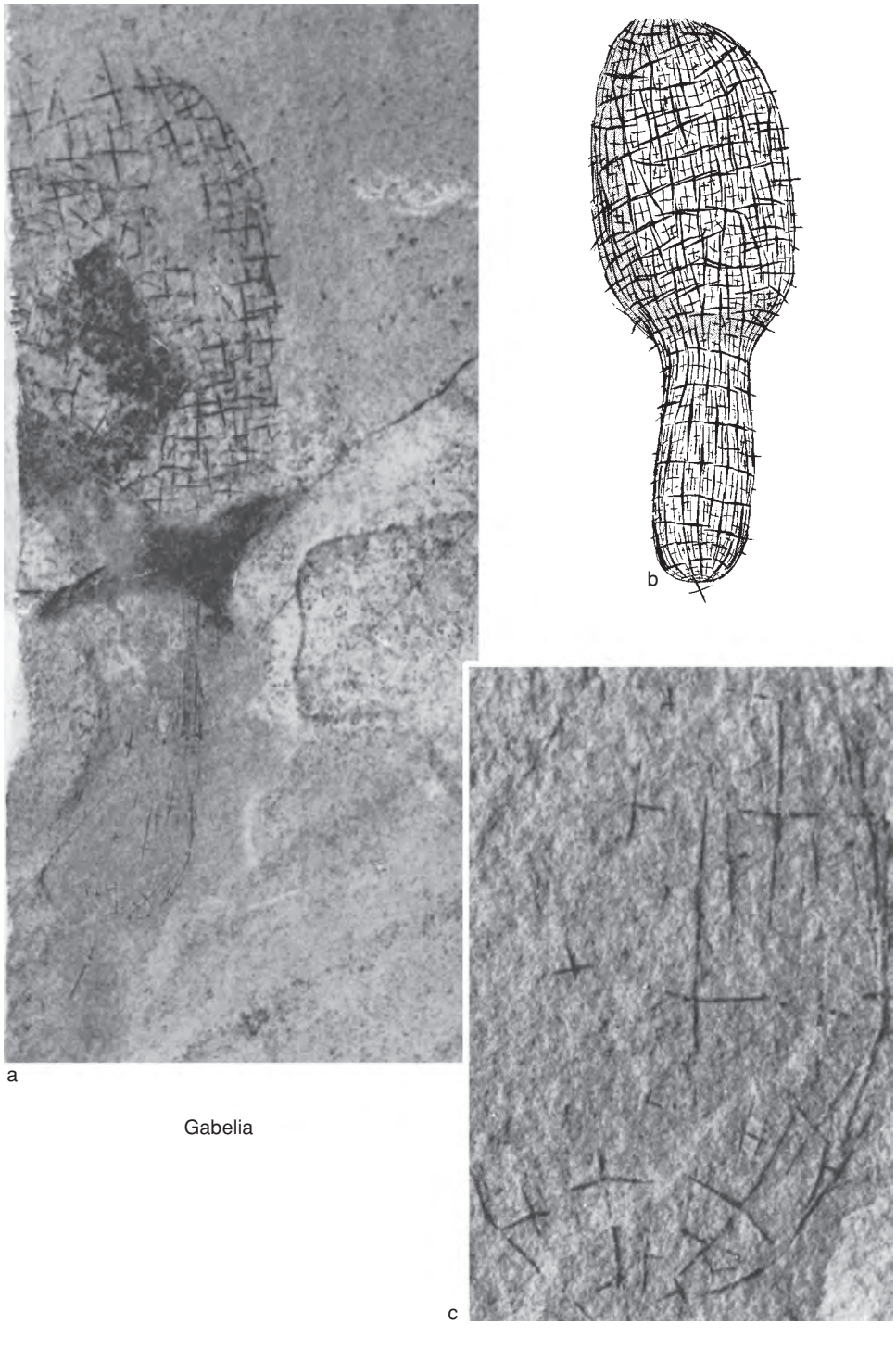


FIG. 222. Protospongiidae (p. 351).

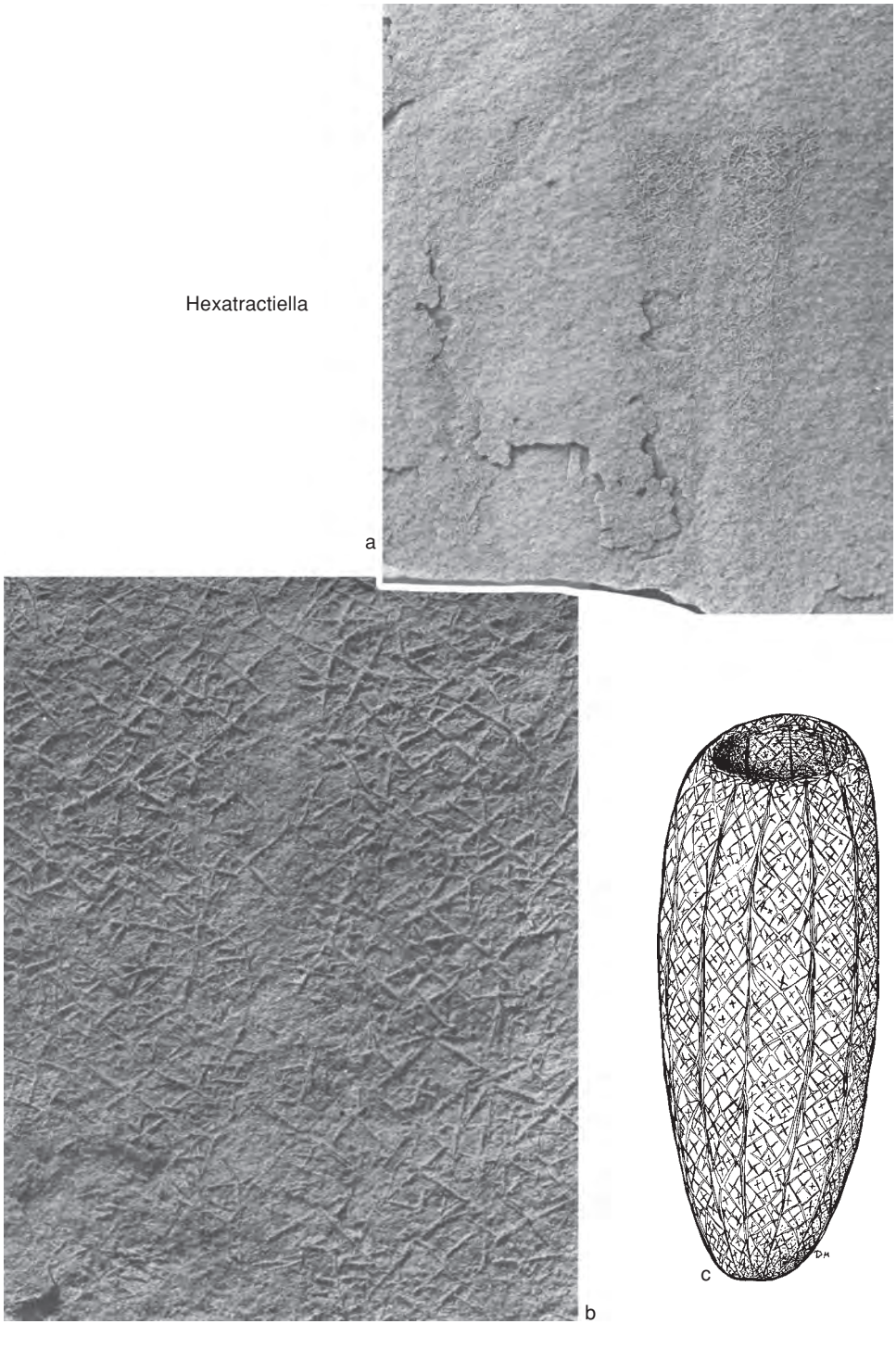


FIG. 223. Protospongiidae (p. 351).

1b

Kiwetinokia

1a

2c

3

Megastylia

2a

Testiispongia

2b

FIG. 224. Protospongiidae (p. 351–357).

quadrate mesh. *Lower Ordovician:* USA (New York).——Fig. 224,*3. *M. caliciformis,* Schaghticoke Shale, Schaghticoke; irregularly preserved, hexactine-based spicules of holotype with some in reticulate arrangement in upper part, NYSM, ×1 (Ruedemann, 1934).

Palaeosaccus Hinde, 1893a, p. 57 [**P. dawsoni;* M]. Large, presumably vasiform sponges with large quadrules (14–20 mm wide) outlined by bundles of rhabdodiactines supplemented by large stauractines, or pentactines at bundle crossings; quadrule interiors with thin layer of small rhabdodiactines, stauractines, and possibly pentactines; stout spicules having form of ropes of spirally twisted, tuberculate filaments associated with this sponge but not connected to it. [Stout spicules were interpreted as basalia of *Palaeosaccus* in the original description, having been earlier assigned to *Hyalostelia metissica* Dawson & Hinde, 1889. Similar spicules were included in *Kiwetinokia* Walcott, 1920, which embraced *H. metissica* among other species.] *Middle Cambrian:* Canada (Quebec).——Fig. 225,*2. **P. dawsoni,* Metis Shale, ?Canadian, Little Metis Bay; holotype with coarse, reticulate net of spicule bundles, including stauractines, ×0.33 (Hinde, 1893a).

Plectoderma Hinde, 1884a, p. 132 [**P. scitulum;* M]. Form unknown but moderately large and probably vasiform; nearly monolayered, spicular net of stauractines or pentactines of at least 3 orders in parallel arrangement; largest spicules may be superposed in groups of two or more at one spot so that primary quadrules are bordered by bundles of parallel, spicule rays; largest spicules may be in overlapping quadrate, rather than quincuncial, arrangement; at least two orders of smaller quadrules may occur in primary quadrules. [Although the original description cites lack of parallelism of smaller spicules as a generic character, examination of topotype material, as well as original illustrations, shows that at least two size orders of smaller, parallel spicules form second- and third-order quadrules.] *Silurian (Ludlow):* Scotland.——Fig. 221,*1a–b. **P. scitulum,* Silurian strata, Edinburgh; *a,* holotype with reticulate, quadruled skeleton of stauractines or possible pentactines, ×1; *b,* part of holotype showing some stauractine spicules in tract junctions, GSS, ×5 (Hinde, 1884a).

Pleodioria Öpik, 1961, p. 50 [**P. tomacis;* M]. Small, conical to vasiform; largest spicules stauractines with reflexed rays, smaller spicules pentactines; paratangential rays of some of both types are terminally bifid. *Middle Cambrian:* Australia (Queensland).——Fig. 221,*3a–b. **P. tomacis,* Roaring Siltstone, Selwyn Range; *a,* holotype, largely a mold but with a few siliceous spicules, CPC 3646, ×3; *b,* drawings of pentactines with bifid, ray tips that occur with normal pentactines and stauractines in holotype, ×10 (Öpik, 1961).

Quadrolaminiella Chen, Hou, & Li, 1990, p. 404 [411] [**Q. diagonalis;* OD]. Large, cylindrical to steeply obconical sponges with skeleton of quadrately arranged, hexactine-based spicules and possibly associated monaxons parallel to spicule rays; space between rays filled with finer spicules that appear as oxeas. [The genus was initially interpreted and described as a demosponge with a four-layered wall. It is interpreted here as a laterally flattened protosponge in which elements of both the lower and upper walls, as flattened and perhaps rotated somewhat, have left impressions of the hexactine-based spicules and possible associated monaxial spicules. Impressions of both walls are possible because there was no infilling of the broad spongocoel before the sponges were flattened. The genus is difficult to distinguish from *Protospongia* or *Diagoniella.*] *Lower Cambrian:* China (Yunnan).——Fig. 226*a–b. **Q. diagonalis,* Chiungchussu Formation, Chengjiang; *a,* flattened, quadrate skeleton of steeply obconical holotype, ×0.88; *b,* enlarged section of holotype showing two quadrate, skeletal layers rotated with reference to one another, probably as flattened, upper and lower walls of thin-walled sponge, NIGPAS 108497, ×8 (Chen, Hou, & Li, 1990).

Saetaspongia Mehl & Reitner in Steiner & others, 1993, p. 310 [**S. densa;* OD]. Moderately small, circular sponges with skeleton a dense accumulation of fine diactines (possible oxeas) arranged in semiparallel, almost plumose-appearing bundles; spicules line but do not protrude from well-defined sponge body; skeleton may include small hexactines in layer beneath bundled spicules. *Lower Cambrian:* China (Hunan, Yunnan).——Fig. 227*a–c. **S. densa; a,* flattened, circular holotype, cluster of diactines dominantly, Niutitang Formation, Yangtze Platform, Hunan, IPFUB San 102-L, ×2 (Steiner & others, 1993); *b,* small, figured specimen, flattened impression, Yu'anshan Member of Qiongzhusi Formation, Maotianshan, Yunnan, ×4; *c,* photomicrograph clusters or tufts of long-rayed spicules in upper and lower right, with hexactine in right center, Yu'anshan Member of Qiongzhusi Formation, Atdabanian, Maotianshan, Yunnan, NIGPAS 115321, ×12 (Rigby & Hou, 1995).

Sanshapentella Mehl & Erdtmann, 1994, p. 316 [**S. dapingi;* OD]. Hexactinellid sponges in which fan-shaped, quadripod-like, dermal pentactines prominent along periphery of sponge; closely spaced spicules with long, slightly curved, paratangential rays in pairs and bent to point in same overall direction into interior of body, but with fifth ray protruding outwardly. [*Sanshapentella* is similar to *Hunanospongia* Ding & Qian, 1988, but spicules of the latter have a central, proximal ray, which is not present in spicules of *Sanshapentella.* It is also similar to *Asthenospongia* Rigby, King, & Gunther, 1981, but in the latter, four of the large rays are tangential to the dermal surface in the well-organized protosponge, and the fifth projects distally.] *Lower Cambrian:* China (Hunan, Anhui).——Fig. 218,*2a–b. **S. dapingi,* Niutitang Formation, Tommotian, Sansha, Hunan; *a,* flattened holotype with prominent, dermal pentactines and interior of

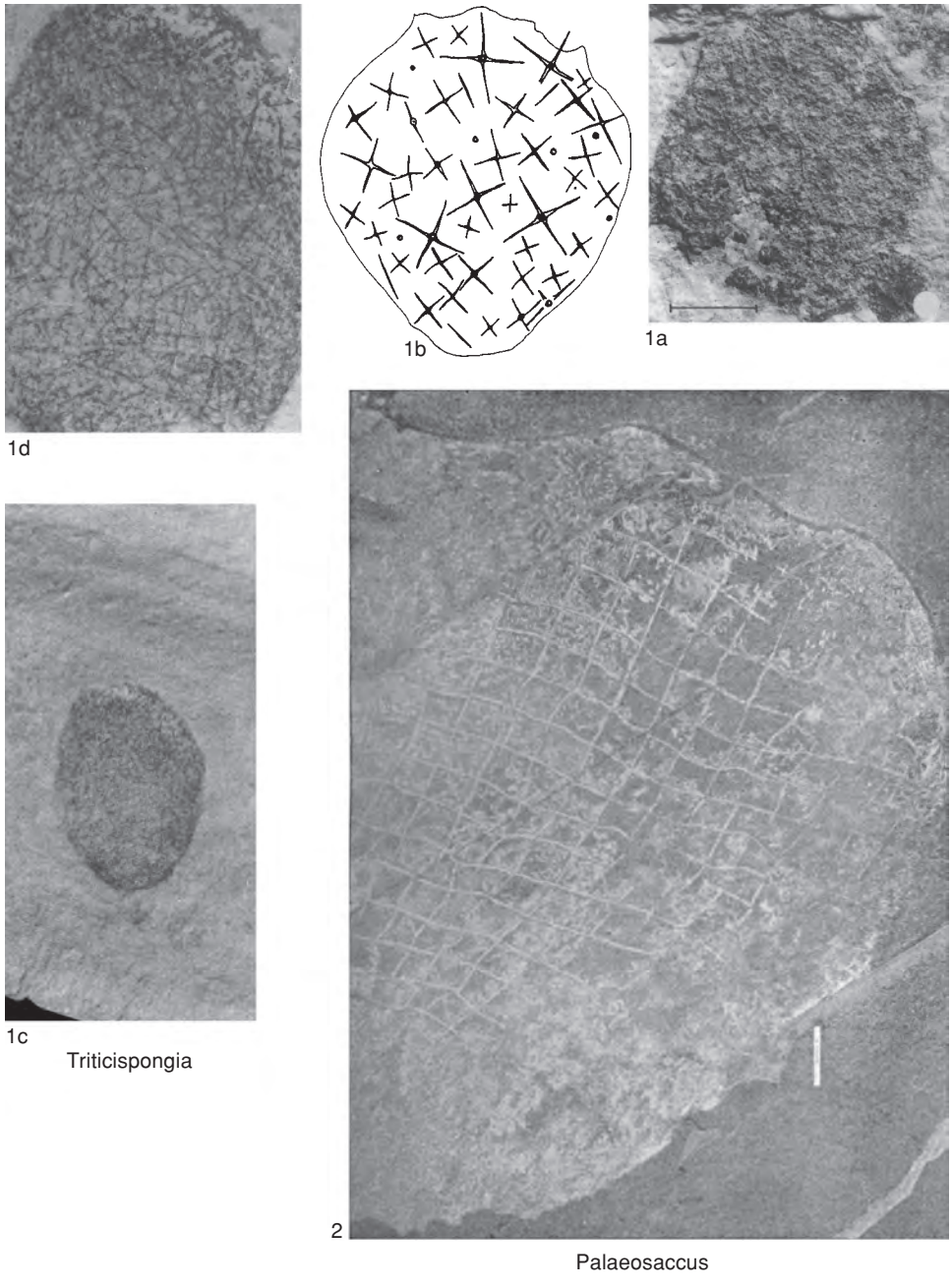


FIG. 225. Protospongiidae (p. 355–359).

hexactine-based spicules arranged in quadrules, IPFUB San 148b, ×4 (Mehl & Erdtmann, 1994); *b,* photomicrograph of paratype with prominently oriented, spicule cluster that represents dermal layer, IPFUB San 118-z, ×4 (Steiner & others, 1993).

?Testiispongia RIGBY, 1983a, p. 262 [**T. venula;* OD] [?=*Protospongia* SALTER, 1864, p. 238 (type, *P. fenestrata,* M)]. Subcylindrical, smooth, test-tube-like, thin-walled protosponge with hemispherical base; stauractine-based skeletal net with main rays principally horizontal and vertical but only in crude

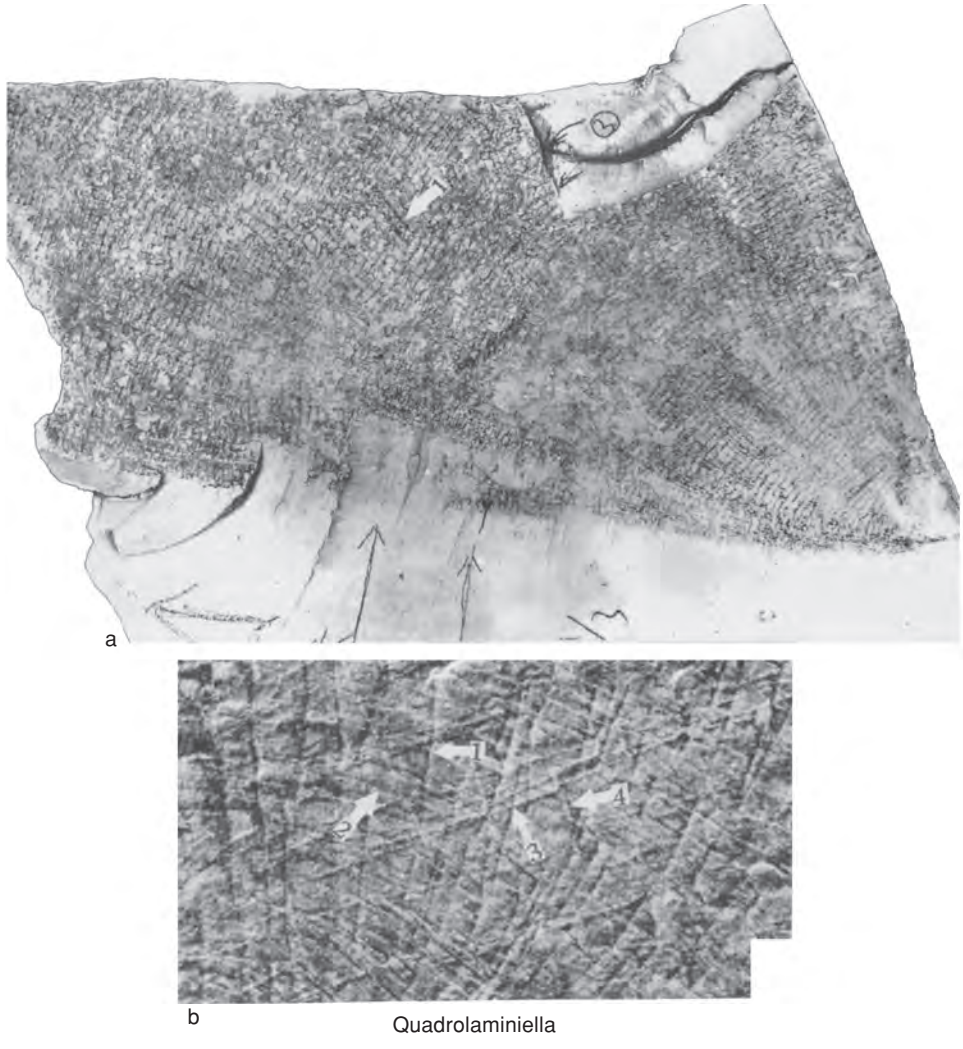


FIG. 226. Protospongiidae (p. 355).

quadrules, with other spicules oriented parallel to major axes of sponge; possible hexactine-based spicules also oriented at odd angles; skeletal net increasingly better organized in upper, chimneylike part of sponge near osculum; parietal gaps not developed and marginalia and prostalia absent, other than possible short, brushlike, root tuft; principal spicules with striated or weakly ribbed, main rays. *Middle Cambrian:* USA (Utah).——FIG. 224,*2a–b.* **T. venula,* Marjum Formation, House Range; *a,* large holotype and small paratype showing test-tubelike form of genus and rectangular, skeletal net in upper part of holotype, with associated, irregular hexactines, ×1; *b,* photomicrograph of somewhat crudely ranked spicules in upper part of holotype, BYU 1747, ×5; *c,* paratype showing form of sponge in limonite replacement, BYU 1749, ×1 (Rigby, 1983a).

Triticispongia MEHL & REITNER in STEINER & others, 1993, p. 307 [**T. diagonata;* OD]. Small, oval, thin-walled sponges with goatee-like root tuft, walls of small triaxons, mainly delicate stauractines, with paratangentalia in diagonal, rectangular, quadruled arrangement. *Lower Cambrian:* China (Hunan, Yunnan, Anhui).——FIG. 225,*1a–d.* **T. diagonata,* Niutitang Formation, Tommotian, Hunan; *a,* flattened, small holotype with diagonal stauractines and possible hexactines, ×5; *b,* sketch of holotype showing positions and orientations of most obvious spicules, IPFUB San 143-x, ×5 (Steiner & others, 1993); *c,* figured specimen with complete, oval skeleton around a deep spongocoel, with a faint, basal,

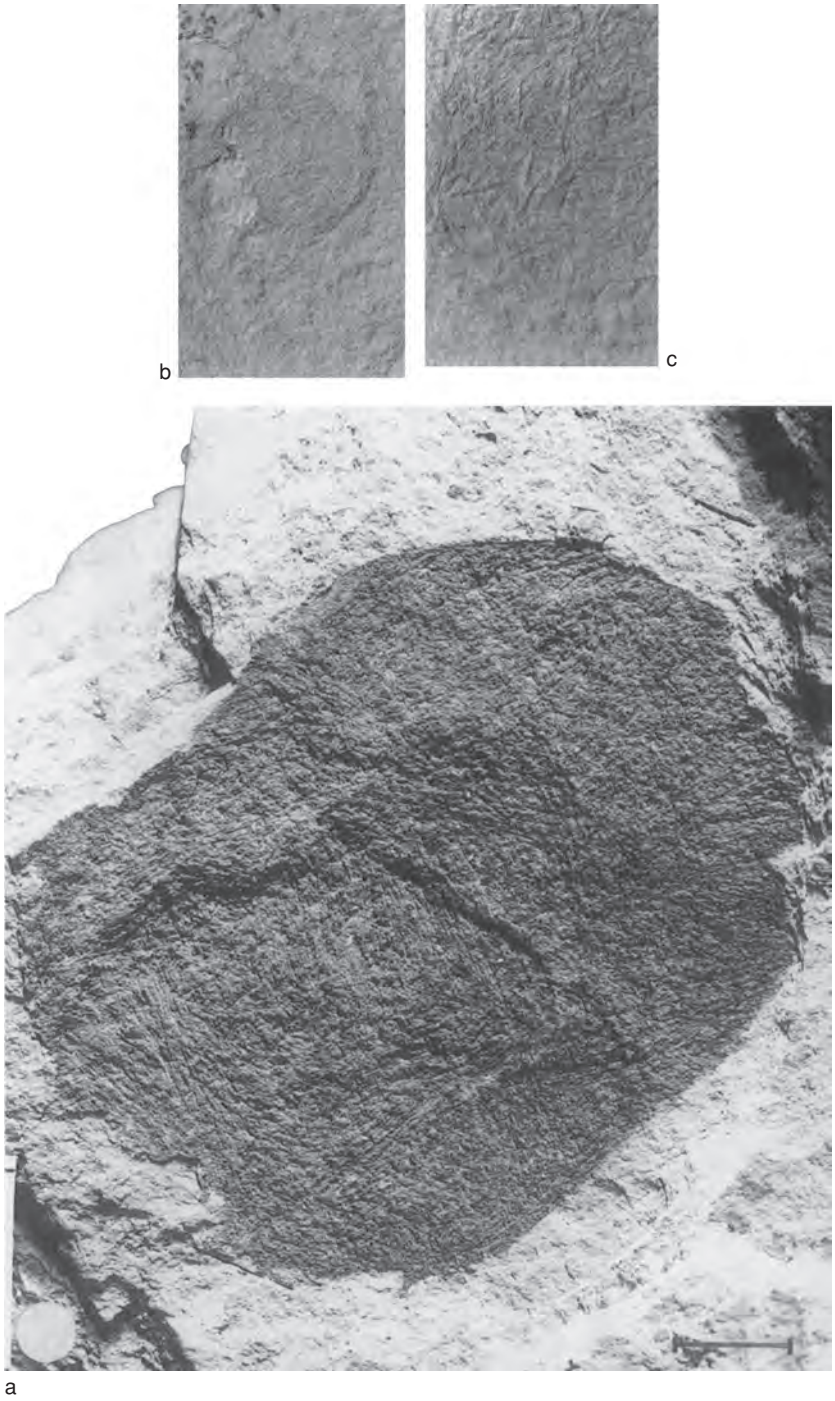


FIG. 227. Protospongiidae (p. 355).

root tuft and hexactine-based skeleton arranged in quadrules, NIGPAS 115320b, ×4; *d,* photomicrograph showing details of hexactine-based skeleton with quadrules most apparent in lower center and right, ×10 (Rigby & Hou, 1995).

Superfamily DIERESPONGIOIDEA Rigby & Gutschick, 1976

[*nom. transl.* Finks, 1983b, p. 109, *ex* Dierespongiidae Rigby & Gutschick, 1976, p. 79]

Reticulosa in which both dermal and gastral layer of simple, parallel hexactines, or reduced derivatives, form principal skeleton; rhabdodiactines or other prostalia may be developed and, in some groups, additional layers of parallel hexactines may be developed internal to dermal and gastral layers; parietal gaps not present. *Middle Cambrian–Holocene.*

Family DIERESPONGIIDAE Rigby & Gutschick, 1976

[Dierespongiidae Rigby & Gutschick, 1976, p. 79]

Mostly spheroidal Dierespongioidea in which skeleton consists of dermal and gastral layers plus long, rhabdodiactine prostalia that radiate from interior of sponge and protrude extensively from outer surface. *Middle Ordovician–Permian (Artinskian).*

Dierespongia Rigby & Gutschick, 1976, p. 80 [**D. palla;* OD]. Spheroidal; body wall composed of two layers (dermal and gastral) of hexactines and stauractines separated by a space; at least dermal layer consisting of parallel spicules of three nested orders of size; radially oriented prostalia distributed evenly over whole body but grouped into clusters of a few spicules each, and are chiefly rhabdodiactines but include hexactines of dermal layer with greatly elongated, proximal and distal rays; prostalia extending from gastral layer to well beyond dermal layer (at least one sponge diameter). *lower Upper Ordovician:* USA (Oklahoma).——Fig. 228,*1a–b.* **D. palla,* upper Blackriver or lower Trenton, Bromide Formation, Criner Hills, Carter County; *a,* holotype with central, inner body, outer cortex, and radiating tufts of prostalia, ×1; *b,* photomicrograph of part showing ranked spicules of cortex and somewhat less well organized net of interior, USNM 188528, ×4 (Rigby & Gutschick, 1976).

Foerstella Ruedemann, 1925, p. 29 [**F. rotunda* Ruedemann, 1925, p. 30; OD]. Compressed specimen with rounded, squarish outline; stout bundles of long, possible rhabdodiactines crossing one another in nonparallel arrangement as presently preserved; each bundle interpreted as enclosing an exhalant cavity that opened separately to surface by an osculum situated in a depression [this does not seem likely]; bundles may be root tufts or internal bundles as in dictyospongiids; between bundles are small stauractines and rhabdodiactines, presumably forming body wall. *Upper Ordovician:* USA (New York).——Fig. 228,*2a–b.* **F. rotunda,* Upper Utica Shale, Holland Patent; *a,* holotype, compressed specimen with bundles of long, monaxial spicules that end in depression in impression, ×0.5; *b,* enlargement of spicules from area between large, spicule bundles, ×5 (Ruedemann, 1925; courtesy of New York State Museum, Albany).

Polylophidium Finks, 1960, p. 111 [**P. discus;* M]. Discoid, perhaps originally globular, with small, root tuft; sponge interior filled with long rhabdodiactines radiating from central point and more or less organized in bundles of one or two dozen spicules, bundles penetrating sponge wall as long tufts regularly spaced over entire sponge body; body wall composed of several layers of simple, slender-rayed hexactines, with an outer layer of similar pentactines and stauractines, possibly of nested sizes but only partly parallel to one another. *Permian (Artinskian):* USA (Texas).——Fig. 229,*2a–c.* **P. discus,* Word Formation, Glass Mountains; *a,* holotype lodged in brachiopod shell with regular, small tufts over sponge surface and ring of monaxons that may be root tuft at upper left, AMNH 28076, ×1; *b,* paratype with part of outer layer removed to show radial bundles of monaxons in interior, AMNH 28067:1, ×1; *c,* enlarged view of outer surface of paratype showing dermal layer of pentactines and stauractines of various sizes, pierced by radial tufts of monaxons, AMNH 2067:1, ×5 (Finks, 1960; courtesy of The American Museum of Natural History).

Polyplectella Ruedemann, 1925, p. 32 [**P. mira* Ruedemann, 1925, p. 35; OD]. Cylindroid to vasiform with terminal osculum; sponge body composed of stauractines, pentactines, or hexactines, and described as having numerous openings in lower part, presumably skeletal canals; long, separate tufts of prostalia (rhabdodiactines or pentactines with elongate, distal ray) distributed over much of sponge body and extending outwardly for at least one sponge diameter; lower part of sponge said to contain a "confused mass of twisted fiberlike" basalia (Ruedemann, 1925, p. 34). [The presence of possible skeletal canal openings suggests a closer relationship to *Cyathophycus* and the Hintzespongiidae, but *Polyplectella* is here retained in the Dierespongiidae on the basis of the more certain tufts of prostalia. In any event the Dierespongiidae and Hintzespongiidae are quite similar, both morphologically and phylogenetically, despite their seeming distance in the present classification, where the latter have been separated out as a stock possibly leading to the Pattersoniidae and Brachiospongiidae.] *Upper Ordovician:* USA (New York).——Fig. 229,*3a–c.* **P. mira,* Frankfort Shale, Rome; *a,* holotype, cylindrical sponge with basal root tufts, approximately ×5; *b,* drawing of sponge body with a large osculum at top and

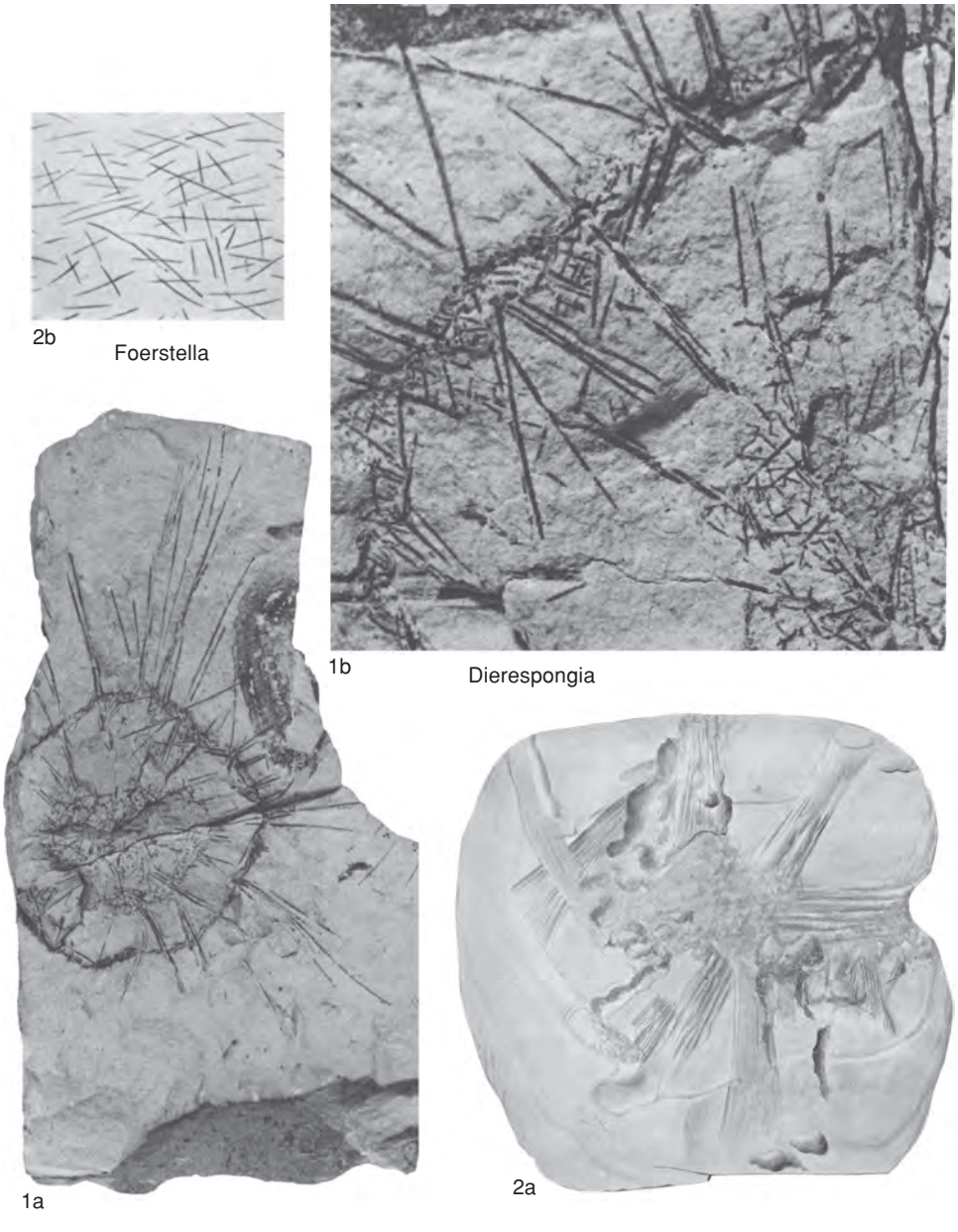


FIG. 228. Dierespongiidae (p. 359).

possible ostia on side, showing cylindrical form of holotype and irregularly distributed tufts of spicules with hexactine-based spicules between, USNM, ×5; *c,* associated specimen with long root tufts, ×1 (Ruedemann, 1925; courtesy of New York State Museum, Albany).

Stephanella HINDE, 1891, p. 23 [**S. sancta;* OD]. Circular masses of possible rhabdodiactines radiating from a center. *Middle Ordovician–Upper Ordovician:* Canada (Ontario), Australia (?Victoria).—— FIG. 229,*1. *S. sancta,* Utica Shale, Upper Ordovician, Ottawa, Canada; drawing of radial spicule structure of type (Hinde, 1891).

Sycodictya RUEDEMANN, 1925, p. 34 [**S. rara;* OD]. Conicocylindrical, vasiform sponge with a thick wall containing skeletal canals (said not to penetrate either dermal or gastral surface); skeleton said to consist of "monactines (derived from hexactines),"

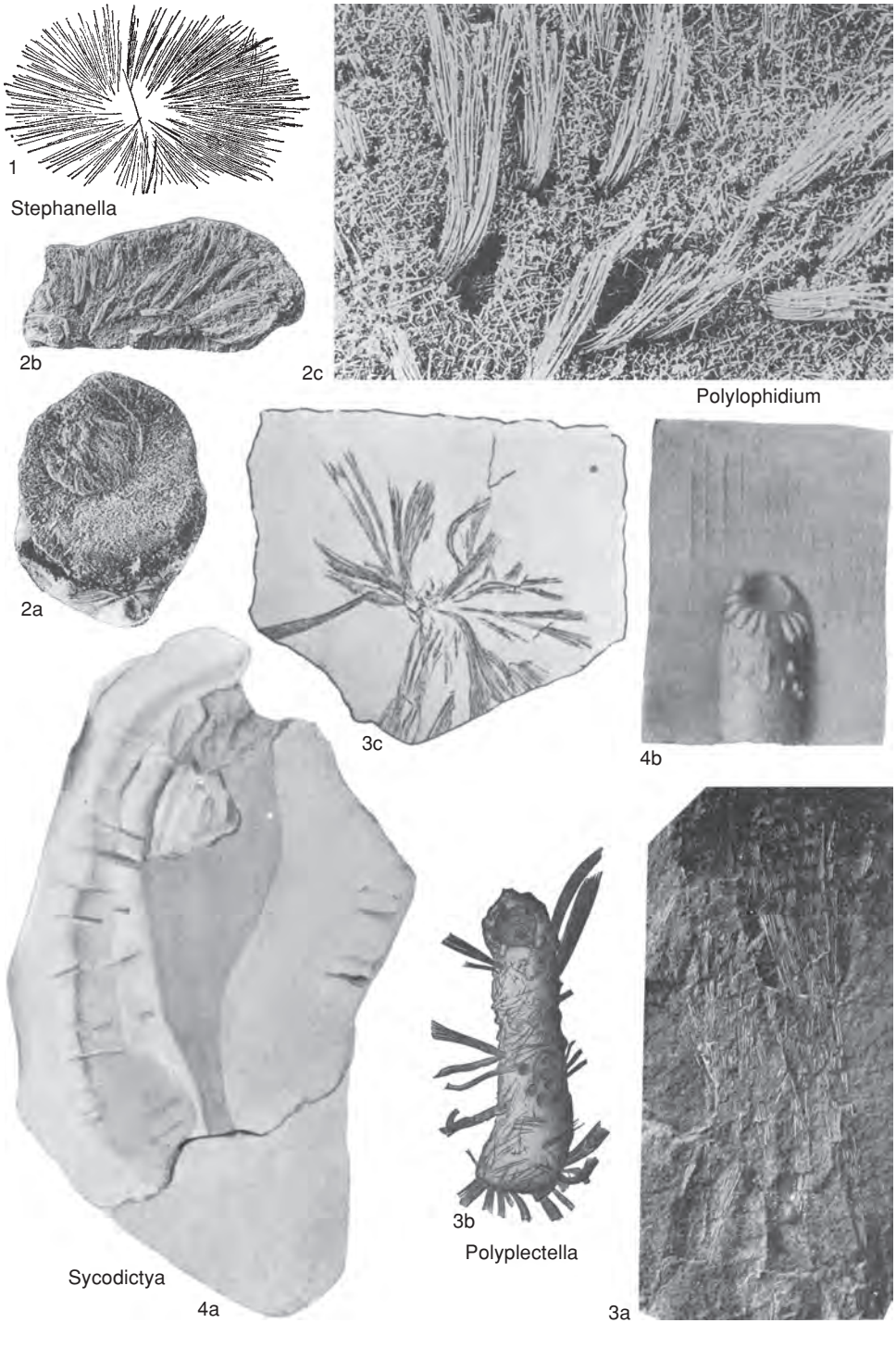


FIG. 229. Dierespongiidae (p. 359–362).

i.e., rhabdodiactines, "arranged in radiating and concentric systems," together with dermalia that are long, thin tetractines (RUEDEMANN, 1925, p. 35). [If the tetractines were tetraxons, which the illustration suggests, this would be a demosponge, but the illustration shows the principal spicules to intersect at right angles, which favors hexactinellid affinities suggested by the author of the genus and an interpretation of the dermalia as modified hexactines. The dubious inclusion of the genus in the present family is mainly for convenience and is based on its co-occurrence with more certain members of the family and on the predominance of rhabdodiactines in the skeleton. An isolated sexiradiate on the same slab as the sole specimen raises the question of heteractinid affinities.] *Upper Ordovician:* USA (New York).——FIG. 229,*4a–b. *S. rara,* Upper Utica Shale, Holland Patent; *a,* holotype, side view with dark, matrix-filled spongocoel and thick walls with radial canals, ×1; *b,* regular, spicular structure of wall and extremity of canal, ×10 (Ruedemann, 1925; courtesy of New York State Museum, Albany).

Family HYDNODICTYIDAE Rigby, 1971

[Hydnodictyidae RIGBY, 1971, p. 52]

Thin-walled but sculptured Dierespongioidea in which orientation of spicules in gastral layer differs from that in dermal layer, although spicules within each layer are parallel to each other; prostalia may be present. *Middle Cambrian–Upper Ordovician.*

Hydnodictya RIGBY, 1971, p. 53 [**H. acantha;* OD]. Sponge vasiform, base and osculum unknown; thin walls bearing sharp-crested, ridgelike nodes capped by tufts of prostalia; wall composed of two quadrate layers of stauractines and hexactines; presumed outer layer arranged parallel to longitudinal axis of sponge, presumed inner at about 45° to this axis; irregularly oriented spicules also occur; no parietal gaps or skeletal canals. *Upper Ordovician:* Canada (Manitoba).——FIG. 230,*1a–b. *H. acantha,* Red River Formation, Caradoc–Ashgill, Lake Winnipeg; *a,* flattened holotype with prostalia tufts along nodose margins, with generally quadrate skeleton best shown in upper part, ×0.9; *b,* enlarged section of sponge surface with quadrate skeleton best shown in upper part, GSC 25907, ×4.5 (Rigby, 1971; courtesy of Minister of Public Works and Government Services, 2000, and the Geological Survey of Canada).

Valospongia RIGBY, 1983a, p. 264 [**V. gigantis;* OD]. Large, conicocylindrical to keg-shaped, thin-walled hexactinellid with separated, low, hemispherical protuberances spaced less than their diameter apart that appear to overlie circular, aporhysal gaps in principal net over entire surface; protuberances formed of a finer, more irregular, spicule net that outlines numerous circular pores in fractal-like repetition of larger net on smaller scale; protuberances of two sizes, smaller alternating quincuncially with larger ones; oscular margin without spicule fringe; skeleton hexactines and stauractines and possibly with three layers: inner layer of principal net forming large quadrules parallel to sponge axis with roughly rectangularly arranged, long fibers or rays; intermediate and probably overlying layer composed of diagonally oriented quadrules, each likewise enclosing one of large mounds; third layer, between and connected to both series, includes smaller quadrules, both longitudinal and diagonal; finest are same size as net on protuberances and may represent a continuous layer of autodermalia that covers entire sponge of hexactine-based spicules; some nodes may have short, spinose tips. *Middle Cambrian:* USA (Utah).——FIG. 230,*2a–b. *V. gigantis,* Marjum Formation, House Range; *a,* flattened holotype showing form of sponge and mounds of skeleton along margins, ×0.5; *b,* photomicrograph showing impressions of irregularly oriented, hexactine-based spicules and general distribution of flattened mounds as circular interruptions, BYU 1745, ×5 (Rigby, 1983a).

Family AMPHISPONGIIDAE Rauff, 1894

[Amphispongiidae RAUFF, 1894, p. 275]

Sponges with strongly radiate, coarse spicules in lower part and reticulate skeleton including stauractines, pentactines, and diactines in upper part. *upper Silurian.*

Amphispongia SALTER, 1861, p. 135 [**A. oblonga;* OD]. Tubular to oblong sponges with lower radiate mass of coarse styles radiating from a central point; upper part solid or with a narrow, central spongocoel and skeleton of fine, reticulate stauractines, pentactines, and thin diactines; common spicule T-shaped with bulbous ray junction and arranged transverse to axis. *upper Silurian:* Scotland.——FIG. 231,*2. *A. oblonga,* upper Ludlow beds, Ludlow, Pentland Hills, Scotland; side view of sponge preserved as mold, with coarse, basal spicules and finer, reticulate, upper skeleton, ×1.5 (Rauff, 1893).

Family MULTIVASCULATIDAE de Laubenfels, 1955

[Multivasculatidae DE LAUBENFELS, 1955, p. 77]

Encrusting Dierespongioidea in which additional layers of parallel hexactines are intercalated between and parallel to dermal and gastral layers. *Upper Cambrian.*

Multivasculatus HOWELL & VAN HOUTEN, 1940, p. 7 [**M. ovatus;* OD]. Numerous low cups connected by an intervening, encrusting sheet; spicules mostly simple, slender hexactines in parallel orientation, with distal rays aborted on dermal and gastral surfaces; body wall moderately thick with more than

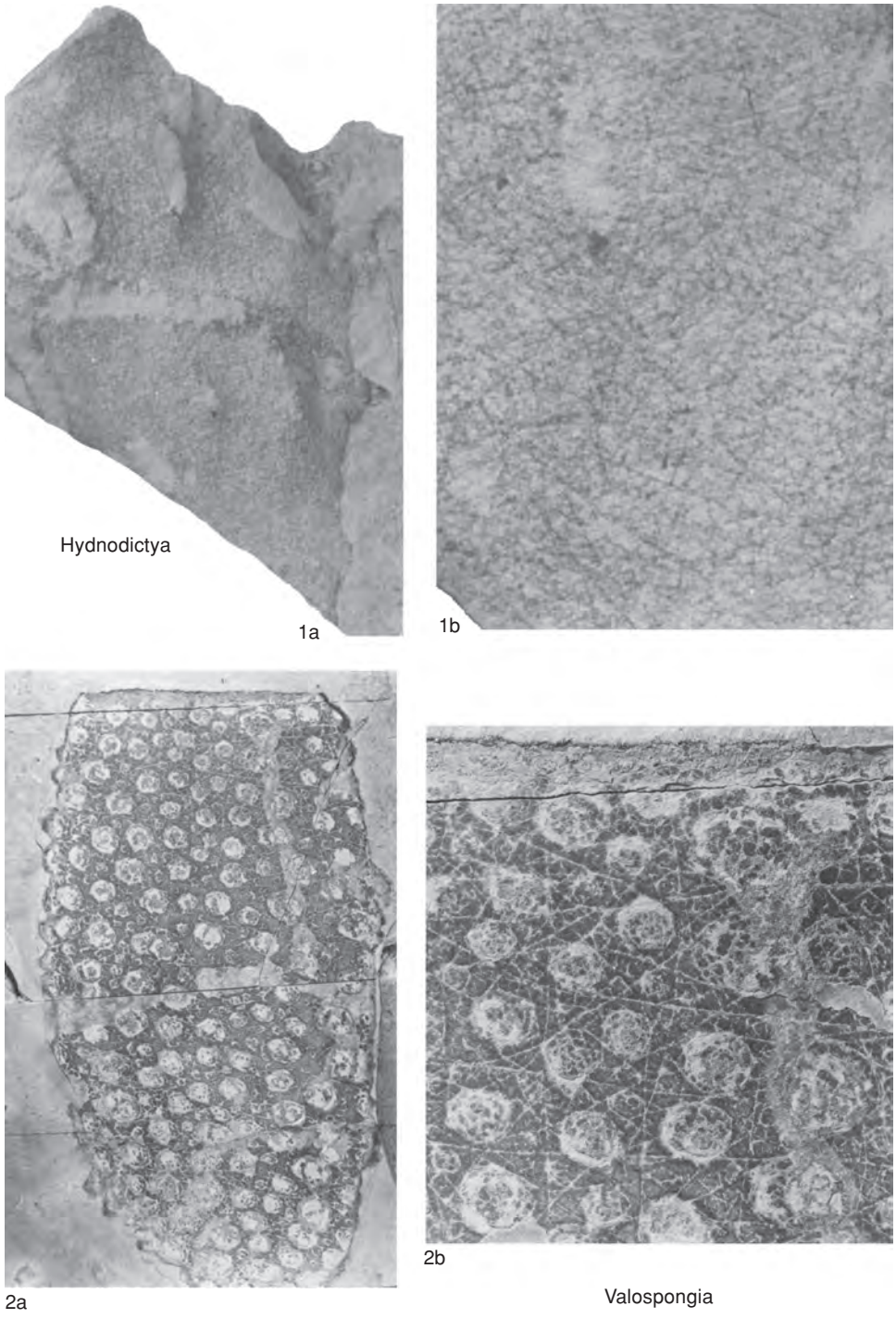


FIG. 230. Hydnodictyidae (p. 362).

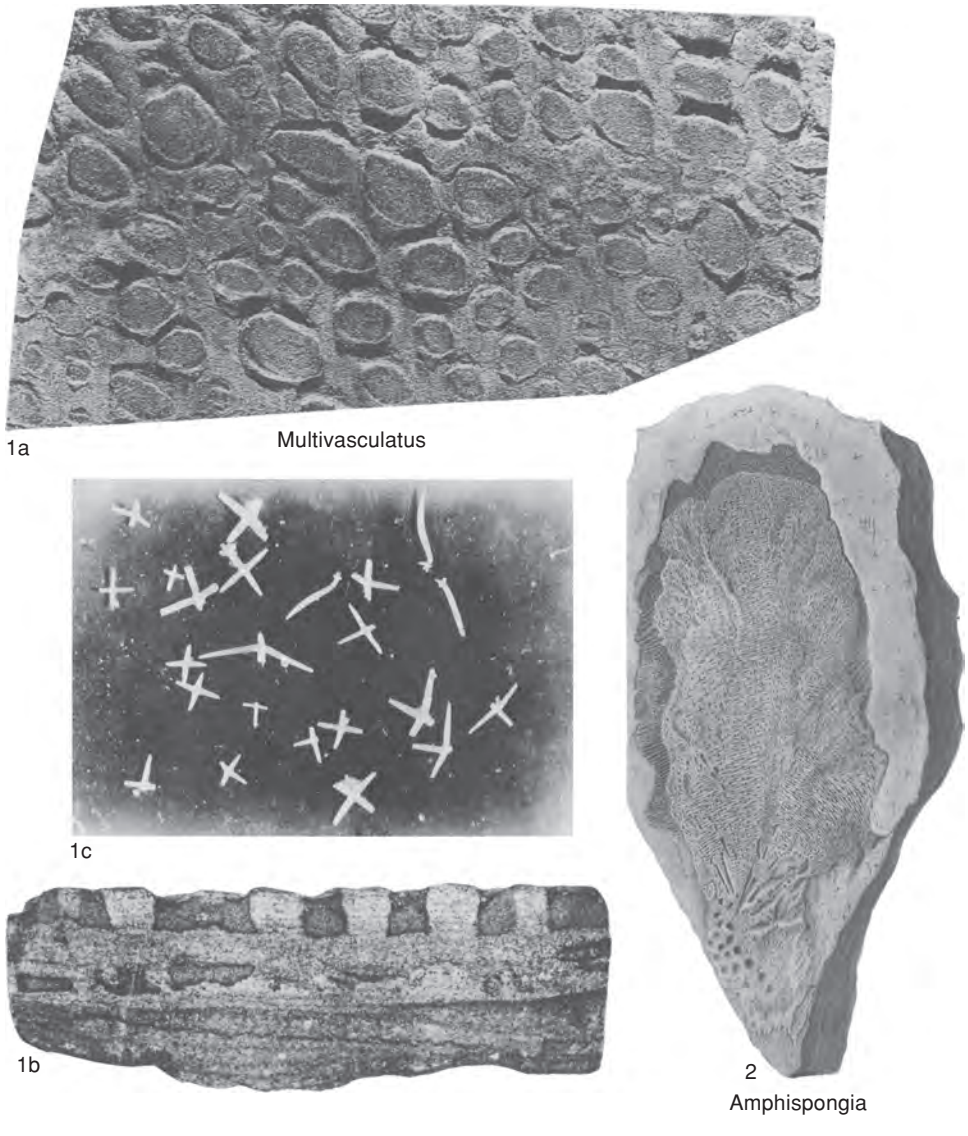


FIG. 231. Amphispongiidae and Multivasculatidae (p. 362–364).

one layer of hexactines between dermal and gastral layers; substauractines also present, as are hexactines in which five rays are reduced and sixth curved at an angle to crossing and papillose; simple rhabdodiactines occurring in matrix and may have been prostalia. *Upper Cambrian:* USA (Wyoming, Nevada).——FIG. 231,*1a–c.* **M. ovatus,* Gallatin Formation, Bighorn Mountains, Wyoming; *a,* view from above of holotype colony; *b,* side view of part of holotype colony, PU 5229a, ×1; *c,* hexactine-based spicules from holotype, PU 5229b, ×10 (Howell & van Houten, 1940).

Family TITUSVILLIDAE Caster, 1939

[Titusvillidae CASTER, 1939, p. 1]

Tubular, branching, segmented Dierespongioidea in which dermal and gastral layers, accompanied by prostalia, may enclose an additional layer, or layers, of spicules. *Upper Devonian–Holocene.*

Titusvillia CASTER, 1939, p. 1 [**T. drakei;* OD]. Long, slender, somewhat sinuous branches that diverge

initially at angles close to 90°; each branch consisting of a linear series of subequal, nested funnels or cups; in some branches cups opening away from origin of branch, in other branches opening toward it; surface bearing fine, quadrate reticulation parallel to branch axis; peripheral ring of apparent prostalia fringes edges of some cups; longitudinal, paratangential rays of dermalia thinner than horizontal ones and slightly bowed outwardly; distal ray reduced to small knob; continuous, internal cylindrical tube about half maximum diameter of sponge apparently representing a cloaca; it may be eccentrically located and lined by quadrate mesh somewhat finer than dermal one; mesh showing spiral orientation; space between dermal and gastral surfaces apparently contained spicules in less regular orientation, including possible rhabdodiactines and clemes, but said to be too poorly preserved to analyze; a third quadrate mesh lying just under and subparallel to center mesh; rings of tubercles on cloacal, internal mold were interpreted as canals leading from expanded flange of cup where there is evidence in some cups of a circle of perforations just inside cup margin. *Carboniferous (Lower Mississippian):* USA (Pennsylvania).——Fig. 232,*2a–c. *T. drakei,* Tidioute Member of Oil Lake Series, Titusville; *a,* side view of branched holotype, ×0.75; *b,* enlargement to show growth form with sequence of cups in branch, UCM 22130, ×1; *c,* restoration of upper part of cup showing canals and possible spiculation of skeleton, approximately ×2 (Caster, 1939).

Annulispongia Rigby & Moyle, 1959, p. 401 [**A. interrupta;* M]. Sponge cylindrical, with sharp-edged, upwardly flaring, annular expansions; body wall thick with exhalant canals said to extend inwardly and downwardly to cloaca; spicules small hexactines arranged in concentric layers, more densely spaced in interior of body wall; horizontal rays more pronounced in exterior layers and vertical rays longer within body wall. [The poriferan nature of this genus is in doubt. Spicule impressions may be foreign.] *Carboniferous (Lower Mississippian):* USA (Utah).——Fig. 232,*1a–b. *A. interrupta,* Manning Canyon Shale, Chesterian, Oquirrh Mountains; *a,* side view of weathered, annulate-appearing holotype, ×1; *b,* polished, transverse section showing possible canals and spicule character, BYU 11029-1, ×2 (Rigby & Moyle, 1959).

Armstrongia Clarke, 1920, p. 143 [**Ceratodictya oryx* Clarke, 1918, p. 180; M]. No spicules are preserved, but in external form it shows no difference from *Titusvillia* Caster, 1939, including the reversed expansion of annulations in some branches (that is, flaring toward point of branching); suggestions of terminal prostalia, as in *Titusvillia,* also noted by author. [This genus could be regarded as a senior synonym of *Titusvillia.*] *Upper Devonian:* USA (Pennsylvania).——Fig. 233,*3. *A. oryx* (Clarke), Upper Chemung Group, Erie; part of cast of original slab preserved as mold, ×0.5 (Clarke, 1920; courtesy of New York State Museum, Albany).

Iowaspongia Thomas, 1922, p. 87 [**I. annulata;* M]. Large, conical to broadly turbinate, but incipiently cylindrical in upper part, with sharp-crested, annular ridges separated by broad, smooth, concave interspaces that are generally asymmetrical, contracting rapidly from crest below, then gradually flaring outwardly and upwardly to next crest. [Personal observation of the holotype by Finks confirms the original author's statement that a skeletal net is not clearly preserved, except for some locally visible, finely spaced, vertical and horizontal ridges. It is possible that this object is a burrow or cubichnium, with vertical striations representing slickensides, a result of differential movement in a soft, clay matrix, and horizontal ones in the sedimentary laminae.] *Upper Devonian:* USA (Iowa).——Fig. 233,*2. *I. annulata,* Lime Creek Shale, Rockford; side view of regularly annulate, steeply obconical co-type, approximately ×0.5 (Thomas, 1922).

Protoarmstrongia Caster, 1941, p. 488 [**P. ithacensis;* OD]. Said to differ from *Titusvillia* and *Armstrongia* in that annulations are toroidal rather than infundibuliform. *Upper Devonian:* USA (New York).——Fig. 233,*1a–b. *P. ithacensis,* Enfield Shale Member, Portage Formation, Senecan, Ithaca; *a,* part of holotype slab showing growth form and intertwined structure of branches, ×0.9; *b,* enlargement of basal part of one colony of holotype slab with limonite crust of spicule felt, ×2 (Caster, 1941).

Sclerothamnus Marshall, 1875, p. 171 [**S. clausi;* OD]. Shape and size much like *Titusvillia* but branching simpler; dictyonine strands spined; microscleres tylohexasters. *Holocene:* East Indies.——Fig. 234. **S. clausi,* off Timor; branched sponge with most nodes as ceratodictyan double nodes rather than cups, ×0.25 (Caster, 1941).

Family AGLITHODICTYIDAE Hall & Clarke, 1899

[*nom. transl.* Finks & Rigby, herein, *ex* Aglithodictyinae Hall & Clarke, 1899, p. 53]

Thick-walled, conoidal Dierespongioidea, in which several layers of spicules are intercalated between dermal and gastral layers; skeletal canals are present. [All the genera assigned here to the family Aglithodictyiidae are confined to the Late Devonian or Early Carboniferous, have similar thick walls with radial slits, a central cloaca, and a cubic mesh that may be dictyonine. This is probably, therefore, a natural group of worldwide occurrence.] *Upper Devonian–Carboniferous (Visean).*

Aglithodictya Hall & Clarke, 1899, p. 145 [**A. nummulina;* OD]. Sponge small, turbinate, but abruptly contracted toward osculum, bearing possible radial canals upon upper slope; peripheral frill may be present about widest part; obscure, quadrate

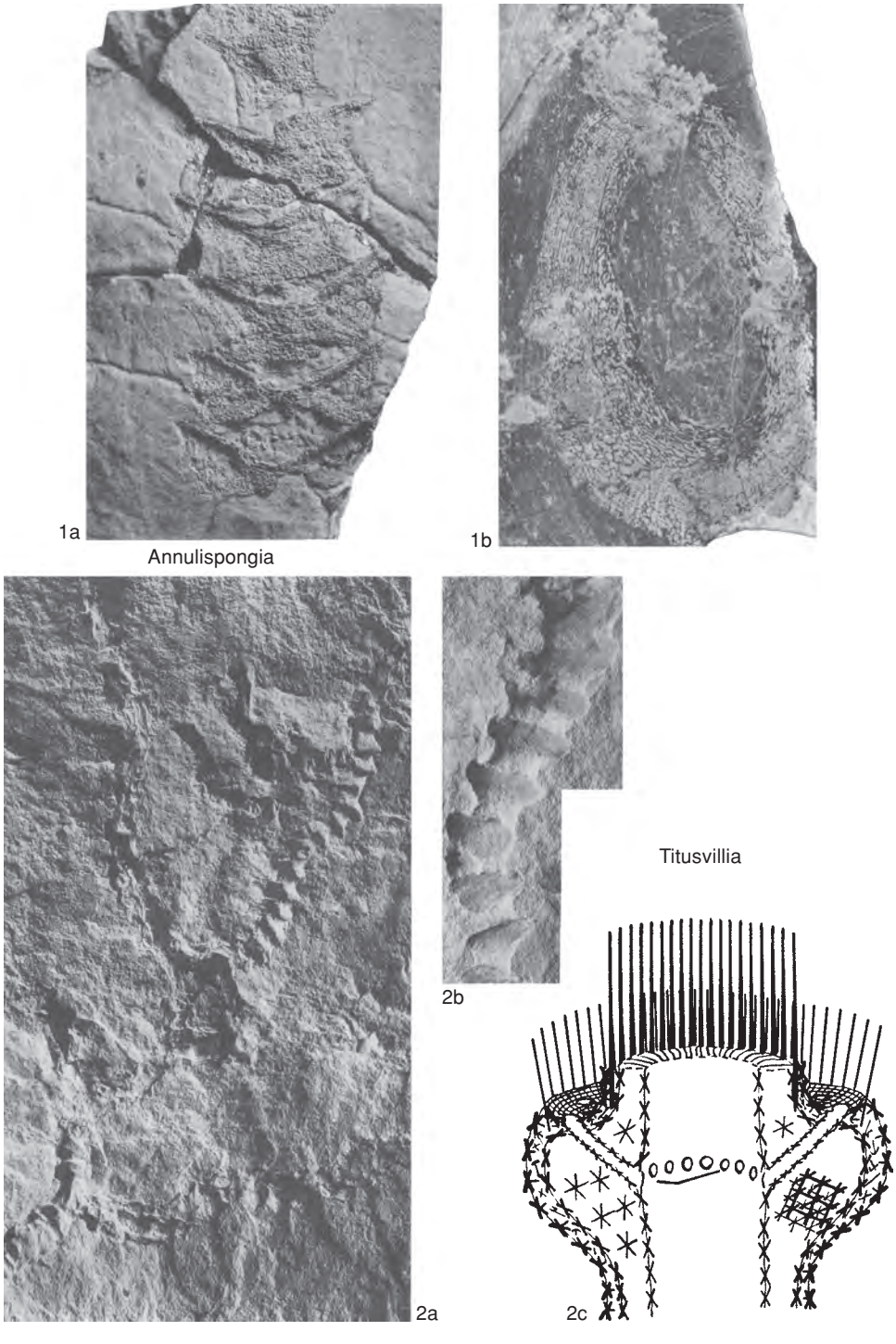


FIG. 232. Titusvillidae (p. 364–365).

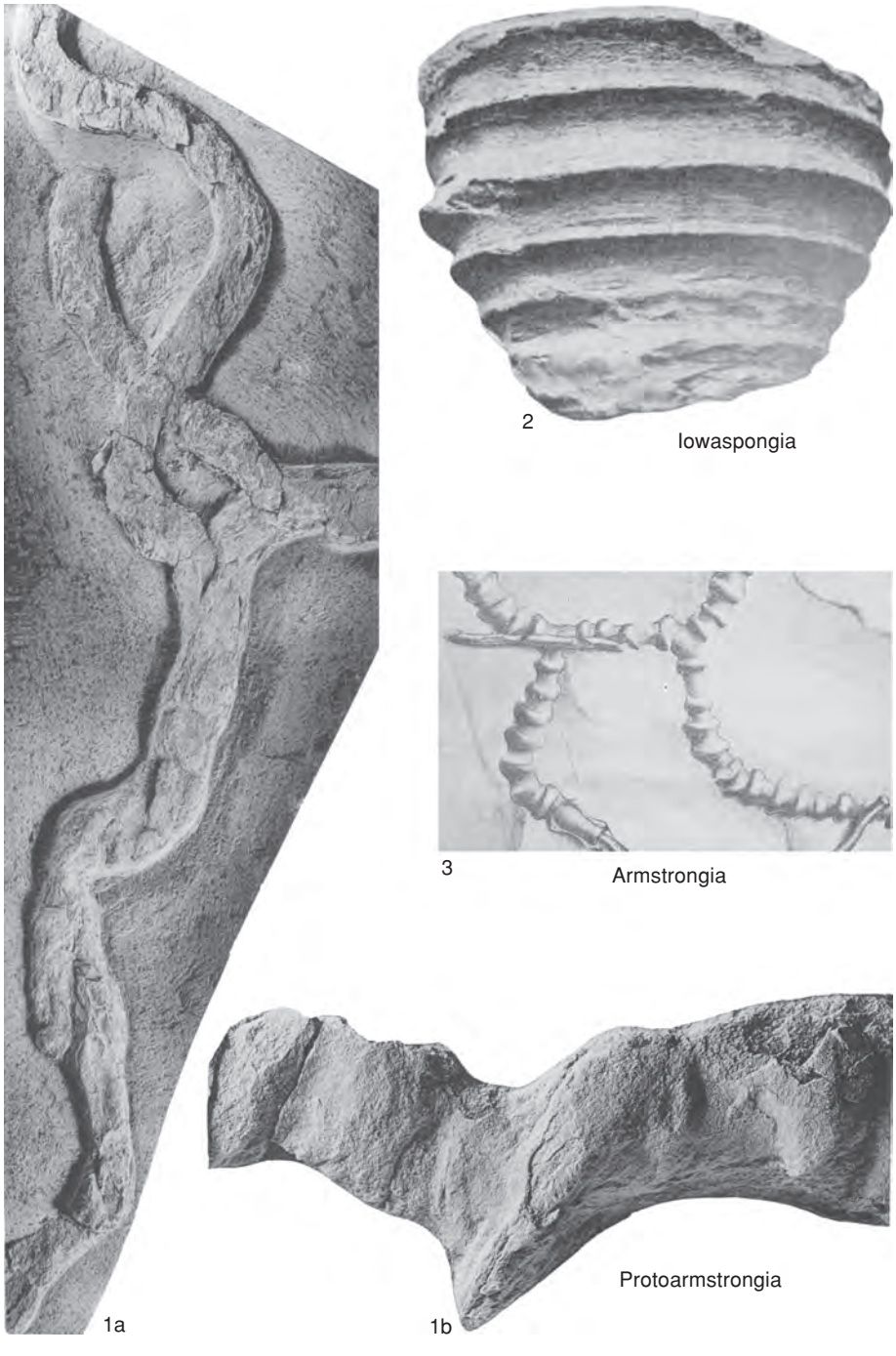


FIG. 233. Titusvillidae (p. 365).

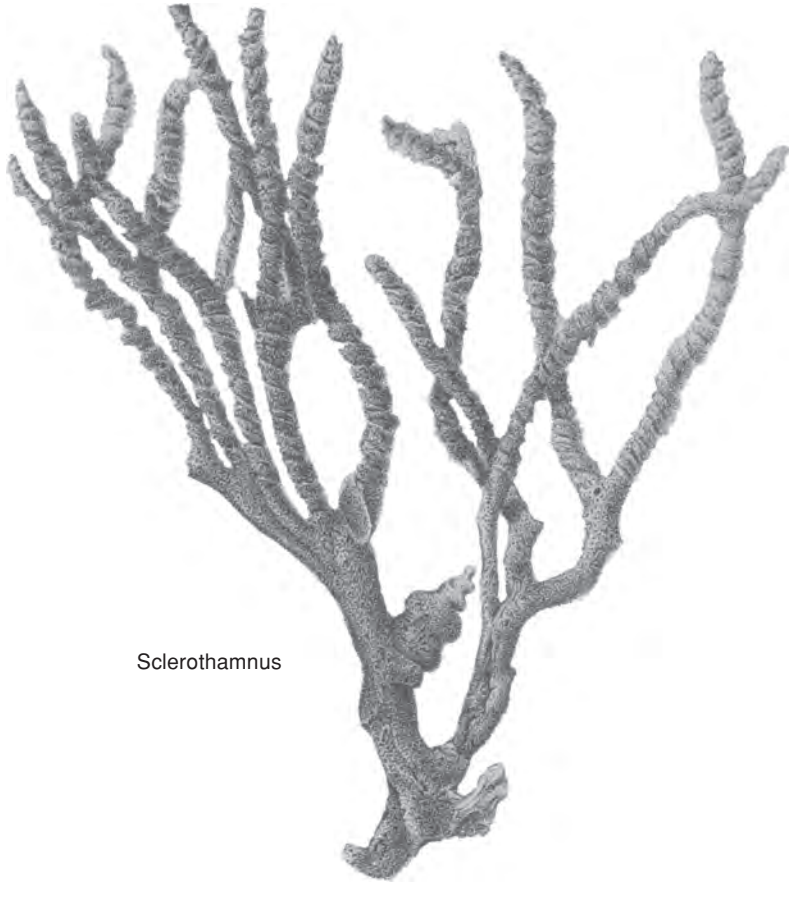


FIG. 234. Titusvillidae (p. 365).

mesh seemingly present. [HALL and CLARKE, whose description of the sole specimen is paraphrased, suggested that the sponge may be thick-walled, presumably corresponding to the width of the canal-bearing upper surface, and thus not a true dictyosponge.] *Upper Devonian:* USA (Pennsylvania).——FIG. 235,*1a–c. *A. nummulina,* Chemung Group, Lawrenceville, as cited in text but from Cohocton, New York, as cited in plate explanation; *a,* side view of holotype showing steeply obconical form that abruptly tapers in upper part to osculum; *b,* view into osculum from above, ×1; *c,* enlarged view of skeletal net showing reticulate pattern, NYSM, ×4 (Hall & Clarke, 1899).

Asociatella HURCEWICZ, 1985, p. 285 [**A. fruticum;* OD]. Sponge with club-shaped branches; thin walled with deep cloaca; skeleton possibly dictyonine; short canals present. *Devonian (Frasnian):* Poland.——FIG. 235,*2a–c. *A. fruticum,* lower Frasnian limestones, Wietrznia; *a,* side view of globular sponge, ×1; *b,* photomicrograph of spicules in skeletal fragment, ×50; *c,* drawings of skeletal structure in holotype, MUZ IG 1501.II/1, ×19 (Hurcewicz, 1985; courtesy of Panstwowy Instytut Geologiczny, Warsaw).

Czarnockiella HURCEWICZ & CZARNIECKI, 1986, p. 342 [**C. concinella;* OD]. Broadly conical with beveled, upper margin; no cloaca; top surface shallowly concave with numerous circular, closely spaced, exhalant pores that are openings of exhalant canals rising inwardly and upwardly through much of interior; dermal skeleton small hexactines or stauractines in parallel arrangement; principal skeleton of much larger hexactines, pentactines, stauractines, tauactines, and rhabdodiactines, of various sizes, in more or less parallel arrangement. [The external shape of the type species resembles *Aglithodictya* HALL & CLARKE, 1899.] *Carboniferous (Visean):* Poland.——FIG. 235,*3a–i. *C. concinella,* Carboniferous limestone, Galezice, Holy Cross Mountains; *a,* side view of holotype with characteristic shape, ×0.5; *b,* view of holotype from above, AI-68/34, ×0.5; *c,* vertical section showing canal and skeletal development, AI-68/25, ×0.5; *d,* photomicrograph of endosomal, skeletal structure showing axial hexactine, regular hexactines, and stauractines,

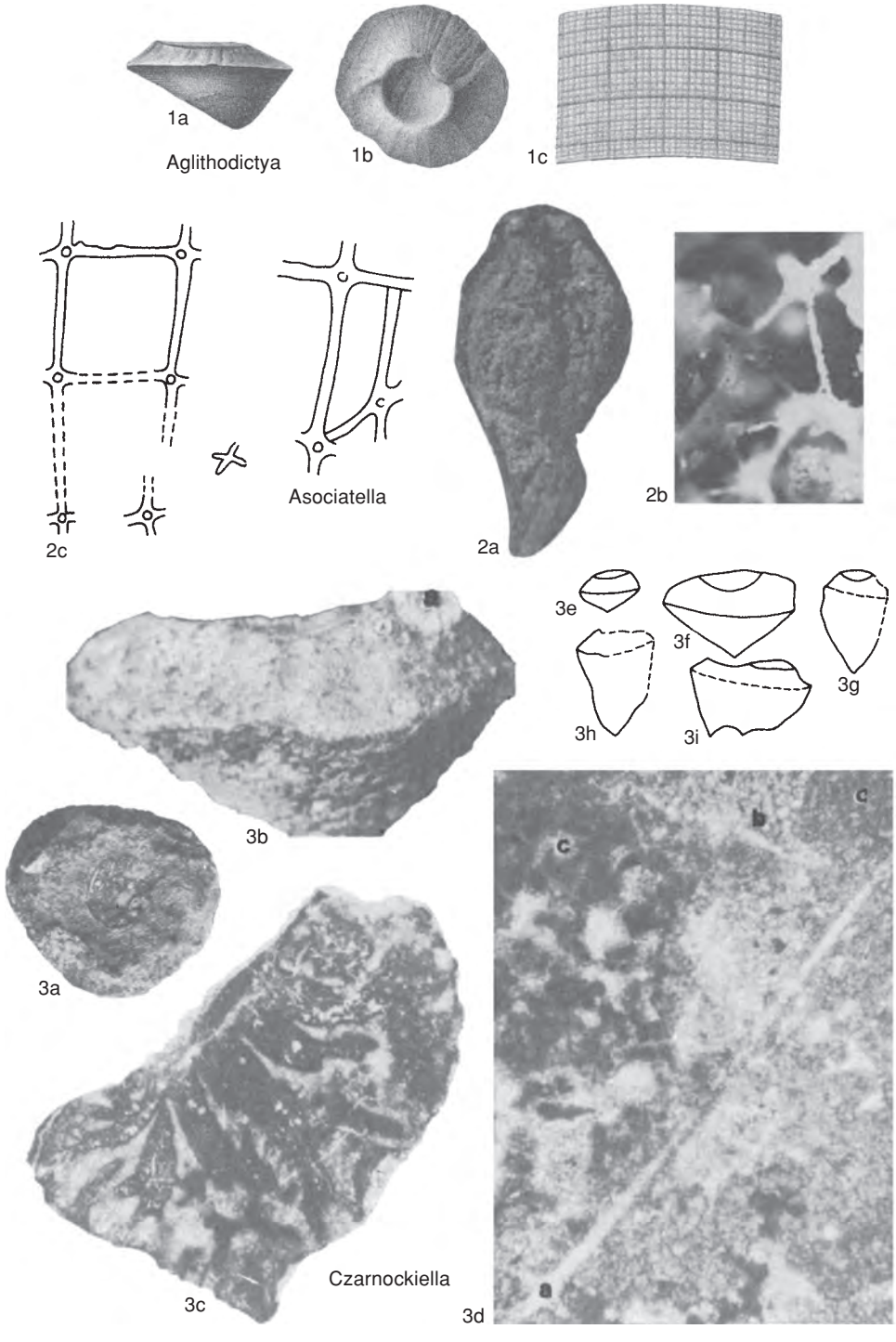
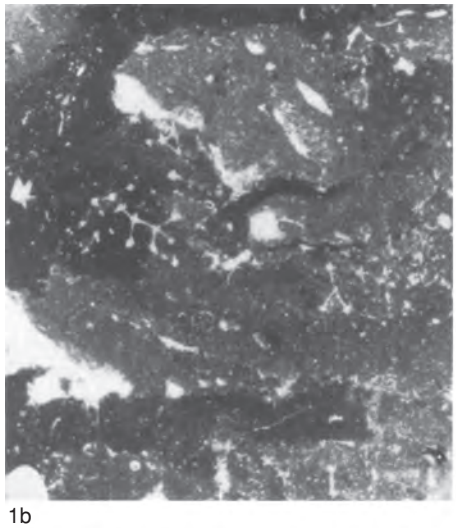
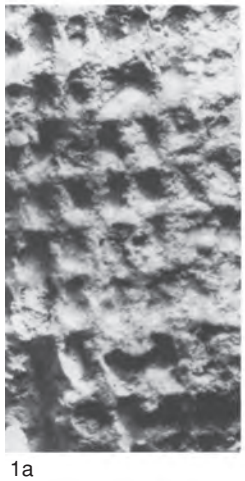


FIG. 235. Aglithodictyidae (p. 365–371).

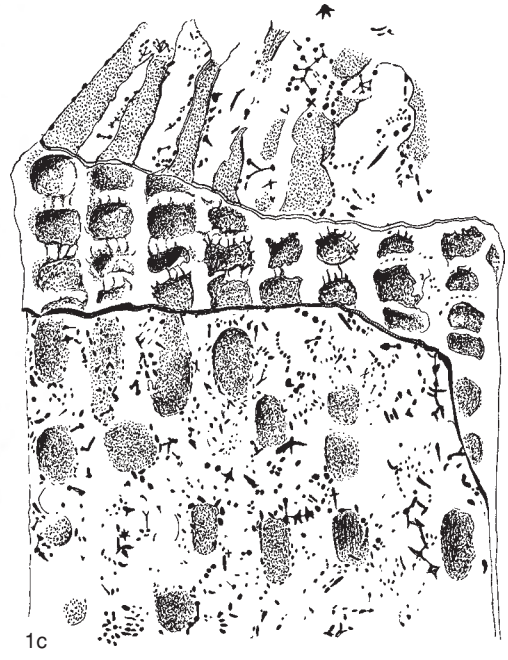


1b

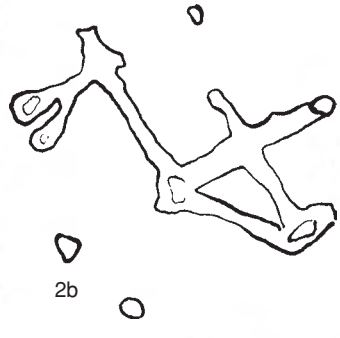


1a

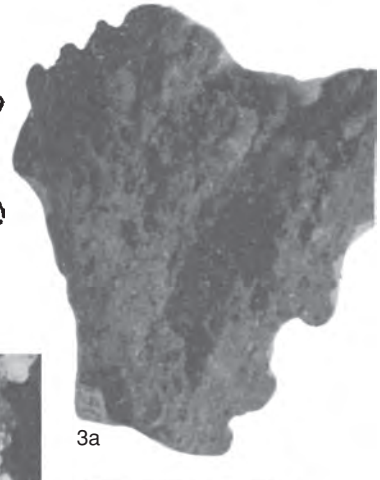
Pachyspongia



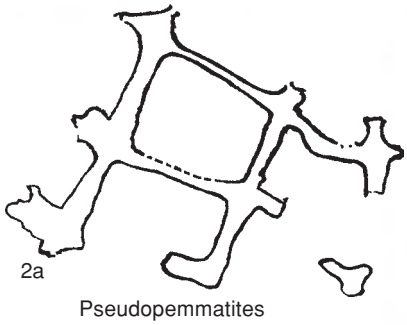
1c



2b



3a

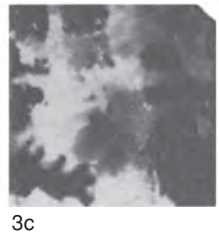


2a

Pseudopemmatites

3b

Paleostauronema



3c

FIG. 236. Aglithodictyidae (p. 371–372).

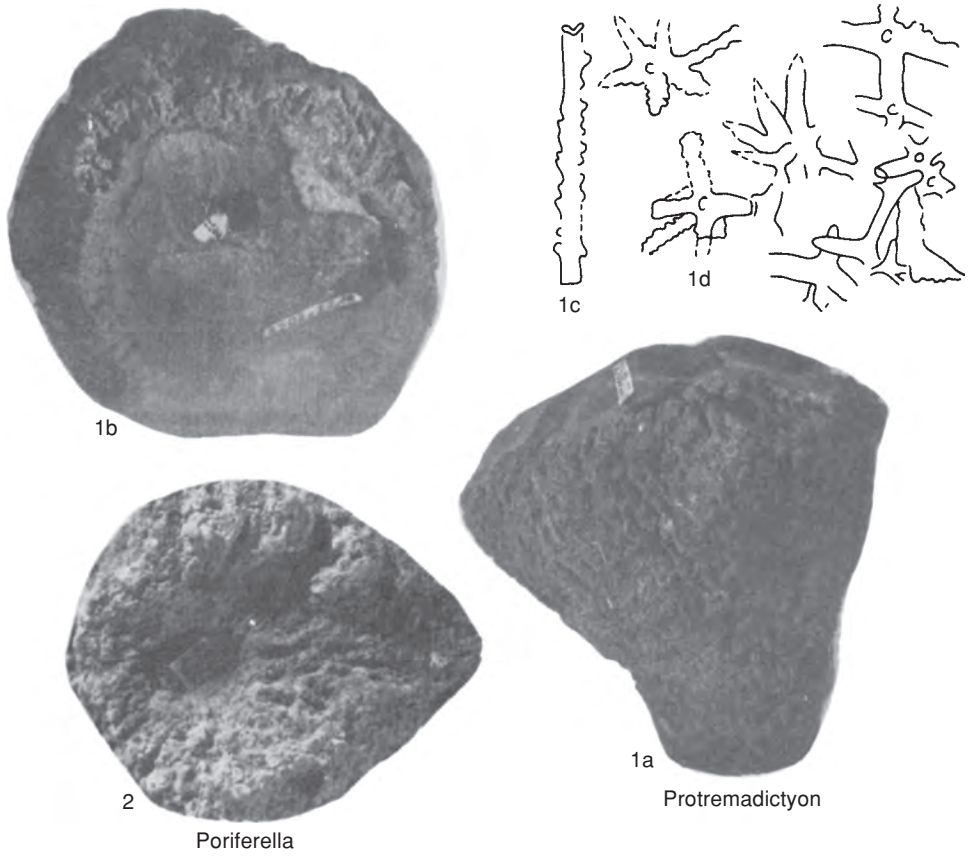


FIG. 237. Aglithodictyidae (p. 371–372).

AI-68/22a, ×100; *e–i,* drawings showing variations in outlines within type species, not to scale (Hurcewicz & Czarniecki, 1986; courtesy of Polish Geological Society, Krakow).

Pachyspongia TERMIER & TERMIER in TERMIER, TERMIER, & TSIEN, 1981, p. 292 [**P. columbarium;* OD]. Thick-walled fragment; exterior bearing quadrules, each outlined by a raised wall or ridge; it is not clear whether ridges are largest hexactines, in overlapping orientation outlining quadrules of one ray length, or whether they are erect lamellae like those of *Clathrospongia* HALL, 1884; interior containing several layers of smaller hexactines in parallel orientation, forming a cubic mesh, interrupted by somewhat irregular, anastomosing canals wider than mesh spaces; shape of whole sponge not known. *Devonian (Frasnian):* Belgium.——FIG. 236,*1a–c.* **P. columbarium,* Neuville Formation, Philippeville; *a,* exterior surface of holotype fragment with numerous ostia of radial canals, ×5; *b,* photomicrograph showing dictyonine, skeletal net interrupted by dark, matrix-filled canals, ×8; *c,* drawing of skeletal and canal relationships showing shaded, radial canals in main net and ostia in cortical layer in front, ×20 (Termier, Termier, & Tsien, 1981).

Paleostauronema HURCEWICZ, 1985, p. 282 [**P. transversallos* HURCEWICZ, 1985, p. 283; OD]. Conical, thin walled, with deep cloaca; canals or parietal gaps present in walls; spinose hexactines in parallel arrangement forming cubic mesh (possibly dictyonine); synapticulae present. *Devonian (Frasnian):* Poland.——FIG. 236,*3a–c.* **P. transversallos,* upper Frasnian limestone, Kowala; *a,* longitudinal section of syntype with open spongocoel and moderately thick walls, ×1; *b,* photomicrograph showing dictyonal structure; *c,* photomicrograph of spinose spicules, MUZ IG 1501.II/8, ×50 (Hurcewicz, 1985; courtesy of Panstwowy Instytut Geologiczny, Warsaw).

Poriferella HURCEWICZ, 1985, p. 283 [**P. formosum;* OD]. Conical, thick-walled, deep, central cloaca; vertical, slitlike aporhyses or possibly epirhyses; skeleton possibly dictyonine with smooth hexactines. *Devonian (Frasnian):* Poland.——FIG. 237,*2.* **P. formosum,* upper Frasnian limestone, Kowala; view of holotype from above with central spongocoel and thick walls, with elongate ostia on

gastral surface, MUZ IG 1501.II/65, ×1 (Hurcewicz, 1985; courtesy of Panstwowy Instytut Geologiczny, Warsaw).

Protremadictyon Hurcewicz, 1985, p. 284 [**P. kainos;* OD]. Conical, thick walled with narrow, central cloaca; vertically elongate, radial canals (possible aporhyses) covered by dermal layer; spinose hexactines or stauractines forming irregular net with broad mesh spaces. *Devonian (Frasnian):* Poland.——Fig. 237,*1a–d. *P. kainos,* upper Frasnian limestone, Kowala; *a,* side view of holotype with prominent, inhalant ostia; *b,* top view with small, axial spongocoel and canals around margin, ×1; *c–d,* silicified fragments of uncinates (*a*) and parenchymal skeleton with dictyonal structure in part (*b*), MUZ IG 1501.II/1, ×20 (Hurcewicz, 1985; courtesy of Panstwowy Instytut Geologiczny, Warsaw).

Pseudopemmatites Fraipont, 1911, p. 197 [**F. fourmarieri;* OD]. Sponge broadly conical with flat base and volcano-like summit, bearing oscular opening; lateral slopes of upper surface bearing closely spaced, radial slits (possible aporhyses) that do not reach osculum; skeletal net of hexactines in parallel arrangement and forming cubic mesh, but spicules not clearly organized into continuous, dictyonal strands as claimed by Fraipont, because there are instances of offsets in spicule series (see his fig. FN 132C–132D). [The upper surface of the sponge resembles that of the contemporaneous *Aglithodictya* Hall & Clarke, 1899, and the general canal and skeletal-net structure resembles that of other Frasnian genera in the family, particularly that of *Poriferella* Hurcewicz, 1985.] *Devonian (Frasnian):* Belgium.——Fig. 236,*2a–b. *P. fourmarieri,* Frasnian limestone, Villers-en-Fagne; *a,* drawing of characteristic fragment of skeletal net showing dictyonine structure, scale not given; *b,* drawing showing some irregularities in skeletal net, scale not given (Fraipont, 1911).

Superfamily DICTYOSPONGIOIDEA Hall & Clarke, 1899

[*nom. transl.* Finks, 1983b, p. 109, *ex* Dictyospongiidae Hall & Clarke, 1899, p. 52]

Reticulosa in which one or more layers of vertical and horizontal bundles of spicules (rhabdodiactines or other hexactine derivatives) are developed beneath dermal layer; dermal skeleton of hexactine derivatives usually differentiated into an outer (possibly autodermal) quadrate mesh of finer spicules and an inner (possibly hypodermal), quadrate mesh of coarser spicules of nested sizes; similar gastral layer, usually of finer spicules, may be developed; rarely both dermal and gastral layers may be suppressed; sponges almost always vasiform; root tuft with bidentate spicule terminations may or may not be present; comitalia of short, stout, curved strongyles and short-shafted, bidentate anchors frequently present; zigzag clemes may be present in root tufts and internal spicule bundles; tauactines and pinulelike spicules often present. *Ediacaran–Upper Triassic (Carnian).*

Family DICTYOSPONGIIDAE Hall & Clarke, 1899

[Dictyospongiidae Hall & Clarke, 1899, p. 52]

Thin-walled Dictyospongioidea with fine, autodermal and hypodermal, quadrate mesh of nested sizes of simple spicules; internal, vertical and horizontal bundles regularly and widely spaced; root tuft may be absent; dermal armor of closely spaced paraclavules may be developed; tripinuli in some genera. *Ediacaran–Permian (Roadian).*

Subfamily DICTYOSPONGIINAE Hall & Clarke, 1899

[Dictyospongiinae Hall & Clarke, 1899, p. 52]

Dictyospongiidae that are basically tubular with prism faces sometimes developed at top. *Ediacaran–Permian (Roadian).*

Dictyospongia Hall & Clarke, 1899, p. 72 [**Dictyophyton sceptrum* Hall, 1890b, p. 56; OD]. Sponge cylindrical, elongate, with narrow, conical base terminating in a root tuft; contracted slightly about osculum; surface smooth and unornamented except for usual quadrate, skeletal mesh that has relatively subdued differentiation into several orders of quadrule size; paraclavules, curved strongyles, and spinose hexactines reported from Mississippian species, otherwise spicules unknown except for root tuft, possible rhabdodiactines; incipient prism faces reported from upper end of larger specimen. [Pre-Upper Devonian species described by Hall and Clarke (1899) are not this genus or are not identifiable.] *Silurian (?Wenlock), Middle Devonian (?Givetian), Upper Devonian–Carboniferous (Lower Mississippian):* Canada (Northwest Territories, Cornwallis Island), *?Wenlock;* USA (Nevada), *?Givetian;* USA (New York, Indiana, ?Alabama), *Upper Devonian–Carboniferous (Lower Mississippian).*——Fig. 238,*2. *D. sceptrum* (Hall), Chemung Group, New York; side view of slender, nearly complete reference individual with circular, transverse section and characteristic, skeletal grid, UCC 13148B, ×0.5 (Hall & Clarke, 1899).

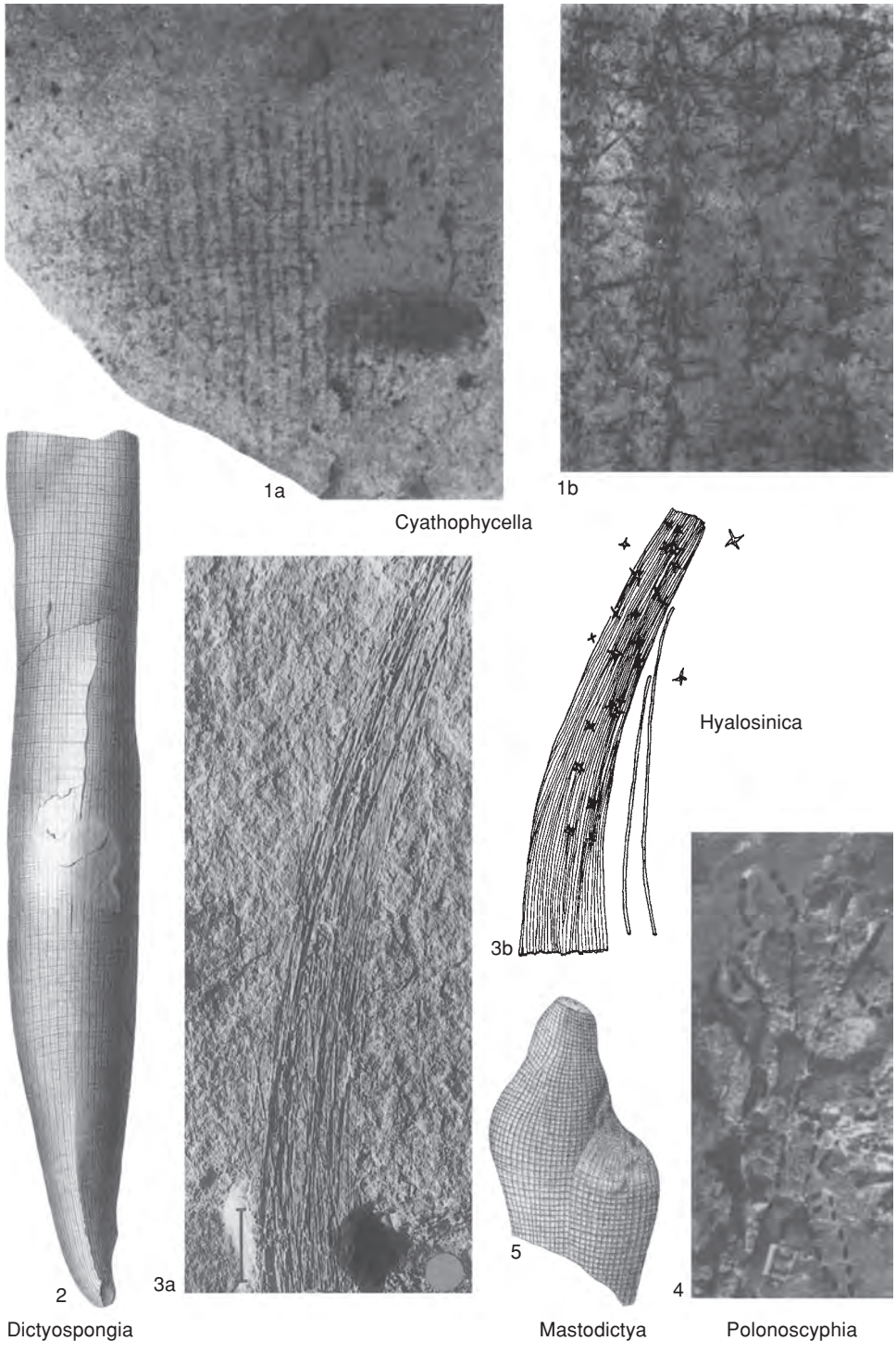


FIG. 238. Dictyospongiidae (p. 372–376).

Cyathophycella Rigby & Stuart, 1988, p. 135 [**C. quadrata;* OD]. Thin-walled dictyosponge with vertical and horizontal tracts composed of latticelike, rectangularly arranged hexactines and hexactine derivatives in ranked arrangements within individual skeletal tracts. *Silurian–Devonian:* USA (Nevada).——Fig. 238,*1a–b. *C. quadrata,* Roberts Mountains Formation, Independence Mountains; *a,* flattened holotype with slightly radiating, skeletal tracts cross connected by less continuous, horizontal ones, ×1; *b,* photomicrograph of upper center of holotype with vertical tracts of ranked stauractines and hexactines, USNM 415785, ×10 (Rigby & Stuart, 1988).

Dialyscyphia Hurcewicz & Czarniecki, 1986, p. 344 [**D. breviramosa* Hurcewicz & Czarniecki, 1986, p. 345; OD]. Cylindrical, branching; no cloaca; exhalant depression at apex of branch; exhalant canals concentrated in axial region and open on both sides and top; skeleton of parallel hexactines (pentactines at surface in nonquincuncial arrangement) such that primary quadrules are two ray lengths on a side and are subdivided by nine smaller hexactines having similar arrangement. *Carboniferous (Visean):* Poland.——Fig. 239,*2a–f. *D. breviramosa,* Carboniferous limestone, Galezice, Holy Cross Mountains; *a,* side view of holotype, ×1; *b,* transverse section of lower part showing inhalant canals (*a*) and axial, exhalant area (*b*), ×20; *c–f,* drawing of spicules from holotype and their distribution, *c,* outline of pores in skeletal network; *d,* scheme of spicule distribution; *e–f,* small and large hexactines, bar scale, 0.1 mm, AI-68/28 (Hurcewicz & Czarniecki, 1986; courtesy of Polish Geological Society, Krakow).

Dictyorhabdus Walcott, 1892, p. 165 [**D. priscus;* OD]. Fragments of tubelike sponge with bulbous swellings along one side, with thick walls of latticework skeleton. [Position in the family is uncertain.] *Ordovician:* USA (Colorado).——Fig. 239,*1a–b. *D. priscus,* Harding Sandstone, Middle Ordovician, Cañon City; *a,* side view of fragment with swellings on one side, ×3; *b,* photomicrograph of reticulate, skeletal structure, ×5 (Walcott, 1892).

Hyalosinica Mehl & Reitner in Steiner & others, 1993, p. 305 [**H. archaica;* OD]. Stalk and root tuft of coarse, anisoactine spicules with loosely twisted texture; small hexactines, stauractines, and pentactines are associated; body of sponge unknown except for a few triaxial spicules in proximal end of tuft. *lower Lower Cambrian–middle Lower Cambrian:* China (Anhui, Hunan).——Fig. 238,*3a–b. *H. archaica,* Niutitang Formation, Tommotian, Hunan; *a,* flattened, holotype stalk and root tuft of coarse, anisoactine, triaxial spicules, ×1 (Steiner & others, 1993); *b,* sketch of tuft and associated, small hexactines, pentactines, and stauractines, IPFUB San 109 A, B, ×1.5 (Mehl, 1996).

Lobospongia Hurcewicz, 1985, p. 280 [**L. varsovia;* OD]. Foliose, irregular; no cloaca; hexactines (pentactines in dermal layer) in nonquincuncial arrangement, so that quadrules are formed by two ray lengths; some hexactines have longitudinal rays that are longer than other rays. *Devonian (Frasnian):* Poland.——Fig. 239,*5a–d. *L. varsovia,* upper Frasnian limestone, Kowala; *a,* irregular, lobate holotype from side, ×1; *b–d,* spicules from holotype, including regular hexactines from parenchymal skeleton, pentactines from cortex, and network pattern of axial hexactines, MUZ IG 1501.II/15, ×25 (Hurcewicz, 1985; courtesy of Panstwowy Instytut Geologiczny, Warsaw).

Mastodictya Hall & Clarke, 1899, p. 167 [**Dictyospongia (Mastodictya) osculata;* OD]. Sponge small, seemingly fusiform, but incomplete at each end; orientation not clear; examination of specimen suggests that supposed oscula of Hall and Clarke may be broken parts, that narrowest part may be basal apex, and supposed second protuberance an irregularity partly covered with matrix; skeletal net consisting of very small stauractines or pentactines of at least three orders of size, largest with overlapping rays and possibly accompanied by smaller comitalia (possible rhabdodiactines); a few of larger spicules with knoblike, distal ray; skeletal net locally slightly irregular and curved to follow outlines of body; Hall and Clarke reported paraclavules and curved strongyles. [This may be a young sponge of another species, but the fusiform shape seems distinctive.] *Carboniferous (Lower Mississippian):* USA (Indiana).——Fig. 238,*5. *M. osculata* (Hall & Clarke), Keokuk Group, Crawfordsville; side view of small sponge with complete oscular margin, but broken at base, NYSM, ×1 (Hall & Clarke, 1899).

Microstaura Finks, 1960, p. 103 [**M. doliolum;* M]. Sponge barrel-shaped to cylindrical and subprismatic; wall thick, composed of cubic mesh of very small hexactines (pentactines at outer and cloacal surfaces) of up to three orders of size, at least at surface, with largest having overlapping rays; possible internal, vertical bundles of rhabdodiactines; root tuft not certainly known; osculum and cloaca broad, but sponge generally contracting toward oscular opening. [This is similar to a short, thick-walled *Dictyospongia*.] *Permian (Artinskian–Roadian):* USA (Texas).——Fig. 240,*3a–c. *M. doliolum,* ?Word Formation, Leonardian, Glass Mountains; *a,* side view of holotype showing its general form, with a crushed osculum at top and silicified skeleton on flattened side, ×2; *b,* magnified view of part of dermal surface with skeleton mainly of pentacts, mostly of one size, with overlapping rays, USNM 127648, ×10; *c,* silicified, skeletal net fragment of paratype showing cubic arrangement of simple, overlapping hexactines in wall interior, USNM 127649d, ×10 (Finks, 1960; courtesy of The American Museum of Natural History).

Ozospongia Clarke, 1918, p. 185 [**O. johnstoni;* OD]. Sponge begins as slender, cylindrical stalk that branches upwardly one or more times, each branch expanding into a fusiform or club-shaped body that contracts toward osculum; surface bearing closely spaced, longitudinal ridges, sometimes

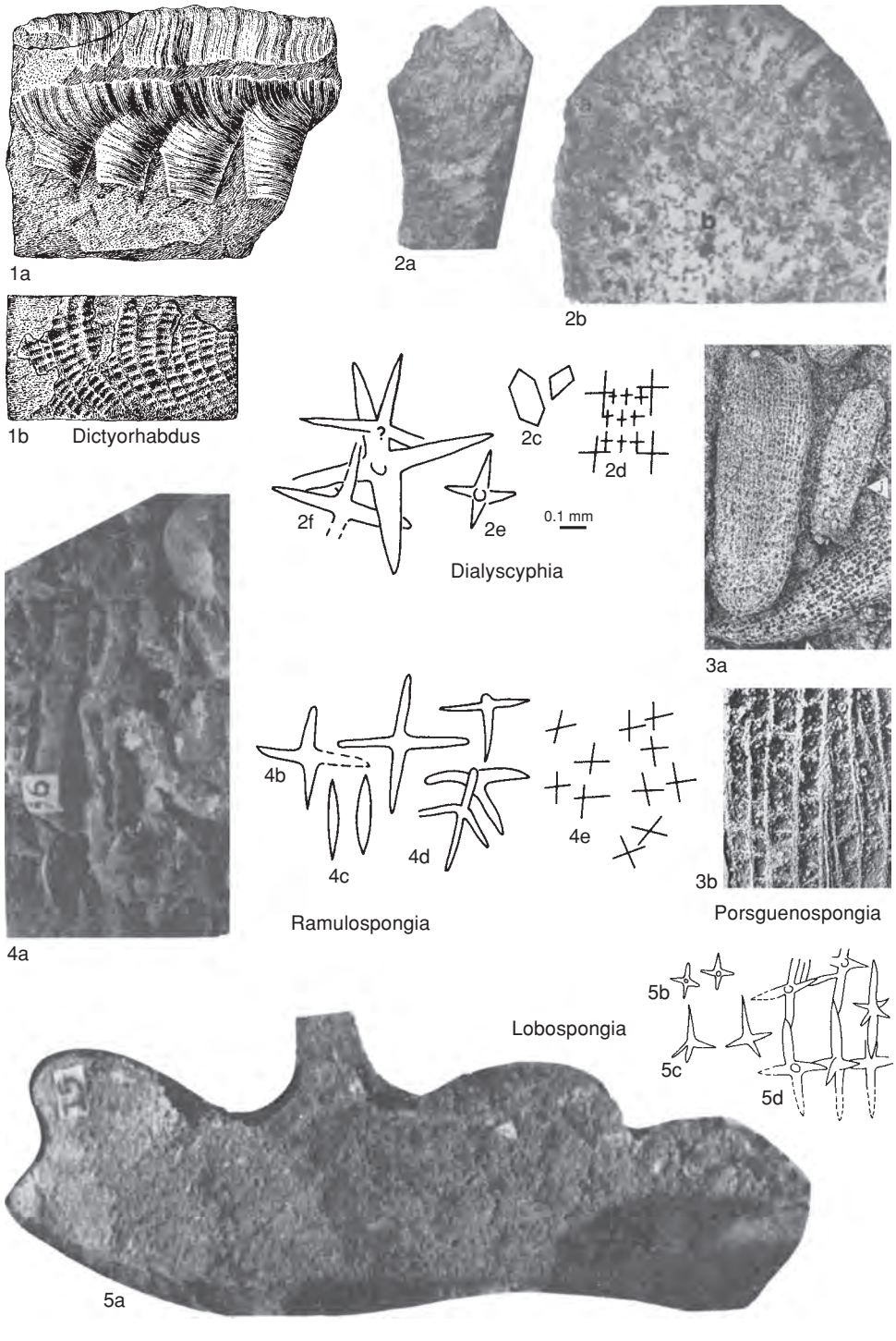


FIG. 239. Dictyospongiidae (p. 374–376).

irregular or discontinuous; they are crossed by less prominent horizontal ridges, producing coarse quadrules reminiscent of *Thysanodictya* or *Clathrospongia;* spicules not known. *Upper Devonian:* USA (New York); ?Poland, *Frasnian.*——Fig. 241. **O. johnstoni,* Chemung Sandstone, Upper Devonian, Hinsdale, New York; side view of plaster case of natural mold of branched holotype showing growth form and reticulate skeleton, New York State Museum, ×1 (Clarke, 1918; courtesy of New York State Museum, Albany).

Palaeophragmodictya Gehling & Rigby, 1996, p. 188 [**P. reticulata;* OD]. Convex disc- to hemispherical-shaped sponges with reticulate skeleton where straight, radial tracts and laterally perpendicular, concentric tracts combine to produce rectangular, dictyosponge-appearing, skeletal structure; principal disc surrounded by peripheral frill marked by radial ridges that appear to be extensions of reticulate net of main disc. [The genus is questionably included here because of its gross morphology and reticulate, quadrate, skeletal structure. The fossils, however, consist largely of three-dimensional impressions without clearly identifiable individual spicules. These are the oldest dictyosponges and the oldest body fossils of sponges known.] *Ediacaran:* South Australia.——Fig. 242*a–c.* **P. reticulata,* Ediacara Member, Rawnsley Quartzite, Chase Range; *a,* silicone rubber cast of flattened holotype with mesh on right surrounded by frill impression, SAM P32324a, ×0.8; *b,* flattened paratype with anastomosing ridges and surrounding frill, SAM P32325, ×0.8; *c,* generalized restorations and flattened impressions, not to scale (Gehling & Rigby, 1996).

Phormosella Hinde, 1888, p. 125 [**P. ovata;* M]. Small, ovoid sponges without apparent osculum or root tuft; spicules stauractines or pentactines of three size orders, the largest arranged regularly so as to produce quadrules parallel to longitudinal axis of sponge. [The smaller spicules were said to be irregularly arranged, thus distinguishing this from *Protospongia,* but illustrations show only a slight disarray that does not obscure an arrangement into three size orders of quadrules. The genus is possibly a synonym of *Dictyophytra* and *Prismodictya* (*q.v.*).] *Silurian (Ludlow):* England.——Fig. 240,*2a–b.* **P. ovata,* Ludlow strata, Shropshire; *a,* impressions of nine sponges of species, holotype, ×1; *b,* enlargement of part of one sponge showing spicule structure of wall, British Geological Survey Museum, ×5 (Hinde, 1887b).

Polonoscyphia Hurcewicz, 1985, p. 279 [**P. delicatula* Hurcewicz, 1985, p. 280; OD]. Sponge small, obconical, thin walled with deep cloaca; spicules unconnected triactines. *Devonian (Frasnian):* Poland.——Fig. 238,*4.* **P. delicatula,* upper Frasnian limestone, Kowala; side view of thin-walled holotype, MUZ IG 1501.II/11, ×1 (Hurcewicz, 1985; courtesy of Panstwowy Instytut Geologiczny, Warsaw).

Porsguenospongia Pickett & Plusquellec, 1998, p. 718 [**P. lejalnicolae;* OD] [=*Platyphyllum* Lejal-Nicol, 1976, p. 341, obj.]. Small, cylindrical to vasiform, thin-walled dictyosponges with rounded base; oscular margin without supplementary spicules; skeletal net with long stauractines and oxeas grouped into prominent, primary, vertical tracts that are cross connected by continuous, less robust horizontal tracts; openings between primary tracts subdivided by smaller, more discontinuous, second- and third-order tracts. *Devonian (Famennian):* France.——Fig. 239,*3a–b.* **P. lejalnicolae,* Famennian II, Schistes de Porsquen, Brest; *a,* type sponges in latex cast, ×1; *b,* enlarged part of skeletal net showing long rays in vertical bundles and some shorter horizontal rays of stauractines in spaces between, approximately ×5 (Pickett & Plusquellec, 1998; courtesy of *Geobios*).

Ramulospongia Hurcewicz, 1985, p. 279 [**R. rasus;* OD]. Thin branches without cloaca; spicules hexactines, pentactines, stauractines, tauactines, and rhabdodiactines in parallel orientation. *Devonian (Frasnian):* Poland.——Fig. 239,*4a–e.* **R. rasus,* upper Frasnian limestone, Kowala; *a,* side view of branched holotype, ×1; *b–d,* outlines of spicules from holotype, parenchymal skeleton, cortex, and associate fusiform diactines; *e,* sketch of spicule positions in cortex, MUZ IG 1501.II/56, ×25 (Hurcewicz, 1985; courtesy of Panstwowy Instytut Geologiczny, Warsaw).

Repospongia Hurcewicz & Czarniecki, 1986, p. 347 [**R. carbonaria* Hurcewicz & Czarniecki, 1986, p. 348; OD]. Colonies broadly conical to discoidal with depressed, upper surface, composed of small, hollow, ellipsoidal individuals that branch from one another in spiraling panicles, their hollow interiors being serially connected; spicules small hexactines of two sizes in parallel orientation, with stauractines at surface. *Carboniferous (Visean):* Poland.——Fig. 243,*1a–c.* **R. carbonaria,* Carboniferous limestone, Culm of Orlej, southern Poland; *a,* top view of holotype showing branched form, ×1; *b,* section through individual branch, ×10; *c,* drawings of spicules from thin section, showing small and large hexactines, AI-68/47, bar scale, 0.1 mm (Hurcewicz & Czarniecki, 1986; courtesy of Polish Geological Society, Krakow).

Retifungus Rietschel, 1970, p. 31 [**R. rudens;* M]. Upper portion resembling *Prismodictya,* fusiform and eight sided; lower portion long and tubular passing into long, twisted root tuft; spicules include rhabdodiactines of various sizes and possibly stauractines, pentactines, and hexactines in quadrules of main body; root tuft strands appear to pass upwardly into body as regularly spaced, vertical, spicule bundles. *Devonian (Pragian):* Germany.——Fig. 240,*1a–c.* **R. rudens,* Siegenian, Hunsrückshiefer, Hunsrück; *a,* upper end of holotype stalk with lower end of reticulate sponge, SMF 19992, ×1; *b,* upper end of paratype showing twisted spicules of long root stalk, ×0.5; *c,* restoration of long root stalk and upper sponge body, approximately ×0.25 (Rietschel, 1970).

Sanshadictya Mehl & Reitner in Steiner & others, 1993, p. 304 [**S. microreticulata;* OD]. Sponges

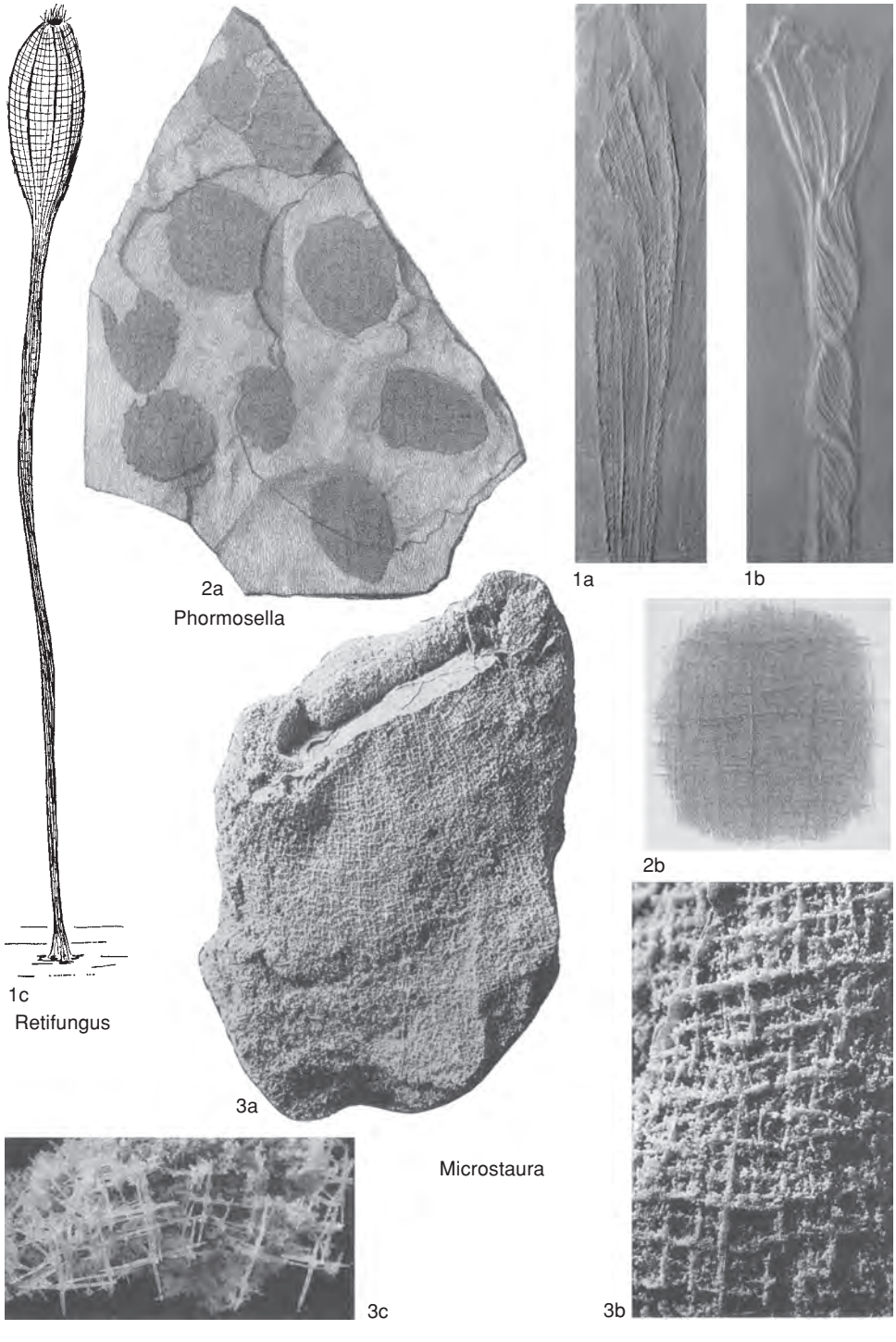


FIG. 240. Dictyospongiidae (p. 374–376).

Ozospongia

FIG. 241. Dictyospongiidae (p. 374–376).

with a skeleton of regular, rectangularly arranged, parallel bundles of thin diactines and stauractines, with at least three orders of very fine quadrules; may have had anchoring spicules. [Fragments of the reticulate sponge document that development of dictyosponge skeletal structure had taken place by the Early Cambrian.] *Lower Cambrian:* China (Hunan).——FIG. 243,*2a–b. *S. microreticulata,* Niutitang Formation, Tommotian; *a,* flattened holotype fragment of reticulate bundles of diactines and stauractines, ×1.5 (Steiner & others, 1993); *b,* sketch of holotype interpreting bundles and presence of stauractines in upper right, IPFUB San 117, ×5 (Mehl, 1996).

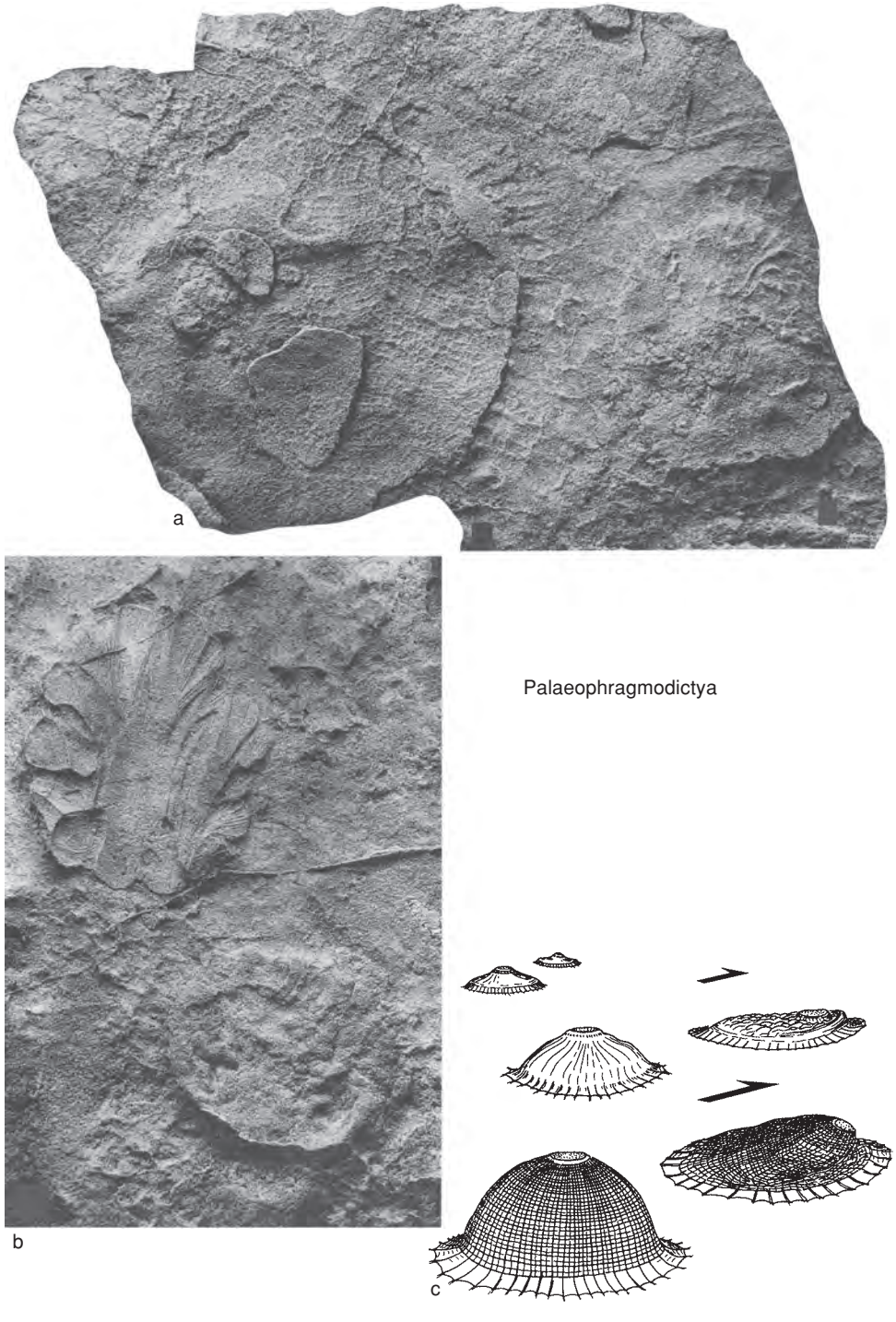


Fig. 242. Dictyospongiidae (p. 376).

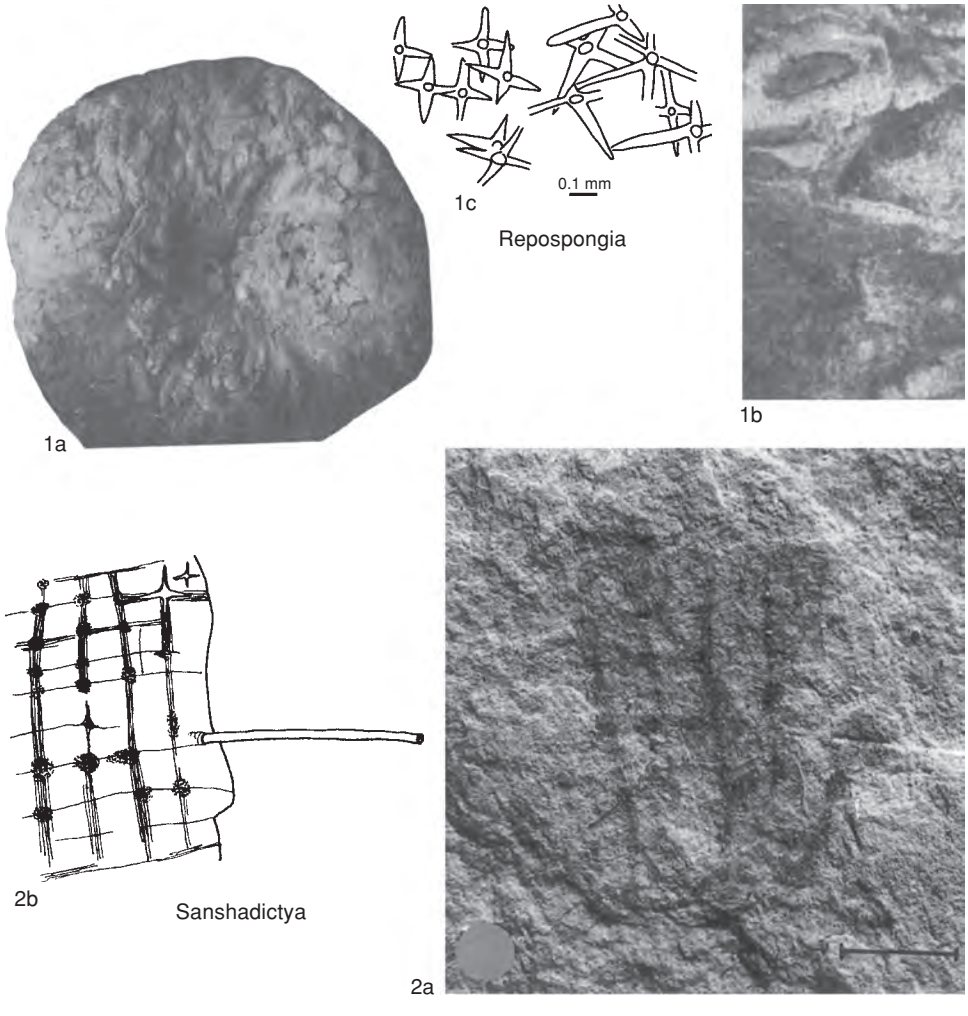


FIG. 243. Dictyospongiidae (p. 376–378).

Subfamily PRISMODICTYINAE de Laubenfels, 1955

[Prismodictyinae DE LAUBENFELS, 1955, p. 74]

Dictyospongiidae with well-developed prism faces and no protuberances. [These are one of the earliest and presumably most primitive groups of the dictyosponges.] *Upper Ordovician–Carboniferous (Serpukhovian).*

Prismodictya HALL & CLARKE, 1899, p. 79 [**Dictyophyton telum* HALL, 1884, p. 470; OD] [=*?Dictyophyton* HALL, 1863, p. 87 (type, *D. filitextile* HALL, 1863, p. 88, SD MILLER, 1889, p. 158), *nom. oblit.; ?Phormosella* HINDE, 1887b, pl. 3,*2;* HINDE, 1888, p. 125 (type, *P. ovata,* M), *nom. oblit.; ?Dictyophytra* RAUFF, 1894, p. 249 (type, *Tetragonis danbyi* M'COY, 1855, p. 62, M), *nom. oblit.; ?Helicodictya* HALL & CLARKE, 1899, p. 114 (type, *H. trypania,* OD); *?Ithacadictya* CASTER, 1939, p. 16 (type, *I. cornelli,* M)]. Sponge prismatically conicocylindrical to strongly fusiform, often contracting toward aperture as well as having a pointed base; generally light prism faces, each often slightly concave with interfacial angles sharp; some individuals with spiral twisting of prism faces about longitudinal axis; *Helicodictya* here considered to be based on extreme examples of such twisting, and to be, therefore, a junior synonym of *Prismodictya.* Spicules unknown (traces of simple stauractines or pentactines of the usual orders of size are preserved

in somewhat doubtful Mississippian *P. polyhedra,* as well as in the Silurian *Phormosella*); net composed of usual quadrules of several orders of size, although differences in widths of outlining ridges not strongly marked; neither root tufts, lateral tufts, nor apertural fringes are known. [The type of *Dictyophyton* HALL, 1863, appears to be a species of *Prismodictya,* as does the type of *Dictyophytra* RAUFF, 1894, and possibly also that of *Phormosella* HINDE, 1887b. All three genera are senior to the better-known *Prismodictya,* but they have not, to my knowledge (RMF), been used in this sense during the past fifty years. They are treated here as *nomina oblita.*] *upper Silurian–Upper Devonian, Carboniferous (?Lower Mississippian):* England, USA (New York, Pennsylvania, ?Indiana).——FIG. 244,*3*. **D. telum* (HALL), Chemung Group, Upper Devonian, Wellsville, New York; side view of characteristic specimen with prismatic, transverse section and typical, reticulate, skeletal grid, NYSM, ×1 (Hall & Clarke, 1899).

?Dictyophyton HALL, 1863, p. 87 [**D. filitextile* HALL, 1863, p. 88; SD MILLER, 1889, p. 158]. The type specimen, as described and illustrated by HALL and CLARKE (1899, pl. 21,*7*), appears to be a rather straight-sided *Prismodictya* with subdued and convex prism faces. [If so, *Dictyophyton* would then be a senior synonym of *Prismodictya* HALL & CLARKE, 1899. We believe *Dictyophyton* should be suppressed as a *nomen oblitum* under the *Code* (ICZN, 1999).] *Devonian (Frasnian):* USA (New York).

?Dictyophytra RAUFF, 1894, p. 249 [**Tetragonis danbyi* M'COY, 1855, p. 62; M]. [Although apparently intended as a so-called correction of the name *Dictyophyton* HALL, 1863, the only species definitely referred to it by RAUFF was the Silurian *Tetragonis danbyi* M'COY, 1855, which thereby becomes the type by monotypy. (Another new species, *D. (?) walcotti* RAUFF, 1894, Upper Ordovician, was referred to it with a query. That species is not generically assignable.) The name is, thus, available for a genus that includes M'COY's species. Examination of the type specimens shows that they are indistinguishable from *Prismodictya.* This species is not *Dictyospongia* as concluded by HALL and CLARKE (1899). There is a possibility that *D. danbyi* is also conspecific, or at least congeneric, with the type of *Phormosella* HINDE, 1887b, which is very nearly contemporaneous and sympatric. *Dictyophytra* is, thus, a senior subjective synonym of *Prismodictya* HALL & CLARKE, 1899, and possibly a junior subjective synonym of *Phormosella* HINDE, 1887b. *Dictyophytra* qualifies as a *nomen oblitum* under the *Code* (ICZN, 1999). See discussion under *Prismodictya,* above.] *Silurian (Ludlow):* England.——FIG. 245,*2a–b*. **D. danbyi* (M'COY), upper Ludlow beds, Kendal; *a,* side view of cast of small type with reticulate skeleton, ×1; *b,* enlarged part of surface showing quadruled skeletal structure, WMC, ×5 (Rauff, 1894).

?Helicodictya HALL & CLARKE, 1899, p. 114 [**H. trypania;* OD]. Resembles a *Prismodictya* in which prism faces have been spirally twisted about longitudinal axis of sponge, with a helical angle of 45° or more to axis. [The genus is here considered to be a possible junior synonym of *Prismodictya.*] *Devonian (Frasnian):* USA (New York, Pennsylvania).——FIG. 244,*1*. **H. trypania,* Chemung Group, Senecan, Wellsville, New York; side view of holotype with helical ridges parallel to one of reticulate, spicule series, ×1 (Hall & Clarke, 1899).

?Ithacadictya CASTER, 1939, p. 16 [**I. cornelli;* OD]. The characters cited as distinguishing this genus from *Prismodictya,* namely, the small size, comparatively weak, secondary reticulation (nevertheless, four orders of quadrule size are recognized), and nearly isotelous shape, are not considered here to be significant at the generic level; genus is, therefore, treated as a possible junior synonym of *Prismodictya. Devonian (Frasnian):* USA (New York).

Norfordia RIGBY & HARRIS, 1979, p. 976 [**N. gabrielsei;* OD]. Small, conicocylindrical, thin-walled sponge with pointed base and root tuft, sponge widest at oscular end and with deep, simple spongocoel; skeletal net of irregular tracts and bundles of principally diactine spicules (rhabdodiactines or oxeas) arranged in vertical bundles cross connected by less distinct, horizontal bundles forming rectangular net in which quadrules twice as high as wide; oscular margin unornamented; entire surface blanketed by mainly vertically arranged diactines of thin (possibly dermal) layer. [The genus is placed here because of its rectangular net and thin walls of prominent tracts, even though hexactines have not been clearly identified in the only moderately well-preserved type specimen, where most spicules are broken. A possible placement as a demosponge resembling the heliospongiids is a less likely alternative.] *Silurian (Llandovery)–Carboniferous (Serpukhovian):* Canada (British Columbia), *Llandovery–Wenlock;* USA (Montana), *Serpukhovian.*——FIG. 244,*2a–b*. **N. gabrielsei,* unnamed Silurian siliceous siltstone, Llandovery–Wenlock, near Ware, British Columbia, Canada; *a,* side view of small, flattened, cylindrical holotype with rectangularly arranged, skeletal net of ropy tracts; ×2; *b,* enlarged view of middle part of sponge showing vertical bundles of diactines cross connected by horizontal bundles, GSC 60644, ×3 (Rigby & Harris, 1979).

Tiddalickia RIGBY & WEBBY, 1988, p. 77 [**T. quadrata* RIGBY & WEBBY, 1988, p. 78; OD]. Thin-walled skeleton of rectangularly arranged straps principally of monaxons or rhabdodiactines but with moderately large stauracts and rare hexactines at strap junctions; horizontal straps apparently distal; radial straps absent; dermal layer thin, of irregular hexactines; one order of reticulate straps developed, quadrules not subdivided into smaller units. [The genus is placed within the Prismodictyinae with some question because only a fragment is known, and the shape of the sponge or skeletal details of other parts are uncertain.] *Upper Ordovician:* Australia (New South Wales), Canada (Manitoba).——

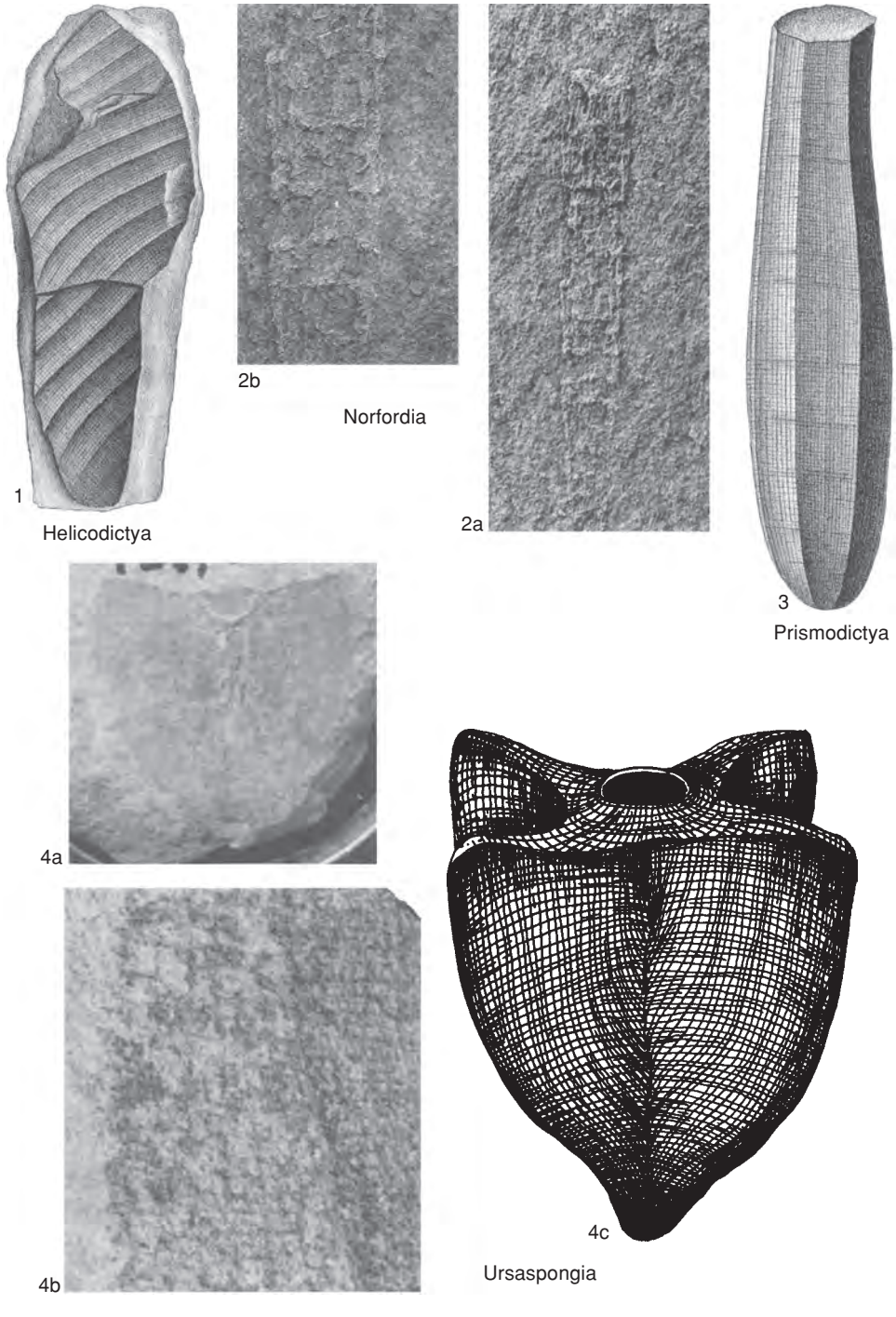


FIG. 244. Dictyospongiidae (p. 380–384).

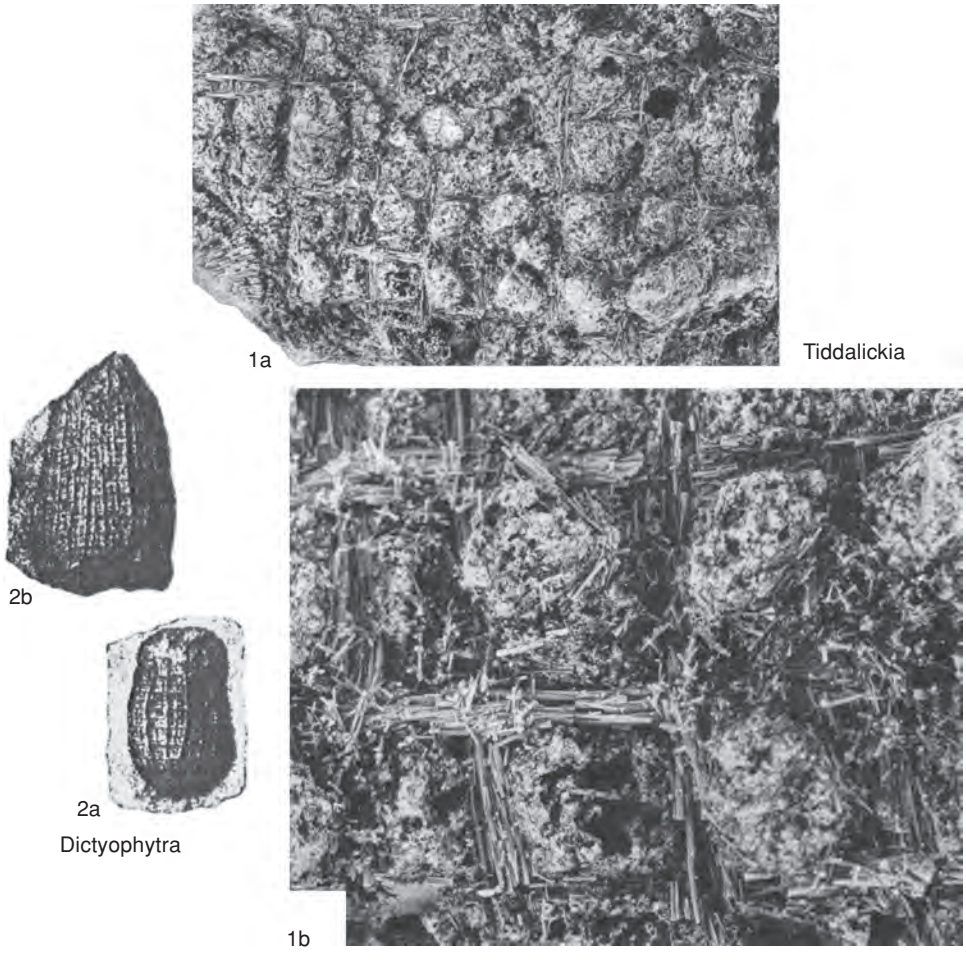


FIG. 245. Dictyospongiidae (p. 381–383).

FIG. 245,*1a–b. *T. quadrata,* Malongulli Formation, Caradoc–Ashgill, Cliefden Caves area, New South Wales; *a,* most of holotype showing rectangularly arranged spicule straps and spiculiferous matrix into which straps are impressed, ×2; *b,* photomicrograph of skeletal net with straps composed of monaxons or rhabdodiactines but with large stauracts at strap junctions; dermal layer, if present, was probably composed of small, irregular hexactines like those in intervening quadrangles, AMu. F66895, ×8 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Ursaspongia RIGBY, 1986c, p. 451 [**U. tulipa;* OD]. Small to medium size, thin walled, unbranched prismodictyids with upwardly expanding, indented, X-shaped cross section, with rounded base and circular, restricted osculum at top of simple, deep spongocoel; skeletal net of hexactines and hexactine-derived simple spicules, in narrow bundles or tracts arranged horizontally and vertically in rectangular pattern in side walls but radially and concentrically around oscular margin in sharply inwardly flexed top; horizontal tracts straight across in juvenile forms but upwardly arcuate in larger adult forms; irregularly preserved, secondary bundles subdividing primary quadrules into smaller rectangles; much of skeleton may be bundles of monaxons; dermal layer ill defined. *Carboniferous (Serpukhovian):* USA (Montana).——FIG. 244,*4a–c. *U. tulipa,* Heath Formation, Fergus County; *a,* side view of flattened holotype showing smooth walls and rounded base of sponge with regular, skeletal net, UMG 5718, ×1; *b,* photomicrograph of skeletal net with moderately well defined horizontal and vertical bundles of hexactine-based spicules of paratype, UMG 5720, ×10; *c,* generalized

restoration showing shape of sponge, rounded osculum and regular skeletal net, approximately ×2 (Rigby, 1986c).

Subfamily HYDNOCERATINAE new subfamily

[Hydnoceratinae Finks & Rigby, herein] [type genus, *Hydnoceras* Conrad, 1842, p. 267]

Conicocylindrical Dictyospongiidae with annular expansions that may bear quite large protuberances; if prism faces are present, the protuberances are at interfacial angles. [This group may have arisen from the Prismodictyinae by development of annular expansions and protuberances.] *Middle Cambrian–Carboniferous (Lower Mississippian).*

Hydnoceras Conrad, 1842, p. 267 [**H. tuberosum;* M]. Sponge conicocylindrical with alternating, annular expansions and contractions; each expansion bearing a whorl of generally eight nodes, or four double nodes, of varying degrees of protrusion that range from simple, conical bumps to pendulous, saccular protuberances resembling those of *Botryodictya;* on forms with low nodes, a conspicuous vertical ridge, which probably corresponds to an internal spicule bundle, connects each vertical series of nodes and causes sponge to resemble a nodose *Prismodictya;* each node may bear a protruding tuft of spicules; nodes are subdued or missing near apex; skeletal net a quadrate mesh of five orders of size of squares, each smaller size being outlined by progressively smaller sizes of ridges, as in most dictyosponges; largest quadrule about a centimeter wide, each order about half as wide as next larger order; spicules not known, but on basis of other dictyosponges, it is likely that net consisted of parallel stauractines or pentactines, whose ray lengths equaled widths of quadrules, largest quadrule outlined by overlapping rays, the rest not, and with rhabdodiactine bundles underlying each sets of rays; occasional malformations of net show by curving bands that a linear series of spicules was fundamental unit of construction, rather like dictyonines. [Not only does *Hydnoceras* represent a middle ground between *Prismodictya* and *Botryodictya* (=*Tylodictya*), it could also be considered a nodose *Ceratodictya* (of which *Rhabdosispongia* may be an internal, poorly preserved mold) as well as a more regular *Hydnocerina* or *Clepsydrospongia,* although these genera differ from *Hydnoceras* in having a more uniform, fine quadrate mesh. *Cleodictya,* too, is like a *Hydnoceras* with one whorl of nodes.] *Upper Devonian:* USA (New York), France.——Fig. 246,*3. *H. tuberosum,* Chemung Group, Senecan, reported to have come from near Cohocton, New York; side view of plaster cast of holotype, ×0.5 (Hall & Clarke, 1899).

Botryodictya Hall & Clarke, 1899, p. 111 [**Dictyophyton ramosum* Lesquereux, 1884, p. 827; OD] [=*Tylodictya* Hall & Clarke, 1899, p. 151 (type, *T. warrenensis,* OD)]. Sponge composed of smooth, cylindroid stalk surmounted by an abruptly wider cylindroid body whose wall bears horizontal and vertical rows of long, saccular, pendulose protuberances that may bifurcate or quadrifurcate; diaphragm may separate body from stalk; skeletal net fine meshed with small, parallel stauractines or pentactines, and with larger pentactines or horizontal and vertical, spicule bundles outlining slightly larger quadrules; vertical bundles have a radial arrangement on diaphragm; stalk has same kind of skeletal net as body. *Devonian (Frasnian)–Carboniferous (Lower Mississippian):* USA (Pennsylvania).——Fig. 246,*1. *B. ramosa* (Lesquereux), Chemung Group, Upper Devonian, Lawrenceville; side view of nearly complete sponge with cylindrical, basal stalk and nodose, upper cup, NYSM, ×0.5 (Hall & Clarke, 1899).

Ceratodictya Hall & Clarke, 1899, p. 117 [**Dictyophyton annulatum* Hall, 1863, p. 90; OD]. Sponge conicocylindrical and elongate, bearing transverse annular expansions and contractions; in some species alternate contractions are broader and deeper, causing expansions to be grouped in pairs; surface otherwise smooth and quadrate mesh uniformly fine; spicules not known. *Devonian (Frasnian):* USA (New York, Pennsylvania).——Fig. 246,*2a–b. *C. annulata* (Hall), Senecan, Chemung Group; *a,* side view of holotype with regular annulations and reticulate skeleton, western New York state, locality lost; *b,* side view of larger specimen with less pronounced annulations, Upper Devonian, Naples, New York, NYSM, ×1 (Hall & Clarke, 1899).

Cleodictya Hall, 1884, p. 467 [**C. gloriosa* Hall, 1884, p. 479; OD]. Cylindroid, expanding from possible flat base to an equatorial whorl of low, rounded nodes, thence generally contracting, but expanding again slightly to oscular rim; external, dermal armor of closely packed paraclavules (head ends outwardly) overlying a layer of small stauractines or pentactines that form primary, skeletal mesh; comitalia of fine, possible rhabdodiactines; beneath this outer layer is a layer of vertical bundles over a layer of similar, horizontal bundles of long, possible rhabdodiactines, each spicule paralleled by smaller comitalia of same form; bundles parallel each row of stauractines of outer mesh, but every few bundles are thicker with bigger spicules, and these outline larger quadrules of reticulum. [Spicular structure described herein is based on personal examination (RMF) of the holotype of *C. mohri* Hall & Clarke, 1899. In addition to the spicules cited above, Hall and Clarke (1899, p. 184 ff.) reported from the same species: smooth and spinose hexactines, tripinules, clemes, anadiaenes, various irregular spicules (see their p. 186, fig. 37,*14–15*), and possible exfoliated spicule rays (their p. 186, fig. 36,*4* and 37,*17.*] *Carboniferous (Lower Mississippian):* USA (Indiana, Ohio).——Fig. 247*a. C. claypolei* Hall

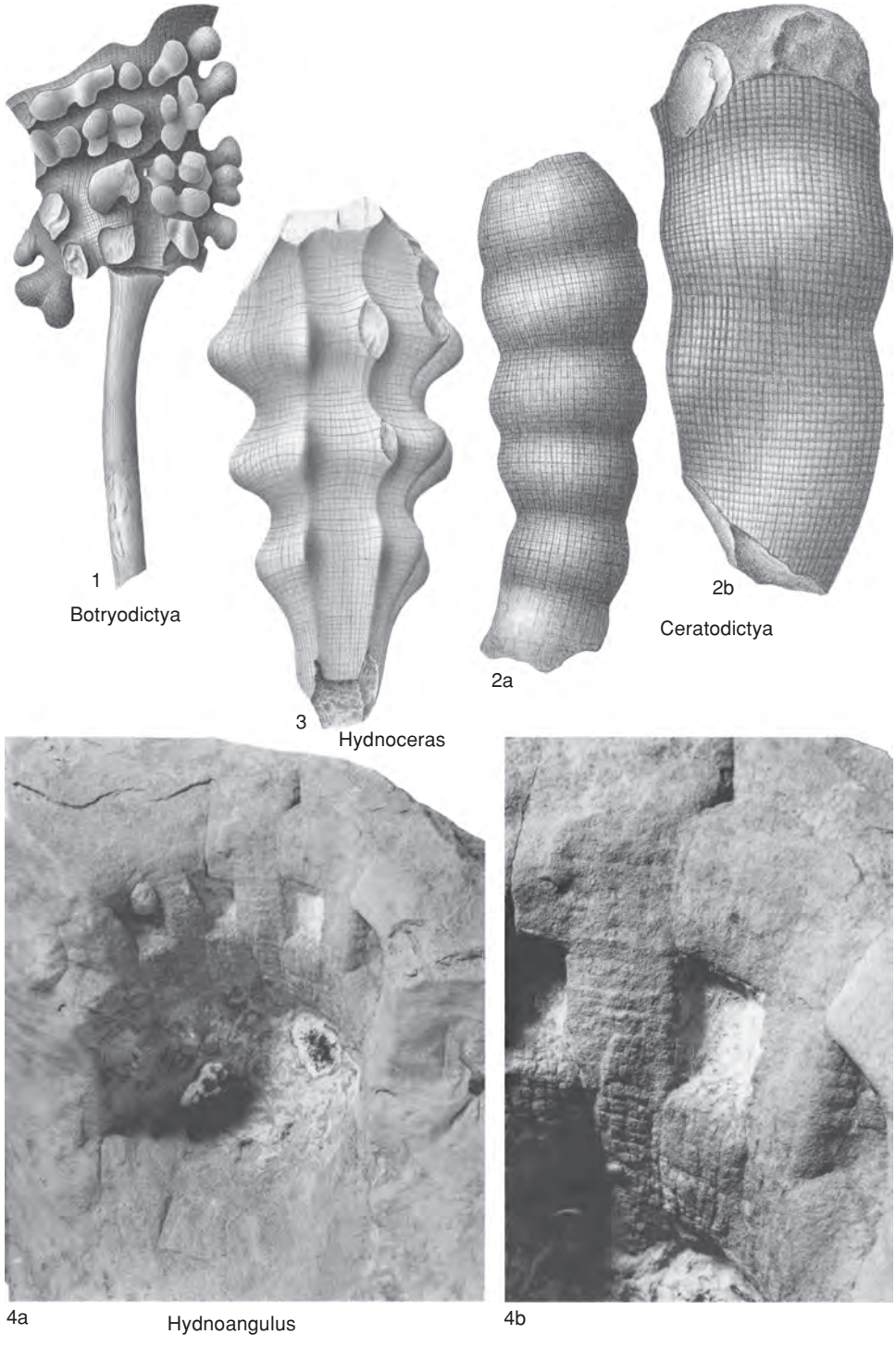


FIG. 246. Dictyospongiidae (p. 384–389).

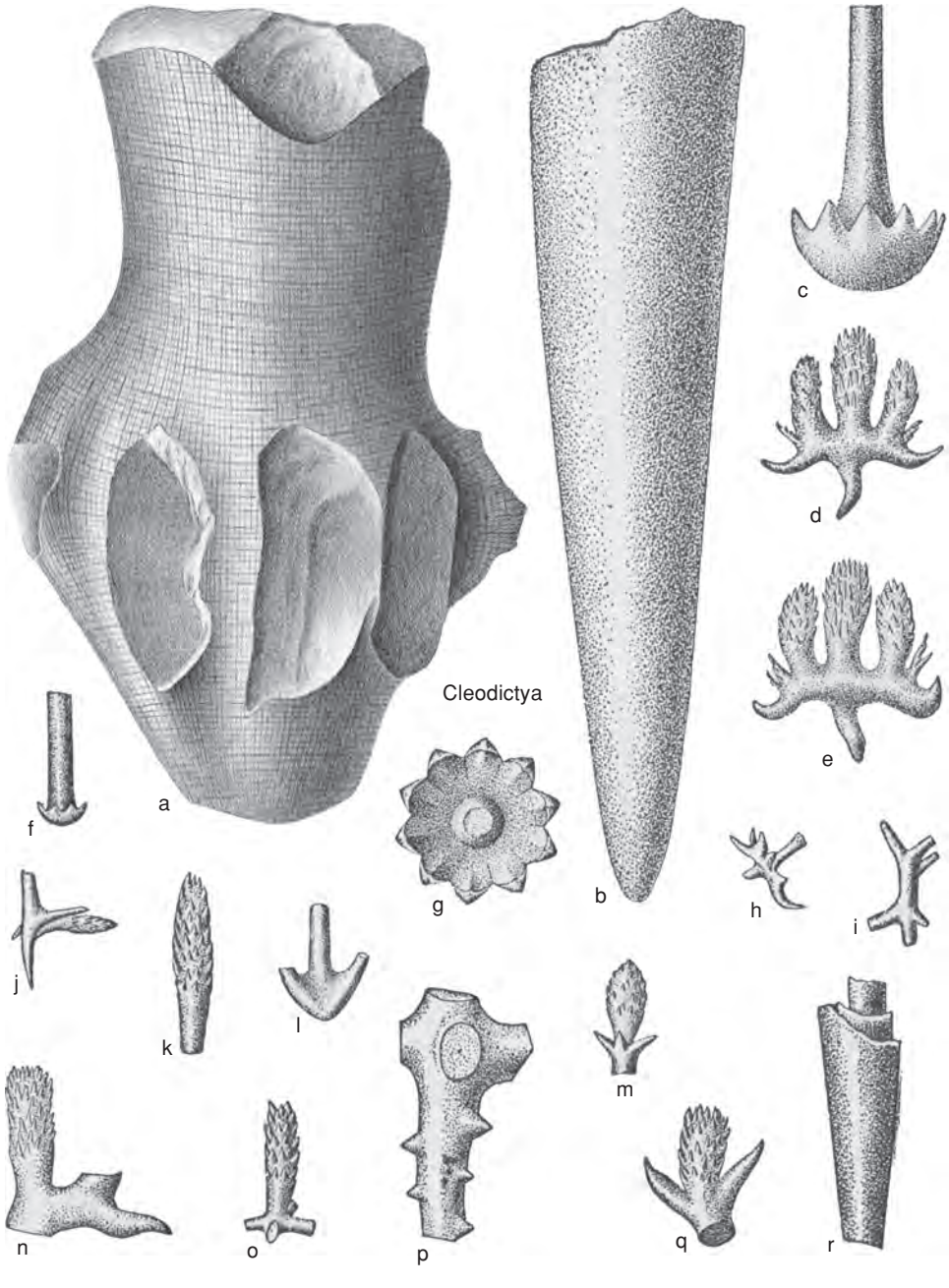


FIG. 247. Dictyospongiidae (p. 384–386).

& CLARKE, Waverly Group, Kinderhookian–Osagean, Akron, Ohio; side view of vase-shaped sponge with lower ring of prominent nodes and expanded oscular area, ×1 (Hall & Clarke, 1899).——FIG. 247*b–r.* isolated spicules of *C. mohri* HALL & CLARKE, ×400 (Hall & Clarke, 1899).

?Clepsydrospongia HALL & CLARKE, 1899, p. 71 [**C. matutina;* OD]. Sponge cylindroid, contracted in middle; top and bottom not preserved; contracted

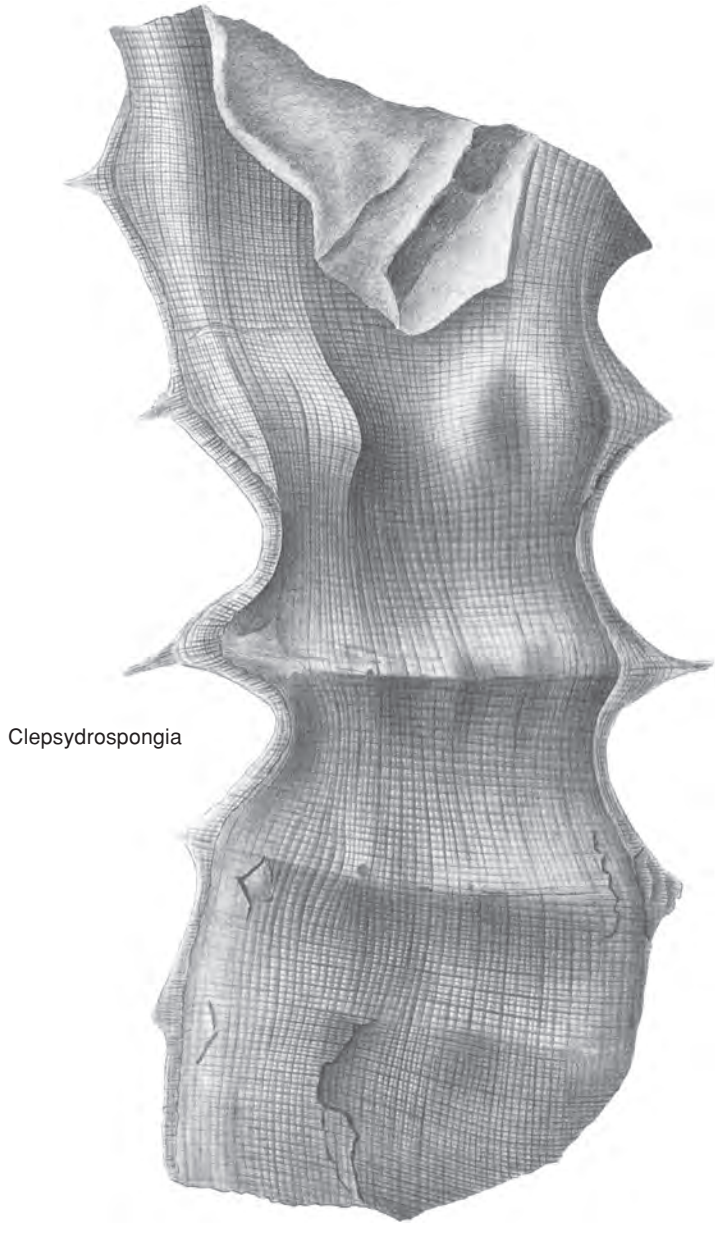


FIG. 248. Dictyospongiidae (p. 386–387).

portion bearing alternate, annular swellings and contractions, with swellings each bearing a single series of low, rounded nodes with a protruding, spicular tuft. Spicular net fine, uniform, quadrate mesh; spicules not known. [This may be an aberrant *Hydnoceras* or *Hydnocerina.*] *Devonian (Frasnian):* USA (New York).——FIG. 248. **C. matutina,* Senecan, Portage Group, Naples; side view of holotype with contracted, median, nodose area and with spicule tufts on nodes, ×1 (Hall & Clarke, 1899).

Hydnoangulus RIGBY & AUSICH, 1981, p. 377 [**H. quadratus* RIGBY & AUSICH, 1981, p. 378; OD]. Thin-walled, lotuslike to upwardly expanding and flaring funnel-shaped or goblet-shaped dictyosponge, with generally smoothly circular cross

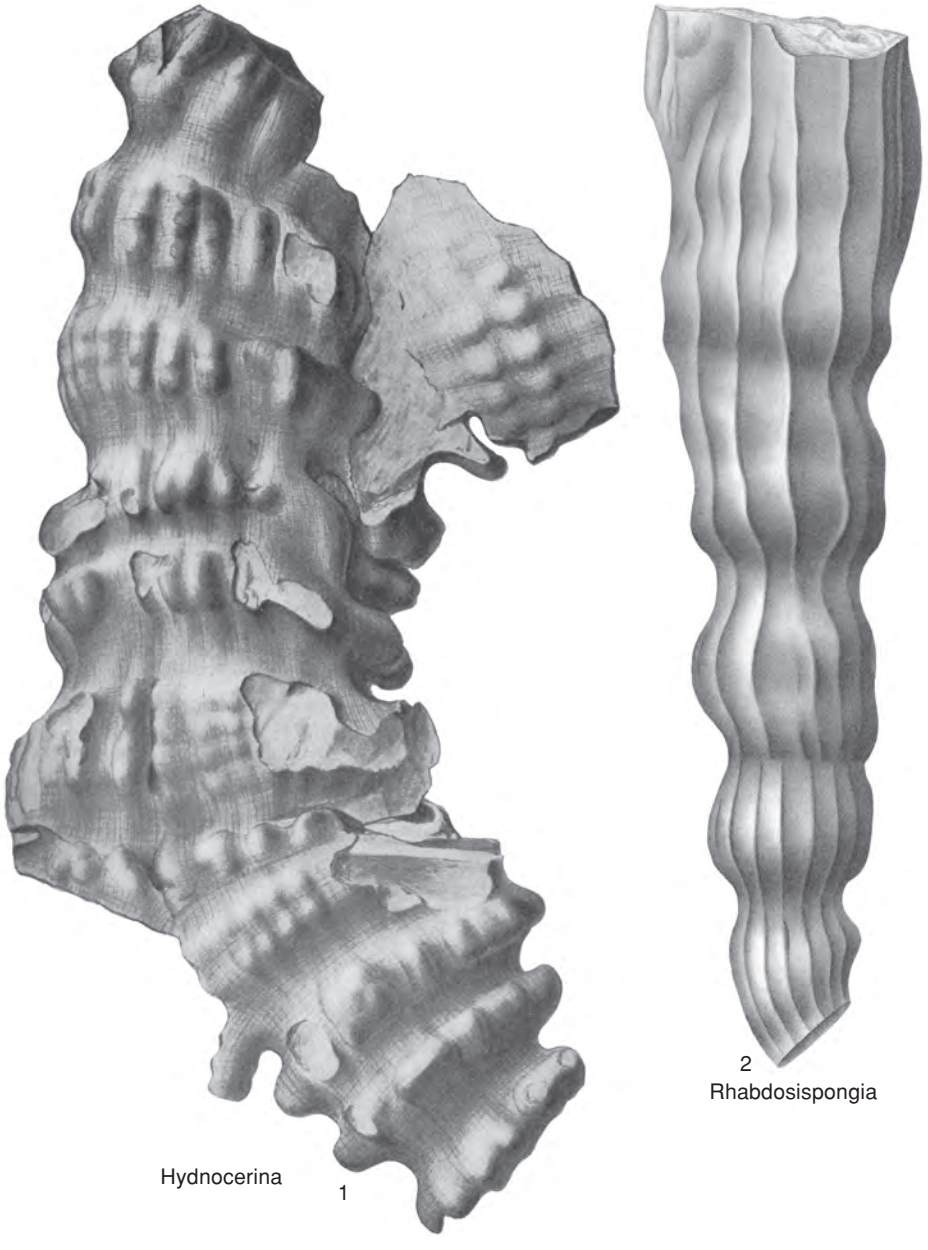


FIG. 249. Dictyospongiidae (p. 389–390).

section marked by sharply defined, rectangular, boxlike nodes, each of which terminates radially in a short, single ridge, like an elongate housetop; skeletal net of moderately uniformly arranged horizontal and vertical straps that outline quadrangles that may be subdivided into secondary and tertiary quadrules by smaller straps or single spicules; oscular margin and base unknown. *Carboniferous (Lower Mississippian):* USA (Indiana).——FIG. 246,*4a–b.* **H. quadratus,* Edwardsville Formation, Lower Mississippian, Monroe Reservoir, Monroe County; *a,* partial mold with rectangular nodes, skeletal net as in other dictyosponges, ×0.5; *b,* interior of spongocoel with skeletal net

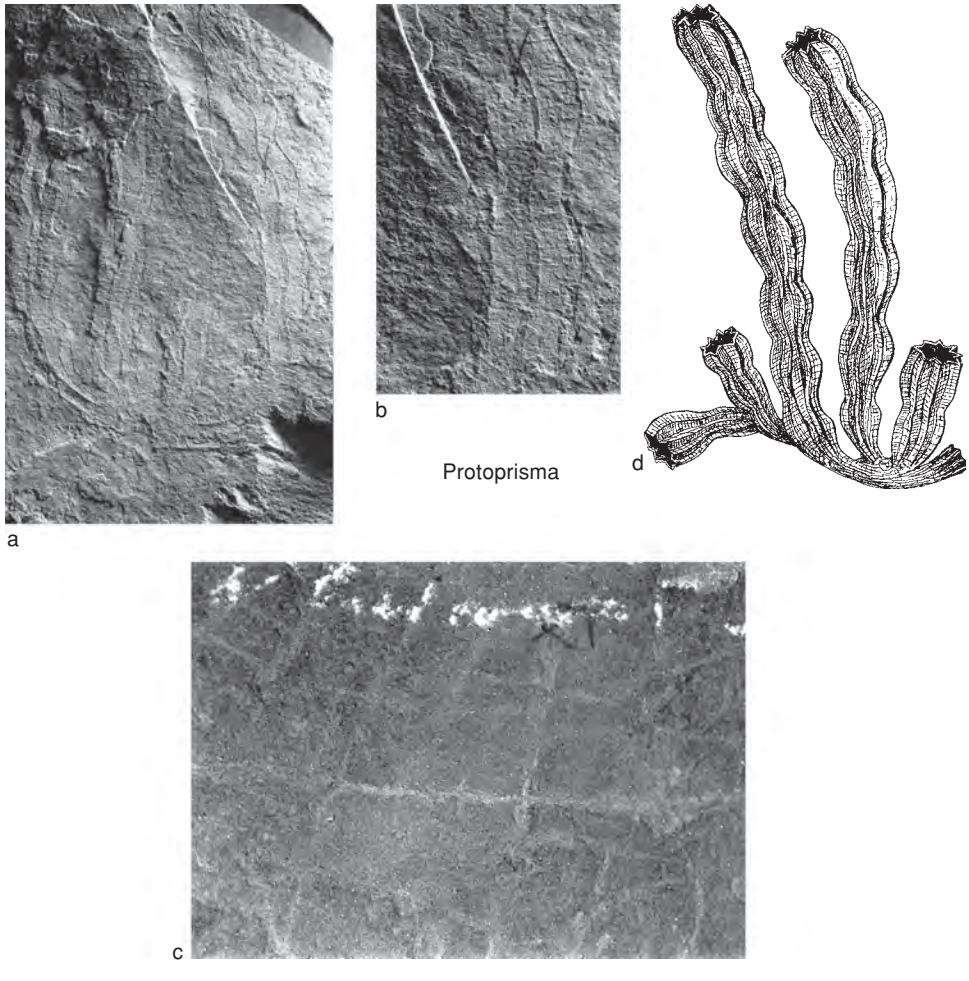


FIG. 250. Dictyospongiidae (p. 389–390).

emphasized by prismatic, outward bulges of nodes, IU 15107-47, ×1 (Rigby & Ausich, 1981).

Hydnocerina CLARKE, 1918, p. 182 [**H. armstrongi;* OD]. Sponge conicocylindrical, bearing more or less regularly spaced, horizontal rows of closely spaced protuberances; each protuberance is low, rounded, and usually elongate vertically, although often broken up vertically into two or three subprotuberances; all protuberances in a horizontal row have same number of sub-protuberances; spicule net a fine, uniform, quadrate mesh without conspicuous ridges or spicule bundles; spicules probably as in other dictyosponges, but not known. [Sponge resembles a *Cleodictya* with multiple whorls of nodes.] *Devonian (Frasnian):* USA (Pennsylvania, New York).——FIG. 249,*1. *H. armstrongi,* Chemung Group, Senecan, Erie, Pennsylvania; side view of holotype with horizontal annulations capped by multiple series of nodes in upper part, ×1 (Clarke, 1918; courtesy of New York State Museum, Albany).

Protoprisma RIGBY & COLLINS, 2004, p. 81 [**P. annulata;* OD]. Handlike, upwardly digitate, branched sponges with annulate conicocylindrical stems marked by vertical, angular ridges that produce prismatic, polygonal, transverse sections; each annular ridge and trough with spicule strands cross connected by horizontal strands to produce reticulate, skeletal net; intervening walls with thatch of fine, vertical monaxons; hexactines with horizontal and vertical rays regularly oriented in horizontal and vertical strands. *Middle Cambrian:* Canada (British Columbia).——FIG. 250*a–d. *P. annulata,* Stephen Shale, Raymond Quarry, Mount Stephen; *a,* flattened holotype with low-angle illumination from right to emphasize its branches, their sculpture, and common, curved base, ROM 43557, ×0.5; *b,* right branch of sponge,

illuminated from right, with rectangular-appearing skeletal structure, annulations of branch, and prominent, vertical, angular ridges and troughs of skeleton, ×1; *c,* photomicrograph of sponge surface with rectangular skeletal grid of vertical and horizontal tracts, with moderately preserved hexactines in lower right, ×1; *d,* restoration of the species to show its general skeletal form and sculpture, ×0.5 (Rigby & Collins, 2004).

Rhabdosispongia Hall & Clarke, 1899, p. 116 [**Dictyophyton amalthea* Hall, 1890b, p. 58; OD]. Sponge conicocylindrical with annular contractions alternating with somewhat broader expansions; surface with more or less continuous vertical ridges that are more numerous than the eight seen in *Prismodictya,* although apical portion in French species commences with eight; these ridges may represent vertical bundles of rhabdodiactines, but no spicules nor any other traces of skeletal net are known in type species; in French species a fine quadrate mesh is present. [Vertical ridges separate this genus from *Calathospongia* and from the more sharply annulate *Ceratodictya,* the absence of nodes separates it from *Hydnoceras.*] *Devonian (Frasnian):* USA (Pennsylvania), France.——Fig. 249,*2.* **R. amalthea* (Hall), Senecan, Chemung Group, Susquehanna County, Pennsylvania; side view of tall sponge with broad annulations and sharp, vertical ridges, ×0.5 (Hall & Clarke, 1899).

?Tylodictya Hall & Clarke, 1899, p. 151 [**T. warrenensis;* OD]. The type specimen (Hall & Clarke, 1899, p. 152, fig. 19–20), which is incomplete, resembles part of the upper portion of a *Botryodictya.* It is here considered a junior synonym of *Botryodictya. Carboniferous (Lower Mississippian):* USA (Pennsylvania).

Subfamily CALATHOSPONGIINAE Hall & Clarke, 1899

[Calathospongiinae Hall & Clarke, 1899, p. 53]

Smooth, cylindroid Dictyospongiidae, more or less hourglass shaped, sometimes vertically fluted. [This group may have arisen from the Hydnoceratinae by subduing annulations and protuberances.] *Upper Devonian–Carboniferous (Serpukhovian).*

Calathospongia Hall & Clarke, 1899, p. 155 [**Dictyophyton redfieldi* Hall, 1863, p. 88; OD]. Sponge cylindroid with a few broad contractions and expansions; most specimens illustrated by Hall and Clarke (1899) are shaped somewhat like an hourglass, but they seem incomplete both at top and bottom. Holotype of type species (*ibid.,* pl. 49,*2–4*) with globose upper end, surmounting more slender, downwardly expanding portion; another specimen (*ibid.,* pl. 48) with three expanded areas with intervening contractions; surface otherwise smooth and unornamented; quadrate mesh rather uniform with relatively subdued differentiation of quadrule sizes, horizontal bands said to be characteristically more prominent than vertical ones; spicules not known. [de Laubenfels (1955) assigned *Calathospongia* to *Ectenodictya,* but that genus is known from fragments only and is considered unrecognizable.] *Carboniferous (Lower Mississippian):* USA (Ohio, Pennsylvania, Indiana).——Fig. 251. **C. redfieldi* (Hall), Waverly Group, Akron, Ohio; side view of large, annulate sponge with nearly complete, oscular margin at top with faint, prismatic faces, ×0.9 (Hall & Clarke, 1899).

Corticospongia Caster, 1939, p. 14 [**C. bradfordensis;* OD]. Sponge subquadrately cylindroid, being broadly fluted vertically into four lobes; thin walled; lower part unknown; surface covered by horizontal, lenticular swellings resembling lenticels of tree bark, and produced by local crowding of swollen, horizontal rays of surface hexactines that have a knoblike distal ray and horizontal pair of tangential rays more strongly developed than vertical pair; hexactines and possibly pentactines of several orders of size, occasionally not in parallel orientation; discontinuous, vertical bundles of fine, spicule rays locally visible. *Upper Devonian (Famennian):* USA (Pennsylvania).——Fig. 252,*1a–d.* **C. bradfordensis,* Chautauquan, Lewis Run Sandstone Member, Venango Stage, Chautauqua Series, Lewis Run; *a,* side view of holotype showing part of lobate aperture and barklike exterior, ×1; *b,* enlargement of part of exterior showing lenticular bundles of spicules and finer, horizontal elements, ×3; *c,* drawing of holotype fragment showing generalized, reticulate, skeletal structure and general form of genus, approximately ×0.5; *d,* generalized diagram of spicule relationships adjacent to one of lenticular bundles, approximately ×5 (Caster, 1939).

Cryptodictya Hall, 1890b, p. 60 [**C. alleni;* OD]. Flattened, irregular objects (possible concretions) with irregularly distributed bumps; surface smooth, showing no trace of spicules except for supposed spicular impressions in matrix on bedding planes adjacent to bumps. *Upper Devonian:* USA (New York).——Fig. 252,*2.* **C. alleni,* Chemung Sandstone, Senecan, Alfred; side view of holotype with irregular, nodose sculpture, UCC 13153A, ×0.5 (Hall & Clarke, 1899).

?Ectenodictya Hall, 1884, p. 466 [**E. implexa* Hall, 1884, p. 475; SD Hall & Clarke, 1899, p. 164]. This genus is unrecognizable, having been based on fragmental material, as Hall and Clarke (1899, p. 164–165) stated. They suggested that the type species represents fragments of the type species of *Calathospongia.* This is by no means certain, and to make such a synonymy would have the unfortunate, undesirable, and unnecessary effect of making the better-founded genus, *Calathospongia,* a junior synonym of *Ectenodictya.*

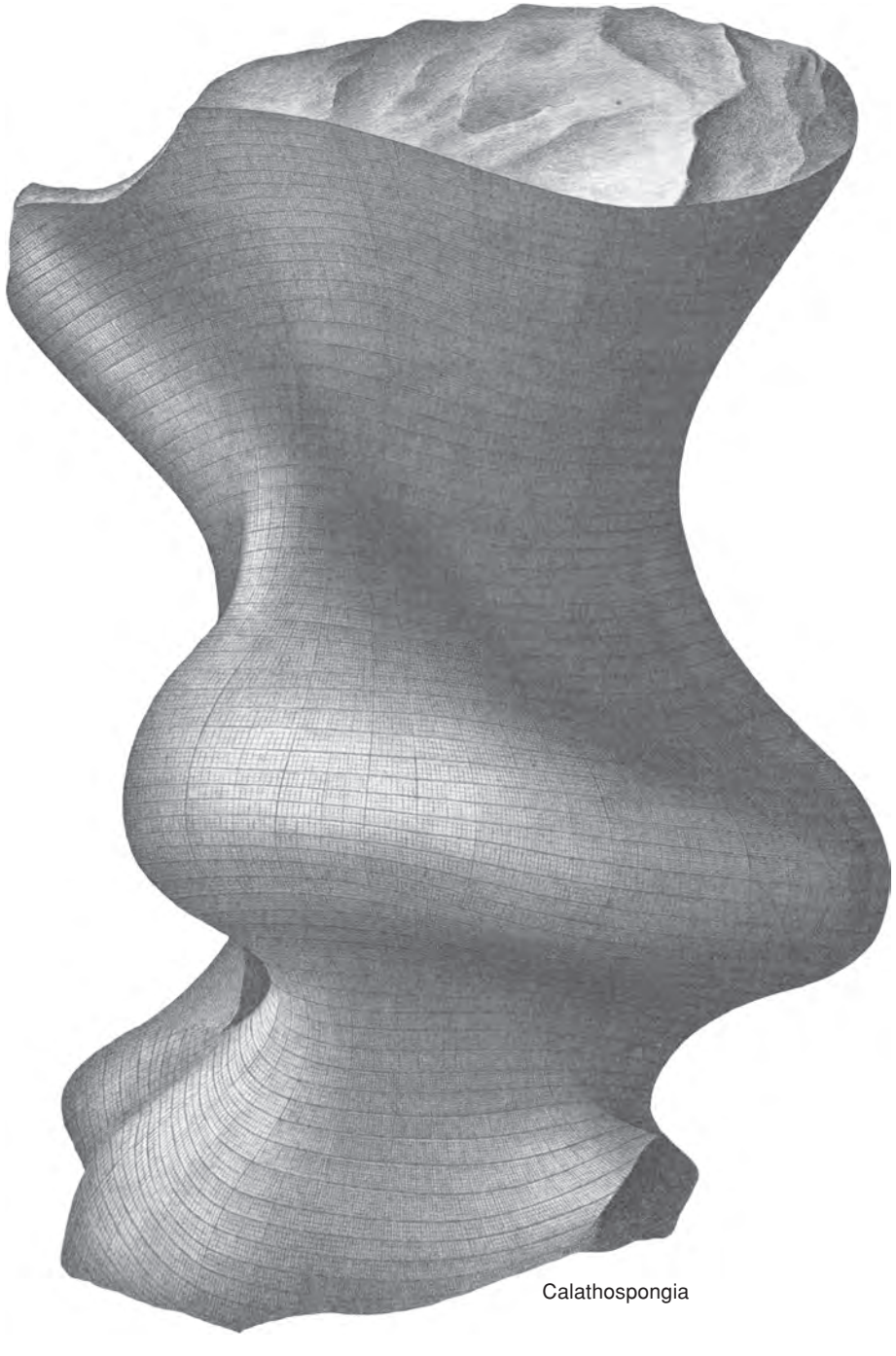


FIG. 251. Dictyospongiidae (p. 390).

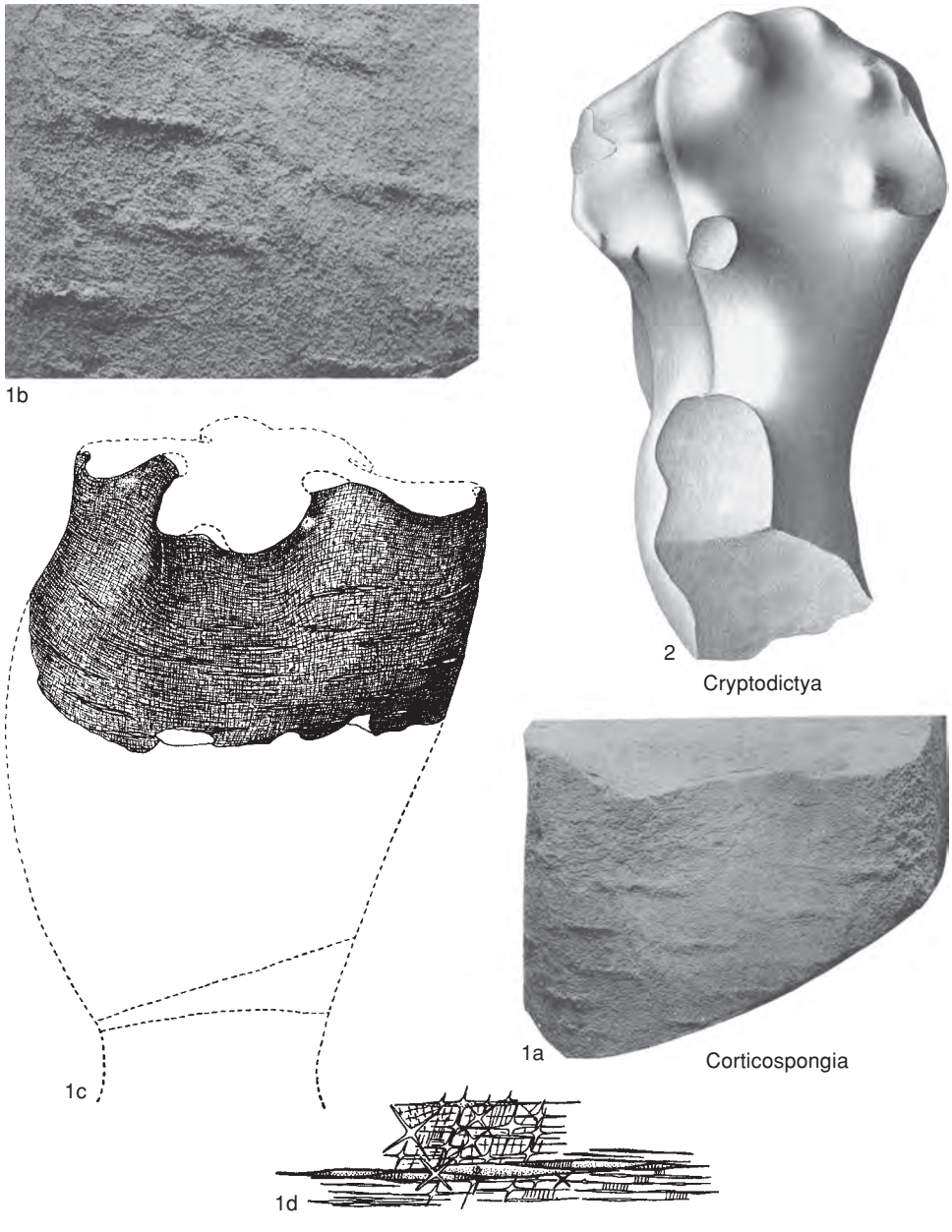


FIG. 252. Dictyospongiidae (p. 390).

Carboniferous (Lower Mississippian): USA (Pennsylvania, Ohio).

Griphodictya HALL & CLARKE, 1899, p. 179 [**G. epiphanes* HALL & CLARKE, 1899, p. 180; OD]. Sponge cylindroid but contracted in middle, smooth surfaced; lateral surfaces have a continuous layer of closely spaced, possible rhabdodiactines perpendicular to surface; these seem continuous with a solid mass of similar spicules that occupy interior of sponge, and whose orientations follow paths that sweep inwardly and upwardly in upper half of sponge, but inwardly and downwardly in lower half of sponge so that spicules are vertical in axial part of sponge; obscurely defined bundles of similar spicules, perhaps including hexactines, pentactines, or stauractines, locally

outlining a quadrate mesh of dimensions in other dictyosponges but here composed of bundles rather than a layer of single spicules; in addition, a few larger vertical bundles of stouter spicules (possible rhabdodiactines) seem to extend much of length of sponge. [In addition to above spicules, reported by HALL and CLARKE (1899, p. 180–181, fig. 33), personal examination of holotype and sole specimen (RMF), showed presence of hexasters with three-pronged and four-pronged branches on some rays, paraclavules with seven and eight teeth, and spicule rays with spinose tips.] *Carboniferous (Lower Mississippian):* USA (Indiana).——FIG. 253,*2a–l*. **G. epiphanes,* Keokuk Group, Crawfordsville; *a,* side view of small sponge from which spicules shown in views *b–l* were taken, ×1; *b–l,* spicules of genus, UCC 13186, ×200 (Hall & Clarke, 1899).

Hallodictya HALL & CLARKE, 1899, p. 140 [**H. sciensis;* OD]. Genus based on an incomplete specimen with broadly undulating surface on which are local, elongate, subparallel depressions of irregular distribution; surface said to bear impression of fine, quadrate mesh of two orders of size. *Upper Devonian:* USA (New York).——FIG. 254. **H. sciensis,* Chemung Group, Scio; holotype impression of interior of large sponge with irregular growth and node development but regular, reticulate, skeletal grid, ×1 (Hall & Clarke, 1899).

Hydriodictya HALL & CLARKE, 1899, p. 77 [**Dictyophyton patulum* HALL, 1884, p. 469; OD]. Type species known from a single specimen without top or bottom; broadly flaring cone; spicular net, as described, consisting of vertical and horizontal spicules (possible rhabdodiactine) bundles of equal size, forming broad, quadrate mesh that is subdivided by smaller, vertical and horizontal bundles to form finer quadrules; surface of sponge smooth. *Devonian (Frasnian)–Carboniferous (Mississippian):* USA (New York), *Frasnian;* USA (Indiana), *Mississippian.*——FIG. 255,*2*. **H. patulum* (HALL), Chemung Group, Senecan, Cohocton, New York; side view of holotype showing flaring form and quadruled, reticulate skeleton, ×1 (Hall & Clarke, 1899).

Lyrodictya HALL, 1884, p. 466 [**L. romingeri* HALL, 1884, p. 476; OD]. Sponge as illustrated by HALL and CLARKE (1899) broadly conical, base and top unknown; prominent, relatively thick, vertical bundles of possible rhabdodiactines with slightly plumose structure, rather widely spaced, and new ones intercalated in upper (wider) part of sponge; corresponding horizontal bundles not known but traces of finer quadrules present between bundles; large clemes present in these bundles have their barbs pointing downwardly rather than upwardly; other spicules reported include pentactines, larger with coarse spines and curved rays, and paraclavules. *Carboniferous (Lower Mississippian):* USA (Indiana, ?Iowa).——FIG. 255,*1*. **L. romingeri,* Keokuk Group, Crawfordsville, Indiana; side view of broadly obconical holotype with prominent, vertical bundles or tracts in reticulate skeleton, ×1 (Hall & Clarke, 1899).

Phragmodictya HALL, 1884, p. 466 [**Dictyophyton catilliforme* WHITFIELD, 1881, p. 18; SD MILLER, 1889, p. 163]. Cylindroid, expanded at base and top; broadly conical basal disk; downwardly directed, basal frill (periloph) at junction of basal disk and sides; rounded vertical ridges on sides, often discontinuous, continue onto basal frill; fine reticulum on smooth, basal disk radial and concentric; fine reticulum on sides outlined by pentactines with comitalia of possible rhabdodiactines; other spicules present include tauactines, *psi*-shaped stauractines, tylote stauractines, curved, stout strongyles, and spinose fragments, some of which may be parts of pinules. [It is possible that the basal disk and frill were an oscular sieve, as in the living *Euplectella,* and that the sponge has been restored upside down. *Phragmodictya* resembles *Thysanodictya* but without the coarse reticulation, among other things.] *Carboniferous (Lower Mississippian, Serpukhovian):* USA (Indiana, Alabama).——FIG. 253,*1a–c*. **P. catilliforme* (WHITFIELD), Keokuk Group, Osagean, Crawfordsville, Indiana; *a,* small, nearly complete individual with characteristic form and sculpture in reticulate skeleton; *b,* side view of somewhat fan-shaped, thin specimen with nearly complete, basal disc; *c,* side view of same specimen showing structure of basal disc, ×0.9 (Hall & Clarke, 1899).

Subfamily PHYSOSPONGIINAE Hall & Clarke, 1899

[Physospongiinae HALL & CLARKE, 1899, p. 53]

Dictyospongiidae with strongly developed, vertical and horizontal spicule bundles, with bullate protuberances between them. [This group may have arisen from the Prismodictyinae or from early members of the Hydnoceratinae.] *Middle Devonian–Carboniferous (Lower Mississippian).*

Physospongia HALL, 1884, p. 467 [**Uphantaenia dawsoni* WHITFIELD, 1881, p. 16; SD MILLER, 1889, p. 163]. Sponge conicocylindrical; surface divided into checkerboard of small rectangles usually (but not always) wider than high that are outlined by interpenetrating, horizontal and vertical bundles of possible rhabdodiactines of several sizes; every second vertical bundle twice as wide as others; vertical bundles, in part, external to horizontal ones; each rectangle occupied by either a saccular protuberance (bulla) or a depression, which alternate in quincuncial pattern (local asymmetries may occur); paraclavules present normal to surface with head ends oriented outwardly; they appear to lie, in part, below outermost layer of spicules and are interspersed among spicules of bundles; small rhabdodiactines tangential to surface forming a radial pattern about center of each bulla; principal skeletal net of both bullae and depressions

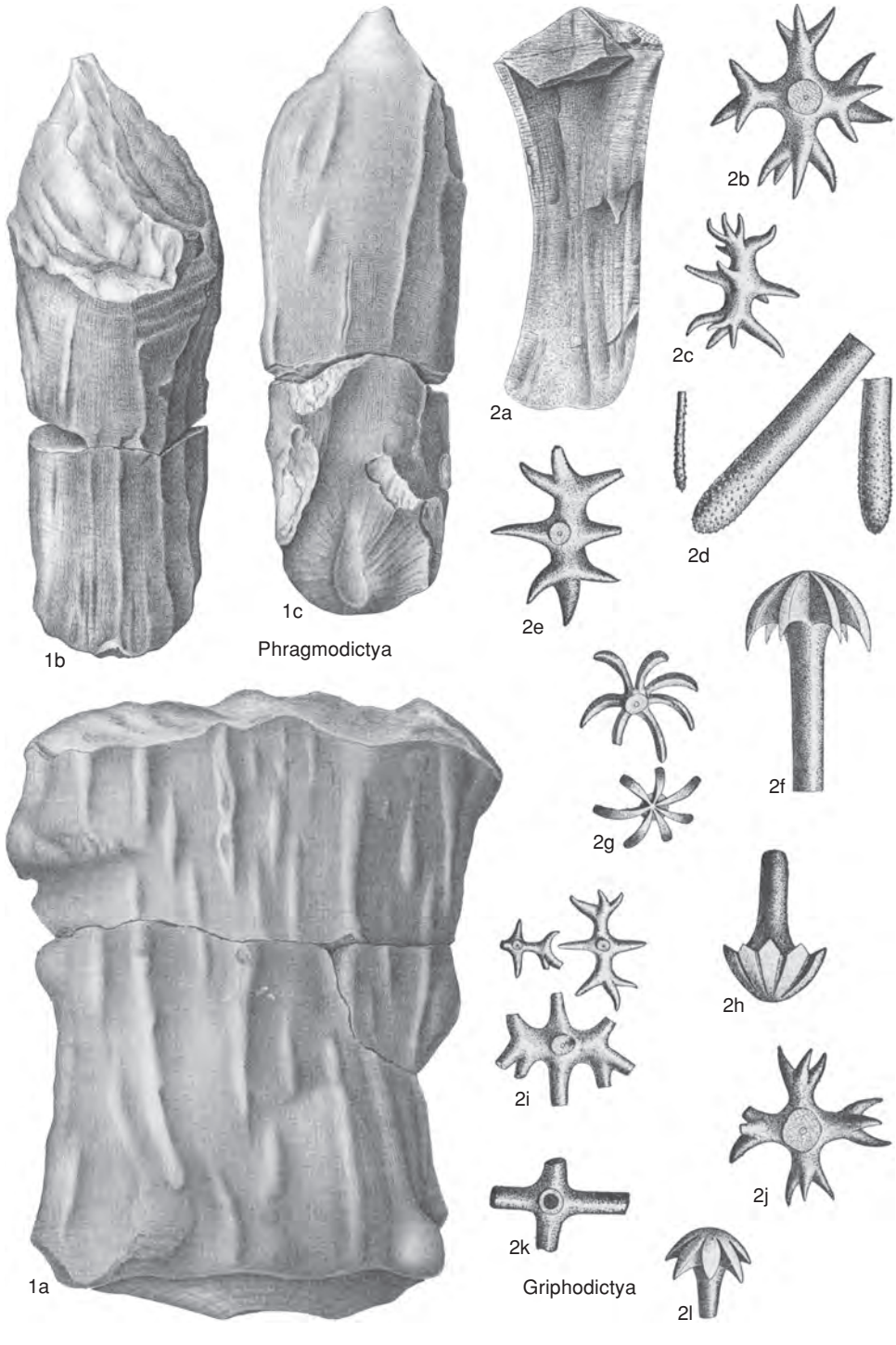


FIG. 253. Dictyospongiidae (p. 392–393).

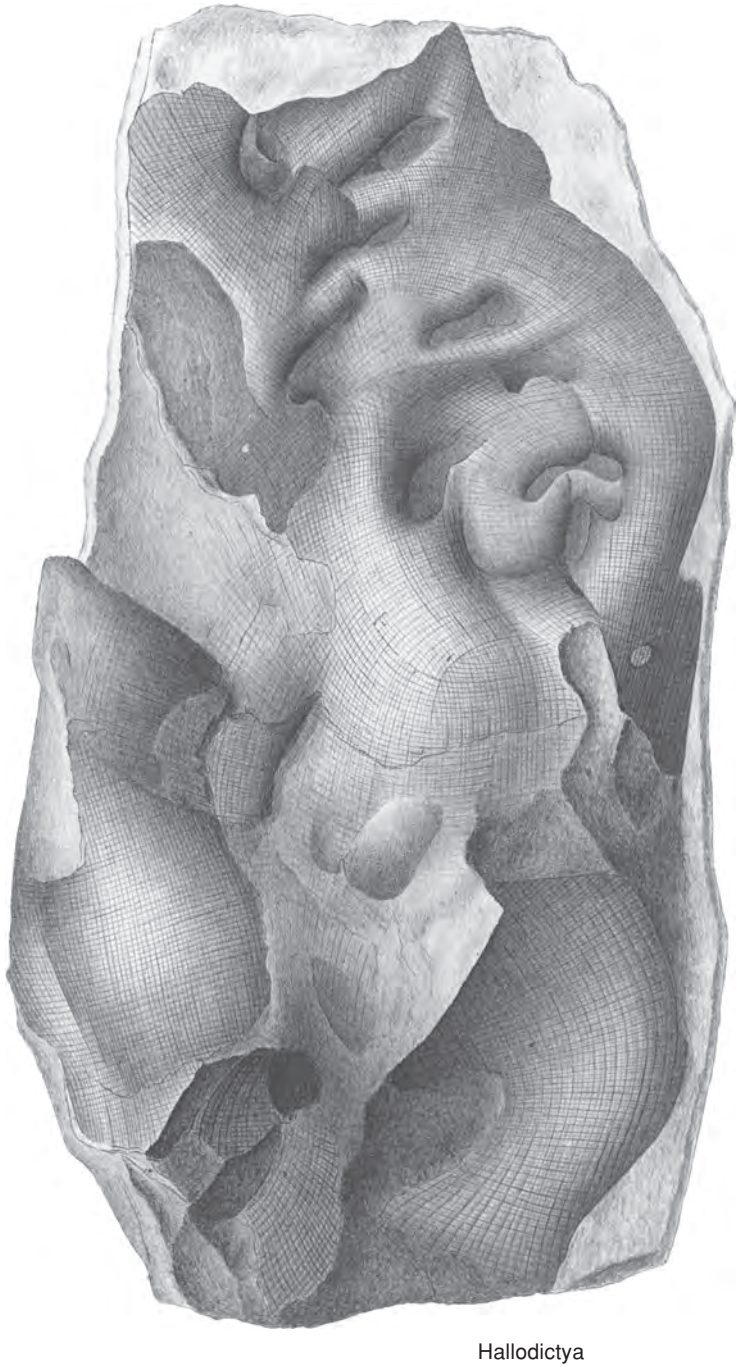


Fig. 254. Dictyospongiidae (p. 393).

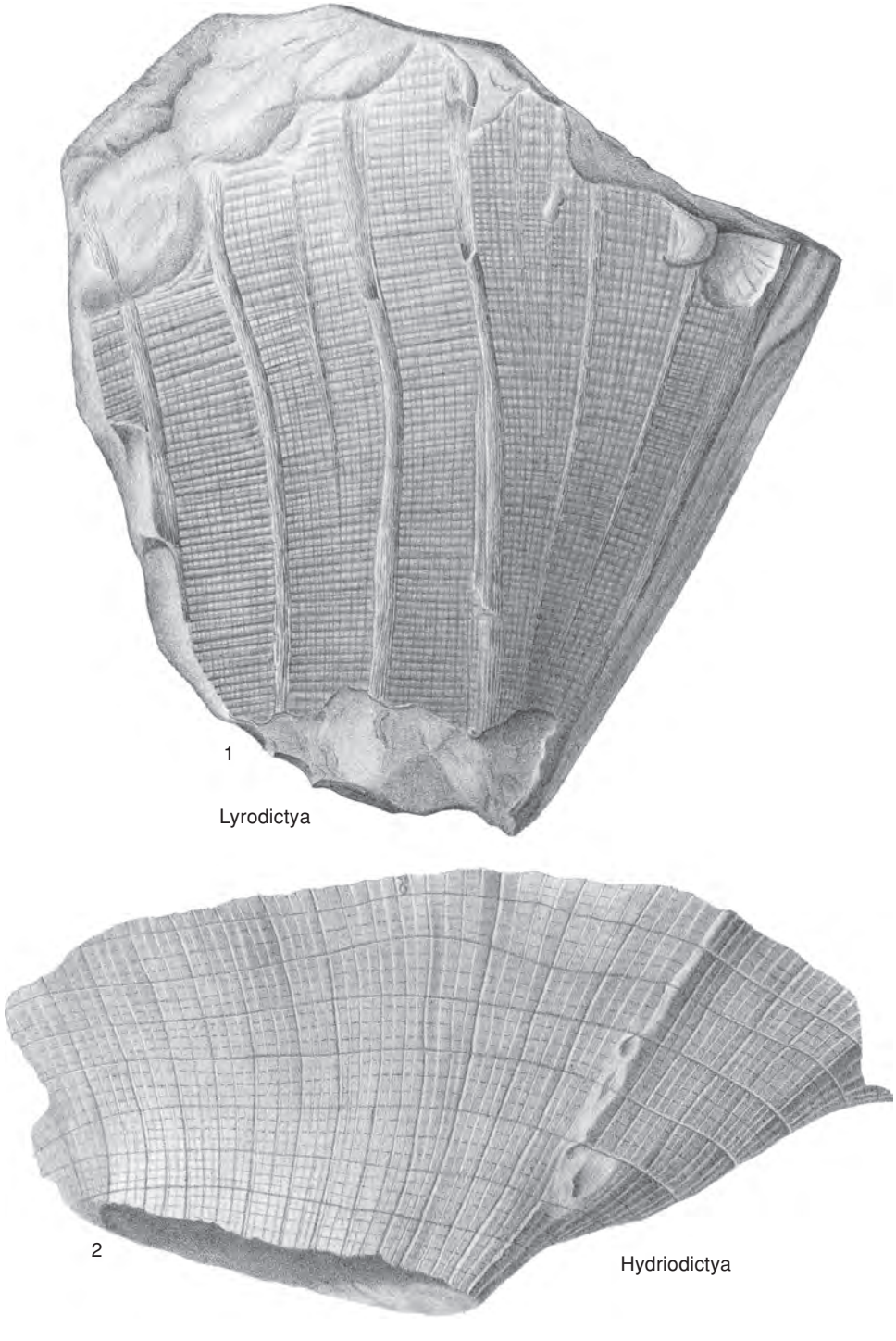


Fig. 255. Dictyospongiidae (p. 393).

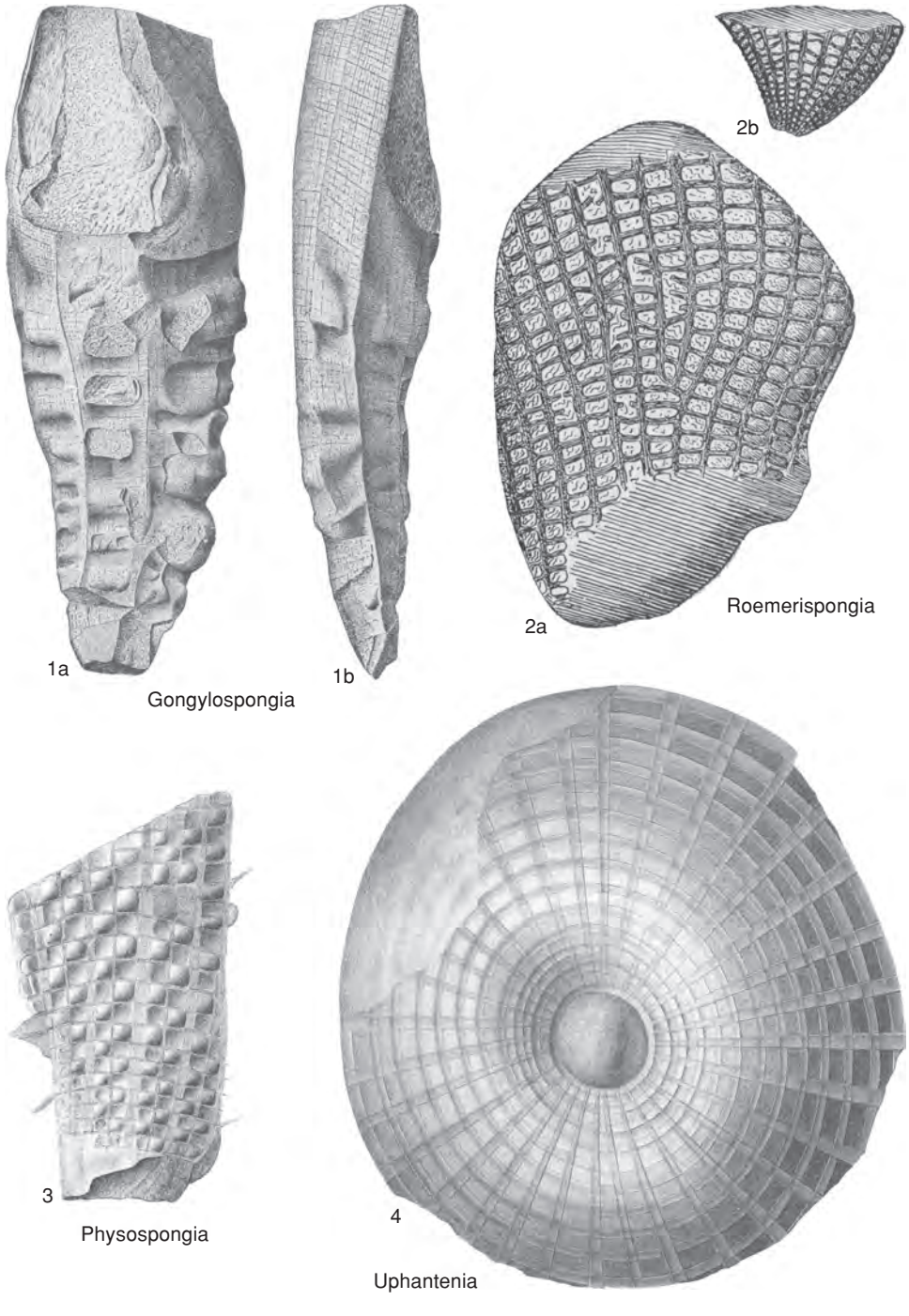


FIG. 256. Dictyospongiidae (p. 393–398).

consisting of fine, quadrate mesh of parallel, uniformly small stauractines (or possible pentactines); anadiaenes and clemes occurring in vertical bundles (pointed ends up), appearing to be concentrated on exterior side of bundle; lateral projections, much longer than bullae, frequently seen in profile opposite horizontal bundles, and unclear whether they are tufts of lateralia or some other structure. Spinose spicule rays and strongyles have been reported from some specimens. *Carboniferous (Lower Mississippian):* USA (Indiana).——Fig. 256,*3*. **P. dawsoni* (Whitfield), Keokuk Group, Crawfordsville; side view of small, obconical sponge with typical node and skeletal strap development, UCC 13176B, ×1 (Hall & Clarke, 1899).

Gongylospongia Hall & Clarke, 1899, p. 92 [**G. marshi;* OD]. Sponge conicocylindrical and distinctly prismatic; on each prism face is a single, vertical row of low, rounded protuberances alternating with low, rounded depressions, most strongly developed in middle part of sponge; protuberances and depressions wider than high and at approximately same level in adjacent rows; skeletal net a quadrate mesh with at least two orders of size of quadrules; spicules not known, but probably as in other dictyospongiids, with vertical, spicule bundles underlying prism angles. [The prismatic shape and simple, horizontally elongate protuberances distinguish this genus from *Hydnocerina,* and the nonquincuncial arrangement of protuberances (among other things) differentiate this genus from *Physospongia.*] *Devonian (Frasnian):* USA (New York).——Fig. 256,*1a–b*. **G. marshi,* Senecan, Chemung Group, Wellsville; *a,* side view of holotype with characteristic alternation of nodes and depressions on prism faces; *b,* lateral view of same sponge, ×0.5 (Hall & Clarke, 1899).

Roemerispongia Hall & Clarke, 1899, p. 67 [**Dictyophyton gerolsteinensis* C. F. Roemer, 1883, p. 707; OD]. Steeply obconical to subcylindrical sponge with pointed base; skeleton of relatively robust, subequal, vertical bundles of spicules, crossed by narrower, horizontal, spicule bands in moderately regular, rectangular pattern, to define quadrules that bulge outwardly with convex surfaces such as in *Physospongia,* but without well-defined, subordinate, spicule bands. *Middle Devonian:* Germany.——Fig. 256,*2a–b*. **R. gerolsteinensis* (Roemer), Gerolstein, Eifel; *a,* side view of steeply obconical upper part with prominent, rectangularly arranged, skeletal bands, but convex bulges of quadrules not well shown; *b,* pointed base with convergent, vertical, spicule bands and somewhat more irregular, horizontal tracts, ×1 (Hall & Clarke, 1899).

Uphantenia Vanuxem, 1842, p. 183 [**U. chemungensis;* M] [=*Hyphantaenia* Hall & Clarke, 1899, p. 137, *nom. van.*]. Sponge large and discoid, similar to a bowl with central, uplifted area in base; concentric (horizontal) and radial (vertical) spicule bundles outlining rectangular interspaces that form alternately wide and narrow, radial rows; in each wide, radial row, every second interspace occupied by what appears to have been either horizontally elongate, protuberant bulla, or elliptical parietal gap; spicules not preserved but possibly skeletal net was similar to that of *Physospongia.* [This sponge is a bit like a flat, circular *Gongylospongia.*] *Devonian (Frasnian):* USA (New York).——Fig. 256,*4*. **U. chemungensis,* Senecan, Chemung Group, Tioga County; discoidal sponge with characteristic concentric and radial skeletal bundles around interspaces, ×0.5 (Hall & Clarke, 1899).

Subfamily THYSANODICTYINAE Hall & Clarke, 1899

[Thysanodictyinae Hall & Clarke, 1899, p. 52]

Dictyospongiidae with coarse, ridgelike, quadrate mesh that may represent radially erect lamellae, spicule bundles, coarse pentactines, or a combination thereof. [This group may have arisen from the Physospongiinae.] *Upper Devonian (Frasnian)–Carboniferous (Serpukhovian).*

Thysanodictya Hall & Clarke, 1899, p. 125 [**?Dictyophyton (Phragmodictya) halli* Hall, 1890b, p. 59; OD; =*Thysanodictya edwinhalli* Hall & Clarke, 1899, p. 126, *nom. van.*]. Gross morphology resembles that of *Phragmodictya* but with coarse ridges, interpreted by Hall and Clarke as erect lamellae as in *Clathrospongia,* outlining larger quadrules; reticulum of basal disk is quadrate rather than radial and concentric, although in type species it appears radial (Hall & Clarke, 1899, pl. 24,*2*), also vertical fluting, or low, rounded ridges, seen in *Phragmodictya,* are absent; spicules unknown. [It is possible that the basal disk is an oscular sieve and the sponge is restored upside down. This is especially likely for *T. hermenia* (Hall & Clarke, 1899, pl. 40) and *T. scyphina* (*ibid.,* pl. 42,*8*), in which the supposed upper end is contracted to an apex. The former species is the only one in which the quadrate mesh of the basal disk is shown. This genus differs from *Clathrospongia* Hall, 1884, in the presence of the flat base and frill.] *Devonian (Frasnian)–Carboniferous (Lower Mississippian):* USA (New York, Pennsylvania, Alabama).——Fig. 257,*2a–b*. **T. halli* (Hall), Chemung Group, Senecan, Wellsville, New York; *a,* side view of nearly complete, steeply obconical sponge with coarse, reticulate skeleton, ×1; *b,* side view of lower part of subcylindrical sponge with broad, flaring frill at margin of basal disk, ×1 (Hall & Clarke, 1899).

Acloeodictya Hall & Clarke, 1899, p. 177 [**A. marsipus* Hall & Clarke, 1899, p. 178; OD]. Sponge cylindroid, widest just above base, which

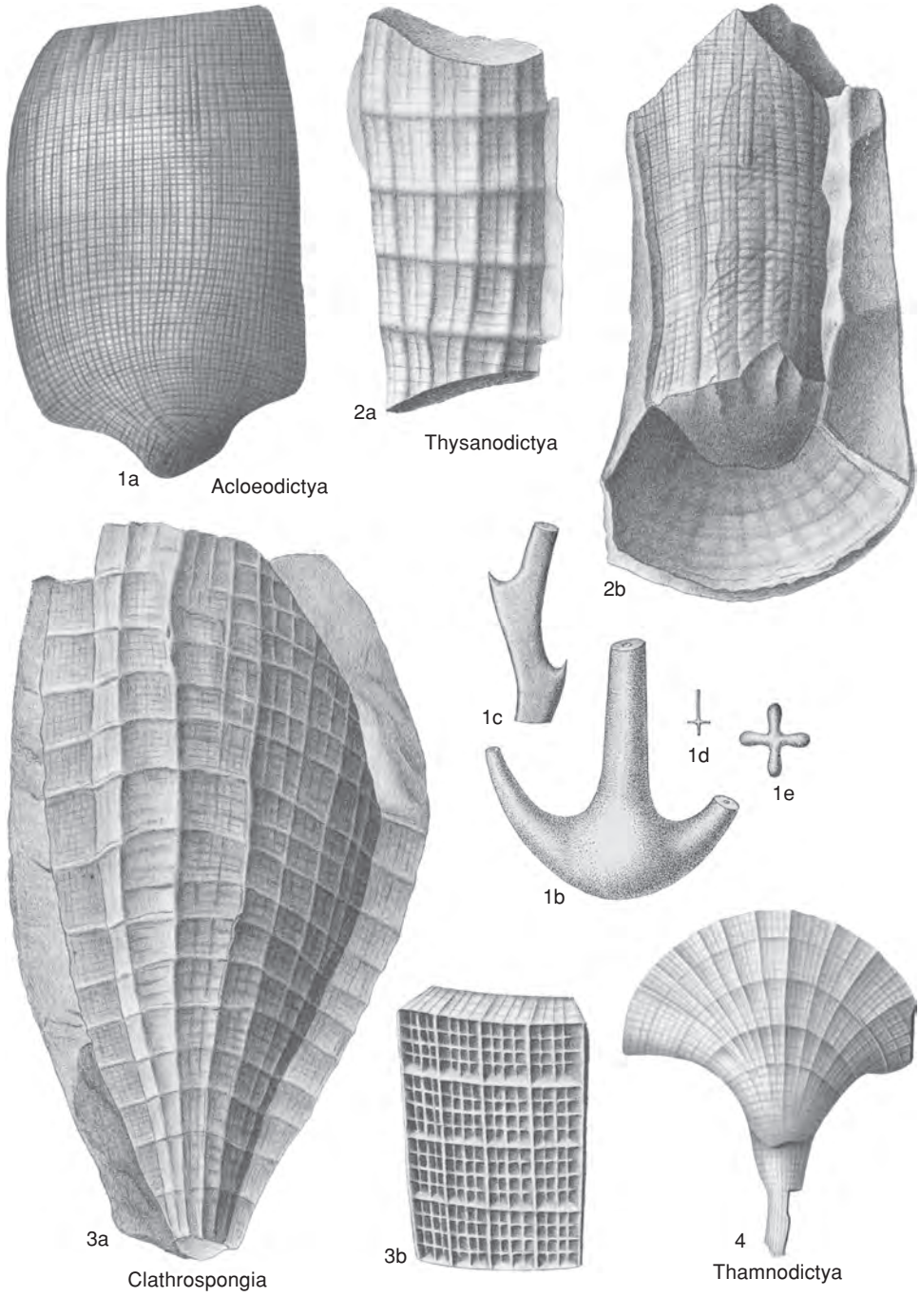


FIG. 257. Dictyospongiidae (p. 398–403).

is broadly conical and ends in pointed apex; quadrate mesh composed of large quadrules subdivided by finer ones; continuations of vertical elements converging to apex on base; if the only syntype that preserves the spicules (HALL & CLARKE, 1899, pl. 55,*4,* UC 131858) is truly conspecific with those that show external form, then large quadrules are outlined by large stauractines or pentactines, in quadrate arrangement with partly overlapping rays. These spicules accompanied by underlying vertical and horizontal bundles of comitalia that may be rhabdodiactines. HALL and CLARKE (1899, p. 178) mentioned the presence of large anadiaenes, in addition to large pentactines with curved rays. They interpreted the anadiaenes as basalia. Clemes and small, blunt-rayed pentactines or stauractines also occur; finer quadrules on this specimen appear to be composed of thinner bundles of rhabdodiactines. [HALL and CLARKE (1899, p. 178 and pl. 55,*4*) stated that the vertical and horizontal spicule bundles "were produced into erect reticulating lamellae" as in *Clathrospongia* (*ibid.,* p. 177). It is not clear from personal examination of the syntype that the structure referred to in the figure caption was an erect or vertical lamella, or that it contained regular, fine quadrules. If it were such, then *Acloeodictya* would differ from *Clathrospongia* only in its more abruptly conical base and in the presence of large pentactines.] *Carboniferous (Lower Mississippian):* USA (Indiana).——FIG. 257,*1a–e.* **A. marsipus,* Keokuk Group, Indian Creek; *a,* side view of nearly complete, robust, subcylindrical sponge, ×0.5; *b–e,* spicules from genus, ×200 (Hall & Clarke, 1899).

?Arystidictya HALL & CLARKE, 1899, p. 136 [**A. elegans;* OD] [=*Arystidictyon* HALL & CLARKE, 1899, p. 13, per DE LAUBENFELS, 1955, p. 72, *nom. null.*]. Sponge funnel shaped, flaring upwardly from flat base; broad, quadrate reticulum of vertical and horizontal spicule bundles is all that is preserved; it is probable that finer, quadrate mesh external to it has been lost. [Were such a fine mesh present, all that would distinguish this genus from *Thamnodictya* would be its flat base; it is possible that *Arystidictya* is merely a poorly preserved *Thamnodictya.*] *Devonian (Frasnian):* USA (New York).——FIG. 258,*2. *A. elegans,* Senecan, Lower Chemung Group, Avoca; side view of flaring sponge with reticulate skeleton in base and radiating channels in oscular margin, ×0.5 (Hall & Clarke, 1899).

Clathrospongia HALL, 1884, p. 121 (as subgenus) [**Dictyophyton (Clathrospongia) abacus* HALL, 1884, p. 474; OD]. Sponge narrowly conical with acute apex; as HALL (1884) and HALL and CLARKE (1899) interpreted structure, largest quadrules (about a centimeter wide as in many other dictyosponges) outlined by lamellae several millimeters high and oriented perpendicular to sponge surface; each lamella bearing secondary and tertiary quadrules, as does sponge wall between them; HALL and CLARKE further infer (1899, p. 153, and pl. 49,*6*) that smaller quadrules also produced perpendicular lamellae to form a three-dimensional, open boxwork; presumably each lamella was ultimately built of a layer, or layers, of fine pentactines or stauractines; spicules are unknown. [There is some question about whether the primary lamellae existed; they are preserved in concrete form only at the sides of some specimens, where they are distinguished from the rest of the skeletal net only by the fact that they lie flat on the bedding surface rather than arching over the sediment, filling the sponge. It is possible that they are collapsed parts of the sponge. Elsewhere they are present only as low ridges outlining the quadrules, which could be produced by interior, spicule bundles; evidence for the finer boxwork is even less compelling, for it rests on the low ridges that outline the finer quadrules and their prolongation onto the primary lamellae; this genus differs from *Thysanodictya* in lacking a flat base and basal frill.] *Devonian (Frasnian)–Carboniferous (Serpukhovian):* USA (New York, Pennsylvania, Ohio, Alabama).——FIG. 257,*3a–b. *C. abacus* (HALL), Waverly Group, Kinderhookian–Osagean, Warren, Pennsylvania; *a,* side view of obconical type with what are interpreted to be erect horizontal and vertical lamellae in three-dimensional skeleton, ×1; *b,* interpretation of structure in deep skeleton, ×1 (Hall & Clarke, 1899).

Lebedictya HALL & CLARKE, 1899, p. 169 [**L. crinita* HALL & CLARKE, 1899, p. 170; OD]. Sponge broadly conical but not flaring; base unknown; larger quadrules outlined by what are said to be "erect spicular bands" (HALL & CLARKE, 1899, p. 169) but these could not be seen on the syntype studied (U.C. 13184; HALL & CLARKE, 1899, pl. 61,*5*), rather quadrate mesh formed from parallel pentactines or stauractines of at least three orders of size, largest seeming mostly to be in quadrate, not quincuncial, arrangement with overlapping rays; resulting quadrules are subdivided by next smaller spicules and those by next; comitalia (possible rhabdodiactines) forming vertical and horizontal bundles under rays of pentactines; long, longitudinal, spicule ray, much larger than largest pentactines, also present; fringe of parallel, vertical, spicule rays (possible rhabdodiactines) crowning upper rim; fringe on possible gastral surface and may have been covered by a fine, quadrate mesh of small pentactines or stauractines on specimen studied; other spicules reported by HALL and CLARKE include paraclavules, tripinules, spinose pentactines, and strongyles. [The shape of this sponge is not as flaring as that of *Thamnodictya* or *Arystidictya.*] *Carboniferous (Lower Mississippian):* USA (Indiana).——FIG. 258,*1a–m. *L. crinita,* Keokuk Group, Crawfordsville; *a,* side view of broadly obconical holotype with pronounced fringe of prostalia around oscular margin, bundle of vertical spicules in interior, on right, and traces of spicule bundles that form coarse quadrules on exterior, ×0.5; *b–m,* spicules from type species, ×400 (Hall & Clarke, 1899).

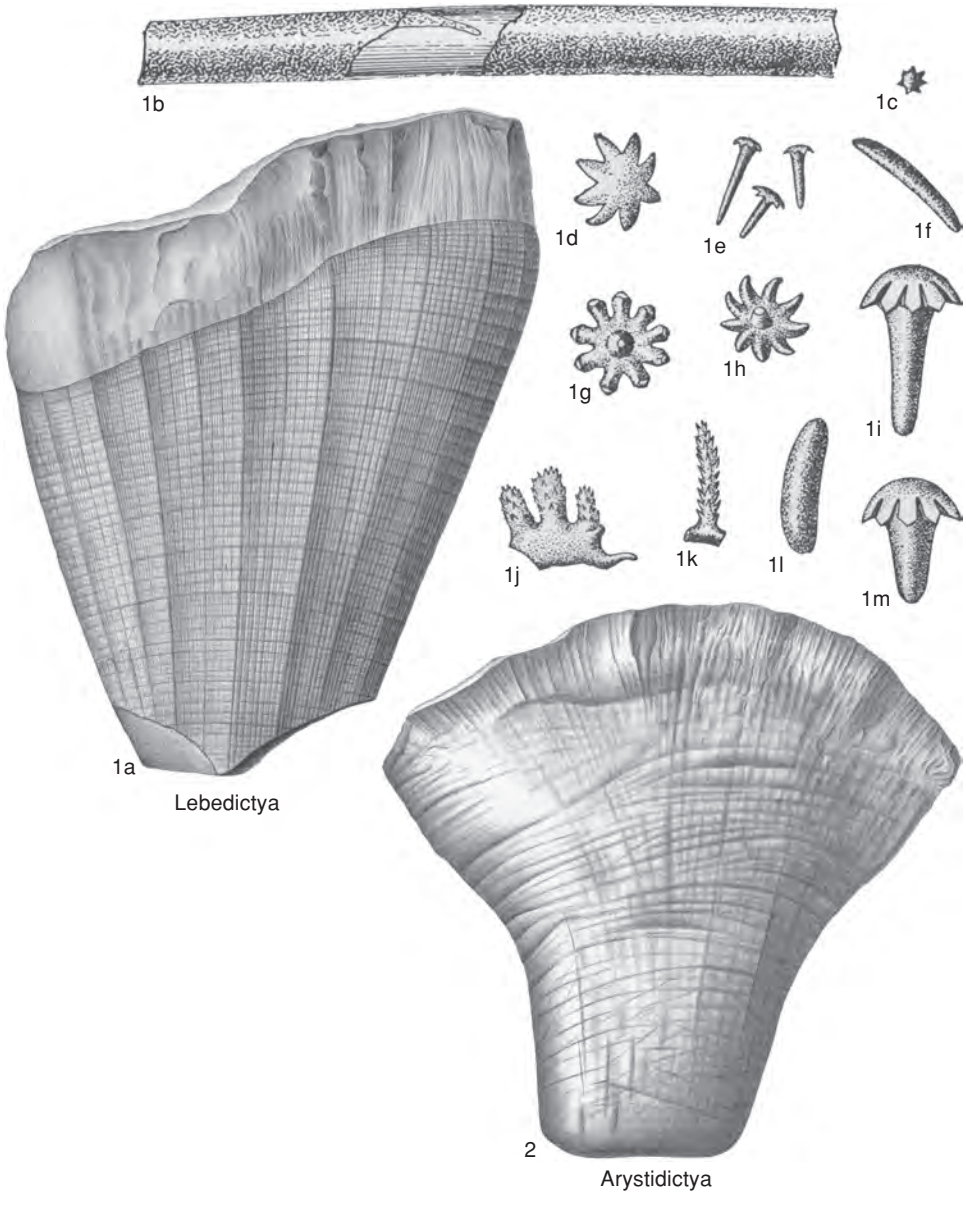


FIG. 258. Dictyospongiidae (p. 400).

Mattaspongia RIGBY, 1970a, p. 8 [**M. apaches* RIGBY, 1970a, p. 9; OD]. Sponge broadly conical and rapidly expanding, although less so in upper part; thin walled, composed of simple, moderately large, parallel hexactines coated by smaller, rhabdodiactine comitalia that cause quadrule spaces to have circular outline (parietal gaps of original description); large, single, widely spaced, rhabdodiactine prostalia projecting outwardly and upwardly at an acute angle; at least two nested orders of size of hexactines seem to be present, larger perhaps in quadrate, nonquincuncial arrangement with overlapping rays; as sponge expands upwardly, new vertical rows of hexactines intercalated. [Genus is similar to *Lebedictya* and *Acloeodictya*.] *Devonian (Frasnian):* Canada (Alberta).——FIG. 259*a–b.* **M. apaches,* Mount Hawk Formation, Front Range; *a,* holotype

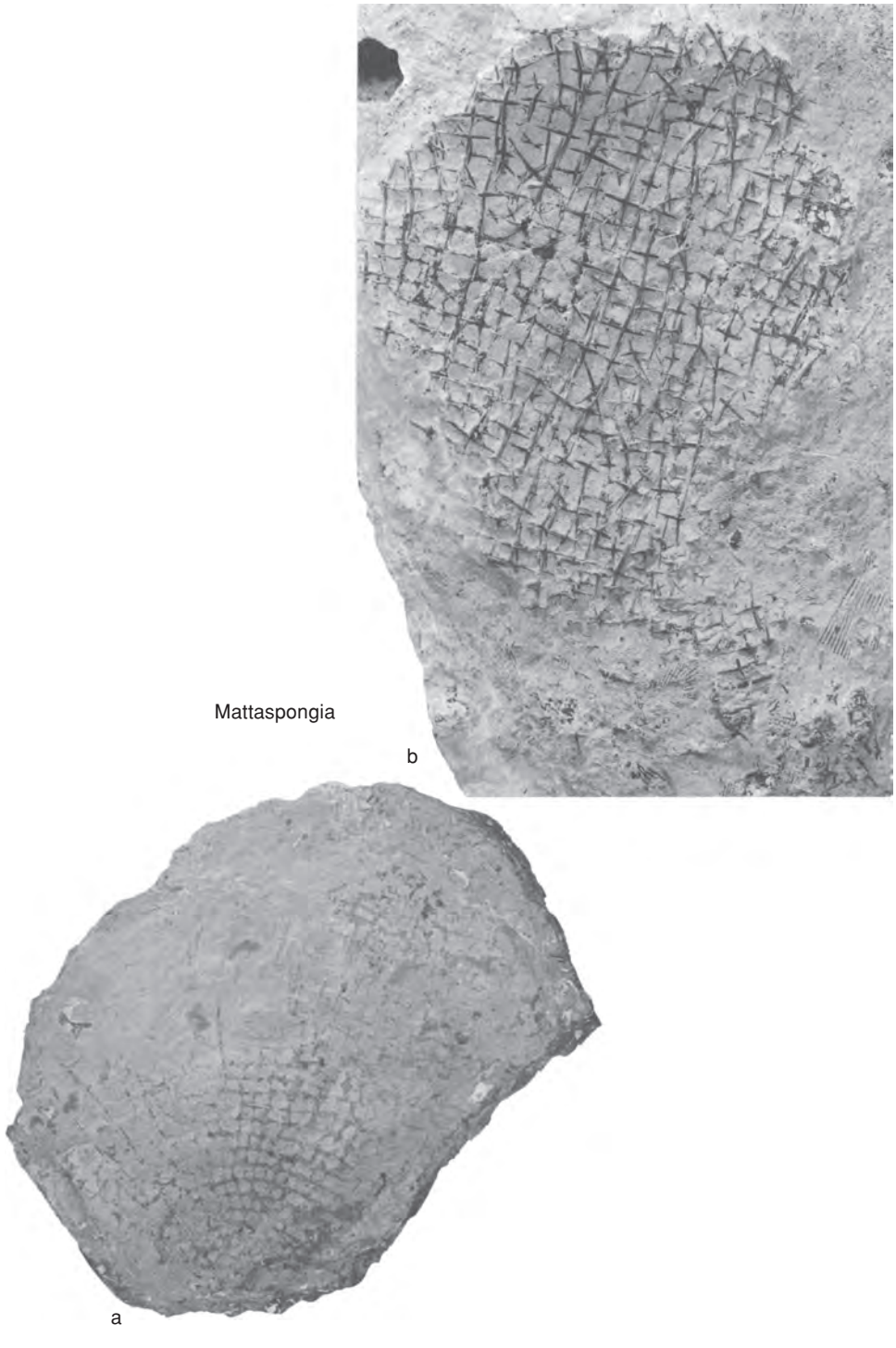


FIG. 259. Dictyospongiidae (p. 401–403).

Mattaspongia

FIG. 260. Dictyospongiidae (p. 401–403).

showing thin-walled fragment with regular, reticulate, hexactine-based skeleton perforated by matrix-filled, parietal gaps, GSC 24500, ×0.5; *b,* paratype, skeletal fragment, GSC 24800, ×2 (Rigby, 1970a).——FIG. 260. **M. apaches,* Mount Hawk Formation, Front Range; paratype with hexactines arranged into rough, vertical rows and less continuous horizontal rows in reticulate skeleton, irregular orientation of some spicules apparently normal, their rays interleaving with adjacent spicules, ×4 (Rigby, 1970a).

Thamnodictya HALL, 1884, p. 466 [**Dictyophyton newberryi* HALL, 1863, p. 87; OD]. Sponge funnel shaped, flaring upwardly from a narrow, tubular, stalklike base; conspicuous vertical and horizontal, spicule bundles outline larger quadrules, which are not rectangular because of upward flaring, within which is a finer quadrate mesh. [This genus is similar to *Arystidictya* in form.] *Carboniferous (Lower Mississippian, ?Serpukhovian):* USA (Ohio, ?Alabama, New York).——FIG. 257,*4.* **T. newberryi* (HALL), Waverly Group, Kinderhookian–Osagean, Cuyahoga Falls, New York; side view of funnel- or frondlike sponge with narrow base and expanding, quadruled skeleton, ×0.5 (Hall & Clarke, 1899).

Family DOCODERMATIDAE Finks, 1960

[Docodermatidae FINKS, 1960, p. 118]

Dictyospongioidea with coarse hypodermalia of several sizes, often tuberculate and often with supernumerary, paratangential rays; root tuft usually present; asymmetrical tauactines typically present as comitalia or as constituents of rather coarse, internal, spicule bundles. *Silurian (Ludlow)–Permian (Roadian, ?Wordian–?Capitanian).*

Docoderma FINKS, 1960, p. 120 [**D. rigidum* FINKS, 1960, p. 121; OD]. Large, vasiform, thick-walled sponge with root tuft; primary, paratangential rays of hypodermalia strongly reflexed and distally papillose; in type species, additional, nonreflexed, paratangential rays arising from crossing and fusing

to form beamlike structures with digitate ends in adult sponge that interlock so that hypodermalia form a rigid net; in *D. papillosum* additional paratangential rays occur only in special smaller hypodermalia, and beamlike structures are not developed; in both species an autodermal mesh of fine, parallel hexactines or stauractines forming continuous cover over hypodermalia and, in adult sponges, fusing with these and with each other; hypogastralia with similarly papillose, paratangential rays but more slender and without supernumerary rays; parenchymalia include hexactines (those near dermal surface often papillose and with extra rays), tauactines, and rhabdodiactines; parenchymalia, hypodermalia, and hypogastralia in nonparallel orientation; root tuft of rhabdodiactines and clemes; very small, short, curved rhabdodiactines, some blunt ended like strongyles, as well as tauactines (in *D. papillosum*), coating all larger spicules as comitalia; large aporhyses covered distally by hypodermalia and autodermalia. *Carboniferous (Middle Pennsylvanian)–Permian (Roadian, ?Wordian–?Capitanian):* USA (Texas, ?New Mexico), Mexico (?Sonora).——Fig. 261*a–d. *D. rigidum,* Word Limestone, Leonardian, Glass Mountains, Texas; *a,* basal end of holotype showing solid, dermal layer of skeleton and root tuft, ×0.5; *b,* enlarged view of main dermal skeleton in which each star-shaped configuration is formed by fused, outer, supernumerary rays of single spicules, with spherical nodes on beam edges; larger openings are noncircular, parietal gaps, ×5; *c,* enlarged view of inner surface of dermal layer with reflexed, tangential rays of dermal spicules, which are most of larger rays, and several smaller hexactines of interior of wall, which is interrupted by circular, parietal gaps, USNM 127659, ×5; *d,* sketch of mature, dermal spicule with beamlike, supernumerary rays above principal rays of spicule, not to scale (Finks, 1960; courtesy of The American Museum of Natural History).

Acanthocoryna Finks, 1960, p. 128 [**A. stauroma* Finks, 1960, p. 129; OD]. Sponge thick walled and probably vasiform but known only from fragment; possible hypodermalia hexactines with long, stout, fusiform, proximal ray, slender, paratangential rays and distal ray replaced by a cluster of oblique, branching, conical spikes; possible hypogastralia somewhat smaller pentactines with long, stout, fusiform, proximal ray bearing a ring of six to eight conical spikes just below crossing; above ring ray becomes slender; paratangential rays of hypogastralia short and slender with protuberance on distal surface of each near crossing; paratangential rays of both hypodermalia and hypogastralia are in parallel orientation and in quadrate arrangement; principal parenchymalia are several layers of simple hexactines in subparallel orientation, with pentactines and stauractines nearest dermal and gastral surfaces; accompanying hexactines are bundles of fusiform rhabdodiactines parallel to sponge surface but intersecting at irregular angles and partly outlining skeletal canals and pores; small, subcircular openings of possible epirhyses and aporhyses with openings on presumed dermal surface larger than those on presumed gastral surface, suggesting that original designation of surfaces should perhaps be reversed (which was based on spicule size and supernumerous rays). *Permian (Roadian):* USA (Texas).——Fig. 262,*1a–b. *A. stauroma,* Word Limestone, Leonardian, Glass Mountains; *a,* photomicrograph of holotype fragment showing top of dermal surface with dermalia that have varying development of distal rosettes; spicule at bottom has rosette rays bisecting angles between main rays; *b,* photomicrograph of gastral spicule associated with smaller hexactines, USNM 127663, ×15 (Finks, 1960; courtesy of The American Museum of Natural History).

Carphites Finks, 1960, p. 125 [**C. plectus;* OD]. Thick-walled, probably vasiform sponge, with root tuft but known only from fragments; hypodermalia very large, thick-rayed hexactines with distal ray variably shortened (or, rarely, replaced by cluster of spherical knobs); hypodermalia in subparallel, quincuncial arrangement with rays overlapping and crossing at half length; a much finer, possibly autodermal, quadrate mesh of bundles of small tauactines lies external to hypodermalia; similar tauactines, along with small, short, curved rhabdodiactines (both oxeote and strongylelike) and small hexactines, coating hypodermal spicules as comitalia; parenchymal spicules are tauactines of various sizes organized into bundles; bundles have a rectangular arrangement near hypodermal spicules but more randomly disposed interiorly, curving about large, circular aporhyses; tauactines largest near gastral surface, but other than a single hexactine of comparable ray thickness (much more slender than hypodermalia) there is no sign of hypogastralia or gastralia; gastral surface bearing large, circular openings of aporhyses, which may branch or anastomose within body wall; smaller, subcircular openings on dermal surface may be epirhyses. *Permian (Artinskian, Roadian, ?Wordian):* USA (Texas).——Fig. 262,*2a–c. *C. plectus,* Word Formation, Leonardian, Glass Mountains; *a,* outer surface of holotype showing dermal hexactines and finer, subdermal triactines around circular, parietal gaps; *b,* broken edge of holotype showing coarse, dermal hexactines at top and finer spicules in interior and on gastral surface, at bottom; *c,* gastral surface of holotype showing large triactines and circular, parietal gaps, USNM 127661, ×1.5 (Finks, 1960; courtesy of The American Museum of Natural History).

Corticulospongia Rigby & Chatterton, 1989, p. 41 [**C. floccosa;* OD]. Sheetlike, thin-walled sponge; presumed dermal surface with interlaced bundles of rhabdodiactines in irregular, but dominantly possible longitudinal orientation parallel to surface; gastral surface with similar, but finer and less

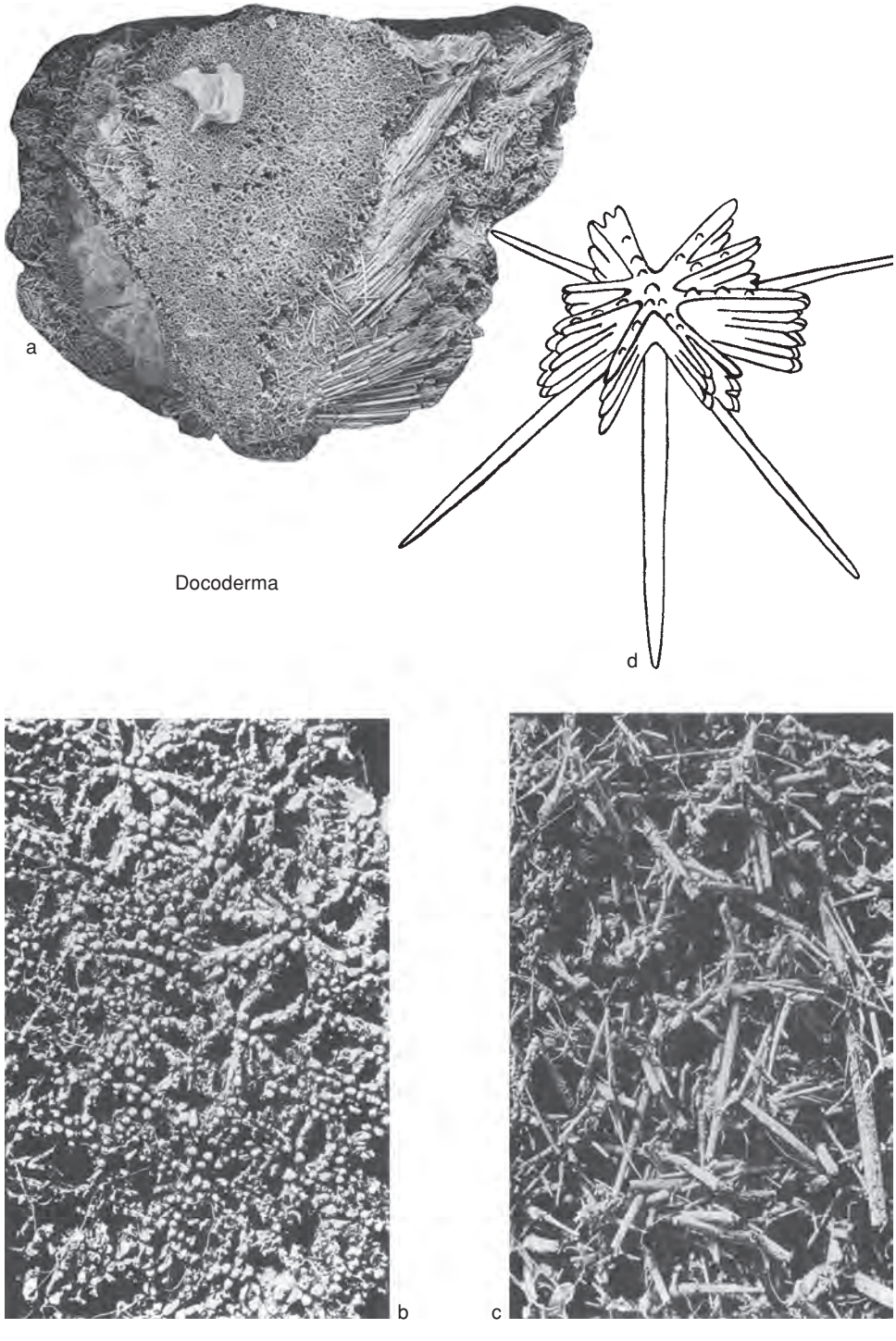


FIG. 261. Docodermatidae (p. 403–404).

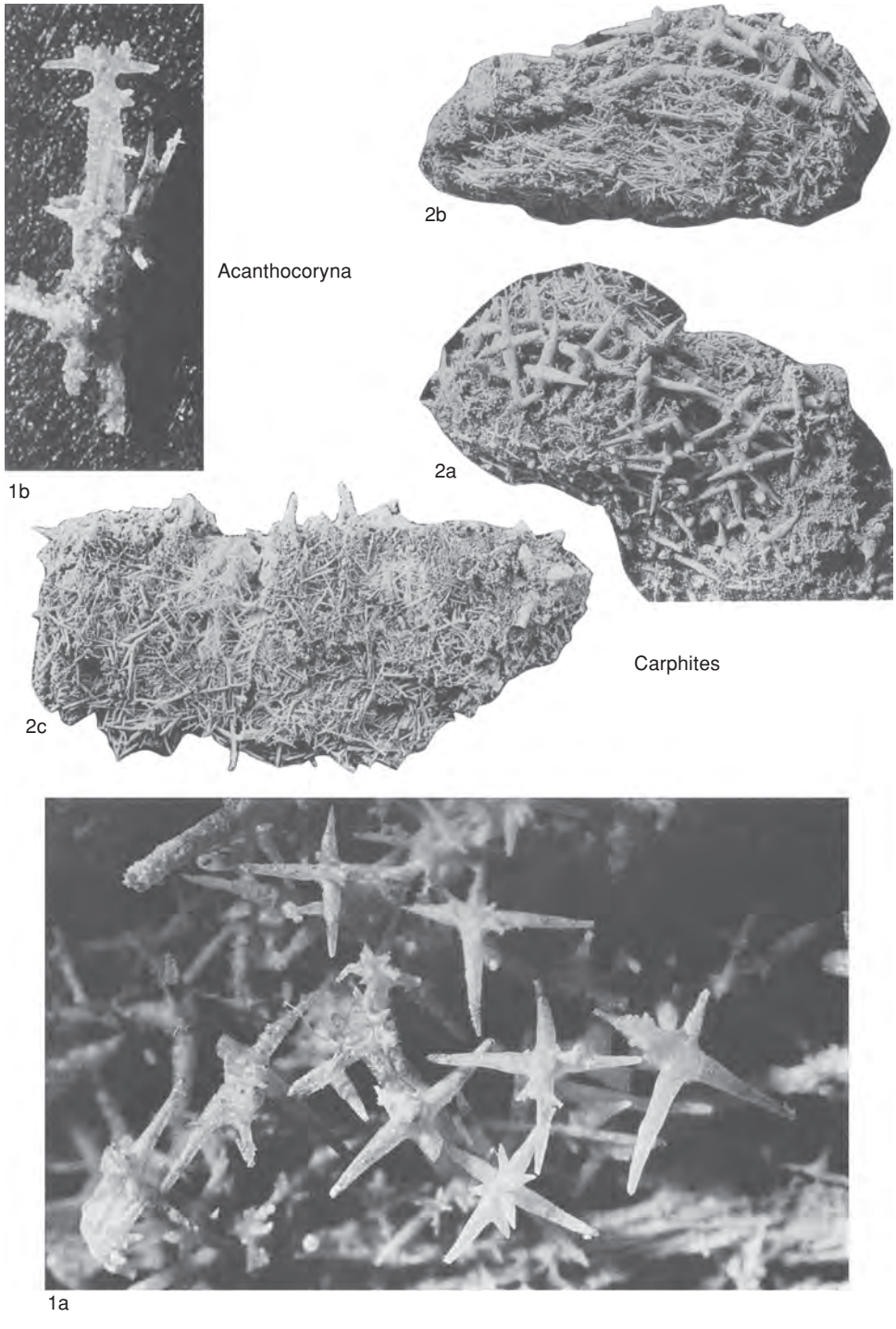


FIG. 262. Docodermatidae (p. 404).

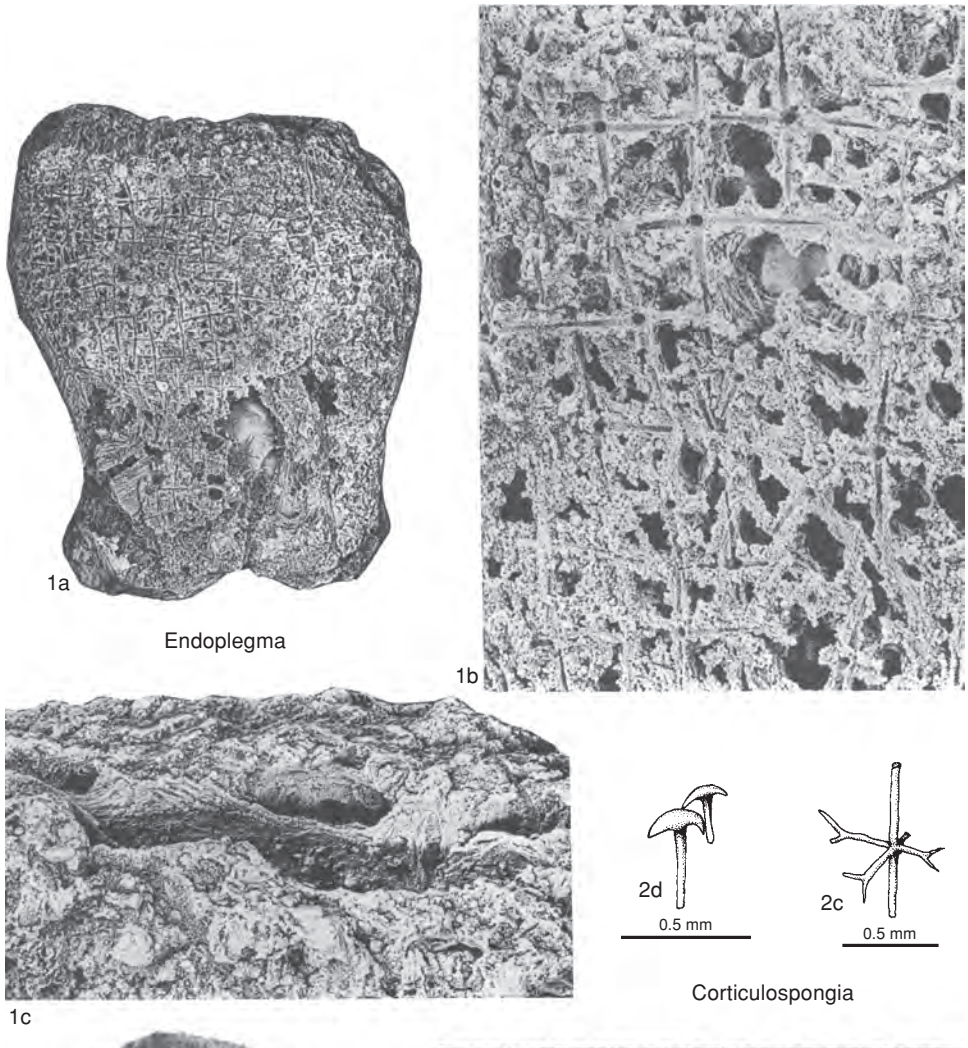


FIG. 263. Docodermatidae (p. 404–408).

well defined bundles; similar bundles in sponge interior diverging upwardly from midplane of wall toward both surfaces, meeting them at an angle; small, closely spaced, polygonal openings between bundles on both surfaces are openings of epirhyses and aporhyses, respectively; small, irregularly oriented hexactines, down to microsclere size, occurring in and beneath gastral layers, along with true oxyhexasters, short-shafted, bidentate anchors occurring rarely in interior. [The genus resembles *Endoplegma* FINKS, 1960, without the large, dermal pentactines. It is possible that they were present and became detached before burial, for in the holotype of *Endoplegma* they are preserved only as molds on the interior silicification. It could also be that this is a genus in which such dermalia were not developed. The spicule bundles that make up the wall are here identified as rhabdodiactines. In the holotype of *Endoplegma* they also look like monaxons, but in better preserved topotype specimens of that genus (personal observation, RMF) are seen to be very long tauactines (FINKS, 1960, p. 128, footnote, there identified as *Carphites diabloensis* FINKS, 1960). It is possible that they are tauactines here as well. Another feature this genus shares with *Endoplegma* is the presence of oxyhexasters and bidentate anchors, which occur in *Endoplegma diabloense*.] *Silurian (Ludlow):* Canada (Northwest Territories, Baillie-Hamilton Island).——FIG. 263,*2a–d.* **C. floccosa,* Cape Phillips Formation, Baillie-Hamilton Island; *a,* dermal surface of holotype showing coarse clusters of subparallel spicules, ×1; *b,* photomicrograph of gastral surface with range of spicules in irregularly subparallel clusters of mixed rhabdodiactines and oxeas, with delicate hexactines as hairlike spicules between, irregular openings are exhalant ostia, UA 7733, ×10; *c–d,* camera lucida drawings of spicules from holotype: fragment of oxyhexaster with subdivided, ray tips and clemes with curved, anchor-shaped rays that may have been part of root tuft or wall, scale indicated by bars (Rigby & Chatterton, 1989; courtesy of Minister of Public Works and Government Services, 2000, and the Geological Survey of Canada).

Endoplegma FINKS, 1960, p. 105 [**E. calathus* FINKS, 1960, p. 106; OD]. Vasiform, subprismatic, rather thick-walled sponge with root tuft; hypodermalia large but slender rayed, pentactines of two orders of size in parallel orientation, larger arranged quincuncially; parenchymalia with several layers of broad, straplike, vertical and horizontal bundles of long-rayed tauactines and possibly rhabdodiactines; gastralia apparently absent; autodermalia not known; comitalia include tauactines, hexactines, and small, curved rhabdodiactines, some of which are strongylelike, and accompany hypodermalia; large, circular aporhyses outlined by parenchymal bundles and covered by hypodermalia; epirhyses may also be present; short, spreading root tuft continuous with parenchymal bundles. A paraclavule and an oxyhexaster have been found in a specimen of *E. diabloense* (FINKS, 1960), a species formerly assigned to *Carphites. Permian (Artinskian, Roadian):* USA (Texas).——FIG. 263,*1a–c.* **E. calathus,* Word Formation, Leonardian, Glass Mountains; *a,* side view of laterally flattened holotype showing molds of dermal pentactines in silicified, outer layer; straplike clusters of monaxons at base may have projected as root tufts, ×0.5; *b,* enlarged part of dermal layer showing molds of dermal pentactines extending across circular, parietal gaps, which are outlined by interior layer of monactines, ×2; *c,* diagonal view into flattened osculum showing lining of straplike bundles of monaxons in gastral surface of spongocoel, USNM 127651, ×2 (Finks, 1960; courtesy of The American Museum of Natural History).

Family STEREODICTYIDAE Finks, 1960

[Stereodictyidae FINKS, 1960, p. 107]

Dictyospongioidea with three-dimensional, gridlike skeleton composed of multiple layers of closely spaced, vertical and horizontal bundles made of reduced or whole hexactines; finer quadrate mesh of dermal or gastral hexactines present in one species; possibly no root tuft. [This aberrant group appears to have retained only (or almost only) the inner, parenchymal layer of spicule bundles, which has become greatly expanded by multiplication of layers.] *Carboniferous (Visean)–Upper Triassic (Carnian).*

Stereodictyum FINKS, 1960, p. 108 [**S. orthoplectum;* OD]. Skeleton composed of several alternating layers of vertical, horizontal, and radial bundles of spicules that appear to be mainly four-rayed, with two rays mutually perpendicular to each other and to remaining two; sponge in form of curving sheets, sometimes thick, that may be encrusting (in this instance radial bundles would be vertical in position). Skeletal canals may be present in larger individuals. [D. F. TOOMEY, J. M. PARKS, and J. L. WILSON (personal communications, 1970s) report the sponges in encrusting positions in Virgilian reefs in New Mexico. A specialized dermal layer is not known in the type species but in the lower Pennsylvanian species *S. proteron* RIGBY & WASHBURN, 1972, a finer mesh of small, parallel hexactines is present on one surface; this species is said to have complete hexactines, as well as reduced ones, forming the main interior mesh, and also to have long, possible rhabdodiactines in some of the superficial spicule bundles.] *Carboniferous (Visean)–Permian (Artinskian):* Spain, *Visean;* USA (Texas, New Mexico, Nevada), *Upper Pennsylvanian–Artinskian;* China, *Moscovian.*——FIG. 264*a–e.*

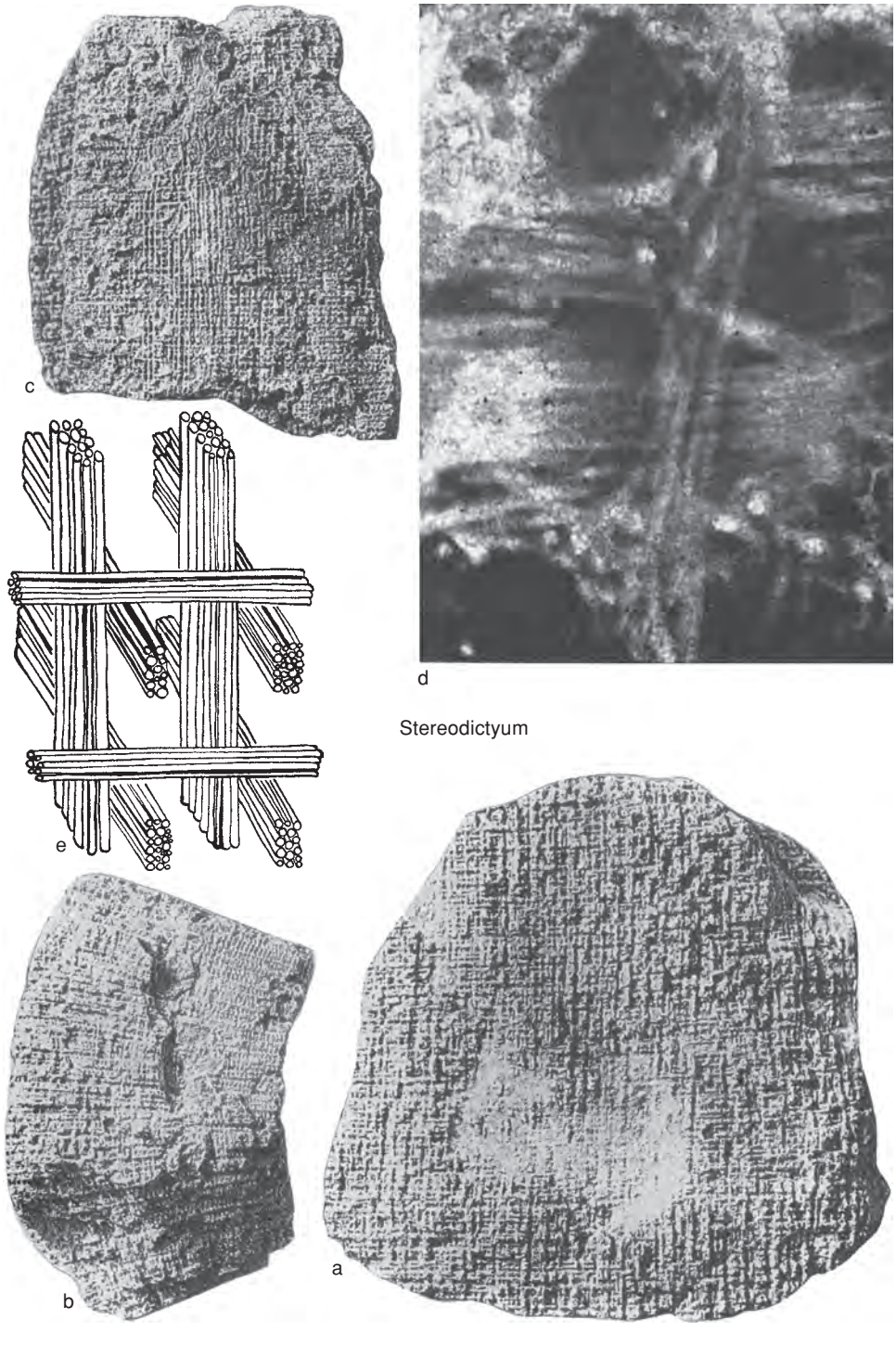


FIG. 264. Stereodictyidae (p. 408–410).

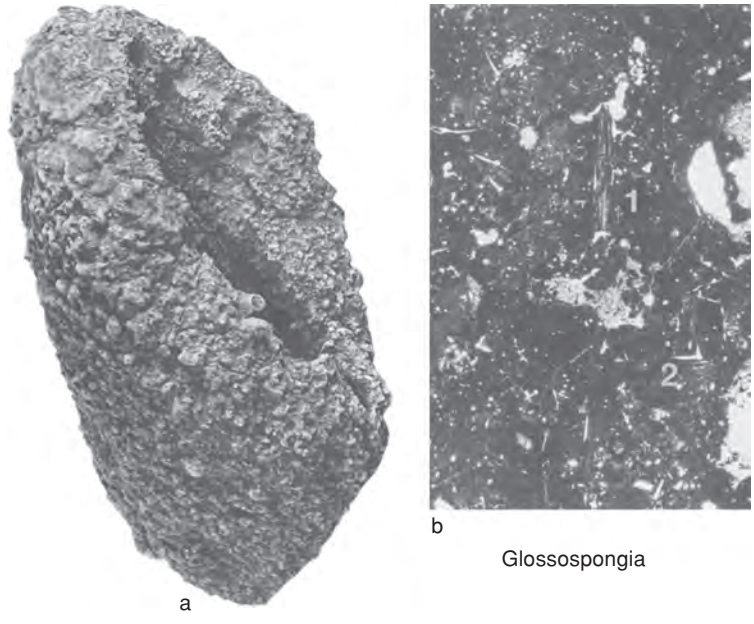


FIG. 265. Stereodictyidae (p. 410).

**S. orthoplectum,* Texas; *a,* eroded, outer surface of holotype showing reticulate, skeletal structure of thick-walled sponge, Wolfcamp Formation, Wolfcampian, Glass Mountains, ×1; *b,* horizontal section through wall showing uniform, reticulate, skeletal structure, with gastral surface to right, Wolfcamp Formation, Wolfcampian, Glass Mountains, ×1; *c,* longitudinal section through wall with gastral surface to left, Wolfcamp Formation, Wolfcampian, Glass Mountains, USNM 127654, ×1; *d,* photomicrograph of longitudinal thin section of paratype showing annular, spicule bundle, top to bottom, and intersecting longitudinal bundles, USNM 127657a, Hueco Formation, Sierra Diablo, Texas, ×25; *e,* diagram of spicule bundles in three-dimensional relationships, with spongocoel toward left and osculum toward top, not to scale (Finks, 1960; courtesy of The American Museum of Natural History).

Glossospongia WU Xichun, 1989, p. 767 [**G. angustoscula* WU Xichun, 1989, p. 768; OD]. Bell-shaped to tongue-shaped sponges with laterally flattened but deep, simple spongocoel with thick walls; skeleton a crude network of upwardly radiating bundles and roughly horizontal bundles of hexactine-based spicules, possibly with additional bundles at right angles, to make a three-dimensional net; areas between bundles not filled by canals, with skeleton formed of irregularly oriented and spaced, small hexactines and hexactine-based spicules around prominent canals that appear radially oriented and normal to dermal-gastral surfaces; most distinctive spicules coarse, hexactine-derived forms in which one or two of normal six rays aborted to produce long spicules with fairly short rays normal to bundle trend; gastral margin with coarse, honeycomb-like, exhalant ostia. *Triassic (Carnian):* China (Sichuan).——FIG. 265*a–b.* **G. angustoscula,* Hanwang Formation, Jushui; *a,* laterally flattened, steeply obconical specimen with nodose exterior and thick walls around deep spongocoel, S-1095, ×1; *b,* photomicrograph showing nearly continuous, vertical spicule bundle (*1*) and less distinct, horizontal bundle of hexactines with irregularly oriented hexactines in spaces between bundles, IGASB R6-11, ×10 (Rigby, Wu, & Fan, 1998).

Superfamily HINTZESPONGIOIDEA Finks, 1983

[Hintzespongioidea FINKS, 1983b, p. 110]

Thin-walled Reticulosa in which an outer dermal layer of parallel, slender-rayed hexactines or derivatives, as in Protospongioidea, is underlain by a layer of slender-rayed hexactines or derivatives in non-parallel orientation that surround closely spaced, circular gaps or aporhyses that are covered by dermal layer; rhabdodiactine prostalia perpendicular to outer surface commonly present. *Lower Cambrian–Carboniferous (Upper Mississippian).*

Family HINTZESPONGIIDAE Finks, 1983

[Hintzespongiidae Finks, 1983b, p. 110]

Obconical, ovate, or vasiform Hintzespongioidea with defined osculum but major prostalia absent. *Lower Cambrian–Devonian (Givetian).*

Hintzespongia Rigby & Gutschick, 1976, p. 81 [**H. bilamina* Rigby & Gutschick, 1976, p. 82; OD]. Sponge thin walled, possibly conical to barrel shaped or ovoid, with an outer, dermal layer of parallel, slender-rayed stauractines of at least four orders of size, overlying a layer of slender-rayed stauractines and hexactines in nonparallel orientation, that outline circular, parietal gaps of more or less quincuncial arrangement. [It is possible that the senior genus *Ratcliffespongia* Rigby, 1969, is the inner layer of a *Hintzespongia*.] *Middle Cambrian:* USA (Utah).——Fig. 266*a–b. *H. bilamina,* Marjum Limestone, House Range; *a,* holotype fragment with prominent, irregular spiculation around parietal gaps of inner, skeletal layer of sponge, ×2; *b,* photomicrograph of parts of both layers of skeleton, with regular, dermal layer of ranked stauractines and hexactines on left and more irregularly spiculed, gastral layer on right, BYU 1153, ×10 (Rigby & Gutschick, 1976).

Cyathophycus Walcott, 1879, p. 18 [**C. reticulatus;* OD] [=*Cyathospongia* Dawson & Hinde, 1889, p. 44, *nom. van., non* Hall, 1882; *Cyathodictya* Hall & Clarke, 1899, p. 200, *nom. van.*]. Conicocylindrical, slightly contracted about broad osculum; single, outer layer of parallel stauractines or pentactines arranged to form a series of quadrules of three orders of size, parallel to longitudinal axis of sponge; short, root tuft present at base; inner layer not resolvable into spicules but possibly composed of them, bearing circular openings resembling parietal gaps, that have about same diameter and spacing as largest quadrules but which do not coincide regularly with these quadrules. [*Cyathospongia quebecensis* Dawson, 1888, from the Middle Cambrian is here considered to belong to *Acanthodictya* Dawson & Hinde, 1889.] *Middle Ordovician–Devonian (Givetian):* USA (New York, Nevada), *Middle Ordovician–Upper Ordovician;* Canada (British Columbia, Northwest Territories), *Llandovery–Wenlock;* USA (Nevada), *Givetian.* ——Fig. 267,*1a–c. *C. reticulatus,* Utica Shale, Trentonian, Holland Patent, New York; *a,* side view of characteristic specimen with pointed base, rounded osculum, and reticulate, quadruled skeleton, ×1; *b,* enlarged base showing development of root tuft, ×3; *c,* enlarged part of quadruled skeleton with ranked stauractines overlying irregularly developed aureoles, ×5 (Hall & Clarke, 1899).

Ratcliffespongia Rigby, 1969, p. 126 [**R. perforata;* OD]. Conicocylindrical sponge; thin body wall composed of stauractines of several sizes in nonparallel arrangement, outlining closely spaced, oval to circular parietal gaps that have a quincuncial arrangement; possible rhabdodiactine prostalia may be present. [It is possible that this is the inner layer of *Hintzespongia* Rigby & Gutschick, 1976.] *Middle Cambrian:* USA (Utah).——Fig. 268*a–b. *R. perforata,* Marjum Limestone or Wheeler Shale, House Range; *a,* steeply obconical holotype with prominent, parietal gaps outlined by irregularly oriented, hexactine-based spicules, ×1; *b,* photomicrograph of lower part of holotype showing irregularly oriented spicules with rays tangent to margins of parietal gaps, BYU 1482, ×5 (Rigby, 1969).

Stephenospongia Rigby, 1986a, p. 55 [**S. magnipora* Rigby, 1986a, p. 56; OD]. Conicocylindrical, thin-walled reticulosid, walls with numerous large, vertically elliptical, parietal gaps outlined by tracts of irregularly oriented and unclumped, thin rhabdodiactines or fine stauractines of several sizes; base not known. [This resembles the mesh of *Sentinelia* Walcott, 1920, and *Valospongia* Rigby, 1983a, but apparently lacks the fine, quadrate mesh over the large openings. However, one of the broader tract areas shown at the left side of figure 7 on plate 18 of Rigby, 1986a, has a fine quadrate mesh and may, in fact, be the dermal covering of an underlying opening.] *Middle Cambrian:* Canada (British Columbia).——Fig. 267,*2a–b. *S. magnipora,* Stephen Formation, *Ogygopsis* shale, Mount Stephen, near Field; *a,* holotype fragment with hairlike, hexactine-based spicules in matte around large, parietal gaps, ×1; *b,* photomicrograph of part of matte showing irregular, delicate spicules and gaps, ROM 433127, ×5 (Rigby, 1986a).

Family TEGANIIDAE de Laubenfels, 1955

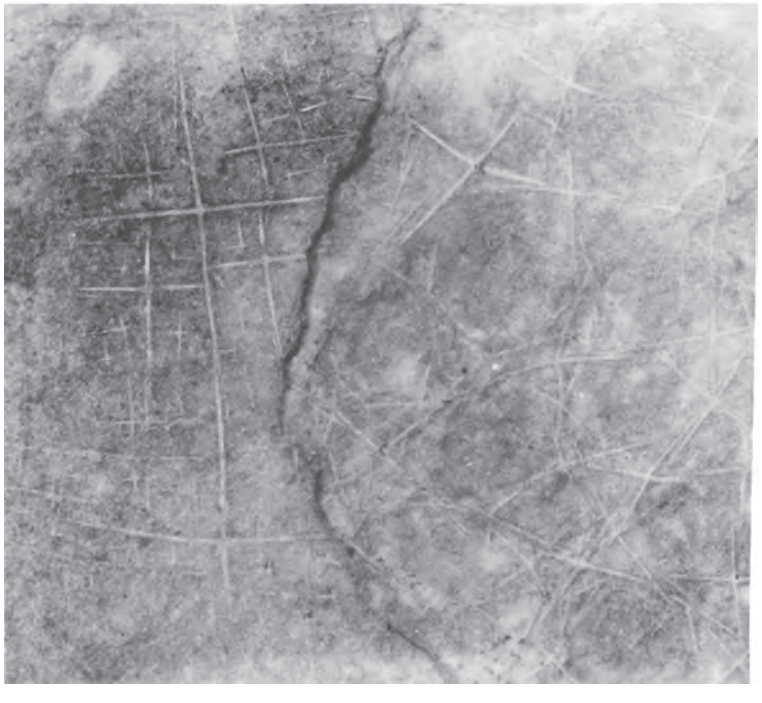
[Teganiidae de Laubenfels, 1955, p. 70]

Spheroidal Hintzespongioidea without osculum and with numerous short, closely spaced prostalia. *Cambrian (Furongian)–Carboniferous (Upper Mississippian).*

Teganium Rauff, 1894, p. 256 [**Cyathophycus subsphaericus* Walcott, 1879, p. 19; OD] [=*Sphaerodictya* Hall & Clarke, 1899, p. 26, obj.]. Spherical; relatively thick, outer layer of rhabdodiactine (or possibly pentactine) prostalia, together with a quadrate mesh of hexactines or derivatives, of nested sizes in parallel orientation; inner layer of hexactines or derivatives in nonparallel orientation, surrounding closely spaced, circular aporhyses; neither osculum nor root tuft known. [The foregoing description is based on Hall and Clarke's illustrations of topotypes (Hall & Clarke, 1899, pl. 1,*14–22*). Personal observation of Walcott's holotype and Rauff's hypotypes confirm Hall and Clarke's statements (1899, footnotes, p. 24–26) and their quotation of

a

Hintzespongia



b

FIG. 266. Hintzespongiidae (p. 411).

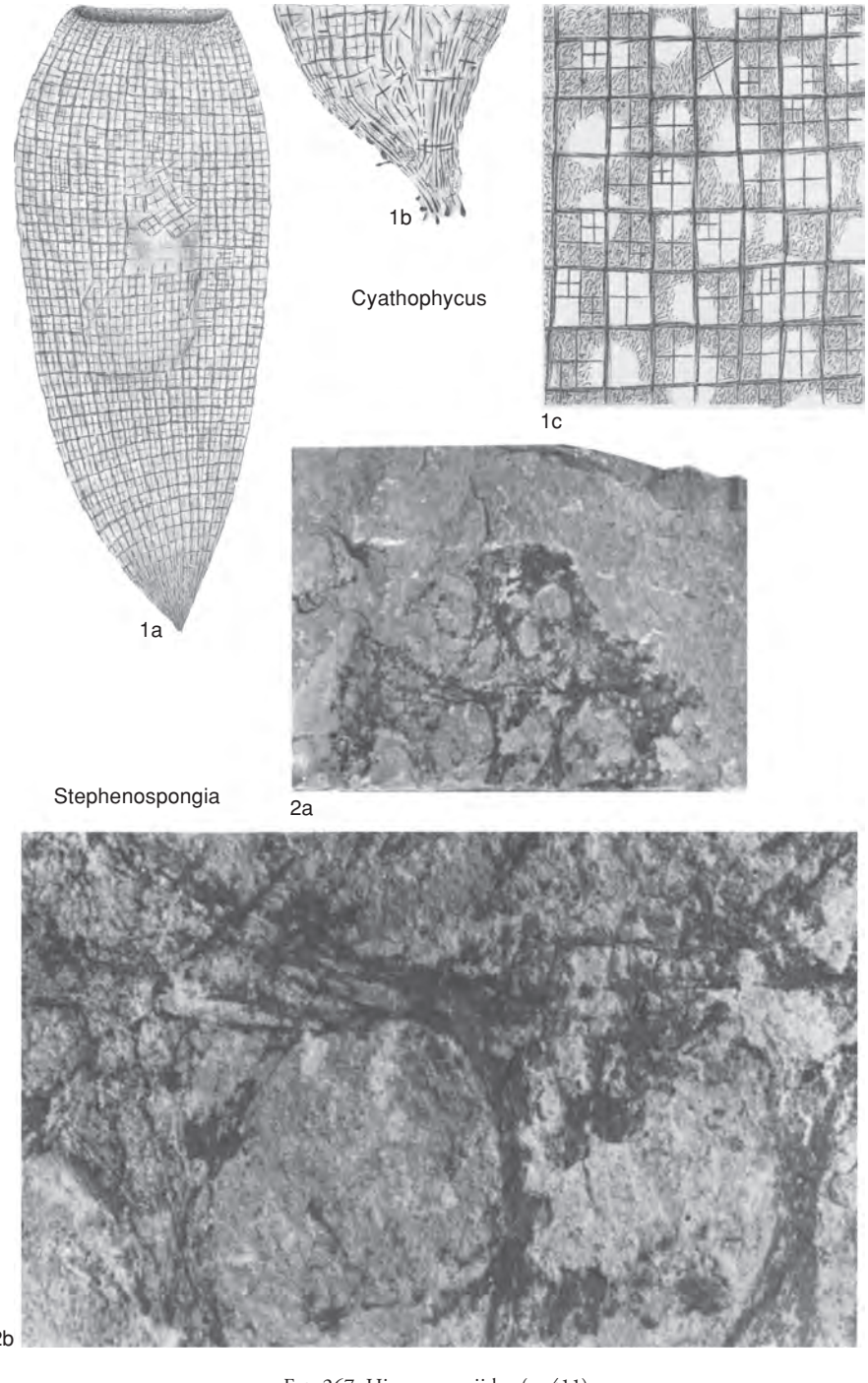
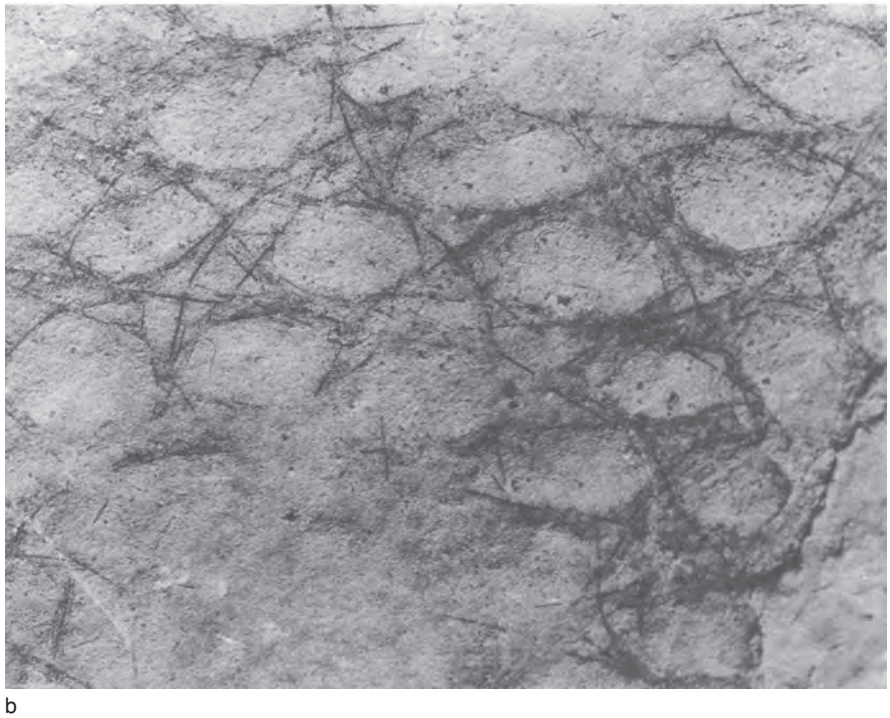


Fig. 267. Hintzespongiidae (p. 411).

a

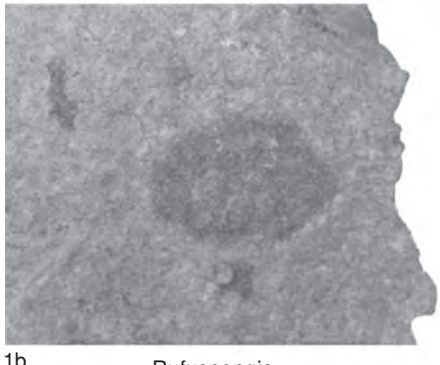
Ratcliffespongia



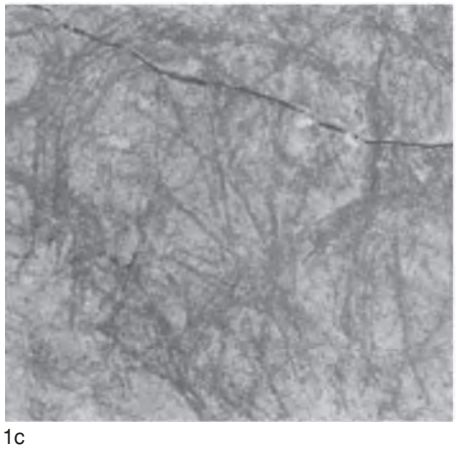
b

Fig. 268. Hintzespongiidae (p. 411).

1a

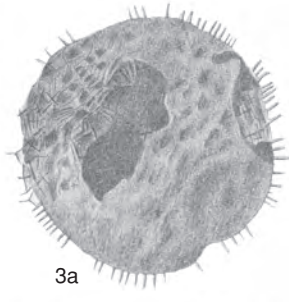


1b Rufuspongia

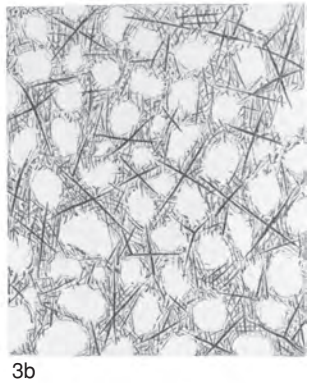


1c

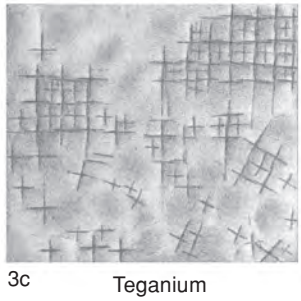
2 Rhombodictyon



3a



3b



3c Teganium

FIG. 269. Teganiidae (p. 411–419).

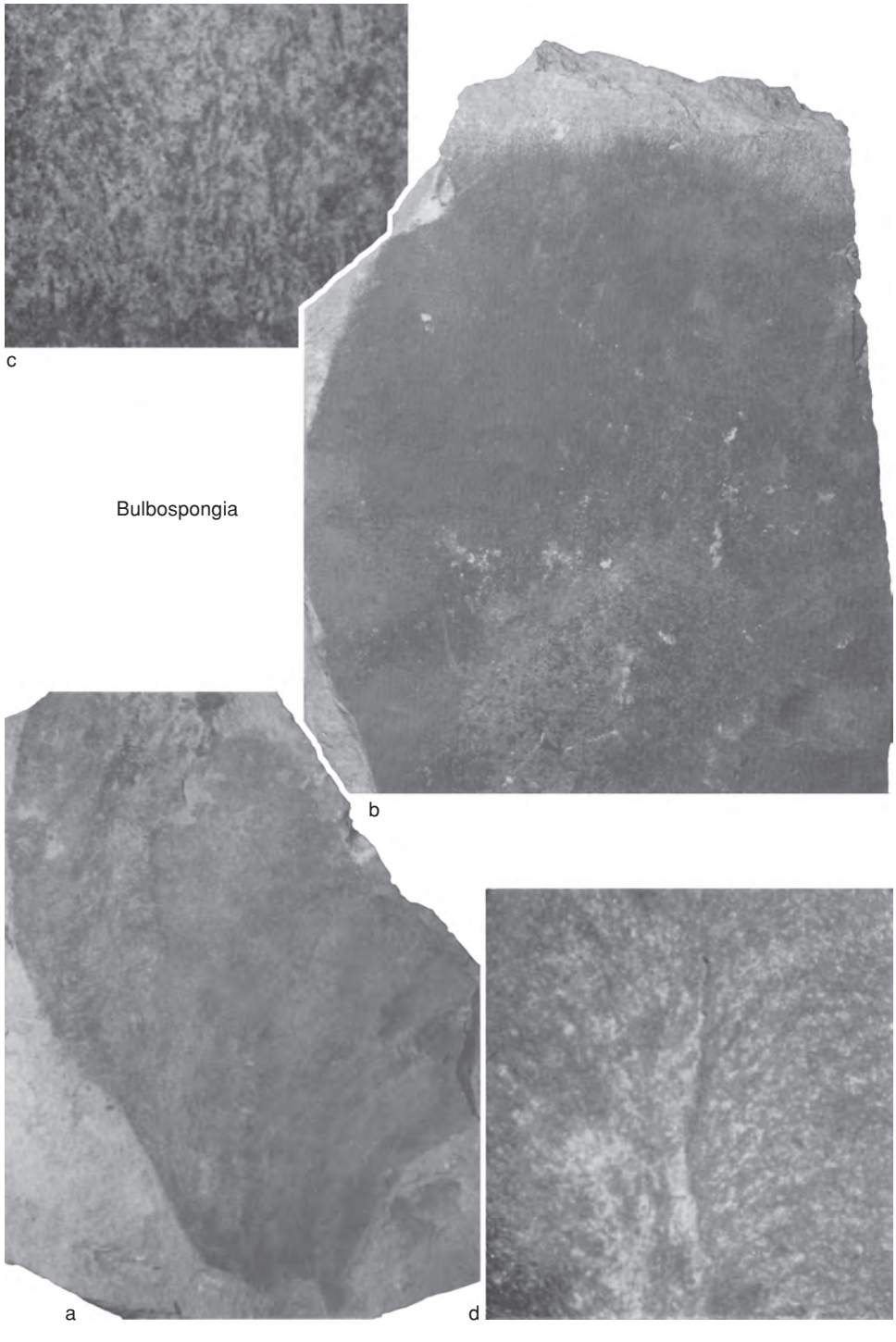


Fig. 270. Teganiidae (p. 417).

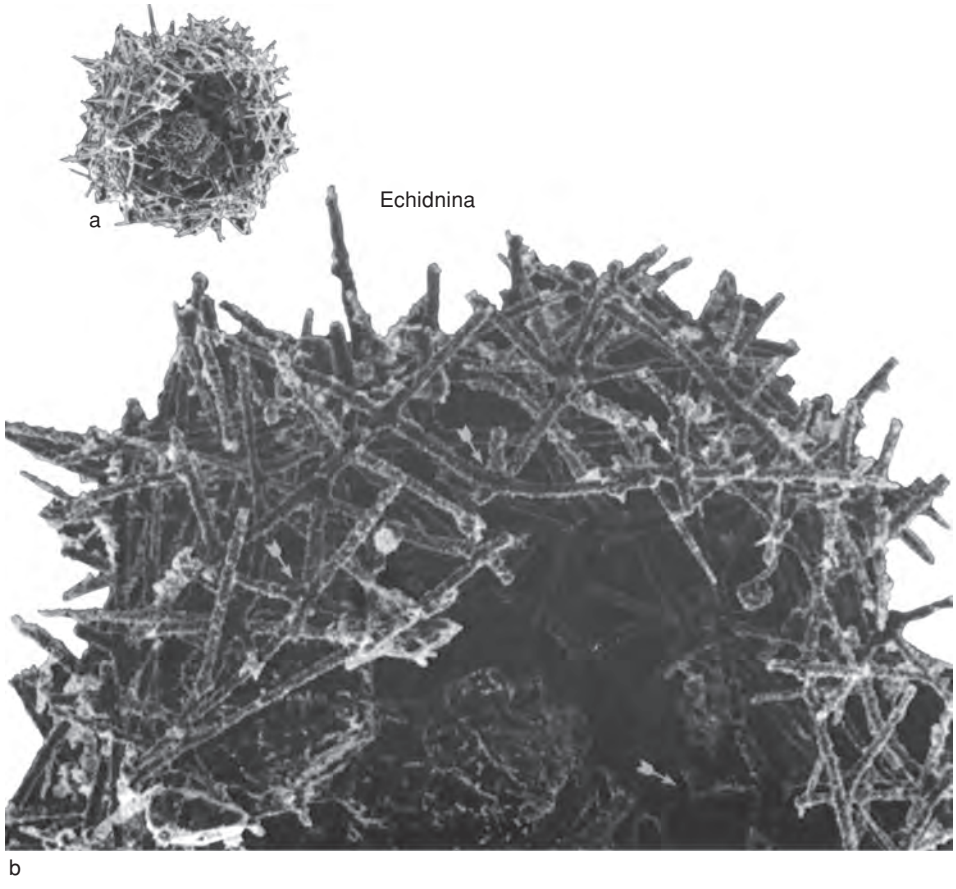


FIG. 271. Teganiidae (p. 417–418).

SCHUCHERT's statements (*loc. cit.*) that the spicules are not visible and that the supposed osculum and cup shape reconstructed by RAUFF are not supported by the specimens. RUEDEMANN (1925) designated a new holotype for *Sphaerodictya subsphaerica* (WALCOTT) HALL & CLARKE but this is not valid.] *Upper Ordovician:* USA (New York).——FIG. 269,*3a–c.* **T. subsphaericum* (WALCOTT), Utica Shale, Holland Patent; *a,* enlarged type showing general form, cruciform spicules on surface, and radiate, marginal spicules; *b,* enlargement of part of inner wall showing aureoles defined by irregularly oriented, cruciform spicules; *c,* enlargement of part of outer wall showing regular, quadruled, skeletal net, ×3 (Hall & Clarke, 1899).

Bulbospongia RIGBY & MEHL, 1994, p. 141 [**B. bullata;* OD]. Vase- or balloonlike, teganiid sponge with bulbous, upper part above steeply obconical, lower part; thin walls have low, vertical ridges in lower part but are smooth in upper part; fine-textured skeleton upwardly divergent and locally plumose, composed of mixed fine and moderately coarse, long spicules that are mainly diactines, but includes some stauractines; without coarse hexactines or rhabdodiactines, as well as reticulate spicules and prominent pores or gaps; inner part of wall with coarser spicules. *Devonian (Givetian):* USA (Nevada).——FIG. 270*a–d.* **B. bullata,* Red Hill beds, northern Simpson Park Range; *a,* side view of vertically ridged, but now flattened, thin-walled holotype preserved as hematite impression, USNM 463560, ×1; *b,* hematite-replaced paratype with prostalia forming spiculed, oscular rim at top, USNM 463561, ×1; *c,* photomicrograph of coarse diactine spicules of paratype with parallel, thatchlike, skeletal structure, USNM 463560; *d,* upwardly plumose diactines that diverge from one of flattened ridges, USNM 463574, ×5 (Rigby & Mehl, 1994).

Echidnina BENGTSON, 1986, p. 202 [**E. runnegari;* OD]. Tiny, globular, thin-walled, with broad osculum as opening to cloaca; skeleton of hexactines, pentactines, stauractines, and possibly rhabdodiactines in irregular orientation, so that external

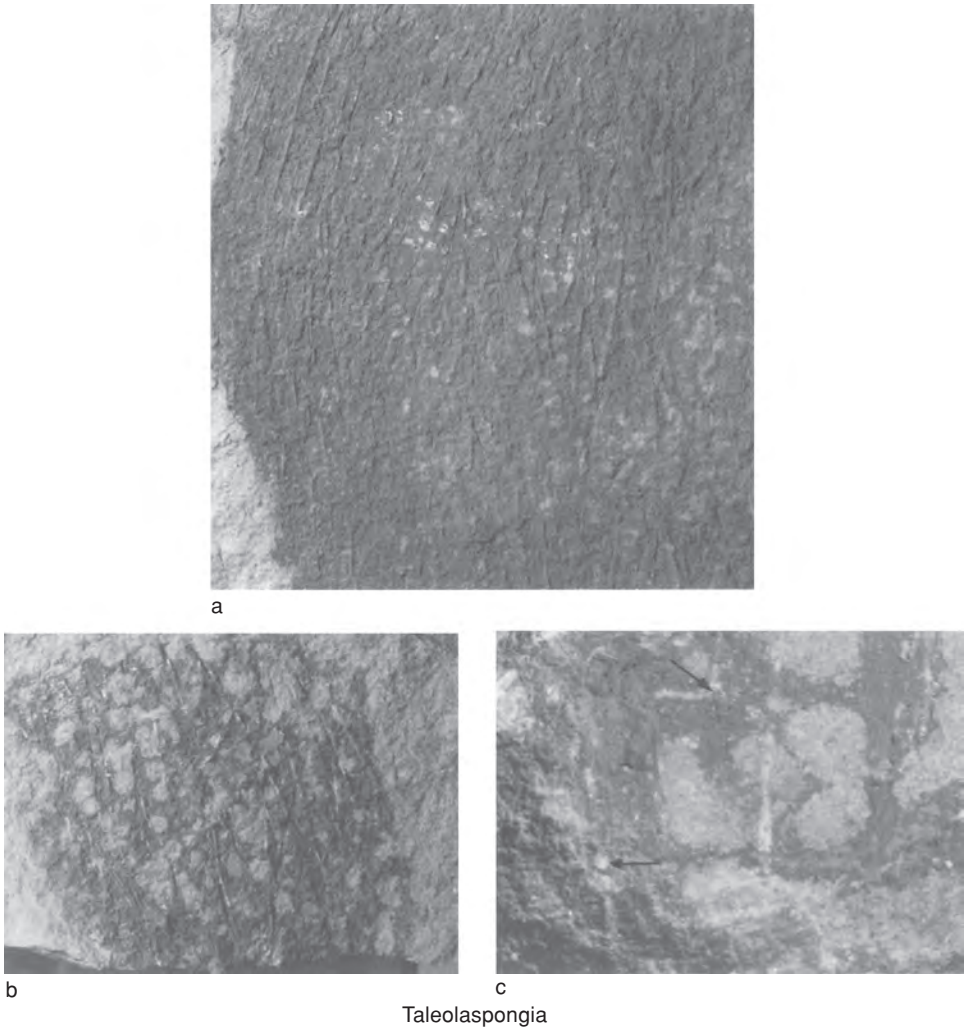


FIG. 272. Teganiidae (p. 419).

surface is spiny because of protruding rays. [These may be juveniles, propagules, or adults.] *Cambrian (Furongian):* Australia (Queensland).——FIG. 271*a–b.* **E. runnegari,* Mindyalian, Mungerebar Limestone, western Queensland; *a,* holotype globular, thin-walled, spicule cluster with broad osculum; ×100; *b,* enlargement of part of holotype showing spicule relationships, UNE F16424, ×450 (Bengtson, 1986).

Rhombodictyon WHITFIELD, 1886, p. 347 [**R. reniforme;* OD]. Subglobular sponge with rhomboidal mesh spaces in primary skeleton formed by diagonally oriented, rodlike elements, probably spicule rays, crossing at angles other than right angles. *Devonian:* New York.——FIG. 269,*2.* **R. reniforme,* Normanskill Shale, Chazyan, Kenwood; side view of globular fossil with diagonal, skeletal meshwork, ×1 (Whitfield, 1886).

Rufuspongia RIGBY & MEHL, 1994, p. 133 [**R. triporata;* OD]. Sheetlike to low, funnel-shaped teganiid sponge with two-layered skeleton; gastral layer with coarse pores and dermal layer with smaller pores; skeleton of hairlike diactines or possibly rhabdodiactines and stauractines with associated, small stauractines; spicules grouped in irregular clusters and tangentially around pores or gaps; without regular arrangement of protospongiid or dictyospongiid structure. *Devonian (Givetian):* USA (Nevada).——FIG. 269,*1a–c.* **R. triporata,* Red Hill beds, northern Simpson Park Range; *a,* holotype with fractured outline of dense, hematitic-replaced, skeletal net with large,

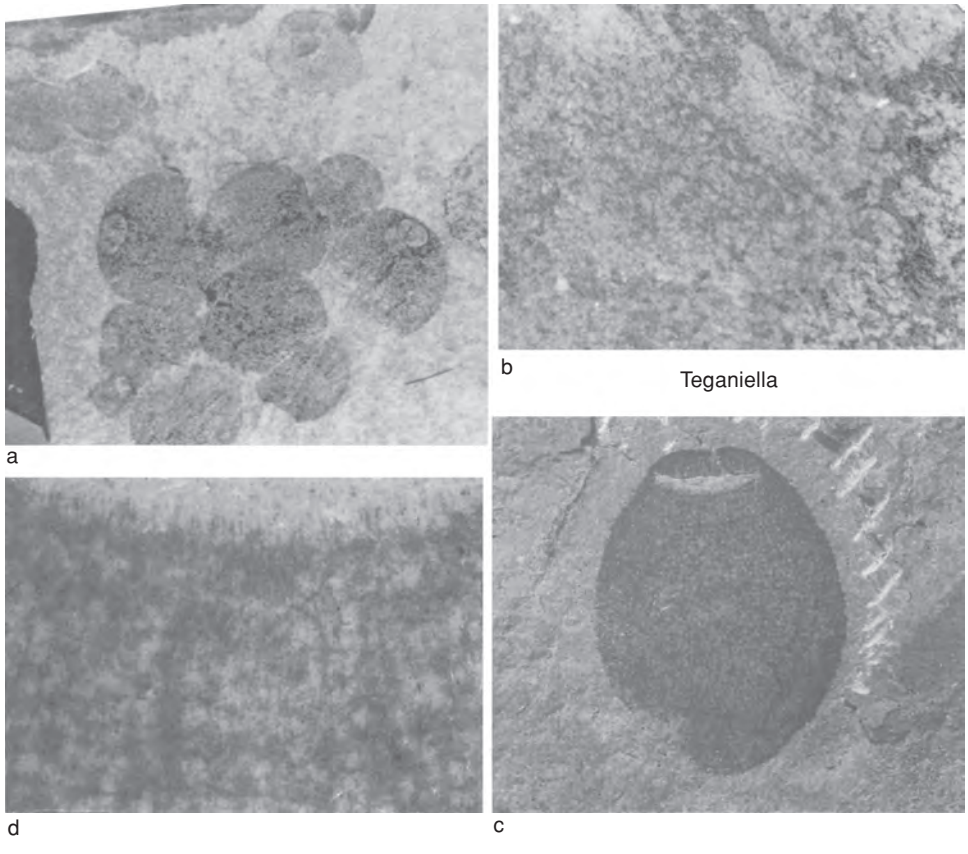


FIG. 273. Teganiidae (p. 419–420).

oval, gastral gaps interrupted by smaller, circular gaps in dermal layer, USNM 463548, ×0.5; *b,* relatively obscurely spiculed, paratype fragment in which layers of spicules obscure larger opening and only intermediate-sized openings are evident, USNM 463572, ×1; *c,* coarse, oval gap outlined by tangential, spicule bundles as seen through finer-textured, more dermal layer with circular, intermediate-sized openings and smaller openings in skeleton of paratype, USNM 463552, ×5 (Rigby & Mehl, 1994).

Taleolaspongia RIGBY & MEHL, 1994, p. 137 [**T. modesta;* OD]. Broad, open funnel-shaped to palmate, teganiid sponge with thin wall constructed of two major skeletal elements: hexactine and hexactine-derived, small, hairlike spicules that are regularly oriented in irregular thatch, and coarse, upwardly divergent hexactines and rhabdodiactines with elongate, vertical rays generally subparallel, although not in regular, protosponge orientations, in midwall or possibly as separate layer; wall pierced by coarse, circular to oval gaps or ostia with moderately uniform diameters and possibly arranged in crude rows. *Devonian (Givetian):* USA (Nevada).——FIG. 272*a–c. *T. modesta,* Red Hill beds, northern Simpson Park Range; *a,* dense, dermal net of holotype sculptured by positive impressions of moderately regularly oriented and spaced, coarse hexactines, light gray matrix fills gaps in net, USNM 463554, ×1; *b,* well-preserved paratype with dark, dermal layer interrupted by light gray gaps, light colored hexactines showing through net, USNM 463556, ×1; *c,* photomicrograph with light gray hexactines in dark, skeletal net, interrupted by medium gray matrix in gaps, USNM 463556, ×5 (Rigby & Mehl, 1994).

Teganiella RIGBY, 1986c, p. 449 [**T. heathi;* OD]. Globular to egg-shaped sponges with rounded base and flattened, upper, oscular rim; thin walls of delicate hexactines of several sizes, with shortened, distal and proximal rays; irregularly arranged in two orientations, either parallel or diagonal to longitudinal axis, but it is not clear whether these represent two distinct layers; meridional bundles of long rays (possible rhabdodiactines) also

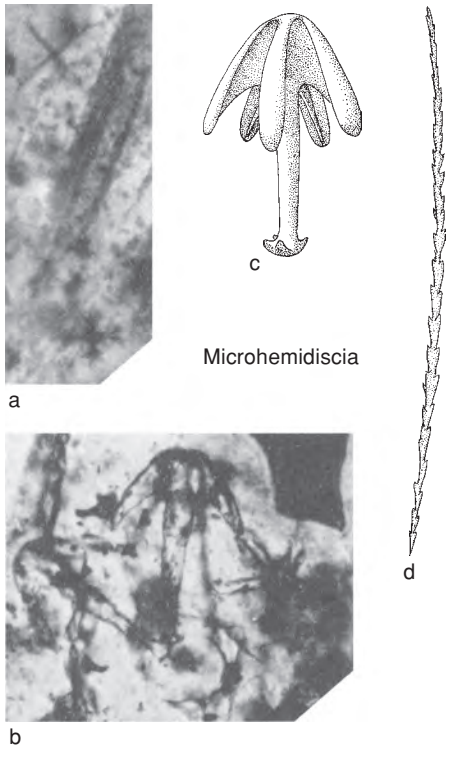


FIG. 274. Microhemidisciidae (p. 420).

present; numerous small, vertically elongate ostia of about quadrule size apparently developed only in dermal layer; marked prostalia absent; basalia unknown. [These could be juveniles of some larger dictyospongid and rather resemble the juveniles of the Permian *Microstaura* FINKS, 1960, except for the thinner wall and diagonal orientation of some skeletal elements.] *Devonian (Givetian)–Carboniferous (Upper Mississippian):* USA (Nevada), *Givetian;* USA (Montana), *Upper Mississippian.*——FIG. 273*a–b.* **T. heathi,* Heath Formation, Chesterian, Fergus County, Montana; *a,* cluster of sponges with holotype, UMG 5723 on right, and paratype, UMG 5724, on left, ×1; *b,* photomicrograph of skeletal net of holotype with crudely rectangular pattern of hexactine-based spicules with one layer diagonal and other horizontal-vertical, ×10 (Rigby, 1986c).——FIG. 273*c–d. T. ovata* RIGBY & MEHL, Red Hill beds, Givetian, Simpson Park Range, Nevada; *c,* holotype, side view of globose sponge with skeletal structure parallel to oscular margin in upper part but diagonally in middle and lower part, USNM 463539, ×2; *d,* photomicrograph of skeletal structure at oscular margin with fringe of short prostalia above regular, reticulate skeleton, USNM 463539, ×10 (Rigby & Mehl, 1994).

Order HEMIDISCOSA Schrammen, 1924

[*nom. transl.* REID, 1958, p. xliv, *pro* Hemidiscaria SCHRAMMEN, 1924a, p. 18]

Amphidiscophora whose principal microscleres are hemidiscs. *Carboniferous (Upper Pennsylvanian).*

Family MICROHEMIDISCIIDAE new family

[Microhemidisciidae FINKS & RIGBY, herein] [type genus, *Microhemidiscia* KLING & REIF, 1969, p. 1433]

Hemidiscs with spatulate teeth on major umbel, occurring together with uncinates. *Carboniferous (Upper Pennsylvanian).*

Microhemidiscia KLING & REIF, 1969, p. 1,433 [**M. ortmanni;* OD]. External form unknown; principal skeleton of unfused, simple hexactines, pentactines, and rhabdodiactines accompanied by uncinates and hemidiscs; hemidiscs bearing five long, spatulate rays at one end and five (rarely six) short, conical rays at other end. *Carboniferous (Upper Pennsylvanian):* Uruguay.——FIG. 274*a–d.* **M. ortmanni,* Itararé Formation, Rio Negro, Tacuarembó-Durazno; *a,* uncinates from paratype, GPIT Po 1340/6, ×300; *b,* hemidiscs from holotype, GPIT, Po 1340/5, ×200; *c,* drawing of hemidisc from holotype, GPIT Po 1340/5, ×250; *d,* drawing of uncinate from paratype, GPIT Po 1340/6, ×150 (Kling & Reif, 1969).

Subclass HEXASTEROPHORA Schulze, 1887

[*nom. transl.* REID, 1958a, p. xliv, *ex* Hexasterophora SCHULZE, 1887b, p. 36]

Hexactinellida with microscleres that include hexasters but not spicules with umbellate ray terminations (such as paraclavules, hemidiscs, amphidiscs, staurodiscs, or hexadiscs). [The oldest known hexasters are early Carboniferous (Mississippian) and were found within a paraclavule-bearing sponge (*Griphodictya* HALL & CLARKE, 1899), here included with the Amphidiscophora. Hexasters have also been found in the late Carboniferous (Pennsylvanian) amphidisc-bearing *Itararella* KLING & REIF, 1969. Although late Paleozoic isolated hexasters are known, none have been found physically within sponges here included with the Hexasterophora. Paleozoic sponges

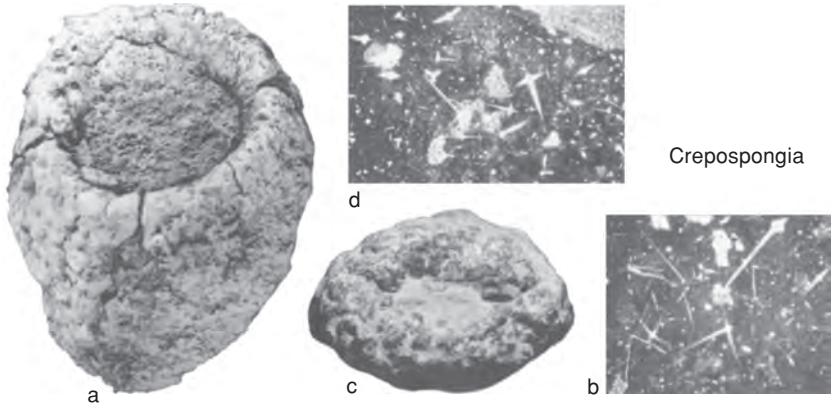


FIG. 275. Crepospongiidae (p. 421–422).

are herein assigned to the Hexasterophora on the strength of a graded, morphologic series extending back from the Permian possible hexactinosan *Pileolites* FINKS, 1960, in the Ordovician *Brachiospongia* MARSH, 1867. Other than the paraclavule or amphidisc-bearing genera cited, *Arakespongia* RIGBY, CHAMBERLAIN, & BLACK, 1970 (Pennsylvanian), the dubious *Erythrospongia* HUDSON, 1929 (Carboniferous), and a single hexaster occurring with a single paraclavule in the Permian *Endoplegma* FINKS, 1960, there are no hexaster-bearing, whole, Paleozoic sponge fossils known. It is worth noting, however, that the type specimens of *Pileolites* were found in association with isolated hexasters in the accompanying sediment.] *Ordovician–Holocene.*

Order LYSSACINOSA Zittel, 1877

[*nom. transl.* REID, 1958a, p. xliv, *ex* tribus Lyssacinaria SCHRAMMEN, 1924a, p. 18, *nom. transl. ex* order Lyssakina ZITTEL, 1877b, p. 22; *emend.,* IJIMA, 1927, p. 319]

Hexasterophora without dictyonal strands. [It is possible that many isolated hexactines, as well as isolated hexasters, from Paleozoic sediments were derived from disintegrated lyssacines other than the genera with more coherent skeletons described below.] *Ordovician–Holocene.*

Superfamily CREPOSPONGIOIDEA new superfamily

[Crepospongioidea FINKS & RIGBY, herein] [type genus, *Crepospongia* WU, 1989, p. 768]

Lyssacinosid sponges with skeleton of irregularly oriented and spaced hexactines and related spicules; without bundled spicule tracts or differentiated layers of coarse dermalia or gastralia. *Triassic (Carnian).*

Family CREPOSPONGIIDAE new family

[Crepospongiidae FINKS & RIGBY, herein] [type genus, *Crepospongia* WU, 1989, p. 768]

Lyssacinosan sponges with skeletons of irregularly oriented and spaced hexactines, stauractines, and related spicules of several sizes; differentiated, coarsely spiculed, dermal and gastral layers absent. *Triassic (Carnian).*

Crepospongia WU, 1989, p. 768 [**C. circulana;* OD] [=*Oospongia* WU, 1989, p. 768 (type, *O. radiocanalis,* OD); *Calpidospongia* WU, 1989, p. 768 (type, *C. rhynchoprocta* WU, 1989, p. 769, OD); *Pyrenospongia* WU, 1989, p. 769 (type, *P. omalohemisphaera,* OD)]. Spheroidal to ovate or urn- or slipper-shaped sponges with deep, central spongocoel and moderately thick walls; coarse, exhalant oscula irregularly placed and shaped on gastral surface; skeleton mainly of irregularly oriented and spaced stauractines and hexactines of several sizes, and may include small oxeas or

rhabdodiactines. *Triassic (Carnian):* China (Sichuan).——Fig. 275*a–b. *C. circulana,* Hanwang Formation, Mianzhu County; *a,* side view of slipper-shaped holotype showing moderately thick wall around sediment-filled spongocoel, ×1; *b,* photomicrograph of variously sized hexactines and related spicules in wall of holotype, ×15 (Wu, 1989).——Fig. 275*c–d. C. radiocanalis* (Wu), Hanwang Formation, Mianzhu County; *c,* view from above of ovate holotype with nodose, thick walls around sediment-filled spongocoel, ×1; *d,* photomicrograph of characteristic, irregularly spaced and sized hexactines in wall, ×12 (Wu, 1989).

Superfamily BRACHIOSPONGIOIDEA Beecher, 1889

[*nom. transl.* Finks, 1960, p. 115, *ex* Brachiospongiidae Beecher, 1889, p. 13]

Vasiform sponges that rest directly on sea floor without root tuft or other attachment structure; enlarged hypodermalia and sometimes hypogastralia that are commonly differentiated from irregularly oriented, parenchymal hexactines that are usually organized around epirhyses and aporhyses; autodermalia and autogastralia may be present. *Upper Ordovician–Permian (Guadalupian).*

Family BRACHIOSPONGIIDAE Beecher, 1889

[Brachiospongiidae Beecher, 1889, p. 13]

Lobate brachiospongioids in which hollow, radial protuberances of body serve as props; larger, hypodermal spicules may bear distal knobs; epirhyses and aporhyses present. *Upper Ordovician–Silurian (Ludlow).*

Brachiospongia Marsh, 1867, p. 88 [**Scyphia digitata* Owen, 1858, p. 111; SD Beecher, 1889, p. 13]. Sponges open, round-bottomed cup bearing subequatorial expansion from which 6 to 12 subequal, hollow, fingerlike precursors curve outwardly and downwardly and terminate in blunt to acute tips at about same level well below base of central cup; protuberances may bifurcate distally in some forms; body wall maintaining constant, moderate thickness throughout all parts so that cloaca constitutes most of internal volume of protuberances and central cup; one species reported as externally tuberculate; small, closely and evenly spaced, circular openings penetrate body wall seemingly as exhalant and inhalant canals but end short of opposite surface; between them are smaller skeletal pores; skeletal net consisting of outer layer of small pentactines in parallel orientation that cover inhalant openings as well as rest of surface, hypodermal layer consisting of larger, nonparallel hexactines in which distal ray reduced to round knob (surrounded by four similar knobs, one on distal surface of each tangential ray near crossing) and inner, parenchymal spiculation consisting of hexactines, some of which are spinose, in nonparallel orientation; no root tuft. [This is similar to *Rhaeaspongia* Lamont, 1935 and *Colospongia* Lamont, 1935, but they are not identical.] *Upper Ordovician:* USA (Kentucky, Ohio, Tennessee), Canada (Ontario, Manitoba).——Fig. 276,*1a–c. *B. digitata* (Owen), Bigby Limestone, Trentonian, Frankfort, Kentucky; *a,* side view of original specimen showing incomplete, lower, hollow digitations and upper, thin-walled chimney with incomplete, oscular margin; *b,* view from above showing radial pattern of digitations, YPM, ×0.5; *c,* enlarged outer surface with dermal, spicular mesh and nodes of rays of large, hypodermal pentacts, ×20 (Beecher, 1889).

Colpospongia Lamont, 1935, p. 307 [**C. lineata* Lamont, 1935, p. 308; OD]. Genus could be interpreted as resembling a small *Brachiospongia* in which radial protuberances coalesce laterally to form radial flutes; inner surface of cloaca apparently bore grooves confluent toward osculum; no spicules known, nor is it clear from illustration and description whether this was truly built like *Brachiospongia* or whether it was a simple, open cup, as originally described. *upper Upper Ordovician:* England.——Fig. 276,*2. *C. lineata,* Sholeshook Limestone, Haverfordwest; internal cast of plicate, bowl-shaped holotype viewed from below, BMHN S 735, ×1 (Lamont, 1935).

Fistellaspongia Rigby & Maher, 1995, p. 1,027 [**F. inclinata;* OD]. Small, cylindrical sponges with deep spongocoel, moderately thin walls made of irregularly, although dominantly diagonally arranged hexactines of several sizes; coarsest hexactines with paratangential rays diagonal to sponge axis, but not in regular or quadruled pattern, and with short, proximal and distal rays normal to that surface; coarse spicules separated by smaller, irregularly oriented and spaced spicules; canal system irregularly developed in feltlike, irregular skeleton. *Silurian (Ludlow):* USA (Nevada).——Fig. 277,*1a–c. *F. inclinata,* Roberts Mountains Formation, Snake Mountains; *a,* side view of flattened, tubular holotype with skeleton of diagonally arranged, hexactine-based spicules with felted structure, ×2; *b,* photomicrograph of lower part of holotype showing spicules of various sizes, with most diagonally arranged, USNM 480436, ×10; *c,* photomicrograph of paratype showing distinct layer of uniformly spaced and oriented, coarse, dermal hexactines along left, USNM 480437, ×10 (Rigby & Maher, 1995).

Rhaeaspongia Lamont, 1935, p. 305 [**R. mactagguarti;* OD]. Genus differs from *Brachiospongia,* insofar as preservation permits comparison, in that radial protuberances are broader and more irregular and expand distally to form branched, wedge-shaped segments that terminate at a common circumference; no spicules known.

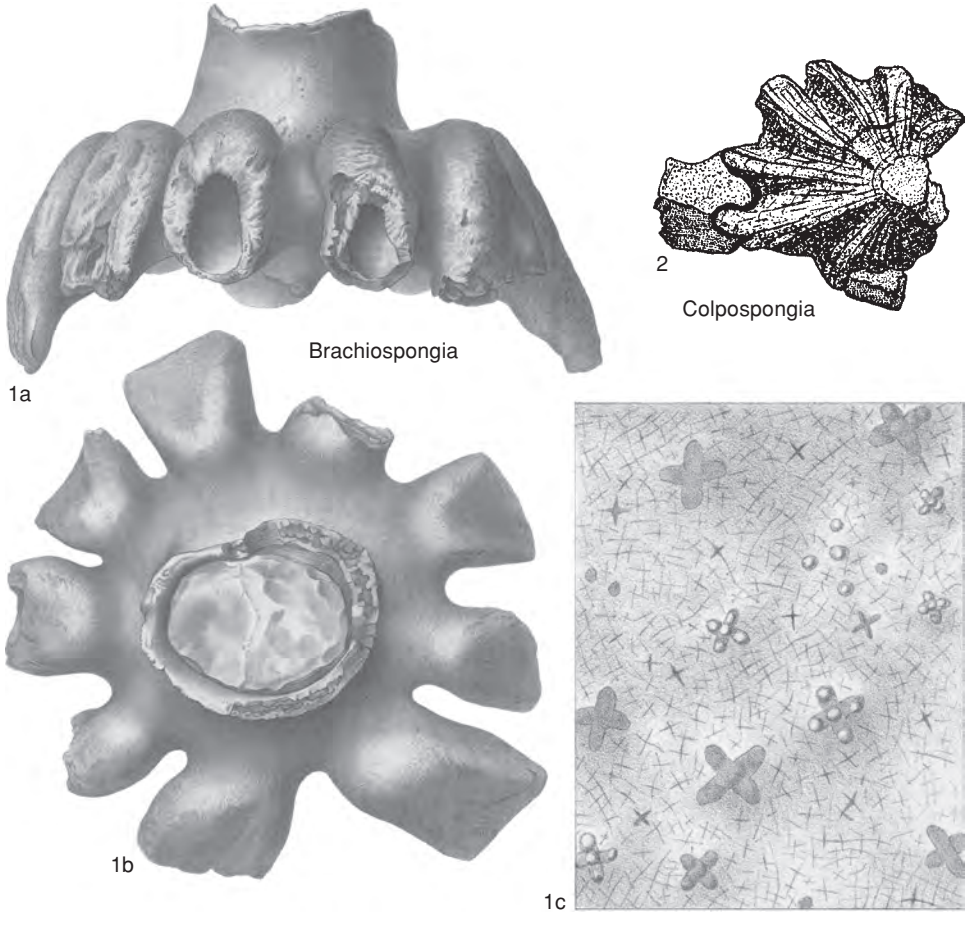


FIG. 276. Brachiospongiidae (p. 422).

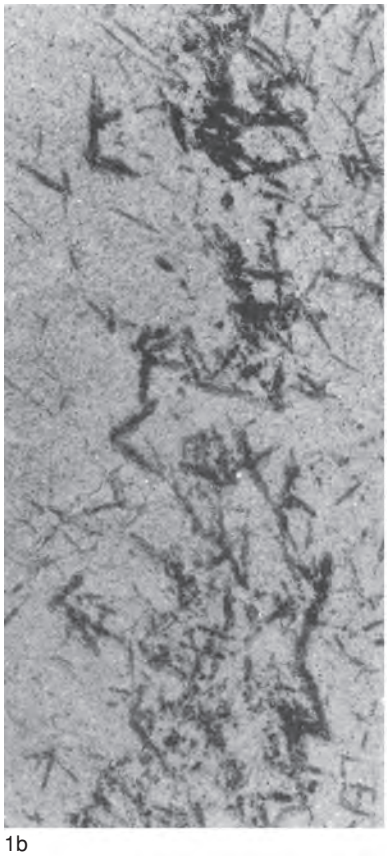
[Some Upper Ordovician species assigned to *Brachiospongia* may belong here.] *upper Upper Ordovician:* Scotland, ?North America.——FIG. 277,*2a–b. *R. mactagguarti,* Lower Drummock Group, Dailly, Scotland; *a,* small holotype, internal cast as viewed from below, with central base of attachment and flared, radial arms, ×1; *b,* drawing of holotype from above showing considerable irregularity in shape and placement of radial arms, HM P 5200, ×1 (Lamont, 1935).

Family PYRUSPONGIIDAE Rigby, 1971

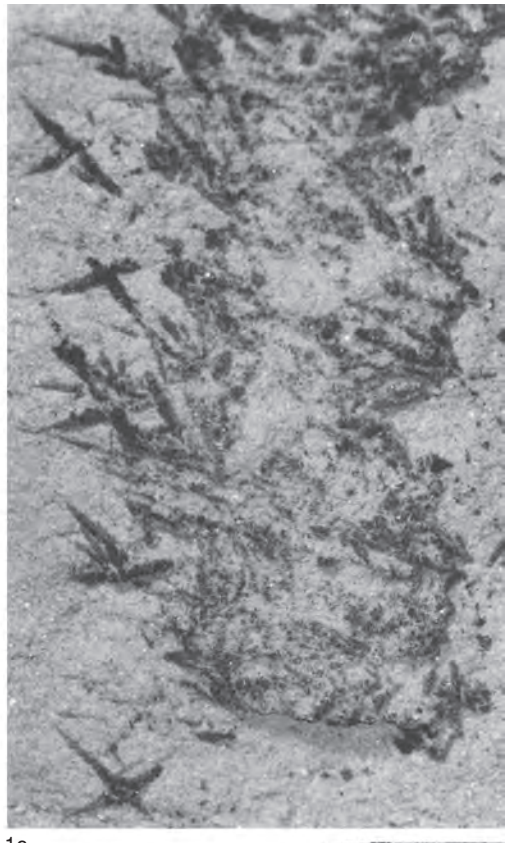
[Pyruspongiidae RIGBY, 1971, p. 59]

Vasiform brachiospongioids without prominent skeletal canals; skeleton with enlarged, simple, hypodermal pentactines or hexactines over irregularly oriented, parenchymal hexactines. *Upper Ordovician.*

Pyruspongia RIGBY, 1971, p. 60 [**P. ruga;* OD]. Sponge moderately thin-walled with flat base and vertically ribbed sides, cylindrical in lower part, globose or bowl-shaped in upper part with broad osculum; parenchymal spicules hexactines in nonparallel, or only locally parallel, arrangement, with outer (possibly hypodermal) layer of larger, stubby pentactines and hexactines; no parietal gaps or large, skeletal canals. [Genus resembles *Oncosella* in external form but differs in the lack of skeletal canals and in having smooth rather than spiny hexactines.] *Upper Ordovician:* Canada (Manitoba).——FIG. 278,*2a–b. *P. ruga,* Cat Head Member, Red River Formation, Caradoc–Ashgill, Lake Winnipeg; *a,* side view of ribbed, bulbous holotype preserved as limonite mold, GSC 25410, ×1; *b,* restoration based upon holotype, approximately ×1 (Rigby, 1971; courtesy of Minister of Public Works and Government Services, 2000, and the Geological Survey of Canada).



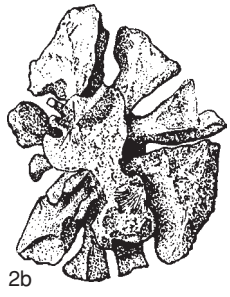
1b



1c

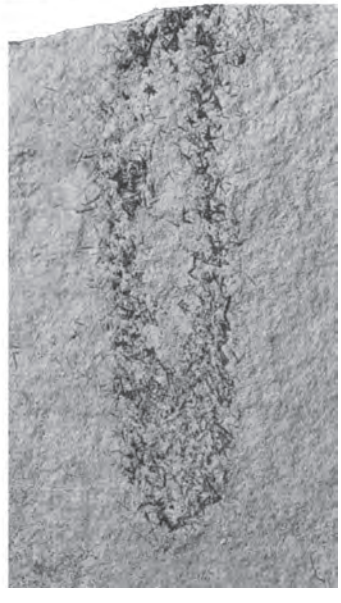
Fistellaspongia

2a



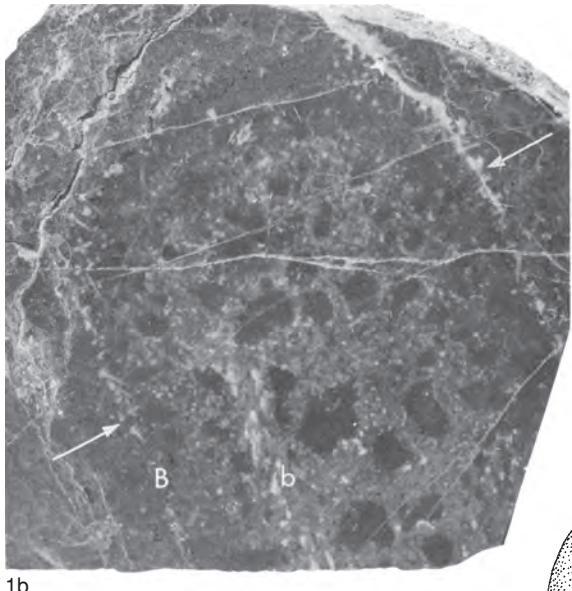
2b

Rhaeaspongia



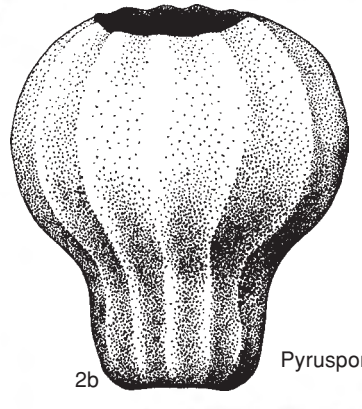
1a

FIG. 277. Brachiospongiidae (p. 422–423).



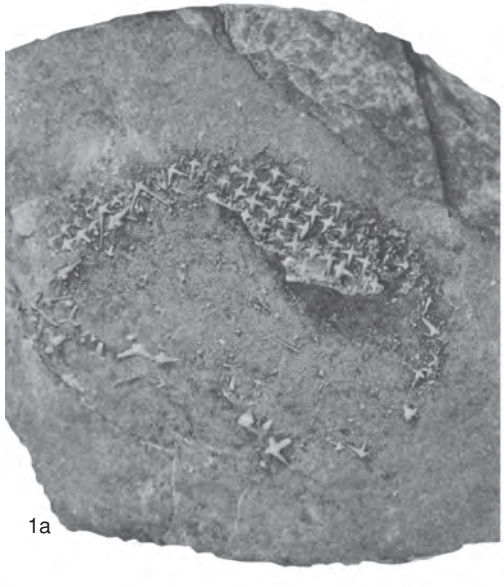
1b

2a



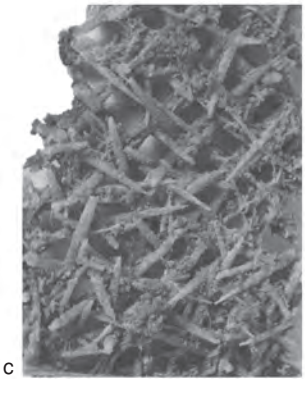
2b

Pyruspongia



1a

Toomeyospongia



1c

FIG. 278. Pyruspongiidae and Toomeyospongiidae (p. 423–429).

Family MALUMISPONGIIDAE Rigby, 1967

[Malumispongiidae Rigby, 1967b, p. 769]

Barrel-shaped to bowl-shaped brachiospongioids with epirhyses and aporhyses well developed; dermalia not differentiated from parenchymalia other than by abortion of distal, and possibly proximal, rays; all spicules irregularly oriented; rhabdodiactines may be present. *Upper Ordovician–Carboniferous (lower Tournaisian).*

Malumispongium Rigby, 1967b, p. 770 [**Aulocopium hartnageli* Clarke, 1924, p. 10; OD]. Vasiform to cylindroid, uniformly moderately thick walled; widest near flat, centrally concave base, contracting somewhat toward broad osculum; cloaca of same shape as exterior; large, closely spaced, cylindrical, inhalant and exhalant canals, perpendicular to surfaces, almost penetrating body wall and communicating with smaller, skeletal canals within body wall; specialized dermalia and gastralia not preserved, perhaps not developed; parenchymalia simple, smooth hexactines of various sizes in nonparallel orientation; basalia not present. *Silurian (Wenlock):* Canada (Quebec, Gaspe).——Fig. 279,*1a–b.* **M. hartnageli* (Clarke), La Vieille Formation, Gaspe Peninsula, Quebec; *a,* vertical section through lectotype showing large, matrix-filled spongocoel and thick walls with light matrix in parietal gaps and canals, NYSM 12562, ×0.5; *b,* photomicrograph of thin section from syntype showing variation in hexactine size and in orientation, NYSM 12566, ×10 (Rigby, 1967b).

Carbonella Hurcewicz & Czarniecki, 1986, p. 341 [**C. rotunda;* OD]. Spheroidal to pyriform; thick walled; outer surface with irregularly distributed, low protuberances; no osculum; cloaca narrow and of stellate cross section (because of entering possible canals); canals of circular cross section, closely spaced in more or less quincuncial arrangement, open on exterior; dermal skeleton of small stauractines and rhabdodiactines; principal skeleton of larger hexactines and stauractines, including irregularly distributed, much larger ones; gastral layer containing vertically oriented rhabdodiactines. *Carboniferous (Visean):* Poland.——Fig. 279,*2a–g.* **C. rotunda,* Carboniferous limestone of Galezice, Holy Cross Mountains; *a,* side view of holotype, ×0.5; *b,* longitudinal section showing cribrate, skeletal structure, ×1; *c,* skeletal fragment with diactine (*a*), stauractine (*b*), and larger hexactines with axial rays (*c*), ×100; *d–g,* drawing of spicules from thin section, *d–e,* stauractines and diactines in dermal skeleton; *f,* hexactines and stauractines in endosomal skeleton; *g,* diactines, scale bar, 0.1 mm, AI-68/32 (Hurcewicz & Czarniecki, 1986; courtesy of Polish Geological Society, Krakow).

Oncosella Rauff, 1894, p. 264 [**O. catinum;* OD]. Vasiform to cylindroid, somewhat broader than high, and contracting slightly toward osculum from flat, centrally concave base; sides bearing vertical ridges that increase in prominence downwardly and extending a short distance onto basal surface; numerous inhalant and exhalant canals extending nearly through body wall, exhalant canals short and opening onto cloacal surface with uniformly large pores; inhalant pores of larger and smaller sizes; parenchymalia spinose hexactines of various sizes in nonparallel orientation; gastral, canalar, and dermal surfaces may bear paratangential stauractines and pentactines; outer surface also bearing short, slender, slightly spinose rhabdodiactines (but not clearly uncinates); latter paratangential to surface but otherwise nonparallel except on crests of ridges that they parallel; a few similar rhabdodiactines found within body wall; autodermalia possibly present as hexactines or derivatives that cover some inhalant openings; no basalia present. *Silurian (Wenlock):* England.——Fig. 280,*1a–c.* **O. catinum,* Wenlock Limestone, Dudley; *a,* side exterior view of holotype with broad base, vertical ridges, and rounded, oscular summit, ×1; *b,* vertical median section showing broad spongocoel and thick walls with radial, inhalant and exhalant canals, ×1; *c,* spinose, parenchymal hexactines from wall, ×25 (Rauff, 1893).

Scaphiomanon Gutschick & Perry, 1959, p. 981 [**S. nodulosum* Gutschick & Perry, 1959, p. 982; OD]. Thick-walled, bowl-shaped, with more or less flat base and rounded sides curving in toward wide, oscular opening; cloaca of same diameter as osculum; large, exhalant canals with tributaries enter cloaca from below and sides, separated by less than their diameter; exterior bearing ostia smaller than exhalant canals; each ostium is infundibuliform and leads into an inhalant canal; small, meandriform canals occur within wall but internal connections of canal system not clear; spicules poorly preserved, but include hexactines according to Rigby (1977b, p. 132). [Assessment of the genus is hampered by poor preservation of the skeleton, but it is placed in the family because of its similarity to *Malumispongium* Rigby, 1967b.] *Carboniferous (lower Tournaisian):* USA (Montana).——Fig. 280,*3a–b.* **S. nodulosum,* Kinderhookian, Sappington Sandstone, Three Forks; *a,* oblique view of bowl-shaped holotype with broad osculum; *b,* median, vertical section showing broad spongocoel and coarse, parietal gaps, filled with light matrix, and thick walls of holotype, USNM 137942, ×0.5 (Gutschick & Perry, 1959).

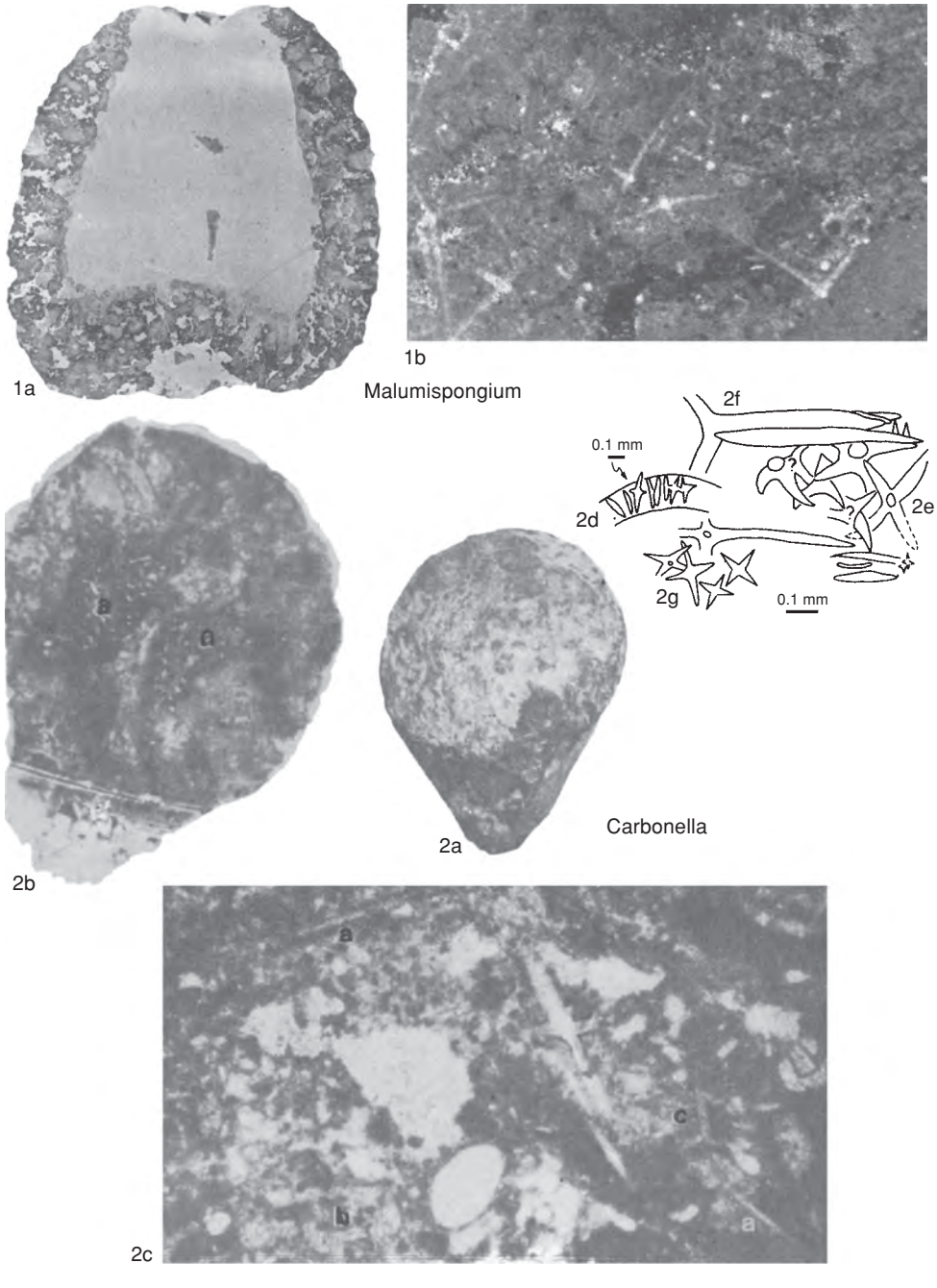


FIG. 279. Malumispongiidae (p. 426).

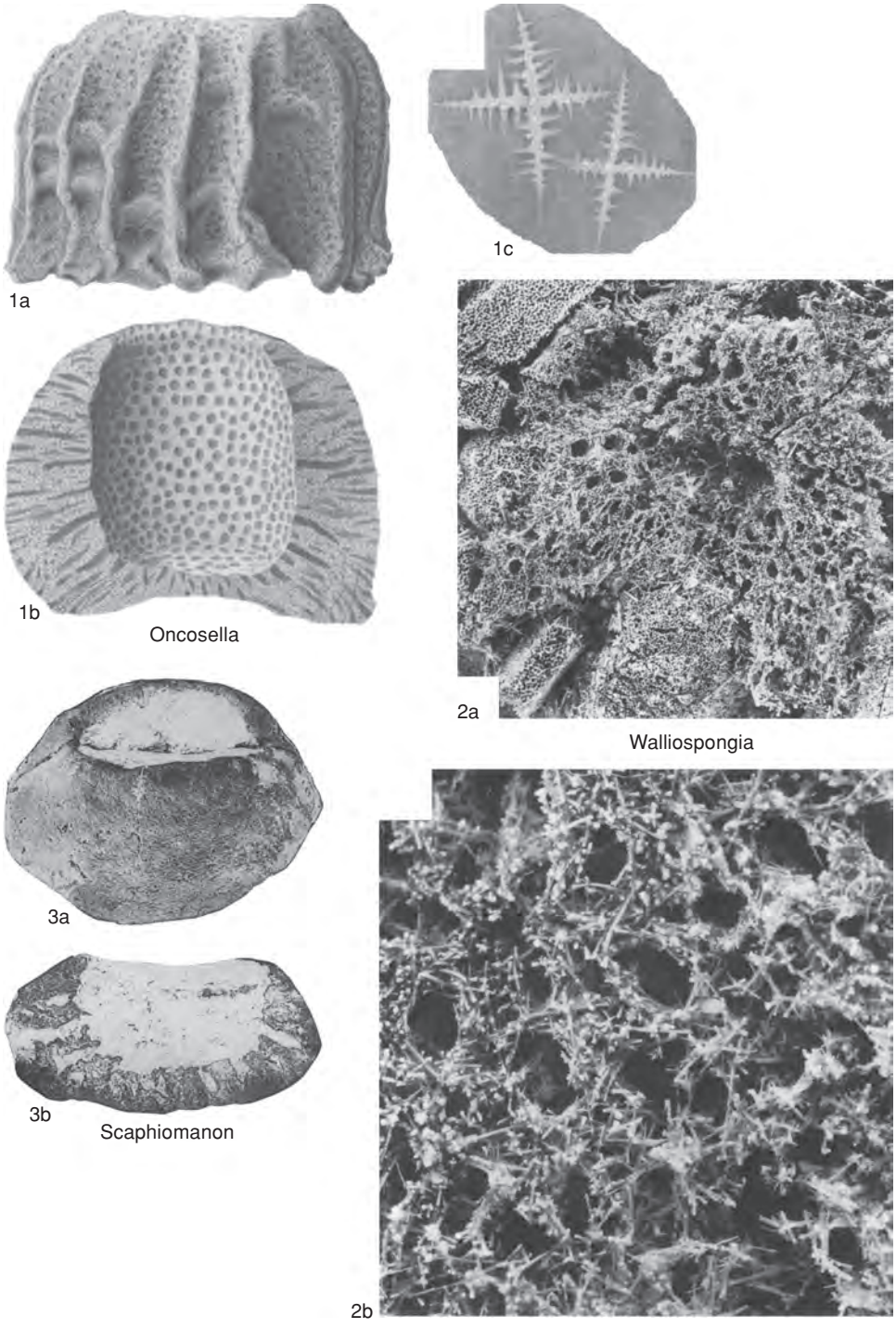


FIG. 280. Malumispongiidae (p. 426–429).

Walliospongia Rigby & Webby, 1988, p. 82 [**W. gracilis* Rigby & Webby, 1988, p. 83; OD]. Saucer shaped to low-conical with delicate, open, porous, skeletal net of fine and uniformly sized hexactines, all irregularly oriented around major, excurrent canals that converge upwardly and inwardly toward spongocoel; incurrent canals in tracts between excurrent series in full diplorhysis; both series end blindly; gastral spicules with four tangential rays; dermal layer ill defined; canals not in rectangular pattern. *Upper Ordovician:* Australia (New South Wales).——Fig. 280,*2a–b. *W. gracilis,* Malongulli Formation, Cliefden Caves area; *a,* view down into open, saucer-shaped spongocoel showing form of species and its delicate skeleton with moderately uniformly spaced ostia of radial canals on gastral surface, ×2; *b,* photomicrograph of gastral surface with excurrent openings of radial canals and open-textured skeleton composed of moderately irregularly oriented, small hexactines, AMu. F66903, ×10 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Family TOOMEYOSPONGIIDAE new family

[Toomeyospongiidae Finks & Rigby, herein] [type genus, *Toomeyospongia* Rigby, Horrocks, & Cys, 1982, p. 317]

Massive hemispherical to bowl-shaped or tubular brachiospongiids with prominent, coarse, exhalant canals but less well defined inhalant openings in thick walls, skeleton of irregularly oriented hexactines and hexactine-derived spicules; prominent, dermal layer of coarse pentactines or hexactines with regular, subparallel orientation of tangential rays. *Permian (Guadalupian).*

Toomeyospongia Rigby, Horrocks, & Cys, 1982, p. 317 [**T. apachensis* Rigby, Horrocks, & Cys, 1982, p. 318; OD]. Massive, subhemispherical sponge with coarse stauracts and pentactines as dermalia, which have regular orientation and strongly reflexed tangential rays, but without supernumerary rays or sculpture on distal surface of pentacts, other than single nodes near base of each tangential ray; equal-sized dermalia overlap to outline quadrules of one ray length; interior skeleton of variously sized and irregularly oriented hexactines or reduced derivatives, including numerous tauactines (and possible rhabdodiactines) among smaller sizes; interior skeleton perforated by coarse, circular, radial (possible exhalant) canals, which do not penetrate through dermal layer, and by smaller, interconnected, canal series. [Genus differs from *Docoderma* Finks, 1960, in the absence of extra, paratangential rays.] *Permian (Guadalupian):* USA (Texas), Mexico (?Sonora).——Fig. 278,*1a–c. *T. apachensis,* Lamar Limestone of Bell Canyon Formation, Capitanian, Apache Mountains, Texas; *a,* weathered, lateral surface of silicified holotype with large, systematically oriented, dermal pentactines, top of sponge is to upper right, USNM 304046, ×1; *b,* polished surface through holotype showing nonvasiform nature of sponge and large, circular, matrix-filled canals of central part of sponge, ×1; *c,* view up into region directly below dermal layer in paratype showing reflexed tips of dermal pentacts and smaller hexactines that unite in strong skeleton, USNM 303046b, ×2 (Rigby, Horrocks, & Cys, 1982).

Superfamily LUMECTOSPONGIOIDEA Rigby & Chatterton, 1989

[*nom. transl.* Finks & Rigby, herein, *pro* Lumectospongiidae Rigby & Chatterton, 1989, p. 39]

Hexastrophoran sponges with thick-walled skeleton mainly of irregularly felted uncinates, and less commonly, irregularly spaced and oriented, smooth-rayed hexactines. [Certain taxonomic placement of these sponges is impossible because definitive microscleres have not been observed in them. Rigby and Chatterton (1989), however, placed tentatively the then-described single family within the lyssacinosid Hexasterophora because of the common occurrence of uncinates within that subclass. They also observed that these sponges lack dictyonal strands and, thus, were included in the Lyssacinosa Zittel, 1877b. That placement is continued here. The Lumectospongioidea Rigby & Chatterton, 1989, lack the enlarged hypodermalia or hypogastralia that characterize the associated Brachiospongioidea Beecher, 1889.] *Silurian (Ludlow).*

Family LUMECTOSPONGIIDAE Rigby & Chatterton, 1989

[Lumectospongiidae Rigby & Chatterton, 1989, p. 39]

Hexactinellids with skeleton principally an irregular, felted mass of uncinates with less common, irregularly spaced and oriented, smooth-rayed hexactines. *Silurian (Ludlow).*

Lumectospongia Rigby & Chatterton, 1989, p. 39 [**L. uncinata* Rigby & Chatterton, 1989, p. 40; OD]. Thin-walled, obconical to bowl- or cup-shaped skeleton of uncinates and less common,

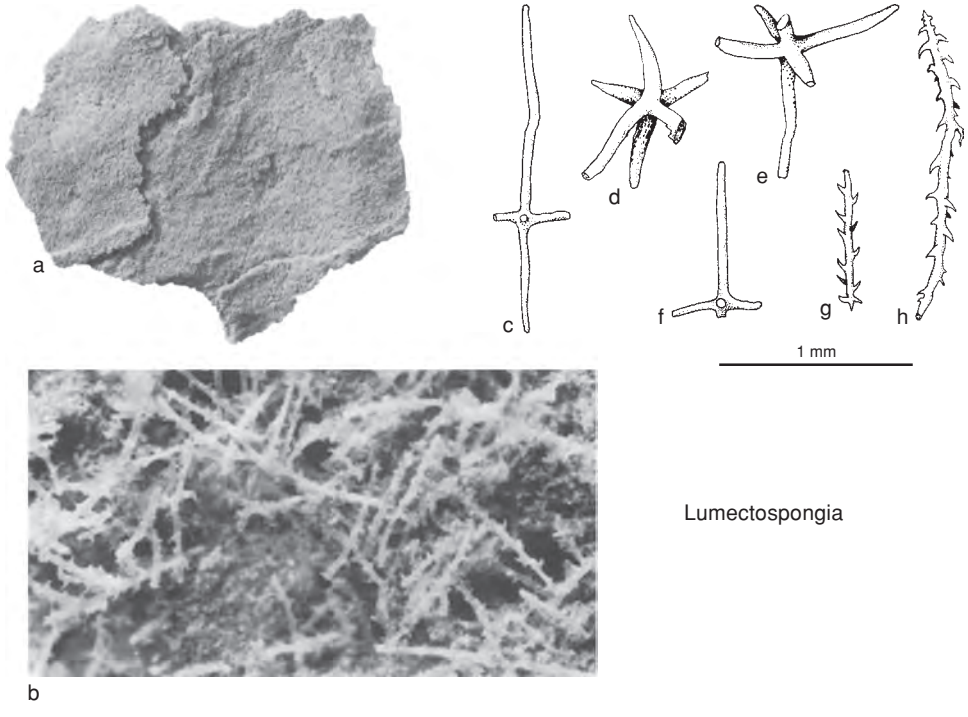


FIG. 281. Lumectospongiidae (p. 429–430).

smooth hexactines of same size in felted mass; hexactines irregularly oriented and spaced; pores widely spaced and ill defined. *Silurian (Ludlow):* Canada (Northwest Territories, Baillie-Hamilton Island).——FIG. 281*a–h*. **L. uncinata,* Cape Phillips Formation, Baillie Hamilton Island; *a,* side view of flattened and folded, thin-walled holotype showing smooth surface and uniform texture of wall composed of felted mass of uncinates, ×1; *b,* photomicrograph of irregularly oriented uncinates in gastral skeleton, ×50; *c–h,* camera lucida drawings of spicules of holotype, *c–f,* more or less uniform hexactines, *g–h,* spinose uncinates that make up most of skeleton, UA 7732, ×25 (Rigby & Chatterton, 1989; courtesy of Minister of Public Works and Government Services, 2000, and the Geological Survey of Canada).

Order HEXACTINOSA Schrammen, 1903

[*nom. transl.* DE LAUBENFELS, 1936, p. 185, *ex* Tribus Hexactinosa SCHRAMMEN, 1903, p. 4; *sensu* SCHRAMMEN, 1912, p. 190]

Hexasterophora with dictyonal strands that do not bear lychnisc nodes. *Upper Ordovician–Holocene.*

Superfamily PILLARASPONGIOIDEA Rigby, 1986

[*nom. transl.* FINKS & RIGBY, herein, *pro* Pillaraspongiidae RIGBY, 1986b, p. 40]

Hexasterophora with dictyonal, euretoid, thick-walled skeletons and primary canals in full diarhyses. *Devonian (Frasnian–Famennian).*

Family PILLARASPONGIIDAE Rigby, 1986

[Pillaraspongiidae RIGBY, 1986b, p. 40]

Skeleton dictyonal, euretoid, with thick walls and primary canals in full, well-developed diarhyses; canals in simple, vertically stacked series. *Devonian (Frasnian–Famennian).*

Pillaraspongia RIGBY, 1986b, p. 40 [**P. ellimberia* RIGBY, 1986b, p. 41; OD]. Obconical to globular, thick walled, with well-defined spongocoel and coarse, radial diahryses in regular pattern in vertical

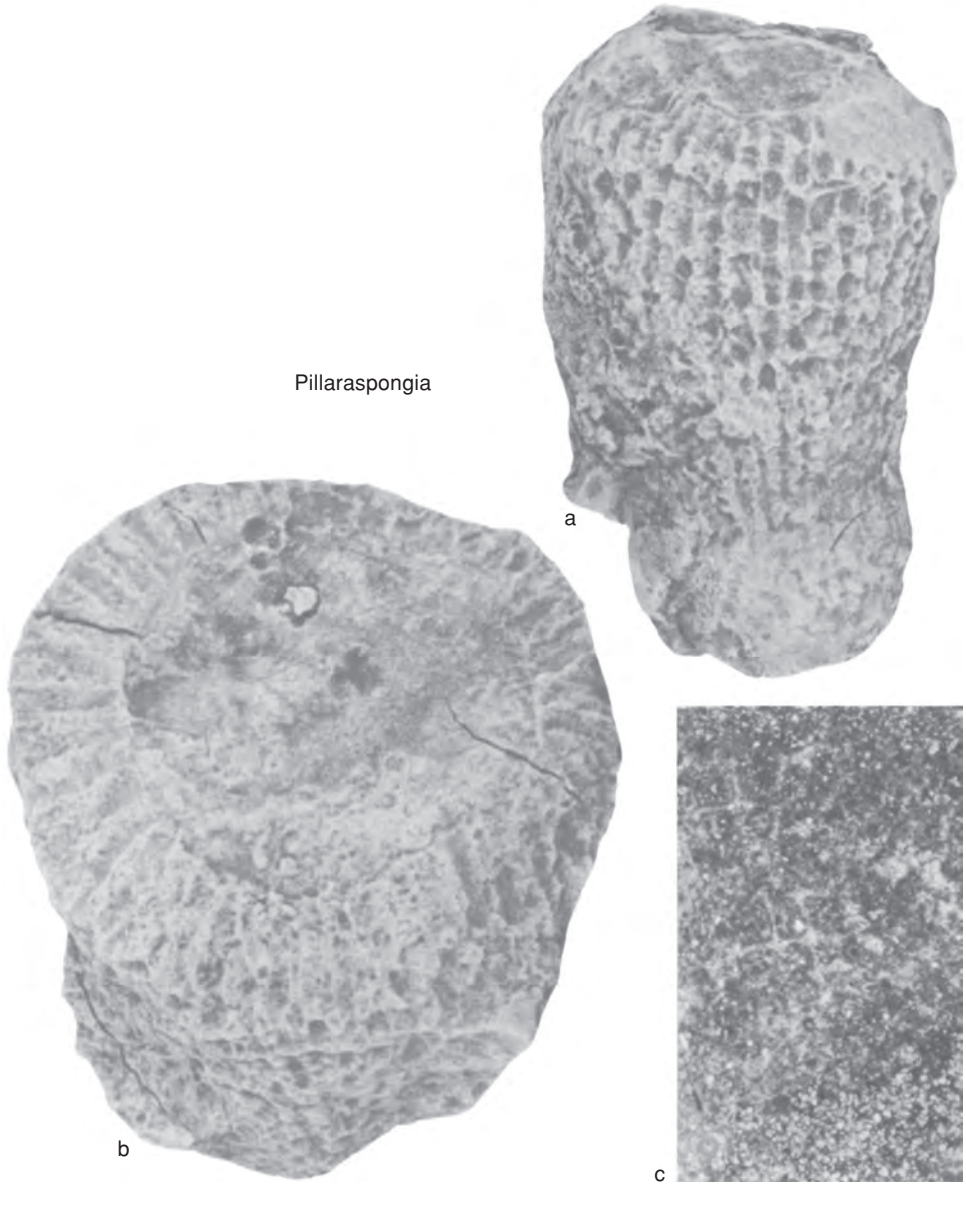


FIG. 282. Pillaraspongiidae (p. 430–431).

series; skeletal net euretoid with framework bilateral, nearly symmetrical, strands diverging upwardly and outwardly in outer wall and inwardly in inner part; apparently without differentiated dermalia, gastralia, and cortex. *Devonian (Frasnian–Famennian):* Western Australia.——FIG. 282*a–c.* **P. ellimberia,* Virgin Hills Formation, Lawford Range; *a,* side view of holotype showing inhalant canals filled with dark matrix and an ill-defined osculum filled with matrix at summit, GSWA F7231, ×1; *b,* oblique view of paratype with large, radial, parietal gaps in thick walls around matrix-filled spongocoel, GSWA F7232, ×1; *c,* photomicrograph showing fused, rectangular, skeletal net in horizontal, thin section of paratype, GSWA F7233, ×10 (Rigby, 1986b).

Superfamily PILEOLITOIDEA Finks, 1960

[*nom. transl.* Finks & Rigby, herein, *pro* Pileolitidae Finks, 1960, p. 139]

Hexasterophora with layers of dictyonal strands in aulocalycoid organization parallel to layers, together with hexactines and rhabdodiactines connected by synapticulae; layers parallel to gastral surface; sponges grew by adding new layers gastrally and by extending layers peripherally; spicules of dermal surface ornamented with spherical nodes, perhaps at crossings of dictyonal strands; sub-euretoid to euretoid structure may be developed. *Upper Ordovician–Holocene.*

Family PILEOLITIDAE Finks, 1960

[Pileolitidae Finks, 1960, p. 139]

All layers of one kind, and parallel to upper (possibly gastral) surface; dictyonal strands, or hexactines or rhabdodiactines, oriented irregularly within layer; no cloaca; vertical aporhyses perpendicular to layers; rhabdodiactines perpendicular to layers, some bundled, some single, many free in aporhyses; dermal layer on base and sides, with stouter spicules and spherical nodes, is composed of same spicule types as interior layers, but on sides of sponge layer oriented perpendicularly to interior layers; component strands of this lateral, dermal layer mostly oriented irregularly, although occasionally may have parallel, vertical strands; base flat; hexasters present. *Permian (?Asselian–?Sakmarian, Artinskian)–Middle Triassic.*

Pileolites Finks, 1960, p. 139 [**P. baccatus* Finks, 1960, p. 140; OD]. Small cake, wedge, or thimble-shaped sponges with characteristics of family; tangential, dermal layer fused to inner, dictyonal strands and consisting of coarser spicules or dictyonal strands, in which distal rays are replaced by spherical knobs; internal (parenchymal), dictyonal strands parallel to upper surface and fused to one another by synapticulae and at points of mutual contact; dictyonal strand layers penetrated by perpendicular, cylindrical aporhyses that run from just inside basal, dermal layer to upper surface of sponge; long, fusiform rhabdodiactines oriented vertically in aporhyses and in parenchymal, dictyonal net; oxyhexasters in sediment accompanying type specimens. *Permian (?Asselian–?Sakmarian, Artinskian):* USA (Texas).——Fig. 283,*1a–c.* **P. baccatus,* Leonard Formation, Glass Mountains; *a,* enlarged view of basal (or possibly side) of paratype with well-developed, spherical nodes in place of distal rays on tangential dermalia, USNM 127668f, ×10; *b,* enlarged view of open-textured, basal surface of paratype with spherical nodes less well developed, but with irregular orientation of long, slender rays and their common cross connection with synapticulae, tangential rays thickened with secondary silica, ×10; *c,* top surface of paratype showing long, tangential rays of irregularly oriented, choanosome spicules united into a continuous net with synapticulae, particularly in ladderlike clusters, USNM 127668e, ×10 (Finks, 1960; courtesy of The American Museum of Natural History).

Hexactinoderma Pisera & Bodzioch, 1991, p. 196 [**H. trammeri* Pisera & Bodzioch, 1991, p. 197; OD]. Thick-walled, tubular or deep, cup-shaped lyssacinosans with distinct, similar, dermal and gastral layers of fused hexactines with rays of various sizes and lengths, distal rays short or aborted but tangential and proximal rays elongate; these layers covering dermal and gastral ends of dominantly radial canals, which may branch; spicules of dermal layer without spherical knobs replacing aborted, distal rays. [*Hexactinoderma* resembles *Cypellospongia* Rigby & Gosney, 1983, in having a distinct, dermal layer, but in *Cypellospongia* that layer is composed of delicate hexactines rather than of robust hexactines. The two genera also differ in general shape. *Hexactinoderma* differs from *Pileolites* Finks, 1960, in lacking the coarse, dermal knobs in place of aborted, distal rays on spicules of the dermal layer. *Hexactinoderma* is placed in the family with some question.] *Middle Triassic:* Poland.——Fig. 283,*2a–c.* **H. trammeri,* Muschelkalk, Karchowice beds, Anisian, Strzelce Opolskie; *a,* holotype interior with gastral layer, ×0.75; *b,* gastral surface of holotype with specialized hexactines and ostia of canals, ZPAL PfV/20, ×15; *c,* interior of endosomal skeleton where individual hexactines show in more open structure, ZPAL PfV/5, ×10 (Pisera & Bodzioch, 1991).

Family WAREEMBAIIDAE new family

[Wareembaiidae Finks & Rigby, herein] [type genus, *Wareembaia* Rigby & Webby, 1988, p. 85]

Layers conoidal, surrounding cloaca; of differing organization within each layer; outermost layer sub-euretoid with dictyonal strands (and possibly rhabdodiactines) parallel to one another, and perpendicular to (upper or outer) growing edge of layer; external, spherical nodes confined to exposed parts of this layer on sides of sponge, but not on base; next interior layer aulocalycoid,

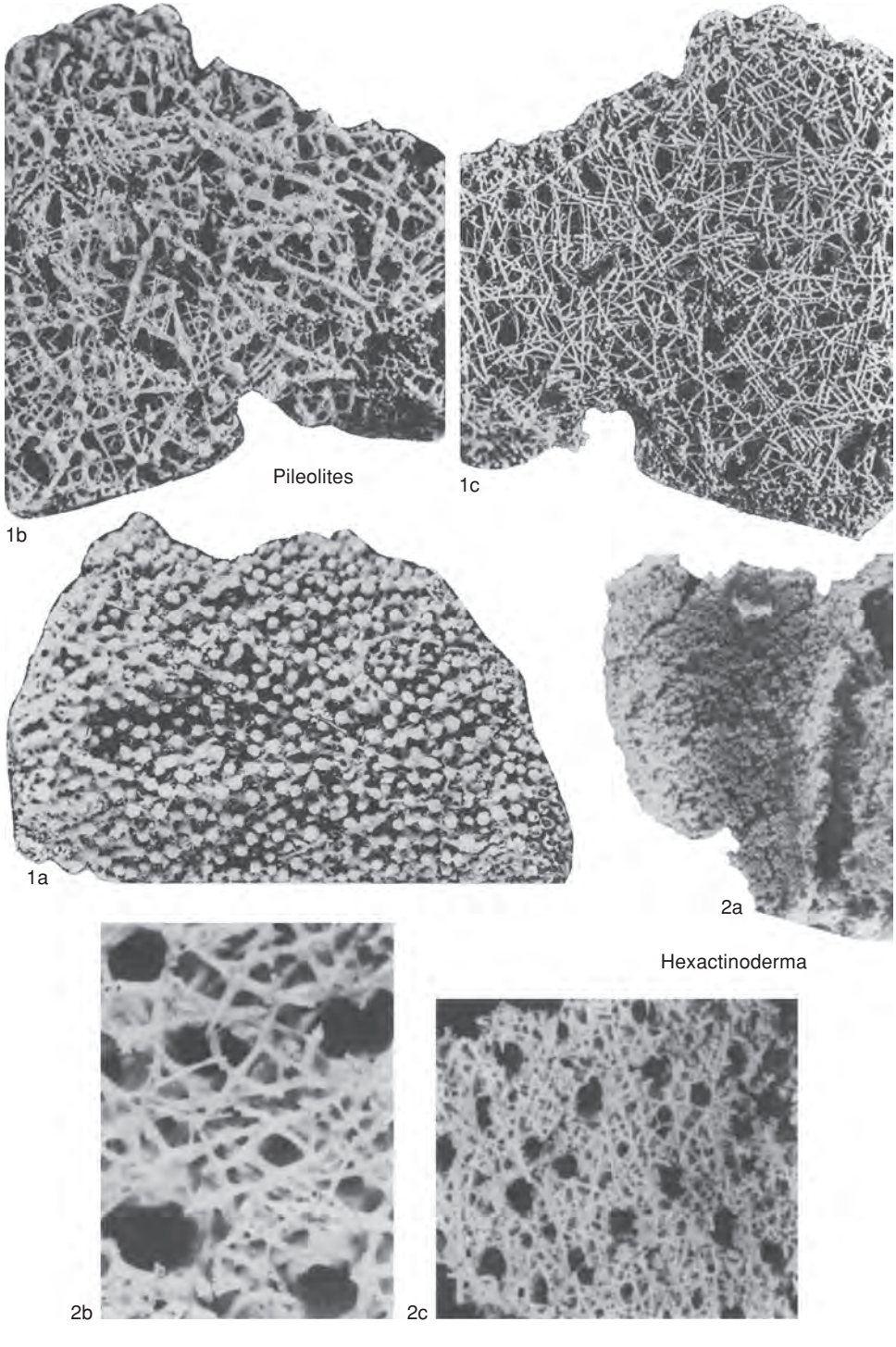


FIG. 283. Pileolitidae (p. 432).

with curved, dictyonal strands mostly subhorizontal; radial, bladelike, inward extensions of this layer separate vertical, exhalant spaces between this layer and next interior layer, which is aulocalycoid with irregularly oriented, curving, dictyonal strands (and possible hexactines or rhabdodiactines) parallel to layers; this sequence of layers may be repeated inwardly and upwardly, cone-in-cone like; transverse sieve of hexactines may cross cloaca at base, and possibly at oscular end. *Upper Ordovician.*

Wareembaia Rigby & Webby, 1988, p. 85 [**W. concentrica* Rigby & Webby, 1988, p. 86; OD]. Subcylindrical, stemlike, with expanded base; specialized, sievelike, gastral layer (or possible oscular sieve) surrounding possible central osculum; cylindrical part consisting of imbricate, conical sheets of spicules (like cone-in-cone, expanding upwardly); each sheet composed of outer layer of parallel, closely spaced, vertically oriented, stout rhabdodiactines or dictyonal strands, next inner layer of finer, paratangential, sinuous, mostly subhorizontal, possible dictyonal strands connected by synapticulae; both these layers produced toward interior as radial, vertical blades that separate parallel, vertical canals; inner ends of these blades connect with innermost layer of paratangential, irregularly oriented, interlaced, stout, curving, very long hexactines or rhabdodiactines, or dictyonal strands; stout vertical elements of outer layer appear to arise from subhorizontal dictyonal strands, curving upwardly like candelabra; where these vertical elements reach exterior surface, their outer surfaces becoming coated with a single series of spherical nodes (possibly corresponding to spicule crossings within dictyonal strands) that become larger upwardly; innermost layer of large curving spicules or strands also repeated cone-in-cone-wise, separated by zones of vertical canals; it is likely that these are the same vertical canals that underlie two outer layers and that each inner layer becomes successively transformed upwardly into next outer layer as expanding cone nears outer surface; very center of cylinder is a shallow, possible spongocoel; in basal expansion, vertical elements of outermost layer are subhorizontal and radial and do not bear spherical nodes, they radiate from a circular area (base of possible spongocoel), which in well-preserved examples contains a grid of parallel, large hexactines, surrounded by a circle of innermost layer of tangential spicules; surrounded by zone of canals separated by radial, bladelike extensions of outer two layers (it is clear that this is beginning of nested series of layers). [*Wareembaia* somewhat resembles the Permian *Pileolites* Finks, 1960, but differs in the arrangement of the parts. The horizontal layers of the main skeleton of *Pileolites* correspond to the obliquely vertical, innermost layers of *Wareembaia.* The spherical nodes on the external surfaces of *Pileolites* are almost identical to those on *Wareembaia,* but the vertical rhabdodiactines or dictyonal strands on which they occur in the latter are not present in *Pileolites,* unless the vertical rhabdodiactines in the interior of *Pileolites* are their homologues. *Pileolites* is a simpler sponge than *Wareembaia.* If the two are in fact related, the history of the hexactinosan Hexasterophora goes back to the Ordovician.] *Upper Ordovician:* Australia (New South Wales).——Fig. 284*a–e.* **W. concentrica,* Malongulli Formation, Cliefden Caves area; *a,* side view of holotype showing relationships of flaring, dermal layer, with dictyonine structure, to canal system that separates it from endosomal part of skeleton that has an irregularly spiculed structure, ×2; *b,* vertical view down into central spongocoel and showing endosomal skeleton with alternating layers of dense and open texture, ×2; *c,* vertical view of basal attachment surface showing radiating, irregularly fibrous, crudely dictyonine net and hexactine-based skeleton above, ×5; *d,* enlarged side view showing nature of spiculation of outer, fused, dictyonine, dermal layer and less regularly oriented, principal, endosomal net made of long-rayed hexactines, AMu. F66905, ×5; *e,* photomicrograph of fused, dictyonine, dermal layer of paratype showing dermal nodes and taper of vertical rays, with *en echelon* replacement, that are fused laterally by horizontal elements, layer pierced by small pores, AMu. F66909, ×20 (Rigby & Webby, 1998; courtesy of Paleontological Research Institution, Ithaca).

Kalimnospongia Rigby & Webby, 1988, p. 87 [**K. pertusa;* OD]. Open, conical to frondescent with multi-layered walls; inner layer with large ostia bordered by rays of large hexactines; ostia subdivided by ten finlike, radial blades, each more or less supported by hexactine rays that extend into ostium; principal part of skeleton irregularly oriented hexactines and derivatives, all fused at ray crossings with synapticulae or synapticular webs; gastral layer thin, or fused, bubbly-appearing net not obviously hexactine based; dermal layer of two units: inner part a porous, subdermal layer of delicate, widely spaced and irregularly oriented, hexactine-based spicules with curved rays largely tangential; outer part of dermal layer fused, vertically elongate, dictyonine hexactines in picket-fence-like structure with principal rays vertical, secondary proximal and distal rays more limited but thoroughly fused into solid structure, synapticulae also occurring in dermal layer. [*Kalimnospongia* might be only the upper, broadly expanding, funnel-like part of a more complex sponge, if it and *Wareembaia* are parts of a single species (Rigby & Webby, 1988, p. 89). They certainly have considerable structural similarity in their distinctive, dermal layers, but they differ in skeletal structure internally. Until additional material is investigated and the two types of structure are found as part of one sponge, they will be treated as

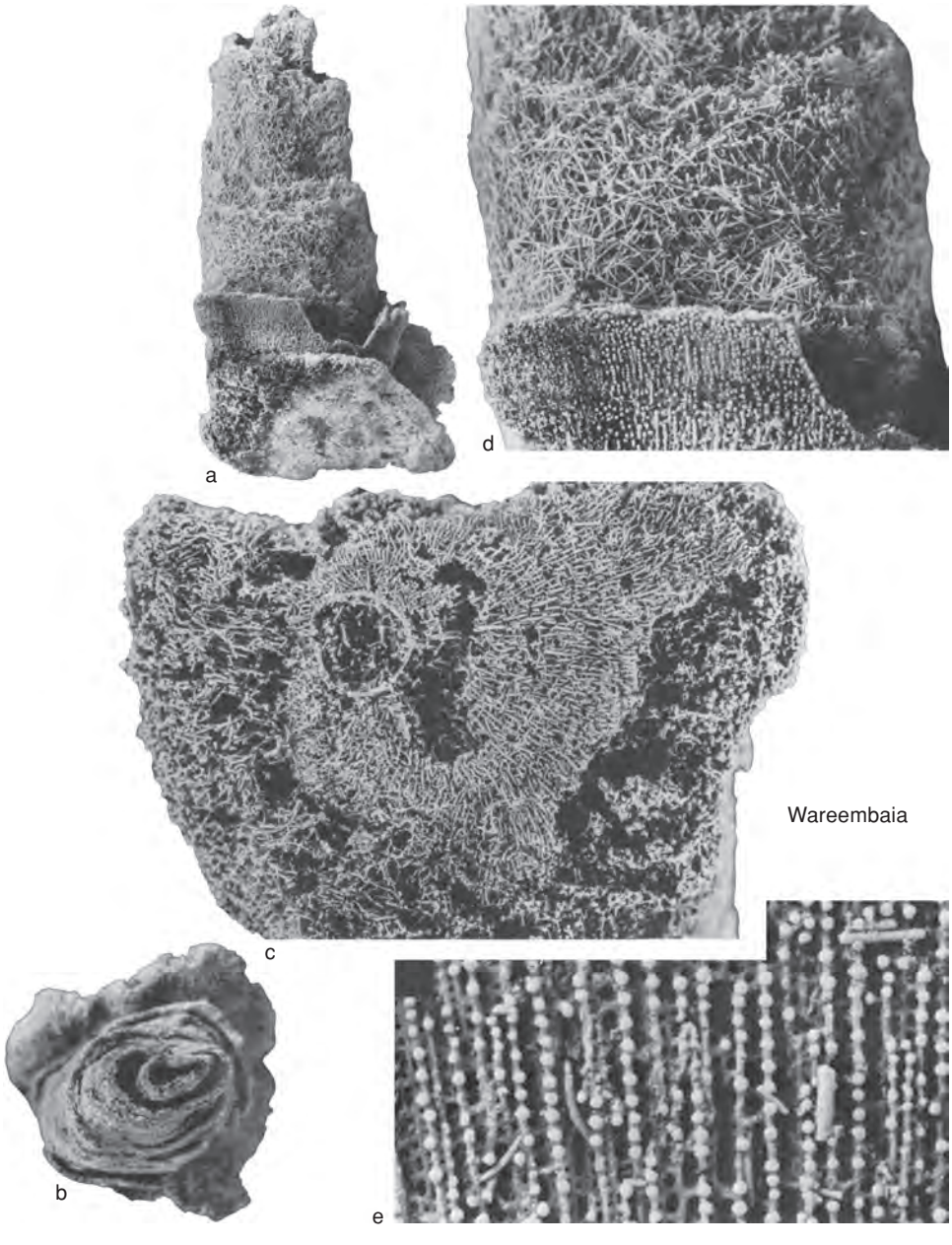


FIG. 284. Wareembaiidae (p. 434).

separate taxa.] *Upper Ordovician:* Australia (New South Wales).——FIG. 285*a–d. *K. pertusa,* Malongulli Formation, Cliefden Caves area; *a,* holotype (*arrow*), associated with several other genera of sponges, including coarse-textured, skeletal elements around open-bladed pore (*1*), as well as dense, thin-walled, frond fragments immediately below (*2*), ×1.6; *b,* gastral view of a large pore with bladed partitions and surrounding endosomal and gastral parts of skeleton; coarse hexactine rays are reflexed and supporting blades in pore, beyond which are coarse, endosomal hexactines that are locally united with synapticulae into asolid structure, and overlie irregularly

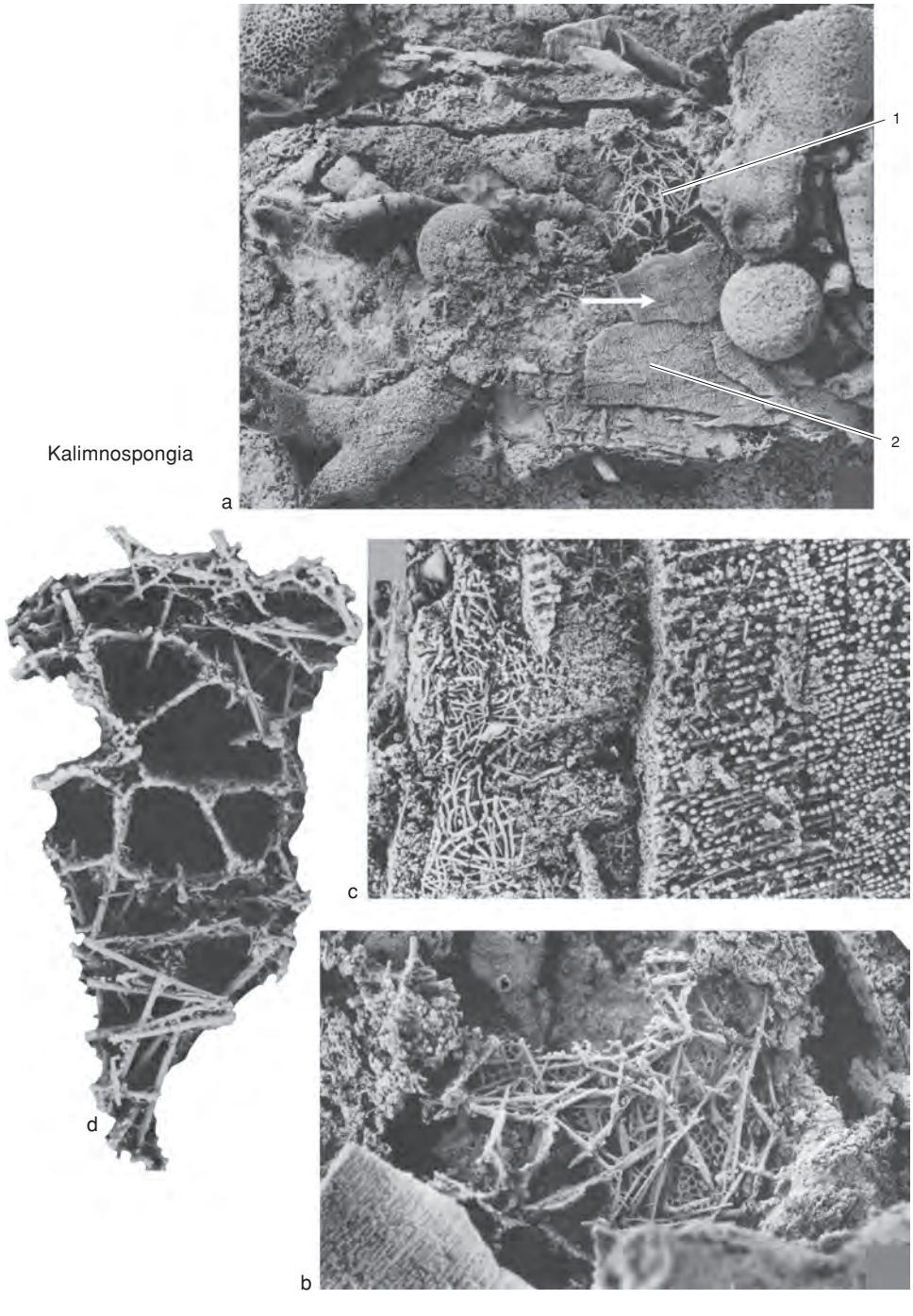


Fig. 285. Wareembaiidae (p. 434–437).

vesicular gastral layer in background, ×3; *c,* photomicrograph of dictyonine, outer layer and underlying, irregular, endosomal layer of thin-walled part of sponge, which are reminiscent of *Wareembaia,* AMu. F66915, ×7.5; *d,* endosomal view of paratype showing bladed pore and irregular, coarse hexactines with synapticulae around pore, AMu. F66916, ×5 (Rigby & Webby, 1988; courtesy of Paleontological Research Institution, Ithaca).

Family EURETIDAE Zittel, 1877

[Euretidae Zittel, 1877b, p. 35] [=Monakidae Marshall, 1876, p. 121; Coscinoporidae Zittel, 1877b, p. 36, *partim;* Maeandrospongidae Zittel, 1877b, p. 38, *partim;* Chonelasmatidae Schrammen, 1912, p. 190; Pleurothyrisidae Schrammen, 1912, p. 192; Myliusiidae de Laubenfels, 1955, p. 82, *partim;* Wapkiosidae de Laubenfels, 1955, p. 85]

Primary skeletal meshwork three dimensional and not constructed in layers, with subparallel, dictyonal strands in longitudinal or radial orientation ending at dermal surface or some at each surface; some with secondary meshwork in which dictyonal strands are absent, other than in primary meshes; skeletal canalization normally absent or limited to skeletal pores (ostia, postica) or shallow, radial canals (epirhyses, aporhyses) that open into underlying meshes; some with true, radial canals but not in regular series; amararhyses in one genus; modified, primary meshwork or added secondary meshwork may form dictyonal cortex at one or both surfaces. Modern forms normally with scopules, rarely sarules or no sceptrules, never clavules. [Only Paleozoic forms are discussed here. Younger forms are treated in the section on Mesozoic hexactinosans, p. 463 herein.] *Upper Devonian (Frasnian).*

Paleoramospongia Rigby & Pisera in Rigby & others, 2001, p. 470 [**P. bifurcata;* OD]. Branched, medium-sized hexactinosan sponges with deep spongocoel in each branch; canals in possible diplorhysal pattern in dictyonine skeleton with asymmetric, upwardly expanding structure where primary strands are at or near gastral margin. [Genus is questionably included in family Euretidae.] *Upper Devonian (Frasnian):* Poland.——Fig. 286,*1a–c. *P. bifurcata,* Holy Cross Mountains; *a,* longitudinal section of holotype, slightly etched, showing branching form and deep spongocoel in each branch, ZPAL Pf.XI/207; *b,* oscular view of branched reference specimen, ZPAL Pf.XI/51, ×1; *c,* dictyonine, skeletal structure of holotype in longitudinal thin section, ×10 (Rigby & others, 2001).

Paleoregulara Rigby & Pisera in Rigby & others, 2001, p. 468 [**P. cupula;* OD]. Small, steeply obconical to barrel-shaped hexactinosan sponges with regular, three-dimensional, skeletal net uninterrupted by major canals. *Upper Devonian (Frasnian):* Poland.——Fig. 286,*2a–b. *P. cupula,* Holy Cross Mountains; *a,* side view showing regular, skeletal network in cylindrical paratype, ZPAL Pf.XI /69, ×2; *b,* regular, skeletal network in polished, longitudinal section of paratype, ZPAL Pf.XI142, ×10 (Rigby & others, 2001).

Family CRATICULARIIDAE Rauff, 1893

[Craticulariidae Rauff, 1893, p. 191] [=Euretidae Zittel, 1877b, p. 35, *partim;* Leptophragmidae Schrammen, 1912, p. 191; Craticularinae de Laubenfels, 1936, p. 186; Leptophragmatidae de Laubenfels, 1955, p. 80; Laocaetidae Mehl, 1992, p. 71]

Skeletal framework three dimensional initially, constructed as in Euretidae, but normally with fully developed epirhyses and aporhyses; skeletal canals typically radial and blind, arranged with epirhyses and aporhyses in alternating, longitudinal series, and often so that each canal of one sort stands quincuncially between four of others; apertures then arranged in longitudinal and transverse rows; some genera with epirhyses open at both ends or arranged without order, or without aporhyses in some individuals; dictyonal strands spreading subequally to both surfaces from interior, or running mainly or all to dermal surface; beams between ends of strands usually forming cortical meshwork, which secondary accretions may make thicker or denser; superficial meshwork in some genera, formed from dictyonal hexactines, or additionally by ankylosis of dermal or gastral stauractines; scopules in a living example. [Only Upper Devonian forms are treated here. Other genera of the family and their subfamilies are discussed in the section on Mesozoic dictyonine sponges, p. 476 herein.] *Upper Devonian.*

Conicospongia Rigby & Pisera in Rigby & others, 2001, p. 483 [**C. annulata;* OD]. Obconical, weakly annulate, large hexactinosans with deep,

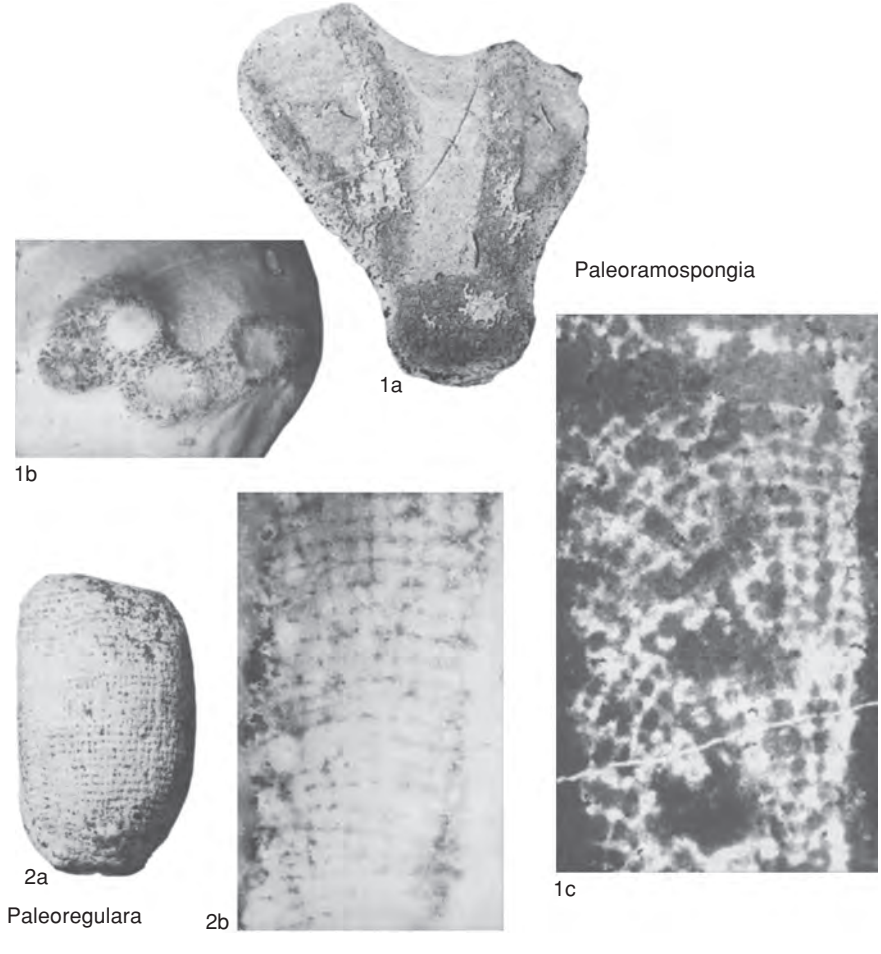


FIG. 286. Euretidae (p. 437).

V-shaped spongocoel and thick walls pierced by densely, but irregularly, spaced canals in diplorhysal pattern; skeleton symmetrical with primary strands in midwall diverging gently toward both dermal and gastral surfaces. *Upper Devonian (Frasnian):* Poland.——FIG. 287*a–c.* **C. annulata,* Holy Cross Mountains; *a,* side view of holotype, ZPAL Pf.XI/321; *b,* longitudinal section of reference specimen showing thick walls and oblique canals, ZPAL Pf.XI/194, ×0.5; *c,* details of dictyonal, skeletal structure in same reference specimen, ×0.75 (Rigby & others, 2001)

Cordiospongia RIGBY & PISERA in RIGBY & others, 2001, p. 471 [**C. conica* RIGBY & PISERA in RIGBY & others, 2001, p. 472; OD]. Broadly obconical, small- to medium-sized, heart-shaped, hexactinosan sponges, with deep, axial spongocoel and irregular, craticulariid, canal system in which both inhalant and exhalant canals flex downwardly into midwall; dictyonine skeleton expanding upwardly and outwardly, with primary strands at or near gastral margin. *Upper Devonian:* Poland.——FIG. 288,*1a–c.* **C. conica,* Holy Cross Mountains; *a,* longitudinal section of holotype showing deep spongocoel and nature of walls and canal development, ZPAL Pf./XI/85, ×1; *b,* inhalant ostia and nature of skeletal net as exposed on dermal surface of holotype; *c,* polished, longitudinal section of holotype showing structure of skeletal net, ×10 (Rigby & others, 2001).

Paleocraticularia RIGBY & PISERA in RIGBY & others, 2001, p. 474 [**P. elongata;* OD]. Large or medium-sized, tubular hexactinosan sponges with simple spongocoel and diplorhysal, canal system; canals in distinct, vertical rows producing ribbed exterior; dictyonine skeletal structure diverging

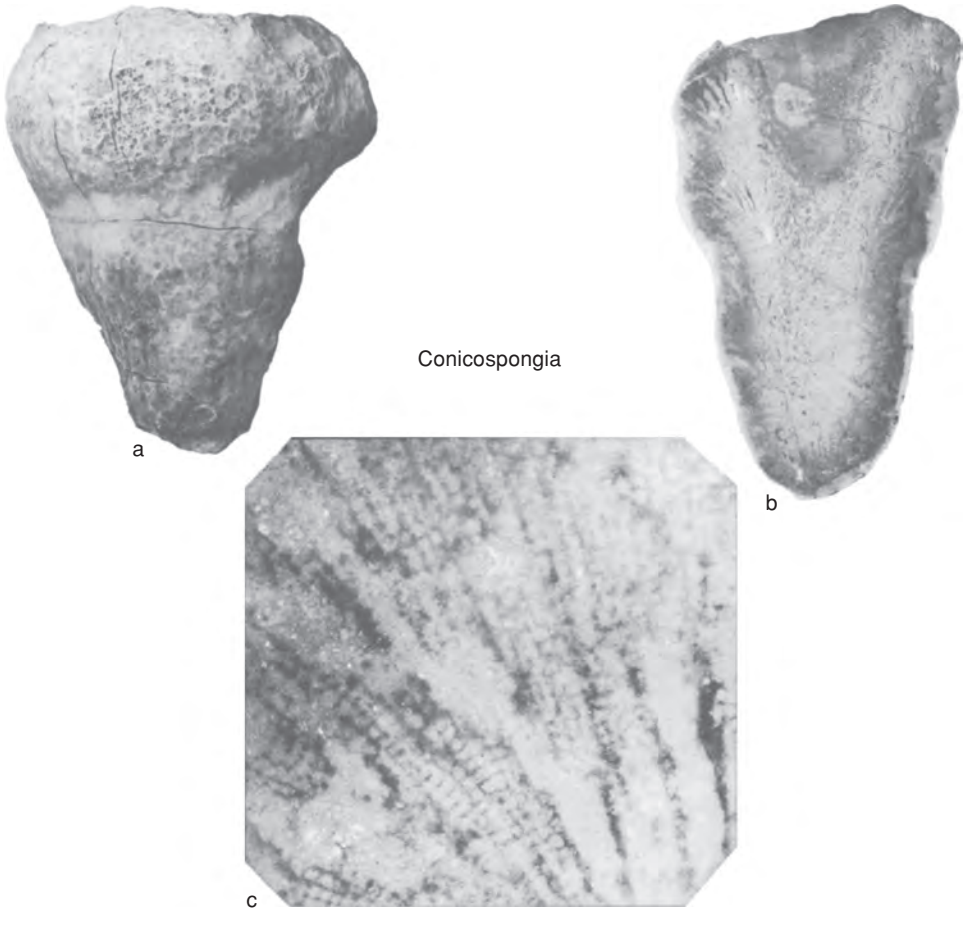


FIG. 287. Craticulariidae (p. 437–438).

gently in symmetrical pattern but meeting dermal surface at moderate angles and gastral surface at low angles. *Upper Devonian (Frasnian):* Poland. ——FIG. 288,*2a–b. *P. elongata,* Holy Cross Mountains; *a,* weathered holotype showing form of sponge with ribbed exterior produced by vertically aligned, inhalant ostia, ZPAL Pf.XI/20, ×1; *b,* regular, skeletal net in polished, longitudinal section of holotype, ×10 (Rigby & others, 2001).

Polonospongia RIGBY & PISERA in RIGBY & others, 2001, p. 476 [**P. devonica* RIGBY & PISERA in RIGBY & others, 2001, p. 478; OD]. Large, cylindrical, hexactinosan sponges with deep spongocoel and coarse, irregular, diplorhysal, canal pattern; skeleton asymmetric with primary strands parallel to gastral margin but divergent toward dermal margins at high angles. *Upper Devonian (Frasnian):* Poland.——FIG. 289,*1a–d. *P. devonica,* Holy Cross Mountains; *a,* side view of cylindrical holotype showing irregular distribution of dermal ostia, ZPAL Pf.XI/212, ×0.37; *b,* transverse section of holotype showing wall thickness and canal pattern, ×0.37; *c,* polished, longitudinal section of paratype, with outer surface to right, showing nature of skeletal net, ZPAL Pf.XI/209, ×7.5; *d,* weathered surface showing skeletal net and distribution of inhalant ostia in paratype, ZPAL Pf.XI/23, ×7.5 (Rigby & others, 2001).

Urnospongia RIGBY & PISERA in RIGBY & others, 2001, p. 482 [**U. modica;* OD]. Large, broadly obconical, stalked, hexactinosan sponges with shallow spongocoel; canal system irregularly diplorhysal, with vertical, exhalant canals in massive base and parallel strands in upper walls; inhalant canals may empty into these canals rather than into spongocoel; skeleton upwardly divergent from near midwall, primary strands diverging

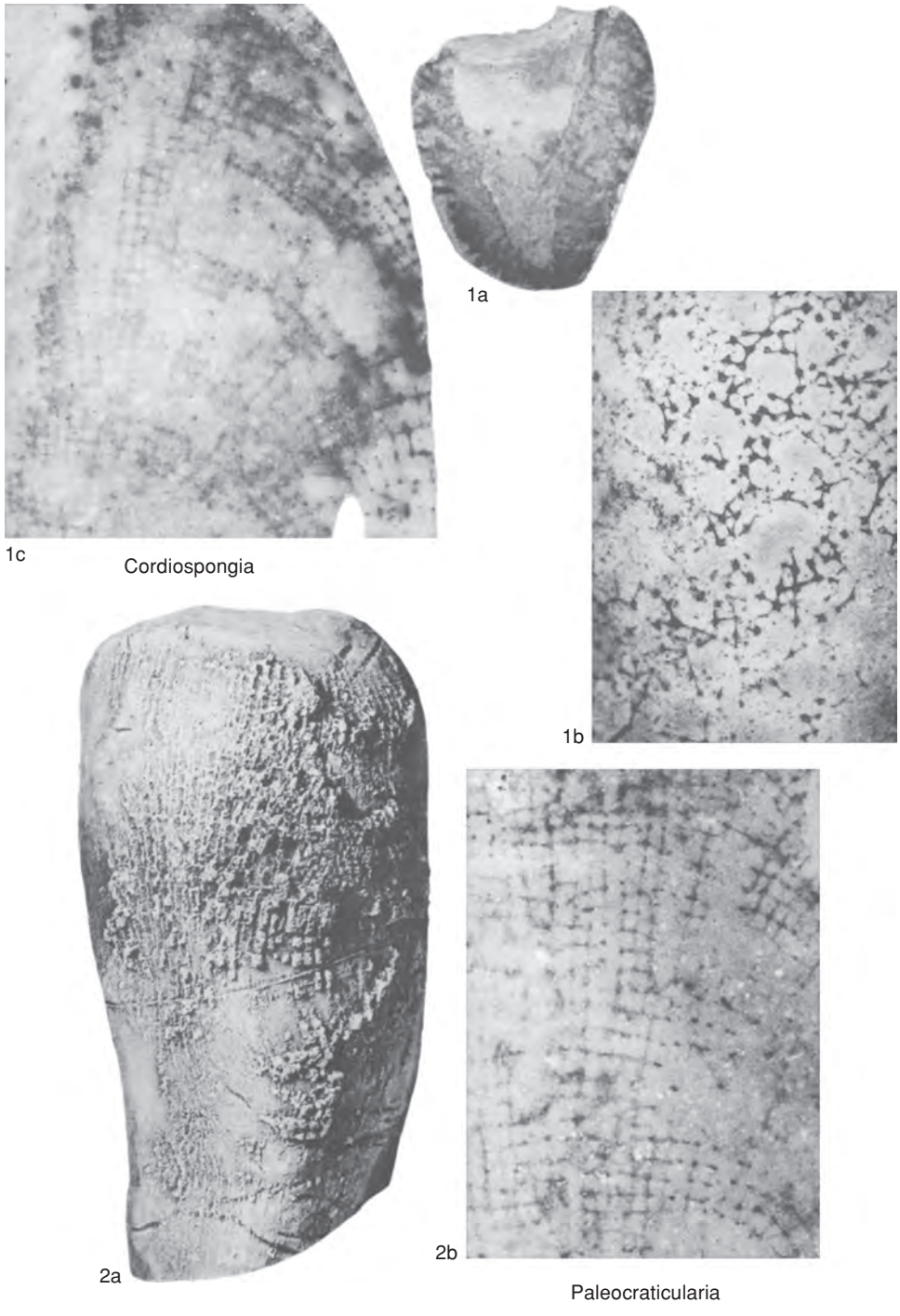


FIG. 288. Craticulariidae (p. 438–439).

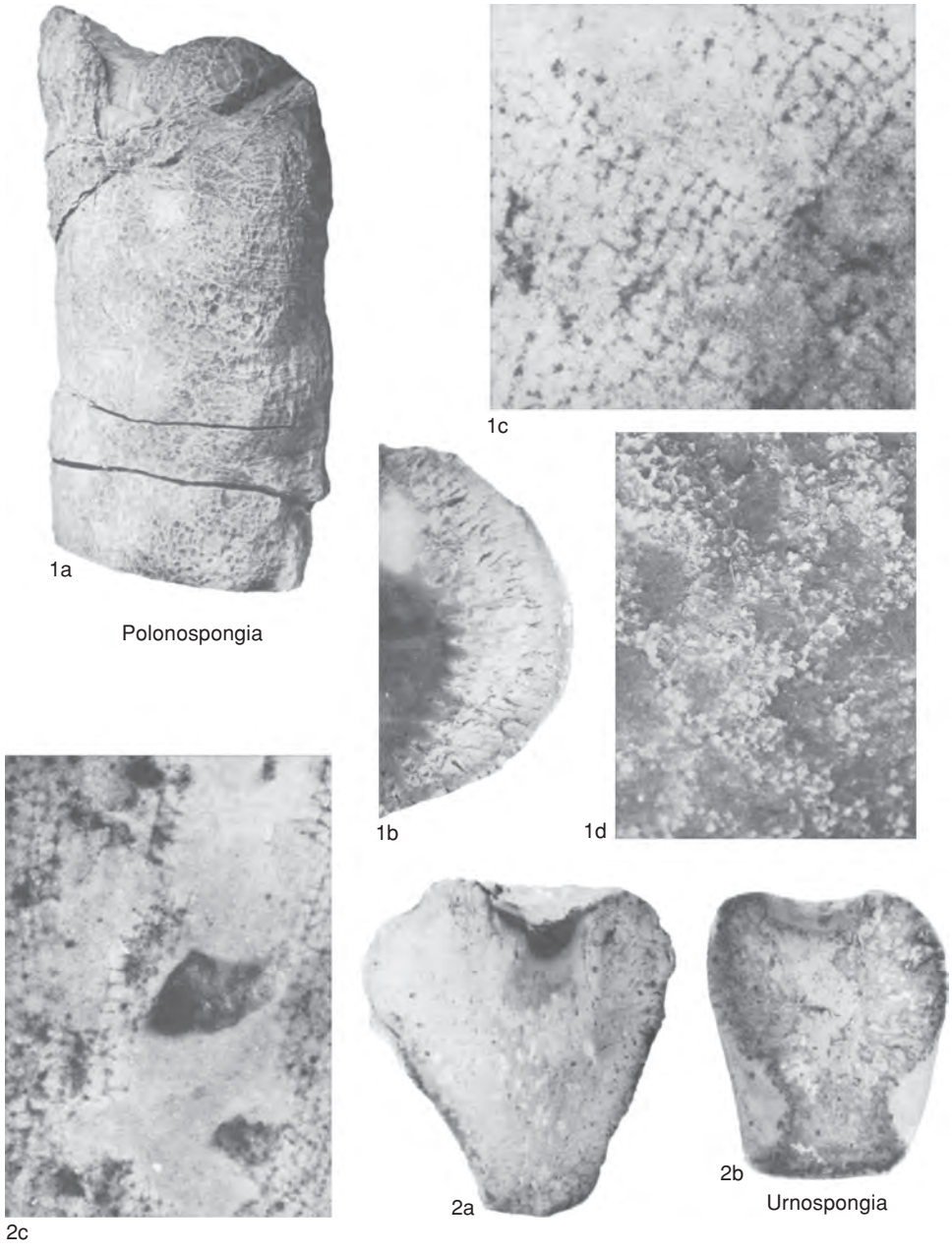


FIG. 289. Craticulariidae (p. 439–441).

abruptly toward dermal surface and gently toward gastral surface. *Upper Devonian (Frasnian):* Poland.——FIG. 289,*2a–c.* **U. modica,* Holy Cross Mountains; *a,* longitudinal section of holotype showing shallow spongocoel with basal cluster of vertical, exhalant canals and thick walls, ZPAL Pf.XI/25, ×0.5; *b,* longitudinal, polished section of reference section to show shape, wall thickness, and canal development, ZPAL Pf.XI/201, ×0.50; *c,* photomicrograph of longitudinal section of reference specimen showing skeletal organization and canals, ×7.5 (Rigby & others, 2001).

FIG. 290. Pileospongiidae (p. 442).

Family PILEOSPONGIIDAE Rigby, Keyes, & Horowitz, 1979

[Pileospongiidae RIGBY, KEYES, & HOROWITZ, 1979, p. 712]

Massive, encrusting sponges with inhalant and exhalant canals opening on same surface; skeletal net built of layers, parallel to surface, composed of irregularly oriented rhabdodiactines, with fewer numbers of hexactines. *Carboniferous (Serpukhovian).*

Pileospongia RIGBY, KEYES, & HOROWITZ, 1979, p. 713 [**P. lopados;* OD]. Discoidal, thinning toward rounded edges; upper surface covered with small, closely spaced papillae of uniform size, each bearing a terminal pore (osculum); papillae locally basally confluent along ridges that radiate from central area; obscure, dendritic, surface grooves between some of papillae also radiate away from center; large, vertical canals (possibly exhalant) open onto tips of papillae; both papillae and canals may be inclined toward periphery; smaller, vertical canals (possibly inhalant) opening onto surface between papillae; horizontal canals parallel to upper surface (possibly corresponding in part to surface grooves) may connect vertical canals; spicules organized in layers parallel to upper surface; they are nonparallel to one another, are tangent to outlines of vertical canals, radially arranged about each papilla, and parallel to upper surface; most spicules appear to be small, smooth, straight, or slightly curved rhabdodiactines, with fewer numbers of somewhat smaller hexactines; basal surface encrusting upon shell debris; large, vertical canals do not extend to base. *Carboniferous (Serpukhovian):* USA (Alabama).——FIG. 290. **P. lopados,* Monteagle Limestone, Weeden-Madkin Mountains, Madison County; central part of nodose holotype with craterlike mounds pierced by vertical canals, ×0.45 (Rigby, Keyes, & Horowitz, 1979).——FIG. 291*a–c.* **P. lopados,* Monteagle Limestone, Weeden-Madkin Mountains, Madison County; *a,* section of dermal layer with ostia of canals in nodes, USNM 245146, ×2; *b,* photomicrograph of horizontal section of paratype showing straight to gently curved diactines outlining vertical canal, USNM 245147, ×20; *c,* photomicrograph of thin section from holotype with hexactines and diactines around canal, in upper part, USNM 245146, ×20 (Rigby, Keyes, & Horowitz, 1979).

Order and Family UNCERTAIN

Australispongia DONG & KNOLL, 1996, p. 177 [**A. sinensis;* OD]. Sponges known as isolated, pentactine spicules with four lateral rays of varying length in propeller-like structure normal to proximal or central ray; that ray may be straight or

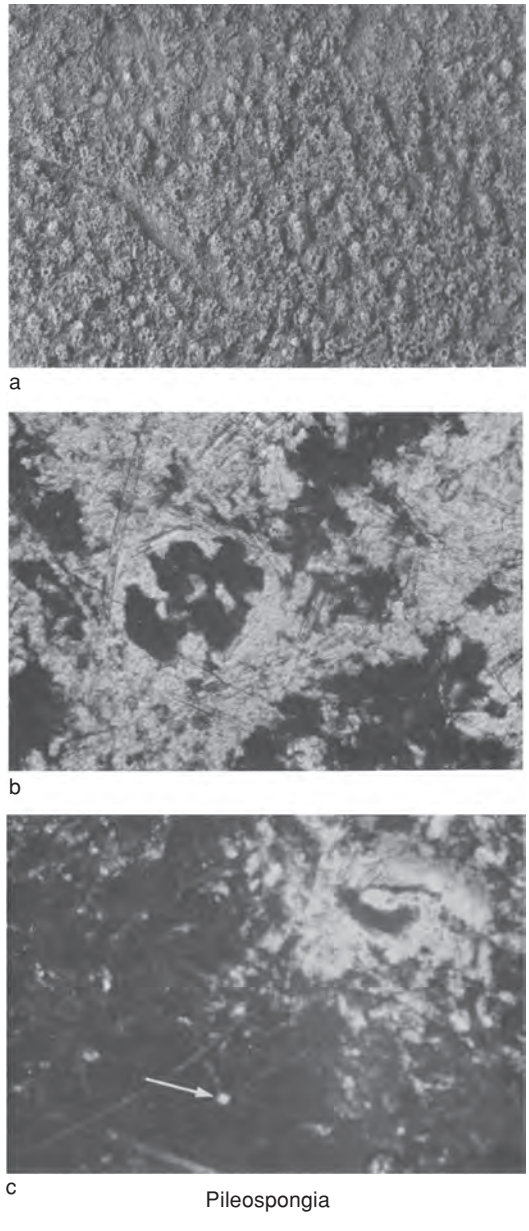


FIG. 291. Pileospongiidae (p. 442).

curved to moderately twisted, and flaglike or elaborated into three or four longitudinal flanges, edges of which may be serrate or smooth. [Ordovician and Permian occurrences have been reported by KOZUR, MOSTLER, & REPETSKI, 1996.] *Lower Cambrian–Permian (Guadalupian):* China (Hunan), *Lower Cambrian;* USA (Nevada), *Tremadocian;* USA (Texas), *Guadalupian.*——FIG. 292,*4a–c. *A. sinensis,* Bitiao Formation, Upper Cambrian, Huayuan, Hunan, China; *a,* holotype spicule of form A showing four lateral rays at top and flanged, central, lower ray, PDS92030, ×25; *b,* type spicule of form B, ×25; *c,* type spicule of form C, ×25 (Dong & Knoll, 1996).

Chelispongia WEBBY & TROTTER, 1993, p. 32 [**C. prima;* OD]. Isolated spicules with elongate,

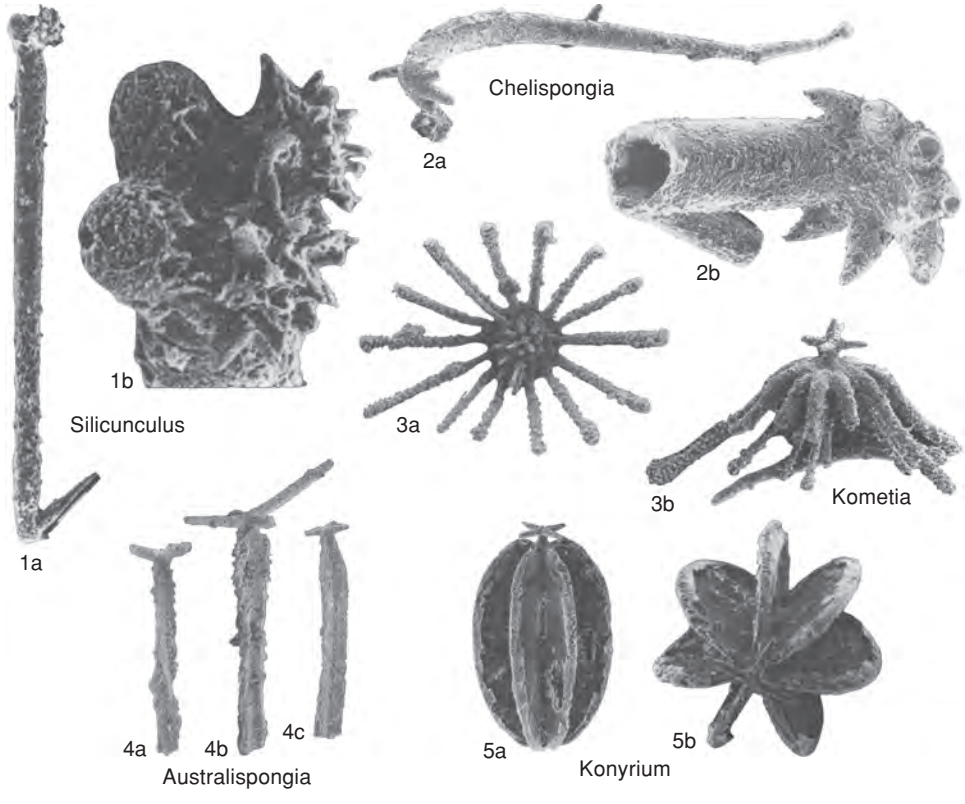


FIG. 292. Uncertain (p. 442–445).

sigmoidal, central ray and small, bulbous, possible proximal tip; opposite end enlarged with recurved, palmate claw with 3 to 11 pointed, tiplike, lateral rays; broken main ray sometimes showing internal axial cavity. *Ordovician:* Australia (New South Wales).——FIG. 292,*2a–b. *C. prima,* Malongulli Formation; *a,* characteristic spicule with swollen tip on one end and clawlike structure on other, SUP 85104, ×20; *b,* spicule fragment showing large, axial cavity and recurved tips of claw, SUP 85105, ×100 (Webby & Trotter, 1993).

Kometia WEBBY & TROTTER, 1993, p. 32 [**K. cruciformis;* OD] [=*Flosculus* DONG & KNOLL, 1996, p. 175 (type, *F. gracilis* DONG & KNOLL, 1996, p. 177, OD)]. Modified hexactine spicules with small, propeller-like structure of four pointed, lateral rays diverging at right angles from two central rays; latter comprise small, unmodified, pointed tip toward one pole and a much modified, central ray in opposite direction, with expanded, attachment disc (umbel) extending into an outwardly and backwardly radiating series of long, weakly club-shaped, hispid, accessory rays, with outer ones best developed. *Upper Cambrian–Upper Ordovician:* China, *Upper Cambrian;* Australia, *Upper Ordovician.*——FIG. 292,*3a–b. *K. cruciformis,* Malongulli Formation, Upper Ordovician, New South Wales, Australia; *a,* view of numerous rays of possible proximal part of paratype spicule, SUP 85121; *b,* side view of holotype spicule with propeller-like structure above and expanded ray cluster below, SUP 85120, ×50 (Webby & Trotter, 1993).

Konyrium NAZAROV & POPOV, 1976, p. 41 [**K. varium;* OD]. Isolated, distinctly pentactine spicules with prominent propeller at one pole consisting of four lateral rays that diverge essentially at right angles in plane slightly off perpendicular to spicule axis; thin vanes diverging radially from spicule axis and with outer, somewhat thickened, arched margins. *Upper Cambrian–Middle Ordovician:* Australia (Queensland), Canada (Northwest Territories), *Upper Cambrian;* Kazakhstan, Canada (Newfoundland), USA (Texas), *Middle Ordovician.*——FIG. 292,*5a–b. K. mariae* BENGTSON, Mungerebar Limestone, Mindyalian, western Queensland, Australia, holotype spicule; *a,* from side, ×50; *b,* from below, ×200 (Bengtson, 1986).

Silicosphaera HUGHES, 1985, p. 603 [**S. asteroderma;* OD]. Siliceous, spheroidal bodies with latticelike, outer shell and single aperture and central cavity; prominent hollow, radial rays forming much of

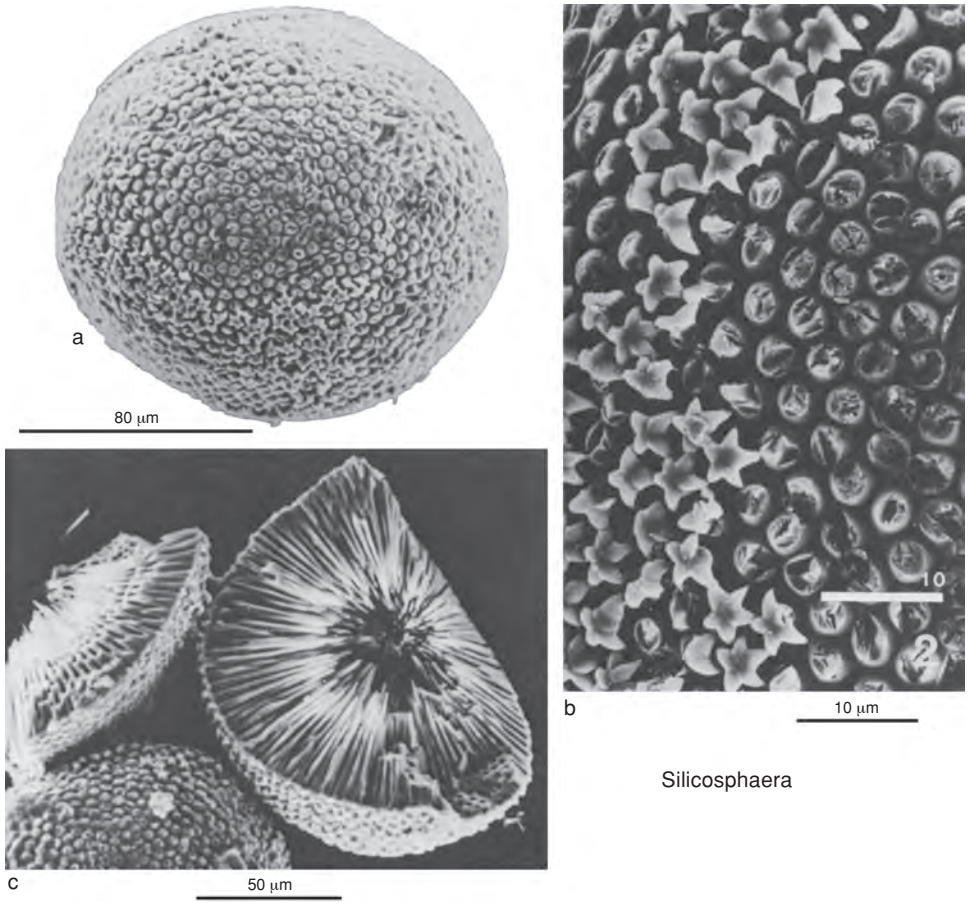


FIG. 293. Uncertain (p. 444–445).

body and with outer, 4- to 5-rayed terminations that are closely spaced so rays may touch but not in growth contact. *Neogene (Miocene)–Holocene:* South China Sea.——FIG. 293*a–c.* **S. asteroderma,* Holocene mud, Sedili River, western Malaysia; *a,* exterior view of spheroidal holotype, scale bar, 80 μm; *b,* detail view of outer surface of holotype with rayed terminations preserved on left, where not abraded, scale bar, 10 μm; *c,* broken holotype showing radial structure, central cavity, and outer layer, Sample Sedili F10, Robertson Research Laboratories, Singapore, scale bar, 50 μm (Hughes, 1985; courtesy of *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte*).

Silicunculus BENGTSON, 1986, p. 200 [**S. australiensis* BENGTSON, 1986, p. 201; OD]. Isolated spicules consisting of a long ray, either straight or slightly curved, bearing a long, slender tip, sharply recurved at acute angle, and at other end, four spinose protuberances resembling aborted, paratangential rays of a pentactine. [This was interpreted as a hexactinellid spicule, but it is so peculiar for a sponge that one wonders whether it is not a scolecodont or other nonporiferan skeletal element.] *Cambrian (Furongian):* Australia (Queensland).——FIG. 292,*1a–b.* **S. australiensis,* Mindyalian, Mungerebar Limestone, western Queensland; *a,* holotype spicule with recurved tip and protuberances on upper end, ×50; *b,* enlargement of upper end to show details, UNE F16418, ×250 (Bengtson, 1986).

Class and Order UNCERTAIN

Family STROMATIDIIDAE Finks, 1960

[Stromatidiidae FINKS, 1960, p. 136]

Skeleton composed of layers of possible pentactines with bifurcated rays, the missing ray being distal. [REID (personal communication) is of the opinion that the spicules are modified demosponge tetraxons rather than

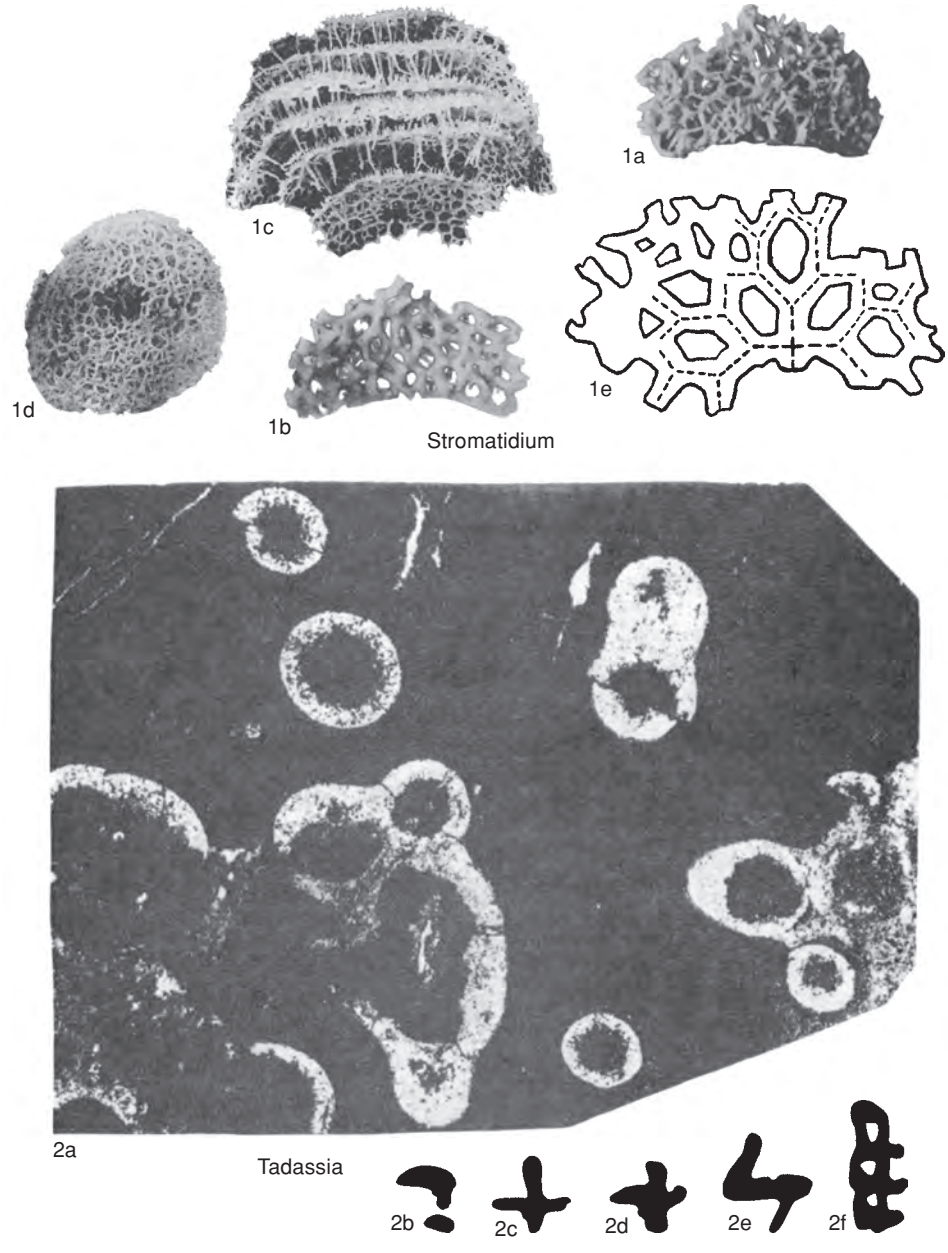


FIG. 294. Stromatidiidae and Tadassiidae (p. 446–448).

hexactinellid pentactines, based on the presence of similar pseudopentactines in some living demosponges. In addition to the Late Permian *Stromatidium typicale,* REID has found similar, but apparently nonfused, spicules in the Carboniferous (Mississippian).] *Carboniferous (Guadalupian)–Permian.*

Stromatidium GIRTY, 1909, p. 77 [**S. typicale;* OD]. Cylindrical sponges with central cloaca; skeleton composed of domical layers, parallel to upper surface, of fused, spinose spicules having form of pentactines with repeatedly bifurcated, paratangential rays; downwardly directed, proximal ray usually terminally bifurcated; upper surface of paratangential rays and sides of proximal rays are densely spinose. *Permian (Guadalupian):* USA

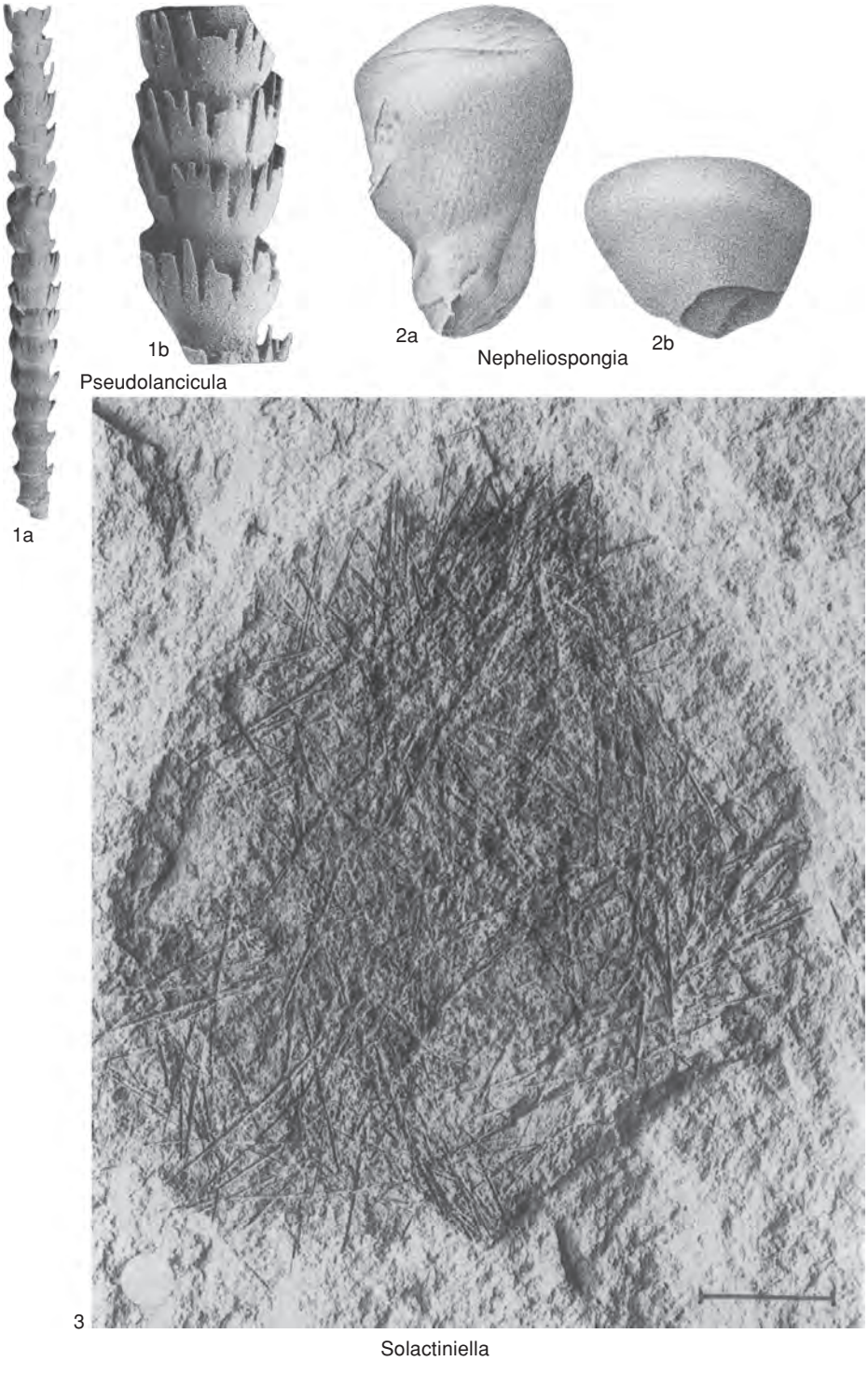


FIG. 295. Uncertain (p. 448).

(Texas).——Fig. 294,*1a–e.* **S. typicale,* Bell Canyon Formation, Delaware Mountains; *a,* lectotype from interior showing complex nature of fused skeleton, ×10; *b,* dermal view of lectotype showing coarser, fused rays of fragment, USNM 118134a, ×10 (Girty, 1909); *c,* side view of silicified specimen showing arched layers of silicified, fused pentactines, at bottom right four primary rays of a spicule form a small, rectangular cross, AMNH 28080, ×5; *d,* view of arched, convex top showing oscule in center surrounded by fused, bifurcated rays, ×5; *e,* camera lucida drawing of fragment of horizontal spicule layer figured by Girty (1909, pl. 27,*9*), with *dashed lines* indicating fused branches of a single spicule, whose center is shown by the *solid cross,* ×18 (Finks, 1960; courtesy of The American Museum of Natural History).

Family TADASSIIDAE Zhuravleva & Pyanovskaya, 1995

[Tadassiidae Zhuravleva & Pyanovskaya, 1995, p. 31]

Chambered colonial and single organisms with one or two walls; chambers nearly spherical to irregularly elongate and may be in shapeless heaps or clusters; chamber walls with irregularly distributed, small pores of rare, radial, curved canals; skeleton of intergrown spicules including stauractines. *Middle Cambrian–Upper Cambrian:* South Tien Shan, Russia.

Tadassia Zhuravleva & Pyanovskaya, 1995, p. 31 [**T. bogambirica;* OD]. Chambers spherical to irregularly elongate, may have one or two concentric walls; gastral surface rough and spongy but dermal surface smooth; wall pierced by pores without pattern of distribution; rare, radial canals curved and margins follow endings of spicules; skeleton primarily siliceous of united stauractines of various sizes as macrospicules united in rectangular lattice; smaller spicules present in outer part of external wall. *Middle Cambrian–Upper Cambrian:* Uzbekistan.——Fig. 294,*2a–f.* **T. bogambirica,* Koibulak Formation, North Nuratau Range, southern Tien Shan; *a,* several colonies in thin section, including holotype in lower center; sponges with open chambers and single walls pierced by pores and canals, CSGM 934/1, ×4; *b–e,* drawings of macrospicules as separate elements on left; *f,* united on right, CSGM 934/8, ×4 (Zhuravleva & Pyanovskaya, 1995; courtesy of Geologiya i Geofizikia, Novosibirsk).

Class, Order, and Family UNCERTAIN

Nepheliospongia Clarke, 1900, p. 189 [**N. typica;* OD]. Vase shaped to obconical cup shaped, moderately thick walled, with skeleton of inosculating spicules that form small, irregular polygons, nature of spicules unknown. *Middle Devonian–Upper Devonian:* USA (New York).——Fig. 295,*2a–b.* **N. typica,* Lower Chemung beds, Upper Devonian, Naples; *a,* side view of obconical sponge with reticulate, skeletal pattern, NYSM, ×1; *b,* side view of smaller sponge with ovoid, cross section, and with characteristic reticulation on exterior of moderately thick walls, NYSM, ×1 (Clarke, 1900).

Pseudolancicula Webby & Trotter, 1993, p. 34 [**P. exigua;* OD]. Siliceous, gently tapering acanthostyle with spines arranged in verticillate pattern, and with an axial filament. *Upper Ordovician:* Australia (New South Wales).——Fig. 295,*1a–b.* **P. exigua,* Malongulli Formation; *a,* holotype spicule, SUP, ×30; *b,* holotype spicule, SUP, ×75 (Webby & Trotter, 1993).

?Solactiniella Mehl & Reitner in Steiner & others, 1993, p. 309 [**S. plumata;* OD]. Irregular cluster of mainly, or exclusively, diactine spicules that are organized into bundles that radiate toward margins of sponge body. [The cluster is composed of only one or two types of spicules, and they have a preferred radial orientation that suggests this is part of a sponge. Because of the low order of structural development, taxonomic position of the cluster must remain uncertain.] *Lower Cambrian–Middle Cambrian:* China (Anhui, Hunan).——Fig. 295,*3.* **S. plumata,* Niutitang Formation, Tommotian, Sansha, Hubei; holotype spicule matte with coarse diactines that radiate toward margin, SAN 102, ×3 (Steiner & others, 1993).